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Editorial:
Third Issue – Journal of Electronic Systems and Programming

We are pleased to announce the publication of the third issue of the Journal of Electronic Systems and Programming (JESP).

First of all, we would like to express our gratitude to the all members of Electronic Systems and Programming Center for their unlimited support and dedication that has made JESP what it is today.

In this issue, we are pleased to report that JESP is recognized as the one of the useful journal for dissemination of high-quality research within the Libyan academic community.

Finally, we thank our editorial board team, reviewers and authors for their fundamental contribution to the third release of the Journal. We still hope authors could consider JESP to be a place where to publish their work.

Dr. Khari A. Armih
Editor-in-Chief

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REVIEW OF MECHANICAL WEAR MODELS

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Abstract

The wear modelling is of fundamental issue in the industrial field, mainly correlated to the economy and safety. Therefore, there is a need to study the wear models and wear estimation. This paper introduced the literature review for mechanical wear models. The function of wear models is to predict the rate of material removal from the surface. Classical wear theory begins by considering the rate of material removal as a function of some parameters such as load, sliding speed, sliding distance and hardness of material. In sliding wear models there are more than 100 different variables and constants. These models contains between two to twenty six variables in a single equation. Unfortunately, some constants are assigned to represent specific quantitative phenomena which are not readily measurable such as surface strength, and fatigue life of an asperity. Between 1957 and 1992, that there were 182 wear equations for the several types of wear. The most important issue of the 182 equations is that it include on a great number of variables. Each author combines a different array of variables, often for the same mechanical system.

Keywordsmechanical wear models, review, classical wear theory, computer simulations.

1.INTRODUCTION

Wear is usually defined as the removal of material from contacting surface by mechanical action [1]. Wheel wear and rail wear are the loss of material from the contacting surface due to rail/wheel interaction. Rail wear is dependant on several parameters such as axle load, train speed , wheel material type, rail material type, curvature, traffic type, lubrication, and environmental conditions [2]. Wheel wear is one of the most significant problems affecting the cost and performance of railway transportation systems [1]. Wheel and rail wear is a significant issue in railway systems. Accurate prediction of this wear can improve economy, ride comfort, prevention of derailment and planning of maintenance interventions. Poor prediction can result in failure and consequent delay and increased costs if it is not controlled in an effective way. However, prediction of wheel and rail wear is still a great challenge for railway engineers and operators.

2.REVIEW OF WEAR MODELS

Reye in 1860 considered that the volume of material removed from a body was proportional to the energy dissipated into it by the relative motion of the two contacting surfaces such as shown in the following equation[3], [4], [5].

$$V = K_R W \tag{1}$$

Where Vthe volume of material is removed, K_R is Reye's wear constant and W is the work dissipated into the material. Reye's approach was one of the primarily methods to calculate the wear in terms of energy dissipated.

Holm in 1946 considered that the process of wear with regard to the relative motion of surface asperities. He suggested that the individual atoms on opposite asperities were moving towards each other and colliding. His suggestion stated that the wear was a function of the properties of the materials in contact and the load applied over the contact such as shown in the following equation [7],[3], [6],[8].

$$V = Z\,\frac{p}{p_m} \tag{2}$$

In the above equation V is the volume of material removed per unit sliding distance, Z is the probability of removal of an atom per atomic encounter and would depend on the properties of the materials in contact, p is the load applied, and p_m is the flow pressure of a worn surface “hardness of material”.

Burwell and Strang suggested that the volume of wear material can be calculated using the following equation [6]:

$$Q = k\,\frac{W\,d}{H} \tag{3}$$

Where k is the probability of removing wear particles, W is the load, d is the sliding distance, and H is the hardness of material. Thus the wear volume per unit sliding distance w is [6]:

$$w = k\,\frac{W}{H} \tag{4}$$

Archard in 1953 studied the wear process and suggested that there were a number of key considerations that must be included in a wear model. Archard has referenced Holm in his publications and his work could be thought of as an extension or furthering of Holm’s wear equation. Archard assumed that two rough surfaces are in discrete contact “The contact consists of individual spots”. The area of each spot expands from zero to maximum $\pi\,a^2$,and then shrinks back to zero such as shown in Figure 1. Normal load can determined by the following equation [3], [9]-[11]:

$$p_n = \pi\,a^2 p_m \tag{5}$$

Where : p_m is the yield pressure of a plastically deformed asperity, and a is the contact spot radius.

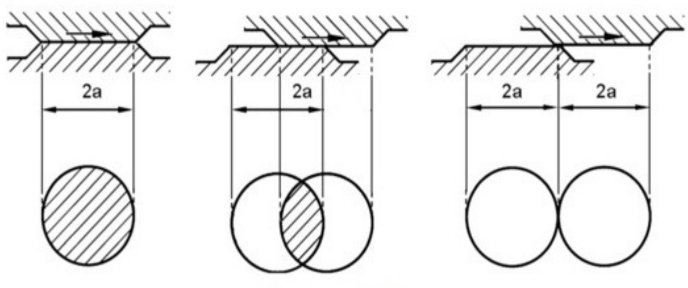

Figure 1: Archard wear model[9], [11]

Assume that this volume consists of a half-sphere of radius a, the volume is given by:

$$V_n = \frac{2}{3} \pi a^3 \quad (6)$$

Wear rate (per unit distance of sliding) is given by:

$$i_n = \frac{V_n}{2 a} \quad (7)$$

Then:

$$i_n = \frac{\pi a^2}{3} \quad (8)$$

Therefore:

$$i_n = \frac{P_n}{3 P_m} \quad (9)$$

The total wear rate would be equal to the total contribution from all contact spots:

$$I^* = \sum i_n = \frac{P}{3\ P_m} \quad (10)$$

Where the total normal load on the contact is:

$$P = \sum P_n \quad (11)$$

Archard assumed that the wear can be calculated using the following equation:

$$I = k\, I^* \quad (12)$$

Where k is constant.

It is written as:

$$I = \frac{k\,P}{3\,P_m} \quad (2.13)$$

It is convenient to designate $K = \frac{k}{3}$ and assume that $P_m = H$.

Then the equation of wear develops in the form:

$$I = \frac{K\,P}{H} \ (mm^3/mm) \quad (14)$$

Where: I is the volume worn per unit sliding distance (wear rate), P is the normal load, H is the hardness of the softer material, and K is the wear coefficient.

Then Archard expressed the wear equation such as shown in the following form: [3], [6], [7].

$$V = k\,\frac{N\,S}{H} \ (mm^3) \quad (15)$$

Where: V is the volume of wear (mm^3), k is the wear coefficient (-), N is the normal load (N), S is the sliding distance (mm), and H is the hardness of material (N/mm^2).

The wear coefficient (k) can calculated using the following equation [1], [12], [13]:

$$k = \frac{V\,H}{L\,F_N} \tag{16}$$

Where: kis the non-dimensional wear coefficient, Vis the volume of wear (mm^3), H is the hardness of material (N/mm^2), F_N is the normal load (N) and Lis the sliding distance (mm). The wear coefficient k is dimensionless and always less than 1 [9], [14].

The values of wear coefficient k for various materials against steel under dry conditions using pin-on-disc tests are illustrated such as shown in Table 1.

Table 1:Wear coefficient values [14]

Material	k
Mild steel (on mild steel)	7×10^{-3}
α/β brass	6×10^{-4}
PTFE	2.5×10^{-5}
Copper–beryllium	3.7×10^{-5}
Hard tool steel	1.3×10^{-4}
Ferritic stainless steel	1.7×10^{-5}
Polythene	1.3×10^{-7}
PMMA	7×10^{-6}

Wear coefficient k for unlubricated surfaces is shown in Table 2.

Table 2:Wear coefficient unlubricated surfaces [15]

Material combination	k
Low carbon steel on low carbon steel	70×10^{-4}
60/40 Brass on tool steel	6
Teflon® on tool steel	0.25
70/30 Brass on tool steel	1.7
Lucite on tool steel	0.07
Molded bakelite on tool steel	0.024
Silver steel on tool steel	0.6
Beryllium copper on tool steel	0.37
Tool steel on tool steel	1.3
Stellite #1 on tool steel	0.55
Ferritic stainless steel on tool steel	0.17
Laminated bakelite on tool steel	0.0067
Tungsten carbide on low carbon steel	0.04
Polyethylene on tool steel	0.0013
Tungsten carbide on tungsten carbide	0.01

The wear coefficient depends on several parameters such as a contact pressure, sliding velocity, and temperature and the degree of lubrication in the contact area, therefore, it is a very complex parameter to determine. A wear map can used to describe the wear coefficient as a function of contact pressure and sliding velocity. Each wear map corresponds to a certain rail and wheel material (The rail and wheel are assumed to have similar material properties). Figure 2 shows a wear map which is describes four approximate regions, in this chart, the contact pressure limit at 0.8H corresponds to 80% of the hardness, and the wear coefficient depends on the sliding velocity [16].

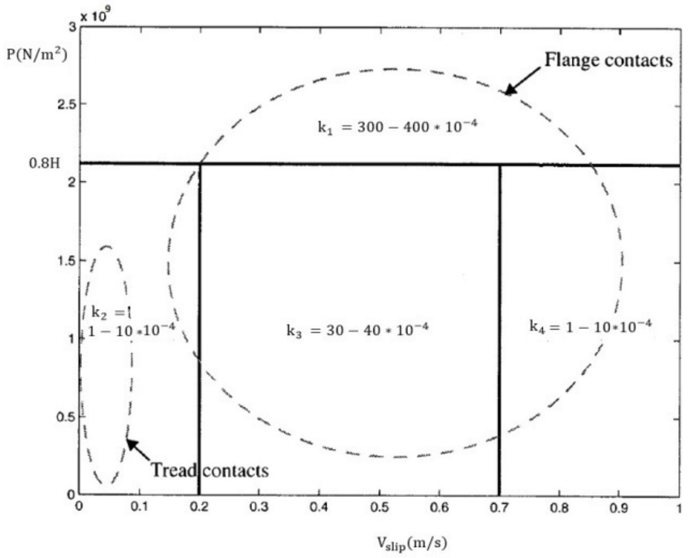

Figure2:Wear chart for the wear coefficient [16]

Montgomeryet al., [3] stated that "there are a number of problems with the assumption that the wear rate is directly proportional to the load, as stated by Archard. The surface characteristics of the materials in contact will be changing as a result of material being removed, they will generally become rougher and therefore a change in the friction coefficient by a factor of two or three could result in a change of the rate of wear by one or more orders of magnitude".

The weakness of using the Archard model for wear modelling is that it depends on the proper calculation of wear coefficient k, where the wear coefficient k is a very complex parameter to determine, if k is not calculated correctly, it will lead to inaccurate results of wear modelling.

The Royal Institute of Technology Stockholm (KTH) developed the following wear model based on the Archard model. The volume of worn material is written as:

$$V = K_A \frac{P\ S}{H} \tag{17}$$

Where: V is the volume of wear in (mm^3), Sis the sliding distance in (mm), Pis the normal force in (N), His the hardness of the softer material in (N/mm^2), and K_A is wear coefficient. The values of wear coefficient K_A which shown in Table 3 were obtained using a pin-on-disc test, and a twin disc test rig using different materials. Where p is the contact pressure and $\dot{S}$ is the slip velocity [17], [18].

Table 3:Wear coefficient (KTH) [17], [18]

Pressure p[GPa]	Slip velocity $\dot{s}$[m/s]	K_A[-]
$p > 2.1$	any $\dot{s}$	$300 - 400.10^{-4}$
$p < 2.1$	$\dot{s} \geq 0.2$	$1 - 10.10^{-4}$
$p < 2.1$	$0.2 \leq \dot{s} < 0.7$	$30 - 40.10^{-4}$
$p < 2.1$	$\dot{s} \geq 0.7$	$1 - 10.10^{-4}$

The University of Sheffield (USFD) developed the following wear model. The wear function developed by the USFD relates to the wear rate, which expresses the weight of lost material (μg) per distance rolled (m) per contact area A(mm^2), to the wear index Tγ as follow [18]:

$$\text{Wear rate} = K\ \frac{T\gamma}{A} \tag{18}$$

Where: K is wear coefficient, and Tis the creep force, γis the slip, and A is the contact area.

The wear equations presented by the USFD are shown in Table 4. This formulation was developed using twin disc rig experiments. The USFD wear function was developed for wheel (R8T) and rail (UIC60 900A) materials.

Table 4: The USFD wear function [18]

Wear regime	Wear range $\frac{T\gamma}{A}$ (N/mm^2)	Wear rate ($\mu g/m/mm^2$)
Mild	$\frac{T\gamma}{A} < 10.4$	$5.3\,\frac{T\gamma}{A}$
Severe	$10.4 \leq \frac{T\gamma}{A} < 77.2$	55.0
Catastrophic	$\frac{T\gamma}{A} \geq 77.2$	$61.9\,\frac{T\gamma}{A}$

The Royal Institute of Technology Stockholm model and the University of Sheffield model can be used for wear modelling, but this is also dependent on the correct calculation of the wear coefficient k.

British Rail Research (BRR) developed equations to describe wear behavior as shown in Table 5. Wear is calculated as material loss expressed in mm^2 of lost area from any radial section through the profile per km rolled. Where: Tis the creep force (N), γ is the creepage [-], and D is the wheel diameter in (mm) [17],[19]. These equations were obtained from twin disc tests on R8T (wheel) and BS11 (rail) steels.

Table 5:Equations of the BRR wear function [19]

Friction	Regime	Tγ (N)	Wear Rate (mm2/km rolled)
Dry	Mild	< 100	0.25Tγ/D
Dry	Mild Plateau	> 100 and < 200	25.0/D
Dry	Severe	> 200	(1.19Tγ - 154)/D

The British Rail Research model can be used for wear modelling, but the main limitation of the BRR wear model lies in the fact that the equations given in Table 2.5 are only valid for the specific materials considered.

R. Lewis and U. Olofsson[1] presented an approach which can be used for wheel wear modelling (expected wear proportional to wear indexWI) as provided bellow:

$$\mathrm{WI} = \mathrm{K}(\mathrm{T}_1\gamma_1 + \mathrm{T}_2\gamma_2) \qquad (19)$$

Where K is the constant, $\mathrm{T}_1, \mathrm{T}_2$ are the longitudinal and lateral creep forces respectively, and γ_1, γ_2 are the longitudinal and lateral creepages respectively. This relationship between the energy dissipation and material removal can be used to predict wheel/rail wear. This model is one of the most common models which have been used in recent works for wear modelling; accordingly, it has the same drawbacks as most of the classical wear models, which are dependent on the value of certain constants.

The American Society for Testing and Material (ASTM) developed a wear model which can be used to model the pin wear and disc wear for pin-on-disc experiments as shown in the following equations [20], [21], [22]:

$$\text{Pin volume loss} = \frac{\pi\,\mathrm{h}}{6}\left[\frac{3\,\mathrm{d}^2}{4} + \mathrm{h}^2\right](\mathrm{mm}^3) \qquad (20)$$

The height of material removed for pin (h) is given by:

$$\mathrm{h} = \mathrm{r} - [\,\mathrm{r}^2 - \frac{\mathrm{d}^2}{4}\,]^{0.5}(\mathrm{mm}) \qquad (21)$$

Where: d is the pin wear scar diameter, and r is the pin radius.

$$\text{Disc volume loss} = 2\,\pi\,\mathrm{R}\,[\,\mathrm{r}^2\sin^{-1}\left(\frac{\mathrm{d}}{2\mathrm{r}}\right) - \left(\frac{\mathrm{d}}{4}\right)(4\,\mathrm{r}^2 - \mathrm{d}^2)^{0.5}]\mathrm{mm}^3 \qquad (22)$$

Where:R is the disc wear track radius, r is the pin radius, and d is the disc wear track width.

The accuracy of pin/disc wear modelling using the ASTM model is dependent on the proper measurements of the pin wear scar dimensions and disc wear scar dimensions, this requires an accurate instrument. The ASTM model has a limitation however, it can only be used to model the pin/disc wear, but it cannot be used for wheel and rail wear modelling.

In the survey of the wear modelling equations, many equations were found for wear modelling; for example, [23] presented 28 equations for erosion wear modelling, and a couple of equations for sliding wear modelling; the problem with these models is that they depend on different variables and constants.

The modelling of wear can be carried out with mathematical models and computer simulations [7]. The railway wheel wear prediction is a very significant problem in railway systems. In the past, the reprofiling intervals of railway wheels have been planned according to designer's experience. Today, computer simulation tools can be used to predict the wheel wear [24].

3. Review of the computer simulations for wheel/rail wear prediction

The following sections present a review of using the computer simulations for wheel/rail wear prediction.

Pearce and Sherratt [25] presented a model which is shown in Figure 3 to predict the wheel wear. VAMPIRE software was used to simulate the dynamics of the railway vehicles. The wear algorithm is shown in Table 6, the material lost is proportional to the energy dissipated in the contact zone. For wheel wear prediction, two track inputs were selected from VAMPIRE input files, it is a straight track and a curved track. The P8 wheel profile and P11 wheel profile were used in this study. The position of the contact on the wheel, creepage, and creep forces are correlated and summed to calculate the material loss distribution across the wheel profile. The contact patch data were recomputed before each journey and then this step was repeated until a desired mileage was achieved.

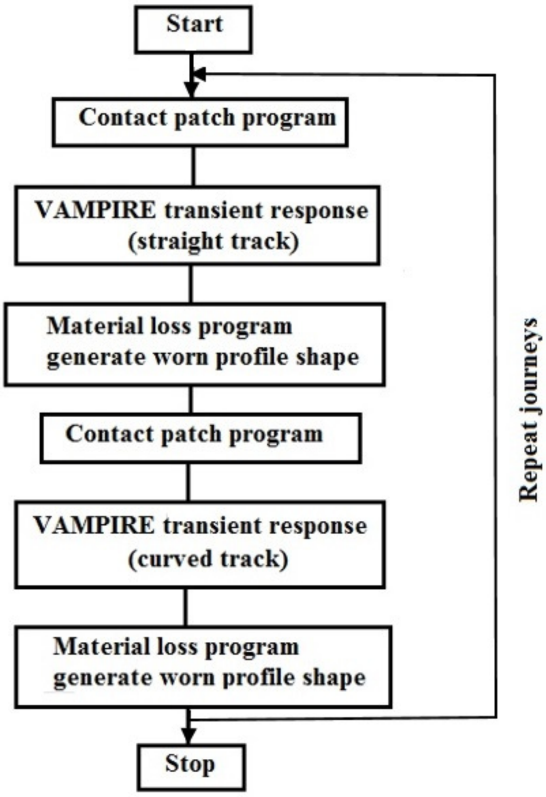

Figure 3:Wheel wear prediction model [25]

Table 6:Wear algorithm [25]

$T\gamma < 100N$	material loss $0.25\,T\gamma/D$
$100 \leq T\gamma < 200N$	material loss $25.0/D$
$T\gamma \geq 200N$	material loss $(1.19T\gamma - 154)/D$

Where T is the creep force (N), and γ is the creepage [-], and D is the wheel diameter in (mm).

Shu et al., [26] used a NUCARS vehicle/track multibody simulation program to estimate the rail wear. The advantage of NUCARS is that the rail profile can be modified online based on wear index (Tγ) and the rail profile is automatically updated for the next run. The rail wear model is shown in Figure 4. A wheel database, consisting of new wheel profiles, little worn wheel profiles, and heavy worn wheel profiles. This to reflect the effects of wheel shape on wear. The rail wear predicted using NUCARS model was validated using rail wear test results. The simulation predictions were very close to the test results.

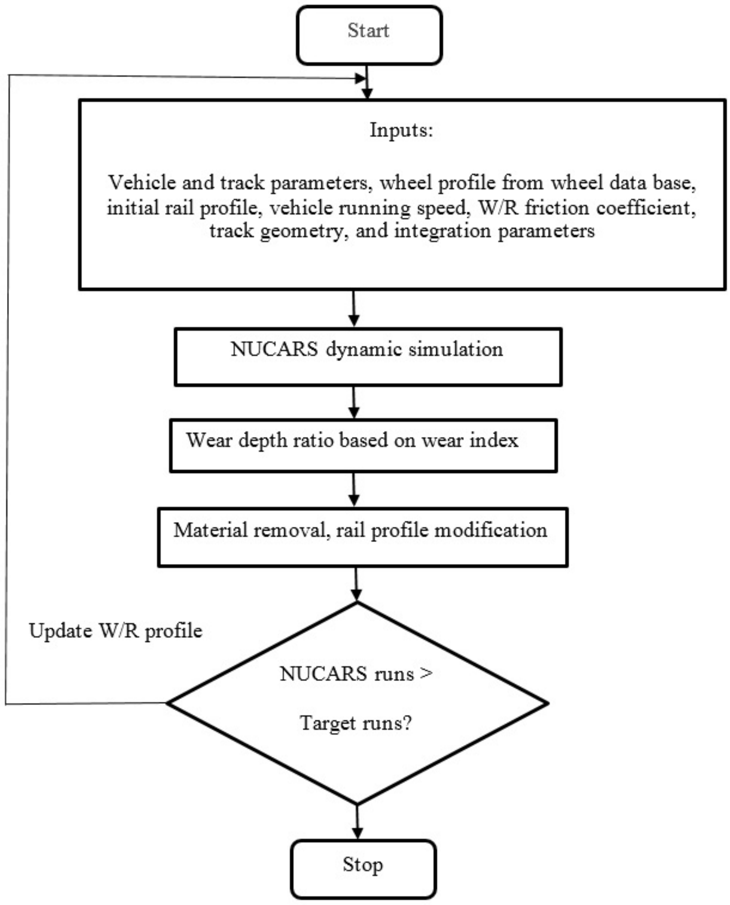

Figure 4: Rail wear simulation procedures in NUCARS [26]

Ward et al., [27] presented a model to predict the wheel wear as shown in Figure 5 and Table 7. To generate the wear coefficients (k) for the model, a twin disc test was carried out. The approach for wheel wear prediction in this model is based on a wear index. The wear rate was calculated using the following equation:

$$\text{Wear rate} = k\,\frac{T\gamma}{A} \tag{23}$$

Where A is the contact area, T is tractive force, and γ is slip at the wheel/rail interface.

Multi-body dynamics simulations of a railway wheelset were carried out using ADAMS/Rail software. The wheel profile was discredited into strips and the wear was determined for each strip. The worn wheel profile is then fed back to the ADAMS/RAIL to update the wheel profile to predict the wheel wear.

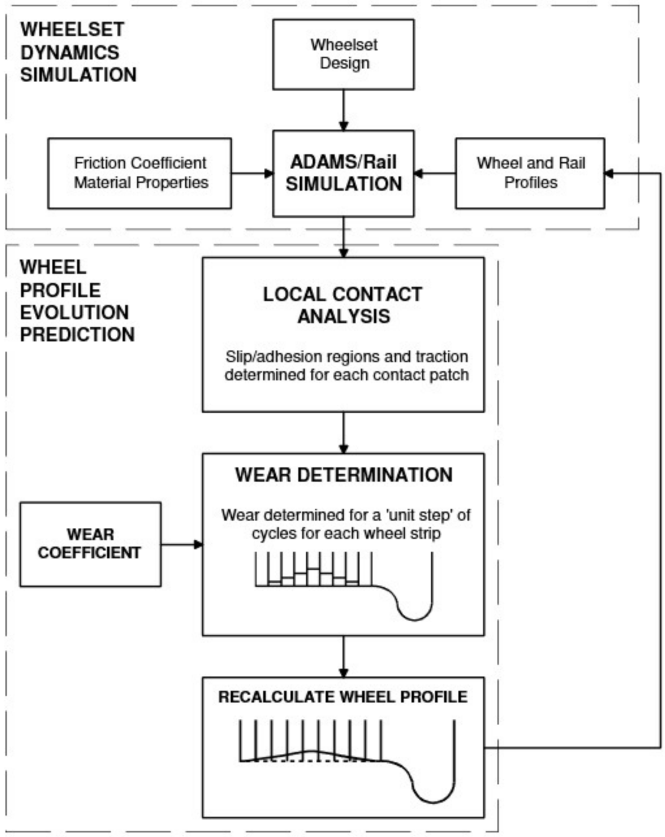

Figure 5:Railway wheel wear modelling scheme [27]

Table 7: Wear regime

Regime	$\frac{T_Y}{A}$ (N/mm^2)	Wear rate (μg/m/mm^2)
k_1	$\frac{T_Y}{A} < 10.4$	$5.3 \frac{T_Y}{A}$
k_2	$10.4 < \frac{T_Y}{A} < 77.2$	55
k_3	$77.2 < \frac{T_Y}{A}$	$61.9 \frac{T_Y}{A}$

Enblom [28] presented a model for wheel wear prediction as shown in Figure 6. A commercial Multibody Software (MBS) was used to simulate the dynamics of the railway vehicles. The wheel wear was calculated using the Archard wear model. The wear coefficient was determined using a wear chart, where the value of wear coefficient is a function of contact pressure and sliding velocity. Laboratory tests (twin disc test rig and pin-on-disc rig) were used to determine the wear coefficient. In this paper, the wheel wear was predicted using MBS simulation tool. The wheel wear predicted has been validated by comparing it to wheel wear measured (Stockholm commuter network).

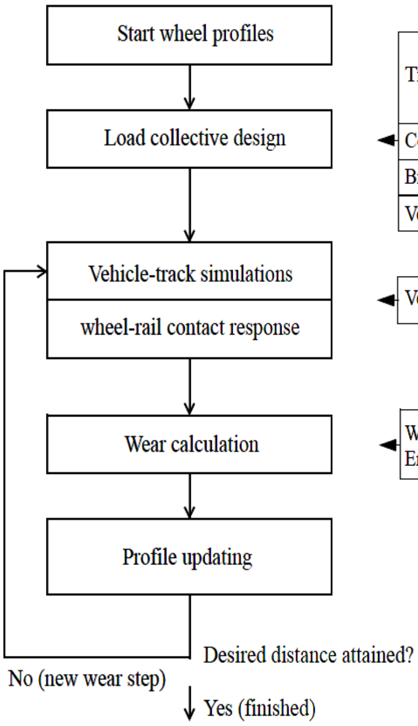

Figure 6: Wheel wear prediction model [28]

Pombo et al., [24] presented a model to predict the wheel wear as shown in Figure 7. A commercial Multibody Software (MBS) software was used to simulate the dynamics of the railway vehicles. The MBS tool was applied in this paper in order to assess the effect of primary suspension stiffness,rail cant, traction/braking forces, and vehicle velocity on wheel wear. The wear was calculated using the energy dissipated in the wheel-rail contact.

Pombo et al., [29] presented a model to predict the wheel wear as shown in Figure 7. The MBS was used to simulate the dynamics of the railway vehicles. The MBS was applied in this paper in order to show the capabilities of MBS computational tool for wear prediction by evaluating the effect of trainset design, track layout, friction conditions, and wheel flange lubrication on wear. The wheel wear was calculated using the energy dissipated in the wheel-rail contact.

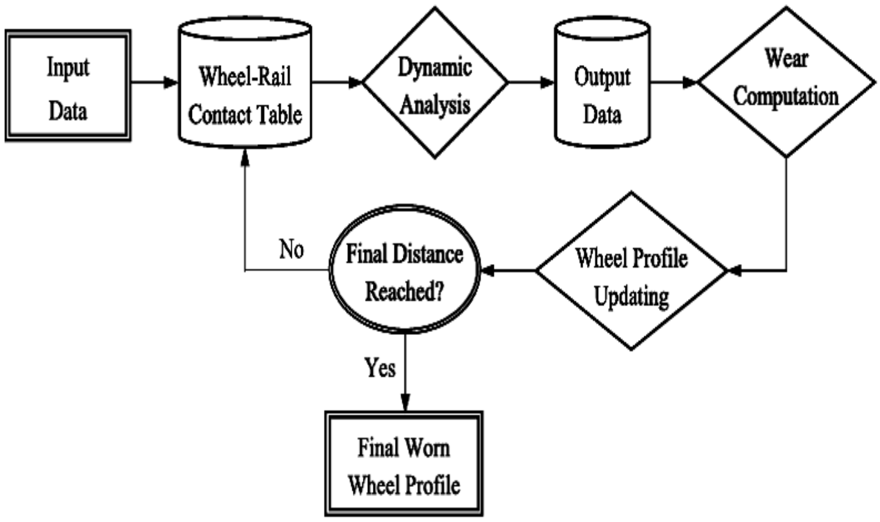

Figure 7:Schematic representation of wear prediction [24], [29]

Bevanet al., [30] provided a model to predict wheel wear. The methodology of wheel wear prediction is shown in Figure 8. VAMPIRE vehicle dynamics software was used to simulate the dynamics of the railway vehicles. The VAMPIRE software generated the wheel-rail contact data and forces, these forces and wheel/rail contact data were used as inputs to the model to predict wear. This procedure is used to update the wheel profile, and the volume of material removed was determined using the Archard wear model and energy model. The wear coefficient (k) was determined from a map of wear for wheel/rail steels.

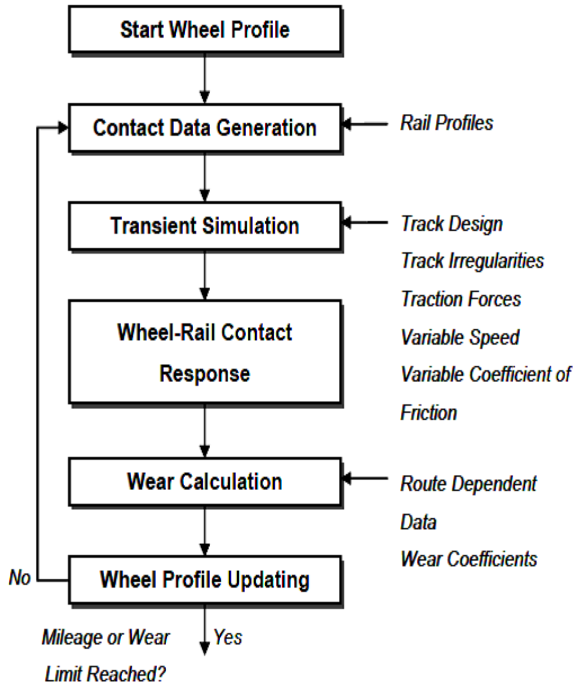

Figure 8:Methodology of wheel wear prediction [30]

Arandojo [31] presented a model for wear prediction as shown in Figure 9. The GENSYS software was used in this paper to predict railway wheel wear. The track type, running distance, and type of rail and wheel profiles were loaded to the model as inputs. The vehicle-track interaction is performed in GENSYS software. The wear was calculated based on the Archard law. The GENSYS software is a three-dimensional general multi-body-dynamics program. Several simulations were carried out to predict the railway wheel wear of the first wheelset. A passenger vehicle was used in simulations, it consists of a single carbody with two bogies, four wheelsets and eight wheels.

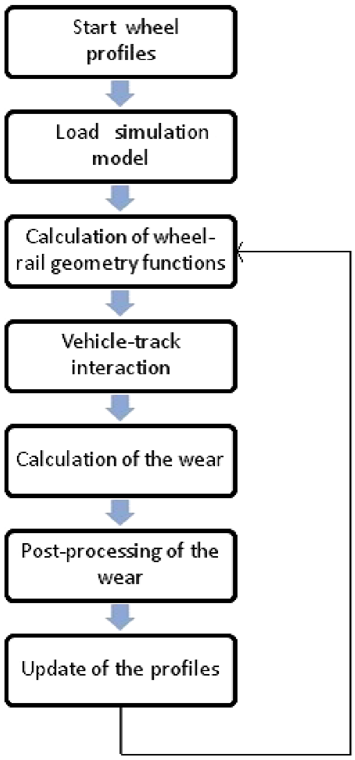

Figure 9:Wheel wear prediction model [31]

Tanifuji [32] used SIMPACK software for wheel wear prediction. The lateral movement of the wheel/rail contact patch and the energy dissipated (Tγ) between wheel and rail were used to estimate the wheel wear as shown in Figure 10. Simulation tests were carried out on a straight track and on a curved track to predict the wheel wear. The running distance was 268000 km. Comparisons between wear predicted using SIMPACK software and wear measured were carried out to validate the wheel wear on flange and on tread. The results showed that the wear predicted using SIMPACK software was very close to the wear measured.

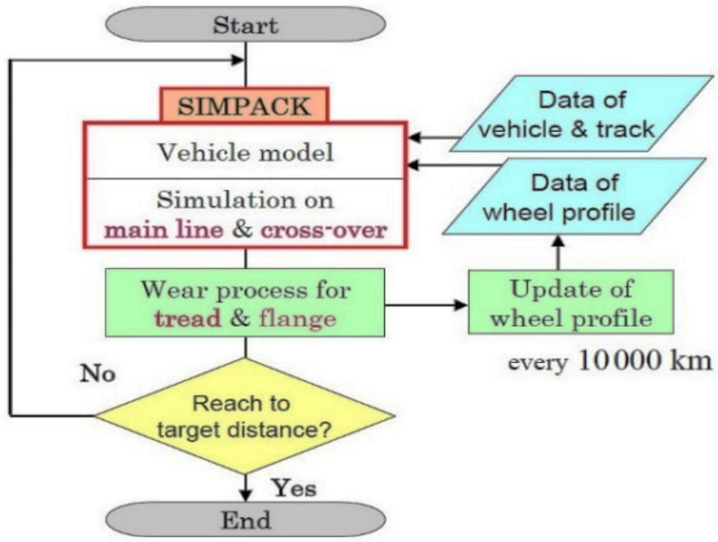

Figure 10:Flow chart for wear prediction [32]

A Nonlinear Autoregressive model with eXogenous input neural network (NARXNN) was developed to predict the wheel and rail wear for the twin disc rig experiments[33]. The NARXNN was used to predict wheel wear and rail wear under deferent surface conditions such as dry, wet, lubricated, and sanded conditions. The neural network model was developed to predict wheel wear in case of changing parameters such as speed and suspension parameters. VAMPIRE vehicle dynamic software was used to produce the vehicle performance data to train, validate, and test the neural network. Three types of neural network were developed to predict the wheel wear: NARXNN, backpropagation neural network (BPNN), and radial basis function neural network (RBFNN).

4. Conclusion

Regarding the literature review, two basic types of wear models have been used for wear modelling: sliding models such as Archard wear model, and energy transfer models. The Archard wear model is the most frequently used for wear modelling in practical engineering applications; once the wear coefficient is obtained, the amount of wear can be simulated. The American Society for Testing and Material (ASTM) developed a model which can be used for pin wear and disc wear modelling for a pin-on-disc test.

The computer simulation packages such as VAMPIRE, ADAMS/Rail, GENSYS, Multibody Software (MBS), SIMPACK, and NUCARS together with the models which were shown in this review are very useful tools to study railway wheel/rail wear. The software packages have some advantages, for example, the ADAMS has the advantage of a strong Graphical User Interface (GUI). This means the users can see exactly what they are constructing on the screen in a 3-dimensional form, which can be manipulated around a variety of axis and all the necessary functions can be accessed from the menu system. With respect to this review, it can be noticed that the wear was calculated using either Archard's model or the energy dissipated model. The computer modelling of railway vehicle dynamics can be performed using a number of different commercial software packages.

Artifical neural networks developed to predict the wheel and rail wear for the twin disc rig experiments, and to predict wheel/rail wear under deferent surface conditions such as dry, wet, lubricated, and sanded conditions. The neural network model was developed to predict wheel wear in case of changing parameters such as speed and suspension parameters.

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WeDRisk Approach for Management of Web and Distributed Software Risks: Evaluation Experiment (Part 1)

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Abstract

WeDRisk is an approach designed to manage risks of web and distributed software development. The WeDRisk approach aims to address the weaknesses of existing approaches to risk management, which are less able to deal with the specific challenges of web and distributed development. A key part of the approach is flexibility, to deal with the rapid evolution which is typical of such developments. This paper presents the approach and describes the design, execution and analysis of a controlled experiment that has been used to evaluate some central parts of the approach, in terms of their usefulness, ease of understanding and usability. The paper focuses on the evaluation of estimation module part. Other parts will be introduced in next papers. The experiment result illustrated how the estimation module is useful, understandable, flexible easy to use, and considers web and distributed development risks factors.

KeywordsWeb and Distributed software risks, Risks Clustering, Risks Estimation, Evaluation Experiment.

1. INTRODUCTION

SOFTWARE industry is continuously evolving and it becomes more and more vulnerable to new challenges and risks. Web and Distributed (WD) software development is an example of that. Due to the development environment and technologies acceleration WD development faces a new set of challenges and risks (e.g. evolving, lack of face to face meetings, time zone difference, cultural differences and communications failures [1], [9], [4] and [5]. These risks and challenges are difficult to be managed with traditional management approaches, which already they have many weaknesses such as; they are not flexible as they offer only one type of Risk Management (RM), and they do not consider WD factors that affect WD risks (i.e. dependencies, sites distribution and communication) [2]. Indeed, there is a need for developing new flexible and evolvable methods, approaches and tools to accommodate the risk management needs for the WD development. WeDRisk [1], [3] is an approach that has been designed for this purpose. It is proposed in order to tackle some weaknesses of the existing software risk management approaches in managing the WD development risks. While the approach is particularly aimed towards WD development, it should be applicable to the modern software developments in general. The approach is designed to be flexible, customizable and able to evolve. Moreover, it considers the risks from three perspectives (project, process, and product).

In additional to the introduction section the paper structure consists of five other sections which include; Section II introduces WeDRisk approach structure and the module which is targeted for the evaluation. In Section III the evaluation experiment scope, questions, hypothesis background and related work, method (e.g. apparatus, material, and subjects), injected situations, validation, controlling measures design, result and analysis are presented. Paper discussion is in Section IV, limitations are in Section V and finally, Section VI introduces the conclusion and future work.

2. WEDRISK STRUCTURE

Figure 1 shows the main structure of the WeDRisk approach, which, consists of three phases namely; RM Establishment phase, RM Implementation phase and RM Evaluation and Evolution phase. It is also provided with a communication channel. The phases consist of modules, which contain components, steps, techniques and guidelines [1], [3].

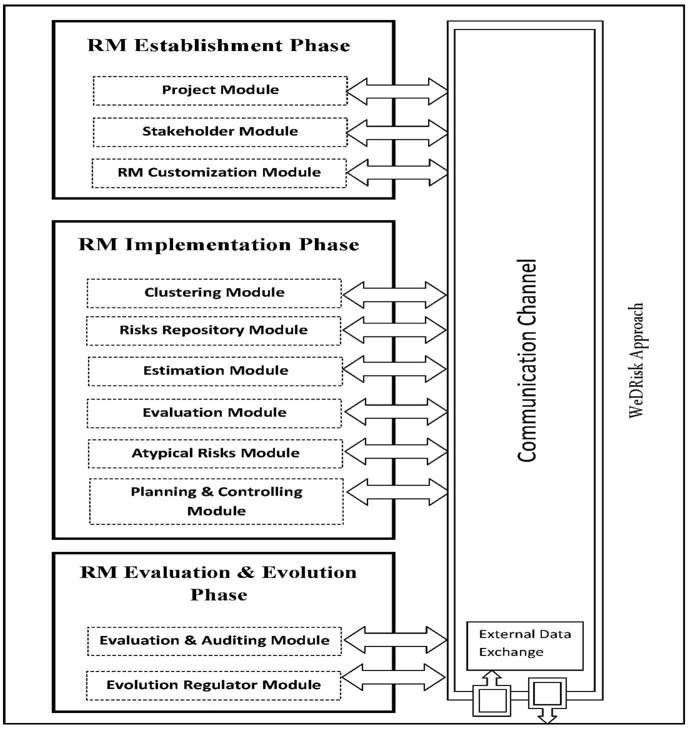

Figure 1:WeDRisk Approach Main Structure [1], [3]

Parts of this paper appear in a PhD thesis [1]. The paper reports a controlled experiment which has been conducted at School of Computing Science - Newcastle University- UK to evaluate some WeDRisk approach modules. As this paper focuses on the estimation module, therefore, the only this module is described in the following section:

A. Estimation Module

The estimation module in the WeDRisk approach offers two options for risk estimation. First option uses the ordinary Risk Exposure (RE) equation (1), whereas, the second option uses an improved equation named as Total Risk Estimation Value (TREV) equation (2), which, is intended to include Web and Distributed Factors (WDF). The module uses a special estimation matrix to estimate the total value of WDF. Following section describes the two equations and the WDF estimation matrix.

1) Risk Exposure (RE): RE is a famous equation (1) that has been used for many years to estimate software risks. It depends on the estimation of the probability of the risk occurring (RiskProb) and magnitude of the losses if the risk is occurred (RiskMag).

$$RE = RiskProb * RiskMag \quad (1)$$

There are different ways (qualitative and quantitative methods) to estimate the probability and magnitude of the risks. In our estimation module we tried to mix between the qualitative and quantitative estimations. For this purpose, a ranked line as shown in Figure 2 is used by the WeDRisk estimation module.

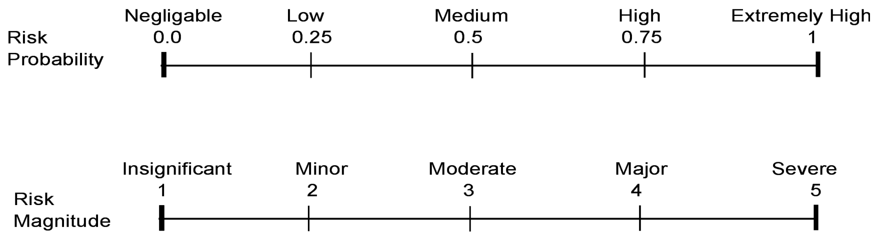

Figure 2: Probability and Magnitude Estimation Line [1]

As can be seen in Figure 2 the probability is ranged from Negligible to Extremely High with values from 0 to 1. On the other hand, the values for risk magnitude are ranged from 1 when the risk associated loss is Insignificant to 5 when it is Severe. This technique is used for its simplicity of use and at the same time it represents the ascending sequence of the probability and magnitude of the risk with quantitative values.

RE equation was used for the assessment of collocated software development risks since the late of 80s [6], [7]. However, the software industry is evolutionary industry and rapidly growth especially with the new phenomenon of WD software industry, which involve a new set of factors that could have an effect on the risks and need to be considered by the estimation equation. Therefore, we believe that the RE equation could be improved by including the WD factors. The TREV is an attempt to produce an improved equation for this purpose.

2) Total Risk Estimation Value (TREV): In additional to the two main aspects of the risk (Probability and Magnitude) the TREV equation (2) includes the WDF as a part of the question [1]. In fact, this equation is an improved equation based on the RE equation to estimate WD development risks. A special matrix is designed to estimate the total WDF.

Both the TREV equation and the WDF estimation matrix are described below.

$$TREV = RE * \sum WDF \qquad (2)$$

Where,RE is the Risk Exposure and WDF is the Web and Distributed Factor

3) WDF Estimation Matrix: The WDF estimation matrix (see Table I) estimates three WD factors (Sites Dependency, Sites Distribution and Communication Availability), which, could have considerable and changeable affect on risk exposure. For instance, the importance of a risk could be changed if we considered the dependency level on other sites or risks. The WD factors and used ranking system in the matrix are described below [1]:

I) Sites Dependency Level

In distributed development, one site progress could depend on other site progress. This means any delay (e.g. due to a risk) in a site affects other dependent sites. This will have worst affect when there is a large number of sites depending on each other or there is a cross dependency between them. Usually, the dependency is not considerable issue during the estimation of the probabilities and magnitudes of the risks, as the developers do not see the big picture of the relations between the sites and they just deal with the risks individually.

II) Sites Distribution

The number and the distribution of development sites have an important influence on the risks in terms of type, number and significance. Multisite projects, which have sites in different countries are much more vulnerable to the distribution risks (e.g. time zone and cultural differences) than the ones, which are multisite but in one country. Therefore, we need to consider this factor during the estimation of risks. See how the WDF estimation matrix Table I ranks that.

III) Communication Availability

Communication plays a vital role in web and distribution development. Occasionally, availability and reliability of communication are different from situation to another and from time to another. Therefore, the effect of communication on the risks needs to be considered as a part of risks estimations.

The above three WD factors have been resulted from reviewing of challenges and risks of the WD development. Summary, these factors are selected and considered due to the following reasons:

- We believe that the consideration of these factors could change the importance of risks priorities.
- These factors are changeable from risk to risk, from situation to situation and from time to time.
- Developers/Managers should not just deal with the WD development risks individually; they should have a pig picture about their relations and dependencies.

IV) Matrix Ranking Technique

The ranking values in the matrix increase gradually starting from 1 and ending with 5. One means the factor has a very low or negligible affect where the value five means that it has the highest negative effect on the risks. The given values are assigned based on the importance of each level and its affect on the risks. Each factor might have different values in different times. In the case when there is no any change in any of the factors the ranking value will take a default value, which is one. At the end the total of the assigned values will be added to each other to obtain the total WDF value for the desired risk (see Table I).

The aspects that are targeted for the evaluation in this study include; consideration and coverage of WD factors, usability and usefulness of WDF estimation matrix and the TREV equation.

3. THE EXPERIMENT

A. Problem Being Solved

This experiment aims to evaluate some novel aspects of the WeDRisk approach, mainly, the consideration and estimation of web and distributed factors. The experiment is divided into three sections. Each section tests different hypothesis(es) to evaluate one of the WeDRisk modules. The idea behind this experiment is to present (inject) some distribution and none distribution risky situations and then asking the subjects to deal with these risky situations. Based on the evaluation needs the subjects could be divided into control and experimental groups. Experimental group subjects use the WeDRisk modules to deal with the injected risky situations; whereas, control group subjects depend on their knowledge and experience [1].

The experiment methodology was chosen to evaluate the WeDRisk modules due to the following reasons [15], [12]:

- To emulate the same working environment for all the subjects.
- Many observations, measures and support works need to be done or provided during the evaluation of the modules and the experiment is the best option for that.
- It is good for focusing on specific variables, measures, and the relationships between them with extra flexibility in asking questions.
- Novelty of the evaluated modules, so that we could not find suitable data set form the previous approaches that can be used to evaluate these modules. Also due to the imposed restrictions on data by the developers. However, there are some limitations associated with the use of the experiment technique, which, are pointed out under limitations section.

B. Experiment Scope

This experiment is mainly designed to evaluate three WeDRisk modules (estimation, customization and atypical).

C. Questions and Hypothesises

The experiment is mainly designed to answer the following three questions [1]:

Q1: What is the coverage and consideration of WD factors by the WeDRisk approach?
Q2: How easy is it to understand and use the WeDRisk approach?
Q3: How usable and helpful are the evaluated modules?

In order to answer these questions, five hypothesises were tested in this experiment to evaluate the three WeDRisk modules (estimation, customization and atypical). Hypothesises H1 and H2 were used to evaluate the estimation module, which are:

H1: The TREV equation is an ideal option to estimate the WD development risks and to consider the WD factors compared with the RE equation.
H2: The WDF estimation matrix is useful, understandable and helpful to estimate and consider WD factors.

TABLE I : WDF ESTIMATION MATRIX [1]

	Factors Levels				
WD Factor	***1**	***2**	***3**	***4**	***5**
Sites Dependency Level n=1	NO Dependency (D)	Low D. Affects One Node	Medium D. Affects One Node + It is Cross D.	High D. Affects Multi Nodes	Very High D. Affects Multi Nodes + it is Cross D.
Sites Distribution n=2	1 site	>1 site but in the same city	Sites are in different cities but at the same country	Sites are in different countries but at the same continent	Sites are in different cities, countries and different continent
Communication Availability n=3	Excellent 24/7/12 available, excellent history and infrastructure	Good Go od History and infrastructure. Very rare to face problems	Acceptable The history and infrastructure are fine but there is a very small chance for problems	Bad Faces problems from time to time and either the history or infrastructure are bad	Totally Unavailable Currently not available and both the history and infrastructure are very bad
Sub Totals = (No. of Ticks * Factor Level)					
WDF =	$\sum SubTotals$				

D. Related Work

WeDRisk approach has been developed to manage WD risks and to tackle some of the existing approaches weaknesses. A number of evaluation cycles including case studies, experts and experiments [8] were conducted to evaluate the usefulness and usability of WeDRisk approach and its coverage to the WD development RM needs. The design (e.g. hypothesis, subjects selection, data collection, biases avoiding, validation, procedures tasks and instructions) of this experiment is inspired by the design of some software engineering experiment and empirical studies and evaluation techniques in [9], [11], [12], [13], [14].

E. Method

The method of this experiment can be summarized as follows:

1) Apparatus: The apparatus that were used in this experiment include normal stationary, hard copies of the experiment material, data collection forms and sport watch. A computer was used for data saving and Minitab tool was used for statistical analysis purpose.
2) Materials: Hard copies of all required information and forms were prepared and provided on equality base for all the subjects.
3) Subjects: We recruited by email about 35 subjects to participate in this experiment. Of these the researcher selected 24 subjects to participate in this experiment as they met the conditions (experience and knowledge in software development). The subjects were researchers, PhD student at School of Computing Science/Newcastle University, some visitor students and researchers at Center for Software Reliability - Newcastle University. The subjects either they were involved in software projects or had at least attended software engineering courses.In order to improve the design of the experiment a pilot study was carried out before starting the real experiment sessions. The pilot study was conducted using another group of participants. A number of issues were addressed and improved for the real experiment including; tasks required time estimation, tasks sequence, instructions to subjects, data collection procedure and risky situation design.
4) Data Confidentiality: All subjects' bibliographic data and the collected data are confidential to the experimenter and his supervisor. The only use of the data is for the research purpose.All subjects were given reference names and their actual data is just used for providing the 10 Amazon vouchers as compensating for their time.
5) Variables: The dependent variable of this experiment was the injected situations whereas; the independent variable was the subjects' reactions.

6) Measurement Units: Table II defines the measurement units, which are used in this experiment.

TABLE II: EXPERIMENT MEASUREMENT UNITS

Unit	Definition	How it is measured
Used Time	A duration of time that spent to implement as specific task	Difference between starting time and ending time of the task implementation
Effort	The exertion spent to implement a specific task or achieve the goal	Observations, used time comparison, asking specific questions, feedbacks and tries to implement the task

F. Injected Risky Situations

Emulating the management of WD development risks in this controlled experiment was not easy task. In this regard, we tried carefully to design a number of risky situations to inject them during the running of the experiment phases with consideration to:

- The situation should cover the evaluation aspects of the modules.
- It can be reused to evaluate more than one module.
- Working independently (standalone).
- It should reflect the real risky situation as possible as can.
- It should be simple, self-explanation, consistent and understandable.
- It must be short to avoid any boring and wasting time.

For these purposes the designed situations were tested many times and improved based on the comments and notifications taking into the account the reading time. Generally, the evaluation of the modules is almost independent operation. Only the injected situations were shared (to reduce the reading and understanding time) without any considerable affect on the evaluation operation. Therefore, in order to avoid any biases the situations were injected randomly with a time gap between them. The injected situations covered collocated development and WD development and they were given reference numbers for the use during the experiment stages.

G. Generalization and Threats Validity

1) Generalization: A number of measures have been taken in order to make the experiment sample reflect the real population of real WD development. Mainly, the selected sample was concentrated on a set of subjects who are working or worked in the field of software development or have attended software engineering courses. In fact, all of the recruited subjects were either software researchers who are working in WD software development projects or PhD students who are involved also in software researches and had experiences in related projects. The selected sample of subjects is intended to reflect the real software projects. However, it is costly and almost impossible to cover all software development population in this experiment. Different evaluation techniques were used to evaluate the WeDRisk approach including case studies, other experiment and expert evaluations in order generalize as much as can.
2) Validation: The experiment validity is an important issue to insure the quality and generalization of findings. Two types of validity are involved in this experiment. Internal validity, which is concerned with the study supports to the findings and the external validity which is concerned with the generalization of the results [9], [10]. The threats to internal

and external validity are addressed and taken into account as follows:

- Internal Validity

Selection: The assigning of the subjects to the experimental and controlled groups were done on random bases, as well as the risky situation were also injected randomly.

History: The subjects were selected from the same place, therefore, in order to reduce the influence affect we recruited and contacted them individually and they performed the tasks individually in different times.

Motivation: As the implementation of the tasks does not take a long time, so that there was not much concern about boredom or losing of enthusiasm during the experiment.

Time: It is expected that the subjects might perform the tasks in harry, as they afraid that the time is not enough which could affect the taken decisions and the results. Thus, in the pilot study we estimated the required time for the experiment and we informed the subjects about the estimated time when they were recruited to consider that. Moreover, during the experiment, they have been told to take enough time when they perform the tasks and also they can stop if they are not willing to continue.

Training: Before performing the tasks in the experiment, a brief description is given to the subjects. Moreover, enough clarification and training were provided before each section of the experiment. Also the subjects have been told that they have the right to ask any questions during the experiment.

- External Validity

Subjects: The difficulties of generalizing from students to professionals have been taken into account. Therefore, the subjects were mixed (students and researchers) who work in software projects. In fact, the use of students as subjects in this experiment may not have that threatens since most of the students were PhD students who had experience with software projects and have almost some sort of professional abilities.

Tasks: We tried to reduce the number of tasks as much as possible. Environment: The experiment environment tried to emulate the real development environment (developer, place, project and risks).

H. Controlling Measures

The controlling measures in the experiment were taken in order to reduce the involved biases and keeping everything the same except the tested variable. They are also to make the experiment ready for any replication. The controlling measures include the following aspects:

Environment: The environment was controlled because we want to record the time consumption individually, avoid the affect of subjects on each other, provide the help on equality bases, observe subjects progress during the tasks implementation, to give the same chances of time and support to all of the subjects.

Injected Situations: The same injected situations were used by all of the subjects but in random order and using reference numbers. The injection of the situations is controlled by the experimenter to avoid any biases.

Tasks Sequence: The sequence of tasks is maintained by the experimenter during all experiment stages, but if any subject refused to continue at any stage then there won't be any affect on the other stages and the data from the implemented stages can be considered as a part of the experiment result.

Provided Support: All of the essential information, support and training material were provided on equality bases.
Control Group: The control group were used in this experiment as a part of controlling measures and for results comparisons.

I. Experimenter and Subjects Tasks
At the beginning of the experiment, the experimenter gave a brief description about the experiment stages and assigned tasks, and then the subjects read, filled and singed the consent from. After that the experimenter requested the subjects to understand and perform the assigned tasks (e.g. reading the injected risky situation and using the provided modules) and also asked them to be accurate as they can. The subjects were also told that they have the right to ask any related questions to get the required clarification and they have the right to stop at any time if they are not comfortable. At the end of each section the subjects were asked to give their feedbacks and provide any suggestions or comments that could improve the desired module. Generally, during the experiment the experimenter has to do other tasks which include:

- Providing the training, related material and required support on equality base
- Injecting the risky situation on random base.
- Managing tasks sequence during the experiment.
- Collecting the data, observing experiment progress, assigning the tasks and recording the time. Distributing the subjects into control and experimental groups (on random base).

Subject tasks: In additional to the common subjects tasks (e.g. reading and signing the consent forms), the subjects have to perform some specific tasks to evaluate the modules, which include: specifying a suitable estimation equation (RE or TREV) for each injected risky situation and then using that equation to estimate the involved risk.

J. Biases Avoiding

Biases are always expected in any experiment, following are the measures that were taken to avoid the potential biases during this experiment:

- Randomizing the subjects grouping and the risky situations injection.
- Providing the required information, material and support on equality base.
- In order to avoid any subjective answers, the subjects were implemented the tasks without any time pressure.
- All of the subjects were able to clarify and ask any related questions and get the needed answers.
- The subjects and injected situations were given reference numbers to avoid the consequence of remembering them.
- The subjects have freely expressed their comments and suggestion at the end of each module evaluation.

K. Procedures

This section describes the experiment design and the procedures to evaluate the estimation module. All the tasks were implemented individually by the subjects (one subject in each session).

Three main tasks that were performed by the subject in this stage (specifying a suitable estimation equation, estimating the involved risk using that equation and giving a feedback). These tasks are described in details below:

I) Specifying a Suitable Estimation EquationFour prepared risky situations were randomly and individually injected by the experimenter. Then the subjects were asked to specify which estimation equation (RE or TREV) is suitable to deal with each situation. The subjects read the injected situations and based on their understanding and experience indicated a suitable estimation equation to estimate the involved risks. Regardless, the selected equations, the subjects were also requested to justify their decisions by writing down the reasons behind their selections. The experimenter monitored the implementation progress of this task and recorded the time that used to take each decision. After the implementation of this task the subjects were asked to declare any comments or suggestions about the equations.

II) Estimating Using the Specified EquationSince the estimation equation is specified for each risk, the next step is the risk estimation using the specified equation (RE or TREV). Thus, if the decision is the RE equation, then the subject needs firstly to estimate the probability and magnitude of the risk and then apply the ordinary RE equation to estimate the risk. On the other hand if the decision is the TREV equation, then the subject estimates the total WDF value for the risk before using the TREV equation to estimate the risk. The implementation details for the both equations (RE and TREV) are provided below:

- RE Equation (Eq. 1): In order to estimate the RE value (Eq. 1), the subject needs to read the injected risky situation first and then uses the line estimation technique (Figure 2) to estimate the probability and magnitude for the involved risk. Based on his ranking on the lines he can obtain the associated values for the probability and magnitude. Subsequently, RE is obtained by multiplying the probability and magnitude values (see Eq. 1). The minimum value of RE is zero, which happens only when there is no any chance for the risk to be occurred and the maximum is five when the risk is certain and its magnitude is severe.

- TREV Equation (Eq. 2): Before applying the TREV equation the subject needs to estimate the RE value using the same above technique and then estimates the second part of TREV equation, which is the ∑WDF (see Eq. 3) (the second part of TREV equation) using the WD estimation matrix (See Table I on page 3). Subsequently, the subject applies the TREV equation to get the TREV estimation for the desired risk.

$$\sum WDF = \sum_{n=1}^{3} (ColTicksNo * Factor - Level\ n) \qquad (3)$$

Where, n is the number of WD factors
ColTicksNo is the number of ticks in each column
Factor-level is the rank of the WD factor during the estimation time

Subsequently, the subject applies the TREV equation to get the TREV estimation for the desired risk.

III) General Feedback

Once the estimation task is completed for the four injected risky situations, then the subject is requested to give his feedback about the estimation operation in general. Four guided questions are designed for this purpose (see Table V). The subject can also write any comments or suggestions that might help to improve the estimation module.

L. Result and Analysis

Hypothesis H1 is used to evaluate the estimation module as following:

Hypothesis H1: The TREV equation is an ideal option to estimate the WD development risks and to consider the WD factors compared with the RE equation.

Three tasks were implemented by the subjects to test hypothesis H1, which are; specifying a suitable estimation equation (RE or TREV), justifying their decision and giving a feedback regarding the suitability of TREV or RE for the WD development. As can be seen in Table III, the result demonstrated that there is a consensuses in the taken decisions (e.g. for the situation number 6004 there were 17 subjects agreed to use the RE against only 6 for TREV and for the situation referenced 0901 there were 22 subject agreed to use TREV against only 1 for RE). Chi-square is a test that used to determine whether there is a significant difference between two or more frequencies in one or more categories. Therefore, Chi-Square (x2) test is used and as a result there is an evidence to support that the proportion of subjects who selected RE equation in situations numbered 6004 and 1072 is significant higher than the subjects who selected TREV equation in the same situation with Chi-Square (x2) of 23 with p-value of 0.001 (<0.05). In contrast, it is the opposite in situations numbered 0901 and 8033, the number of subjects who selected TREV is significant higher than the subjects who selected RE. In fact, the result complies with what we have expected regarding the suitability of RE or TREV equations for each situation. Generally, the time that was used to decide what type of estimation is suitable for the situations was slightly higher in some situations due to the differences in text long. The justifications of the subjects' decisions (see Table IV) are concentrated on the number of sites, involvement of WD factors or complexity of the situation. They justified the selection of RE with; it is a single site or less involvement of WD factors or

simplicity of the situation and the opposite is correct for the TREV equation.
The subjects were asked (To what extant do you agree that TREV is more suitable than RE for WD risks estimation?). As can be seen in Table V the result showed that most of the subjects were agreed or strongly agreed with the suitability of the TREV equation for the WD development risks. Meanwhile, the subjects are also agreed that WD factors should be considered at the estimation of the WD development risks.

Hypothesis H2: The WDF estimation matrix is useful, understandable and helpful to estimate and consider WD factors.
The consensuses of the estimated WDF values, subjects feedbacks regarding the usefulness, helpfulness and ease of use of the matrix,

TABLE III: SUMMARY OF ESTIMATION DECISION (RE/TREV) [1]

Situation No.:	**6004**	**0901**	**1072**	**8033**
RE **TREV**	17 6	1 22	5 18	19 4
Avg. Used Time	22.0	27.9	32.8	28.0

TABLE IV: RE/TREV DECISION JUSTIFICATIONS SUMMARY [1]

Justifications for RE	Justifications for TREV
Single site and no distribution **N**o involvement of WD factors **S**imple and RE is enough	**M**ulti Sites and WD factors are involved **C**omplexity of the situation and involved factors **T**REV gives more abilities

confusing or a need for support and experimenter observation parameters were used to test this hypothesis. The statistics calculations for the WDF estimated values for situation number 0901 illustrated that the mean is 12.455 and the median is 12.00, the standard deviation is 1.057 and the P-value is less than 0.05. This indicates that the data is very close together and the data clusters around the mean. Meanwhile, looking at the distribution of WDF for situation number 1072 as illustrated by statistical graphically summary (see Figure 3), we see that the mean is 10.611 and the median is 10.50. This indicates that the data is very close together, also the standard deviation is 1.145 and P-value is less than 0.05 indicating that the data clusters around the mean. Therefore, the WDF estimation for both situations (numbered 0901 and 1072) have demonstrated a highly consensus taking in the consideration that the values of WDF in the matrix are ranged from 3 to 15 (minimum of WDF is (3*1 = 3) when all of the selected options are at the first level, and the maximum of WDF is (3*5 = 15) when all of them are at fifth level).

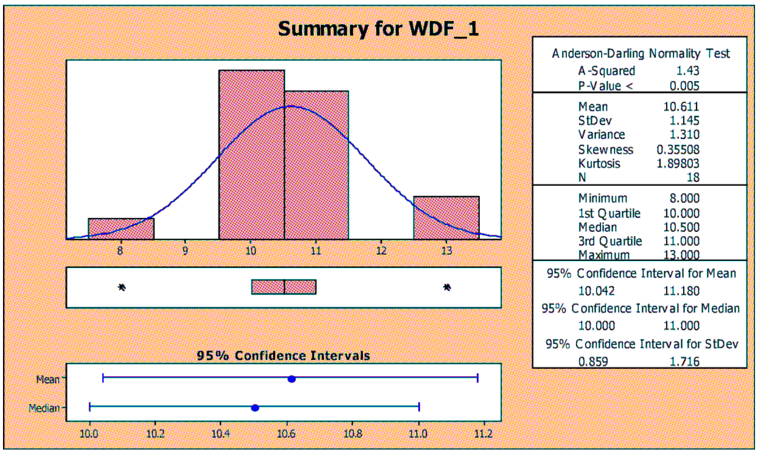

Figure 3: Statistics Graphical Summary for (WDF situation 1072) [1]

The estimated values of WDF (sites dependency, sites distribution and communication availability) for the two situations numbered 0901 and 1072 have also shown a highly consensus as statistics calculations exhibited. Figure 4 illustrates an example for statistics graphical summary for the sites distribution factor estimation of the situation number 1072.

Generally, the average time used for the estimation using the TREV equation was 3.069 minutes which is acceptable and was not so high compared with the average time of using RE equation, which is 1.375, taking into the account that in TREV case, the estimation includes additional WD factors estimation and extra calculations.

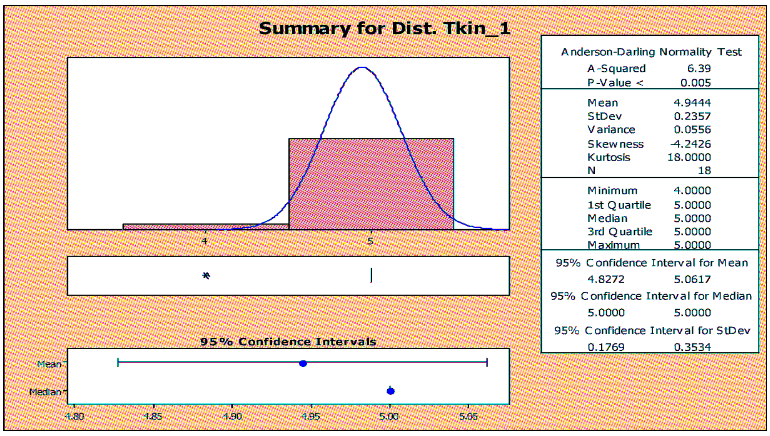

Figure 4: Statistics Graphical Summary for (Sites Distribution 1072) [1]

At the end of this evaluation stage, the subjects were asked to give a general feedback about the estimation module by answering some guided questions and also providing their suggestions and comments to improve the module. Table V summarizes the answers and the feedbacks regarding the WD factors, TREV equation and the support matrix. The subjects were asked to rate the usefulness of the estimation matrix, 17 subjects were responded. Their answers as showed in Table V were ranged from Useful to Very Useful with percentage rate (29.4%) for Useful, (52.9%) for Very Useful, (17.6%) for Strongly Useful and the other options (Not Useful and Somewhat Useful) have got (0%) of ticks. The next question was about the ease of use of the matrix to estimate the WDF which was answered by 23 subjects. As Table V illustrated the answers were asserted on the ease of use of the matrix. The values as shown on the table were rated as (0%) ticks to Difficult and Somewhat Easy, (13%) for Moderate, (52.1%) for Easy and (34.7%) for Very Easy. The subjects were agreed with including of the WDF at the estimation of WD development risks with percentage rate (59.0%) for Strongly Agree and (40.9%) for the Agree option and (0%) for the rest of the options (Neutral, Disagree and Strongly Disagree). The subjects has showed their support to the included factors as they did not criticize the three factors; however, some of them suggested to include other factors as can be seen in Table V.

4. DISCUSSION

The estimation module was evaluated in this controlled experiment. For the simplicity purpose the experiment was designed with a very minimum of dependency so that the evaluation of each module can be conducted individually and without any affect on the evaluation of other modules. The evaluation aspects include; ease of understand and use, usability and the usefulness of the modules. The result of the experiment was used to explore what sort of improvements that need to be made on the WeDRisk modules.

Hypothesises H1 and H2 were tested to evaluate the estimation module. Experiment result regarding these hypothesises is discussed below:

Hypothesis H1: The TREV equation is an ideal option to estimate the WD development risks and to consider the WD factors compared with the RE equation.

TABLE V: EVALUATION FEEDBACK FOR THE ESTIMATION MODULE

To what extent do you rate the usefulness of WD Factors estimation matrix?				
Not Useful	Somewhat Useful	Useful	Very Useful	Strongly Useful
0	0	5	9	3
How easy the use of the WD factors estimation matrix?				
Difficult	Somewhat Easy	Moderate	Easy	Very Easy
0	0	3	12	8
To what extant do you agree that TREV is more suitable than RE for WD risks estimation?				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
8	12	2	0	0
To what extant do you agree that WD factors should be included at W-D risks estimation?				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
13	9	0	0	0
Any other WD factors that should be considered: - Reliability of the sites - Sites local communications - Used methods and technologies compatibility across the sites - Geographical or environmental phenomena				
Any comments / suggestions: - It is easy to learn and use, clear and gives a quick result - Lack of finance information consideration - Estimate sites risks individually and then combine the overall sites estimations - The formula (WD/TREV) works well depending on how much information provided for each scenario - Use different guidance for TREV (big company risks different from small company risks)				

The result of the experiment regarding this hypothesis implies the following two points:

I) Experiment result exhibited a consensus in subjects' decisions regarding the suitability of RE and TREV for each injected situation and it came as what the experimenter has expected. The subjects justified their decisions (see Table IV) with the simplicity, not involvement of WD factor or the situation is single site for the RE selection and they justified the TREV selection with complexity, multisite or involvement of the WD factors. From the result, it can be understood that the subjects have decided to use RE equation for none WD development situations and TREV equation for the WD situations.

II) The subjects were agreed or strongly agreed that the TREV equation is more suitable than RE equation to estimate the WD development risks.

Therefore, based on the above result it can be concluded that hypothesis H1 has got a very strong support from the experiment result.

Hypothesis H2: The WDF estimation matrix is useful, understandable and helpful to estimate and consider WD factors.

The evaluated matrix involves three WD factors (sites dependency, sites distributions and communication), which could have an effect on the WD development risks. These factors are not final and one of the evaluation aims is to explore if they need to be modified or if there is any other factors need to be considered. In this regard, as the result showed in the previous section the matrix has helped the subjects to estimate the risks with consideration to the involved WD factors. The matrix was easily used with negligible confusing and with highly understanding and it gave consensuses result. Some subjects were argued to add some other factors to the matrix (e.g. reliability of the sites; sites local communications; used methods; technologies compatibility across the sites and geographical or environmental phenomena). However, the factors that should be included in this matrix are the ones which have an effect on the risks, but not the risks themselves. Therefore, the above suggested factors and others could be revised and added to the matrix if they comply with the WDF factor definition. Changing and modification of the matrix factors is easy task and the matrix could be used in other types of software development with some changes.

Based on the consensus in the estimated WDF values as it is demonstrated with situations 0901 and 1072, the positive feedback regarding the usefulness of the matrix, ease of use of the matrix, suggestions and comments regarding the matrix as described above and also the experimenter observations it can be concluded that the hypothesis H2 has got a strong support in this experiment. Meanwhile, observation, suggestions and discussions regarding the TREV equation during the experiment stages exhibited that there is an ability to use the TREV equation for other types of software development risks, if the factors (the ones which affect the risks) of those types are identified and considered. A good issue with this matrix is that if any of the WD factors is not included in desired development, a default value " 1" will be given to that factor, which has no effect on the result. Finally, from the experiment result, it is obviously there is a chance to generalize the TREV equation and upgrading the matrix by including different factors when there is a need.

5. LIMITATIONS

Although in this controlled experiment we tried to emulate real risky situations in order to evaluate the WeDRisk approach, but there is a number of limitations associated with this experiment. Some of these limitations are general and related to the use of experiments method and some others are specific to this experiment. Hereafter, the involved limitations:

- The experiment running cost is high so it limited the number of subjects; therefore, the experimenter tried to tackle that by focusing on involved subjects type.
- Sometimes the samples in the experiments do not reflect the real population, but in this experiment most of the subjects have an experience in software projects via their work, study or research backgrounds.
- Usually experiments are affected by biases. In this experiment a number of measures were taken to avoid and reduce the involved biases.
- It is preferred if the subjects were from distributed software industry, but due to time limitation and imposed data restriction we could not.
- Due to the experimenter ability limitation at the experiment running time, the subjects were participated individually (one by one) in order to ensure providing needed support, observing tasks implementation and recording tasks implementation used time.

6. CONCLUSION AND FUTURE WORK

The rapid and evolved web and distributed development face many specific challenges and risks. The existing software risk management approaches are not able to accommodate these challenges and risks.

Existing approaches either they are designed for the collocated development type or they have many weaknesses. In this paper we presented an approach called WeDRisk, which is designed mainly to manage the web and distributed software development risks. The WeDRisk approach aims to address the weaknesses of existing approaches to risk management. It is flexible approach and able to deal with the rapid evolution nature of the web and distributed developments. This paper also described the design, execution and analysis of a controlled experiment that has been used to evaluate some central parts of the approach (Estimation module is one of them), in terms of their usefulness, ease of understanding and usability. Many reasons lead to conduct this controlled experiment such as:

- The novelty of the evaluated modules, so that we could not find suitable data form pervious approaches that can be used to evaluate the WeDRisk approach modules.
- Due to developers data restrictions, we could not find a suitable case study to evaluate the WeDRisk modules.

Finally, as described and discussed above it can be concluded that estimation module has successfully and effectively dealt with the injected risky situations. The experiment result illustrated how this module covers and considers the web and distributed factors and it is useful, understandable and easy to use. The experiment result exhibited that there are some improvement could be done on the modules which came in terms of suggestions, observations or form result analysis (e.g. TREV equation can be generalized and used to estimate risks in other types of software developments.

ACKNOWLEDGMENT

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The Effect of Nafion Ionomer Equivalent Weight (EW) on Polymer Electrolyte Membrane Fuel Cell Catalyst Layer Performance

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Abstract

Nafion ionomers with different Equivalent Weight (EW) 1000, and 1100 were incorporated with 4 mg/cm^2 commercial Palladium supported carbonof a 30% Pd/C (ETEK) catalyst, in the Polymer Electrolyte Membrane(PEM) fuel cell catalyst layers and their effects on the catalyst layer optimization and performance were evaluated by measuring the PEM fuel cell *i–V* characteristics. The results showed that, for 4.0 ± 0.1 mg/cm^2 of 30 % Pd/C loading, the optimum value Nafion ionomer percentage in the catalyst layer is 33 wt.% and this value is not change with the Nafion ionomer equivalent weight. Furthermore, it is possible to get high performance in PEM fuel cell under higher temperature (85°C) by employing the ionomers with 1000 EW.

Key words: PEM fuel cells, catalyst layer Performance, Renewable Energy, Nafion Equivalent Weight, Polarization Curve**.**

1. Introduction

Catalyst layer (CL) is one the key components for achieving a high performance with reducing costs of a polymer electrolyte membrane (PEM) fuel cell. The structure and elemental distribution of the composition in the catalyst layer determine a fuel cell efficiency, precious catalyst loading and a fuel cell durability [1-9]. The catalyst layer is a heterogeneous porous composite structure of carbon aggregations (electronically conductive), ionomer (transporting protons), catalytic nanoparticles to promote the electrochemical anodic hydrogen oxidation and/or the cathodic oxygen reduction. The Nafion ionomer incorporated in the catalyst layers acts both as a binder and a proton conductor and it should be moisturized properly to maintain its proton conductivity. Therefore, the membrane electrode assembly (MEA) hydration is a necessary step to maintain the protonic conductivity between the catalyst layer and the electrolyte membrane due to the presence of Nafion ionomer in their composition. The water uptake capability of the ionomer material is dependent on its equivalent weight and it could therefore influence the catalyst layer performance. The equivalent weight is defined as the weight of dry polymer in grams containing one mole of exchange sites [10-12]. It was reported that the ionic conductivity and water uptake capacity of the recast membrane with EW 1000 were 0.11 S/cm and 45 %, respectively, the values being about 1.1 and 1.3 times higher than those of the membrane with EW 1100 [13,14]. The better electrochemical properties of the recast membrane with EW 1000 are due to the larger population of sulfonic acid groups (about 1.1 times) in the ionomer than that of the membrane with EW 1100. The main objective of the present study is to evaluate the impact of the equivalent weight (EW) of Nafion ionomer on the performance of catalyst layers that include in PEM fuel cells using the *i*-V polarization curve under varies temperatures.

2. Experimental

Membrane Pre-treatment

Before being used in the membrane electrode assembly (MEA), the polymer electrolyte membranes made of Nafion 1035 (Sigma-Aldrich UK, 89 µm thickness, and 1000 EW) with a 3 cm diameter, were washed in various solutions to remove trace organic and inorganic contaminants and to change their form. The pre-treatment procedure involved boiling the polymer electrolyte membrane in 3 wt% aqueous H_2O_2 solutions for 1 h at 85-90℃, followed by boiling for 1 h in deionised water at 85-90℃, and subsequently boiling for a further 1 h in a fresh sample of deionised water. The membrane was then boiled for 1 h in 0.5 M H_2SO_4 to get a fully H^+-form exchanged membrane. After that, the membrane was boiled for 15 min. in pure water at temperature 85-90℃ to remove the remaining H_2SO_4 on the surface of the membrane, followed by storing in fresh deionised water until use.

Catalyst Layers Preparation and Membrane Electrode Assembly (MEA)

Catalyst inks were prepared by mixing 4.0 ± 0.1 mg/cm^2 of Palladium supported carbon (30% Pd/C, ETEK) with 5% Nafion_ solution (EW 1000, Solution Technologies, Inc., PA), and glycerol (Fisher Scientific, NJ). Different Nafion amount was used according to the calculation. The inks were ultrasonicated for 30mins and stirred vigorously overnight to achieve a uniform suspension. The formed catalyst ink was brush painted onto a 50 cm^2 Teflon discs. After painting the decals were left into dry air at room temperature for 30 min., and then weighed. The process of painting and drying was repeated until the desired catalyst loading was reached. The membraneelectrode assembly (MEA) was prepared by placing each pairs (cathode and anode) catalyst layers at both sides of the pre-treated Nafion 1035 membrane, followed by hot-pressing at 140℃ and

200 atm for 2 min. The formed MEA’s were then hydrated by boiling them in 0.5 M H_2SO_4 for 1 h, followed by boiling in pure deionized water for 10 min., with excess water subsequently being removed. When the catalyst layer is poorly bonded to the SPE, the catalyst particles detached during the boiling. Finally, the MEA was dried on a heated vacuum table at room temperature for 120 minutes.

Fuel cell Assembly and performance measurements.

PEM fuel cell was assembled by placing the MEA in a single cell test fixture (Electrochem Inc., USA) and connected to fuel cell test station (Nara Cell Tech Corp., Korea) provided with gas humidifier, mass flow controller, temperature indicator-controller etc. The current–voltage (*i*–V) characteristics of the cell was evaluated, using hydrogen and oxygen reactants at 1 atm, at 85 °C using HPCS1 high power potentiostat/ galvanostat along with WBCS3000 battery cycler system (WonA Tech., Korea).

3. Results and Discussion

Fuel cell catalyst layers with a palladium loading of 4.0 ± 0.1 mg/cm^2 of 30% Pd/C were prepared with different Nafion ionomer (EW 1000) weight percentage ranging from 20 to 40 wt.% and assembled with Nafion 1035 membrane to form membrane electrode assembly (MEA). The cells performance was evaluated at 85 ˚C, with humidified hydrogen-oxygen reactants, at 1 atm pressure and the results are presented in Figure 1. It can be seen that; the catalyst layer performance is very low at 20% Nafion ionomer content. The performance increases as the Nafion ionomer percentage increased from 20 to 33%. Further increase to 35% Nafion content results in decrease in performance.

A new set of PEM fuel cell catalyst layers with the same palladium loadings of 4.0 ± 0.1 mg/cm^{2}Pd/C and different Nafion ionomer (EW 1100) weight percentage ranging from 20 to 40 wt.% were prepared and assembled with Nafion 1035 membrane to form membrane electrode assembly (MEA). The performance of these catalyst layers, were tested with humidified hydrogen-oxygen reactants at 85 °C, and 1 atm pressureto find the optimum Nafion ionomer content. It was found that the best catalyst layer performance is obtained at 33 wt.%Nafion ionomer content in the catalyst layer as shown in figure 2. Thus, optimum Nafion ionomer percentage which is needed in the PEM fuel cell catalyst layer to get the maximum cell performance is not change with the Nafion ionomer EW.

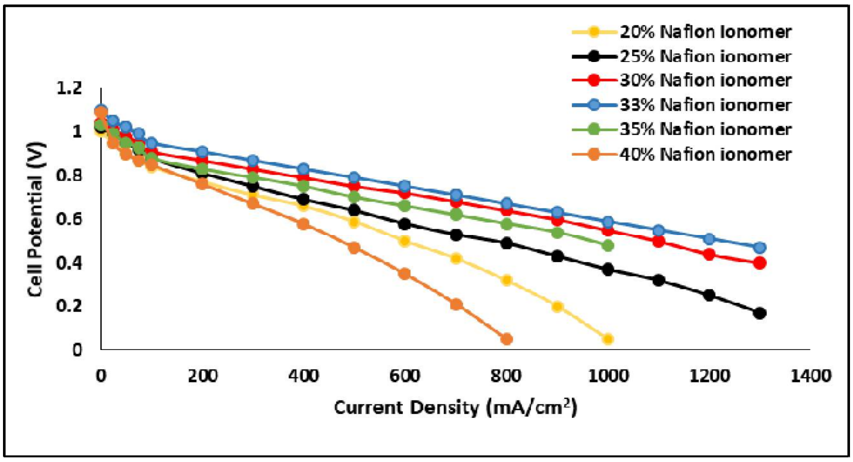

Figure 1: the current-voltage (*i*-V) characteristics of the catalyst layer with Pd/C of 4.0 ± 0.1 mg/cm^{2}and different Nafion ionomer (EW1000) contents, ranging from 20 to 40 wt.%, with humidified hydrogen-oxygen reactants at 85 °C, temperature and, 1 atm pressure.

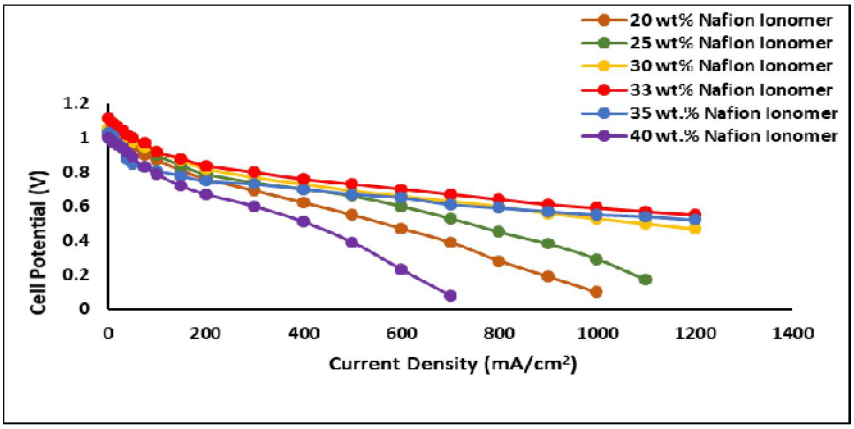

Figure 2: the current-voltage (*i*-V) characteristics of the catalyst layer with Pd/C of 4.0 ± 0.1 mg/cm^{2}and different Nafion ionomer (EW1100) contents, ranging from 20 to 40 wt.%, with humidified hydrogen-oxygen reactants at 85 $^{\circ}$C, temperature and, 1 atm pressure.

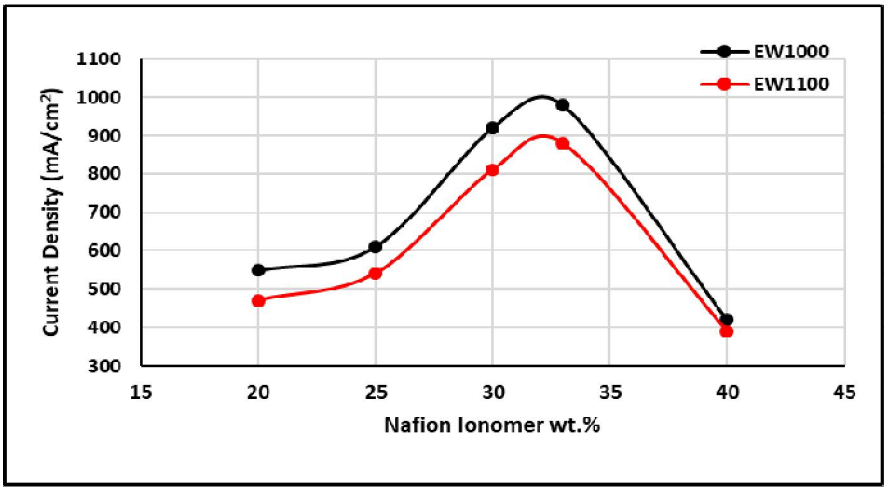

Figure 3, the effect of Nafion ionomer wt.% in the PEM fuel cell catalyst layer performance using Nafion ionomers of EW1000 and EW1100, at 95°C and 1 atm operating conditions.

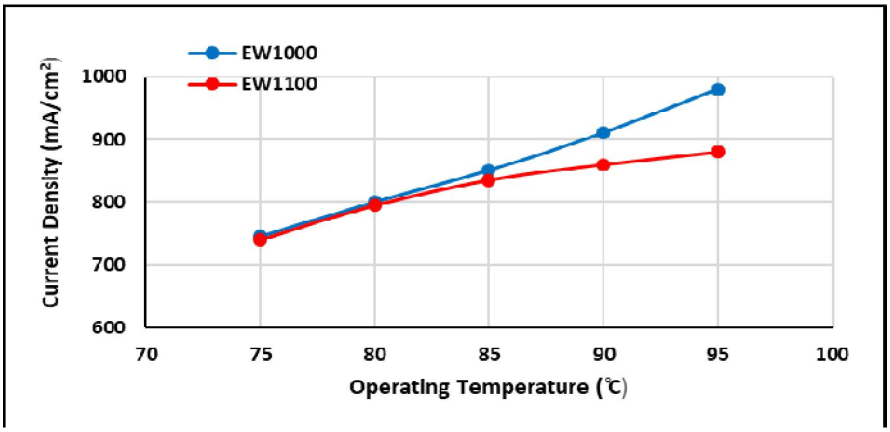

Figure 4: the effect of the cell operating temperature on the catalyst layers' performance with 4.0 ± 0.1 mg/cm2 30 % Pd/C and 33 wt.%of two different equivalent weight Nafion ionomers.

The same tests were carried out with humidified hydrogen-oxygen reactants at 95˚C and 1 atm. operating conditions, and the results are depicted in Figure 3. All the measurements were repeated at least four times at this temperature to confirm the reproducibility of the results. As can be seen in the figure, the optimum Nafion ionomer wt.% in the catalyst layer requirement does not change with the equivalent weight of Nafion ionomer used even at higher operating temperature. However, catalyst layers of EW1000 exhibit higher current density than that of EW1100. Figure 4. shows the effect of the cell operating temperature on the performance of the catalyst layers containing the same composition of 4.0 ± 0.1 mg/cm^2 30 % Pd/C and 33 wt.% of two different equivalent weight Nafion ionomers. The cells performance was evaluated at 1 atm pressure, with humidified hydrogen-oxygen reactants, and different temperatures ranging from 75 ˚C to 95 ˚C. The figure shows that at the temperatures below 85 ˚C, there was no appreciable difference in performance between two MEAs. However, at the temperatures 85 ˚C, the MEA with EW 1100 ionomer showed less performance than the MEA with EW1000. This behavior could be attributed to the ability and capability of the EW 1000 ionomer to capture and preserve moisture to maintain its proton conductivity under a sufficiently humidified condition [15]. This shows the effect of the lower EW ionomer (1000) which is more effective in preserving moisture and proton conductivity than the higher EW ionomer (1100).

4. Conclusions

The effects of equivalent weights of the ionomer involved in the catalyst layers on the PEM fuel cell performances have been investigated at different temperatures ranging from 75 ˚C to 95˚C and 1 atm operating conditions. Nafion ionomers with two different Equivalent Weight (EW) 1000, and 1100 were incorporated with 4.0 ± 0.1 mg/cm^2 of 30% Pd/C commercial Palladium supported carbon(ETEK) catalyst, in the Polymer Electrolyte Membrane(PEM) fuel cell catalyst layers and their effects on the catalyst layer optimization and performance were evaluated by measuring the PEM fuel cell *i–V* characteristics. The optimum value Nafion ionomer percentage in the catalyst layer requirement does not change with the Nafion ionomer equivalent weight. However, the effect EW1000 ionomer became more apparent as the cell operating temperature got far from 85˚C. This is because of the ability and capability of the EW 1000 ionomer to capture and preserve moisture to maintain its proton conductivity. In conclusion, it is possible to get high performance in PEM fuel cell under higher temperature (≈85˚C-95˚C) by employing the ionomers with EW1000.

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Direct Adaptive Control of DC Motor Using Radial Basis Function Neural Network

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Abstract

A variety of a non-linear complex system such as robotics and many other electrical systems require modeling and control. A direct adaptive control method is considered in this work for controlling of a DC motor system. The proposed direct adaptive control scheme is implemented in MATLAB and the simulated results show that the design requirements are achieved by using 10 radial basis functions with the optimum number of centres being determined by using K-means clustering algorithm. The optimum value for the learning factor is determined through simulation tests. Least mean square method is used to calculate the weight values for output layer for adaptive control scheme with radial basis function network. The direct adaptive control scheme provides a systematic approach for the automatic adjustment of controllers in real time, therefore, it can be used to maintain a desired level of control system performance when the system parameters are changing in time.

Keywords direct adaptive control, DC motor, radial basis function neural network, feedforward control.

1.INTRODUCTION

Radial basis function neural network (RBFNN) has a simple architecture consisting of one input layer, one output layer and only one array of hidden nodes called centers [1]. The training of the RBFNN is very fast because the learning in the hidden layer means selection of centers and widths and the learning in the output layer means selection of the weights [2]. The K-means algorithm is reliable, simple, offers fast convergence and can handle large data sets. But it is sensitive to the initial cluster centers meaning that average values of all objects in the same class are considered as cluster centers. The least mean squares (LMS) algorithm is the common algorithm which can be used to adapt the weights of RBFNN because of its simplicity and reasonable performance [1]. The RBFNN has good nonlinear function approximation ability so it is widely used to solve many problems related to modeling and control of nonlinear systems. The Euclidean distance method could be employed to measure the width of the Gaussian function, which is a positive constant that represents the standard deviation of the function [2].

The control of nonlinear systems using RBFNN studied, where the RBFNN has a good generalization, strong tolerance to input noise, and online learning ability. The properties of RBFNN make it very suitable to design flexible control systems. The main advantage of a direct adaptive control scheme over an indirect adaptive control scheme is that in a direct adaptive control scheme there is no need for explicit system identification. In indirect adaptive control scheme, the system is generally identified off-line from its input-output data and the controller is designed based on the identified system model [3].

The mathematical model of the speed control for the DC motor is developed and implemented in MATLAB. Then the proposed direct adaptive control scheme is implemented in MATLAB and simulations are used to determine the optimum values for the learning factor and number of RBFs which should be employed to achieve the design requirements [4-9]

2.RADIAL BASIS FUNCTION NEURAL NETWORK (RBFNN)

A. *Radial Basis Function neural Network Structure*

The RBFNN has a feed forward structure consisting of three layers as shown in Figure 1.

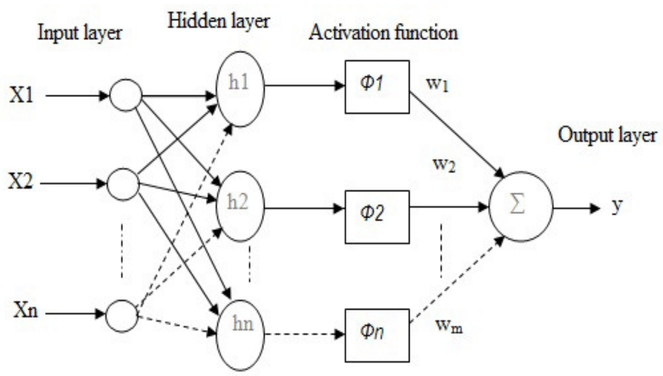

Figure 1: Radial Basis Function Neural Network Structure

The input layer passes the input data to the hidden layer. The hidden layer consists of an array of nodes and each node contains a parameter vector called a center. The output layer is only a set of weighted linear combinations of the activation function. The only adjustable parameters in the output layer are the weights.

The output vector y is given by:

$$y = \sum_{j=1}^{N} W_j \emptyset_j \qquad (1)$$

Where (W_j) is the weight of the (j^{th}) node and ($\emptyset_j$)is the activation function. The hidden node calculates the distance between the center and the RBFNN input vector, and then passes the result through the nonlinear activation function ($\emptyset$) to the output layer.

The Gaussian activation function can be written as

$$\emptyset_j(x) = exp \frac{-\sum_{j=1}^{n}(x_i - c_j)^2}{\sigma_j^2} \qquad (2)$$

i = 1,2,3,....,n , j = 1,2,3,....,m

Where ($\emptyset_j$) is the output of the (j^{th}) unit in the hidden layer, (X_i) is the input data to the network, (C_j) is the center of the j^{th} unit in the input space, (σ_j) is the width of the Gaussian function, (m) is the number of centers and (n) the dimension of the input space. The major requirement is that the function must tend to zero quite rapidly as the distance increases between the input X and center C. This can be assured by using the Gaussian exponential function.

The Radial Basis Function Network consists of three important parameters, centers (C), widths (σ) and weights (W). The value of these parameters is generally unknown and may be found during the learning process of the network. There are a variety of methods to allow the RBF network to learn. These processes are generally divided into two stages, as each layer of the RBF perform a different task: The first learning stage involves selecting the centers and the widths in the hidden layer, and the second stage is to adjust the weights in the output layer [1].

The major problem is how to select an appropriate set of RBFNN centers. To overcome this problem, the network requires some strategy for selecting the adequate set of centers, hence clustering algorithm have been used extensively. The objective of clustering algorithm is to categorize or cluster the data. The classes must be found from the correlation of an input data set. So, the clustering is a way of grouping similar patterns and separating dissimilar (different) ones. Assume there is a set of data to be used as input to an RBFNN and no information is known about the number of classes that may be present in this set. Clustering in such a case involving identifying the number of classes and assigning individual datum membership of these classes. The vectors in the same cluster are similar which means that they are close to each other in the input space. There are many clustering algorithms, but the most popular algorithm is K-means clustering algorithm [1]. The choice of subsets of data as centers for the radial basis function is a very important task, since network performance relies upon good generalization [1, 10]. The K-means clustering algorithm is used for selecting the number of the centers; this algorithm has been used in this work because of its simplicity and ability to produce good results, the basic steps of K-means algorithm shown in Fig. 2.

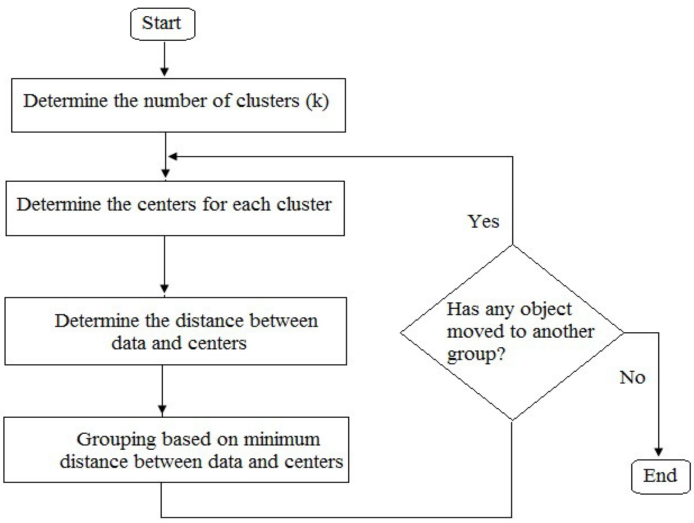

Figure 2: Classical K-means clustering algorithm

The next task would be the proper selection of the width between the centers. The width of the Gaussian function is a positive constant that represents the standard deviation of the function. RBFNN with the same σ in each hidden unit have the capability of universal approximation. The most common method used is the Euclidean distance measure [2]. This method is widely used because it is simple to calculate and more reliable. The shortest distance between vector *X* and vector *C* is the Euclidean distance which is defined as:

$$E_{dist} = \sqrt{\sum_{i=1}^{n} (Xi - cj)^2} \quad (3)$$

Where n the vector dimension, and Edist isthe Euclidean distance.

In this work the feed-forward neural networks was considered in direct adaptive controller by RBFNN, the network uses the input vector to produce the estimate actual RBFNN output $y(t)$ compared with the true desired output of the network $y_{d(t)}$to generate an error vector e(t). If there is no difference, no learning takes place; otherwise, the weights are adjusted to reduce the error [6]. The Least Mean Squares rule for adapting the weights can be written as:

$$W_j(n+1) = W_j(n) + \mu\left(y_d(t) - y(t)\right)g_j(n) \quad (4)$$

$j = 1,2,3,\ldots,H,$ *and* $n = 1,2,3,\ldots,N.$

Where *H* is the number of centres, *N* is the number of inputs to the network,*y(t)* is the output of the RBFNN,$y_d(t)$ is the desired output of the network, $g(n)$ are the Gaussian output, $W_j(n)$ are the previous weights originally set to zero, $W_j(n+1)$ are the updated weights, and μ is the learning rate, where $0 < \mu \leq 1$ is a positive gain factor term that controls the adaptation rate of the algorithm.

The adaptation algorithm described by equation (4) is illustrated in Figure 3.

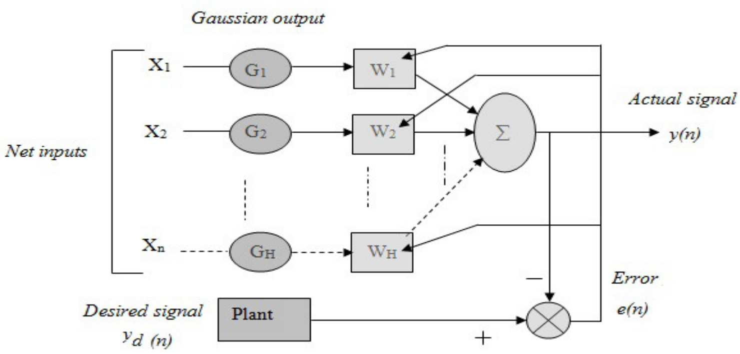

Figure 3: The adaptive LMS algorithm [6]

The training process of LMS algorithm consists of the following steps:

- Apply the input vector *(X)* from the training data set to the input layer.
- Compute the output of the hidden layer.
- Compute the RBF network output vector *(y)*. Compare this to the desired vector (y_d), and then adjust the vector W so as to reduce the difference.
- Repeat steps 1 to 3 for each vector in the training set.
- Repeat steps 1 to 4 until $(y - y_d)$ tends to zero or other terminating conditions occur (in our work until the speed of DC motor reached to 1 rad/sec).

K-means clustering algorithm is used to resolve cluster problems because this algorithm is simple and fast for large data collection. Fig.4 shows the steps of chose the initial cluster centers by using K-Means [11, 12, 13].

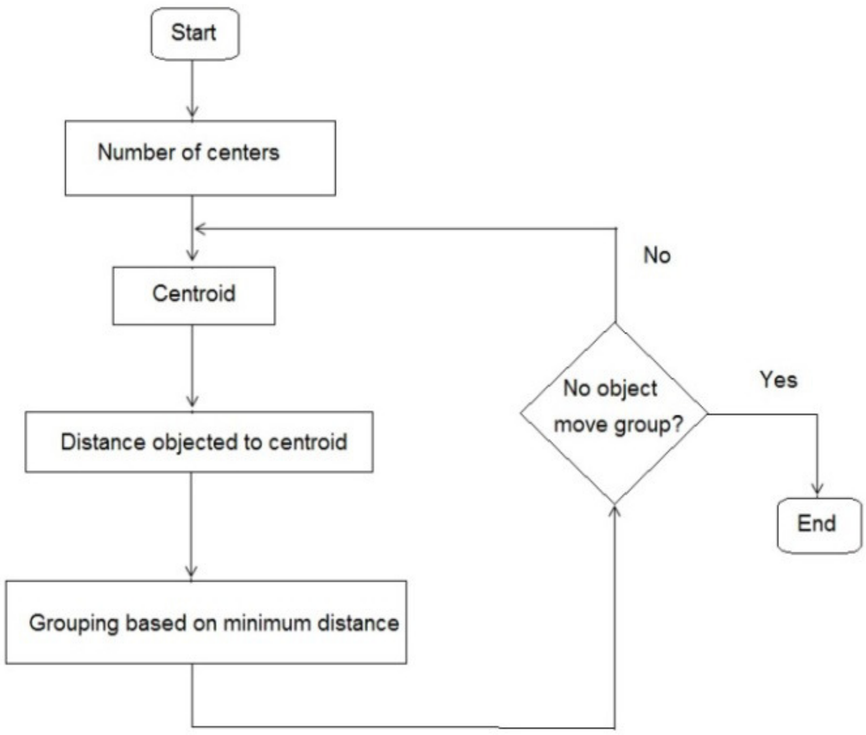

Figure 4:K-means clustering algorithm

3.DIRECT ADAPTIVE CONTROL USING RBFNN

A direct adaptive control (or the on-line) method is used to overcome the problems associated with the off-line approach. In this method, the neural network learns during the on-line feed forward control period [1, 2, 14]. As shown in Fig. 5, the controller network is placed in front of the plant, whereby the net output control signal $Uc(t)$ is an input to the plant.

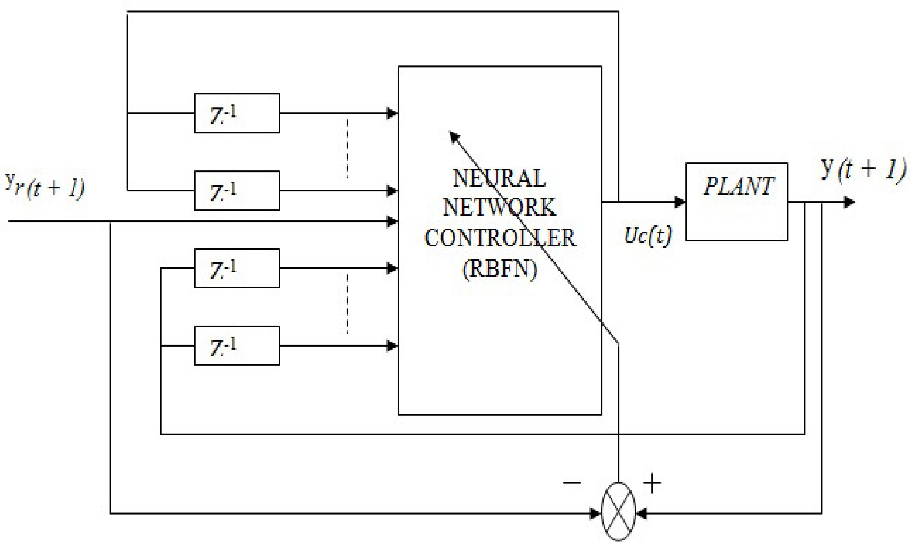

Figure 5: Direct adaptive control configuration using RBFNN

The control signal can be realized as:

$Uc(t) = RBFNC[X(t)]$(5)

Where:

The desired reference signal y_r *(t + 1)* was used instead of the unknown y *(t + 1)*, this can be rewritten as:

$$X(t) = [y_r\,(t+1), y(t), \ldots., y(t-n+1), U(t-1), ., U(t-m+1)]^T \quad (6)$$

During the training of the network, the centers are assumed selected, presumed to have been prior to training and are given as:

$$C_{ji} = [C_{11} C_{12} \,\ldots\ldots. C_{1n}]^T \quad (7)$$

$i = 1, 2\ldots n$ & $j = 1, 2\ldots m$

Where n is the network input space dimension and m is the number of centers (hidden units) with $m \leq n$. It is recommended that the width between the centers is also selected, remembering that the same number of centers and the width value obtained during the modeling are used for the purpose of controlling the system. Therefore, only the weights of the networks are adapted using the LMS algorithm to decrease the error between the reference signaly_r *(t + 1)* and the actual output *y (t + 1)* in every iteration step. After the learning process is finished, the connection weights between the output layer and the hidden units will have been adjusted so that $y_r (t + 1) \cong y (t + 1)$.

The learnt inverse model may then be able to take a desired response and calculate an appropriate control signal $U_c(t)$, equation (6) can be rewritten as:

$$X(t) = [y_r\,(t+1), y_r\,(t), ., y_r\,(t-n+1), U(t-1), ., U(t-m+1)]^T \quad (8)$$

The direct adaptive control method is considered in our work for controlling the non-linear dynamic models due its simplicity and robustness, especially when the proper parameters are selected. One limitation which might affect the performance of the controller is the choice of the learning factor (μ) which controls the convergence of the LMS algorithm. Care must be taken by the user when selecting this value; the correct value can be selected according to the experience or by a trial and error procedure.

4.CASE STUDY- DC MOTOR SPEED CONTROL

A common actuator in control systems is the DC motor. It directly provides rotary motion and, coupled with wheels or drums and cables, can provide translational motion [8,9,15]. The electric equivalent circuit of the armature and the free-body diagram of the rotor are shown in the following Fig. 6.

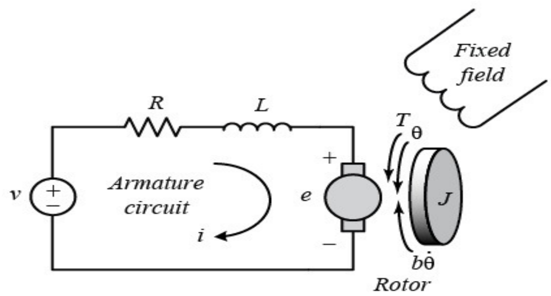

Figure6: Electric circuit of DC motor speed control

The DC motor speed control system can described sung the following transfer function:

$$\frac{\dot{\theta}(s)}{V(s)} = \frac{K}{(J\,S+b)(L\,S+R)+K^2}\left(\frac{rad/sec}{v}\right) \qquad (9)$$

Where:

J moment of inertia of the rotor (*J* = 0.01 kg.m^2);

K motor torque constant (*K*= 0.01 N.m/Amp);

R electric resistance (*R* = 1 Ohm);

L Electric inductance (*L*= 0.5 H).

Convert the equation (9) to z domain, and then, the difference equation to the DC motor model found as:

$$\dot{\theta}(k) = 1.885\,\dot{\theta}(k-1) - 0.8868\,\dot{\theta}(k-2) + 0.00009\,V(k-1) + 0.0000092\,V(k-2) \qquad (10)$$

Where: $\dot{\theta}$ is the rotational speed (output) and V is the armature voltage (input).

The design requirements are:

1. The speed of DC motor steady at 1 rad/sec.
2. Settling time 0.2 Sec
3. Overshoot less than 2%.

SIMULATION RESULTS

A. Selection of centers for proposed adaptive control scheme with RBFNN

This section covers the investigation of centers selection for a direct adaptive controller with RBFNN. Fig. 7 shows the simulation results for the applied cases on the DC motor model.

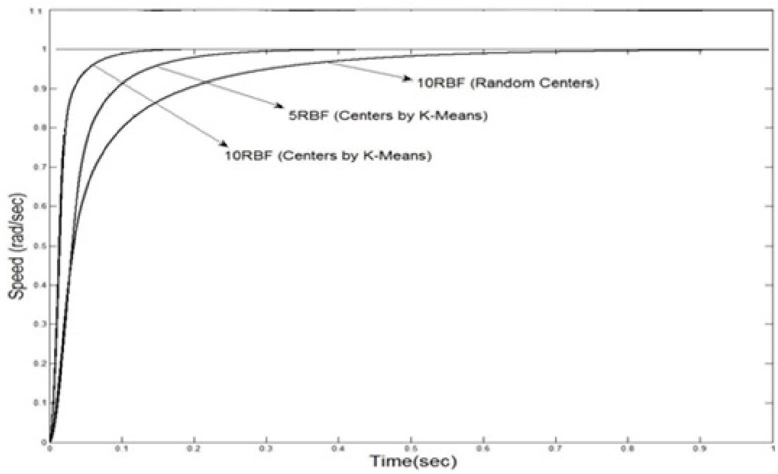

Figure7: Simulation results using RBFNN

When 10 random centers are considered for the RBFNs controlling the DC motor model, the system response is slow, settling time is large (0.8 Sec) and the design requirements are not satisfied. The second case refers to five centers determined with K-Means clustering algorithm and the system response is faster and the settling time is 0.3 Sec. The third case considers 10 centers determined with K-means clustering algorithm and the response becomes faster and settling time is 0.15 Sec, the steady value for the DC motor speed is 1 rad/sec and the overshoot is zero therefore the design requirements are satisfied. So this is the best method which should be used for the selection of centers. Simulation results show that the value of overshoot is zero in studied cases.

B. Selection of the learning factor for proposed RBFNN

This section explains the selection of the learning factor on the convergence algorithm. The values of learning factor are μ = 0.01 and 0.001 (Figure 8) and the simulated results show that any increase in the controller learning rate is leading to an increase in the desired response and faster convergence. On the other hand it causes an overshoot on the control signal itself. However, a small value of μ causes a slow convergence rate. Therefore a careful selection of the learning rate values is requested.

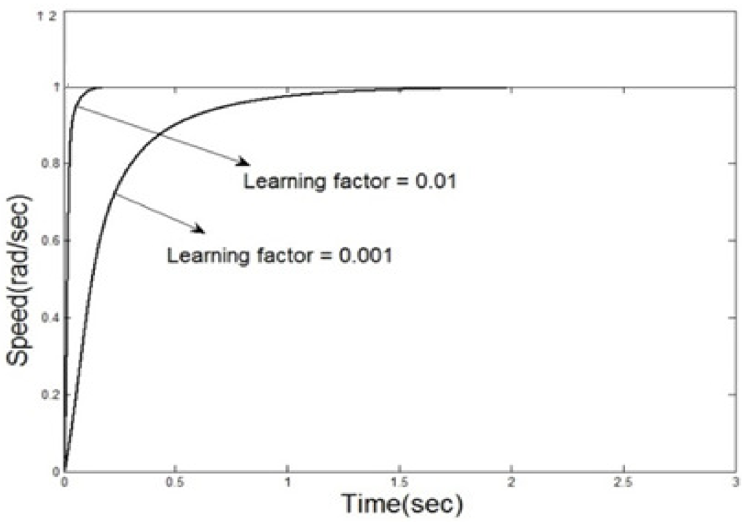

Figure 8: Effects of learning factor μ on simulated DC motor response

C. Weight adaptation for proposed RBFNN

This section presents the adaptation of the weights of the RBFN output layer by using LMS algorithm (Figure 9). The value of the weight is changed until the speed of the system response of the DC motor model reaches the steady value of 1 rad/sec. So the final value for the weight of the RBFNN output layer is 1.58 and it is obtained by applying the LMS algorithm for weight adaptation.

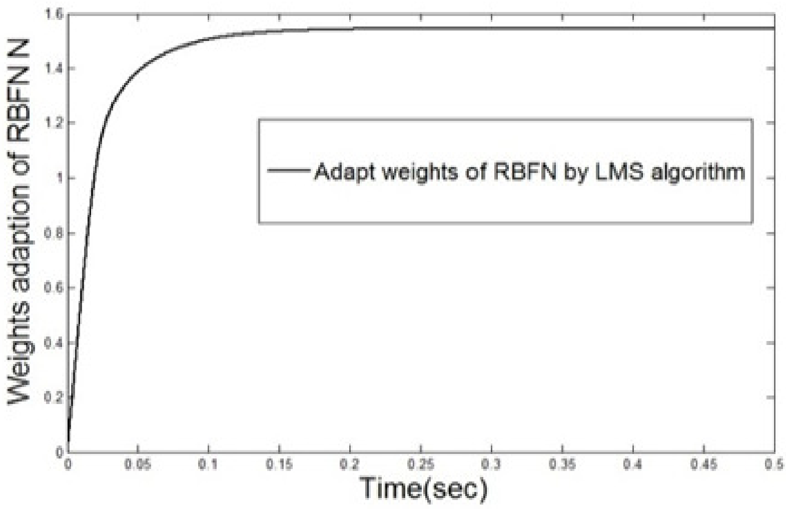

Figure 9: LMS weights adaptation of RBFNN used for the direct adaptive control of DC motor speed

5. CONCLUSION

The proposed direct adaptive control scheme is implemented in MATLAB and the simulated results show the choice of learning factor is very important in order to obtain faster convergence and high performance of the adaptive controller.It is observed that the larger the learning rate, the faster the algorithm will adapt. However, if the learning rate is too large, the output may not be robust. Finally, the simulation results show that the adaptation of the weights of the RBFNN output layerhas significant effects on the performance of the direct adaptive controller. The direct adaptive control scheme using radial basis function neural network can used to control of nonlinear system (DC motor) effectively. The results have that the on-line RBFNN controller is an effective and robust algorithm; one of the advantages is the adaptivety of the algorithm i.e., the quick modification in the behavior of the controller when there are changes in the dynamics of the process.

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The Impact of Nafion Ionomer in Polymer Electrolyte Membrane (PEM) Fuel Cell Catalyst Layer Performance

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Abstract

Nafion ionomer content in the PEM fuel cell catalyst layer is the most important parameter in designing high performance PEM fuel cell. In this study, different catalyst layers were prepared by mixing numerous Nafion ionomer (EW 1000) weight percentage (wt.%) ranging from 20 to 40 wt.% with 3.2 ± 0.1 mg/cm^2 of palladium supported carbon ((30% Pd/C,) catalyst, and assembled with Nafion 1035 membrane to form membrane electrode assembly (MEA). The results showed that the best performance of the PEM fuel cell is obtained when 35 % of the Nafion ionomer is present in the catalyst layer. In addition, the microstructural study for the catalyst layers containing higher Nafion ionomer than 35 wt.% suggests that a very thin Nafion layer is produced on the outer surface of catalyst layer leads to blocking of the active sites of the palladium catalyst on the catalyst layer surface and decreased electrochemical reactions.

Key words: PEM fuel cells, catalyst layer, scanning electron microscopy, decal transfer method, optimum Nafion ionomer, renewable clean energy.

1. Introduction

With the growth of new energy economy, proton exchange membrane (PEM) fuel cell has great potential to be success as a clean and efficient electrochemical power sources for use in materials handling and transportation applications [1-4]. However, the lack of high-performance catalyst layer (CL) especially at cathode limits its applications [4]. The main components of the PEM fuel cell are a membrane electrode assembly (MEA) which is composed to the catalyst layers (CLs), and the proton exchange membrane (PEM), and gas diffusion media (GDM). The catalyst layer CL is a porous composite layer, consisting of the recast Nafion ionomer, and the nano-particle precious metal catalyst supported on micro-particle carbon. One of the key parameters in the manufacture of CLs is the content of Nafion_ ionomer. Incorporation of Nafion ionomer in the catalyst layer improves the performance of PEM fuel cells by increasing the three-phase boundary, so optimum Nafion content in the catalyst layer is important to achieve good performance [5]. An insufficient amount of Nafion ionomer in the catalyst layer results in poor contact of the membrane electrolyte with the catalyst and reduces the triple-phase boundary. Excessive quantities of Nafion ionomer also cause a decrease in the catalyst layer performance by blocking the active catalyst sites and reducing the gas permeability [6,7]. In this work, PEM fuel cell catalyst layers with different distribution and various weight percent's (wt.%) Nafion ionomer, and palladium supported carbon (30 % Pd/C) were prepared using the decals method [8], and examined for PEM fuel cell electrodes using The current–voltage(*i*-V) method in order to investigate the effect of Nafion ionomer on cell performance

2. Experimental

Membrane Pre-treatment

Before being used in the membrane electrode assembly (MEA), the polymer electrolyte membranes made of Nafion 1035 (Sigma-Aldrich UK, 89 µm thickness, and 1000 EW) with a 3 cm diameter, were washed in various solutions to remove trace organic and inorganic contaminants and to change their form. The pre-treatment procedure involved boiling the polymer electrolyte membrane in 3 wt.% aqueous H_2O_2 solutions for 1 h at 85-90 ˚C, followed by boiling for 1 h in deionised water at 85-90 ˚C, and subsequently boiling for a further 1 h in a fresh sample of deionised water. The membrane was then boiled for 1 h in 0.5 M H_2SO_4 to get a fully H^+-form exchanged membrane. After that, the membrane was boiled for 15 min. in pure water at temperature 85-90 ˚C to remove the remaining H_2SO_4 on the surface of the membrane, followed by storing in fresh deionised water until use.

Catalyst Layers Preparation

Catalyst inks were prepared by mixing the carbon-supported catalyst (30% Pd/C, ETEK) with 5% Nafion_ solution (1000 EW, Solution Technologies, Inc., PA), and glycerol (Fisher Scientific, NJ). Different Nafion amount was used according to the calculation. The inks were ultrasonicated for 30 min. and stirred vigorously overnight to achieve a uniform suspension. The formed catalyst ink was brush painted onto a 50 cm^2 Teflon discs. After painting the decals were left into dry air at room temperature for 30 min., and then weighed. The process of painting and drying was repeated until the desired catalyst loading was reached.

Membrane Electrode Assembly (MEA)

The membrane-electrode assembly (MEA) was prepared by placing each pairs (cathode and anode) catalyst layers at both sides of the pre-treated Nafion 1035 membrane, followed by hot-pressing at 140 $^{\circ}$C and 200 atm. for 2 min. The formed MEA's were then hydrated by boiling them in 0.5 M H_2SO_4 for 1 h, followed by boiling in pure deionized water for 10 min., with excess water subsequently being removed. When the catalyst layer is poorly bonded to the membrane, the catalyst particles detached during the boiling. Finally, the MEA was dried on a heated vacuum table at room temperature for 120 minutes.

Fuel cell Assembly and performance measurements.

PEM fuel cell was assembled by placing the MEA in a single cell test fixture (Electrochem Inc., USA) and connected to fuel cell test station (Nara Cell Tech Corp., Korea) provided with gas humidifier, mass flow controller, temperature indicator-controller etc. The current–voltage (*i*–V) characteristics of the cell was evaluated, using hydrogen and oxygen reactants at 1 atm., at 85 $^{\circ}$C using HPCS1 high power potentiostat/ galvanostat along with WBCS3000 battery cycler system (WonA Tech., Korea).

Scanning Electron Microscopy (SEM)

Samples of dimensions 12 x 12 mm were cut from the middle of the MEA and used for scanning electron microscopy (SEM) examinations. SEM analysis of surface and cross-sectional specimens was performed using a Philips XL30 scanning electron microscope equipped with a thermal field emission gun (FEG- SEM) under the control of standard Philips data acquisition software. Investigations were carried out in the secondary electron and backscattered electron modes. Typical operating conditions employed a 20 kV accelerating voltage. Prior to examination, the cross sectional samples were coated with a carbon deposit (10-15 nm in thickness) to minimize problems associated with charging.

3. Results and Discussion

PEM fuel cell catalyst layers were prepared by mixing 3.2 ± 0.1 mg/cm^2 of 30% Pd/C with different Nafion ionomer (EW 1000) weight percentage ranging from 20 to 40 wt.% and assembled with Nafion 1035 membrane to form membrane electrode assembly (MEA).The prepared catalyst layers' specifications are presented in table 1. All the measurements were repeated at least four times to confirm the reproducibility of the results and the polarization curves were taken after supplying dry gases to the anode and cathode of the cells at room temperature for 48h which had previously undergone a cell test at 1 atm. pressure, and 85 ˚C under fully humidified conditions.

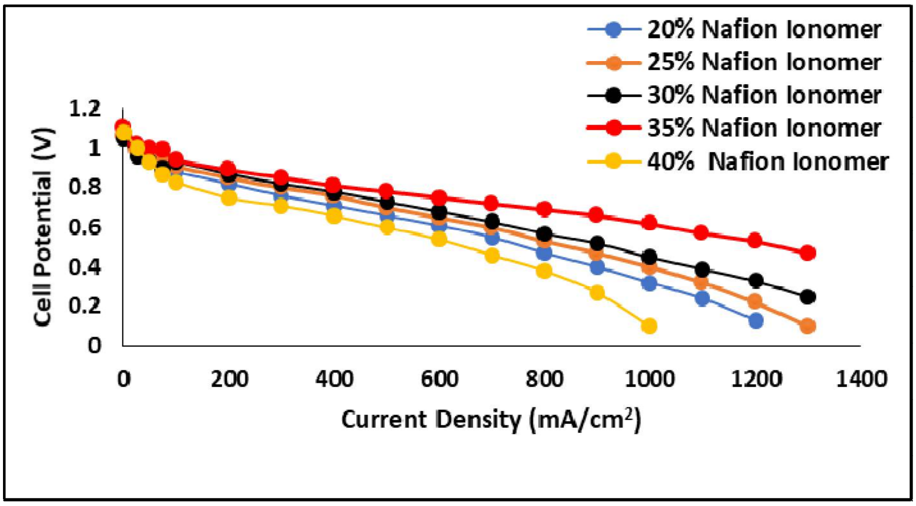

Figure 1: The current–voltage (i–V) characteristics of catalyst layers with catalyst loadings (30 % Pd/C) of 3.2 ± 0.1 mg/cm^2 catalyst loadings and various Nafion ionomer contents, at 85 ˚C, and 1 atm. pressure.

Figure 1, illustrates the current–voltage characteristics (*i*-V) of these catalyst layers. The catalyst layer performance is low when 20 wt.% of the Nafion ionomer is present in the catalyst layer. By increasing the Nafion ionomer amount from 20 wt.% to 35 wt.%, the catalyst layer performance improves This result was expected since the increase in the amount of Nafion ionomer in the catalyst layer improves the proton conductivity of the catalyst layer [9-11]. the best performance of the PEM fuel cell is obtained when 35 % of the Nafion ionomer is present in the catalyst layer. However, a significant decrease in catalyst layer performance with further increase in the amount of Nafion ionomer (above 35 wt%) was observed. This behavior could be attributed to the high Nafion ionomer concentration in the catalyst layer, which then blocked the catalyst sites as an electronic insulator, reducing the electronic conductivity and gas permeability in the catalyst layer.

Further microstructural characterization studies of the catalyst layers (CL6) were carried out using SEM to gain more information about the impact of increase in the Nafion ionomer on the catalyst layer performance and the results are presented in figure 2, and figure 3. The SEM results suggest that during the catalyst layer preparation, the increase of Nafion ionomer concentration leads to a high dispersion of carbon aggregates in the catalyst ink. Nafion ionomer fills the gap between the carbon aggregates. Due to the geometry and the size of the carbon aggregates, large pores are formed when the catalyst layers are dried. In addition, a dense film, consisting of recast Nafion ionomer, forms on outer surface of the catalyst layer (arrow A in figure 2 and figure 3).The thickness of this film depends on the Nafion ionomer concentration in the catalyst layer. The Nafion film formation results in a decreased electronic conductivity between the catalyst layer and the gas diffusion layer, blocking of the palladium sites on the catalyst layer surface, and a decreased rate of the electrochemical reactions, which take place at the catalyst layer surface. Xie,*et. al*, [12] proposed that when the catalyst ink is applied on the Teflon decal surface by the hand painting method, the polytetrafluoroethylene backbones (-CF-chains) of the Nafion ionomer in the ink layer adjacent to the decal surface are almost certainly more strongly attracted to the hydrophobic Teflon decal surface than the polar solvent system in which they are dissolved [12]. Because the majority of the Nafion ionomer backbone consists of –CF-chains, Nafion ionomer rod-like aggregates [13] in this ink layer are deposited onto the decal, forming a very thin layer of Nafion.

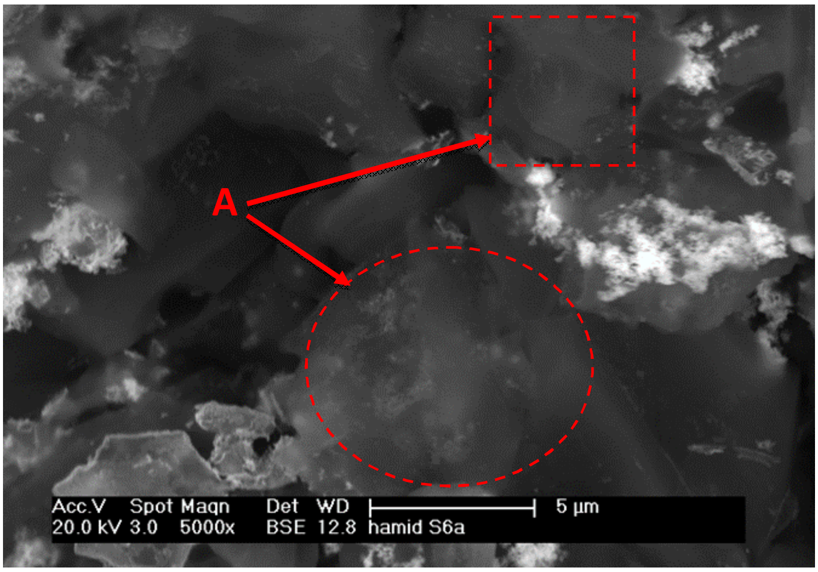

Figure 2: Backscattered electron surface image for the catalyst layer CL6 to explain the dense film formation process.

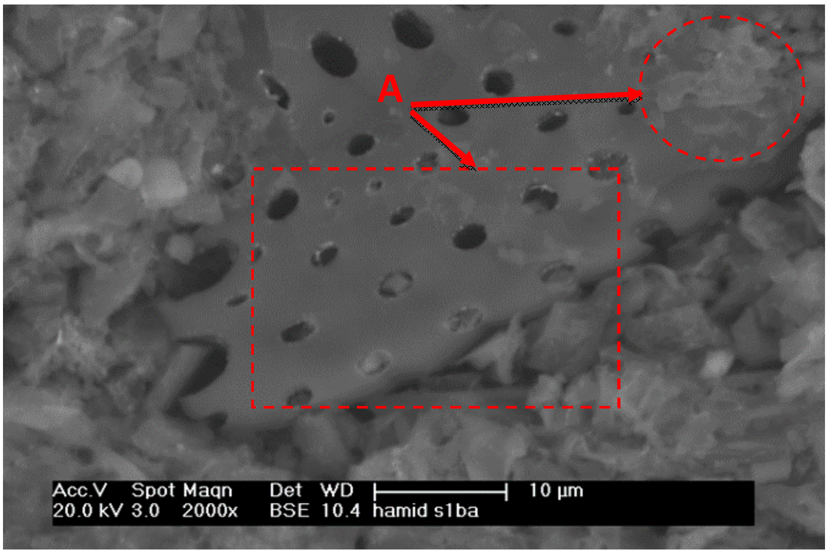

Figure 3: Backscattered electron surface image for the catalyst layer CL6 to explain the dense film and pores formation process.

As the rod-like aggregates are accumulated on the Teflon decal surface, the concentration of rod-like ionomer aggregates is reduced in the ink layer close to the Teflon decal surface and a concentration gradient of ionomer aggregates. is produced. The concentration gradient of the Nafion ionomer enhances the diffusion of rod-like aggregates towards the Teflon decal surface as long as the ink is in the liquid state, resulting in Nafion ionomer segregation. When the catalyst layer is assembled with the membrane, to form the MEA, the inner layer becomes the catalyst layer outer surface. By applying this mechanism to the present system a clear picture of the impact of Nafion ionomer in the PEM fuel cell catalyst layer performance is gained. When the catalyst ink which contains higher Nafion ionomer (above 35 wt.%) is applied onto the Teflon decals, the rod-like Nafion ionomer aggregates are attracted by the strongly hydrophobic Teflon decal, diffuse to surface of the Teflon decal driven by the Nafion ionomer aggregate concentration gradient, accumulate on the decal surface, and form a Nafion ionomer film on the outer surface of the PEM fuel cell catalyst layer. Because of the thickness of Nafion layer, it cannot be removed by boiling the MEA. Although the increase in the Nafion ionomer in the catalyst layer leads to an increase in the protonic conductivity between the catalyst layer and the membrane, it blocks the active sites of the palladium catalyst on the outer catalyst layer surface and electrochemical reactions are decreased. In addition, when the Nafion ionomer increases, a good dispersion of the carbon aggregates will be produced, and as a result the primary pores will be blocked or filled by the Nafion ionomer in the catalyst ink, due to the increase in the Nafion coverage on the carbon aggregates.

4. Conclusion

Optimum amount of Nafion ionomer in the catalyst layer is required for good PEM fuel cell performance. In the present study, catalyst layers were prepared by mixing 3.2 ± 0.1 mg/cm^2 of 30 % Pd/C with different Nafion ionomer (EW 1000) weight percentage ranging from 20 to 40 wt.% and assembled with Nafion 1035 membrane to form membrane electrode assembly (MEA). The PEM fuel cell performance was evaluated at1 atm. pressure, and 85 $^{\circ}$C. The results showed that the best performance of the PEM fuel cell is obtained when 35 % of the Nafion ionomer is present in the catalyst layer. However, a significant decrease in catalyst layer performance with further increase in the amount of Nafion ionomer (above 35 wt%) was observed. To gain more information about the performance of the catalyst layers that containing higher Nafion ionomer wt.% (above 35 wt.%) microstructural characterization studies of the catalyst layers (CL6) were carried out using SEM. The SEM analysis suggests that a very thin Nafion layer is produced on the outer surface of catalyst layer leads to blocking of the active sites of the palladium catalyst on the catalyst layer surface and decreased electrochemical reactions.

Table 1: Structural specifications of the catalyst layers with **3.2 ± 0.1 mg/cm^{2}of 30% Pd/C catalyst loadings anddifferent Nafion ionomer (EW 1000) weight percentage ranging from 20 to 40 wt.%**

Catalyst Layer Number		Catalyst Layer Weight (mg)	Nafion Ionomer Loading (wt.%)	Catalyst Layer Thickness (µm)	Catalyst Layer Composition Volume Fraction			
					C	Pd	Nafion	Pores
CL1	Anode	12.8	20.0	20.0 ± 0.1	0.436	0.041	0.215	0.308
	Cathode	12.8	20.0	20.0 ± 0.1	0.436	0.041	0.215	0.308
CL2	Anode	13.2	25.0	20.5 ± 0.2	0.424	0.040	0.243	0.293
	Cathode	13.2	25.0	20.5 ± 0.2	0.424	0.040	0.243	0.293
CL3	Anode	13.7	30.0	21.1 ± 0.1	0.414	0.039	0.272	0.275
	Cathode	13.7	30.0	21.1 ± 0.1	0.414	0.039	0.272	0.275
CL4	Anode	14.2	33.0	21.7 ± 0.1	0.404	0.038	0.302	0.256
	Cathode	14.2	33.0	21.7 ± 0.1	0.404	0.038	0.302	0.256
CL5	Anode	14.7	35.0	22.2 ± 0.2	0.395	0.036	0.333	0.236
	Cathode	14.7	35.0	22.2 ± 0.2	0.395	0.036	0.333	0.236
CL6	Anode	15.0	40.0	22.7 ± 0.2	0.38	0.035	0.355	0.23
	Cathode	15.0	40.0	22.7 ± 0.2	0.38	0.035	0.355	0.23

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Development of learning Style Agent for Intelligent Tutoring System

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Abstract

Despite the spread of smart learning systems in the field of training and education around the world, there are many great challenges in making these systems more effective, to provide an intelligent educational system in line with the standards of modern education. So there is a need to study the impact of the dissemination of smart learning methodology in the Libyan context.

This study aimed to develop an intelligent learning system to assist trainees in QACC (Quality Assurance Certification Center) according to Fleming's VAK Model (Visual , Auditory, and Kinesthetic),in the training course using Intelligent Learning System, from which these systems derive from the application of artificial intelligence techniques to educational systems, programs designed to simulate the behavior of trainees and the preferred learning method, they are able to explain the trainees' behavior and preferred learning style so that the system can capture patterns Learning and cognitive skills of trainees, and able to interpret the responses of complex trainees.

The main purpose is to compare the effects of two different methods of training (VAK training, traditional classroom training) on trainees' achievement.
The study was conducted on a sample of 46 trainees, divided into two groups. The first group contains (23) trainees in the maintenance course using the traditional learning method. The second group contains (23) trainees who use intelligent learning technique and do the questionnaire before the trial begins. The results of the study showed that the intelligent learning group's the academic achievement that use the VAK model is higher than the traditional learning group, and noted that the results also indicated that there are statistical differences ($\alpha \leq 0.05$) for the learning types of trainees at QACC in both (VAK, traditional training).

Keywords ITS, Maintenance, Training, Fleming VAK Learning Style.

1.INTRODUCTION

According to previous studies, the focus should not only be on technology, but on the structure of the education process in a way that is in line with the age. Smart learning systems have provided various unexpected methods of learning so that different learning methods can be used to support students and trainees by introducing a private tutoring system to enable students and trainees to learn in different ways. The intelligent tutoring System(ITS) is defined as a system capable of simulating the training of trainees in all aspects, related to the support of trainees as they gain knowledge [1][2].

People have different learning styles and cognitive skills, which may affect the learning contents provided by the system. Any e-learning system should provide a simulated environment so that the trainee can learn as much as possible. The system must be able to capture the learning patterns, cognitive skills of learners to provide a system of personal adjustment lessons. With this system, subjects are taught to students, are presented in audio, visual, and written form [3].

According to the researchers; ITS provides more effective results than traditional classroom instruction. Karaci, Akyuz, Bilgici and Arici (2018) conducted a study to investigate effects of Intelligent Tutoring Systems on academic achievement and retention. As a result of their implementation, they found that the academic achievement'sintelligent tutoring System had higher than the group students who did not use this system [4].

In this study, will discuss how to use smart learning based training using the QACC model to conduct the students. The implementation of a pilot project to develop excellence is a training course using the VAK method and then analyzing the results of the study as well as comparing the results of the intelligent learning method with the traditional learning method.

2.PROBLEM STATEMENT

For classroom based learning tutor can easily identify their student preference ,therefore tutor can adapt learning material in different context ,by providing different type of resources such as graphics and figures , case study , brainstorming ,group activity, peer discussion ,to ensure learner understand the lesson well.

For intelligent tutoring system, it is critical issue to identify learning style of individual learner and adapt or personalize learning content to fit with each learner preference [5]. There is a need to introduce an agent, which can identify learning style and enable intelligent tutoring system to adapt content to meet learner preference, which leads to learner progress.

3.THE OBJECTIVES OF THIS STUDY ARE:

1. Identify a system to determine the trainee's Preference to adapt the educational materials in a different context for raise the educational level and knowledge of the trainee.
2. Assign an educational content to suit each trainee and improve methods of academic learning to the learner.
3. Proposing and developing a system (factor) that can determine the learning method of the learner based on the VAK learning method.
4. Comparison between traditional learning method and smart learning method.

4. Questions and hypotheses study

A. The study tries to identify answers to some questions:

1. Is there an effective impact of smart learning style on the trainee's academic achievement level in the maintenance course?

2. How does the average scores of trainees between the smart learning group and the traditional learning group in the final achievement test?
3. Are there statistically significant differences between the average scores of trainees who received training in traditional classroom and trainees who received training in intelligent learning according to the VAK model (visual, audio, kinetic)?

B. Study hypotheses

There are statistically significant differences at the mean level ($\alpha \leq 0.05$) between the average scores of the two groups (the group taught using intelligent learning method and the other taught usingthe traditional method).

C. Study Sample

The study limited to a group of trainees in the Quality Assurance and Professional Calibration Center in a training maintenance course, consisting of 46 trainees, 23 trainees for the training group using smart learning method, and 23 trainees for the learning group in the traditional way.

D. Aimed Study

The study aimed to measure the impact of intelligent learning using VAK model method in developing the learning skills of the trainees in a maintenance course.

E. Study variables

The independent variable to identify the style of the trainee using the VAK model for the experimental group (smart learning) to produce the proposed solution.The dependent variables represent the trainees' grades for the group:

- Classes are using intelligent learning style (VAK Method).
- Classes are using traditional learning style.

5. LITERATURE REVIEW

A. Intelligent Tutoring System

An intelligent tutoring system is defined as any system which is capable of emulating an instructor's behavior in all aspects relating to supporting students as they acquire knowledge [6, 8]. The teacher is not present and it is the system itself, which guides the student as they learn different concepts.

One of the objectives of intelligent tutoring systems is to adapt hypermedia courses to each individual user by means of [7]: control of the learning level, control of course navigation, adaptation to available information, adaptation of the teaching methodology, explanation of errors, replies to the student's questions, advice, etc.

In other words, the intelligent tutoring system is a model, which enables a student to be evaluated and taught a subject and also for the education to be adapted to the student's performance.

B. Intelligent Tutoring System Components

There is widespread agreement within the ITS community that an ITSconsists of four "expert" modules as shown in Figure 1, [9].

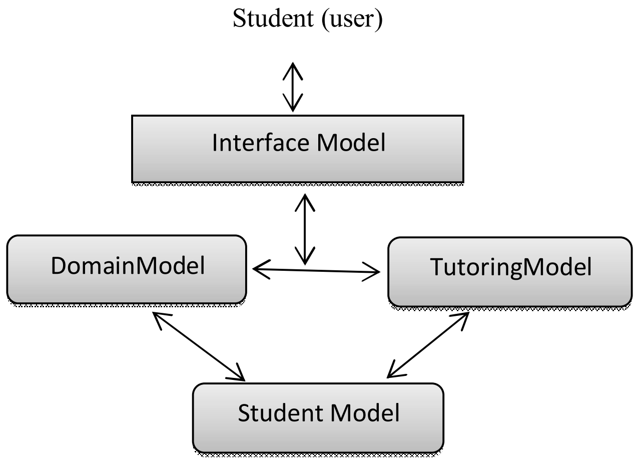

Figure 1: Component of ITS

Interface Model: The model concerned with the representation of the user (user model) and representation of the application (domain model).The main aim of the model is capturing the appropriate raw data of the learner and representing the interface.

Domain Model: which also known as expert model, it stores information about the material being taught. This model contains concepts and relationship between concepts, solutions for the question, lessons and tutorials, and problem solving strategies of the domain. It stands as a backbone of the content of the system.

Student Model- It represents Domain dependent and independent characteristics of each individual user. These characteristics are acquired from user explicit responses, analysis from the interaction data, through assessments etc. It consider as a core component of the ITS system.

Tutoring Model: The teacher model accepts information from field and student models and makes choices about teaching strategies and procedures. At any stage of the problem-solving process, the learner may ask for guidance on what to do next, for his or her current location on the form. In addition, the system recognizes the time of the learner's deviation from the model's production rules and provides timely feedback to the learner, resulting in a shorter period to reach efficiency with targeted skills [10].

6. ADVANTAGES of LEARNING PATTERNS

1. Learning patterns theory states that the amount of learning a person learns depends on the fact that learning experiences are directed more towards his learning style than on the individual's intelligence.
2. Knowledge of learning patterns helps the teacher to prepare classroom situations so that they are meaningful andeffective for students.

3. Knowing the patterns of student learning helps the teacher to choose the appropriate educational learning strategiesthat achieve the objectives of learning effectively.
4. Learning is more successful when the educational method in which the educational task is presented is consistent with the style and pattern of the student's learning.

7. LEARNNING STYLE THEORY

A. Kolb Learning Style

This learning style theory proposed by Kolb (1985) [11] is based on the Experiential Learning Theory and the main styles proposed in this model are as follows:

- The converging learner style (abstract, active).This type includes the learner being good at problem solving and taking decisions. They prefer to deal with technical rather than interpersonal issues.
- The diverging learner style (concrete, reflective). This type includes being imaginative and aware of meanings and values and views concrete situations from many perspectives.
- The assimilating learner style (abstract, reflective). This type prefers abstract conceptualization and reflective observation. They are concerned with ideas and abstract concepts rather than with people.
- The accommodating learner style (concrete, active). This type likes doing things, carries out plans and gets involved in new experiences. They are good at adapting to change and are at ease with people but can seem impatient.

B. Felder and Silverman index of learning styles

The Felder-Silverman (FS) learning styles model (Felder and Silverman, 1988) was developed to describe the learning styles in engineering education and suggest different teaching styles to address learners‟ needs. The FS model defined five dimensions of preferred learning style: perception (sensory-intuitive), input (visual auditory), organization (inductive-deductive), processing (active-reflective) and understanding (sequential-global).

C. Honey and Mumford's learning style model

A learning style model developed by (Honey and Mumford in 1982) is based on Kolb's work but is somewhat different. It includes four key stages of learning styles:

- Activists enjoy new ideas and tasks and like to be very active in the learning process. Activists learn best when they are involved in new experiences, problems and opportunities. They like to work in groups, work with tasks [12].
- Reflectors are more drawn back than the activist. They prefer standing aside and think what is happening. They learn best by observing someone else, collecting information about it and going through what was learned. They like to produce analyses and reports.
- Theorists prefer analytical and rational thinking over subjectivity and emotions.
- They like complex problems where they can use their skills and knowledge.

D. Anthony Gregorc's model

Anthony Gregorc and Kathleen Butler organized a model describing different learning styles rooted in the way individuals acquire and process information differently. This model posits that an individual's perceptual abilities are the foundation of his or her specific learning strengths, or learning styles [13].

In this model, there are two perceptual qualities: concrete and abstract, and two ordering abilities: random and sequential. Concrete perceptions involve registering information through the five senses, while abstract perceptions involve the understanding of ideas, qualities, and concepts, which cannot be seen. In regard to the two ordering abilities, sequential ordering involves the organization of information in a linear. The model posits that both of the perceptual qualities and both of the ordering abilities are present in each individual, but some qualities and ordering abilities are more dominant within certain individuals [13].

8. FLEMING VAK LEARNING STYLE MODLE

The VAK model is one of the most popular models used to identify learning styles due to its simplicity. Some however would define the VAK model as a learning preference rather than a style. VAK identifies that learner's process information using the three main sensory receivers:

- Visual
- Auditory
- Kinesthetic

Why VAK learning style Questionnaire?

There are many different learning style methodology have been used but according to the evaluation was conducted by Sampson and Karagianidis[14].The result of evaluation concluded that Fleming's VAK would be a suitable learning style to incorporate within a model offering Personalization and adaptability to the learner. The main reasons for this choice are that the VAK learning style offers a concise questionnaire for a learner to complete comprising of a minimum number of relevant questions and that the learning style categories map clearly to learning object file types[13]. This mapping is in contrast to other learning styles, for example the approach taken by Dunn and Dunn in which the mapping will be more complex.

The research within this paper therefore has selected VAK the type of learning style to be used for the proposed system (Agent), as defined in the hypothesis. Mechanism can be developed to personalize learning materials to an individual learner according to their learning style.

9. THE STUDY PROCEDURES

A. The first procedure

We will use Fleming's VAK questionnaire to produce proposed solution that simulate style preference agent, VAK questionnaire consist of 30 questions with 3 choice for each (A or B or C), and based on learner'sanswers, we will know his/her learner style. Flowchart of proposed solution is shown in figure 2.If answer of any question is A,it means his/her learning style is Visual, or if answer is B, it means is of Kinesthetic or ifanswer is C it means is auditory. After answering of each question we add one to counters (suma or sumb or sumc). Finally we compare summation of all answers, so if suma is greater than sumb and sumc then the learning style is Visual or if sumb is greater than suma and sumc then learning style is kinesthetic, or if sumc is greater than sumb and suma then the learning style is auditory.

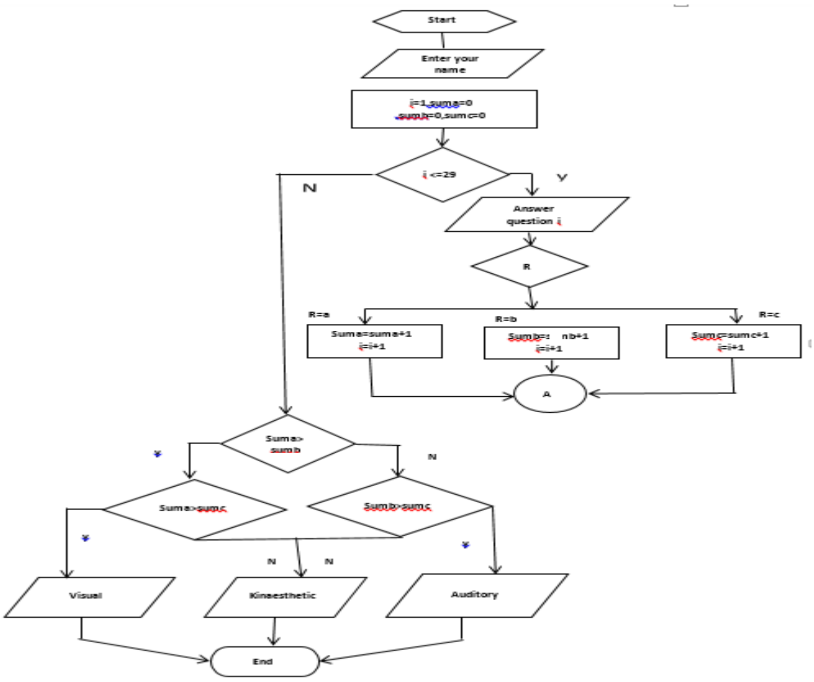

Figure 2: Flowchart of proposed solution

Table 1: used variable

Symbol	Mean
I	Counter
suma	Sum of visual
sumb	Sum of Auditory
sumc	Sum of Kinaesthetic

Based on the learner's answers, Sample group 23 trainees Approximately 9 trainees (39%) are visual methods of learning, about 4 trainees (17%) were audio learning methods, and about 10 trainees (44%) is a kinesthetic learning method as shown in Figure 3.

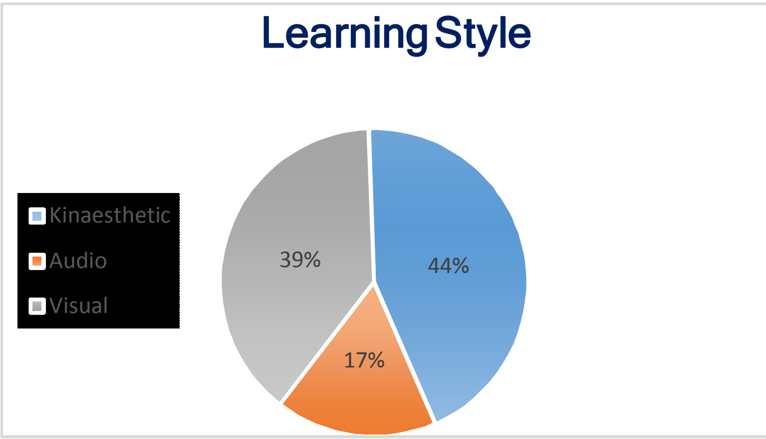

Figure 3: illustrates the distribution of learning styles to the group of trainees in a smart learning way

B. The second procedure

After completion of the training course for both groups, we compared of test results for both groups (Smart Learning Group and Traditional Learning Group) using the SPSS program and using the independent T.test statistical test to find differences of average grades for the two groups. To test the NULL hypothesis of whether there were statistically significant differences between the two samples

10.TEST RESULTS and DISCUSSION

The hypothesis stated that there are no statistically significant differences at($\alpha \leq 0.05$) between the intelligent learning group and the traditional learning group.

To answer this hypothesis, SPSS has been used to find the mathematical averages and standard deviations for trainees score of both groups by figure 4 and by using T.test test to compare the average performance of the two groups to determine if there are Statistically significant differences between the performance of a group of intelligent learning and traditional learning group were the results of the two groups as shown in table 2.

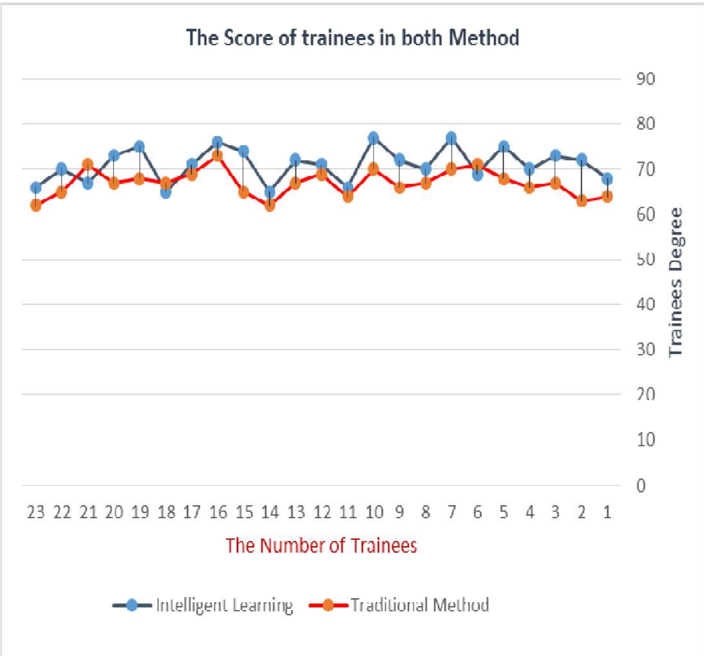

Figure 4: shows the distribution of trainees' scores for both groups

Table 2: The average score of the trainees

Group	Sample Size	Arithmetic Mean	Standard Deviation	Value T	Significance Level
Intelligent learning style	23	71.96	5.56	2.79	0.0423
Traditional learning style	23	68.04	7.04		

Table 2 shows that the average score of the trainees who studied using the intelligent learning style was higher than the average score of the trainees who have studied using the traditional method, where the arithmetic average of the smart learning group was (71.96) and the standard deviation (5.56). The arithmetic average of the traditional learning group was (68.04) and the standard deviation (7.04).This confirms that there is a difference in achievement between the two groups.

To find out whether there are statistically significant differences at the level of($\alpha \leq 0.05$) we conducted T.test. We found that there were statistically significant differences at the level of the dialysis ($\alpha \leq 0.05$) with (T) calculated (2.79) at a level indication (0.0423), which is a non-statistical function at the level of the dialect($\alpha \leq 0.05$). Therefore, the null hypothesis is rejected (there are no statisticallysignificant differences at level ($\alpha \leq 0.05$) between the average trainees of the two groups). This indicates the effectiveness of using the method and technique of intelligent learning.

The results also showed a significant effect in developing the skills of the trainees learning for intelligent learning group using VAK method and this result is consistent with many previous studies that refer to the use of technology and modern techniques in achieving the best ways of learning among trainees, This is due to the fact that the method of intelligent learning develops the trainee's ability and contributes to the development of the trainee behaviorally and cognitively and provides him with the capabilities to enable him to absorb the data of the modern area, It also helps trainees to prefer the type of learning and encourage them to study the appropriate with each trainee by learning the pattern of each trainee as appose to other learning methods.

11.RECOMMENDATIONS

After reviewing the results of the study, we can come up with a set of suggestions and recommendations that can be performed as follows:

1. Urge officials to benefit from the positive effect of using intelligent learning system and methods.
2. Educating students and trainees about the importance of smart learning system through holding seminars and conferences.
3. Conducting new studies in the impact of using intelligent learning style and involving various topics and different classes' level.
4. Organizing information and educational programs to facilitate knowledge transfer.
5. Change traditional ways of communicating information, so that the learner can better understand the content and maximize knowledge retention.
6. Training trainees on how to use modern methods related to training methods using intelligent learning system.
7. To use Audio, Visual, and Kinesthetic aids that allows the trainee to develop his abilities according to his preferred learning methods.
8. Updating and developing teaching methods to follow the latest scientific trends of trainees.

12.CONCLUSION

The purpose of this study is to identify the impact of using intelligent learning VAK method on the trainees and compare it with traditional classroom training method used in the QAAC courses (in Libya), and to improve the learning process through specializing a learning environment using the smart system based on the basis of identifying the patterns of trainees with the VAK styleBoth groups were significantly improved in learning and improvement in average scores and final achievement tests.

Using the T.test statistical test, we found that there are statistically significant differences in the educational attainment of trainees between the two learning groups.

The results indicated, "The trainees in the VAK group were better than trainees who are in the traditional classroom".

This study concluded that the implementation of training using intelligent learning method develops ability of the trainee and contributes to developing cognitively and behaviorally and enabling him to absorb the data of the modern area.

However, to achieve maximum benefits from smart learning method is to be executed at several different courses, we also need further research for other groups of trainees took the larger in size, and both sexes and on different study levels.

More research should be devoted to ensuring that the most benefits of smart learning applications are gained if training centers and universities can make full use of them.

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Software Reverse Engineering in Education Using VB2ALGO Tool

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Abstract

In recent years programming languages have been included in the curriculum for Libya's secondary schools. It is one of the basic skills taught to computing students and visual basic is one of the tools applied when the students are unfamiliar with programming languages. Often students experience difficulty in terms of understanding and then executing certain programs, and the program procedures to show the results. With the growth in software reverse engineering where the practice of analysing a software system help to extract design and implementation information.

We present a new tool named *VB2ALGO* that generates an algorithm (a flow chart and pseudo code) of the source code of Visual Basic program to help students and teachers using this algorithm to understand the program or to build the same program in other languages.

General Terms Education, Algorithms, Design
Keywords Revers Engineering, Framework

1. Introduction

Many software systems have been constructed and are widely used today. These systems are so important that their failure would have a very serious impact on the operations of the organization they serve. Therefore, it is vital to keep these systems running. Over time, these systems become more complex and increasingly difficult to understand, maintain, and evolve to meet the user's needs due to changes they go through during the software's life-time.

Technology has been used in development of education and for revolutionising of systems of learning, and this is of vital significance here. Technology produces and changes teaching and educational methods, introducing new opportunities to the education system [1].

Entered to learn programming languages in high school in Libya in recent times were among the materials that will be taught in secondary Schools in Libya are a substance programming Visual Basic language. The programming languages in general, are new to high school students in Libya. Therefore, the student finds it difficult to understand the programs and the manner of implementation and the steps based on the implementation of these programs.

A computer program is composed of individual modules, understandable by a computer, that solve specific tasks. Computer programs these days offer a wide range of techniques for solving problems using programming languages. A technique means the methodology or approach taken to solve a problem rather than being a programming style of language[3].

An Algorithm is a process to achieve a specific task. It is the idea behind any computer program? The algorithm is to solve a large, well-defined problem. An algorithm problem is identified as a full range of cases, it should work on what property the output must be the result of working on one of these cases [2].

The process of aiding a better understanding for software systems is called software reverse engineering.Reverse engineering pertains to any action which is aimed at determining the workings and discussing the basics involved in the function achieved by the system. With regards to the products, an earlier stage of high-level, detailed or a functional specification stage of the development and design process is the aim [4,5].

In this paperwe focus on reverse engineering techniques that produce results by analyzing the source code. The application of these optical techniques through the analysis of any source code and the application of the basic rules will generate algorithms (flowchart and pseudo codes).

Any computer program depends on an algorithm to describe the steps for building that program to find the solution for the problem. Therefore we propose a new toolnamed *VB2ALGO*that generates an algorithm (a flow chart and pseudo code) of the source code of Visual Basic program to help any programmer using this algorithm to understand the program or to build the same program in other languages.

We have chosen VB language for its simplicity, flexibility and it’s used as a teaching language and learning aid in Libyan high schools and all around the globe.

The contributions of thispaper can be summarized as follows:

- Design and implement a new tool that transforms a Visual Basic Source code into an algorithm.
- A review of algorithms and how they are constructed and represented. This will establish a baseline for the future work.
- Evaluation of the implemented tool using a collection of test cases and questionnaire in Libyan high schools.

2. Related Work

The programming tools used in Education have a very limited scope, since not much information has been found over the topic. Hence, the intention of this paper is to enhance the scope of the programming tools in the Education sector by revolutionizing teaching and learning systems.

2.1.Discussion

In most of high schools of the country, the Visual Basic Code is taught as part of the national curriculum. To thoroughly develop this code, an Enterprise Systems Sequence needs to be developed efficiently. Thus, the purpose of this study is to develop a teaching tool which can be used by instructors for the purpose of helping the students understand Visual Basic language.

There are two main reasons why this concept was investigated by the researchers. At first, we are highly knowledgeable and skilled in the field of software programming and the teaching of it, since the subject has been taught in our education system over recent years. Secondly, we are very much interested in acquiring further knowledge about programming tools in view of the increasing trend in favour of computing in today’s innovative and modern world.

We conducted research into the tutoring of the pupils for the sake of comprehending the objects of Visual Basic, this being part of the module requirement, Enterprise tool programming development, so that we can easily control and confirm the functional specifications for the project. In order to sum up the data gathered, a questionnaire has been created which later fostered the production of an outline for a tool that could be created for the project, as shown in Figure1.

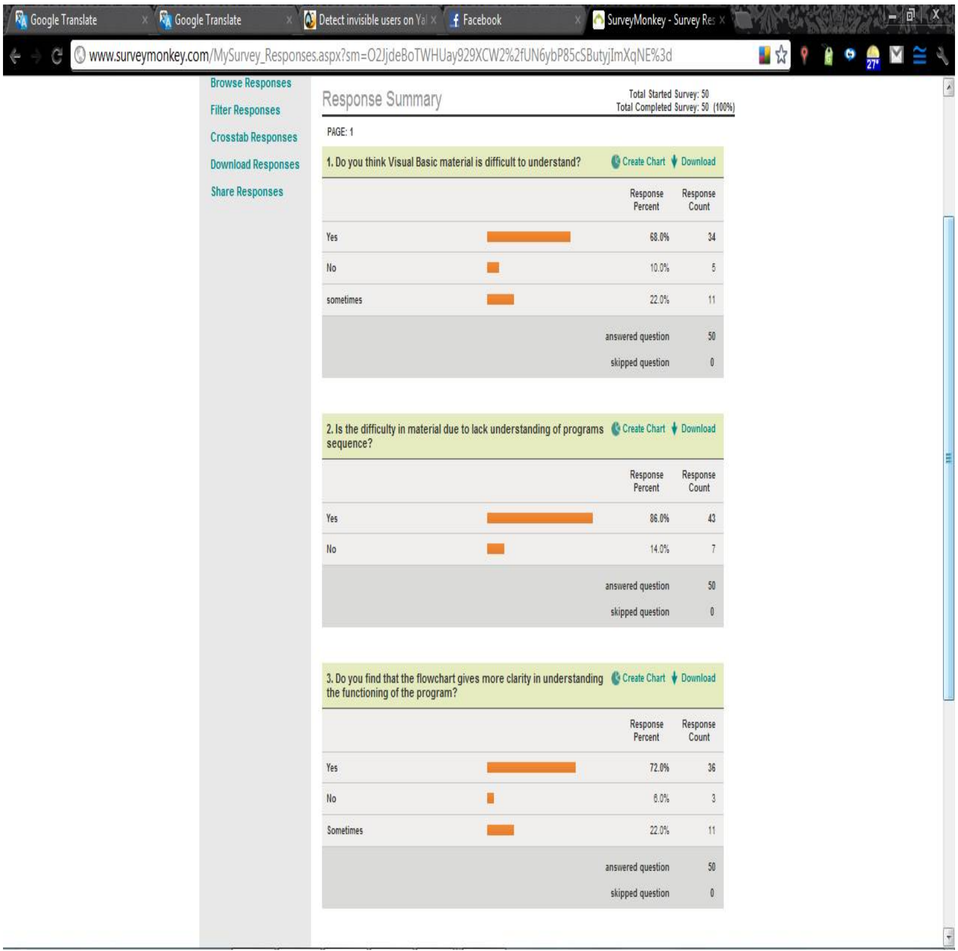

Figure 1: Questionnaire for requirements

So the new tool will help to develop the education system as present in the country by providing an efficient means for teaching. And also the material presented in this paper will be beneficial to readers since it would enhance their academic, professional and practical lives.

3. Proposed VB2ALGO Tool

As shown in Figure2, VB2ALGO tool takes a Visual Basic 6 source code file as an input and produces an algorithm (flowchart and VB6 pseudo-code) as an output.
It uses static analysis techniques to extract an algorithm, where "static analysis produces results that are valid for all executions and for all inputs".

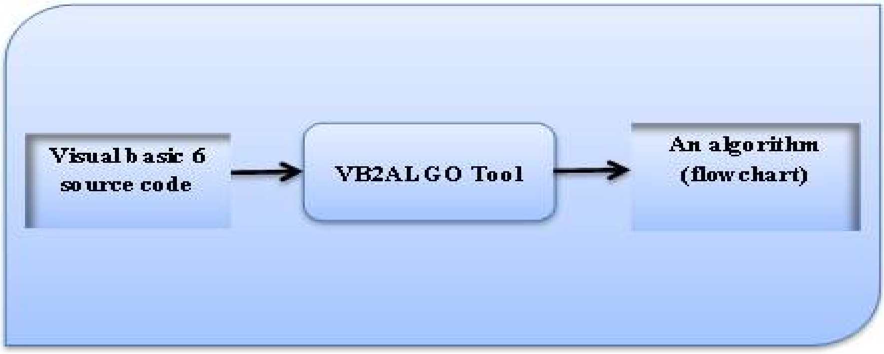

Figure 2: The preliminary architecture of VB2ALGO system

3.1.Methodology

Our research strategy would ordinarily focus on understandingthe process of teaching and learning when involved in computerprogramming. Four cycles were used in this study from March 2013 to July 2014. A pre-exploratory study was conductedin the second half of the school year 2013/2014, the first andsecond cycles in the first half of 2013/2014, and the thirdand fourth cycle in the second half of that academic year. The data collection was provided at the beginning ofthe investigation. This procedure involved some reflections afterlessons were carried out. The observations of the relevant lessonswere focused on and involved also issuing questionnaires with theaim of establishing participant's intuitive ideas about the difficultiesand possible tasks to be developed.

3.2.VB2ALGO Tool's Algorithm

The interface of the tool has been designed in three stages andeach stage depends on the preceding. These stages are: loading thesource code file, analyzing the code and drawing the code. And thealgorithm in Figure 3 shows the general block diagram of the tool.

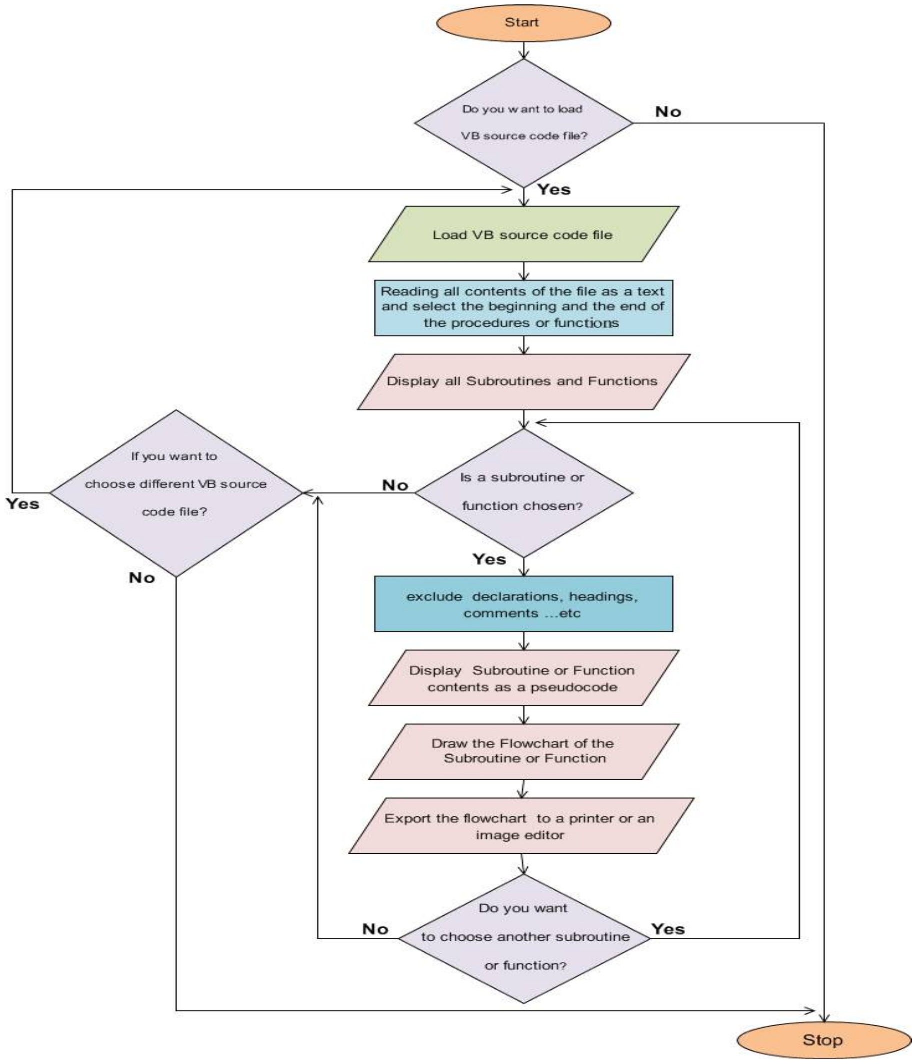

Figure 3: The Tool's Algorithm

4. VB2ALGO Implementation

System implementation describes the development tools that havebeen used in developing the proposed tool.

Given the main screen of the tool in Figure 5, we see that it consists of three sections: the first contains the source code, and the second section contains subroutines and functions that are found in the source code after analysis. The third section contains a summary of the code after choosing the function or the subroutine.

Therefore, the implementation of the algorithm has three main steps:

1- Loading the source code file "Load VBCODE".
2- Analyzing the code "FUNCTIONS AND ROUTINES".
3- Drawing the flowchart "Draw".

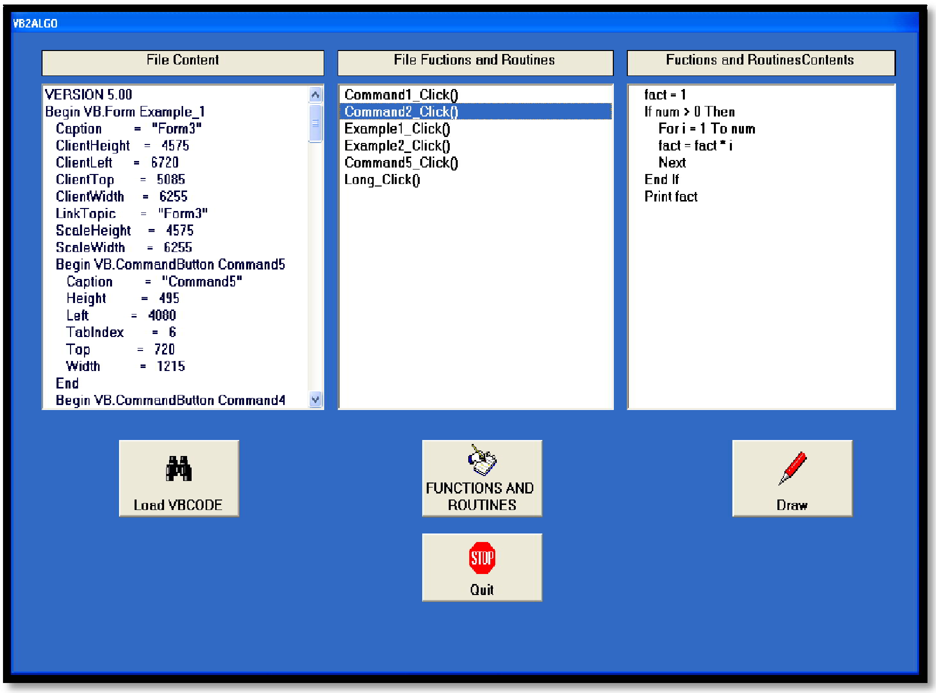

Figure 4: The main screen for the tool VB2ALGO

Figure 5 shows a flowchart generated by the tool. The flowchart depicts a transformation of a function code to print text.

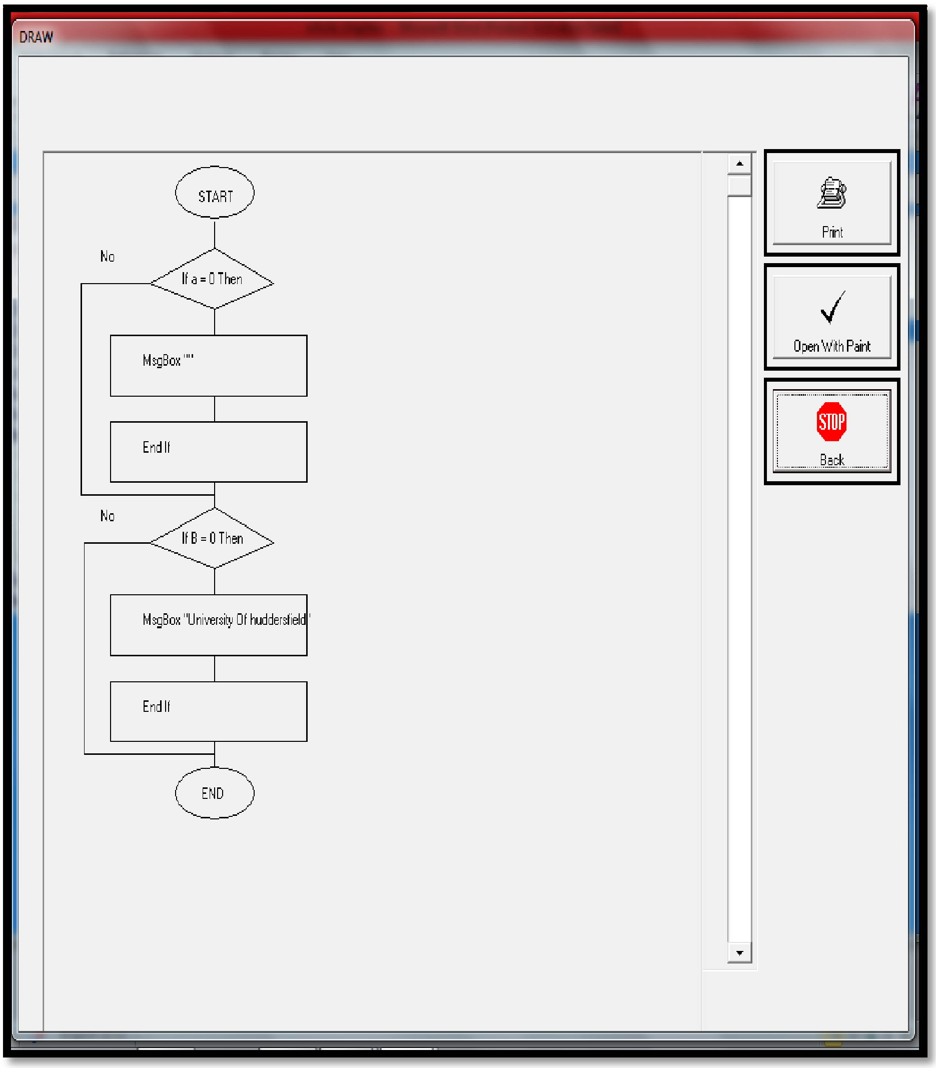

Figure 5: Drawing the code

5. VB2ALGO Evaluation

The questionnaire was distributed to students in the faculty ofscience at the University of Zawia, Department of computing. Thetotal number of students who participated was 125 and the resultsonline are as shown in Figure 6 and Figure 7:

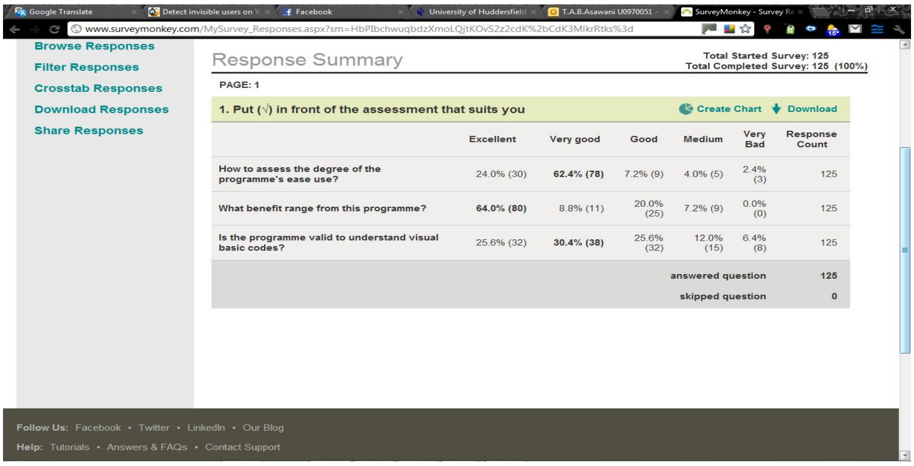

Figure 6: Results from the third question on the questionnaire

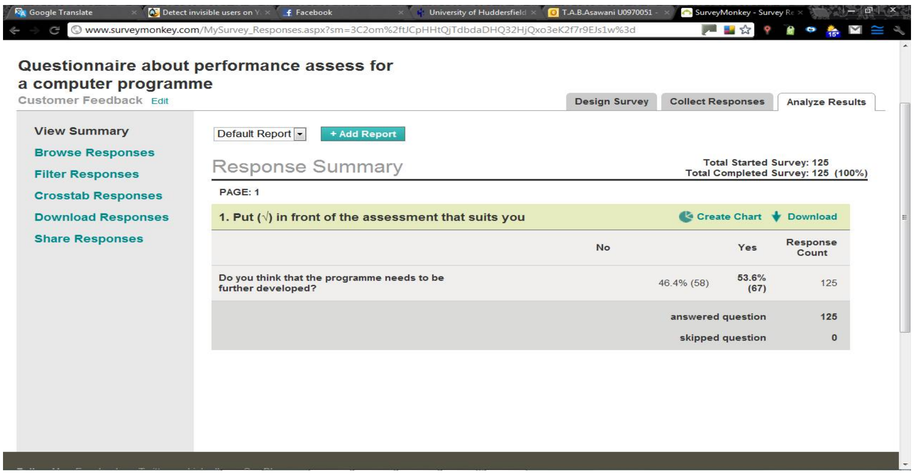

Figure 7:Results from the fourth question on the questionnaire

Table 1 shows the distribution of a sample of students on the criteria proposed. Figure 8 shows the distribution of the sample

Table 1: Distribution of a sample of students for three questions

Criteria	Excellent	Very good	Good	Moderate	Very Poor		
	4	3	2	1	0	Sample size	Average
Usability	30	78	9	5	3	125	3.016
Benefits	80	11	25	9	0	125	3.296
Understanding	32	38	32	15	8	125	2.568

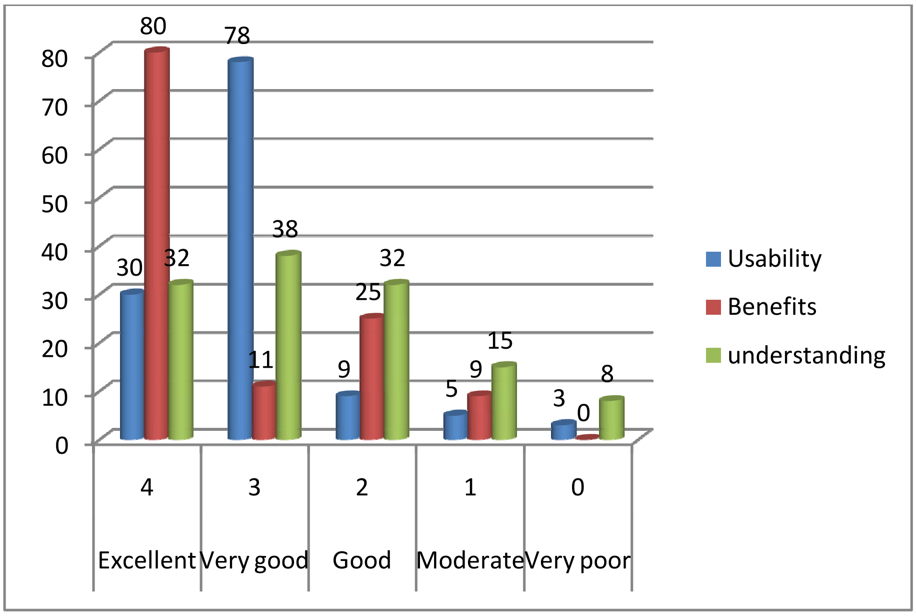

Figure 8: The distribution of the sample of students for three questions.

Table 2 shows the distribution of the sample as criteria stating: "Need development". Figure 9 shows the distribution of the sample.

Table 2:Distribution of the sample for the criteria, "Need development".

Criteria	No	Yes	Sample size
Development	58	67	125
	46.4%	53.6%	%100

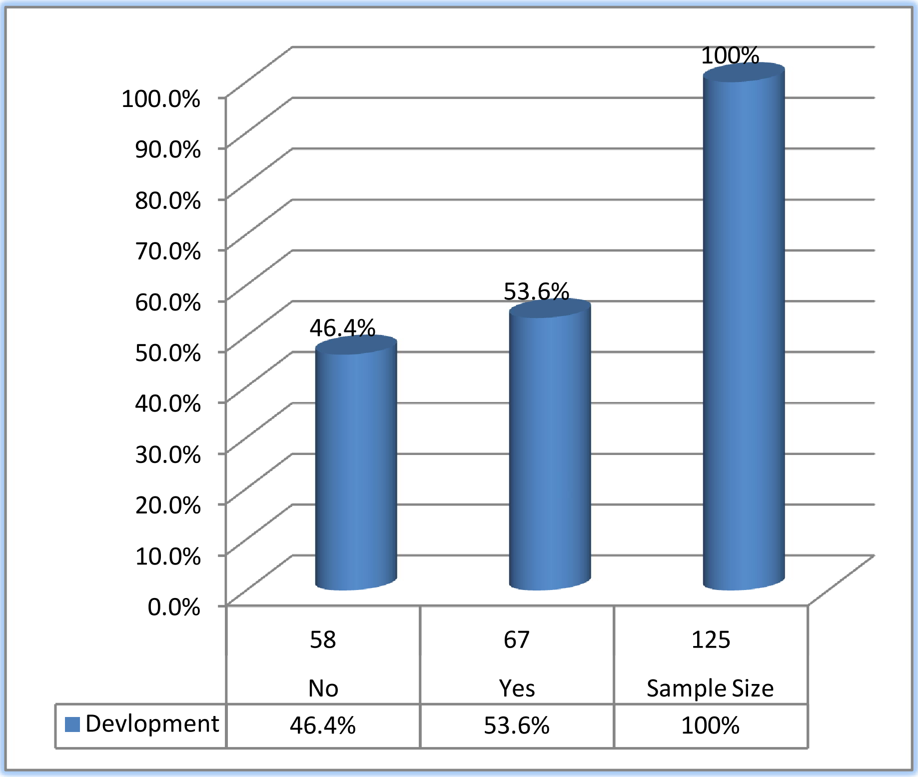

Figure 9: The distribution of the sample for the criteria, "Need development".

Table 3 shows the distribution of a sample of students on "Need support" criteria. Figure 10 showing the distribution of the sample in relation to the "Need support" Criteria.

Table 3: Distribution is ample in terms of "Need support"

Criteria	I do not need	Sometimes need	Often need	Need		
	3	2	1	0	Sample size	Average
Need to Support	45	42	20	18	125	1.912

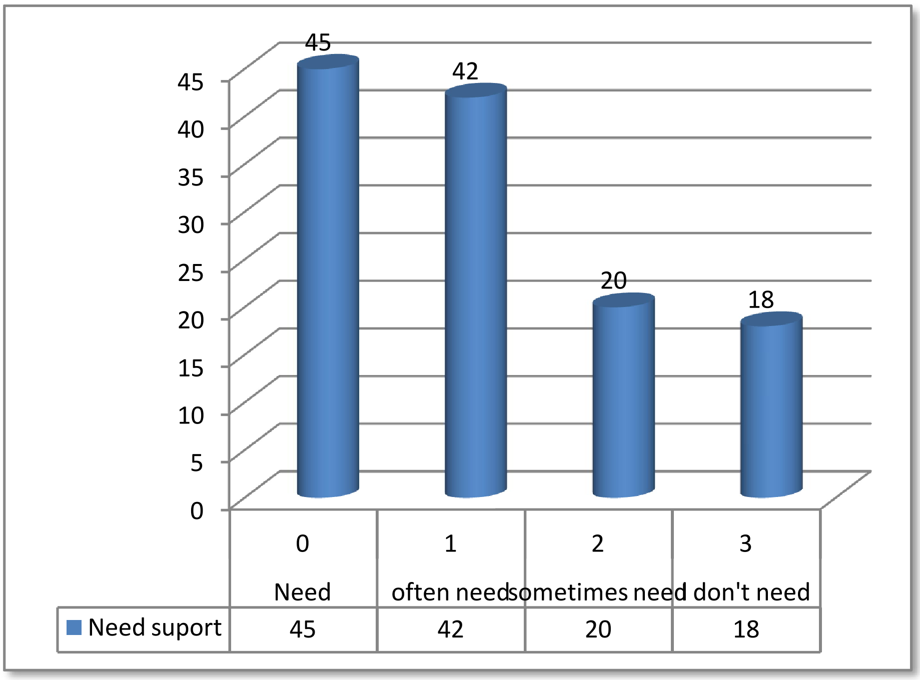

Figure 10: The distribution of the sample on "Need support".

Based on previous results from the questionnaire, and according to the analysis, it can be observed that the results were very good in terms of ease of use, interest earned, and understanding the VB language. Concerning the development of the tool, the results have shown a requirement for some development, such as: developing a user's guide as well as more examples for well-known computer algorithms to illustrate the ability of the tool for converting from a source code into an algorithm.Also, the results show that some professional assistance is required in order to help the user interact better with the tool.

Overall, it can be concluded that the tool can be utilised in the field of education and can help students, as well as the instructors to understand the Visual Basic language.

6. Conclusions and Future Work

In this paper, we have presented a new tool (VB2ALGO) that transforms a Visual Basic Source code into an algorithm.

The proposed tool is to provide a vital resource for teachers, instructors and those students who are involved in programming in their academic lives.

The basic concern of the paper and the main contribution it has been able to provide is in relation to the development of a software tool designed and implemented for students and instructors in a school setting. This would help us to thoroughly understand the application of both Pseudo-code and flowcharts.

The proposed tool does not require any kind of training and existing systems may provide the users with the ability to carry out system analysis and design.

Our work has a number of limitations, which we propose to address in future work:

- New features such as a user guide should be added to provide general information about the facts and figures relating to the algorithms.
- The tool should have the ability to export the flowchart to Excel, PowerPoint, MS Visio and Word.
- All visual basic statements should be managed by the software.
- It should be able to function on a local network.
- A higher version of Visual Basic 6 and its features should also be able to function.
- Each step of the flowchart should be traced by running a source code over the displayed flowchart.
- The tool should be capable of handling all programming languages.

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