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CHARACTERISTICS OF SLURRY INFILTRATED FIBROUS CONCRETE (SIFCON) PRODUCED BY PARTIALLY REPLACING CEMENT BY MINERAL ADMIXTURE AND STEEL FIBERS BY WASTE PLASTIC FIBERS

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Abstract: *SIFCON or Slurry infiltrated fibrous concrete is one of the recommended type of concrete to be used in construction industry particularly for structures carrying cyclic loads. Use of Slurry infiltrated fibrous concrete imparts higher impact strength, flexural strength, ductility and crack resistance property to the structure. However the cost of production of Slurry infiltrated fibrous concrete is higher due to high volume of cement and use of steel fibers. Presently lot of efforts are being put to reduce the cost of construction by different ways. Reducing the cost of concrete is one of the important criteria. The best way to reduce the cost of concrete production is by replacing a part of cement by a material which is cheaper than cement and would not affect the performance of concrete. In this work, some efforts are made to replace a part of cement by mineral admixtures such as Silica fume, metakaolin and Ground granulated blast furnace slag. And a part of steel fibers were replaced by waste plastic fibers. Tests were conducted on hardened concrete produced with these mineral admixtures and waste plastic fibers and the results were compared to that of ordinary Slurry infiltrated fibrous concrete. The results show that the SIFCON produced by replacing 20% of cement by mineral admixtures and replacing 50% steel fibers with waste plastic fibers possess equivalent strength as the ordinary SIFCON, whereas the higher percentage of replacement reduced the strength.*

Keywords: *Cyclic loads, Impact strength, Flexural strength, Silica fume, Metakaolin, Ground granulated blast furnace slag*.

Introduction

Concrete structures are seen everywhere in the world. The importance of concrete in the modern society could not be underestimated. Concrete structures have been regarded as durable material requiring little or no maintenance. However experiences show that many concrete structures are showing the signs of deterioration for a period of only 20-30years.Conventional concrete possess high compressive strength but does not perform well when subjected to tensile forces. Plain concrete fails even under a small tensile stress. So to add tensile strength to the plain concrete reinforcing steel is added. Concrete can be prepared using locally available cheap materials. But it is to be noted that production of cement

involves consumption of lot of heat energy and also there will be emission of CO2 during the conversion of limestone into cement and extraction of limestone will also have an adverse effect on environment. It is important to look for other alternative materials which can reduce the requirement of cement for the concrete. And the preferred alternative material should be cost effective when compared to cement but should not affect the performance of concrete hence we can reduce the consumption of cement considerably. At present, the alternatives used in the construction industry to reduce the consumption of cement are mineral admixtures such as Fly ash, Ground granulated blast furnace slag, silica fume, Metakaolin, rice husk ash etc which are all by-products or waste materials in one or other way that cause environmental pollution. These mineral admixtures can be used in concrete to replace the cement partially and these admixtures do not affect the performance of the concrete when they are used in minimum or optimum percentage. This way it helps reducing a certain part of environmental waste.

On the other hand we have lot of plastic waste generated which is again an environmental concern. The effective way to reduce the plastic waste is by recycling and reusing. But it is also possible to use the plastic waste in concrete industry. Certain types of plastics when used in concrete slightly enhance the tensile and shear strength of concrete.

There have been lot of development in concrete industry to enhance different properties of the concrete namely fibre reinforced concrete, Light weight concrete, high performance concrete, high density concrete, self-compacting concrete, SIFCON etc. Slurry infiltrated fibrous concrete (SIFCON) is a type of concrete produced by infiltrating slurry through a matrix of steel fibers. The volume of fibres in SIFCON will be about 1 to 4 percent. SIFCON possess higher compressive, impact, Flexural and shear strength and considerable tensile strength. As SIFCON has higher impact strength it can be used for the members which carry cyclic or dynamic loads such as deck slab of bridges, pavements etc. The use of SIFCON would be beneficial in those applications where concrete or SFRC has not performed as expected or where high strength and ductility are required.

One of major concerns today in the Highways is the deterioration of bridge decks due to the use of de-icing chemicals. Many methods to control this deterioration has been tried. One common technique has been to increase the thickness of concrete cover over the top reinforcing bars in combination with the use of epoxy coated bars.

If SIFCON is used as a topping material the thickness of the cover can be reduced to half of conventional concrete and also epoxy-coating bars may not be necessary. One must also consider the effect of reduced dead load on the supporting structure. In addition the exceptional crack resistance and durability of SIFCON would reduce future maintenance cost and extend the overall life of the structure.

In this work an effort has been made to develop SIFCON by replacing a part of cement by mineral admixtures and a part of steel fibers by waste plastic fibers. Use of Mineral admixtures and waste plastic fibres reduces the cost of production of SIFCON considerably. The mineral admixtures used are Silica fume, Metakaolin and Ground granulated blast furnace slag. Silica fume is also known as micro-silica is a by-product obtain during the production of Silica, Metakaoline is the anhydrous calcined form of the clay mineral kaolinite and Ground granulated blast furnace slag is obtained by quenching molten iron slag from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. The SIFCON produced with different ratios of mineral admixtures

to cement and waste plastic fibers to steel fibers were tested for Compressive, flexural, shear, impact and tensile strength and convincing results were obtained.

Materials and Methodology

The materials used in this study include ordinary Portland cement, fine aggregate, Silica fume, Metakaoline, Ground granulated blast furnace slag, mixing water, steel fibres, waste plastic fibres and high density poly ethylene fibres.

2.1 Properties of materials

Ordinary Portland cement

Specific surface	3250 cm^2/gm
Normal consistency	34%
Specific gravity	3.15
Setting time a)Initial b) Final	 35min 320min
Compressive strength	41.4N/mm^2

Silica fum

Specific gravity	2.28
Specific surface	15000-20000 cm^2/gm
Bulk density	1350-1510 kg/m^3

Fig.1 Silica fume

Metakaolin

Specific gravity	2.48
Average particle size	1.5 µm
Bulk density	1550-1680 kg/m^3

Fig.2 Metakaolin

GGBS

Specific gravity	2.85
Specific surface	450-475 m^2/kg
Bulk density	1250 kg/m^3

Fig.3 GGBS

Fine aggregates

Specific gravity	2.58
Water absorption	2.5%
Bulk density	1750 kg/m^3

Fig.4 Sand

Steel fibers

Steel fibers of length 35mm and width 1mm having aspect ratio 35 are used.

Fig.5 Steel fibers

HDPE

High density polyethylene fibres are procured from cutting HDPE oil cans. Fibres are cut to a length of 35 mm, 1mm thick and width of 3mm obtaining as aspect ratio of 35. Density of HDPE fibre was found to be 900 kg/m^3.

Fig.6 High density polyethylene fiber

Waste plastic fibers

Waste plastic fibers are obtained by cutting the waste plastic materials like buckets, Jugs, tubs etc. The size of the fibers used here is 35mm length and 1mm wide. The density of WPF varies in the range of 230 – 300 kg/m3and Aspect ratio of waste plastic fibers is 35.

Fig 7 High density polyethylene fibers

2.2 Preparation of SIFCON

SIFCON is prepared by pouring cement slurry through to the matrix of fibers preplaced in to the molds. The mix ratio adopted was 1:1 (Cement: Sand) and volume of fibers adopted was 4%. Water cement ratio adopted was 0.45. The following table shows the different combinations of cement + mineral admixtures and Steel + plastic fibers.

Combinations	Cement + Mineral admixture	Steel + HDPE + WP Fibers
Set 1	90% cement + 10% silica fume	2% + 1%+1%
Set 2	90% cement + 10% Metakaolin	2% + 1%+1%
Set 3	90% cement + 10% GGBS	2% + 1%+1%
Set 4	80% cement + 20% silica fume	2% + 1%+1%
Set 5	80% cement + 20% Metakaolin	2% + 1%+1%
Set 6	80% cement + 20% GGBS	2% + 1%+1%
Set 7	75% cement + 25% silica fume	2% + 1%+1%
Set 8	75% cement + 25% Metakaolin	2% + 1%+1%
Set 9	75% cement + 25% GGBS	2% + 1%+1%
Set 10	100% + 0 + 0 (Control mix)	4% + 0 + 0

Each set includes samples for compression test, Shear, Tensile, Impact and Flexure test. After 24 hours of casting the samples were demoulded and cured for 28days.

2.3 Testing of Samples

The cured SIFCON samples were subjected to following test.

2.3.1 Compression test

Standard size of the Compression test specimen is 150×150×150 mm. The test sample is placed centrally on the compression testing machine and load is applied continuously and uniformly on the surface parallel to the direction of tamping. The load is increased until the specimen fails and the maximum load carried by each specimen during the test was recorded as shown in fig 8

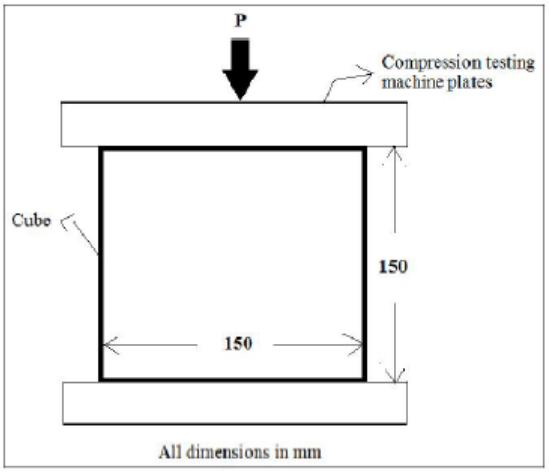


Fig 8 Compression testing

Compressive strength was calculated as follows

Compressive strength = P/A

2.3.2 Tensile test

Standard Size of the tensile test sample is 150mm diameter and 300mm height. Diametrical lines were drawn on two ends of the specimen so that they are in the same axial plane. A plywood strip was placed on the center of the lower platen. The specimen was placed on the plywood strip and aligned such that the lines marked on the end of the specimen are vertical and centered over the plywood strip. The second plywood strip is placed lengthwise on the cylinder centered on the lines marked on the ends of the cylinder. Load is applied without shock and increased continuously to produce a split tensile stress until the specimen fails and no greater load can be sustained.

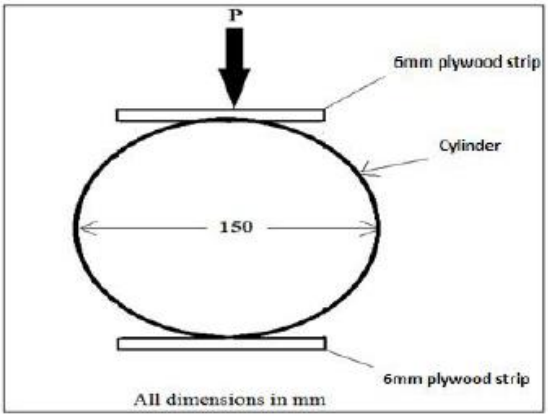


Fig 9 tensile testing

Split tensile strength = 2P/(πdL)
Where,
P = Load in N
d = Diameter of cylinder = 150 mm
L = Length of cylinder = 300 mm

2.3.3 Flexural strength test

The standard size of the flexural test specimen is 100x100x500mm.
Here we are applying two point loading on the beam specimen as shown in the fig.10.
The load was applied till the beam breaks and failure load was noted down.
Flexural strength = PL/BD²
Where,
P = Load in N
L = Effective length of beam = 400 mm
b = Width of the beam = 100 mm
d = Depth of the beam = 100 mm

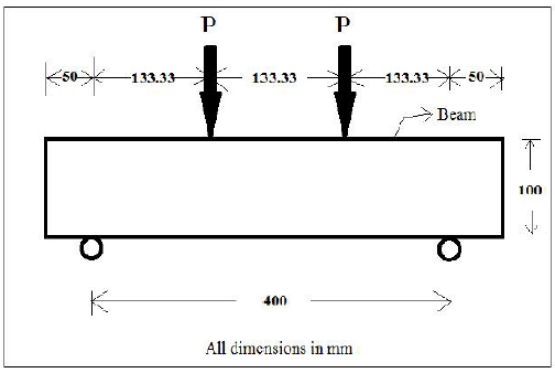


Fig 10 Flexure testing

2.3.4 Shear strength test

The standard dimensions of the shear strength test specimen is shown in the fig.11.
The specimen is placed in the compression testing machine and the load is applied until the cracks are developed and the specimen fails. The cracks and the failure load is notes down.

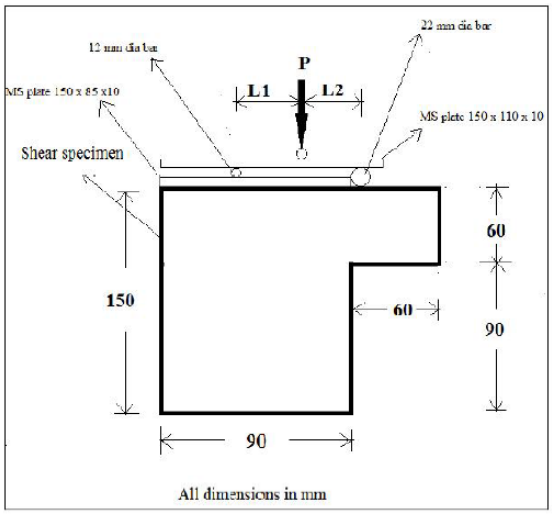


Fig 11 Shear strength testing

Shear strength = Failure load/A

Where,

Failure load = PL1 / (L1+L2)

P = Load in N

A = Area of shear surface = 60 x 150 mm2, L1 = 25 mm, L2 = 25 mm

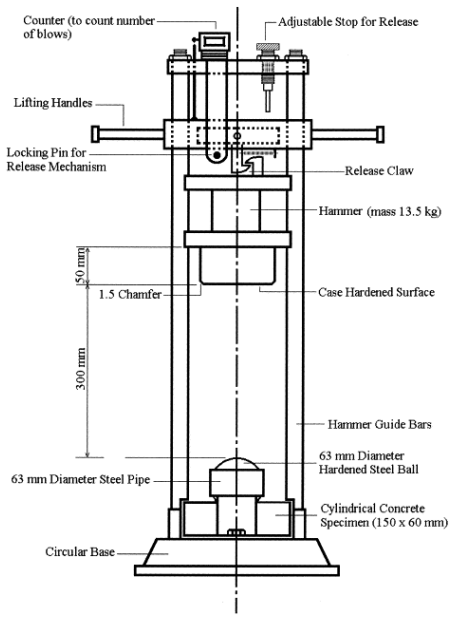
2.3.5 Impact strength test

The standard test specimen thickness is 60mm, diameter 150mm.

The test specimen is placed on the base plate. A bracket is placed over the test specimen which contains a cylindrical sleeve that positions a hardened steel ball on top of the test specimen.

An ASTM D 1557 drop hammer used for compaction of asphalt and soils samples is then placed on top of the ball.

The ultimate failure occurs when sufficient impact energy has been supplied to formation and spreading of the cracks. The number blows at failure are noted down.



Computation of the impact strength is as follows

Impact strength = WHN

Where,

W = Weight of the hammer = 45 N

H = Height of the drop = 457mm

N = Number of blows

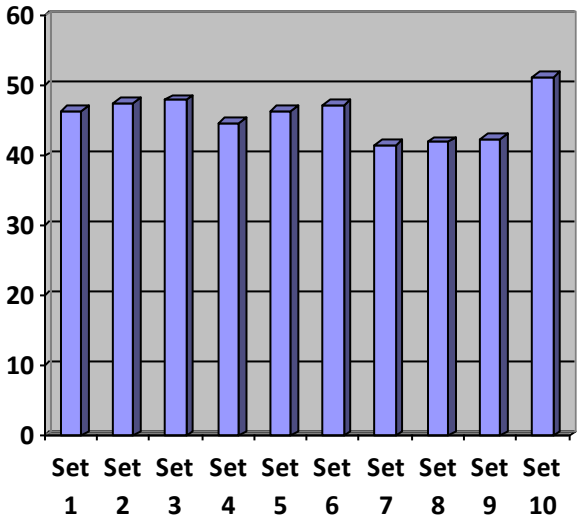
Results and Discussions

The following results were obtained when the tests were conducted on the SIFCON samples

1.1 Compression test results

Combinations	Cement + Mineral admixture	Steel + HDPE + WP Fibers	Compressive strength (N/mm^2)
Set 1	90% cement + 10% silica fume	2% + 1%+1%	46.5
Set 2	90% cement + 10% Metakaolin	2% + 1%+1%	47.1
Set 3	90% cement + 10% GGBS	2% + 1%+1%	49.5
Set 4	80% cement + 20% silica fume	2% + 1%+1%	43.2
Set 5	80% cement + 20% Metakaolin	2% + 1%+1%	43.6
Set 6	80% cement + 20% GGBS	2% + 1%+1%	48.2
Set 7	75% cement + 25% silica fume	2% + 1%+1%	40.4

Set 8	75% cement + 25% Metakaolin	2% + 1%+1%	41.3
Set 9	75% cement + 25% GGBS	2% + 1%+1%	43.2
Set 10	100% + 0 + 0 (Control mix)	4% + 0 + 0	51.5

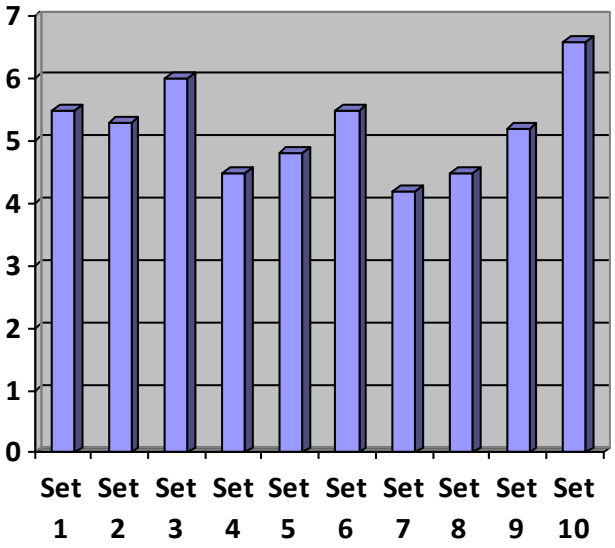


From the above results it can observed that the control mix (Set 10) has a strength of 51.5N/mm^2. When 10% of cement was replaced with mineral admixtures the strength ranges from 46. 5N/mm^2 to 49.5 N/mm^2. When 20% of cement was replaced by mineral admixtures the strength obtained was in the range 43.2 to 48.2N/mm^2. And when the when 25% of the cement was replaced by mineral admixtures the strength drops and was in the range 40.4N/mm^2 to 43.2N/mm^2 which is too low when compared with the control mix. It can be seen that mix with replacement of cement by GGBS performs well under the compression.

3.2 Tensile strength test results

Combinations	Cement + Mineral admixture	Steel + HDPE + WP Fibers	Tensile strength (N/mm^2)
Set 1	90% cement + 10% silica fume	2% + 1%+1%	5.5
Set 2	90% cement + 10% Metakaolin	2% + 1%+1%	5.2
Set 3	90% cement + 10% GGBS	2% + 1%+1%	6.0
Set 4	80% cement + 20% silica fume	2% + 1%+1%	4.3
Set 5	80% cement + 20% Metakaolin	2% + 1%+1%	4.5

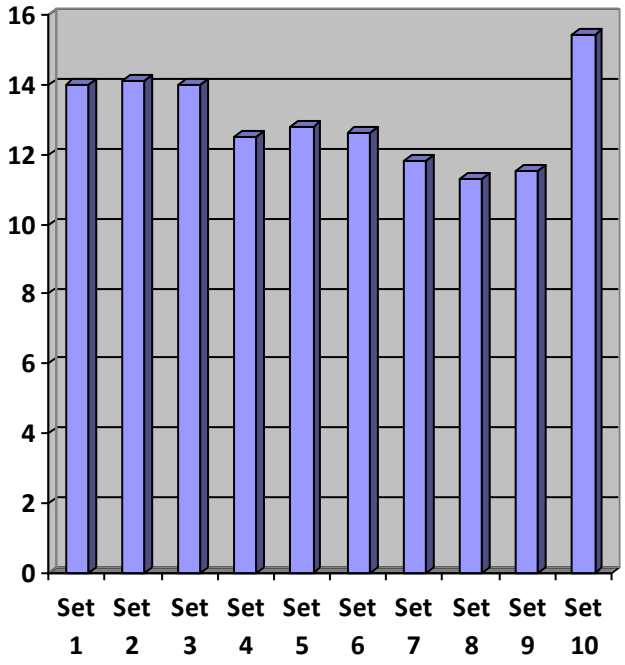
Set 6	80% cement + 20% GGBS	2% + 1%+1%	5.5
Set 7	75% cement + 25% silica fume	2% + 1%+1%	4.1
Set 8	75% cement + 25% Metakaolin	2% + 1%+1%	4.3
Set 9	75% cement + 25% GGBS	2% + 1%+1%	5.2
Set 10	100% + 0 + 0 (Control mix)	4% + 0 + 0	6.5



From the above results it can observed that the control mix (Set 10) has a tensile strength of 6.5N/mm^2. When 10% of cement was replaced with mineral admixtures the strength ranges from 5.2N/mm^2 to 6.0 N/mm^2. When 20% of cement was replaced by mineral admixtures the strength obtained was in the range 4.3 to 5.5/mm^2. And when the when 25% of the cement was replaced by mineral admixtures the strength drops considerably and was in the range 4.1N/mm^2 to 5.2N/mm^2 which is too low when compared with the control mix. It can be seen that mix with replacement of cement by GGBS performs well under the tensile force.

3.3 Flexural strength results

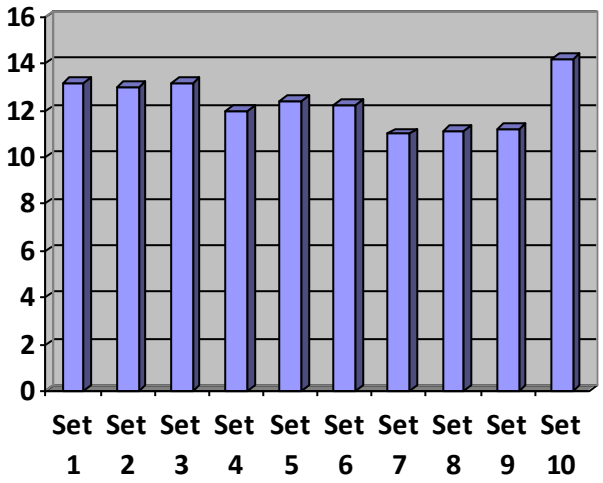
Combinations	Cement + Mineral admixture	Steel + HDPE + WP Fibers	Flexural strength (N/mm^2)
Set 1	90% cement + 10% silica fume	2% + 1%+1%	14.0
Set 2	90% cement + 10% Metakaolin	2% + 1%+1%	14.1
Set 3	90% cement + 10% GGBS	2% + 1%+1%	14.0
Set 4	80% cement + 20% silica fume	2% + 1%+1%	12.5
Set 5	80% cement + 20% Metakaolin	2% + 1%+1%	12.8
Set 6	80% cement + 20% GGBS	2% + 1%+1%	12.6
Set 7	75% cement + 25% silica fume	2% + 1%+1%	11.8
Set 8	75% cement + 25% Metakaolin	2% + 1%+1%	11.3
Set 9	75% cement + 25% GGBS	2% + 1%+1%	11.5
Set 10	100% + 0 + 0 (Control mix)	4% + 0 + 0	15.4



From the above results it can observed that the control mix (Set 10) has a flexural strength of 15.4N/mm^2. When 10% of cement was replaced with mineral admixtures the strength ranges from 14.0N/mm^2 to 14.10 N/mm^2. When 20% of cement was replaced by mineral admixtures the strength obtained was in the range 12.5 to 12.8N/mm^2. And when the when 25% of the cement was replaced by mineral admixtures the strength drops and was in the range 11.3N/mm^2 to 11.8N/mm^2 which is too low when compared with the control mix. It can be seen that at all the mixes perform in a similar way under the flexure.

3.4 Shear strength results

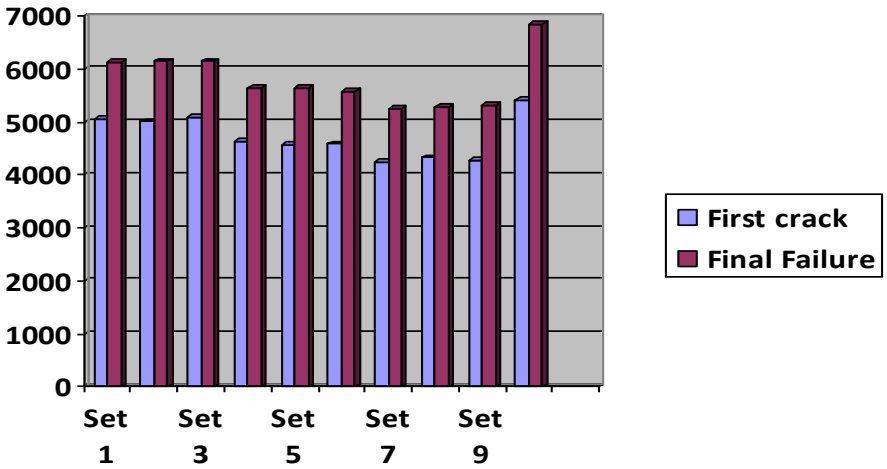
Combinations	Cement + Mineral admixture	Steel + HDPE + WP Fibers	Shear strength (N/mm^2)
Set 1	90% cement + 10% silica fume	2% + 1%+1%	13.2
Set 2	90% cement + 10% Metakaolin	2% + 1%+1%	13.0
Set 3	90% cement + 10% GGBS	2% + 1%+1%	13.2
Set 4	80% cement + 20% silica fume	2% + 1%+1%	12.0
Set 5	80% cement + 20% Metakaolin	2% + 1%+1%	12.4
Set 6	80% cement + 20% GGBS	2% + 1%+1%	12.2
Set 7	75% cement + 25% silica fume	2% + 1%+1%	11.0
Set 8	75% cement + 25% Metakaolin	2% + 1%+1%	11.10
Set 9	75% cement + 25% GGBS	2% + 1%+1%	11.20
Set 10	100% + 0 + 0 (Control mix)	4% + 0 + 0	14.2



From the above results it can observed that the control mix (Set 10) has a flexural strength of 14.2N/mm^2. When 10% of cement was replaced with mineral admixtures the strength ranges from 13.0N/mm^2 to 13.20 N/mm^2. When 20% of cement was replaced by mineral admixtures the strength obtained was in the range 12.0 to 12.4N/mm^2. And when the when 25% of the cement was replaced by mineral admixtures the strength drops and was in the range 11.0N/mm^2 to 11.2N/mm^2 which is too low when compared with the control mix. It can be seen that at all the mixes perform in a similar way under the shear stress.

3.5 Impact strength results

Combinations	Cement + Mineral admixture	Steel + HDPE + WP Fibers	Impact strength at first crack (N-m)	Impact strength at first crack (N-m)
Set 1	90% cement + 10% silica fume	2% + 1%+1%	5068.3	6125.7
Set 2	90% cement + 10% Metakaolin	2% + 1%+1%	5016.2	6150.5
Set 3	90% cement + 10% GGBS	2% + 1%+1%	5102.4	6146.4
Set 4	80% cement + 20% silica fume	2% + 1%+1%	4645.1	5642.1
Set 5	80% cement + 20% Metakaolin	2% + 1%+1%	4575.2	5645.4
Set 6	80% cement + 20% GGBS	2% + 1%+1%	4585.6	5586.2
Set 7	75% cement + 25% silica fume	2% + 1%+1%	4256.4	5264.7
Set 8	75% cement + 25% Metakaolin	2% + 1%+1%	4325.5	5287.4
Set 9	75% cement + 25% GGBS	2% + 1%+1%	4276.4	5325.6
Set 10	100% + 0 + 0 (Control mix)	4% + 0 + 0	5423.5	6854.6



From the above results it can observed that the control mix (Set 10) has Impact strength of 6854.6N-m for final failure. When 10% of cement was replaced with mineral admixtures the strength ranges from 6125N-m to 6150 N/mm^2. When 20% of cement was replaced by mineral admixtures the strength obtained was in the range 5586 N-m to 5645 N-m. And when 25% of the cement was replaced by mineral admixtures the strength drops and was in the range 5264 N-m to 5325 N-m which is too low when compared with the control mix. It can be seen that at all the mixes perform in a similar way under the Impact load.

Conclusions

From the experiments conducted it can be observed that the strength of the SIFCON reduces as the percentage replacement of cement by mineral admixture is higher. But when the percentage replacement of cement was just 10% the strength obtained will be almost nearer to that of the control mix. However 10% replacement of cement by mineral admixtures does not seem to be much cost effective. So if we consider a higher percentage replacement of cement, it can be observed that strength of the SIFCON with 20% replacement of cement is almost nearer to that of the SIFCON produced with 10% replacement of cement by Mineral admixtures, where as if we observe the performance of SIFCON produced with replacement of 25% of cement by mineral admixtures is considerably low.

So we can say that the optimum percentage of replacement of cement by any mineral admixture should be 20. When we observe the performance of each mineral admixtures we can see that the ground granulated blast furnace flag is comparatively better. It can also be seen that 50% replacement of steel fibers with waste plastic fibers does not reduce the strength of the SIFCON significantly.

So after observing the experimental results it can be concluded that we can effectively reduce the cost of production of SIFCON by replacing 20% of cement by GGBS and by replacing 50% of steel fibers by waste plastic fiber without reducing the performance considerably.

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A PRELIMINARY STUDY ON GAIT AND MOTION ANALYSIS FOR REHABILITATION APPLICATIONS

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Abstract: *Human gait analysis is an extensively studied research area since it provides important information for various health related and rehabilitation applications. Application of gait analysis ranges from diagnosis, monitoring, sports activities and early detection of potential hazards such as human fall. There are various types of approaches used in gait analysis including wearable, ambient and vision based devices. Among them wearable based devices is an inexpensive approach, though it requires additional resources and time for setup each time a gait analysis is required. A non-invasive approach could save lot of nursing and additional resources and indeed give more accurate useful information for gait analysis such as using Microsoft Kinect sensor since it can give depth and normal colour images as well. This paper presents a preliminary study on gait analysis which can be applied to various rehabilitation application. The measurements taken includes step width, step lengths, stride lengths, arm spread, trunk sway and angles of knee with respective to hip and ankle while walking. The preliminary results showed that the approach could compute the same parameters as that of the wearable based devices with low error rates.*

Keywords: *Gait Analysis, Lower Body Analysis, Rehabilitation, Depth Sensor*

Introduction

Gait and motion analysis is a key area of research in the field of biomedical engineering and rehabilitations applications. There are basically two approaches used to gather information for gait analysis, namely using wearable sensors and non-invasive devices. Wearable sensors were the most commonly used approach and there are various studies conducted with different sensors such as accelerometers, gyroscopes, flexible angular sensors and electromagnetic tracking systems. Nevertheless, all the approaches are aimed to identify common gait parameters such as stride and kinematics information to apply into the field of rehabilitation and injury prevention. This includes identification of pathological posture and movements, pre- and post-treatment efficacy assessment, early detection of disorders and wellness and safety sports. The use of wearable or integration of ambient sensors are very conventional, however they are not adaptable due to the wearing difficulties, setup time, requirement of additional staffs and resources. At the same time, such approaches used to generate false measurements unlike vision based sensors [1 - 3]. This study aims to propose a completely non-invasive approach to generate the same parameters as that of the wearable

sensors using Microsoft Kinect Sensor. This paper extends the methodology in [1] to perform a complete gait analysis
By considering the upper body movements as well and incorporating the fall risk level identification parameters in [4].

Related Works

There are plenty of studies carried out with different types of sensors to obtain accurate gait information for the required application. This section will only highlight few of such works that employed non-invasive approach. Some of the studies were committed to specific disease such as the study presented by Procházka et al., uses data from Kinect sensor to recognize gait features and for the detection of disorders in movements for people with Parkinson's diseases [5]. The proposed approach uses mathematical model for motion tracking, gait feature selection and classification and for the study of Parkinson's disease. Another study by Galna et al., proposed a method for measuring the clinically relevant movements in Parkinson's disease patients using Kinect sensor. The results of the proposed method showed that the sensor employed was accurate in measuring the timing and gross spatial characteristics of clinically relevant movements, even though it couldn't achieve that accuracy in classifying minor movements like hand clasping and toe tapping [6].

Studies that is based on identification of gait parameters in real time such as the approach presented by Jiang et al., used length of bones and the angles of joints. This Kinect sensor based approach used two features and on this basis they made feature fusion and store feature vector into their own database to apply nearest neighbour classifier. The two features are namely as static feature (length of the bones) and dynamic feature (angles of swing legs and arms) [7]. Similarly, Gabel at el., presented a non-intrusive and accurate gait analysis system using Kinect sensor to extract gait information and measurements including standard stride information, arm kinematics and other parameters [8]. Another study conducted by Preis et al presented an approach for gait recognition based on Kinect sensor for skeleton detection and tracking in real time. This study evaluated few body features together with step length and speed, their relevance for person identification [9]. Alternatively, Bonnechere et al conducted a study to evaluate the validity and reproducibility of Kinect sensor by using a marker-based stereophotogrammetry system as a reference. The results for reproducibility were statistically similar to results from stereophotogrammetry for four exercises [10]. Stone E.E. and Skubic M also conducted an evaluation of Kinect sensor for passive human fall risk assessment in home environment. They basically evaluated the use Kinect sensor for gathering measurements of temporal and spatial gait parameters with Vicon motion capture system [11].

One study also presented a robotic system using Kinect sensor monitoring human gait during normal activities of daily life. Together with this they also presented a study of the robot's accuracy in calculating the parameters required for human fall detection when compared to vicon motion capture system [12].

There were two related studies that conducted a comparison between two non-invasive sensors for its accuracy in gait analysis. The first study presented a comparison between pose estimation from Kinect and with other established motion based techniques for pose estimation. They examined the effectiveness localization of joints and estimation of pose with respect to orientation and occlusion [13]. The other study demonstrated a comparison of motion tracking performance between Kinect sensor and OptiTrack optical system. The experimental results from the study conducted showed that in terms of motion

tracking, Kinect sensor was able achieve a competitive performance as of OptiTrack and also provide "pervasive" accessibility that can enable patients for rehabilitation treatment in clinic or at home [14].

Method

The method proposed in this study uses Kinect data stream to identify the joint position for the analysis of human movements. The algorithm uses the extracted position of joints and measurement of bone from joint to joint, since these are the parameters that constantly changes and which can distinguish human characters according to anthropometry. This paper performs a lower body analysis from leg joint movements and demonstrates an upper body analysis for movements of arm and hip only. This is because lower body analysis is more applicable in many rehabilitation applications. For this, the analysis will be conducted on, step width, step length, step time, stride lengths, stride duration, walking speed and step frequency in steps per minute. The upper body analysis will consider arm spread and trunk sway.

Gait analysis is used to identify the abnormalities in normal gait cycle which depends on various biomechanical features controlled by the nerves system [15]. They are defined as the determinants of gait which consists six variables [16] responsible for maintaining locomotion by reducing the vertical Center of mass (COM). A gait cycle is the time-period of movements when any one-foot contacts the ground to the time when the same foot contacts the ground again or simply a stride whether it is from left or right foot. A stride is the distance between two consecutive initial contacts of the same foot on the ground. A complete gait cycle consists of two phases, namely the time-period when the given foot remains in contact with the ground (stance phase) and the time-period when the same foot is not in contact with the ground (swing phase). The movements during these phases can be further separated into different parts to better understand the actions and for easy identification and classification of the complete gait cycle. For simplification of the gait analysis the proposed methodology divides the complete cycle into four main postures in a way that it will cover the major parts of the gait cycle. The following figure illustrates the chosen postures of the lower body together with the angles used to identify the postures.

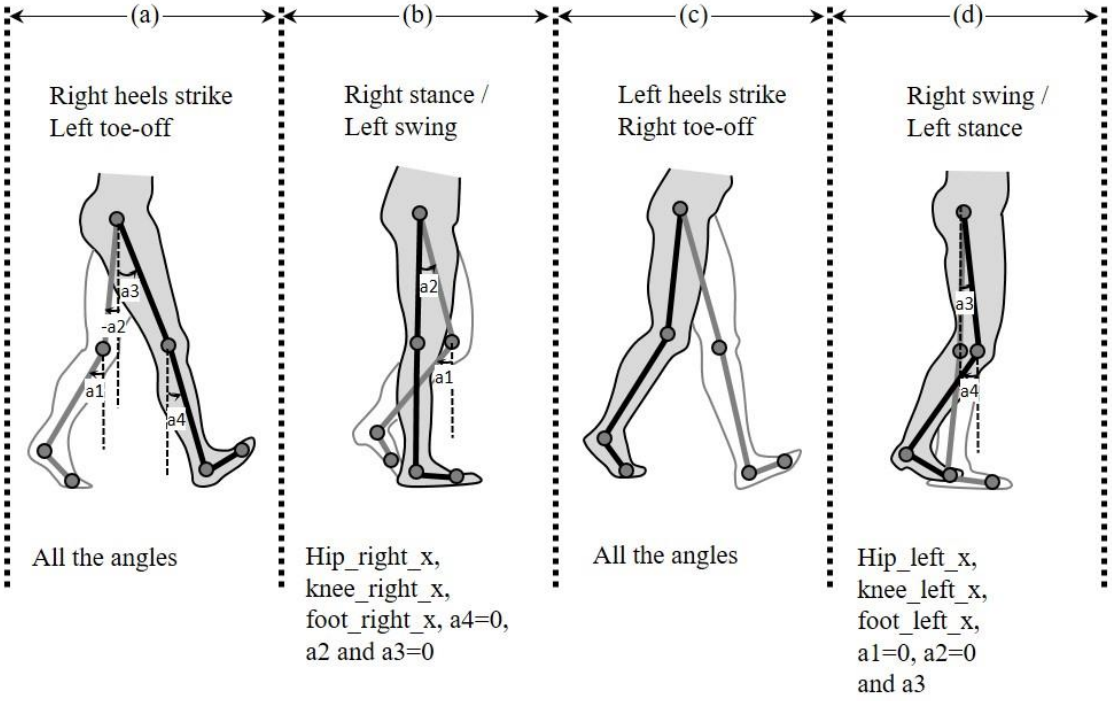

Figure 1: Postures Representing the Complete Gait Cycle

These postures are identified by considering the position and the angles between the joints [17]. The angles and the position of the joints required to identify any posture is described just beneath it. The position of the mentioned joints is used to find which limb is at stance. It is assumed that at stance the hip and the respective knee and foot will be aligned. The angle (a1) is formed between the right knee and right ankle, assuming that the right knee is the center of rotation. The angle (a4) is the same angle formed between the left knee and the left ankle, where the center of rotation is at left knee. The angle (a2) and (a3) is the angle formed between hip center to right knee and hip center to left knee respectively, where the center of rotation is at hip center. It was assumed that the two joints (the joint representing the center of rotation and the 'other' joint) will form a right-angled triangle. The angles mentioned are supposed to change as the 'other' joint moves by keeping the joint representing the COM at stationery point. At a point, the angle will be zero and will again increase as the 'other' joint moves after crossing the center line. These angles are especially helpful to measure the amount of spread between the two limbs.

For the calculation of the angles, adjacent and the opposite of the right-angled triangle formed was used. Adjacent was calculated by subtracting the y-value of the two joints forming the triangle and opposite is the difference of the x-value of the two joints. The tangent formula for right-angled triangle was used where tangent of the angle is equal to the division of opposite and adjacent.

$$a1 = \tan^{-1}\left(\frac{R\_k_X - R\_a_X}{R\_k_y - R\_a_y}\right) \quad (1)$$

$$a2 = \tan^{-1}\left(\frac{H_X - R\_k_X}{H_y - R\_k_y}\right) \quad (2)$$

$$a3 = \tan^{-1}\left(\frac{H_X - L\_k_X}{H_y - L\_k_y}\right) \quad (3)$$

$$a4 = \tan^{-1}\left(\frac{L\_a_X - L\_k_X}{L\_a_y - L\_a_y}\right) \quad (4)$$

Here, R_k, R_a, H, L_k and L_a are right knee, right ankle, hip center, left knee and left ankle respectively. The subscripted x and y refer to x-coordinate value and y-coordinate value respectively.

Once the posture is identified, the parameters required for the fall risk assessment were computed. For the analysis of human movements, measurement from joint to joint is used, since these are the parameters that constantly changes, and which can distinguish characteristics of human activities according to anthropometry. Some of the analysis to be conducted are, step width, step length, step time, stride lengths, stride duration, walking speed and step frequency in steps per minute. These variables can also be categorized into spatial (those concerned with distance) and temporal (those concerned with time) variables.

The spatial variables are computed using the following equations if the direction of the movement is across the sensor. The x and z values in each of the equations will be interchanged if the direction of the movement is horizontal (going far or coming close) to the sensor.

$$\text{Step width} = P\_R_z - C\_L_z \quad (5)$$

$$\text{Left step length} = C\_L_X - P\_R_X \quad (6)$$

$$\text{Right step length} = C\_R_X - P\_L_X \quad (7)$$

$$\text{Left Stride length} = C\_L_X - P\_L_X \quad (8)$$

$$\text{Right Stride length} = C\_R_X - P\_R_X \quad (9)$$

Here Rz, Lz, Lx and Rx are z value of right foot, z value of left foot, x value of left foot and x value of right foot respectively. The prefix C and P means current frame value and previous frame value respectively.

In case, if the direction is vertical to the sensor then the following equations are applied.

$$\text{Step width} = \sqrt{(R_y - L_y)^2 + (R_X - L_X)^2} \quad (10)$$

$$\text{Left step length} = \sqrt{(stepwidth)^2 + \left(\sqrt{(C\_L_y - P\_R_y)^2 + (C\_L_X - P\_R_X)^2}\right)^2} \quad (11)$$

$$\text{Right step length} = \sqrt{(stepwidth)^2 + \left(\sqrt{(C\_R_X - P\_L_X)^2 + (C\_R_y - P\_L_y)^2}\right)^2} \quad (12)$$

$$\text{Left stride length} = \sqrt{(C\_L_X - P\_L_X)^2 + (C\_L_y - P\_L_y)^2} \quad (13)$$

$$\text{Right stride length} = \sqrt{(C\_R_X - P\_R_X)^2 + (C\_R_y - P\_R_y)^2} \quad (14)$$

Here Ry, Rx, Ly and Lx are the y coordinate of right foot, x coordinate of right foot, y coordinate of left foot and x coordinate of left foot respectively. The prefix C and P is meant for current frame value and previous frame value.

The angles and the identified postures are used to compute other variables such as step frequency (cadence), step time, and stride duration. Step time is the time difference between any successive instance of the feet and floor contact of the opposite feet. This is calculated from the same loop used in step frequency calculation, except here the frame difference between two immediate step hit is multiplied by two to state the step time in second. Similarly stride duration, which is the time difference between successive instance of the foot and floor contact of the same foot can also be calculated. This was calculated in a different loop since stride duration can go beyond one seconds but the concept used is the same except that the frame gap between two successive left and right foot is extracted and multiplied by two for left stride and right stride duration respectively.

Walking speed is computed by considering the movement of hip center with respective to time. More preferably, the gait speed can be easily calculated by multiplying the average step length and step time. If the subject is walking across the sensor then the x-coordinate is more practical to calculate the distance travelled and z-coordinate if the subject is going far or coming close to the sensor horizontally. In case, for vertical movements the distance travelled can be calculated using the Equation 15. Once distance travelled is calculated, the speed can be computed by dividing it over the time taken.

Vertical movements =

$$\sqrt{(Current_{hip\_x} - Previous_{hip\_x})^2 + (Current_{hip\_y} - Previous_{hip\_y})^2} \quad (15)$$

Here hip_x and hip_y are the x coordinate and y coordinate of hip center respectively. Current and Previous is to denote current and previous frame.

Stance duration is the time when the given foot is in contact with the floor and the swing duration is the time when the foot is not in contact with the floor. These two parameters can be easily calculated by considering the postures in Figure 1, as it shows the major parts of the gait cycle, the two phases can be separated, and time duration calculated for each phase. In this way, stance duration can be simply calculated by measuring the time taken for the first three postures and the time taken for the last posture will be the swing duration. The time taken for each of the posture can be calculated by counting the number of frames passed to get the new posture over the total number of frames per second. Apart from the spatial and temporal variables, the positional information required are the height of hip, knee and position of foot. Step symmetry is also an important parameter for gait analysis as it estimates the step inequality. This parameters is computed by measuring the left and the right step lengths where the step lengths are the distance between left and right step. Step length is measured using x-axis and z-axis coordinates depending on the direction of the movements. If the direction of the movement is on x-axis then the following equation is used and if the direction of movement is on z-axis then z-values are used instead of the x-values.

$$\text{Step\_symmetry} = \left(x_{R\_foot} - x_{L\_foot}\right)_{PF} - \left(x_{R\_foot} - x_{L\_foot}\right)_{CF} \tag{16}$$

Here, R_foot is the right foot, L_foot is the left foot, x is the x-value or x-axis coordinate value, PF is the previous frame and CP is current frame.

The two parameters used for the analysis of upper body are trunk_sway and arm_spread. Trunk_sway measures how far the subject bends from side to side. It is computed from changes in the torso position with respective to the hip position. This variation can be calculated by taking x-axis values, if the direction of the movement is on z-axis as shown in the following equation 17 and using z-axis values instead of x-values if the direction of the movement is on x-axis.

$$\text{Trunk\_sway} = \frac{\left(Torso_x - \left(\frac{L\_hip_x + R\_hip_x}{2}\right)\right)_{PF} + \left(Torso_x - \left(\frac{L\_hip_x + R\_hip_x}{2}\right)\right)_{CF}}{2} \tag{17}$$

Here, L_hip is the left hip position and R_hip is the right hip position.

Spread_arm is a measure of how much the two arms are spread. This parameter gives important information on physical strengthens, since during a loss of control of the body due to slip or any other fall like event, it is normal to spread the arms to balance the body, especially common among elderly and people with weaker gait. This parameter is computed by taking the difference of torso position and the two (left and right) arms. Similar to Trunk_sway, spread_arm is also calculated from x-axis if the direction of the movement is on z-axis using the formula in the equation 18 and using z-axis values instead of x-values if the direction is on the x-axis. The average of the distance of the two arms to the torso were threshold between the frames to identify any action where the subject is spreading the arms to balance the body or trying to hold something to control the body.

$$\text{Spread\_arm} = \left(\frac{\left(Torso_x - R_{arm_x}\right) + \left(Torso_x - L_{arm_x}\right)}{2}\right)_{CP} - \left(\frac{\left(Torso_x - R\_arm_x\right) + \left(Torso_x - L\_arm_x\right)}{2}\right)_{PF} \tag{18}$$

Here, *R_arm* is right elbow joint and *L_arm* is the left elbow joint.

Results and discussion

The preliminary testing showed promising results in computing the parameters for gait analysis. Several activities were simulated to measure the accuracy of the algorithm. Experimental data were collected on a lab environment with footsteps and measuring tape as shown in Figure 2. Footsteps and measuring tapes were used to compare the actual values of different parameters with the generated values and to find important thresholds. This also help to identify key distinguishing characteristics of different movements. Different experimental environments were also used to assess the ability of the proposed system to handle obstacles blocking the view of the subject.

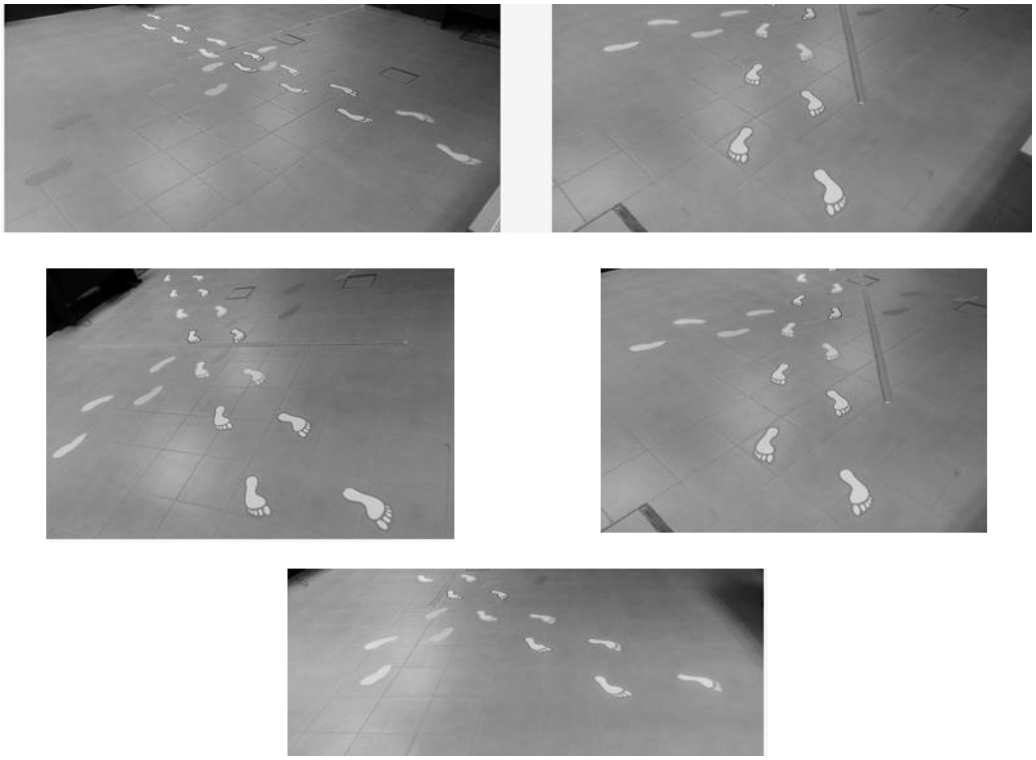

Figure 2: Experimental setup

Walking in different direction were simulated to validate the proposed algorithm as most of the gait parameters were extracted from walking. The table 1 shows the actual and predicted number of steps together with accurately detected number of steps for walking into two directions for three meter. The first column shows the actual number (average of three simulation) of footsteps placed during the experimental walking on each of the directions (across the sensor and vertical to the sensor). The predicted number of steps for each walking experimental is shown in the second column of the Table 1. They are measured by dividing the distance travelled for each of the experiment over the average step length computed (generated by the system from that experiment). The last column shows the number of steps detected by the system for each of the experiments. For walking across the sensor, the system accurately detected all the right and left steps when round-off to a whole number. For experiments on walking vertical to the sensor, the system detected all right steps and failed to classify all left steps. In-terms of the predicted number of steps, the average error for walking across and vertical is 13.63 percentage and 15.18 percentage respectively.

Table-1: Actual and predicted number of steps with accurately detected steps

	Actual no of steps		Predicted no of steps		Accurately detected steps	
	Left	Right	Left	Right	Left	Right
Across	5	6	5.67	6.83	5	6
Vertical	5	6	6	6.67	6	6

The step length and the time taken for the steps also gives important information for the classification of fall risk levels. It was observed that the time taken for the right steps are more than the left steps. This is because the subject is more confident when the weight is loaded on the right leg, since subject is right handed. The time taken to place the first step was also higher and it was then maintained at an equal amount between the two sides. The following figure shows the step lengths for the two legs, stride length and the respective step size for a sample of simulated walking. The first part of the figure shows the left and right stride length together with the average step size for each stride (two step lengths). The average error for all the identified step lengths are also plotted in the same figure. The second part of the figure shows the average step lengths for the respective stride length together with the respective average stride length (left and right stride length).

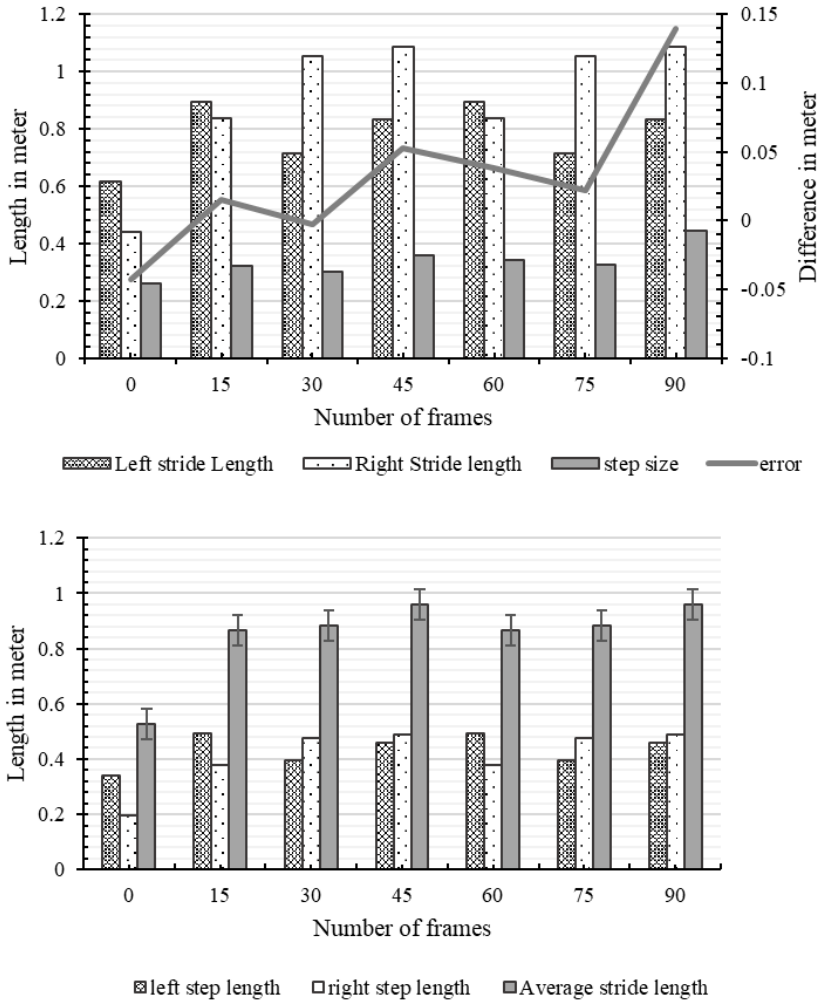

Figure 3: Step and stride measurements with the step size from a single sample

Conclusion

This paper demonstrated the use of Kinect sensor for gait analysis towards rehabilitation applications. The methodologies employed used the common parameters as that of the other approaches and validated the accuracy of the proposed approach in performing the same gait analysis non-invasively. The results showed promising performance as similar to other conventional approaches and thus eliminating hassles involved for the setup of the analysis and reduce the requirement human resources. Since this is just a preliminary study and there are significant improvements and enhancements needed for an accurate gait analysis so that it can be applied in any of biomechanical application reliably.

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A MODIFICATION OF THE UTAUT2 ON ACCEPTANCE OF JOMOPAY SYSTEM FROM PERSPECTIVES OF PUBLIC SECTOR EMPLOYEES IN JORDAN: CONCEPTUAL PAPER

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Abstract: *Recently, the smartphone applications played a critical role in every aspect of our life, as in the case of Jordan Mobile Payment (JoMoPay) system that can be used to save time, effort and money. Despite immense benefits of JoMoPay system, their acceptance by users is very low. Moreover, the related issues of JoMoPay system has not been addressed substantially in the Jordanian context. In this respect, the research model proposed in this paper tries to synthesize the extended Unified Theory of Acceptance and Use of Technology (UTAUT2) model variables. While the key variables in UTAUT2 are namely; performance expectancy, effort expectancy, social influence, facilitating conditions, and price value. In addition to added new variables namely; trust, security, and privacy as immediate predictors of intentions of public sector employees to use JoMoPay system as well as awareness as the moderating variable among them.*

Keywords: *JoMoPay, UTAUT, Acceptance, Awareness, Public Sector and Jordan.*

Introduction

Lately, the use of mobile devices has surged across worldwide, while recent studies showed that the total number of mobile phone users worldwide is more than 4.3 billion people in 2017 (Sanou, 2017; Statista, 2017). While the number of mobile phone users in the global is expected to reach 5 billion marks by 2019 (Statista, 2018). More specifically, Jordan and the rest of the Middle East countries recorded a very high penetration when it comes to mobile phones which is a great opportunity for improving and promoting financial and economic inclusion (Central Bank of Jordan [CBJ], 2017; Sehwail & Bahou, 2017; Ghazal, 2015). The newest statistics showed that the number of the active mobile phones in Jordan reached 16,746,000 in 2016 at a penetration rate of 168% of the Jordanian population (Ghazal, 2017a; Ghazal, 2017b; Ministry of Information and Communications Technology [MOICT], 2017a; MOICT, 2017b; Telecommunications Regulatory Com-mission [TRC], 2016). Based on developments mentioned above, several developed and developing countries have commenced to providing mobile payment systems services, which is also known in Jordan as

JoMoPay system, in order for companies and individuals to interact with one another by using payment transactions, and utilize mobile phones applications.

Therefore, it shows that Internet and mobile phones penetration are a great foundation to use mobile payment system. However, the level of acceptance of mobile payment system in Jordan is still below expectation (Alalwan, Baabdullah, Rana, Tamilmani & Dwivedi, 2018; Gharaibeh & Arshad, 2018; Alalwan, Dwivedi & Rana, 2017; Qasim & Abu-Shanab, 2016; Alalwan, Dwivedi & Williams, 2016; Qatawneh, Aldhmour & Alfugara, 2015; Jaradat & Al-Mashaqba, 2014; Jaradat & Faqih, 2014). Although experiences from other nations showed that petty payments are more popular on mobile phones, this was not popular except in recent years (Qasim & Abu-Shanab. 2016). For example, mobile payments in China improved by up to 255 % in the first three months of 2014, and the mobile payment market accounted for US$623 billion in the year 2014 (Marketingtochina [MC], 2015). In contrast, the number of transactions executed through the Jordan mobile payment (JoMoPay) system in the year 2015, do not exceed 1% and only reached 835 transactions totalling about US$35,601 (Al Shawwa, 2016; CBJ, 2015). Thus, the JoMoPay system is still limited in the Jordanian environment and its rate of adoption very low.

Based on the above discussion, the main objective of this paper was to understand intentions of public-sector employees in Jordan to accept of JoMoPay system by investigation the determine main predictors using UTAUT2 model. The stems significance of this study is the focus to investigate mobile payment system acceptance in the Jordanian context, while has not been addressed substantially in the Arab world contexts. Another reason for the significance of such studies comes with the deep expansion of smartphones usage around the globe. In these days, the use of mobile phones and their application play an important role in every aspect of our life. In real areas, smartphones have made some important changes regarding payment transactions operations in the past recent years, which led to improvements of e-payment transactions though using the mobile payment systems that can be used to save time, effort, and money. Due to the popularity of mobile phones and the Internet, the use of mobile payment system is becoming an appealing option that has recently boomed because of the advent of smartphones and their applications across the world.

Background of UTAUT Model

Unified Theory of Acceptance and Use of Technology (UTAUT2) model originally proposed by Venkatesh, Thong and Xu (2012) was applied as a conceptual model in this paper, to clarify the JoMoPay system acceptance from the employees' perspective in Jordanian public sector. UTAUT model has been formulated based on the combination of eight major theories and models of technology acceptance (Venkatesh, Morris, Davis & Davis, 2003). While the models that were integrated to formulate the UTAUT were; Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), Social Cognitive Theory (SCT), Technology Acceptance Model (TAM), Innovation Diffusion Theory (IDT), Model of PC Utilization (MPCU), Motivational Model (MM), Combined TAM and TPB (C-TAM-TPB). However, UTAUT integrates the technology acceptance domain into one theory with behavioral intention and user behavior as the main dependent variables. This model tries to overcome the difficulties faced by information technology researchers to develop their studies' framework to understand users' acceptance of the technology (Venkatesh et al., 2012; Venkatesh et al., 2003). Table 1 presented all of those models and theories were integrated into UTUAUT model.

Table 1: The Integration of Eight Theories and Models to Access UTAUT.

No.	Name of Theory/ Model	Abb.	Authors
Models and Theories Which Reflect UTUAUT Model:			
1.	Theory of Reasoned Action	TRA	Fishbein and Ajzen, (1975)
2.	Theory of Planned Behavior	TPB	Ajzen, (1985, 1991)
3.	Social Cognitive Theory	SCT	Bandura (1986)
4.	Technology Acceptance Model	TAM	Davis (1989)
5.	Innovation Diffusion Theory	IDT	Moore and Benbasat (1991)
6.	Model of PC Utilization	MPCU	Thompson, Higgins and Howell (1991)
7.	Motivational Model	MM	Davis, Bagozzi and Warshaw (1992)
8.	Combined TAM and TPB	C-TAM-TPB	Taylor and Todd (1995)

UTAUT model has four main factors which influence behavioral intention to use a technology and usage behaviours namely performance expectancy, effort expectancy, social influence, and facilitating conditions. The relationships between these factors, behaviour intention and behaviour of use are moderated by four key factors including gender, age, experience, and voluntariness of use (Venkatesh et al., 2003). Figure 1 displayed the components of the UTAUT model.

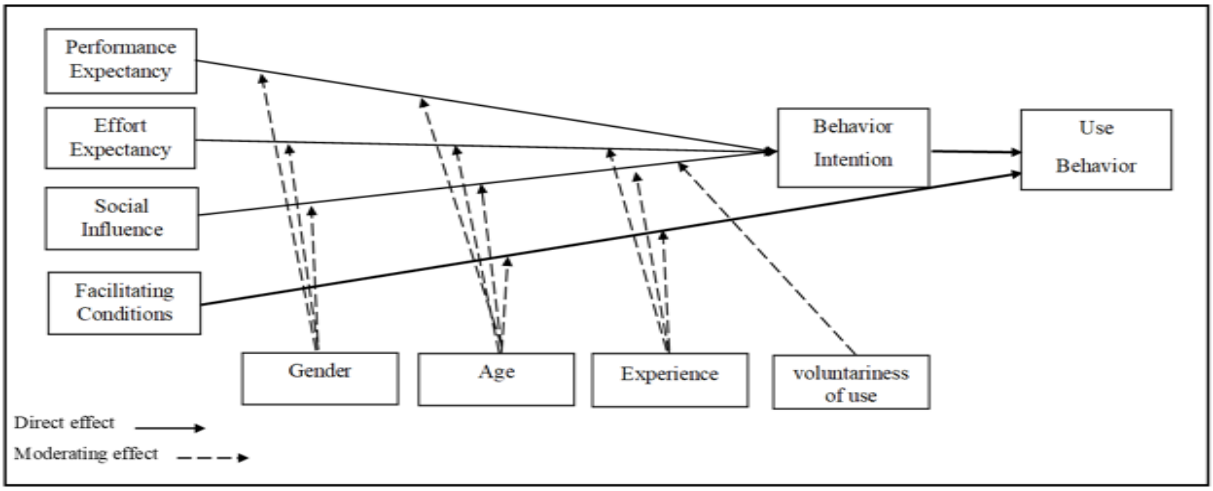

Figure 1: UTAUT Model, Source (Venkatesh et al., 2003).

Venkatesh et al. (2012) developed and made some modifications in the UTAUT model based on their findings from a research conducted in Hong Kong. They presented three new factors to the original UTAUT model. The first factor is hedonic motivation, the second factor is price value, and the third factor is the habit, forming the new UTAUT2 model. Moreover, Venkatesh et al. (2012) claimed that the suggested additions in UTAUT2 exhibited significant changes in the variance explained in behavioral intention and technology use. In total, the new UTAUT2 model posits seven factors are the determinants of behavioral intention and use of technology.

The factors include performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC), hedonic motivation (HM), price value (PV) and habit (HT). They are moderated through irregular degree by gender, age, and experience as shown in Figure 2. In view of this, since UTAUT2 model is relatively new, Venkatesh et al. (2012) recommended to more development and validation of the model were suggested in different contexts such as new context, new culture, and new technology as in the case in this paper.

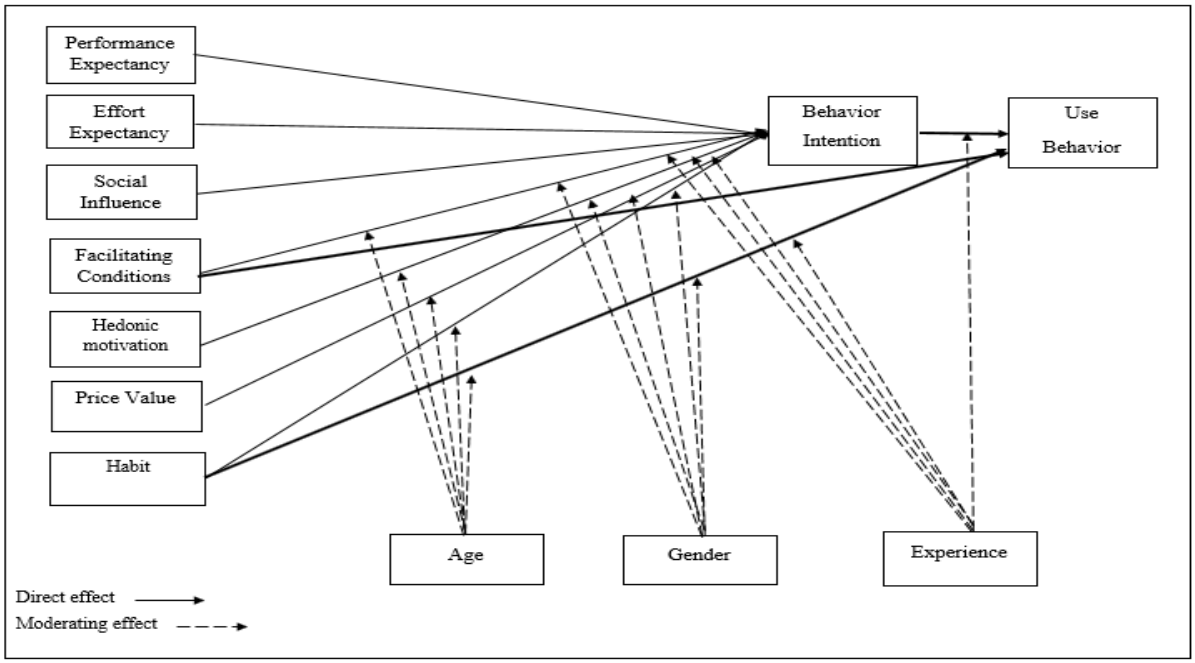

Figure 2: UTAUT2 Model, Source (Venkatesh et al., 2012).

However, in the pursuit of choosing appropriate model covering almost all factors predicting public sector employees' intention to use JoMoPay system, the UTAUT2 has been identified as a fit theoretical basis for the theoretical model utilized in this current paper. As drawn in Figure 3, the key factors of UTAUT2 are namely; performance expectancy (PE), effort expectancy (EE), social influence (SI), and price value (PV) which were proposed as immediate predictors of intention of public sector employees to use JoMoPay system. Further, subjective norm (SN), peer influence (PI), trust (TR), security (SE), privacy (PR), and awareness (AW) were integrated into UTAUT2 model as external factors in the same theoretical model, which is endorsed by Venkatesh et al. (2012) to widen the theoretical prospect of UTAUT2 model.

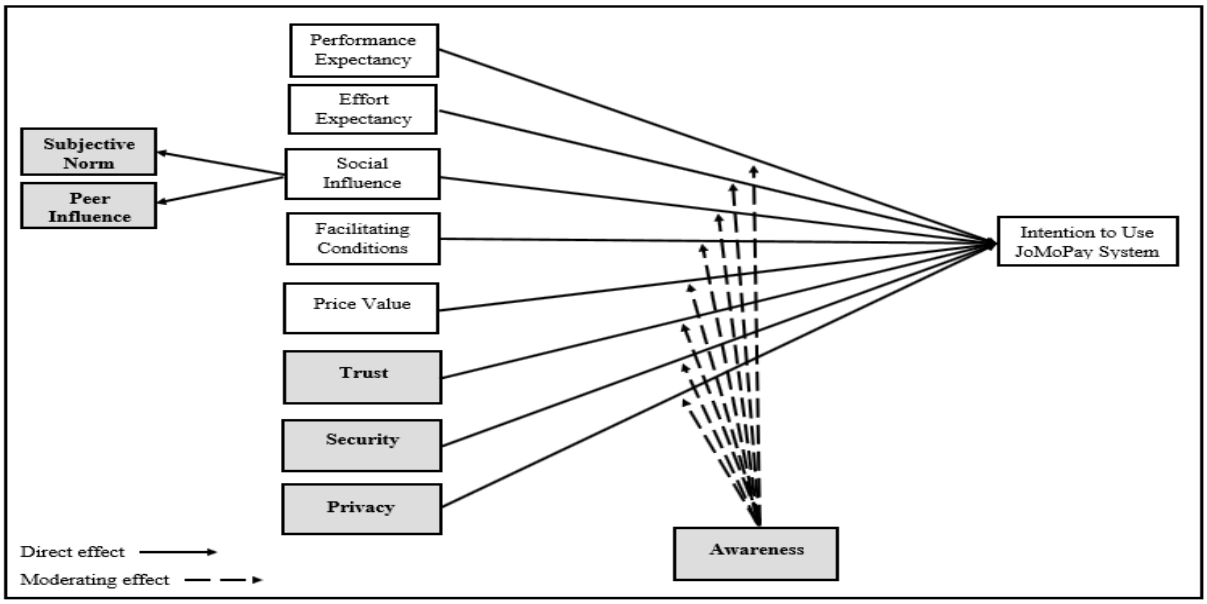

Figure 3: Conceptual Model.

In this paper, the conceptual model will not include the role of habit (HT) and hedonic motivation (HM). This is due to the fact that JoMoPay system is a new payment approach in Jordan, it is the rate of adoption which remains slow and restricted by the number of limitations (Alalwan et al., 2017; Alalwan et al., 2016; Qasim & Abu-Shanab, 2016). This was based on the premise that in order to consider the role of habit (HT), users should be rich experienced in using such a system. However, to study a technology adoption the unit of analysis should be its potential users. Therefore, we propose to examine the conceptual research model on Jordanian ministries employees who have not yet tried to use such a system. In addition, our conceptual model does not also consider hedonic motivation (HT), because technology such as the mobile payment system is not characterized for fun, enjoyment and entertainment. Accordingly, it was challenging to study the role of habit (HT) and hedonic motivation (HM) in the theoretical model of this study and therefore it is the decision was taken to omit the role of hedonic motivation (HM) and habit (HT) from the proposal model.

Moreover, it should be noted also that this paper did not consider and excluded each of the role of user behavior and the moderating effect of gender, age, experience, and voluntariness of use in the conceptual model. Since the JoMoPay system is a new payment method in Jordan, it has a very low adoption rate (Alalwan et al., 2017; Qasim & Abu-Shanab, 2016; Jaradat & Al-Mashaqba, 2014; Jaradat & Faqih, 2014). Thus, the current paper will focus on investigating intention to use JoMoPay system for non-users, not actual use for users. Hence, the user behaviour (for actual users) was excluded by this paper. Lastly, with regard to the moderating effect of gender, age, experience, and voluntariness of use, there are many studies that have excluded use behavior and moderating role in their studies (e.g., Alalwan et al. 2017; El-Masri & Tarhini, 2017; Qasim & Abu-Shanab, 2016; Afshan & Sharif, 2016; Morosan & DeFranco, 2016; De-Sena Abrahão, Moriguchi, & Andrade, 2016; Slade, Dwivedi, Piercy & Williams, 2015; Alshare & Mousa, 2014; Raman & Don; 2013), which has commonly been the case amongst adoption studies that employ UTAUT model (Venkatesh et al., 2012).

In summary, the current paper discusses the direct relationships between 1) performance expectancy as the independent variable and intention to use JoMoPay system as the dependent variable, 2) effort expectancy as the independent variable and intention to use JoMoPay system as the dependent variable, 3) social influence as the independent variable and intention to use JoMoPay system as the dependent variable, 4) facilitating conditions as the independent variable and intention to use JoMoPay system as the dependent variable, 5) price value as the independent variable and intention to use JoMoPay system as the dependent, 6) trust as the independent variable and intention to use JoMoPay system as the dependent variable, 7) security as the independent variable and intention to use JoMoPay system as the dependent variable, and 8) privacy as the independent variable and intention to use JoMoPay system as the dependent variable.

Afterward, there is a discussion on the indirect relationship between 9) awareness acts as the moderating variable between performance expectancy as the independent variable and intention to use JoMoPay system as the dependent variable, 10) awareness acts as the moderating variable between effort expectancy as the independent variable and intention to use JoMoPay system as the dependent variable, 11) awareness acts as the moderating variable between social influence as the independent variable and intention to use JoMoPay system as the dependent variable, 12) awareness acts as the moderating variable between facilitating conditions as the independent variable and intention to use JoMoPay system as the dependent variable, 13) awareness acts as the moderating variable between price value as the independent variable and intention to use JoMoPay system as the dependent variable, 14) awareness acts as the moderating variable between trust as the independent variable and intention to use JoMoPay system as the dependent variable, 15) awareness acts as the moderating variable between security as the independent variable and intention to use JoMoPay system as the dependent variable, and 16) awareness acts as the moderating variable between privacy as the independent variable and intention to use JoMoPay system as the dependent variable. Thus, there are sixteen hypotheses formulated to exam the different relationships in research model. Lastly, Table 2 presented the summary of the direct and indirect hypotheses.

Table 2: Summary of Direct and Indirect Hypotheses

No.	Hypotheses Development for Independent Variables	IV	DV
H1	Intention to use JoMoPay system will be positively influenced by performance expectancy.	PE	BI
H2	Intention to use JoMoPay system will be positively influenced by effort expectancy.	EE	BI
H3	Intention to use JoMoPay system will be positively influenced by social influence.	SI	BI
H4	Intention to use JoMoPay system will be positively influenced by facilitating conditions.	FC	BI
H5	Intention to use JoMoPay system will be positively influenced by price value.	PV	BI

H6	Intention to use JoMoPay system will be positively influenced by trust.	TR	BI
H7	Intention to use JoMoPay system will be positively influenced by security.	SE	BI
H8	Intention to use JoMoPay system will be positively influenced by privacy.	PR	BI

No.	**Hypotheses Development for Moderates Variables**	**IV**	**MOD**	**DV**
H9	Awareness moderate the relationship between performance expectancy and intention to use JoMoPay system.	PE	AW	BI
H10	Awareness moderate the relationship between effort expectancy and intention to use JoMoPay system.	EE	AW	BI
H11	Awareness moderate the relationship between social influence and intention to use JoMoPay system.	SI	AW	BI
H12	Awareness moderate the relationship between facilitating conditions and intention to use JoMoPay system.	FC	AW	BI
H13	Awareness moderate the relationship between price value and intention to use JoMoPay system.	PV	AW	BI
H14	Awareness moderate the relationship between trust and intention to use JoMoPay system.	TR	AW	BI
H15	Awareness moderate the relationship between security and intention to use JoMoPay system.	SE	AW	BI
H16	Awareness moderate the relationship between privacy and intention to use JoMoPay system.	PR	AW	BI

It is worth mentioning that the UTAUT2 model confirms how can different critical factors motivate the acceptance of the new technology. Besides, previous studies stressed other factors related to technology acceptance also factors them also as motivational factors. Thus, the new model still needs to be developed for a deeper understanding of the phenomenon of JoMoPay system acceptance. Therefore, this paper proposed an interactive view of JoMoPay system acceptance by explicitly considering trust, security, and privacy as independent variables and awareness as a moderating variable in the UTAUT2 model. Interestingly, the effect of social influence on the behavior intention will test by using two dimensions in this paper. The first dimension is the subjective norm, and the second dimension is peer influence.

Conclusion

This paper tries to offer critical success factors that can lead to increasing the rate of acceptance of JoMoPay system in the Jordanian public sector. The proposed model in this paper was based on the UTAUT2 model which covers most of the independent variables including performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC), and price value (PV). Further, this paper has also expanded the UTAUT2 model to cover six new factors namely: subjective norm (SN), peer influence (PI), trust (TR), security (SE), privacy (PR) and awareness (AW) to test the acceptance of JoMoPay system among public sector employees in Jordan.

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DISTINCTIVE FEATURES OF ISLAMIC WEBSITES USE

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Abstract: *Many Muslims are regular users of the Internet, in which they browse diverse websites to improve their Islamic knowledge and to spread the religion of Islam worldwide. The technology for surfing Islamic websites seems to be ubiquitous and the accessibility of these online Islamic contents makes it critical to study the distinctive Islamic features of the Islamic websites and the factors that influence Muslims to use these websites, so that the features would be more effective and distinctive. This study illustrates the distinctive features of Islamic websites use preferred by the younger generation of the Muslim society. The distinguishing Islamic features in the questionnaire are adapted from Mansur Aliyu et al. (2013) and Bilal Philip (2008) and there are four features: ethics, services, symbols and website use. The survey involves 110 randomly selected Muslim undergraduate students. The study found that certain distinctive Islamic features have influenced most of the students to use the Islamic websites frequently and effectively and the reasons are supported by few factors. Most significantly, most students acknowledge that they have used Islamic websites regularly to complete their religious subjects' assessments and they will refer to the websites that will often bring up-to-date information in their sites, particularly when the websites are certified by reliable Islamic agencies and bodies. The results are also of considerable significance as some suggestions can aid to design and develop more effective Islamic websites that will encourage more users to visit (including non-Muslims) and to gain valuable knowledge of suitable Islamic lifestyles, and valid teachings and practices.*

Keywords: *Distinctive Features, Website Use, Islamic Websites, Muslim Users and Youths*

Introduction

It is mandatory for students in Malaysian schools to study various aspects of Islamic Studies as a compulsory subject. Malaysian Education Act 1996 in ESPACT (2015) stated that "when there are fifteen or more students professing the Islamic religion, such pupils shall be given religious teaching in Islam by teachers approved by the State Authority. Even at tertiary level, Islamic Studies has been taught as a specific subject at several public and private institutions (Don, et al., 2012). It is perceived that Islamic Studies will instil proper Islamic teachings and values among the Muslim students, so that the characteristics of good Muslims can be cultured. Syed Ali Ashraf (1985: p24) emphasised that "Islamic education trains the

sensibility of pupils in such a manner that in their attitude to life, their actions and decisions and approach to all kinds of knowledge are governed by the deeply felt ethical values of Islam". Nevertheless, recent studies indicated that many students had lesser interest to learn the subject (Zaiton and Hishamuddin, 2012). Rosnani (2004) has criticized the methodology of teaching Islamic education in Malaysia where the most common methods are reading, narrations of stories from Quran and 'Hadith', lectures, dictation of notes and memorization. According to Rosnani Hashim (2019), the classroom of Islamic sciences ought to be more balanced in applying both subject-centred and student-centred approaches in teaching and learning.

Technology has advanced in several aspects of our lives, thus there is also an increase in the emerging use of mechanics and electronics. The educators should make use of materials available in the internet and Islamic websites can be the medium to circulate Islamic knowledge more efficiently. Thus, Islamic educators should expand their pedagogical methods according to the changing times (Rosnani, 2004), especially to increase the youths' interests to study Islamic education. In view of this study, identifying the distinctive features of the Islamic websites use is the main purpose. These features deem to be significant and relevant to the respondents-Muslim youths. The identified Islamic factors in the questionnaire are adapted from Mansur Aliyu et al. (2013) and Bilal Philip (2008) and the four chosen features or factors for this study were ethics, symbols, services, and website use.

Literature Review

Exploring Islamic Websites

At current, learning using the online websites is a vital requirement for most schools and educational institutions, so it is important to explore the possible advantages of online learning. Mansur et al. (2013) further stated that the Internet provides an online medium for Muslim users to seek information and knowledge about Islam in which students can have the opportunities to consult and communicate with scholars from different part of the world and different school of thoughts. To add, Wan Abdul Rahim, Nor Laila, and Shafie (2008, p3) describe an Islamic website as a genre website that highlights Islamic ideologies, norms, and values.

Online users can easily observe the features and presentations of such websites when they surf any Islamic website. Murni et al. (2012) postulate that Muslim intellectuals and Islamic organisations generally utilise the Internet to spread Islamic teachings and preaching to Muslims and non-Muslims. In recent years, many efforts have been conducted to create an Islamic and Muslim identity through Islamic website (Ibrahim, Md. Noor and Mehad, 2009).

On the contrary, Helland (2005) observe that despite the recorded success of Islamic websites, such websites require a deeper understanding of the needs of Muslim users as well as the capability to capture the opinion of users with respect to the information provided on the websites. As a result, Muslims users need to be cautious in choosing appropriate websites with the accurate content, effective features and presentation. Some researchers have discovered that a considerable number of Muslim users have rejected the information derived from various Islamic websites because of their lack of confidence on the validity of the contents (Ibrahim et al., 2010). Other studies in Shafie et al. (2010) also suggested that Muslim users of Islamic websites are hesitant to pursue information from these websites because they are uncertain if they can completely trust the online Islamic scholars.

Distinctive Features of Islamic Websites Use

The availability of these online Islamic contents makes it critical to study the Islamic features of the Islamic websites and the factors that influence Muslims to use these websites, so that the features would be more valuable and legitimate, in terms of the contents. These features may influence the users' perception on the authenticity of the website as genuinely Islamic (Mansur Aliyu et al., 2013). These websites' use depends highly on the extent to which the users think that the features in the websites are genuine, lawful, current, appropriate, and not misleading (Loiacono, Watson & Goodhue, 2007; Song & Zinkhan, 2003). There are other scholars who found that Islamic features are very important measures for evaluating Islamic websites' quality (Hameed, 2009; Mehad, Isa, Noor, & Husin, 2010).

Furthermore, Mansur Aliyu et al. (2013) affirmed that these Islamic features can help the users in identifying the credentials of online scholars, who give scholarly opinion on matters of Islamic law on the website in which will attract more users to continuously browse the websites. Generally, the quality of these features is reflected in the users' perception, not only in website use but also in producing positive users' experiences (Wan Abdul Rahim et al., 2008). Notably, when the users gain trust in the Islamic websites, they may refer to them consistently to seek Islamic teachings and knowledge, and thus, recommend them to their peers and family members for future reference. In order to properly educate the youths and enhance Islamic knowledge among the Muslims, it is vital that the users are browsing suitable Islamic websites.

Islamic ethical value is one of the distinctive features discussed and Hameed (2009: p564) defines Islamic ethical value as "a set of moral principles and guidance that recognises what is the right behaviour from what is wrong or what one should do or not". Another feature, Islamic symbol is explained by Mehad et al. (2010) as the representation of Islamic values to the users, which consist of Islamic images that are specifically relevant and unique to Islam. According to Mansur Aliyu et al. (2013), many Islamic websites at recent offer Islamic online services (third distinctive feature), such as forums, educational training, community development programmes, online marriage opportunity, online donation, relief/assistance activities, and direct consultation with online scholars. The final feature, the website use will deal with the users' experiences and frequencies in using the websites.

Methodology

A semi-structured adapted questionnaire from Mansur Aliyu et al. (2013) and Bilal Philip (2008), using a 5-point scale was used to collect the data to evaluate the content of the Islamic websites. Muslim students were randomly selected as the selected samples from various diploma programmes in one of the local universities in Sarawak, Malaysia. The questionnaire consists of three sections. The first one dealt with demographic details (gender and semester) while the second section identified the respondents' online learning experiences and habits, such as the frequency of utilising Islamic websites per week and who encouraged them the most to use these websites. Section C showed their preferred features when utilising the Islamic websites. One hundred and ten (N=110) respondents have participated in this study and the data was analysed using SPSS version 23. The presentations of the analysis were in tables (frequencies and percentages).

Research Findings

The findings are presented based on the sections of the survey: demographic profiles and reading Islamic Websites (Online experiences and habits), and the distinctive features of Islamic websites use (four features).

Table 1: Demographic Profiles & Reading Islamic Websites (Online Experiences and Habits)

Demographic Profiles	
Gender	42 males 68 females
Semester	Semester 2: 82 respondents Semester 3: 15 respondents Semester 4: 13 respondents
Reading Islamic Websites (Online Experiences and Habits)	
Frequency of Reading Islamic Websites Per Week	Every day: 10 respondents 5-6 times per week: 22 respondents Once a week: 48 respondents Rarely: 30 respondents
Who Encourage (s) the Respondents (s) to Read Islamic Websites	
Who	Self-motivated: 44 respondents Peers: 11 respondents Lecturers: 40 respondents Family members: 15 respondents

Table 1 indicates that more female respondents and Semester 2 students were involved in this study. Viewing their online experiences and habits, 30 respondents rarely visited Islamic websites while 70 respondents browsed these websites between once to 6 times in a week, assumedly to complete their Islamic Subject's assignments. In encouraging them to read these websites, most of them were highly motivated by their lecturers and due to their own efforts and initiatives. These are positive as the motivation to seek Islamic knowledge comes from within the respondents themselves, possibly to become better Muslims or to improve their knowledge.

Table 2: First Feature (Islamic Ethics / Ethical Values)

No	Items	SD	D	N	A	SA
	Islamic Website should:	Percentages				
1	portray belief in the oneness of Allah (SWT)	0	0	9.7	43.7	46.6
2	follow the authentic traditions (Sunnah) of the prophet Muhammad (SAW)	0	0	4.9	50.5	43.7
3	start with "Bismillāh al-Raḥmān al-Raḥīm"	0	0	20.4	41.7	37.9
4	begin with Salam	0	0	19.4	44.7	35.9
5	consistently write the name of Allah SWT	0	0	12.6	49.5	35.9
6	consistently seek blessing for prophet Muhammad when His name is written/mentioned	0	0	8.7	47.6	43.7
7	consistently use the words "Assalām 'alaikum", "Mashā'Allāh", "Alḥamdulillāh", and/or "Jazakallāhukhay¬ran" in communicating with users	0	0	23.3	42.7	34

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

With regards to Islamic Ethics or Ethical Values, these deal with more spiritual values in which the highest percentages are most relevant to the 'belief in oneness of Allah' (90.3% for strong agreement and agreement) and 'the sunnah of the prophet Muhammad' (94.2% for both scales). According to Murni et al. (2012), many Muslim users found Islamic website to become a popular medium through which they can accomplish many of their religious obligations, in which they have discovered an alternative medium through which they can recite the Quran, learn the meaning of the Quran and Hadith, seek religious opinions, and interact with one another as well as with renowned Islamic scholars. The least significant feature would be the use of specific words or phrases in communication with the users, in which the result indicates 76.7%.

Table 3: Second Feature (Islamic Services)

No		SD	D	N	A	SA
	Islamic Website should offer services that include… Percentages					
1	Online Donation	1	2.9	30.1	52.4	13.6
2	Chat rooms with online Islamic scholars or authorities	1	1	22.3	54.4	22.3
3	Islamic software/applications	0	1	16.5	50.5	32
4	Bazaar/online shopping services	1	1.9	34	40.8	21.4
5	Community development	0	0	29.1	50.5	22.3
6	Islamic audio content	0	0	15.5	60.2	25.2
7	Islamic video content	0	1	15.5	58.3	26.2
8	Online youth relief and aid	0	0	22.3	54.4	24.3
9	Online marriage/matrimony	2.9	10.7	39.8	33	14.6
10	Online educational trainings / courses	0	2.9	26.2	43.7	27.2
11	Direct call services to online educational websites	0	3.9	28.2	38.8	29.1

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

Table 3 deals with the feature of Islamic Services. The most popular services chosen by the respondents were 'Islamic audio content' (85.4% for agreement and strong agreement) and 'Islamic video content' (84.5%). These illustrate that the students preferred Islamic services which offer audio and video content, where they were able to visualise and listen to the content. The least popular one was online marriage/ matrimony with 47.6%. The possible reason for this finding is because all the respondents are singles and hence, they might have the lack of interests towards such services.

Table 4: Third Feature (Islamic Symbols)

No	ITEM	SD	D	N	A	SA
	Islamic Website should use / display:				**Percentages**	
1	Arabic text	0	0	35.9	42.7	22.3
2	Islamic arts	0	0	24.3	51.5	25.2
3	Picture of Hijab	0	1.9	40.8	39.8	18.4
4	Picture of Moon	0	1.9	50.5	37.9	10.7
5	Picture of Qur'ān	0	1	19.4	53.4	27.2
6	Picture of Ka'abah	0	1	32	44.7	23.3
7	Picture of scholars	0	1.9	37.9	44.7	16.5
8	Picture of Mosques	0	1	19.4	50.5	29.1

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

In Table 4, it is evident that pictures of the Holy Qur'an (80.6% for strong agreement and agreement) and Mosques (79.6% for strong agreement and agreement) are the significant

Islamic Symbols among the Muslims. These two symbols are deemed to be synonymous with the religion of Islam as Mosque is the Muslims' house of worship, that even the Non-Muslims can relate these symbols to the Muslim community. Ibn 'Abbas in SinniPath (2005) relates: *Mosques are the houses of Allah on the earth. They shine up to the inhabitants of the heavens just as the stars in the sky shine down to the inhabitants of the earth (Tabarānī)*. The Quran on the other hand is: *The irrefutable, inimitable Word of God (Source of Guidance, 2018), which was revealed by God Almighty, through the instrument of Prophet Muhammad (peace be Upon Him)* and thus, the symbol is commonly used and acknowledged among the Muslims. The lowest percentages in this table would be the pictures of the 'moon' (48.6% for agreement and strong agreement) and 'hijab' with (58.2% respectively). The plausible reason is that the moon is considered a general symbolism which can be relevant to anything, not necessarily Islamic in nature while, the 'hijab' is only most relevant to the females.

Table 5: Fourth Feature (Websites Use)

No	Item	SD	D	N	A	SA
		Percentages				
1	I frequently use Islamic website to do my assignments	0	1	12.6	39.8	47.6
2	I spend a lot of time using Islamic website for my own knowledge	0	2.9	34	48.5	15.5
3	I have been using Islamic website for a very long time	1	2.9	33	49.5	14.6
4	I would only refer to Islamic websites that update their sites frequently.	1.9	4.9	26	52.5	17.7
5	I am highly dependent in using Islamic website to educate myself more about Islam	0	7.8	26.2	50.5	16.5
6	Overall, I have good experiences using Islamic Websites	0	3.9	35	49.5	12.6
7	I only refer to Islamic websites that contain authentic materials and have closeness to the Qur'an and Sunnah.	0	2.9	23.3	50.5	24.3
8	I would only refer to Islamic websites that are certified by trustworthy Islamic agencies / bodies such as JAKIM and others	0	1.9	21.4	47.6	30.1

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

Table 5 deals with the fourth feature which is 'Website Use'. The most popular item is 'the students commonly refer to the websites to complete their assignments' with 87.4% and the second highest is 'the students prefer websites that are authorized by reliable Islamic agencies/ bodies' with 77.7%. The respondents also claimed that they referred to Islamic websites that are valid and relevant to the Qu'ran and sunnah (74.8%) and they referred to the Islamic websites that update their websites regularly (70.2%). In Malaysia, the websites that are popular are the trustful Islamic website, such as authoritative websites JAKIM, an Islamic

organization. Bilal (2008) asserted that since a clear majority of Muslims and non-Muslims turn to the World Wide Web to do research and learn more about the various aspects of Islam, ensuring people to read information that are in accordance with the Quran and Sunnah is of extreme importance, rather than falling prey to misleading websites.

Conclusion and Recommendations

Generally, the findings indicate that the most distinctive features under Islamic ethics would be the faith in the mighty Allah and the Prophet's true 'sunnah' while the most preferred Islamic services were video and audio contents. The most significant Islamic symbols chosen by the respondents were the holy Qur'an and mosques. As for 'Website Use' feature, the respondents usually referred to the websites to do their assignments, but the websites must be certified by trustworthy Islamic bodies to ensure the validity and accuracy of the contents. The findings of this study are noteworthy, considering the growing number of Islamic websites and Muslim as well as Non-Muslim Internet users.

This study provides empirical evidence for Islamic website use from the views of Muslim youths. Besides, it is recommended that the users who regularly browse online materials should be selective in choosing the more reliable websites by looking at the specific features that such websites could offer. The results are also of considerable importance as some beneficial points aid to design more effective Islamic websites that will encourage more users to visit. As such, Muslims could gain valuable knowledge about proper Islamic teachings and practices. The empirical results also provide points and guidelines to develop more effective educational

Islamic websites for Muslim students who often refer to such websites to do their assignments. As a result, the improved and carefully considered Islamic websites will also have the potential to encourage more youths to develop their Islamic knowledge in which they will revisit the websites regularly. This also can be the medium to gauge the youths' interests to learn and improve Islamic education, and consequently, to develop knowledgeable Islamic society.

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USABILITY EVALUATION OF UPM LEARNING MANAGEMENT SYSTEM

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Abstract: *The goal of every academic Learning Management System is to provide valuable academic information to its users without any difficulty. Nowadays, web usability is becoming a crucial issue for LMS development most users perceive usability as a key factor in e-learning application planning and use. This study identifies the usability strength and weaknesses levels of UPM LMS from student perspective. The result obtained show that is great improvement on the existing UPM LMS from both the student and the usability expert.*

Keywords: *E-learning, Virtual Learning System, Learning Management System, Learning Application, Usability Evaluation*

Introduction

E-learning or virtual learning system (VLS) is gradually turning into method of teaching and learning through Learning Management System. In support of this, (Wang, Wang, & Shee, 2007) reaffirmed the aforementioned argument, thus, e-learning or learning through internet has become a major phenomenon in recent years. Detailed analysis of the developmental trends of LMS over period of time concurs with the impressions of many educationalists and researcher's world over that, the long-awaited revolution in teaching methodology has evolved, i.e. the traditional method of acquiring and imparting knowledge is being replaced with e-learning or Learning Management System (LMS). In agreement with the assertion, people using LMS, particularly end-users, have the notion that, the method is very influential in the sense that, it encourages good interactions between teachers and students, by providing various materials one needs within the time frame. End-users here refers to students, teachers, researchers, administrators, board management, staff etc. people and various materials are referring as education teaching aids, that are not only cost effective but accessible to everybody at any part of the world to carry out their activities with up to most ease or with the highest peak level of satisfaction. In line with this general concept, (Frey, 2005) described LMS as a means of assisting learners and instructors to accomplish their instructional goals through the use of problem-solving team, simulation online, and questions and answers session, rather than be a tool that just allows printing lecture notes, evaluating lecturers or seeing any updated information made by the instructors. In a similar concept, (Naidu, 2006) defined LMS "as a means an electronic Moodle that include a suite of tools for teaching and learning online". Based on these definitions, my conceptual understanding of the term, LMS is an electronically designed instructional Moodle which is made accessible and cost effective to all and sundry irrespective of distance, time or location in any part of the world.

Literature Review

Different researchers from different domains have conducted usability studies in Learning Management System LMS) and other applicable field of usability, among such are the work of (Al-Khalifa, 2010) evaluated the usability of JUSUR Learning Management System of the department of information and technology in King Saudi University. In the study, two standard questionnaires were used as an evaluation method, which comprises: a) system usability scale (SUS) developed by John Brooke, 1986, the questionnaire consists of ten questions which were used and adapted. b) Learning Management System usability questionnaire (LMSUQ), this questionnaire was constructed and supported by two existing questionnaires which are Web based learning Environment Instrument WLEI and usability and user satisfaction questionnaire adapted from PSSUQ. The questionnaire consists of 31 questions, 18 questions from usability and user satisfaction and 13 from WLEI. A non-probability sampling of 155 female students were selected as respondents for the research work. Furthermore, the evaluation of JUSUR learning management system (LMS) is based on 7 factors namely: system usefulness, learnability, satisfaction, outcome/future use, design/layout and functionality. However, some students observed that JUSUR LMS was user-friendly and easy to use but functionality of the system was complex, as some students revealed that the font size is too small and difficult to find its back button. The study of (Kakasevski, Mihajlov, Arsenovski, & Chungurski, 2008) evaluated the usability of LMS Moodle from four units, namely learning, synchronous and asynchronous communication, submissions of assignment and testing. In the study, four course creators known as teachers, four university professors and two system administrators were included in the evaluation techniques. Also, the course creators create courses and add blocks and tools into the courses. Three different set of questionnaires were used with three different types of questions (open, closed ended questions, and scaled answers). The questionnaires were given to the students after one, two and six weeks of using the Moodle LMS respectively. A non-probability of 84 students participated in the study from the faculty of economic, science and informatics. Based on the survey, it was observed that the Moodle LMS was usable in the perspectives of usability factors: memorability, effectiveness, efficiency, ease of use and satisfaction. In-order to come up with an appropriate questionnaire for UPM Learning Management System, various related papers based on usability evaluation of LMS were reviewed. The observation shows evaluation methods of LMS usability, which includes questionnaire based evaluation, heuristic evaluation, frameworks, models and checklist method, thus, most previous works focus on the (Nielson, 2012) concept, as more than half of the researchers adopted questionnaire as an instrument for usability evaluation of LMS upon which 80 percent directly or indirectly adopted the concepts of Nielsen usability evaluation which comprised of 5 usability factors i.e. learnability, error prevention, satisfaction, efficiency and memorability. Some researchers used all the Nielsen usability factors, whilst others used two to three of the factors. The remaining reviewed papers adopted some of the Nielsen usability factors in their models, framework and heuristic evaluation, but generally most researchers focus on Nielsen concept in evaluating the usability of LMS either directly or indirectly. In this particular research which is related to UPM: LMS evaluation, three factors from (Nielsen, 2012) together with WAMMI based evaluation questionnaire (Caglar & Mentes, 2012) similar to Nielsen usability factors were adopted as an instrument for the study.

Usability Level of UPM LMS

In this research work, four usability levels with their merit points were adopted based on the work of (Abdullah & Koh, 2008) very low, low, high and very high usability levels. In-order to determine the usability level of a given factor, whether it is very low, low, high and very high usability, we first divide the range of a given factor by the number of usability level i.e. RUF/NUL.

Where
RUF=Range of Usability factor
NUL=Number of usability level

After the divided range value of a given factor was obtained, then very low usability level is obtained from the minimum mean value of a given factor to the maximum mean value of that factor i.e. MaxMVVLU = MinMVVLU+ DRV.

Where
MaxMVVLU = Maximum Mean value of very low usability

MinMVVLU=Minimum Mean value of very low usability
DRV=Divided range value
Low usability level was obtained from the maximum mean value of very low usability which becomes the minimum mean value of low usability i.e. MaxMVVLU = MinMVLU +0.01.

Where
MinMVLU=Minimum Mean value of low usability

And the Maximum Mean value of low usability is also obtained from the Minimum Mean value of low usability plus the divided range value i.e. MinMVLU + DRV.
Similarly high usability level was obtained from the Maximum value of low usability which becomes the minimum mean value of high usability i.e. MaxMVLU = MinMVHU +0.01.
Where
MinMVHU=Minimum Mean value of high usability

And the Maximum Mean value of high usability is also obtained from the Minimum Mean value of high usability plus the divided range value i.e. MinMVHU + DRV.
Very high usability level was determined from the maximum mean value of high usability which becomes the minimum mean value of very high usability i.e. MaxMVHU = MinMVVHU +0.01.
Where
MinMVVHU=Minimum Mean value of very high usability

And the Maximum value of very high usability is also obtained from the Minimum Mean value of very high usability plus the divided range value i.e. MinMVHU + DRV.

Analysis and Results

The summary of the usability level of UPM LMS is shown in Table 1 below and depicted graphically in Figure 1.

Table 1: Pre-survey Usability Result

Factors	Usability level	Point
Attractiveness	High	2.61
Controllability	High	2.75
Helpfulness	High	2.67
Efficiency	High	2.58
Learnability	High	2.78
Memorability	High	2.84
Satisfaction	High	2.74
Error prevention	High	2.66

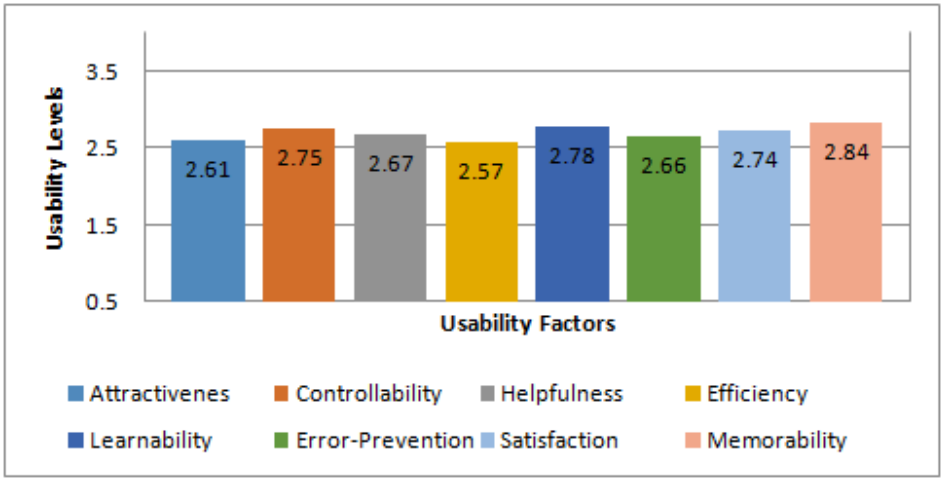

Figure 1: Students Pre-survey Usability Result

Figure 1 above shows the overall responses of 376 students to each factors of WAMMI-Nielsen usability questionnaire, which varies from 0-4 likert scale. All the usability factors were found to be at a "High" level with the value above 2.50. Even though all the usability factors were found to be at high level but looking at their points they are not up to the mid-point of high usability level thus, their point are closer to low usability level than high usability level. Error prevention and efficiency have the low usability level points with 2.54 and 2.58 respectively, and then followed by attractiveness and helpfulness with 2.61 and 2.67 respectively. Satisfaction, controllability are close to each other with the value 2.74 and 2.75, thus this result is not surprising because satisfaction can lead to the acceptance of any factor, but this revealed that, the students are more satisfied towards the controllability. Similarly, learnability and memorability points are also close to each other with the point 2.78 and 2.84, hence this result is obvious because learnability and memorability go hand in hand, you cannot remember without learning and vice versa. Therefore, among all the usability factors students find it easier to remember the features of UPM LMS. Although the UPM LMS was found to be usable but still there is need to improve the level of the usefulness to reach the peak level of students' satisfaction. Therefore, the overall mean of usability level of UPM LMS was found to be towards the high level with the point 2.69 as shown in the Figure 2 below.

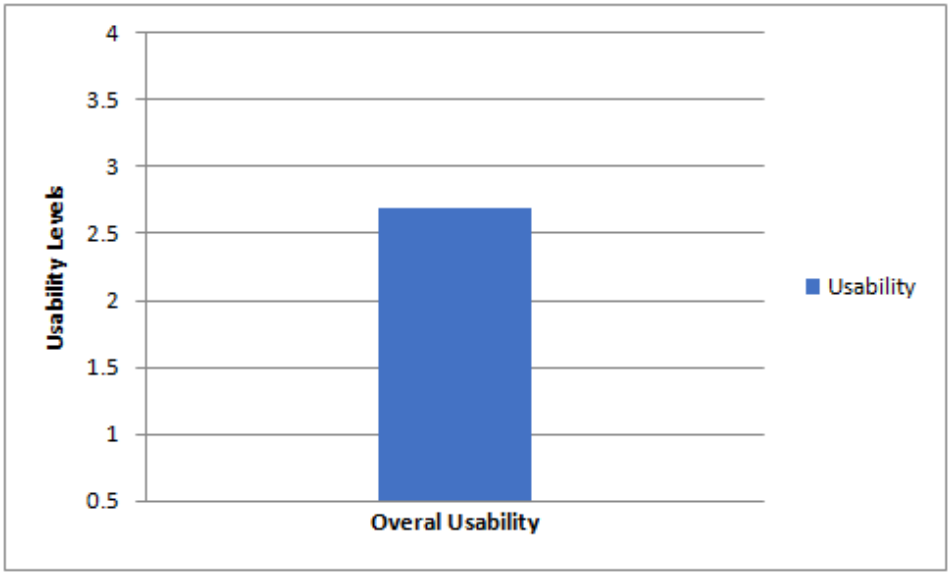

Figure 2: Overall Usability levels of UPM LMS

Due to the differences that occur between the existing UPM:LMS and the proposed one, it becomes necessary to control some factors that lead to such differences. There is need to control memorability, efficiency and learnability factors when evaluating the proposed UPM LMS. Memorability deals with remembering other features and regaining proficiency when not in use of the system for a long time. Threfore, it is not possible for the students to remember the features of the Proposed UPM LMS when using the system for the first time. However, Learnability goes hand in hand with memorability because remembrance is part of learning thus, if a person cannot remember, is very difficult for him to learn. From the authenticated results obtained from the university more than 10,000 students access the existing UPM LMS therefore the efficiency of the system depends on the number of students accessing the UPM LMS at a time. Hence the efficiency of the existing UPM LMS system cannot be compare with the proposed UPM LMS which was accessed by one student at a time. At last memorability, learnability and efficiency factors were not considered in evaluating the proposed UPM LMS as shown in Table 2.

Table 2: Experts' usability Result

Factors	Usability level	Point
Attractiveness	High	2.92
Controllability	High	2.83
Helpfulness	High	3.00
Satisfaction	High	2.92
Error prevention	High	3.01

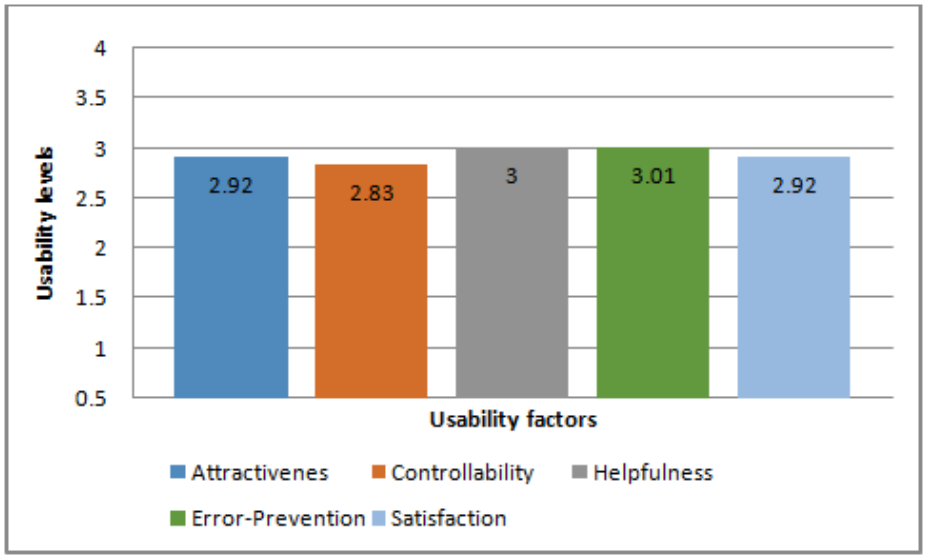

Figure 3: Experts Usability Result

All the usability experts navigate through the proposed UPM LMS and found that the proposed UPM LMS was usable based on the usability factors is shown in Figure 3. Comparing the result with the pre-survey it reveals that there is improvement on the usability factors of the existing UPM LMS as shown in Table 3.

Table 3: Post-test students' usability result

Factors	Usability level	Point
Attractiveness	High	3.33
Controllability	High	3.54
Helpfulness	High	3.43
Satisfaction	High	3.61
Error prevention	High	3.51

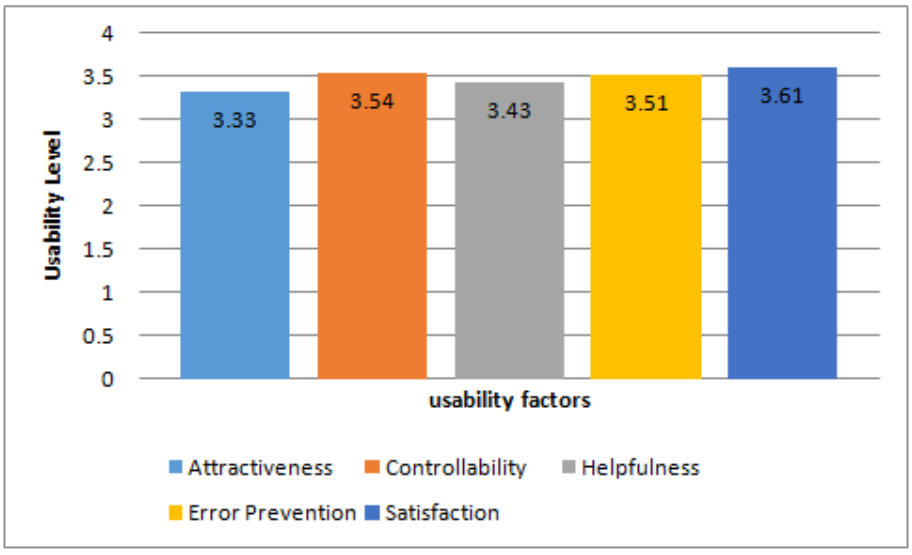

Figure 4: Students Post-test Usability Result

Similarly, figure 4 above reveals that there is great improvement on the proposed UPM LMS based on the usability factors defined above. 30 students evaluated the proposed UPM LMS and majority of the respondents answered the same usability likert scale. Hence the evaluation result from the 30 students is enough to represent the number of students that participated in the pre-survey since most of the student's answers were saturated and fall within the same likert scale.

Conclusion

In this section, we summarized the whole research work in order to show the result obtained from the study. The usability strength and weaknesses level of UPM LMS was revealed out based on the usability factors of WAMMI and Nielsen (2012), Attractiveness controllability, efficiency, learnability, memorability, helpfulness, error prevention and satisfaction. The result of the pre survey shows that all the usability factors were found to be at high level but looking at their point they are not up to the mid-point of high usability level their point are closer to low usability level thus, more attention needs to be given to the factors for better students satisfaction especially efficiency and error prevention which their values were found to be at the border line of low usability level. However, 30 students and 3 usability experts evaluated the proposed UPM LMS, and found out that, there is significant improvement on all the usability factors.

Future Work

In recommendation for future research, the experts are requested to suggest a way forward to improve the UPM LMS. The interface of the prototype was found to be good and usable. However, in order to obtain more usable and successful UPM LMS the menus and the text have to be consistent in all the pages. In addition, the experts also comment on the message page, which lack in differentiating from the read and un-read message. Also, the experts continue to recommend in adding social media in the prototype for active collaboration and networking. This study can also be extended to assess the usability levels of other Learning Management system beside UPM and outside Malaysia. However, there is great need to employ other users such as lecturers, administrators to participate in the study.

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SECURITY ANALYSIS BETWEEN STATIC AND DYNAMIC S-BOXES IN BLOCK CIPHERS

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Abstract: *The development of block ciphers have resulted in a number of cryptographic algorithms such as, aes, aria, blowfish256, desl, and 3d-aes. Aes is one of the best cryptographic algorithms that can be used to protect electronic data. However, the principal weakness in aes is the linearity in the s-box. The objective of this research is to investigate and evaluate the existing work that related to the dynamic s-box. Other than that, the aim of this research is to design dynamic s-box using affine transformation in order to increase the security of the encryption. The method to design is using java with the netbeans software. The proposed block cipher will be tested using nist statistical test suite to test the randomness of the algorithm. Besides, the strength of the s-box will be analyzed uzing s-box evaluation tool (set). The cryptographic strength depends strongly on the choice of s-box. Therefore, this new proposed block cipher can be used by countries, organizations, stakeholders or interested parties as one of the secure algorithm to increase the protection of the information and also will contribute as an alternative to other cryptographic algorithms in computer security research.*

Keywords: *Box, AES, Affine Transformation, NIST, Cryptography*

Introduction

Cryptography is defined as a method or technique of secure communication in the presence of third party. In modern age of computers, cryptography is a technique to scramble plaintext or original message into ciphertext by using cryptographic algorithms. Cryptography is an effective way of protecting sensitive information whether it is stored in media or transmitted. The main objective in cryptography is to attain data confidentiality, data integrity, authentication and non-repudiation. Cryptography is generally divided into two categories which are known as symmetric key cryptography and asymmetric key cryptography. Symmetric key cryptography is a form of cryptosystem in which encryption and decryption are performed using the same key (Forouzan, 2008). Symmetric encryption transforms plaintext into ciphertext using a secret key and an encryption algorithm. It is widely used in symmetric ciphers for instance DES (Data Encryption Standard) and AES (Advanced Encryption Standard).

Asymmetric key encryption is a form of cryptosystem in which encryption and decryption are performed using the different keys. One is public key for encryption and the other one is private key for decryption. Asymmetric encryption can be used for

confidentiality, authentication or both. The most widely used asymmetric key encryption are Rivest-Shamir-Adleman (RSA), Diffie-Hellman key exchange, ElGamal Cryptosystem and Elliptic Curve Cryptography (ECC) (Amandeep, 2017). The asymmetric algorithm as outlined in the Diffie-Hellman paper uses numbers raised to specific powers to produce decryption keys. RSA is the most widely used asymmetric algorithm is embedded in the Secure Socket Layer/Transport Layer Security (SSL/TLS) protocol which is used to provide communications security over a computer network.

Literature Review

Advanced Encryption Standard (AES)

AES is designed on the principle of combination of both substitution and permutation. The AES fixes the block length to 128 bits and supports key lengths of 128, 192 or 256 bits. It represented in matrix form called state matrix and operated on 4x4 column-major order matrix of bytes. Most AES calculations are done in a special finite field $GF(2^8)$. The element of a finite field can be represented in several different ways. For any prime power there is a single finite field, hence all representations of $GF(2^8)$ are isomorphic. Despite this equivalence, the representation has an impact on the implementation complexity. A byte *b*, consisting of bits $b_7\ b_6\ b_5\ b_4 b_3\ b_2 b_1 b_0$, is considered as a polynomial with coefficient in {0,1}:

$$b_7\ x^7 + \ b_6\ x^6 + b_5\ x^5 + b_4\ x^4 + b_3\ x^3 + b_2\ x^2 + b_1 x + \ b_0$$

Example : the byte with hexadecimal value '57' (binary 0101 0111) corresponds with polynomial
$x^6 + \ x^4 + \ x^2 + x + \ 1.$

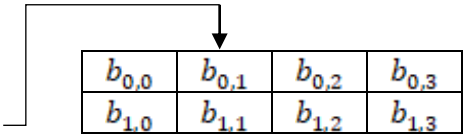
The key size used for AES specifies the number of repetitions of transformation rounds. The number of cycles of repetition is as follows (Daeman, 2002):

i. 10 cycles of repetition for 128-bit keys.
ii. 12 cycles of repetition for 192-bit keys.
iii. 14 cycles of repetition for 256-bit keys.

Encryption process follows four (4) following steps which are

i. The ByteSub Transformation

The ByteSub Transformation is a non-linear byte substitution, operating on each of the State bytes independently. SubBytes is a bricklayer permutation consisting of an S-Box applied to the bytes of the state. Figure 1 below illustrates the effect of the SubBytes step on the state.



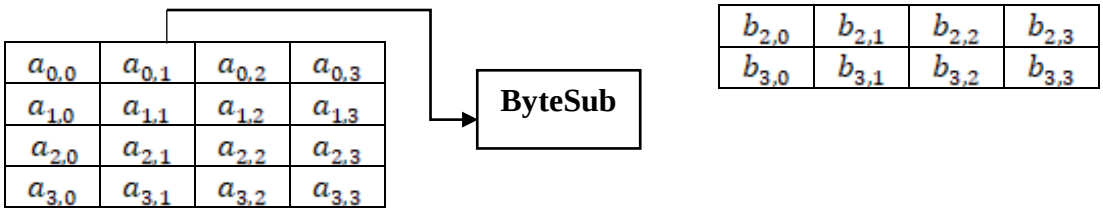


Figure 1: SubBytes Transformation

The substitution table or known as S-Box is invertible and is constructed by the composition of two transformations:

a. First, taking the multiplicative inverse in $GF(2^8)$.
b. Then, applying an affine transformation defined by:

$$\begin{bmatrix} y_0 \\ y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \\ y_6 \\ y_7 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 & 0 & 0 & 1 & 1 \\ 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} x_0 \\ x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \\ x_7 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \\ 0 \\ 0 \\ 0 \\ 1 \\ 1 \\ 0 \end{bmatrix}$$

The affine transformation can also be described as a polynomial multiplication, followed by the XOR with a constant (Rijndael, 2002).

S-Box of AES is generated by equation : $Y = Ax \oplus c \bmod M$ (1)

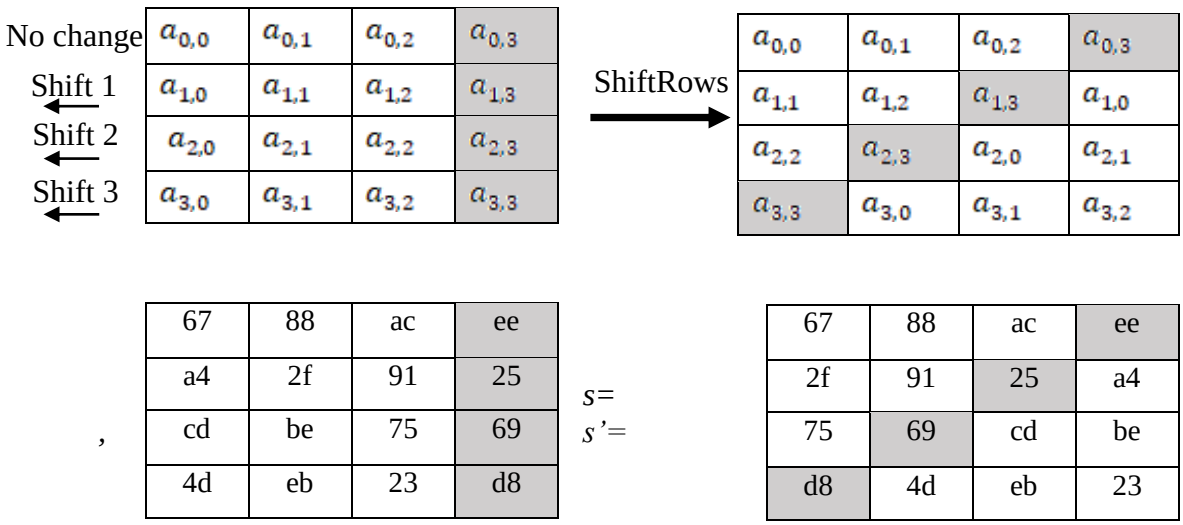
Where 'A' is represented as affine matrix, 'x' is a vector that is multiplicative inverse of element of state matrix, 'c' is affine constant 63 (01100011) and 'M' is irreducible polynomial $x^8 + x^4 + x^3 + x + 1$. The S-Box generated by equation (1) is represented in the Table 1 below.

Table 1: AES S-Box

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	63	7C	77	7B	F2	6B	6F	C5	30	01	67	2B	FE	D7	AB	76
1	CA	82	C9	7D	FA	59	47	F0	AD	D4	A2	AF	9C	A4	72	C0
2	B7	FD	93	26	36	3F	F7	CC	34	A5	E5	F1	71	D8	31	15
3	04	C7	23	C3	18	96	05	9A	07	12	80	E2	EB	27	B2	75
4	09	83	2C	1A	1B	6E	5A	A0	52	3B	D6	B3	29	E3	2F	84
5	53	D1	00	ED	20	FC	B1	5B	6A	CB	BE	39	4A	4C	58	CF
6	D0	EF	AA	FB	43	4D	33	85	45	F9	02	7F	50	3C	9F	A8
7	51	A3	40	8F	92	9D	38	F5	BC	B6	DA	21	10	FF	F3	D2
8	CD	0C	13	EC	5F	97	44	17	C4	A7	7E	3D	64	5D	19	73
9	60	81	4F	DC	22	2A	90	88	46	EE	B8	14	DE	5E	0B	DB
A	E0	32	3A	0A	49	06	24	5C	C2	D3	AC	62	91	95	E4	79
B	E7	C8	37	6D	8D	D5	4E	A9	6C	56	F4	EA	65	7A	AE	08
C	BA	78	25	2E	1C	A6	B4	C6	E8	DD	74	1F	4B	BD	8B	8A
D	70	3E	B5	66	48	03	F6	0E	61	35	57	B9	86	C1	1D	9E
E	E1	F8	98	11	69	D9	8E	94	9B	1E	87	E9	CE	55	28	DF
F	8C	A1	89	0D	BF	E6	42	68	41	99	2D	0F	B0	54	BB	16

ii. The ShiftRow Transformation

The ShiftRows step is a byte transposition that cyclically shifts the rows of the state over different offsets. In AES, the first row is left unchanged. Each byte of the second row is shifted one to the left. Similarly, the third and fourth rows are shifted by offsets of two and three respectively. For example we get *s'* matrix from state matrix *s* after shift row in following transformation:



$a_{0,0}$	$a_{0,1}$	$a_{0,2}$	$a_{0,3}$
$a_{1,0}$	$a_{1,1}$	$a_{1,2}$	$a_{1,3}$
$a_{2,0}$	$a_{2,1}$	$a_{2,2}$	$a_{2,3}$
$a_{3,0}$	$a_{3,1}$	$a_{3,2}$	$a_{3,3}$

$a_{0,0}$	$a_{0,1}$	$a_{0,2}$	$a_{0,3}$
$a_{1,1}$	$a_{1,2}$	$a_{1,3}$	$a_{1,0}$
$a_{2,2}$	$a_{2,3}$	$a_{2,0}$	$a_{2,1}$
$a_{3,3}$	$a_{3,0}$	$a_{3,1}$	$a_{3,2}$

67	88	ac	ee
a4	2f	91	25
cd	be	75	69
4d	eb	23	d8

67	88	ac	ee
2f	91	25	a4
75	69	cd	be
d8	4d	eb	23

Figure 2 : ShiftRows Transformation

iii. The MixColumns Transformation MixColumns

The MixColumns step is a bricklayer permutation operating on the column by column. In MixColumn, column vector is multiplied with a fixed matrix, where the bytes are treated as a polynomials rather than numbers.

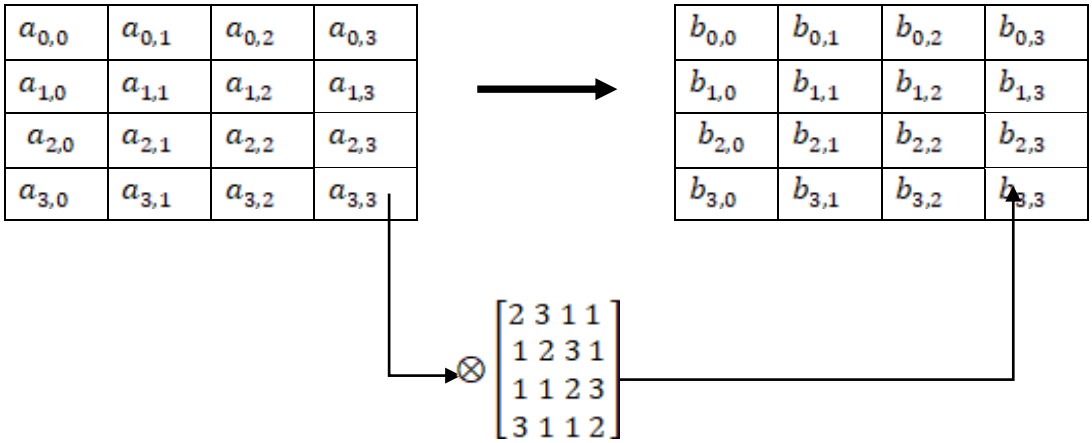


Figure 3 : MixColumns Transformation

iv. Add Round Key

The Add Round key operation is an XOR operation between the State and the Round Key. By doing XOR operation element by element of both State and Round Key, next state of matrix is obtained.

State' (a,b) = State(a,b) ⊕ Round Key(a,b)

$$\text{State} = \begin{bmatrix} 32 & 88 & 31 & e0 \\ 43 & 5a & 31 & 37 \\ f6 & 30 & 98 & 07 \\ a8 & 8d & a2 & 34 \end{bmatrix}, \text{Round Key} = \begin{bmatrix} 00 & a5 & a8 & a0 \\ e9 & 09 & bb & 2a \\ c9 & d4 & b7 & ab \\ f2 & e8 & 60 & 08 \end{bmatrix}$$

The new state will be:

32(hex) ⊕ 00 (hex) = 0011 0010 ⊕ 0000 0000
= 0011 0010 (32)
88(hex) ⊕ a5 (hex) = 1000 1000 ⊕ 1010 0101
= 0010 1101 (2d)

$$\text{State'} = \begin{bmatrix} 32 & 2d & 99 & 40 \\ aa & 53 & 8a & 1d \\ 3f & e4 & 2f & ac \\ 5a & 65 & c2 & 3c \end{bmatrix}$$

S-Box Properties

The strength of block ciphers which work on substitution and permutation like AES is basically depends on the construction of S-Box. The S-Box maps an 8-bit input to an 8-bit output. Both the input and output are interpreted as polynomials over GF(2). First, the input is mapped to its multiplicative inverse in $GF(2^8) = GF(2)[x]/x^8 + x^4 + x^3 + x + 1$. The AES S-Box was specifically designed to be resistant to linear and differential cryptanalysis. This was done by minimizing the correlation between linear transformations of input/output bits, and at the same time minimizing the difference propagation probability. The AES S-Box can be edited which defeats the suspicion of a backdoor built into the cipher that exploits a static S-Box.

The properties of S-Box have been widely used as a base of new encryption technique for instance nonlinearity, differential uniformity and strict avalanche criterion (Zhang, 2013).

i. Bijection – requires a one-to-one and onto mapping from input vectors to output vectors if the S-Box is *n* by *n* bit.
ii. Strict avalanche criterion – occurs if one input bit *i* is changed, each output bit will change with probability of one half. Strict avalanche requires that if there are any slight changes in the input vector, there will be a significant change in the output vector. To achieve this effect, we will need a function that has a 50% dependency on each of its *n* input bits.
iii. Bit independence criterion or correlation immunity – requires that output bits act independently from each other's. In other words, there should not be any statistical pattern or statistical dependencies between output bits from the output vectors.
iv. Nonlinearity – requires that the S-Box is not a linear mapping from input to output. This would make the cryptosystem susceptible to attacks (Coppersmith, 1994). If the S-Box is constructed with maximally nonlinear Boolean functions, it will give a bad approximation by linear functions thus making a cryptosystem difficult to break. The nonlinearity of an S-Box must be high to resist against linear cryptanalysis.

v. Balance – means that each Boolean vector responsible for the S-Box has the same number of 0's and 1's. The significance of the balance property is based on the higher the magnitude of function imbalance, a high probability linear approximation being obtained.
vi. Differential uniformity – the smaller is the differential uniformity, the better is the S-Box's resistance against differential cryptanalysis.

Security Analysis Between Static and Dynamic S-Box

To make a cryptographic algorithm secure against various algebraic attacks it should comply with some standard tests like strict avalanche criterion, non-linearity, balancing and differential uniformity. In order to classify the strong and secured S-Box, the properties of s-Box should be analysed as shown in Table 2.

Table 2: Comparison Between Static and Dynamic S-Box

Algorithm	S-Box Type (Static/Dynamic)	Strict avalanche criterion	Nonlinearity	Balance	Differential uniformity
AES (Daemen, 2002)	Static	0.525	112	Balanced	4
A Novel S-Box Design using Gaussian Distribution (Muhammad, 2019)	Static	0.562500	112	Balanced	-
Chaotic S-Box Design (Musheer, 2014)	Static	0.4907	108	Balanced	
S-Box using affine transformation (Zakaria, 2016)	Static	0.6016	112	Balanced	4
An Improved AES S-Box (Cui,2011)	Static	0.502	112	Balanced	4
High Quality Key-dependent S-Box (Tianyong, 2017)	Dynamic	-	112	Balanced	-
AES with Key Dependent S-Box (Krishnamurthy, 2008)	Dynamic	0.47215	-	Balanced	-
Key-Dependent S-Box Generation (Kazys, 2014)	Dynamic	0.5342	-	Balanced	-
Dynamic Chaotic S-Box (Ghada, 2009)	Dynamic	0.5103	-	Balanced	-

Conclusion

AES has been designed to have a very strong resistance against the classical attacks such as linear cryptanalysis and differential cryptanalysis. However, since AES is very algebraic, new algebraic attacks was appeared (Ferguson, 2001). Therefore, the need for design dynamic S-Box which is key-dependent will help to increase the security of encryption. Most of researchers aware that S-Box properties are very crucial in order to make the S-Box strong enough and secure. However, most of them analyse their S-Box properties based on their perceptions without any proper guideline. In addition, cryptanalysis attempt to break the S-Box properties with all kinds of methods.

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SUSTAINING SARAWAK'S MALAY CULTURAL HERITAGE: YOUTHS AND SOCIAL MEDIA

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Abstract: *Sarawak is the largest state in Malaysia and within the state, there are about 27 ethnic groups with their own distinctive uniqueness, especially in terms of culture, language and lifestyle. Therefore, it is important to preserve these cultural heritages to sustain and protect their values. This paper aims to explore the youths' awareness and interests towards Sarawak's Malay Heritage, focusing on the Traditional Malay Clothing, Music and Dances. It also identifies the effectiveness of social media in promoting Sarawak's Malay Heritage, specifically among youths who are perceived to be avid users of various platforms of social media. The study involves 112 respondents who are undergraduate students of one of the local universities in Sarawak, where they have completed an online survey to address the study's objectives effectively. Exploring the youths' awareness and interest towards the Sarawak's Malay Heritage will create better awareness among the younger generation of the Sarawak's Malays and thus, sustain Sarawak's Malay Cultural Heritage.*

Keywords: *Sarawak's Malay Heritage, Social Media, Youths, Awareness and Interests*

Introduction

Social media allows information-sharing activities, where users can create, share, and bookmark contents and information, as well as creating and establishing network or social relationship across the platform of internet users (Saodah Wok et.al, 2012). Thus, the preservation of cultural heritage using social media will allow more youths to be involved, either to pass the legacy or sustain appropriate memories from the past. Social media platforms can offer vast opportunities for these cultural aspects to be conserved and to bridge the information between the past and the future. Lankton and Tripp (2013) reported that there were 4.021 billion internet users worldwide and a huge percentage of the users use the internet to access social media sites, especially the younger generation. The different platforms of social media will be able to affect, link and mobilize the society in rapid manner.

The Sarawak Malay's cultural heritage is a community identity that includes language, traditional clothing, beliefs, culture, art, customs, festivals, historical buildings, monuments, and all items that this ethnic group owns, worthy of preservation for the future generation. As a

result, social media platform is seen to be most appropriate medium to preserve and sustain cultural heritage, especially among youths. This study explores the youths' awareness and interests towards Sarawak's Malay Heritage, focusing on the Traditional Malay Clothing, Music and Dances. It also illustrates the effectiveness of social media in promoting Sarawak's Malay Heritage, specifically among youths who are commonly the keen users of various social media platforms.

Literature Review

Awareness of Cultural Heritage

United Nations, Educational, Scientific and Cultural Organization or known as UNESCO is the association that encourages the identification, protection and preservation of cultural and natural heritage. They support heritage as a legacy from the past and what should be passed on to the future generations. Jokilehto (2005) views that culture is different from one state law from another. Declaration of this cultural heritage within the ethnic is determined by the law. In the Canadian Law, heritage is a reality, own by community, rich inheritance that being passed on, recognize and participate from the public.

World Commission on Environment and Development or WCED (1987) views that sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It can only be achieved with goals of social equity, economic development and environmental quality. According to Smith (2001), heritage defines our social values that enable us to understand who we really are, culture and community, and guide us in decision making for a sustainable future. The properties of this legacy need to be sustained as they provide a voice from the past to be shared and delivered from one to another and provide opportunity to the community to contribute to the history.

Awareness on cultural heritage must be acknowledged by our own ability to recognize the elements and assets. Vecco (2010) affirms that this awareness can be achieved based on our ability to recognise its aesthetic, historic, scientific, social values etc., or rather, the society and the community must also recognise these values, upon which our own cultural identity can be built. Bandarin and Van Oers (2012) state that the beliefs on the awareness of heritage encompass the symbolic and aesthetic values of places and to a new use of the urban spaces that define the historic city (or site) as a living heritage.

Social Media: Medium to Sustain Cultural Heritage

According to Singh, Priyanka and Yagya (2013), social media is a transformation of social interaction that changes the way we look at love, friendship, family, intimacy, language and expressions. Photographs, video, music, documents and all kinds of information are all within a click. Social media can be a platform of communication to become more effective, engage citizens, gain feedback and participation in the community. Furthermore, Singh, Priyanka and Yagya (2013) add that the social media is more localized where more people get connected. Social media is a group of internet-based applications that are based on the ideological and technological foundations of Web 2.0 as it allows the creation and exchange of users' general contents (Kaplan and Haenlein, 2010). The popular social network sites according to Siti

Eizaleila and Azizah (2010) are Facebook, Twitter, YouTube and Blog while the rest is developed based on the needs of social users in Malaysia. Hence, due to their popularity, social media sites can be effective to sustain cultural heritage so that cultural heritage will not fade and become unknown among the younger generation.

Sarawak's Malay Heritage: Clothing, Music and Dance

The most common Sarawak's Traditional Malay Clothing consist of *Keringkam* (traditional head scarf), Sarawak *Songket* (handwoven fabric) and *Tali Pinggang Besi/ Perak* (traditional alloy belt). *Keringkam* according to Dayang Sandrawati Abang Josmani et al. (2012) is a gold thread piece of embroidered veil or shawl worn by most Malays ladies in Sarawak during weddings, engagements, cultural festivals or other special occasions. Sarawak Malay *Songket* is a fabric which is hand-woven on silk or cotton fabric and intricately patterned with gold or silver threads. *Tali Pinggang Besi/Perak* is an alloy belt that is worn by a Malay girl, either for fashion or to match the attire at that time.

The most common traditional music among the community of Sarawak Malay is *Bermukun* or *Bergendang*, in which the main musical instrument is *gendang* or traditional drum, played by the musicians, who are also the singers. According to Mohammad Syawal Narawi (2016), traditionally, this music was performed basically for young people to gain partners in life, as the girls rarely went of their houses. The instruments include traditional drums or *gendang*, violin, *gong* and accordion. The music begins with the *gendang* or drums performance and they start to sing and recite *pantun* or Malay poetic forms, following the rhythms of the *gendang*.

Sarawak Malay dance is called *Bertandak* and one of the most common dances in Sarawak. *Bertandak* means dance and this *bertandak* is performed during *Bermukun* or *Bergendang* session. Basically, the dance is quite similar to the common Malaysian *Zapin* dance. Traditionally, the dancers are males who often wore masks while dancing. Sarawak's *Zapin* Traditional Dances such as *Zapin Sebat* and *Zapin Sindang* are some of the known Sarawak's traditional Malay dance. These are performed during wedding, engagement day and any special occasions. According to Mohd Ghause Nasuruddin (1989) this traditional dance is a medium to illustrate continuous legendary stories, tales or traditional customs that are performed for entertainment.

Methodology

The study involves 112 respondents who are undergraduate students in one of the local universities in Sarawak, where they have completed an online survey (google forms and were distributed via emails and messaging services) to address the study's objectives effectively. The survey is adapted from Smith (2001) and it consists of five sections: demographic; the awareness towards Sarawak's Malays Cultural Heritage and the awareness towards the different aspects of Sarawak Malay's Cultural Heritage; the sources of Sarawak's Malays Cultural Heritage; Importance of Sustaining Cultural Heritage and Social Media as a platform to sustain Sarawak's Malays Cultural Heritage. The respondents involved are Sarawak's Malays youths, aged between 18-24. The United Nations (2008), for statistical purposes, defines 'youth', as those persons between the ages of 15 and 24 years, without prejudice to other definitions by Member States.

The data was analyzed using SPSS and presented in tabular forms of frequencies (number of respondents).

Findings

Section A: Demographic

Table 1: Gender

Items	Respondents
Male	30
Female	82

Table 2: Age

Items	Respondents
18 – 20 years old	73
21 – 24 years old	39

Table 3: Types of Most Popularly Used Social Media

Items	Respondents
Facebook	87
Instagram	20
WhatsApp	3
YouTube	2

More female respondents were involved in this study where most of the respondents were between 21-23 years old. They were avid users of Facebook while Instagram took second place as the most popular used social media among them.

Section B: Awareness towards Sarawak's Malays Cultural Heritage

Table 4: Awareness towards Sarawak's Malays Cultural Heritage (SMCH)

No	Items	Respondents				
		1	2	3	4	5
1	I know what the aspect of SMCH is	3	9	47	41	12
2	I know *Bertandak* during *Bermukun* is one of SMCH	6	18	18	41	29
3	I know what Sarawak *Zapin* Traditional Dance is	6	17	32	35	22
4	I Know *Keringkam* is one of the elements of SMCH	15	23	41	18	15
5	I know Sarawak's Malay has its own *Sarawak Songket*	1	8	20	41	42
6	I know about Sarawak's Malay Lady accessory: *Tali Pinggang Besi / Perak*	14	17	33	25	23
7	I know *Bermukun or Bergendang* is one of SMCH	5	11	24	32	40
8	I want to know more about SMCH and I am curious about it	0	2	23	36	51

Scale: 1 (Strongly Disagree), 2 (Disagree), 3 (Not Sure), 4 (Agree), 5 (Strongly Agree)

The most significant results from Table 4 above are for the item "I know what the aspect of Sarawak's Malays Cultural Heritage is" with 53 respondents for 'strongly agree' and 'agree' and, the item 'I want to know more about SMCH and I am curious about it' with 87 respondents who chose 'strongly agree' and 'agree'. These are seen as optimistic as many admitted that they know relevant information about Sarawak's Malays Cultural Heritage and most of the respondents are curious to learn more about their cultural heritage. Consequently, these might further indicate that the respondents at certain level are aware of their culture and roots.

Table 5: Awareness towards Different Aspects of Sarawak's Malays Cultural Heritage (SMCH)

No	Items	Respondents						
		1	2	3	4	5	6	7
1	I have known about *Bertandak*	6	13	10	19	20	26	18
2	I have known about *Zapin Sarawak*	6	13	10	19	20	26	18
3	I have known about *Keringkam*	12	7	9	9	12	45	18
4	I have known about *Sarawak Songket*	13	9	11	15	28	18	18
5	I have known about *Tali Pinggang Besi/ Perak*	11	4	6	16	16	40	19
6	I have known about *Bermukun or Bergendang*	15	10	7	16	26	19	19

Scale: 1 (Have Never Known), 2 (Between 1-5 Months), 3 (Between 6 – 12 Months), 4 (1 – 5 years), 5 (6 – 10 years), 6 (10-15 years), 7 (Have Known All My Life)

Table 5 illustrates that the respondents' awareness towards the different aspects of Sarawak's Malays Cultural Heritage in which more than half of the respondents are aware of the existence of *Keringkam* and *Tali Pinggang Besi/ Perak*, between 10-15 years and all their lives. The least aspects that they are aware of are the traditional music of *bermukun / bergendang* and traditional fabric which is *Sarawak Songket.* The possible reasons are the respondents do not have ample opportunities to listen and view *bermukun / bergendang*, while *Sarawak* Songket is rarely worn by Malay ladies nowadays.

Section C: Sarawak Malays Cultural Heritage Sources

Table 6: Most popular sources to gain Sarawak's Malays Cultural Heritage Information

Items	Respondents
Book	7
Family	36
Magazine	6
Museum	5
Exhibition (Open)	9
Exhibition (Science and Technology)	1
Library	2
Resource Center	2
School	28
Friends and Relative	16

This table shows the main sources of Sarawak's Malays Cultural Heritage Information and many respondents opted for family members (36 respondents) and school (28 respondents). The result for the item of family shows that the respondents' family members are their central basis of knowledge when it comes to Sarawak's Malays Cultural Heritage Information. This is made possible as they could gain information from their grandparents and elder relatives who own traditional fabrics and accessories, and they often talk about the traditional music and dances to their younger family members. Dayang Sandrawati Abang Josmani et al. (2012) posit that the exposure from family and community through exhibitions and learning workshops can create better awareness, especially among the younger generation of the Sarawak Malays.

Section D: Importance of Sustaining Sarawak's Malays Cultural Heritage

Table 7: Sustaining Sarawak's Malays Cultural Heritage (SMCH): Importance

No	Items	Respondents				
		1	2	3	4	5
1	SMCH needs to be sustained for the future	0	0	14	26	72
2	I love SMCH because it defines my identity	0	0	19	29	64
3	I'm proud of my SMCH	0	0	14	36	62
4	I will help to sustain SMCH by any means	0	0	20	39	53
5	I don't care about SMCH	64	15	14	10	9
6	Schools should provide activities to sustain SMCH	0	2	21	34	55
7	Community needs to provide activities to sustain SMCH	0	4	22	31	55
8	Museum should provide activities to sustain SMCH	0	0	16	31	65
9	Library should provide activities to sustain SMCH	0	0	23	29	60
10	Radio and television should help to document SMCH	0	0	17	34	61

Scale: 1 (Strongly Disagree), 2 (Disagree), 3 (Not Sure), 4 (Agree), 5 (Strongly Agree)

Table 7 illustrates encouraging feedback as 98 respondents 'agreed' and 'strongly agreed' that Sarawak's Malays Cultural Heritage needs to be sustained for the future and they also admitted that their cultural heritage define their identities and roots (93 respondents 'agreed' and 'strongly agreed'). Another significant finding is 98 respondents were proud of their Malay heritage and thus, this is relevant to the next finding where 92 respondents would aid to protect and preserve their cultural heritage by any means. These indicate positive efforts on their parts as the younger generation.

Section E: Social Media as platform to sustain Sarawak's Malays Cultural heritage

Table 8: Social media as platform to sustain Sarawak's Malays Cultural Heritage (SMCH)

No	Items	Respondents				
		1	2	3	4	5
1	Overall, social media sites can help in sustaining SMCH effectively	0	1	20	35	56
2	Facebook is an effective media to promote SMCH	1	3	21	32	55
3	Instagram is an effective media to promote SMCH	1	2	22	33	54
4	YouTube is an effective media to promote SMCH	0	1	17	31	63

5	WhatsApp is an effective media to promote SMCH	4	5	29	28	46
6	Telegram is an effective media to promote SMCH	5	6	35	23	43
7	Blog as an effective media to promote SMCH	1	1	25	27	58
8	I will help to sustain SMCH by "Sharing" the information in my Social Media account.	1	3	28	30	50

Scale: 1 (Strongly Disagree), 2 (Disagree), 3 (Not Sure), 4 (Agree), 5 (Strongly Agree)

Table 8 shows social media as the platform to sustain Sarawak's Malays Cultural Heritage in which the most popular platform is YouTube with 94 respondents, as the youths would prefer to view and listen to the different aspects of Malay Cultural Heritage videos in the internet compared to others media. The least popular social media sites are WhatsApp and Telegram. Besides, generally, 91 respondents 'strongly agreed' and 'agreed' that social media sites can help in sustaining Sarawak's Malays Cultural Heritage efficiently. Rubin and McClelland (2015) affirm that social networking sites have become central to the way young people communicate in their everyday lives. These sites help users to make new friends, share content, pictures, audios, videos among them and these can include contents that are related to Sarawak's Malays Cultural Heritage.

Conclusion and Recommendations

In general, many of the respondents are aware of certain aspects of Sarawak's Malays Cultural Heritage and most are willing to sustain this heritage as it is part of their cultural identities. Many acknowledged the importance of this heritage and they also claimed that their main source of information would be their own family members. Notably, most are also keen to sustain the heritage by utilizing many mediums, such as the social media sites. As some of Sarawak's Malay Cultural Heritage are slowly losing their popularity and more young people become less aware of their existence, thus, better awareness towards preserving and sustaining this traditional heritage needs to be done.

One of the efforts by the government is conducted by Pustaka Negeri Sarawak, where it has a library collection called *Sarawakiana* which documents all programs and activities to sustain and preserve Sarawak's data of traditional heritage for future generation. Dayang Sandrawati Abang Josmani et al. (2012) suggested that the opportunities in maintaining the cultural and traditional activities should be provided for better information delivery and understanding. Sarawak government can also give support in subsidizing technological product to encourage better use of technology among the citizens, especially in sustaining local heritage. Sarawak's Malays community need to sustain the heritage as their unique Malay identity and another recommendation is that the government agencies or organization, or relevant NGOs can provide more exposure towards the significant elements of the cultural aspects by combining technology (internet) and the information of Sarawak's Malays cultural heritage.

This can be achieved by utilizing social network sites, making this information to become 'trending and viral' and easily accessible. Users who consist of various individuals of all age levels can easily gain relevant information from social media and able to revive these traditional practices. These efforts need to be continuously done to improve the youths' awareness and to

enhance their interests towards the Sarawak's Malay Heritage, and gradually can sustain Sarawak's Malay Cultural Heritage in longer terms.

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A REVIEW OF MULTIMEDIA TOOLS IN THE EDUCATION OF SOCCER PLAYERS: SYNTHESIS AND CHALLENGES

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Abstract: *The use of multimedia applications in spot education has received a special attention from the sport research community in the recent years. This is due to the role of multimedia tools in facilitating soccer players' understanding of complex movements and activities. However, the literature lack evidence to support how the use of certain multimedia strategies in the design of educational processes can influence players' learning and performance of various sport skills. A review of the previous studies was conducted to provide a rich understanding about the role of multimedia tools/applications in the development of soccer players. This review addressed the major challenges facing educational designers in designing multimedia presentations. The results highlighted different useful guidelines related to the design of multimedia program for soccer players. Findings from this review can be used by soccer coaches to identify the best multimedia tools and techniques for teaching various tactical and technical skills. It also offers a way to overcome potential challenges in the presentation of these skills.*

Keywords: *sport education, multimedia in sport, players development, learning strategies*

Introduction

There are a number of studies that utilized multimedia tools in an attempt to promote players' learning of various skills. Many physical education teachers are becoming more familiar with the use of computer aided multimedia applications as a mean for enhancing students learning performance (Chen, 2012; Robinson & Foran, 2011). For example, a study conducted by Lvhua (2011) has demonstrated the role of multimedia tools to assist 10th grade students to research their football game strokes by using biomechanical principles via measurement in movement as shown in Figure 1.

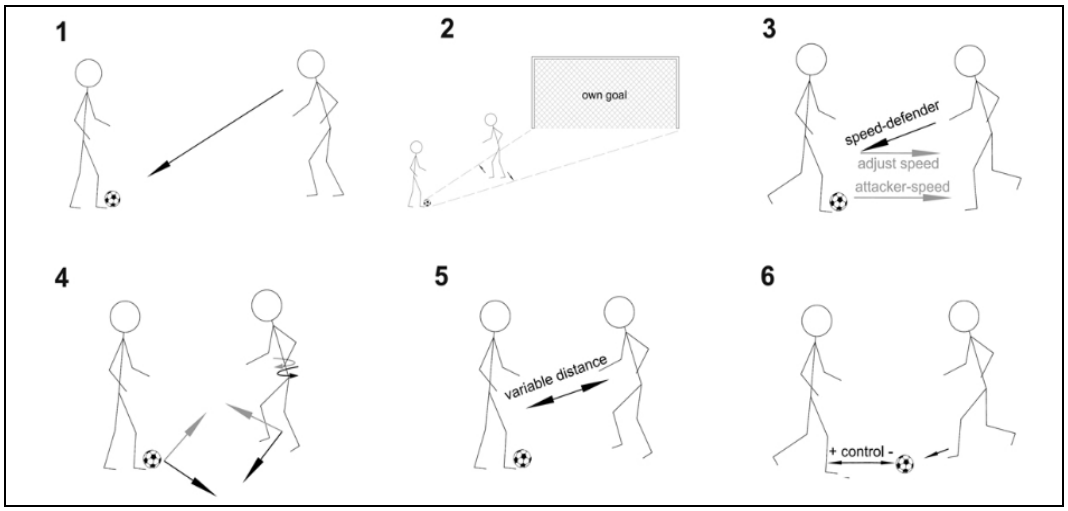

Figure 1: Multimedia demonstration for 10th grade students

There are a few investigations, which inspect how interactive media innovation impacts singular learning execution in the region of game to which it connected to the player intellectual abilities to process data and take activities in evolving circumstance. Nonetheless, little is as yet known on how such mediation would influence understudy results in the engine area. Just a few examinations on engine expertise learning with accentuation on mixed media use were distributed up until this point. For instance, Chu and Chen (2000) addressed the potential of utilizing media applications in physical instruction and game learning. They recognized the requirements for more endeavors on structure and improvement of the substance of mixed media that adequately speak to the association among insight and expertise execution on engine learning. Vernadakis, Avgerinos, Zetou, Giannousi, and Kioumourtzoglou (2006) examined the impact of using visual and laudatory support in facilitating players' understanding of certain game regulations. They also emphasized on the role of multimedia technology in providing guidance, customary guidance and consolidated guidance strategies on learning the long bounce occasion. The current media tools will in general be the best for subjective learning and expertise advancement, while unadulterated mixed media PC helped guidance brought about essentially lower aptitude test scores than different gatherings. Later, Vernadakis, Zetou, Tsitskari, Giannousi, and Kioumourtzoglou (2008) considered examining the role of multimedia tools in providing the learning atmosphere for learning to be able to maintain customary guidance in basketball. They found that understudies had noteworthy contrasts in learning the abilities of shooting and changing position with the sight and sound guide.

The current literature review of these investigations yields on little proof about the capability of multimedia tools in facilitating the learning of soccer players, especially when attempting to perform certain tactical and technical skills. Henceforth, this investigation is directed to address these perspectives by reviewing improvement in soccer players' performance when learning with multimedia tools.

Past research on multimedia in sport education

The past research on the use of multimedia in sport education revealed different perspectives and potentials of this technology in teaching practical aspects of courses, such as motor skills. Leser, Baca, and Uhlig (2011) investigated the capability of interactive media innovation in affecting players' learning by looking at the development in their motor skill capabilities. An aggregate of 35 participants were recruited from a college soccer class who were isolated into two groups. The first group was educated generally without using interactive media while the second group was instructed with sight and sound helped instructional units. The creators thought about the capacity of players to play out a particular breezing through test and a strategic evaluation. They surveyed the capability of media by utilizing poll. The outcome demonstrated no huge contrasts, neither concerning the consequences of the strategy test nor concerning the strategy test. Be that as it may, the consequences of the poll demonstrated a positive understanding among the members in the ease of use and help of mixed media for the games viable course. Lonsdale, Sabiston, Taylor, and Ntoumanis (2011) analyzed the principle psychometric properties in culturally diverse setting. They investigated players' perceived locus of causality and their situational motivation Scale when learning with multimedia tools based on the principle idea of self-assurance hypothesis. This study was conducted in a setting that incorporate information sharing between players. The researchers asked 300 school students from the United Kingdom and 342 from Hong Kong to provide their opinions on their local and situational motivation. The examination result demonstrated that understudies' inspiration and recognition were profoundly connected with self-assurance hypothesis in regard to the inner consistency of the outer and introjected guideline of the locus causality in the HK test. They also found that soccer guideline and natural inspiration were not discernable in either culture in either poll. They additionally tended to the conceivable challenges in the estimation of relevant and situational inspiration in Chinese players in which there appears to be a need for more research to see how understudies from various societies react to things planned or presented on a tap.

Cox, Duncheon, and McDavid (2009) demonstrated an investigation to feature the capability of observations to self-decided inspiration in physical instruction. They profoundly analyzed the impression of educator dependent on the main aspects that were identified based on their perceived emotional support. They likewise researched how such perspectives correspond with the companion regarding acceptance, friendship quality and their impact on sentiments of relatedness, inspiration, and full of feeling reactions in middle school physical instruction students as appeared in Figure 2. An aggregate of 411 school students were recruited to do as such while the outcome demonstrated that apparent relatedness intervened the connection among factors and self-decided inspiration and related straightforwardly to the measure of enjoyment and worry students experienced. Having this at the top of the priority list, the authors additionally recognized that conceivable associations with the two educators and friends are vital for players' perceptions, inspiration, enjoyment, and worry/stress in physical instruction.

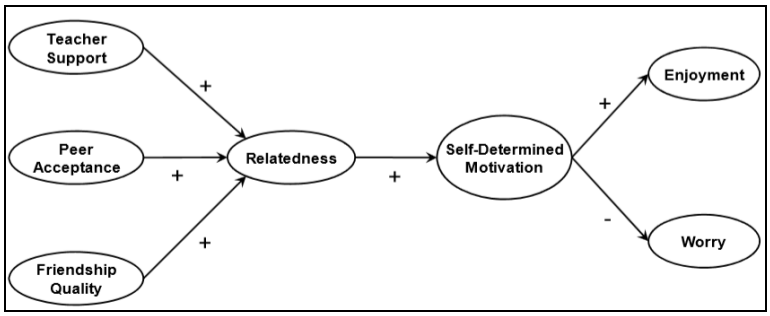

Figure 2: Teacher and peer relationship in a multimedia context

Another study was conducted by Zacks and Tversky (2003) to determine the impact of different interface design and the way for organizing information on user learning. They clarified the use of intellectual standards from fundamental hypothesis and research in which they addressed psychological structure standards from two different perspectives: event cognition and media: These elements were connected to the plan of interfaces for physical education purposes. They delineated that impacts of media, adding proper illustrations to content guidelines can be utilized so as to improve players' learning and memory. This incorporate organizing the substance in a way that guarantee player's understanding which observed to be upheld by incorporating a musical instrument into the learning of certain skills. Despite that both top-down standards were successful in controlling interface plan, they were not adequate. Meanwhile, the authors recommended that future research should investigate the impacts of such standards in different areas. Cairncross and Mannion (2001) examined the use of consecutive model of inspiration in soccer game. A sum of 379 players were utilized to evaluate this potential. The authors considered analyzing autonomy-support, need fulfillment/satisfaction, and enjoyment. The researchers also revealed support for a connection between independence support from mentors and the fulfillment of the fundamental needs. The examination results revealed that if thinking about the players perspective, players can be effectively taking appropriate choices while it can advance mentor control of players' sentiments of self-rule, relatedness just as fitness. They additionally tended to the way that fulfillment was emphatically connected to increasingly self-decided kinds of inspiration. Another study by Castagna, Impellizzeri, Cecchini, Rampinini, and Alvarez (2009) was found to support such findings to the sport domain, showing that the behavior of a coach appear to be associated with need satisfaction, allowing for more self-determined motivational regulations.

In addition, Ntoumanis and Standage (2009) researched the connection between players' autonomy and satisfaction effect on their sportsmanship by studying the main dimensions of motivation when undertaking a certain learning skill. The researchers recommended that such relations can be anticipated by inspiration because of the competitors being bound to play by the principles, as they wish to appreciate the action and hold some characteristic enthusiasm towards it. Different viewpoints identified with players' inclination and feeling were found not really impact players aptitudes. Álvarez, Balaguer, Castillo, and Duda (2009) conducted a study to determine the influence of certain factors on the players' enjoyment and boredom. This was intended to justify the reasons why players' use of certain learning tools may result in different learning consequences. This concept is shown in Figure 3 which illustrates the mediational roles of psychological need satisfaction and self-determined motivation claimed to influence enjoyment and boredom by the authors. The researchers recruited 370 soccer players in an attempt to determine the role of using

technology in promoting these variables. Total mediation was supported in the case of the psychological need satisfaction in the relationship between autonomy support and self-determined motivation, and partial mediation for self-determined motivation in the links between psychological need satisfaction and enjoyment (positive) and boredom (negative). This relation can open the door for new research to determine the effect of motivation in improving players' ability to perform better.

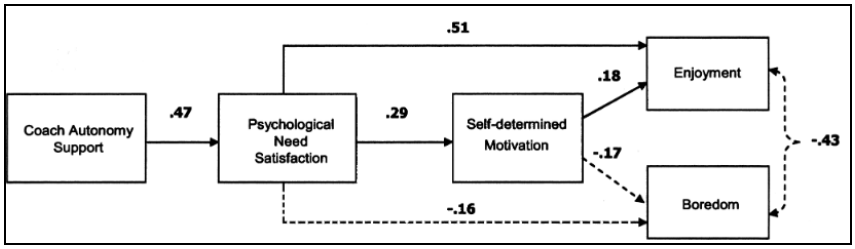

Figure 3: Reformulated structural model Social Environment

According to Khacharem, Zoudji, Spanjers, and Kalyuga (2014), multimedia tools can help soccer trainer achieve a better learning outcomes for their players in the field. This is mostly due to its role in visualizing the complex situations that involves multiple players to coordinate with each. Khacharem et al. examined the use of animation as a multimedia tool to promote soccer players' performance. They directed two investigations to decide how activity of play (soccer) ought to be structured so as to maintain a strategic distance due to the difficulty in estimating such situation in a real setting. For this reason, they utilized static pictures and modifying the animation's introduction speed so as to offer players powerful route for decreasing their subjective burden. Players in the pretest session were acquainted with choose the effect of static stanzas enlivened introductions on learning. The outcomes demonstrated that tenderfoots profited more from the static introduction while specialists profited more from the vivified introduction. On the other hand, players in the second situation were solicited to choose the effect from various dimensions of introduction speed (low versus typical versus high) on learning. The investigation result demonstrated that beginners benefitted more from the low introduction speed while specialists benefitted more from the ordinary and high introduction speeds. This infers the impact of interactive media in improving beginner players comprehension of amusement. The settings used in this study may require considering incorporating other media elements and estimating its impact on players' abilities with regard to the strategic and specialized aptitudes.

Challenges in the current multimedia representation

Despite the potential of using multimedia tools in sport education. The review of previous studies showed some limitations with that regard. For example, the literature revealed that there are still some issues faced by students when learning with multimedia applications. This includes providing the main elements for enabling students to have more control of their learning based on utilization of various techniques for information delivery in which it offers the interactivity for enhancing the learning process by means of creating incorporated learning surroundings (Lagrosen, Grundén, Lind, & Lagrosen, 2011). Although multimedia tools used to combine explanation of event along with illustrative cases, its application in sport still in its fancy stage. A range of media elements can often convey a given message but with the lack of proper organization of content, user may lose interest to learn (Khacharem, Zoudji, Kalyuga, & Ripoll, 2013). Meanwhile, the amount of information provided to the

players can help improve comprehension and understand complex movements. This process however may still impose some challenges on learners especially due to presentation and its structure usually are not given enough consideration (Lance & Kitchin, 2007). As Alben (1996) highlights, for almost any design to achieve success, it has to be in line with the needs along with interests from the users' perspectives who need to be informed by knowledge of their own limitations.

Kennedy and McNaught (1997) expressed that a few difficulties related with the introduction of sight and sound components including intelligent media learning applications may result in different learning consequences including both human-PC and acing hypothesis. Inability to make a move can prompt poor applications that don't satisfy the requirements for supporting students' participation in the learning process. Aldrich, Rogers, and Scaife (1998) tactical skills by offering upgraded conditions for players to follow the sequence of movements. They recognized that understudies regularly focus on the energetic components, for example surfing through video cuts, as opposed to connecting with while utilizing material.

Scaife, Rogers, Aldrich, and Davies (1997) addressed the challenges faced by learners when using advanced technology that utilizes various features which to a large extent are unnecessary. This include processing multiple movements at the same time, providing less support to players when progressing in the learning process. In addition, the lack in understanding students' needs when participating in information sharing practices using various media elements make it difficult for them to progress. This can easily best be performed through fuller consideration of the learning technique itself notwithstanding investigating the points of interest that intelligent mixed media that can be used to convey this.

Based on these, it can be suggested that multimedia systems applications are in need for a better structuring of learning contents. This includes the way in which materials are represented on the screen. In addition, players' tactical skills can be also improved with the use of additional visual aids that incorporate motivational and gamified elements. For instance, an application might be divided into sections, with every section starting an overview followed by more descriptive explanations. Players may also benefit from other learning scenarios that integrate progressive inquiry features in order for them to effectively share and consolidate learning goals. By doing so, learners can gain more knowledge required to improve their skills. Supplementary information can even be accessed through hyperlinks by providing information or perhaps visual elements associated with the main process. Such techniques can be effectively used to help with contextualization and may also inspire exploration along with experimentation, thus leading to a deeper idea of the skill needed to be acquired.

The review also showed that multimedia tools may not necessary provide the navigational means to produce alternative viewpoints that may aid accomplishing a certain learning task. For example, some learners must decide the learning materials related to their learning skills. Sun and Cheng (2007) asserted that learning with multimedia is dependent on individuals' interest on aspects related to information organization into a loosely clustered. Researchers stated that majority of learners would prefer information structured in way that ensure their concentration that it's likely to develop their own learning approaches (Kettanurak, Ramamurthy, & Haseman, 2001). However, students may require more guidance in determining learning strategies or maybe more exact definitions of overall performance outcomes. Liu (2007) demonstrated that students tend to advance through

training materials when they are presented in sequence. Chemers, Hu, and Garcia (2001) report that learners can make more use of multimedia content in comparison with learning outcome. Govindasamy (2001) found that not every learner manages successfully when he is given choice about how to use or access the particular material. Meanwhile, Ford and Chen (2000) addressed the importance of structuring information related to a certain cognitive model for the creation of effective learning settings. As such, future works are still needed to determine the boarder potential of using other multimedia tools in facilitating players' skills from different perspectives and in different settings.

Conclusions

This review showed the potential of using multimedia tools in promoting various skills for soccer players. It described the main antecedents needed for a coach to maintain an effective learning atmosphere for players. A demonstration of previous studies revealed that using personalized multimedia tools could facilitate players' performance through promoting their motivation, engagement, and mastery. There were, however, some challenges that were reported in the literature with regard to multimedia utilization in this context. For example, lack of control and navigation were the main challenges players faced when using multimedia tools. Therefore, future works can be conducted to determine how certain multimedia aid may potentially improve players' control and mastery of the learning process.

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ELECTRONIC VOTING: THE WAY FORWARD

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Abstract: *Online voting is one of effective mechanisms to vote in any election during this digital era. It is believed that electronic voting (E-voting) increases the number of voters, saves time and energy, and the end results of the election will be more credible, transparent and valid. The purposes of this study are to identify the respondents' views towards E-voting: process, users' satisfaction and relevancy, and to determine the usability criteria of E-voting's interface. This study employed a quantitative method and applied the use of self-administered questionnaires. The survey involves 250 respondents or voters, who completed an adapted survey (five Likert scales), right after they had voted for the committee members in two general elections; one social club for the university's staff and one organization for the female staff of the university. The respondents are from different demographic backgrounds and they had cast their online votes using six laptops, which were set up in two different venues in the university. The elections were conducted on two different dates, with a week difference. The data were analysed using Statistical Package for the Social Sciences (SPSS) software. The study found positive responses from most of the voters in which they express that E-voting is convenient and easy to be used in the voting process, illustrates relevant content and generates satisfactory procedures. Notably, the usability criteria of the interface of E-voting as indicated by most respondents are between good to very good scales (navigation, graphic, user friendliness and consistency, content and transparency. It is recommended that this system is efficient to be used in campus future election though some features will need to be improved for better performance.*

Keywords: *Online Voting, User's Satisfaction, Usability Criteria, Electronic voting Interface*

Introduction

In many countries, due to the advancement of technological usage, paper - based voting system has been replaced with the computer - based voting to reduce errors and improve the election method so that the process will be more convenient and integrity for the whole election process will be intact. One of the main issues of the existing manual voting such as paper-based is time-consuming where it takes a lot of time to cast a vote. Besides, it can also give results of fake voting, which is unreliable, and therefore, this traditional method needs to

be upgraded and the need to shift from the manual voting system to a more sophisticated digitalized voting platform could be triggered.

Electronic voting (E-voting) is generally seen as a support tool for making the election process more efficient and effective. If E-voting is properly applied and administered, this solution will ensure the safety of the ballot, accelerate the processing of results and make voting processes to become easier. This paper aims to provide the users' views towards E-voting which include the process, users' satisfaction levels and relevant involvement, and to determine the usability criteria of E-voting's interface as an enhancement. The results of the study will provide proper grounds that will guide the decision makers in customizing the proposed system to fit the voting needs, especially the adoption of such systems in a university's environment or other communal associations. In addition, it will increase the voters' participation, lower the costs of running elections and improve the accuracy of the results.

This paper has been structured; commencing with introduction, literature review that discusses the overview of the electronic voting and the beneficial values from the adapted voting technology. The next section will be methodology, followed by the data analysis and discussion that project the empirical evidence for the study. The final section will provide the conclusion and future exploration in this area of study.

Literature Review

Electronic Voting: The Overview

Democracy as defined by Holcombe (2001) is a collective decision-making institution that stops single individuals from making decisions for the whole group. One of the most important activities within a democratic system is electing representatives to govern the country or to elect leaders, presidents or committee members of an organisation. Jones (2003) lists the common or traditional voting system which consists of methods like paper ballots at polling centres, postal mail, lever voting machine, punch card and optical voting machine. Nonetheless, the main problem with such system is time consuming, where it takes a lot of time for the process of voting.

Historically, the use of mechanics at the voting area was introduced in early 1890s with the invention of the Herman Hollerith punch card machinery for the US census (in Bellis, 2000), and later, the machinery was developed into electronic voting. Over the years, electronic voting is getting more popular where the electronic way of counting the paper ballots has existed for some time, but the actual casting of the electronic ballots has been the more recent trend. Habibu et al. (2017) have also listed various types of voting such as kiosks, the Internet, telephones, punch cards, and mark sense or optical scan ballots. As technology moves forward, online system allows E-voting to utilize a computer and internet.

E-voting is relatively a new concept based on its application and according to Stenbro (2010) this system aims at reducing errors and improving the convenience and integrity of election process. Gibson (2001, p. 564) refers to E-voting as "casting a ballot via a broader range of electronic telecommunications technology including telephones, cable and satellite television, and computers without internet connection". Stenbro (2010) further describes E-voting as a term which includes various types of voting, exploiting both electronic means of casting a vote and electronic means of counting votes. Besides, Bellis (2007) affirms that E-voting also allows a group such as at a meeting or an electorate to decide or express an opinion, usually following discussions, debates or election campaigns.

Several past academicians have noted that E-voting system has influenced the voters' capability to gain their right to vote and their willingness to receive the unaffected election results and outcomes (Aljarrah et al., 2016; Singh and Roy, 2014 & Winchester et al., 2015). In a study by Norazah and Norbayah (2017), it is revealed that the young voters' commitment

to vote was the strongest factor of the students' decision-making and satisfaction in the campus E-voting. Using E-voting to cast vote could enhance the youths' interests to vote and be committed. Moreover, Das (2015) states that India as the world's largest democracy with a community of 1.1 billion, has developed electronic voting machines (EVM) which are supported by the voters for elections as they can solve problems associated with the traditional paper-based voting system.

Beneficial Values of E-voting

The main benefit of utilizing electronic voting technology at the polling stations is time, where this system can speed up the counting of ballots and provide improved accessibility for more voters, including the disabled and the elderlies. Habibu et al. (2017) imply that with the surge of mobile devices, online voting is a convenient option for many members, allowing them to access ballots anytime, anywhere. They add that the Internet could improve the accessibility and provide an even more convenient voting process which then, leading to improved voter turnout in elections. Thakur et al. (2014) have pointed out that E-voting promises an increase in participation and offers voters more options of convenience to vote, encourages more voters to cast their votes remotely, and has great potential to stimulate higher voter turnout.

E-voting also enhances paperless concept and lessen the manual preparation. Tokaji (2005) states that using papers as ballots might cause errors due to paper ballots that are not clearly marked, or mistakes made by those who decipher and count them. According to Habibu et al. (2017), since that E-voting utilizes electronic ballots, there are no rejected, mismarked, or invalid votes as the results are automatically calculated, eliminating the need for manual tabulation or dreaded recounts.

Eilu and Baguma (2012) suggest cost effectiveness as the benefit of E-voting, especially when considering the production costs of printing, postage, and mailing ballots. This is also supported by Habibu et al. (2017) where the materials required for printing and ballots distributions are reduced, while the personnel required to assist in voting stations can be lessen.

According to Kohno et al. (2004), another vital aspect of E-voting is empowerment as it permits members of the organization to have a voice in the leadership and decide upon the direction of their organization. They add that the members who vote will achieve a greater sense of value, ownership, and responsibility. Thus, E-voting can enhance this beneficial value as this system might provide higher level of trustworthiness among the voters and they will be committed and be accountable to vote.

Effective Features of E-voting

An effective E-voting system must consist of few specific features or characteristics to make voting process smoother. Due to its effectiveness, the voters are able to cast their votes quickly and conveniently, without acquiring or possessing any special skills, and this will lead to higher voter participation at the polls (Al-Ameen & Talab, 2013). Effectiveness, user-friendly interface (UI), accuracy, real-time response and convenient are the reasons to decide upon the use of electronic voting (Munusami, 2018). Accuracy criteria is the important factor to make sure that correct input is entered in the system and accurate result will be generated and have been calculated correctly (Cranor & Cytron,1996).

Since electronic voting is an area of growing interest, this paper will include a study of electronic voting or E-voting during two of the university's elections to select the new Committee Members for two different staff's organisations.

Methodology

E-voting system that has been utilised during the elections is an online voting system that is reconstructed by using PHP programming language. The computerised E-voting system offers simple yet easy to use interface. Figure 1 below represents the system architecture that indicates the module and the flow of the processes involved in the system. Generally, the voter will directly interact with the online voting module and the voting result module can be accessed by the administrators and the election staff. In addition, this E-voting comprises the voters' and candidates' information in the database, while the votes, calculation of the total number of votes and the results will also be kept in the database.

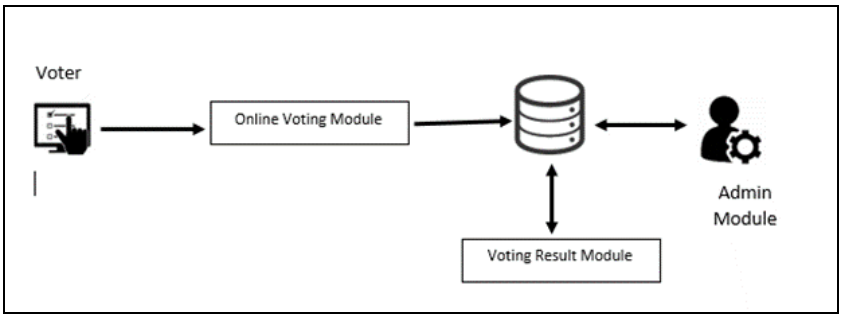

Figure 1: The System Architecture

For the purpose of this study, the questionnaire consists of three sections where Section A requires the demographic profile of the voter who is also the respondent. Section 2 collects the voter's view towards the voting system and process, voter's satisfaction, voter's relevant involvement and E-voting system's interface (navigation, graphic usage features, simplicity, content and transparency features). Meanwhile, the last section allows the voters to make suggestions for system upgrades and usage of system interfaces. For Section 2, the Likert scale statements are graded from strongly agree to strongly disagree and poor to excellent, corresponding to number one to five (1-5).

The survey involves 250 respondents or voters, right after they had voted for the committee members in two general elections; one social club for the university's staff and one organization for the female staff of the university. The respondents are of different demographic backgrounds and they had cast their online votes using six laptops, which were set up in two different venues in the university. The elections were conducted on two different dates, with a week difference. The completed collected questionnaire was then entered and analysed using Statistical Package for the Social Sciences (SPSS) computer program.

Result and Discussion

A total of 250 respondents were involved in this study. Table 1 shows the percentage distribution regarding the demographic profiles of the respondents where the turnout for the female voters representing 66.4 per cent meanwhile the male voters' turnout is only 33.3 per cent. This is due to the fact that the second election involves only female staff of the university. Besides that, almost half of the respondents who have casted the vote are aged between 31 – 40 years old, meanwhile 41.2 % of the voters are aged 41 and above.

Table 1: Demographic Profile

Gender Turnout % of votes cast		Age Turnout % of votes cast			
Male	**Female**	**21-30 years old**	**31-40 years old**	**41-50 years old**	**50 & above**
33.3	66.4	10.0	48.8	32.0	9.2

Table 2: The View Pertaining to the Voting Process Using the Voting Website

Items	Strongly Disagree	Disagree	No opinion or uncertain	Agree	Strongly Agree
The E-voting voting system is easy to use.	0.8	0	0.8	28.0	70.4
Instructions and guidance are easy to understand and follow.	0	0.4	3.2	30.4	66.0
E-voting makes it easier for me to mark a candidate of choice.	0	0.4	2.8	24.0	72.8
I think the voting process of E-voting takes a quick time.	0	0.8	1.2	26.0	72.0
The verification process is simple and efficient.	0	0	4.4	28.8	66.8
My votes have been recorded well.	0.4	0.4	7.6	31.6	60.0
I believe this system keeps my vote confidential.	0.8	1.2	11.2	34.4	52.4
The candidate information displayed on the page is complete.	0	2.0	6.4	36.0	55.6
I need help in using this E-voting system.	20.0	16.8	10.0	28.0	25.2
I do not understand what I really need to do.	46.8	13.2	8.0	15.6	16.4

Table 2 shows the perceptions of the voters towards the voting process while using the voting website. The result showed that the online voting system had outstanding responses where most of the voters agreed that it was easy to use (98.4%), had clear instructions and guidance so it was easy to understand and follow (96.4%). Moreover, they claimed that the real-time results of the voting process and the verification process were simple and efficient; especially to mark a candidate of their choice and this automation can be done easily. There is a need in designing a system that will be attractive and easy to use for all ages with a large range of abilities in using the technological platform. Fundamental requirements for a voting system are usability, correctness (completeness and reliability), privacy, verifiable and additional requirements like fairness, efficiency and practicality which play very important roles in determining the success of a system (Wang, Mondal, Chan and Xie, 2017).

The statistical results of the pertaining to the users' satisfaction while casting their votes via e- Voting, is displayed in Table 3. More than half of the voters agreed that the E-voting allowed them to select their favourite and right candidate and positively agreed that the voting process was conducted in a transparent and fair manner. Notably, most respondents gave good feedback towards the system usage where 96.4% 'strongly agreed' and 'agreed' with the statement (I will vote in the same way in the upcoming campus elections represented) that gives a reflection that they will reuse the same platform in the future. In the words of Daimi, Snyder and James (2006), any errors in using the voting system will result in failure of the egalitarianism in choosing the right candidate which will affect the integrity and disappointment of voters

Table 3: The view pertaining to the use of user satisfaction makes votes via e- Voting

Items	Disagree	Slightly Disagree	No opinion or uncertain	Agree	Strongly Agree
I am satisfied with the candidate I voted.	0.4	0	3.2	37.2	59.2
I will vote in the same way in the upcoming campus elections.	0	0	3.6	35.6	60.8
I'm sure I picked the right candidate.	0	0.4	5.2	33.2	61.2
I am satisfied with the political system on campus via E-voting.	0.4	0.8	5.2	37.6	56.0
The voting process was conducted in a transparent and fair manner.	0.4	0.4	6.0	40	53.2
Enable controlled and comprehensive delivery.	0	0	6.0	39.2	54.8
The voting process is conducted ethically by E-voting.	0	0	4.0	40.4	55.6

The percentage results of the responses that portray the user's relevant involvement to E-voting system are displayed in Table 4. Most of the respondents were optimistic towards this system and claimed that this system is very important to their organizations and hence, this system will be applied and used based on latest trend for this voting process and also to be in line with the current needs. Voters favoured electronic voting technology over the paper-based system because of their perception of its usefulness which include time saving, convenience of access, lower the cost, reduce human error in the electoral process and increase transparency in the elections (Achieng and Ruhode,2013).

Table 4: The view pertains to the relevant involvement of the Voting system

Items	Disagree	Slightly Disagree	No opinion or uncertain	Agree	Strongly Agree
E-voting in is a relevant system for use.	0	0.4	6.0	37.2	56.4
This E-voting is very important to me and my organization	0	0.8	6.0	38.8	54.4
I involved with the campus E-voting process.	0	0.4	6.0	40.4	53.2
I am interested in e-campus voting.	0	0.4	4.8	42.4	52.4
This E-voting has changed my perception and way of thinking.	0	0.4	8.0	40.0	51.6
No propaganda exists on this polling site.	1.6	0.8	10.0	35.6	52.0
E-voting is in line with current needs.	0	0	4.8	38.4	56.8
E-voting is the latest trend for this voting process.	0	0	3.2	37.2	59.6
The use of E-voting for the process is very relevant in this organization.	0	0	3.2	40.4	56.4
E-voting encourages more voters to come to vote.	0	0.4	8.8	38.0	52.8

System interface of the voting system will assist on how an individual user interacts with a digital component. It is essentially a series of visual elements that a user uses for the interaction with the menu, browse through the candidate list, selection and vote a cast for the preferable candidate. Generally, the goal of any interface design is to ease the user's interaction with the device and the interface as smooth as possible. Table 5 reveals the user's view towards E-voting interface in terms of navigation and graphics features. From the list of the statements, the respondents were required to grade the interface from poor to excellent, agreeing to the scale numbers one (1) to five (5). The finding shows that 47.2% from the voters rated the available main menu/navigation bar in the system was excellent. This system also provides an easy-to-use user-interface where all choices of the candidate were displayed clearly (scrolling down the list until the last few choices) while making the selection in using

the command button was also commendable. More than half of the voters evaluated excellent scale for the image sizes, resolution, multimedia elemants and icon.

Table 6 discusses the user's view towards the E-voting system's interface features that are simple and transparent. Most of the respondents graded the interface of E-voting as simple as it offered the transparency of information (reducing searching time), and easily understood features or functions with no or minimal assistance. This minimalist feature will allow the sites to load faster, while consistency is essential for good web design with 52.8% respondents who rated this system excellent for that part. Previously, voting process had faced many challenges like misplaced votes, voting mismanagements, and obviously the complex use of ballot papers that would slow down the voting process. Majority of the voters agreed (above 50%) with the accountability and confidentiality (transparency features) as every voter needed to log in and key in the unique staff Identification number in order to vote. Identifying with unique voting number indicates that the online voting system concept is a better, effective and more efficient way of voting in the institution (Quist, Amegatse and Dickson, 2016).

Table 5: User's View towards the E-voting System's Interface (Navigation and Graphic Usage Features)

Navigation							
	Scale (percentage %)					**Mean**	**Median**
Statement	**1**	**2**	**3**	**4**	**5**		
The main menu /navigation bar is organized.	0	0	4.4	48.4	47.2	4.43	4.000
Help for navigation (visible Links).	0	0.8	5.2	45.2	48.8	4.42	4.000
Easy access to web pages	0	0	5.6	42.8	51.6	4.46	5.000
Users easily manage polls online.	0	0	2.0	44.4	53.6	4.516	5.000
Fast access/access.	0	0	2.4	42.4	55.2	4.528	5.000
Graphics Usage							
	Scale (percentage %)						
Statement	**1**	**2**	**3**	**4**	**5**	**Mean**	**Median**
Image size and resolution.	0	0.8	2.8	44.4	52.0	4.476	5.000
Multimedia content (Animation or audio)	0	0.4	4.4	45.2	50.0	4.448	4.500
Colours, fonts, and text size	0	0	3.2	44.0	52.8	4.496	5.000
Different logos and icons.	0	0	4.8	42.8	52.4	4.476	5.000
Visual appeal / layout.	0	0.4	3.6	43.6	52.4	4.480	5.000

Table 6: User's View towards the E-voting System's Interface (Simplicity, Content and Transparency features)

Simplicity							
Statement	**Scale (percentage %)**					**Mean**	**Median**
	1	**2**	**3**	**4**	**5**		
Transparency of information (reducing search time)	0	0.4	4.8	42.0	52.8	4.472	5.000
The optimized website design is highly sought after.	0	0.4	4.8	42.0	52.8	4.488	5.000
Consistency in website design.	0	0.4	3.2	43.6	52.8	4.680	5.000
Ease of use (including first time users).	0	0	4.8	43.6	51.6	4.484	5.000
Features/functions are easy to understand.	0	0	4.8	42	53.2	4.484	5.000
Content							
Statement	**Scale (percentage %)**					**Mean**	**Median**
	1	**2**	**3**	**4**	**5**		
The website contains relevant information.	0	0	4.4	43.6	52.0	4.476	5.000
Meet user requirements	0	0	4.0	43.2	52.8	4.488	5.000
I am interested to use this site in the future.	0	0	5.2	41.6	53.2	4.492	5.000
Good content quality	0	0	5.2	41.6	53.2	4.480	5.000
Current information	0	0	3.6	44.0	52.4	4.488	5.000
Transparency							
Statement	**Scale (percentage %)**					**Mean**	**Median**
	1	**2**	**3**	**4**	**5**		
Bad spots can be avoided.	0	0.4	5.2	38.0	56.4	4.5040	5.000
The counting of votes can be run automatically.	0	0	3.6	38.0	58.4	4.5480	5.000
Accountability can be applied.	0	0.4	3.6	39.2	56.8	4.5240	5.000
Reliability and security.	0.4	1.2	3.6	39.6	55.2	4.4800	5.000
Confidentiality of individual votes can be ascertained.	0.8	1.2	6.0	38.0	54.0	4.4320	5.000

Conclusions and Recommendations

As a conclusion, the findings in this study reveal that online voting in term of usability has shown the capability to automate the election process and making it flexible, in reducing the unwanted human errors, increasing better data reliability, showing scalability to outreach the voters and making easy interpretation of the results. In addition, online voting also fulfils the user's need as the result significantly shows positive acceptance towards the E-voting platform. As a result, highly efficient and ease of use of such system will lead and increase vote casting percentages drastically.

This research has discovered that E-voting has many beneficial values over the manual voting system and in order to gain a decent application; the developer team should take into consideration all the factors for the users' views on the interface such as navigation, graphics, simplicity, relevant content and transparency activities that could influence the voters, both positively and negatively. As the limitation, the data may not be representative for the whole population because it only involves one social club for the university's staff and one organization for the female staff of the university. For future recommendation, in terms of the application itself, some of the comments emphasize on their security features and mobility. Thus, the developers should not just rely on the basis of essential and functional requirements during the system design phase. It is also recommended that this system is efficient to be used in campus future election but some features will need to be improved for better performance. Meanwhile, the empirical evidence for the structural modelling can also be developed by looking into the direct and moderating effect factors of the acceptance as part of the areas of improvement.

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EVALUATION OF STATES GROSS DOMESTIC PRODUCT USING DISCRETE DYNAMICAL SYSTEMS

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Abstract: *Gross Domestic Product (GDP) represents the total monetary value of all goods and services produced over a specific time period. This study models the GDP data of the state of Melaka and Negeri Sembilan for year 2005-2016. A mathematical model is developed for the state GDP data using Discrete Dynamical system model. The long-term equilibrium value for GDP were estimated using different parameter values. The future GDP for the states were also predicted using the suitable parameter value.*

Keywords: *Gross Domestic Product, Discrete Dynamical Systems.*

Introduction

The Gross Domestic Product (GDP) is one of the primary macroeconomic indicators used to assess the condition of a country's economy. It represents the total monetary value of all goods and services produced over a specific time period. Usually, GDP is expressed as a comparison to the previous quarter or year. For example, if the year-to-year GDP is up till 3%, that means the economy has grown by 3% over the last year. Economic production and growth, what GDP represents, has a large impact on nearly everyone within that economy. When the economy is healthy, typically observe low unemployment and higher wages as businesses demand labour to meet the growing economy. A significant change in GDP, whether up or down, usually has a significant effect on market. Investors always worry about negative GDP growth, because it is one of the factors economists use to determine, whether an economy is in a recession. The graph in Figure 1 shows the Gross Domestic Product (GDP) of States in Malaysia from year 2005 until 2015.

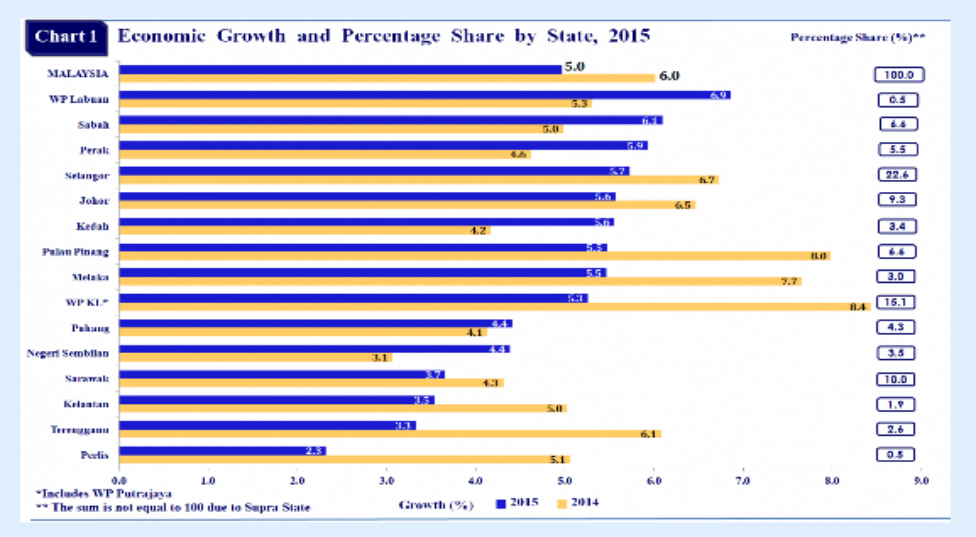


Figure 1: Malaysia States GDP Data in 2010 - 2015

Data that is not monitored and analyzed indeed will affect the economic growth in the long term. Any significant change in the GDP, either up or down, can have a big effect on investing sentiment. For example, if investors believe the economy is improving and corporate earnings along with it, they are likely willing to pay more for any given stock. If there is a decline in GDP or the investors expect a decline, they would only be willing to buy a given stock for less, leading to a decline in the stock market. Apart from that, the economic data releases are also essential for each Forex trader, especially the important reports like the GDP of a country/state which reflects the overall state of the respective economy. Such data create volatility and plenty of speculation is always preceding them. Market players monitor this critical piece of economic data and consider either to enter a new position or add to a current one. Obviously economic activity and growth will be affected if data is not monitored and analyzed. So, to answer this issue, a mathematical model will be employed so that the data shall be monitored and analysed analytically and logically

Literature Review

Probability distribution has been regularly used to model and quantify the GDP. By assuming the distribution of data, analyst can utilize the characteristics of the distribution to make predictions on outcomes. Probability distributions are regularly used to model financial data, (Vincent, 2016). In many studies, assuming data normality is common, however the assumption can be resisted and best fitting distribution (Beiranvand, et al., 2016) and multivariate distribution (Chandrasekara et al., 2016) can be substituted. Forecasting of stock prices are regular example of financial data analysis such as in Induruwage, et al. (2016) and Wang, et al. (2015) use forecasting with a two-state Markov-switching autoregressive model to forecast the stock prices. Differential equation is used to obtain the constant dividend and derived the installment option to owner (Beiranvand and Ivaz, 2015). Another approach to predict the new stock price is by combining the Hilbert-Huang transform (Xuan, et al., 2015). Many studies also used statistical approach to model financial data (Jaber, 2014; Jaber, et al., 2014). The method is used to analyze daily closed price stock market index. For continuous type of data, integral equation is used to value the installment derivatives where the asset price and time are assumed to be a continuous function (Ciurlia, 2011). Data mining and

predictive technologies require the development of an automated computer program to analyze financial data such as work in Cannan, et al. (2010), develop an automated computer program using data mining and predictive technologies to do a fair amount of trades in the markets. Bessonovs (2014) uses a suite of statistical models to predict Latvian GDP. Sample forecasting step had been run out to find out GDP projections and to appraise forecasting accuracy of all individual statistical models. As a conclusion, factor and bridge models are among the best individually performing models in the suite. Forecasting accuracy that was obtained by using disaggregated models of factor and bridge models can be considered as a good alternative to aggregated ones. Furthermore, weighted combination of the forecasts of the statistical models allows obtaining robust and accurate forecasts which leads to a reduction of forecasted errors. Safi (2016) uses Artificial Neural Network (ANN) to predict Palestine Gross Domestic Product (GDP). Time series of quarterly observations on (GDP) in Palestine is collected. Forecasting results of Artificial Neural Network (ANN) are compared with those of the Autoregressive Integrated Moving Average ARIMA and regression as benchmark methods. By using Root Mean Square Error (RMSE), the empirical results show that ANN performs better than the traditional methods in forecasting GDP. Aydin (2015) uses the comparison between non-parametric models to find out the prediction of GDP in Turkey. Two alternative situations had been considered due to seasonal effects. In the first case, a semi-parametric model had been discussed where parametric component is dummy variable for the seasonality. Smoothing spline and regression spline methods had been used for prediction of the semi-parametric models. While in the second case, it had been considered the seasonal component to be a smooth function of time. Therefore, the model falls within the class of additive models. The results obtained by semi-parametric regression models are compared to those obtained by additive non-parametric.

ARIMA modelling techniques also is used by Fatoki, et al, (2010) to predict Nigeria GDP between the year 1980 until 2007. For statistical analysis, graphical methods had been used to display data distributions, Autocorrelation functions (ACF), Partial autocorrelation functions (PACF), Residuals and Forecasts, and differencing to check for stationarity. The results are summarized as the ARIMA (1, 2, 1) model was proposed for the data from the second differences which shows stability and invertibility. Then, forecasts were made for future observations up to thirteen years which shows an increasing trend over time. The Akaike Information Criterion (AIC) and the adjusted multiple correlation coefficient (Adjusted R-Square) provided a good summary of the total variability explained by the chosen fitted model. Cuche & Hess (1999) use Kalman filter technique to estimate deseasonalized monthly series for Swiss gross domestic product at constant prices of 1990 for the period 1980-1998. The results are consistent with the quarterly figures estimated by the Federal Office for Economic Development and Labour. The work presented a general approach using the Kalman filter technique, nesting a great variety of interpolation setups. The work also evaluated competing models and provide a time series that can be used by other researchers.

Methodology

This study uses the modeling methodology as shown in Figure 4.1. Five phases are involved begin with data collection, model development, data forecasting and data analysis.

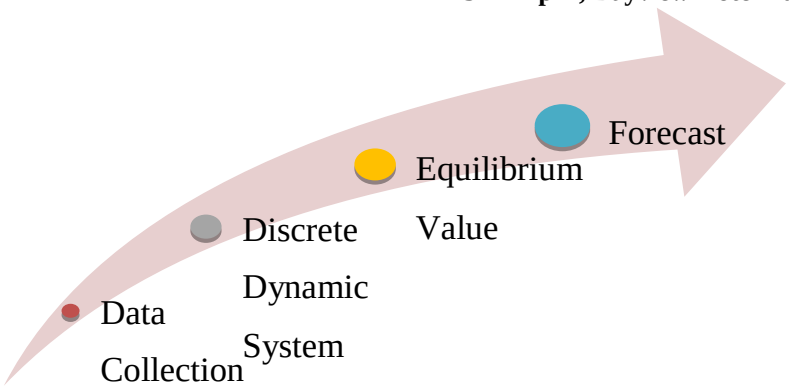


Figure 2: Modeling Methodology

Data Collection

Data set for GDP of Melaka and Negeri Sembilan from 2010 to 2016 is obtained from the Department of Statistics Malaysia website.

Gross Domestic Product / Year	RM Million	
	Melaka	**Negeri Sembilan**
2010	24 187	30 229
2011	25 487	32 007
2012	27 276	33 924
2013	27 933	34 892
2014	30 073	35 951
2015	31 712	37 518
2016	33 155	38 839

Table 1: Gross Domestic Product for Melaka and Negeri Sembilan

Discrete Dynamical System

From the data set, a mathematical model has been developed using the Discrete Dynamical System model. For each GDP data, p_n, the corresponding $\frac{\Delta p_n}{p_n(p_{max}-p_n)}$ value is calculated. The maximum data of $M_{max} = 34567.71$ for Melaka and $N_{max} = 40319.86$ for Negeri Sembilan are estimated.

Melaka:

Year, n	**Data,** M_n	**Forecast,** $\widehat{M_n}$
2010	24187	25487.16092
2011	25487	26685.46836
2012	27276	28305.90725
2013	27933	28892.68249
2014	30073	30772.94913
2015	31712	32180.94918
2016	33155	33397.54376

Table 2: Actual and forecast data for Melaka GDP

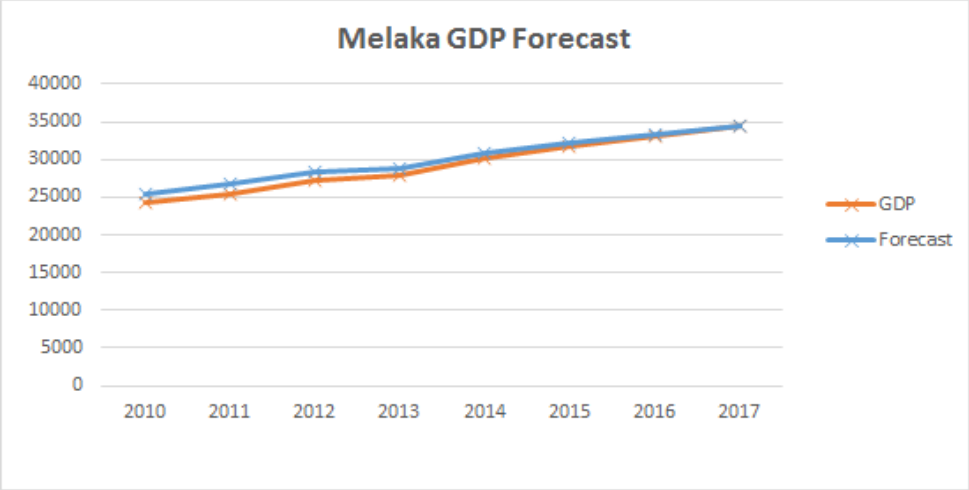


Figure 3: Graph of actual and forecast for Melaka GDP

From the graph of Melaka GDP. The GDP appears to be approaching a limiting value, which seems to be 34567.71.
By computing the ratio, we can estimate a constant value:

$$\frac{\Delta M_n}{(34567.71 - M_n) * M_n} = \frac{1300}{(34567.71 - 24187) * 24187} = 0.00000517766907$$

$$M_{n+1} = M_n + 0.00000517831(34567.71 - M_n) * M_n$$

By simplifying the equation using Nonlinear logistic model, the following equation is obtained;

$$M_{n+1} = M_n + 0.00000517766907(34567.71 - M_n) * M_n$$

$$M_{n+1} = M_n + 0.1789801629\, M_n - 0.00000517766907\, {M_n}^2$$

$$M_{n+1} = 1.1789801629\, M_n - 0.00000517766907\, {M_n}^2$$

$$M_{n+1} = 1.1789801629(1 - 0.00000439165\, M_n) M_n$$

$$0.00000439165\, M_{n+1} = 1.1790023183701(1 - 0.00000439165\, M_n)(0.00000439165) M_n$$

let $a_n = 0.00000439165\, M_n$, the Discrete Dynamical System model can be formed as the following;

$$a_{n+1} = 1.1790023183701(1 - a_n)\, a_n$$

Negeri Sembilan:

Year, n	**Data,** N_n	**Forecast,** $\widehat{N_n}$
2010	30229	31190.22
2011	32007	32845.43
2012	33924	34607.71
2013	34892	35488.79
2014	35951	36445.93
2015	37518	37849.25
2016	38839	39020.24

Table 3: Actual and forecast data for Negeri Sembilan GDP

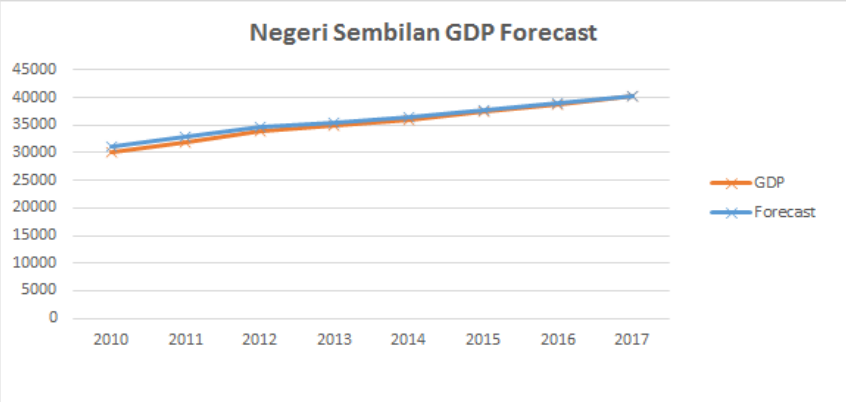


Figure 4: Graph of actual and forecast for Negeri Sembilan GDP

From the graph of the Negeri Sembilan GDP, the value appears to be approaching a limiting value, which seems to be 40319.86
By computing the ratio, we can estimate a constant value:

$$\frac{\Delta N_n}{(40319.86 - N_n) * N_n} = \frac{1778}{(40319.86 - 30229) * 30229} = 0.0000058288$$

$$N_{n+1} = N_n + 0.0000058288(40319.86 - N_n) * N_n$$

By simplifying the equation using Nonlinear logistic growth model, the following equation is obtained;

$$N_{n+1} = N_n + 0.0000058288(40319.86 - N_n) * N_n$$
$$N_{n+1} = N_n + 0.2350164\, N_n - 0.0000058288 {N_n}^2$$
$$N_{n+1} = 1.02350164\, N_n - 0.0000058288 {N_n}^2$$
$$N_{n+1} = 1.02350164\,(1 - 0.00000569495\, N_n) N_n$$
$$0.00000569495 N_{n+1} = 1.02350164\,(1 - 0.00000569495\, N_n)\,(0.00000569495) N_n$$

let $a_n = 0.00000569495\, N_n$, the Discrete Dynamic System finally can be formed:

$$a_{n+1} = 1.02350164(1 - a_n)\, a_n$$

Equilibrium Value

By using Microsoft Excel, the value for all a_n until $n = 2035$ can be calculated. Substituting $M_n = \frac{a_n}{0.00000439165}$ for Melaka and $N_n = \frac{a_n}{0.0000569495}$ for Negeri Sembilan. the predicted GDP for each value of n can be found. Then, a long term equilibrium value can be determined.

Forecasting

From the equilibrium value, the future GDP for Melaka and Negeri Sembilan can be forecasted. For accuracy, the forecast error, ε can be found for each value of data, M_n and N_n, from 2010 to 2016. By changing the parameter, r of the model, the shape of forecasting models can be analysed and the suitable parameter range can be determined to ensure the forecasted GDP data reach its equilibrium and stability.

Results and Analysis

Melaka: Year	GDP	Δ GDP	Ratio GDP	Forecast	Error	Abs Error	Error^2	APE
2010	24187	1300	0.0537479	25487.16	1300.161	1300.161	1690418	5.375453
2011	25487	1789	0.0701926	26685.47	1198.468	1198.468	1436326	4.702273
2012	27276	657	0.0240871	28305.91	1029.907	1029.907	1060709	3.775873
2013	27933	2140	0.0766119	28892.68	959.6825	959.6825	920990.5	3.435659
2014	30073	1639	0.0545007	30772.95	699.9491	699.9491	489928.8	2.3275
2015	31712	1443	0.0455033	32180.95	468.9492	468.9492	219913.3	1.478775
2016	33155	1412.714286	0.0426094	33397.54	242.5438	242.5438	58827.47	0.731545
2017	34567.71	1572.693878	0.045496	34567.71	-0.00077	0.000767	5.89E-07	2.22E-06
2018	36140.41	1545.559767	0.0427654	35846.08	-294.325	294.3245	86626.94	0.814392
2019	37685.97	1673.53561	0.0444074	37077.44	-608.527	608.5269	370304.9	1.614731
2020	39359.5	1424.274826	0.0361863	38382.86	-976.643	976.6428	953831.2	2.481339
2021	40783.78	1522.931364	0.0373416	39471	-1312.78	1312.778	1723386	3.218873
2022	42306.71	1565.495233	0.0370035	40611.27	-1695.44	1695.439	2874513	4.007494
2023	43872.2	1564.962548	0.0356709	41758.37	-2113.83	2113.831	4468283	4.818156
2024	45437.17	1533.646561	0.0337531	42879.72	-2557.45	2557.45	6540551	5.628542
2025	46970.81	1531.248653	0.0326	43954.01	-3016.8	3016.8	9101082	6.422712
2026	48502.06	1521.429797	0.0313684	45002.33	-3499.73	3499.734	12248139	7.21564
2027	50023.49	1562.8914	0.0312431	46019.87	-4003.62	4003.622	16028988	8.003483
2028	51586.38	1542.9487	0.02991	47040.18	-4546.2	4546.203	20667964	8.812797
2029	53129.33	1534.089176	0.0288746	48022.66	-5106.68	5106.676	26078145	9.611784
2030	54663.42	1535.549106	0.028091	48975.05	-5688.38	5688.375	32357615	10.40618
2031	56198.97	1542.101569	0.02744	49903.93	-6295.04	6295.036	39627483	11.20134
2032	57741.07	1543.179077	0.0267258	50812.21	-6928.86	6928.863	48009136	11.99989
2033	59284.25	1542.636773	0.026021	51696.47	-7587.79	7587.786	57574501	12.79899
2034	60826.89	1535.872152	0.0252499	52555.76	-8271.13	8271.129	68411570	13.59782
2035	62362.76			53386.8	-8975.96	8975.959	80567834	14.39314

MAE	3867.325
MSE	22509998
MAPE	7.213016

Table 4: Data forecast for Melaka GDP

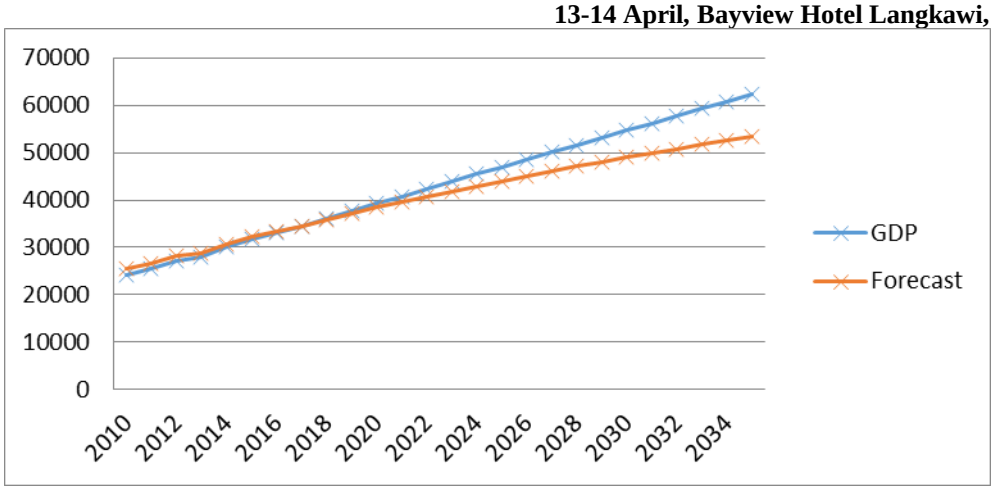
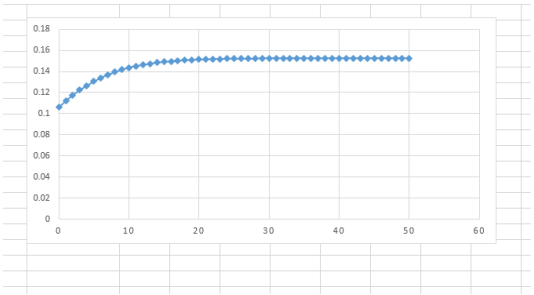


Figure 5: Trend for Melaka GDP

Melaka GDP Logistic Model:

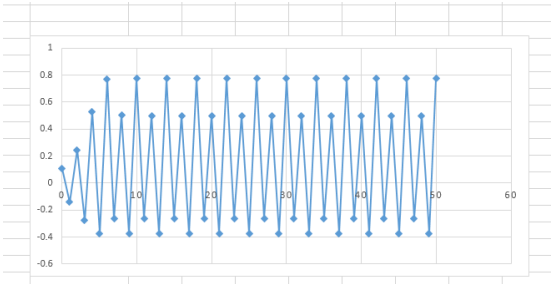
From the graph, for $r = 1.1790023183701$, the forecasted GDP is estimated at RM 152538.845 until 2035.



However, after changing the parameter *r*, the results are given as below:

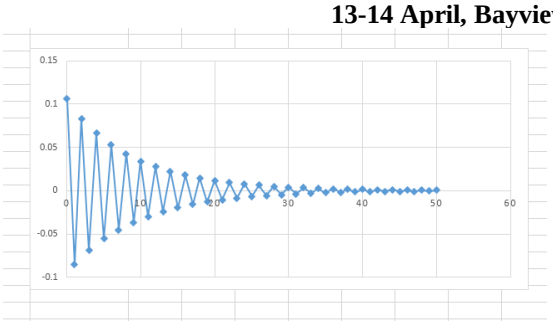
1. $r < -1$: the curve is oscillating and diverging.

For example: $r = -1.50$

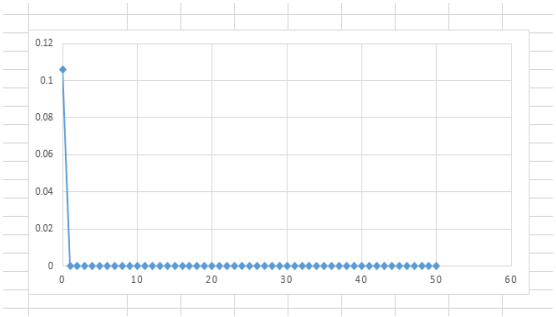


2. $-1 \leq r < 0$: the curve is oscillating and converging to 0.

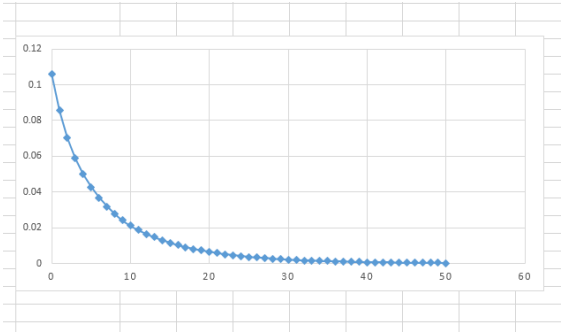
For example: $r = -0.90$



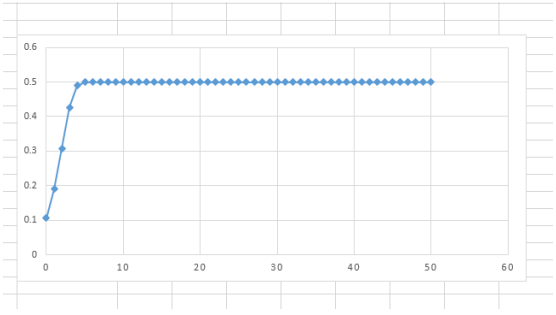
3 $r = 0$: the curve is constant at 0.



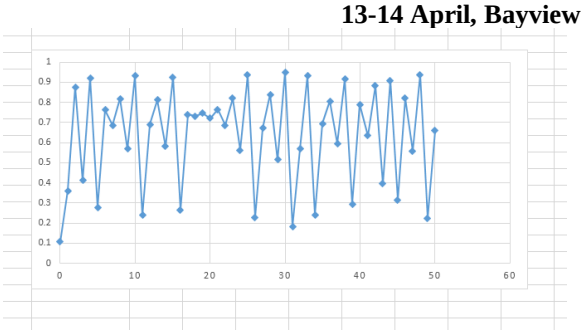
4. $0 < r \leq 1$: the curve converges to 0.
For example: $r = 0.90$



5. $1.12 < r < 2.20$: the curve is converging to a particular point.
For example: $r = 2.00$



6. $r \geq 3.50$: the curve is oscillating and diverging.
For example: $r = 3.80$



Therefore, from the graphs, we can say only in the case of:
$0 < r < 1$ and $0 \leq r < 3.50$
The curve is converging to a particular point, and it is only meaningful to have the parameter in the range of $\{r: 0 < r < 3\}$

Negeri Sembilan:

Year	GDP	Δ GDP	Ratio GDP	Forecast	Error	Abs Error	Error^2	APE
2010	30229	1778	0.0588177	31190.22	961.2158	961.2158	923935.9	3.17978
2011	32007	1917	0.0598931	32845.43	838.4253	838.4253	702956.9	2.619506
2012	33924	968	0.0285344	34607.71	683.7147	683.7147	467465.7	2.015431
2013	34892	1059	0.0303508	35488.79	596.7925	596.7925	356161.3	1.710399
2014	35951	1567	0.0435871	36445.93	494.9347	494.9347	244960.3	1.376692
2015	37518	1321	0.0352098	37849.25	331.2491	331.2491	109726	0.882907
2016	38839	1480.857143	0.0381281	39020.24	181.2384	181.2384	32847.37	0.46664
2017	40319.86	1229.489796	0.0304934	40319.86	0	0	0	0
2018	41549.35	1252.504373	0.030145	41388.37	-160.975	160.9749	25912.92	0.387431
2019	42801.85	1426.600167	0.0333303	42467.09	-334.759	334.7591	112063.7	0.782114
2020	44228.45	1388.392932	0.0313914	43683.71	-544.743	544.7427	296744.6	1.231657
2021	45616.84	1301.838681	0.0285386	44855.43	-761.418	761.4182	579757.7	1.66916
2022	46918.68	1336.483012	0.0284851	45943.06	-975.622	975.622	951838.2	2.079389
2023	48255.17	1323.37572	0.0274245	47048.53	-1206.64	1206.637	1455973	2.500535
2024	49578.54	1369.076892	0.0276143	48132.06	-1446.48	1446.479	2092301	2.91755
2025	50947.62	1355.661503	0.0266089	49241.4	-1706.22	1706.219	2911183	3.348967
2026	52303.28	1324.502553	0.0253235	50328.23	-1975.05	1975.054	3900837	3.776156
2027	53627.78	1335.41424	0.0249015	51378.89	-2248.9	2248.896	5057531	4.193527
2028	54963.2	1350.772021	0.0245759	52427.01	-2536.19	2536.187	6432243	4.614336
2029	56313.97	1345.379381	0.0238907	53475.75	-2838.22	2838.215	8055466	5.039985
2030	57659.35	1344.762327	0.0233225	54508.88	-3150.47	3150.469	9925453	5.463934
2031	59004.11	1336.904349	0.0226578	55530.13	-3473.98	3473.978	12068525	5.887689

2032	60341.02	1341.087086	0.0222251	56534.12	-3806.89	3806.895	14492448	6.308967
2033	61682.1	1346.506583	0.0218298	57529.93	-4152.17	4152.17	17240516	6.731564
2034	63028.61	1343.751159	0.0213197	58518.36	-4510.24	4510.244	20342303	7.155868
2035	64372.36			59493.38	-4878.98	4878.977	23804418	7.579304

MAE	2142.523
MSE	6828711
MAPE	3.772007

Table 5: Data after forecasting for Negeri Sembilan GDP

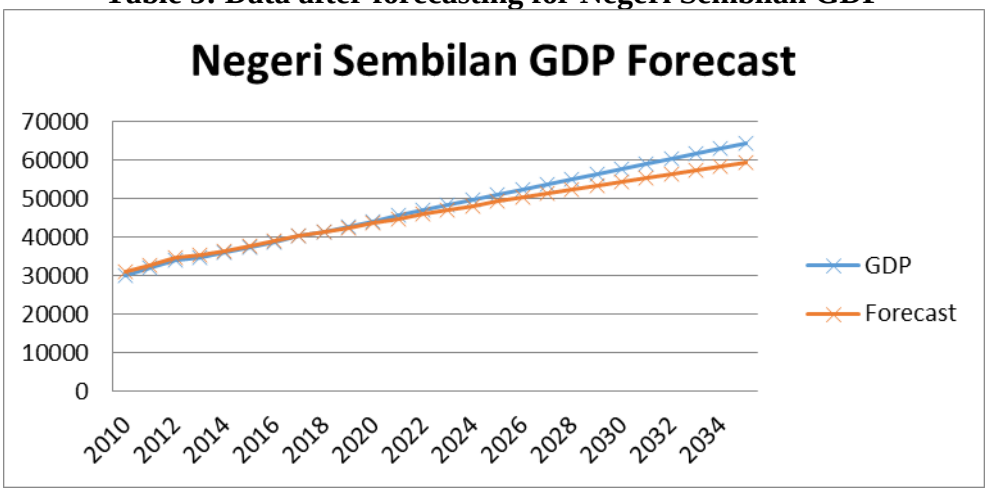
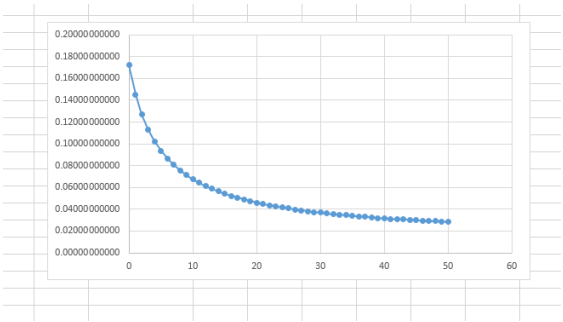


Figure 6: Trend for Negeri Sembilan GDP

Negeri Sembilan GDP Logistic Model:

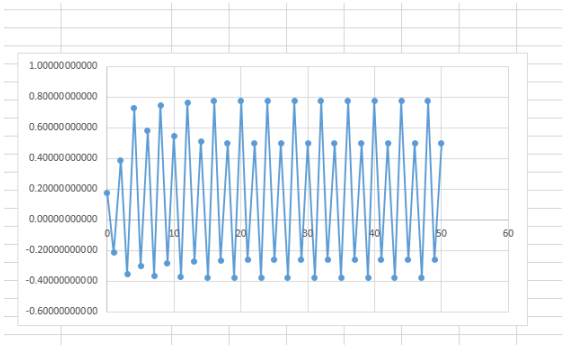
From the graph, when $r = 1.02350164$, the forecasted GDP is estimated ate RM 28443.3 until 2035.



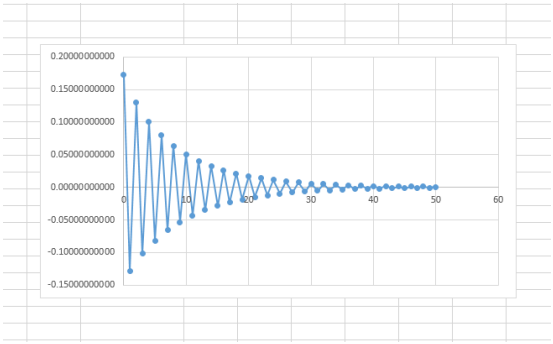
However, after changing the *r* parameter, the results are given as below:

1. $-1.60 < r < -1.55$: the curve is oscillating and diverging.

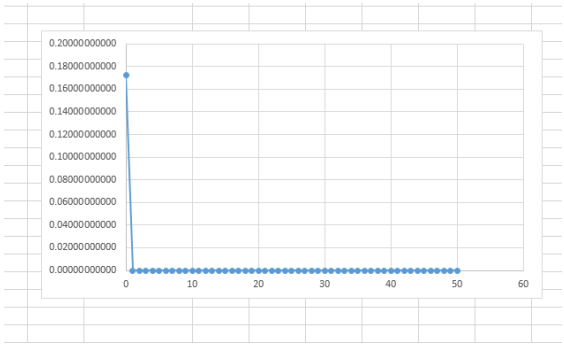
For example: $r = -1.50$



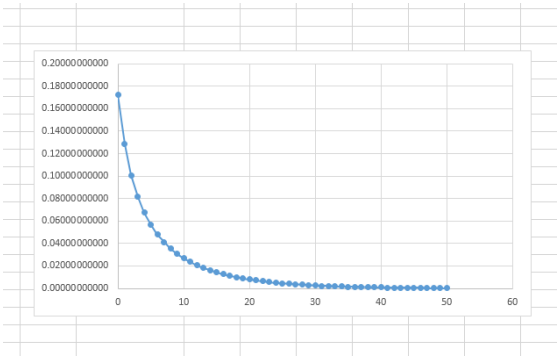
2. $-0.80 \leq r < 0$: the curve is oscillating and converging to 0.
For example: $r = -0.90$



3. $r = 0$: the curve is constant at 0.

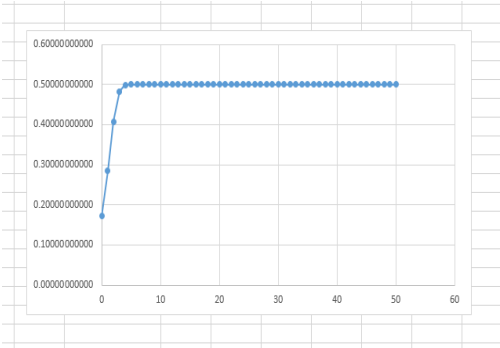


4. $0 < r \leq 1$: the curve converges to 0.
For example: $r = 0.90$

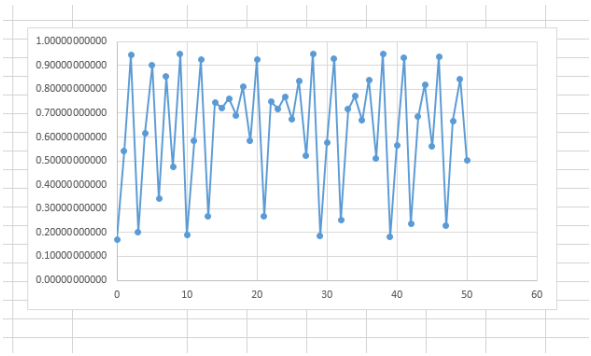


5. $1 < r < 1.23$: the curve is converging to a particular point.

For example: $r = 2.00$



6. $r \geq 3.50$: the curve is oscillating and diverging.
For example: $r = 3.80$



Therefore, from the graphs, we can say only in the case of $0 < r < 1$ and $0 \leq r < 3.50$, the curve is converging to a particular point, and it is only meaningful to have the slope of Discrete Dynamic System in the range of $\{r: 0 < r < 3\}$.

Conclusion

Discrete Dynamical System model is useful for developing a mathematical model to evaluate states Gross Domestic Product (GDP) in Malaysia. The fitness of model has been tested using forecast error with actual GDP. Finally, the model has the ability for tuning its parameter to estimate the GDP long term equilibrium and stability.

Acknowledgement

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PERFORMANCE OF HIGH SPEED BIT-INTERLEAVING TIME-DIVISION MULTIPLEXING PASSIVE OPTICAL NETWORKS

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Abstract: *Time-division multiplexing passive optical networks (TDM-PONs) considered as a good solution for a high bit rate and flexible bandwidth system. In this paper, the simulation of a new bit-interleaving TDM transmitter has carried out. The proposed scheme of downstream TDM-PON based on single Mach–Zehnder modulators (MZM) and laser diode to carry an electrical multiplexed data providing cost effective, high-transmitted power and easy implementation system. The TDM-PON technique has seen widespread since the beginning of this century, especially with FTTH where flexible bandwidth and high bit rate are required. Hence, the simulation of 10, 25, 40, and 50 Gbps TDM-PON have been presented in three scenarios based on two downstream transmitter schemes of FTTH. Those scenarios have carried out the standard single-mode fiber (SSMF) and the free-space optic (FSO) as transmission media, and the single mode dispersion compensating fiber (DCF) and Fiber Bragg Gratings (FBG) as dispersion compensators. The results show that the electrical multiplexed scheme of TDM transmitter provides better performance with comparison of the traditional optical TDM transmitter in different scenarios with different bit rates.*

Keywords: *Time-division multiplexing passive optical networks (TDM-PON), bit interleaving PON (Bi-PON) dispersion compensating fiber (DCF), Fiber Bragg Gratings (FBG), Free Space Optics (FSO).*

Introduction

A good quality access to services become the purpose objective of each operator, the optical networks system can ensuring a good performance for such a system of large number of users. TDM-PON (e.g. GPON and EPON up to 10G PONs) have been widely deployed around the world to provide the needed transmission capacity. The capacity demand growing led to need of future generations of the TDM-PON based on 25 Gbps or higher e.g. IEEE P802.3ca standard that suggested to be implemented by using TDM-PON 25 or 50 Gbps for a single wavelength (as of this writing, the IEEE P802.3ca standard is not published yet) (Houtsma, Van Veen, & Harstead, 2017). TDM-PON is a technique that combine multiple user's data rate channels into a single wavelength channel of a high bit rate and time based multiplexing. This multiplexing technique provides many advantages like management effort reduction, less complexity of end node equipment, power consumption, non-linear effect overcome, and cost (Zhan-Qiang Hui & Zhang, 2014). However, as new applications (like

IPTV, video on demand and High Definition online video game) turn into being more popular, the bandwidth demand is rapidly growing, which is pushing to increase the limited capacity of the traditional TDM-PON, because the capacity is shared for all users by a single wavelength (e.g. 1:256 spilt ratio). So a higher capacity system is required to satisfy future optical access networks. There are some challenges to initiate high speed transceivers in a TDM-PON include: the dispersion effects, time synchronization and the simultaneous additional bit rate demand (Yi et al., 2012).

In a communication system, higher data rate transmission is always a goal for the researcher. R. Kaur and Anjali have proposed a TDM-PON system providing flexible bandwidth and higher bit rate with two types of modulation format. Modified duobinary return to zero (MDRZ) and return to zero (RZ) were carried out there, the comparison results of Q-factor value between these technologies show that TDM-PON system with MDRZ without using repeater has more transmission distance than the system with RZ technology. Where the transmission distance of an acceptable bit error rate (BER) is only up to 300 km in the RZ TDM-PON (Kaur & Anjali, 2017).

D. Veen and V. Houtsma experimentally reported a 25 and 50 Gbps TDM-PON with different modulation formats in 2016 (Veen & Houtsma, 2016). A bi-directional 25G/50G TDM-PON system was experimentally tested by the same researcher (D. Veen and V. Houtsma) in 2017. They have used a single carrier 25 Gbps for the upstream and 50 Gbps for the downstream using a commercial 25G APD receiver with duobinary, where a simple 3x3 fiber splitter has used for the coherent detection scheme of a NRZ On-Off-Keyed (OOK) signal (Houtsma & Veen, 2018).

In this paper, to the best of our knowledge, a new TDM-PON transmitter scheme has proposed as a convenient system to the fiber-to-the-home (FTTH) downstream as well as fiber-to-the-building (FTTB) or fiber-to-the-distribution point (FTTdp) upstream and downstream. In addition, this paper demonstrates a comparison between different bit rates of two architectures at the transmitter side in the optical line terminal (OLT) FTTH network linked either SSMF or FSO. The results obtained by Optisystem 7.

Time-Division Multiplexing Passive Optical Network (TDM-PON) System

Two methods are used for TDM-PON: the first involves packet interleaving while the second one involves bit interleaving.

Packet Interleaving (Packet-By-Packet Transmission)

The packet interleaving TDM-PON, where number of bits grouped together and targeted to a particular optical network unit (ONU), has used for downstream by both two bodies standard (IEEE and FSAN/ITU-T) of PONs, where data is sending to various users by a single downstream optical carrier in assigned slots form, as in Figure (1). While the upstream packets of TDM system are sent from an ONU in an individual time slot at the splitter, which requires careful synchronization at the ONUs, as shown in the Figure (2). To ensure collision-free transmission the data of each ONU should be sent at the right time instant. Practically there is a different relative distance between the ONUs and the OLT. Hence, the using of ranging protocols are essential, round-trip time (RTT) can be used to sense this distance. In the OLT, a burst mode receiver is required, which can handle different levels of the amplitude of the received packets (this amplitude fluctuation due to the path loss experienced difference). Initially, with time division multiple access PONs (TDMA-PONs), as the ONUs are sharing the capacity of OLT, this capacity of each ONU decreases with an increase in the

ONUs number. However, modern TDMA-PONs can adjust each optical network terminal (ONT) bandwidth dynamically depending on the demand of the customer.

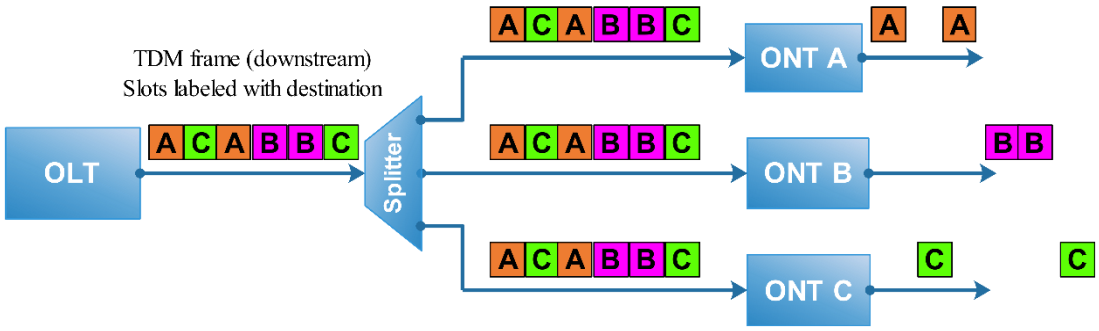

Figure 1. Network Architecture of Packet Interleaving TDM-PON (Downstream).

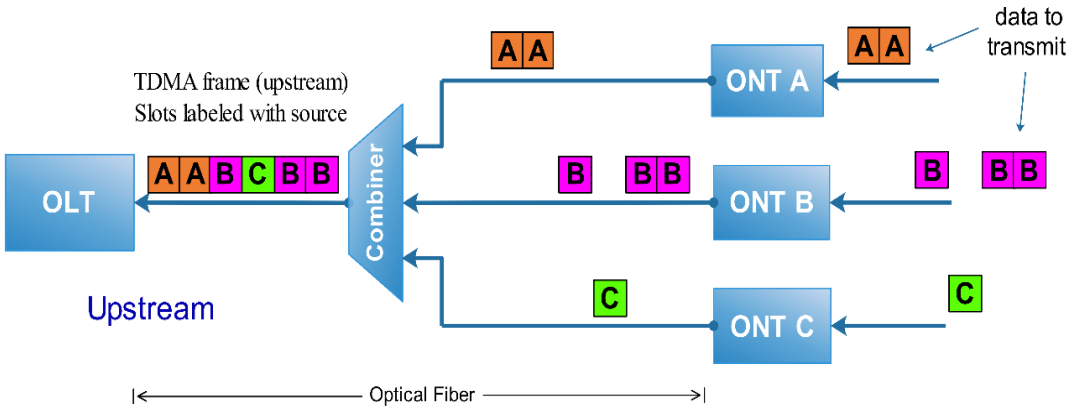

Figure 2. Data Transmitting over Packet Interleaving TDMA-PON (Upstream).

Bit Interleaving (Bit -by- Bit transmission)

In the bit interleaving PON (Bi-PON) all information bits are reorganized in a form of bit-interleaved style according to the targeted ONUs in a regular structure frame, where each ONU can extract its own information easily in a simple periodic style. Bi-PON has reduced the number of functional blocks, which are necessary to operate at full line transmit. Hence, significantly lower dynamic power consumption will be required in a Bi-PON ONU (Chow et al., 2012).

An Optical power source, as illustrated in Figure (3), generates the periodic pulse train of Bi-PON, and by using a splitter to split this pulse stream to K of pulses, then data encoded signals will modulate over those light pulses by external modulator. Optical delay of $i\tau$ will delay each pulse train. If framing pulses are used, at that point, the interpulse width is $\tau = T/(n + 1)$ since $n + 1$ pulses should be transmitted in each bit period.

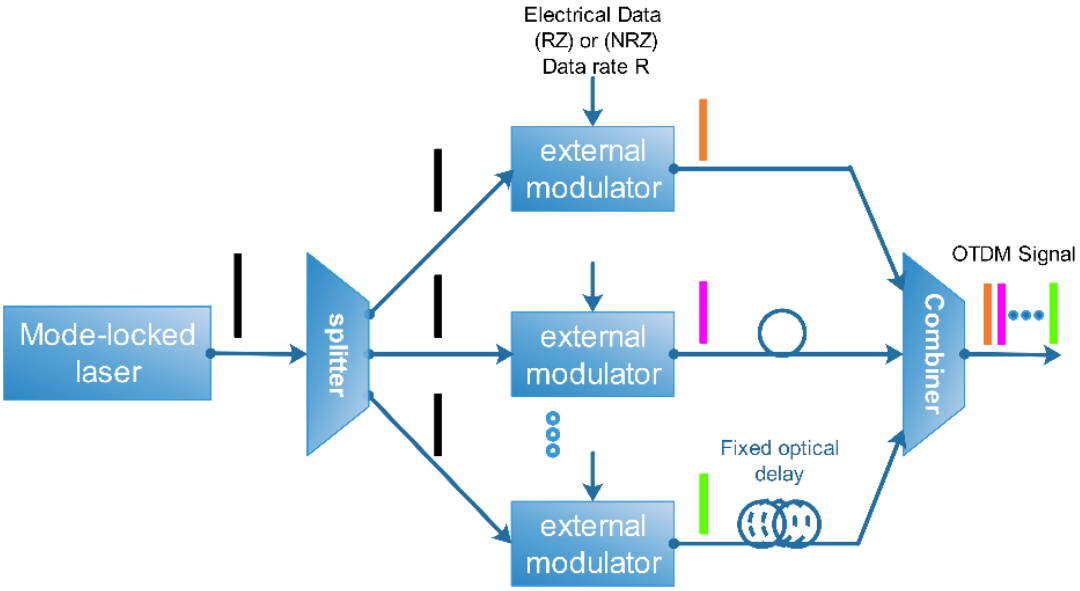

Figure 3. Bit-Interleaved TDM-PON

Dispersion Compensation Techniques

Dispersion compensation is a critical point in the high capacity systems. Narrow time slot between the ONU's pulses makes the TDM-PON very sensitive to the dispersion effect. Hence, two dispersion compensation techniques will discuss where those techniques are implemented in such a system to enhance its tolerance and performance. The first one based on alternating fiber that has negative dispersion value of the first used one, named dispersion-compensation fiber (DCF) or negative-dispersion fiber (NDF). The second technique using Fiber Bragg Gratings (FBG) filter to inverse the dispersion.

Dispersion Compensation by Single Mode Dispersion Compensating Fiber (DCF)

The dispersion compensation using negative-dispersion fiber known as dispersion compensating fiber (DCF), the Figure (4) illustrates the chromatic dispersion characteristic where a null accumulated dispersion is achieved by inserting a suitable length of DCF with the standard single-mode fiber (SSMF). The DCF length is much less than SSMF length because of the often large absolute negative dispersion of DCF (around −300 ps nm^{-1} km^{-1}). Hence, zero overall dispersion will be acquired at the wavelength of 1.55 μm on the transmission channel (Senior, 2009).

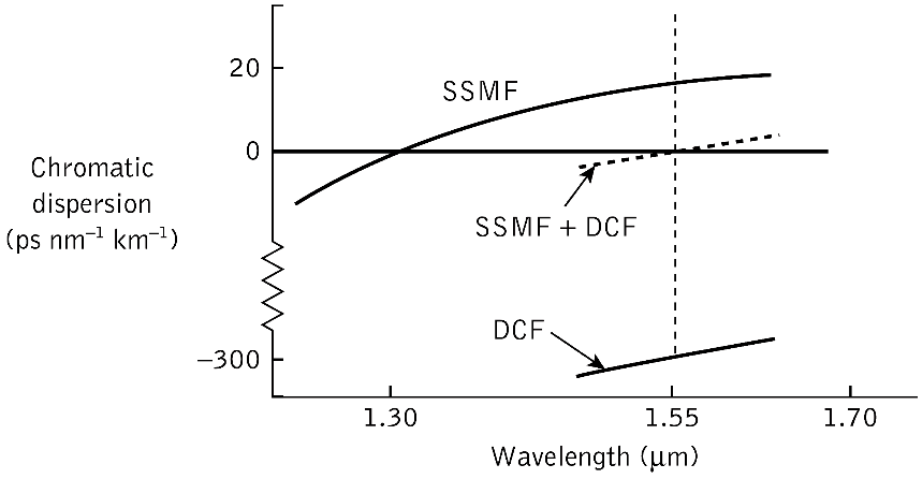

Figure 4. Dispersion Compensation by Using Dispersion-Compensating Fiber (DCF) (Senior, 2009)

There are three algorithms are possible for dispersion compensation schemes using DCF: pre-compensation algorithm where the DCF is placed before the SSMF, the second algorithm is post-compensation where SSMF is placed before the DCF, and the last one is the mixed compensation algorithm where the DCF placed in both before and after the SSMF. By comparison, the mixed compensation method gives the best performances (Rebhi, Najjar, & Houria, 2016).

Dispersion Compensation Using Fiber Bragg Gratings (FBG)

The use of the fiber Bragg gratings have seen significant growth in modern optical communications systems. The operation of the FBG depending on facilitating reflections of different wavelengths, where at each interface between the Bragg regions a portion of the power of signal is reflected back, the principle FBG operation shown in the Figure (5). The total reflection can increase to be about 100% reflection of a wavelength and passing all others if the spaces between those regions are arranged in such a way to make the partial reflections be constructively in phase (Senior, 2009). As a cost effective passive optical component with low insertion losses the FBG has used as a dispersion compensation in the fiber optical transmission systems.

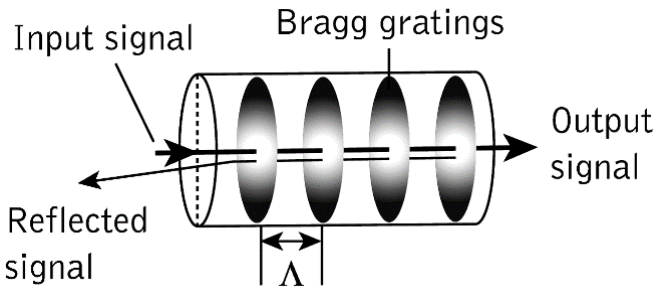

Figure 5. Optical Fiber Core Schematic Diagram With Consisting of Four Fiber Bragg Gratings (Senior, 2009)

System Description

The proposed designs of four ONUs TDM-PON will be evaluated for different bit rates and optical media lengths. Two methods have been used in the OLT of the system for downstream (the OLT is a transmitter). The first one, as shown in Figure (6), consist of a laser diode (wavelength of 1552nm, line width 100 KHz and 5 dBm power), power splitter to divide the optical signal, four external modulators, and four optical delays with time delay of (i / K*bit rate) where i = 0, 1,…, K-1 to make each destination data able to be transmitted at a specific time slot. The second system is a new multiplexer which proposed to enhance the transmitted power and reduce the optical components, connectors and optical fibers inside the OLT, where four electrical delays have used with a combiner then a single modulator and single unshared light source will modulate the multiplexed signal, as shown in Figures (7). Both TDM-PON systems consist of a pseudo-random bit sequence (PRBS) generator and a return to zero (RZ) pulse generator used to generate the data of each user.

At the receiving side, the optical signal that has passed through a specific channel goes to an optical power splitter to be divided for many copies; each one of those signal copies has entered into an ONU subsystem detector to extract the original information. In the de-multiplexing operation, a time delay and clock-recovery should be used to receive the custom signal for this user. Subsequently, by PIN diode photodetector (dark current 5 nA and responsivity of 1 A/W) the optical signal will be converted to an electrical signal with the help of a low pass filter (LPF) of cut-off frequency 0.75*Bit rate. Finally, a 3R-Regenerator will be used to generate the original bit sequence of the data, and the modulated electrical signal of the RZ pulse generator to be used for BER analysis, which measures Q-factor value and BER. Where the Q-factor can evaluate the qualitative-performance of a receiver. The Q-factor can be calculated by:

$$Q = \frac{i_H - \gamma_{opt}}{\sigma_{iH}} = \frac{\gamma_{opt} - i_L}{\sigma_{iL}} \quad (1)$$

$$Q = \frac{i_H - i_L}{\sigma_{iH} + \sigma_{iL}} \quad (2)$$

Where γ_{opt} optimal value of the decision level, i_H and i_L are the current corresponding to the optical power level on the photodetector for both log.1 and log. 0 levels.

In this paper, to evaluate the proposed TDM-PON system performance three scenarios have used for the channel. The first scenario is an SSMF of the attenuation coefficient of 0.2 dB/km, dispersion 16.75 ps/nm/km, non-linearity refractive 2.6e-20 m2/W and dispersion slop 0.075 ps/nm2/km with using FBG filter as a dispersion compensator and without using an amplifier, as in Figure (6). The second scenario is long optical fiber distance consists of a sequence of SSMF/DCF/SSMF with appropriate lengths that ensure almost zero chromatic dispersion, as in Figure (8). To reach a long distance optical power amplifiers must be used to compensate the power dissipated by the fiber. In this work, eribuim dopped fiber amplifiers (EDFAs) of 4 dB noise figure and 22 dB gain have been used. The third scenario of the optical transmission media is the FSO as in Figure (7), where there no dispersion occurs and large attenuation relative with the atmospheric conditions like haze, rain, hot and dry which are dramatically effect on the power received as it clear in the equation (1). More losses can also increase the attenuation of FSO channel due to mispointing, scintillation and other perturbations can be defined as additional losses (Al-Gailani, Mohammad, & Shaddad, 2013). However FSO system provides good advantages, like the initiation cost, deployment time and low maintenance cost, making it a good alternative solution for the last mile connection where using an optical fiber cable is difficult.

$$P_{Received} = P_{Transmitted} \frac{d_R^2}{(d_T + \theta R)^2} 10^{-\alpha R/10} \quad (3)$$

Where d_R is the receiver aperture diameter, d_T transmitter aperture diameter, θ beam divergence (mrad), α atmospheric attenuation (dB/km) and R is the range in km.

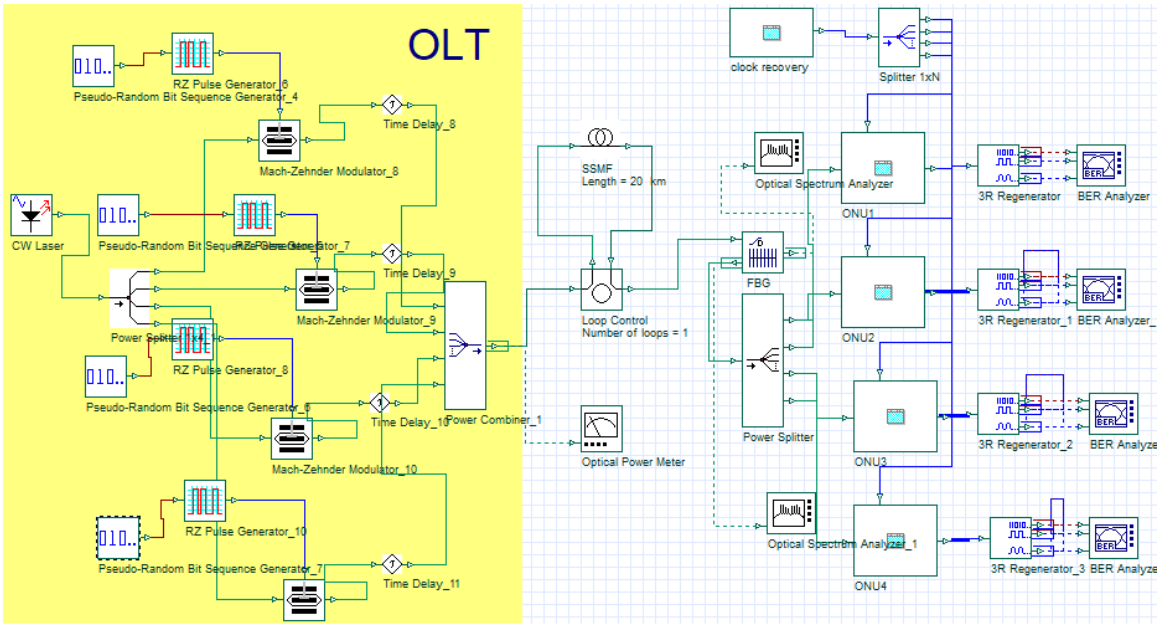

Figure 6. The Schematic Block Diagram of TDM-PON with 4 MZM, The Transmission Media is SSMF and FBG Filter to Compensate the Dispersion.

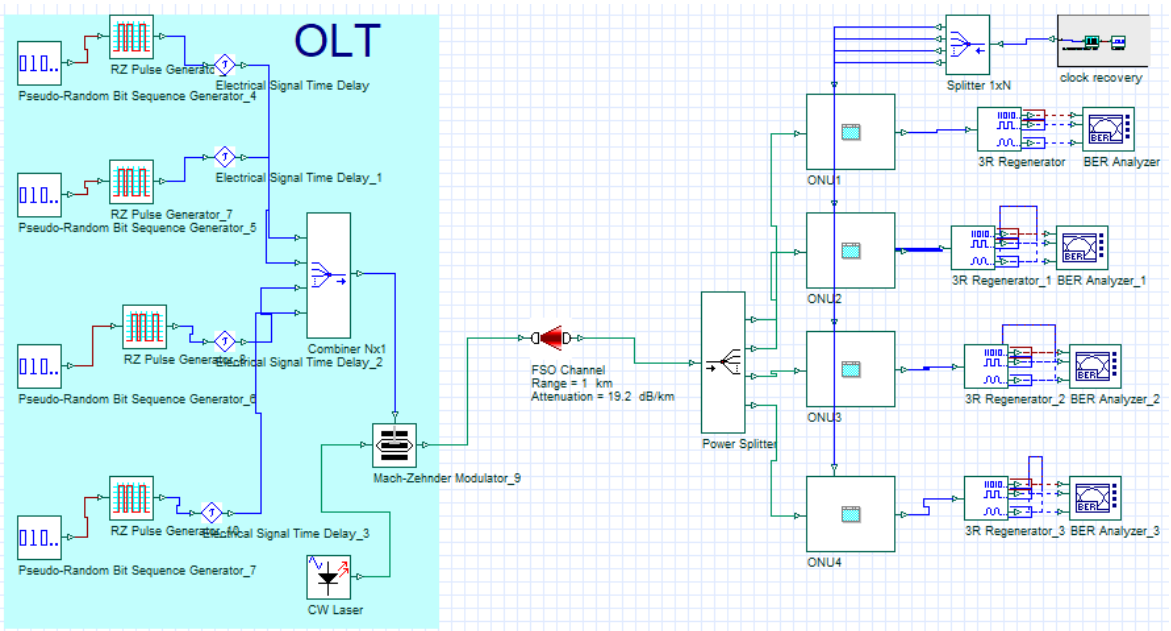

Figure 7. The Schematic Block Diagram of TDM-PON with One MZM, The Transmission Media is FSO.

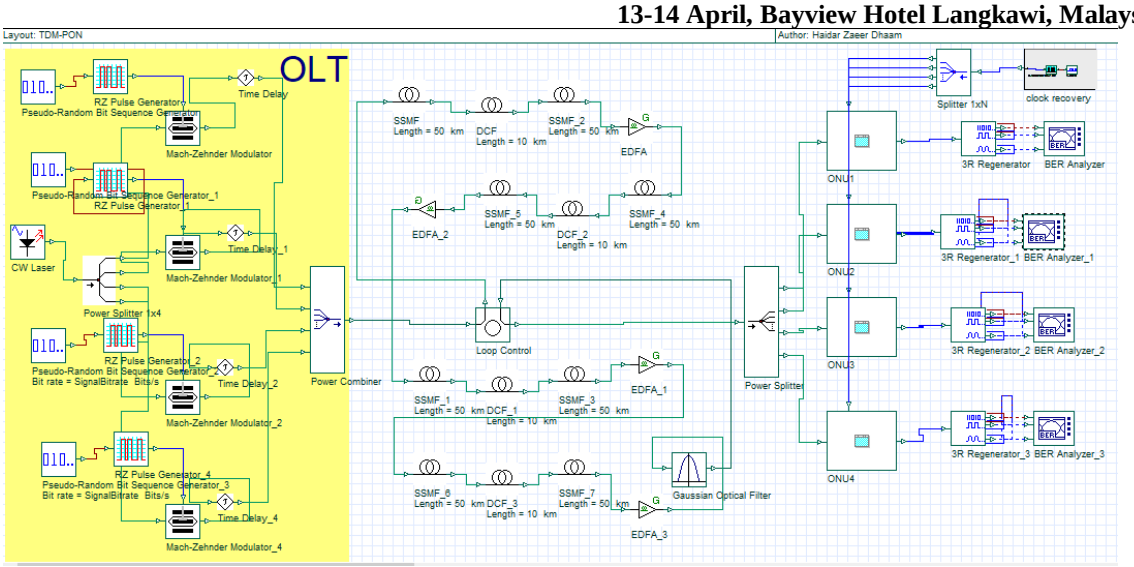

Figure 8. The Schematic Block Diagram of Long Reach TDM-PON over 440 Km, Dispersion Compensation Based on DCF

Results and Discussion

To evaluate the performance of the proposed dispersion compensators of TDM-PON system, a comparison of dispersion compensation based on FBG and DCF by eye diagrams are considered as shown in Figures (9) and (10), with same parameters of transmitters, channels (SSMF range of 110 Km without amplifier) and receivers. It can noted that the RZ TDM-PON system with dispersion compensation based on DCF gives better performance than the RZ TDM-PON system with dispersion compensation based on FBG because eye in Figure (10) has the larger eye opening. In the eye diagram, the more open the eye is, the easier the distinction between ones and zeroes of the received bits. In other words, as the received pulses are more distorted in either phase or amplitude the eye will appear more closed.

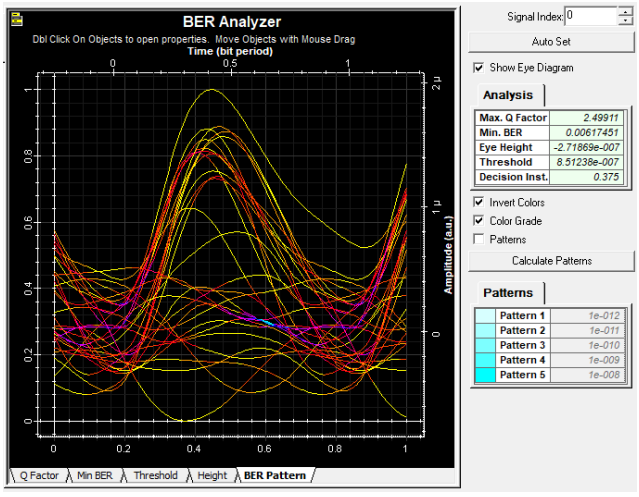

Figure 9: Eye Diagram of RZ TDM-PON System with 25 Gpbs, SSMF Range of 110 Km without Amplifier, And FBG as Dispersion Compensator.

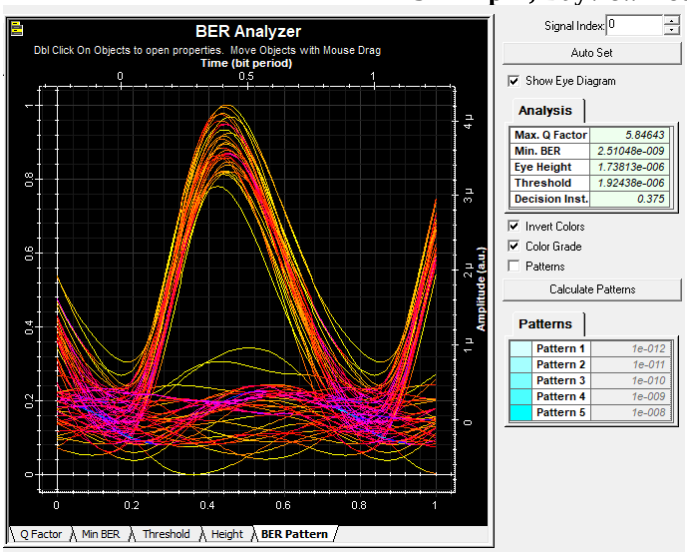

Figure 10: Eye Diagram of RZ TDM-PON System with 25 Gpbs, SSMF/DCF/SSMF Range of 110 Km without Amplifier, And DCF as Dispersion Compensator.

Figure (11) illustrates the relation between the Q-factor performance versus optical fiber distance of the first scenario of the channel, where four users linked to the OLT by SSMF without any amplifier and using FBG filter as a dispersion compensator. Two type of transmitter have been used in the OLT (downstream), the first has used four MZM as an external modulator to modulate data toward four users while the second one used only single MZM for all those users as it mention above.

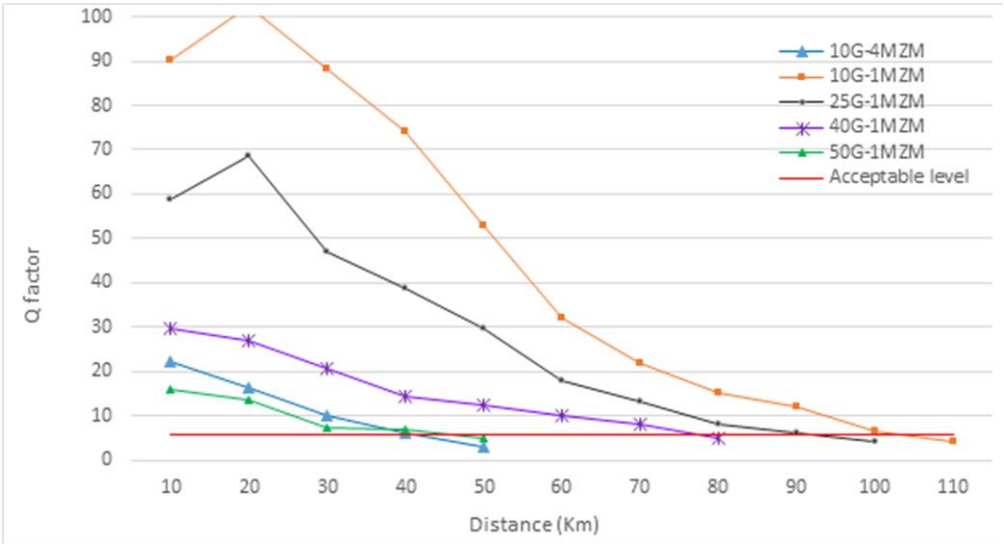

Figure 11. : Comparison Q Factor Performance versus Optical Fiber Distance for Different Bit Rate and Both TDM-PON Proposed Systems with FBG (Four Users)

This Figure shows that the first system (TDM-PON with transmitter of 4MZM) gives lower performance than the second system with 1MZM at 10 Gbps where the launched power is higher even that same laser diode with power of 5 dBm has used for both systems. In this second system different bit rates were also evaluated as shown in Figure (11), the signal of 25 Gbps per line (100 Gbps TDM) stays above the acceptable level for about 92 Km without amplifier which gives better performance than 40 Gbps, while the 50 Gbps was the worst where low Q-factor even with short distances. From the results in this graphical representation it can be noted that the increase of the bit rate leads to reduce the Q-factor at the same fiber length.

Figure (12) illustrates the relation between the Q-factor Performance versus optical fiber distance of the second scenario, where four ONUs linked to the OLT by long range of SSMF with EDFA amplifier of 4 dB noise figure and 22 dB gain and with using DCF as a dispersion compensator. Also in this scenario, the TDM-PON of transmitter of one MZM gives better performance than the system that used single laser and individual MZM per user at the same distance and bit rate. It can be noted from this figure that the high bit rate signals do not reach long distances despite the existence of dispersion compensator, where this steep drop in the Q-factor with the comparison to the performance of 10 Gbps TDM-PON due to the effect of dispersion is more in a high bit rate systems.

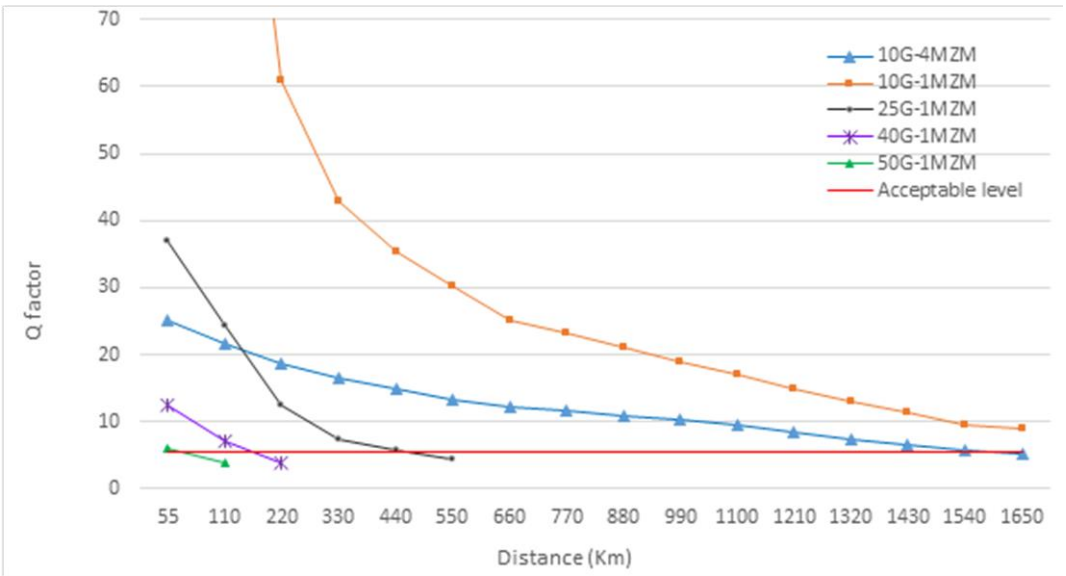

Figure 12: Q-Factor Performance versus Optical Fiber Distance for Different Bit Rate and Both TDM-PON Proposed Systems with DCF and EDFA (with Four Users)

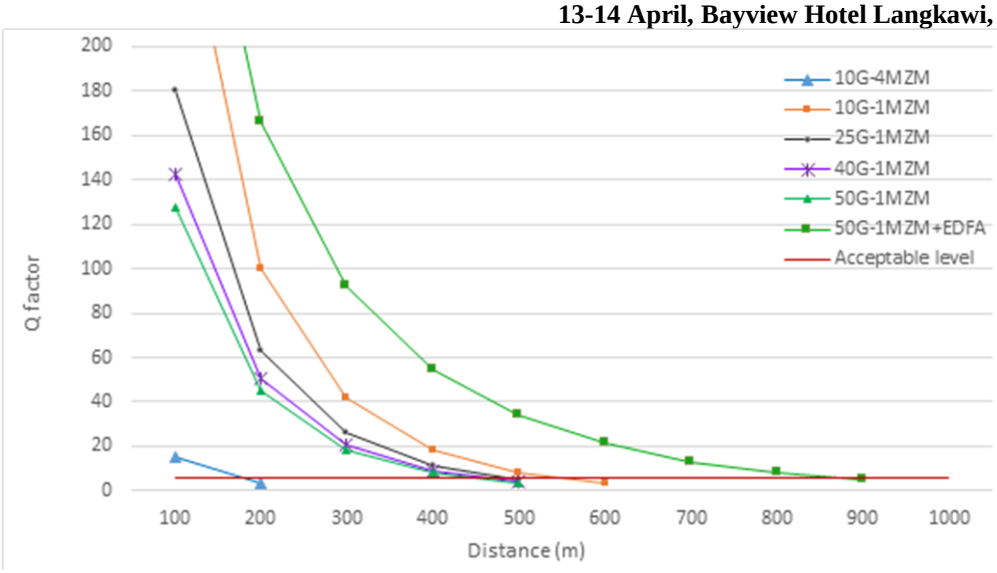

Figure 13: Q-Factor Performance versus FSO Distance under Heavy Rain for Different Bit Rate and Both TDM-PON Proposed Systems (Simulated With Four Users)

In the result FSO system, as shown in Figure (13), it can be noted that the increase of the bit rate do less Q-factor decrement than SSMF system because in the FSO system the light travels through the atmosphere instead of fiber so there is no dispersion occurs and only an attenuation can affect the light signal. As the attenuation is varying with the climate change, a large variation will occur to the power of received signal, in this simulation a heavy rain attenuation of the FSO link are considered. Also it can noted that the worst case is a 10 Gbps with single laser diode shared to four users and four MZM system where the launched power is less than others, on the contrary the best performance was for 50 Gbps with EDFA amplifier. Hence the authors recommend to use an optical amplifier before transmit the signal through the free space.

Conclusion

The worldwide spread of the TDM-PONs with the capacity demand growing and the fact of bit rate increasing that causes a decrease in the Q-factor led to the need to rely on the bit rate higher than 10 Gbps TDM. Hence, 10, 25, 40, 50 Gbps bit-interleaving TDM-PON have been simulated in three scenarios based on two downstream transmitter schemes of FTTH. The proposed scheme of TDM transmitter that use a single MZM and laser diode to carry the data of multiuser, which has cost effective, high-transmitted power and easy implementation system, provides better performance in the TDM-PON linked by SSMF with DCF or FBG as a dispersion compensation and provides much better performance in the FSO system based on different bit rates. The simulation results of the FSO, where there is no dispersion occurs, have shown that the 50 Gbps TDM-PON with EDFA amplifier is better presented than 10, 25 and 40 Gbps without amplifier. In contrast, TDM-PON with the SSMF based on a wavelength of 1550 nm, the 50G TDM showed poor performance even with the addition of an amplifier. Hence, the authors recommend using more complex modulation techniques than RZ and NRZ, more sensitive receiver and using a wavelength within O-band where there is a zero dispersion wavelength (ZDW) for a TDM-PON of 50 Gbps per channel.

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