JOURNAL OF		68	4444 A444 9275	<u>()JTEC</u>
	MUNI	CATIO	DN.	ELECTRONIC
and COM اونيومرسيتي تيڪنيڪل مليسياً ملاك	DIITER	FNG	INF	FRING
	UTLI		INL	
HOME ABOUT LOGIN REGISTER CATEGORIES ARCHIVES ANNOUNCEMENTS	SEARCH	CURRENT		OPEN JOURNAL SYSTEMS
Home > Archives > Vol 10, No 2-3				USER
Vol 10, No 2-3				Username
Technology Innovation in Electrical, Electronics and Inform	nation Tecl	hnology		Password □ Remember me
Chief Editor: Felix Pasila Editors: Yusak Tanoto, Resmana Lim, Murtiyanto Santoso				
Table of Contents				<u>View</u> <u>Subscribe</u>
Articles			DDF	JOURNAL
Challenges and Approaches P. Plageman, A. Momber			<u>PDF</u>	CONTENT Search
Design of Robotic Arm Controller based on Internet of Things (IoT) Mohamad Khairi Ishak Muhammad Izrat Poclan, Khairol Anuar Ishak			PDF	All
Optimum Allocation of Reactive Power Sources for Voltage Stability			PDF	Search
Abraham Lomi, F. Yudi Limpatono			9-13	Browse
Monitoring and Fleet Mainteenance Management			15 10	By Issue By Author
Emotion Recognition using cvxEDA-Based Features			<u>PDF</u>	<u>Other Journals</u> Categories
H. Ferdinando, E. Alasaarela Forecasting System Approach for Stock Trading with Relative Strength Index			19-23 <u>PDF</u>	<u>Satagones</u>
and Moving Average Indicator Yulius Hari, Lily Puspa Dewi			25-29	FONT SIZE
Hybrid PRoPHET-Epidemic Routing Protocol for Optimizing Possibility of Sending Messages in Remote Fishermen Residential Area			PDF	
F.X. Ariwibisono, Achmad Basuki, Fatwa Ramdani Study of Static Under Frequency Load Shedding On IEEE 3 Generators 9 Bus			31-36 <u>PDF</u>	
System Caused of Transient Condition Irrine Budi Sulistiawati, Aga Dia Priasmoro, Abraham Lomi, Ardvono Privadi			37-42	INFORMATION
Human Arm Movement Detection Using Low-Cost Sensors for Controlling			PDF	For Readers
A. Soetedjo, I.K. Somawirata, A. Irawan WabGS Application of Coospatial Technology for Tourist Destination in Malana			43-46 PDF	For Authors For Librarians
Dafid Bayu Firmansya, Fatwa Ramdani, Herman Tolle			47-51	
Information Systems Adoption among SMEs in Developing Country: The Case of Gerbang Kertasusila			PDF	
Trianggoro Wiradinata Prototype of Demand Response Controller for Demand Side Management on			53-59 PDF	
Home Electricity using Particle Swarm Optimization Algorithm Djoni Haryadi Setiabudi, Michael Santoso, Iwan Njoto Sandjaja, Yusak Tanoto			61-66	
Indonesian Batik Image Classification Using Statistical Texture Feature Extraction Gray Level Co-occurrence Matrix (GLCM) and Learning Vector Quantization (LVQ)			<u>PDF</u>	
Nafik'ah Yunari, Eko Mulyanto Yuniarno, Mauridhi Hery Purnomo			67-71	
Power Station to the Bali 16-bus System			<u>PDF</u>	
Remote Spectrum Analyzer based on Web Software Defined Radio for Use in			73-77 <u>PDF</u>	
F. Yudi Limpraptono, Eko Nurcahyo			79-82	
Web-GIS Application using Multi-Attribute Utility Theory to Classify Accident- Prone Roads			PDF	
Anik Vega Vitianingsih, Dwi Cahyono, Achmad Choiron The Development of System Dynamics Model to Increase National Sugar			83-89 <u>PDF</u>	
E. Suryani, R.A. Hendrawan, E. Taufik, I. Muhandhis, L.P. Dewi			91-96	
Implementation of Mamdani and Sugeno Method for Load Forecasting: A Case Study of Malang City			PDF	
Yusuf Ismail Nakhoda, Ni Putu Agustini, Ikhzanul Bagus Ariyanto, Abraham Lomi			97-103	
Geographic Information Retrieval using Query Aware Document Ranking Method Case Study for Surakarta			PDF	
Viny Christanti M, Steven Tionardi, Ery Dewayani Electrolysis Synthesis and Characterization Properties of Nickel Oxide		1	05-111 PDF	
Nanoparticle Vanatra Budi Pramana, Yunia Dwie Nurrahvanie, Muhamad Abdul Jumali		1	<u></u> 13_114	
A Preliminary Study of Technical Eastbility for Mabile Phane Demonstrativities		I	PDE	
In Indonesia Yoni Y. Tanoto, Shu-San Gan, Didik Wahiudi, Juliana Anggono		1	17-121	

Vol 10, No 2-3

Improving Image Classification using Fuzzy Neural Network and Backtracking	PDF
Algorithm	
Abdul Haris Rangkuti, Ayuliana Ayuliana, Muhammad Fahri	123-128
Enhancing Students' Technopreneurship Projects with Mobile Collaboration and	<u>PDF</u>
Communication Application	
Stephanus Eko Wahyudi, Kartika Gianina Tileng, Ian Budi Kurniawan	129-134
A Comparison of Real-Time Extraction between Chebyshev and Butterworth	<u>PDF</u>
Method for SSVEP Brain Signals	
Dwi Esti Kusumandari, Taufik Hidayat, Arjon Turnip	135-139
Comparative Analysis of Thresholding Methods in Cancer Cells Image	PDF
Processing Daniel Martemanggele Wenebadidieie	141 147
Claud Computing Daint of Calco Douglanment for Indenseis Small Medium	141-147
Enterprise	<u>FDF</u>
Adi Survaputra Paramita, Trianggoro Wiradinata	149-152
Call for Paper Information Broadcast Based on Android Application	PDF
Fenny Destasia Chan, Andreas Handoio, Hanny Tabita Listvani, Ivan	153-158
Aldinata, Felicia Felicia	
Modeling of Energy Production of Sengguruh Hydropower Plant Using Neuro	PDF
Fuzzy Network	
Daniel Rohi, Hanny H. Tumbelaka	159-162
High Spatial Grid Resolution of Hydrodynamic Numerical Modeling for Sea	PDF
Current Energy Site Selection in Indonesia	
S Hermawan, H Gunawan	163-167
Brain Computer Interface for Controlling RC-Car Using Emotiv Epoc+	PDF
Thomas Setiono, Andreas Handojo, Rolly Intan, Raymond Sutjiadi, Resmana Lim	169-172
Forward and Inverse Kinematic of a Manipulator Simulator Software Using Unity	PDF
Engine	
Handry Khoswanto, Kevin Nathanael Sugiharto, Iwan Njoto Sandjaja, Thiang Thiang	173-176
Surabaya Tourism Destination Recommendation Using Fuzzy C-Means	PDF
Algorithm	
Raymond Sutjiadi, Edwin Meinardi Trianto, Adriel Giovani Budihardjo	177-181
Saving Matrix Method for Efficient Distribution Route Based on Google Maps API	<u>PDF</u>
Timothy John Pattiasina, Eddy Triswanto Setyoadi, David Wijayanto	183-188
3D Platform Simulator Design Using Discrete Multi-Piston Actuators	<u>PDF</u>
Roche Alimin, Felix Pasila	189-192
Infants Cry Classification of Physiological State Using Cepstral and Prosodic	PDF
Acoustic Features	
Ramon L. Rodriguez, Susan S. Caluya	193-196

This work is licensed under a <u>Creative Commons Attribution 3.0 License</u>.

ISSN: 2180-1843

eISSN: 2289-8131

HOME / Editorial Team

Editorial Team

EDITOR-IN-CHIEF

<u>Associate Professor Ts. Dr. Azmi Awang Md Isa</u>, Universiti Teknikal Malaysia Melaka (UTeM), Malaysia

EDITORIAL ADVISORY PANEL

Professor John Senior, University of Hertfordshire, UK

Professor Garik Markarian, Lancaster University, UK

Professor Eryk Dutkiewicz, University of Technology Sydney (UTS), Australia

Professor Seiji Hashimoto, Gunma University, Japan

Professor Kuldar Taveter, Tallinn University of Technology, Estonia

Professor Tapan K. Sarkar, Syracuse University, NY, USA

Professor Manos M. Tentzeris, Georgia Institute of Technology, Atlanta, USA

Professor Ing. Carl James Debono, University of Malta, Malta

Professor Valdemar C. Da Rocha Jr., Federal University of Pernambuco, Recife, Brazil

Professor Datuk Dr. Mohamad Kadim Suaidi, Universiti Malaysia Sarawak (UNIMAS), Malaysia

<u>Professor Datuk Ts. Dr. Shahrin Sahib @ Sahibuddin</u>, Universiti Teknikal Malaysia Melaka, Malaysia

<u>Professor Datuk Dr. Khairuddin Ab Hamid</u>, University College of Technology Sarawak (UCTS), Malaysia

Professor Ir. Dr. Kaharudin Dimyati, University of Malaya (UM), Malaysia

Associate Professor Dr. M. Hariharan, National Institute of Technology, Uttarakhand, India

Associate Professor Dr. Muhammad Syahrir Johal, Universiti Teknikal Malaysia Melaka (UTeM), Malaysia

Dr. Mazlan Abbas, favoriot Sdn. Bhd., Malaysia

TECHNICAL EDITOR

<u>Ts. Mohd Shahril Izuan Mohd Zin (</u>Chairman of Technical Editor), Universiti Teknikal Malaysia Melaka (UTeM), Malaysia

Dr. Sani Irwan Md Salim, Universiti Teknikal Malaysia Melaka (UTeM), Malaysia

<u>Ts. Siti Rosmaniza Ab Rashid</u>, Universiti Teknikal Malaysia Melaka (UTeM), Malaysia

<u>Ts. Dr. Faiz Arith</u>, Universiti Teknikal Malaysia Melaka (UTeM), Malaysia

Dr. Zarina Mohd Noh, Universiti Teknikal Malaysia Melaka (UTeM), Malaysia

Dr. Norhidayah Mohd Yatim, Universiti Teknikal Malaysia Melaka (UTeM), Malaysia

MAKE A SUBMISSION

Indexed by:







MOST READ

On Optimization of Manufacturing of an Enhanced Swing Differential Colpitts Oscillator Based on Heterostructures to Increase Density of their Elements: Influence of Miss-Match Induced Stress © 138

IoT Based Smart Classroom System • 130

Development of an IoT-enabled Smart Library System for a University Campus © 120

Design and Development of Android Based Speed Limit Warning Application @ 115

Smart City Indicators: A Systematic Literature Review © 96

Journal of Telecommunication, Electronic and Computer Engineering (JTEC) ISSN: 2180-1843 eISSN: 2289-8131

> Platform & workflow by OJS / PKP

3D Platform Simulator Design Using Discrete Multi-Piston Actuators

Roche Alimin¹, Felix Pasila²

¹Department of Mechanical Engineering, Petra Christian University, Surabaya, East Java 60236, Indonesia. ²Department of Electrical Engineering, Petra Christian University, Surabaya, East Java 60236, Indonesia. ralimin@petra.ac.id

Abstract—Generally, 3D simulator uses continuous feedback control system to control their actuator states. The objective of this article is to control the movement of actuators in compliance with 3D position required by simulator. This research uses discrete actuator for 3D simulator with four actuators that is open-loop controlled using Neuro-fuzzy control system. The actuator possesses linear pneumatic actuator with three pistons inside where each piston has independent intake. With the proposed design, the actuator able to give degree of discrete not only two (binary) values but also 26 combinations of discrete values. The 3D simulator proposed in this research have four actuators and two passives like-actuator. This configuration gives 4 degrees of freedom of platform movement. Applying force to the actuator using discrete output controller make possible to get more precise in terms of control and movement of the simulator that very useful for many force control applications.

Index Terms—3D Platform Simulator; Parallel Manipulator; Discrete Actuators; Inverse Static Analysis; Pneumatic Actuator.

I. INTRODUCTION

One of the advantages of parallel manipulator comparing with the serial one is its rigidity. Furthermore, it has more compact in size as well, especially for manipulator that has a degree of freedom more than three. With these excellences', many parallel manipulators were applied in Computer Numerical Control (CNC) machine tool and 3D simulator.

In 3D platform simulator application, the popular parallel manipulator is Gough-Stewart platform which developed and published in 1956 and 1965, respectively, in different area. In Gough-Stewart platform, the degree of freedom (*dof*) is six and the actuator used are six linear actuators. The *dof* will be reduced by x if there are x like-actuators among six actuators. Generally, a continuous feedback control system is used to control their actuator states [1, 2].

Based on the Gough-Stewart platform, this research develops a 3D platform simulator which using pneumatic discrete actuators. Pneumatic actuator uses pressure air as a working fluid so that the common way to control the actuator is using feedback control system with proportional type directional control valve and a linear encoder.

Currently, the only one method to solve the control problem for 3D simulator application is using Inverse Kinematic Analysis (IKA). Inverse Static Analysis (ISA) could not be used as additional control algorithm in order to give control that is more precise. This is because of the pressure of working fluid inside the actuator is almost constant. The constant pressure will give the constant force as well. This research proposes a solution in order to make one actuator could give variable discrete force. The solution is using multi piston inside one actuator.

In order to fulfill the new design actuator, the control method is changed. Discrete control is applied to make the actuator become a discrete force generator [3, 4]. As a result, the 5/3 directional control valve is used instead of the proportional one. Also, cheaper hardware and simpler solution for Inverse Static Analysis of 3D simulator platform can be applied by only open-loop control system using Neuro-fuzzy control system.

Previous studies which are closely linked to the control of discrete parallel manipulator using neuro-fuzzy control system was proposed by Pasila, et al. [3, 5]. This study focused on controlling the six *dof* parallel manipulator using the Neuro-fuzzy architecture. Another example of parallel manipulator that has binary in activating the actuators can be seen on [6-8].

II. RESEARCH METHODOLOGY

The research methodology in this paper is divided into three Sections. Section A is about the designing of the multi pistons actuator, while Section B is about the designing 3D platform simulation that using the actuators, both are using CAD software. The last section C is about a proposed methodology to solve Inverse Static Analysis of the platform.

A. The Design of Multi Pistons Actuator

The multi pistons actuator consists of main components: the cylinder that has multi holes as many as the sum of piston, the pistons, the rods, the main-rod, the cap-end port, and the rod-end port. In this research, the actuator has 3 pistons. Each piston is controlled by one directional control valve, separately with other pistons. The actuator is double action type and the directional control valve is 5/3 solenoid type with free flow spring centered. Each piston has its rod and on the top of the rods is connected together to the main-rod.

Figure 1 depicts the actuator with its components. In order to get a uniform step variation of force, the piston annulus area is designed to have half of piston bore area. That is means each piston will give extended force two times bigger than its retracted force.

The actuator is designed to be discrete actuator and is controlled using discrete way system control as well. For this reason, each piston has three states: extended, floated, and retracted. Because of having three pistons, the actuator will have $3^3 = 27$ variation of forces. Actually, the variation is less than 27. This is because of stability reason whose states that all of pistons should not in floating state at the same time. Otherwise, the platform will be unstable.



Figure 1: Multi Piston Pneumatic Actuator

B. Design of 3D Platform Simulator

The 3D platform simulator design in this paper consists of a pair of body: the upper body that serves as a moving platform and the lower body serves as a fixed body, which is connected by six multi-piston pneumatic actuators. The upper body and the lower body are constructed according to the Gough-Stewart platform principle.

There is one thing that must be considered to determine whether the platform manipulator will experience unstable or not, that is not every installed actuator should be in floating state. If one of actuators in floating state, it means there is one degree of freedom of the platform in unstable condition. Therefore, three pistons inside an actuator should not in floating state in the same time. Figure 2 depicted the 3D platform simulator. The platform uses four actuators that serve as prismatic joint and 2 links. Therefore, the platform has four *dof*. Three pieces Directional Control Valve (DCV) controls each of actuator so that each piston will be able to be controlled independently. All of actuators and links are connected to the upper body and the lower body using universal joints to form Universal-Prismatic-Universal-Revolute (UPUR) construction. In this case, the lower universal joint can rotate with respect to the lower platform, performing similarly to a spherical joint. The actuator purely acts as prismatic joint. It could not perform rotation because of its design.



Figure 2: Three Dimension Platform Simulator

Moreover, the proposed platform simulator should have specifications of both bodies, as shown in Table 1 and the actuators and links, as shown in Table 2.

Table 1 Specifications of The Platform Simulator

Material	Steel	-
Mass the upper body	153	kg
Mass the lower body	67	kg
Circle Diameter between Joints of the upper body	1800	mm
Circle Diameter between Joints of the lower body	2300	mm

Table 2 Specifications of The Actuators And Links

Pneumatic Actuator					
Material	Aluminium	-			
Mass	2315	gr			
Stroke	400	mm			
Piston diameter	15	mm			
Link					
Material	Steel bar	-			
Mass	947	gr			
Link diameter	16	mm			
Link tall	600	mm			

Actuators used are custom dual action type pneumatic actuators with 250 mm stroke and 15 mm bore and work at air pressure range of 6-8 kg/mm². Both ends of the actuators are connected to the universal joints through bar diameter 16 mm, made by ST60 steel.

Joints between actuators and platform can be spherical or universal joints. In this case, the universal joint was chosen. The reason is more rigid and easy to get. In actuator part, that is the multi-piston cylinder; the three pistons could not rotate inside the cylinder. As a compensation, the universal joint must have 3 *dof*. It means one of the end side of the universal joint, either connector between universal joint - upper platform or connector between universal joint - actuator, must have a rotary joint. Figure 3 shows the picture of the universal joint.



Figure 3: The Universal Joint

Every actuator consists of one of cylinder and three of pistons. The three pistons move dependently, but each of the pistons is supplied of compressed air independently. Therefore, each piston must be controlled by a Directional Control Valve as a last control element of electro-pneumatic system which is controlled by digital output of Programmable Logic Controller (PLC). For the proposed simulator platform which has 4 actuators, 12 digital output of PLC is needed. Figure 4 depicted pneumatic circuit diagram of the simulator, shown for one actuator only.



Figure 4: The Pneumatic Circuit Diagram

C. Methodology to Solve Inverse Static Analysis of the Platform

The platform simulator is planned to be controlled discretely using Neural Network as ISA solution for the simulator. The performance of the discretely controlled manipulator is expected to resemble the analogue controlled manipulator. The first step, simulation of CAD solid model of the platform simulator is conducted by using CAD Simulation Software. The software is used to look for the limit of translation and rotation movement between the moving platform and the fixed platform of the design without any interference happen between platforms, actuators and joints. The limit is the constraint of the platform simulator design.

Data for training neuro-fuzzy control is generated by using forward static analysis analytically. Based on the data of geometry design of the platform simulator, depicted in figure 5-7, calculation of force at the end effector of the parallel manipulator, that is in the centroid of the moving platform, is conducted using vector-loop principle for every limb (actuator or link).

$$di = \sqrt{[\boldsymbol{p} + R_B^A \boldsymbol{b}_i^B - \boldsymbol{a}_i]^T [\boldsymbol{p} + R_B^A \boldsymbol{b}_i^B - \boldsymbol{a}_i]}$$
(1)

where: di = the length of *i*-th limb.

p = position vector of centroid of the moving platform (the end effector).

 R_B^A = rotation matrix of the moving platform with respect to fix platform (Euler angle).

 a_i^B = position vector of lower joint point (centroid of the fix platform to lower universal joint.

 \boldsymbol{b}_i^B = position vector of upper joint point (centroid of the moving platform to upper universal joint.

Hence the total force acting on the moving platform by each limb can be written as

$$\boldsymbol{f} = \sum_{i=1}^{6} f_i \, \boldsymbol{s}_i \text{ for } i = 1, 2, \dots, 6.$$
 (2)

where: f = the total force.

- f_i = force generated by each limb (actuator).
- s_i = unit vector pointing from the lower universal joint to the upper universal joint, that is connected by a limb.

Then six linear scalar equation in f_i which can be written in matrix form as

$$[\mathbf{f}] = [\mathbf{s}_1 \ \mathbf{s}_2 \ \dots \ \mathbf{s}_6] [f_1 \ f_2 \ \dots \ f_6]^T$$
(3)

Hence given the actuator forces, the end effector (the centroid of the moving platform) output can be computed directly.



Figure 5: Position of Centroid of the Fix Platform Among the Lower Universal Joints



Figure 6: Position of Centroid of the Moving Platform (the End Effector) Among the Upper Universal Joints



Figure 7: Home Position of the Platform Simulator

In the first step, various of input data is generated and then performing forward static calculation. Both are conducted by using the *Matlab* software. As the input data are translation and rotation of the end effector, and also the force of each actuator. And as the output is the force at the end effector. After enough number of data have been collected, the second step is to use the data for training the neuro-fuzzy control system. The AI network will be trained until the network has learned the most important information for prediction step. High enough number of data will make the network trained well in a specific region. Reaching the local minimum of the objective function is accepted as the training efficiency merit [3] so that after reaching this minimum value, the error function will steadily decrease. It will indicate that the training iteration can be stopped.

III. RESULTS AND DISCUSSIONS

The data generated from Matlab software consists of two signals. The first signal is the data of total force at the end effector and the second signal is the neuro-fuzzy model generated from methods that explained in [3].



Figure 8: Generating data of Total Force compared with the Neuro-Fuzzy Model in Axis X (a), Axis Y (b) and Axis Z(c)

All forces at the end effector are calculated via a combination of the known parameters and chosen by the interval, so the data collected is only 1435 data from the huge number of the possible combination. The view of force in X, Y and Z axis and their neuro-fuzzy model can be shown in Fig.8. The Root Mean Squared Error (RMSE) of the 1435 data is calculated via training of neuro-fuzzy model and the results of RMSE is 0.0648.

IV. CONCLUSION

As a conclusion, this paper discusses the design of 3D simulator platform presented: 1) discrete actuator for a 3D simulator with four actuators that are controlled in open loop way; 2) the actuator possesses linear pneumatic actuator with three pistons inside where each piston has an independent intake. The proposed design of the actuator could give not only degree of discrete two (binary, 1 or 0) values but also 26 combinations of discrete values.

The conclusion that can be drawn from this research-based from the value of the RMSE is that the 3D Simulator platform is designed in this research works relatively well with mechanical training error RMSE = 0.0648 or below 7%.

ACKNOWLEDGEMENT

All authors would like to thank Department of Higher Education of Indonesia (Menristek-Dikti) for supporting this research with number 25/SP2H/PDSTRL_Pen/LPPM-UKP/IV/2016.

References

- Gough V.E., "Contribution to discussion of papers on research in Automobile Stability, Control and Tyre Performance". *Proc. Auto Div. Inst. Mech. Eng.*: 392–394, 1956-1957.
- [2] Stewart D., "A Platform with Six Degrees of Freedom". Proc. Institution of Mechanical Engineers (UK). 180 (Pt 1, No 15), 1965– 1966.
- [3] Pasila F, Alimin R., "Applications of artificial intelligence control for Parallel Discrete-Manipulators", International Conference on Advanced Informatics: Concepts, Theory and Application, ICAICTA 2016; Penang, Malaysia, 2016
- Pasila F., Alimin R., Natalius H., "Neuro-Fuzzy Architecture of the 3D Model of Massive Parallel Actuators", *ARPN Journal of Engineering and Applied Sciences, vol. 9, pp. 2900-2905*, 2014.
 Pasila F., Alimin R.," Coordinates modelling of the discrete hexapod
- [5] Pasila F., Alimin R.," Coordinates modelling of the discrete hexapod manipulator via artificial intelligence", Lecture Notes in Electrical Engineering Vol 365, Pages 47-53, Springer, 2016
- [6] Ioannis D., Papadopoulos E., "Model-based control of a 6-dof electrohydraulic Stewart–Gough platform", Mechanism and Machine Theory 43, pp.1385–1400, Elsevier, 2008
- [7] Yang P., Waldron K.J., "Massively Parallel Actuation", 2001 IEEE/ASME International Conference on Advanced Intelligent Mechatronics, pp. 868-873, 2001.
- [8] Lichter D., Sujan V.A., Dubowsky S., "Computational Issues in the Planning and Kinematics of Binary Robots", *Proceedings of the 2002 IEEE International Conference on Robotics and Automation*, pp. 341-346, 2002.

Information about JTEC was coveraged by SCOPUS in year 2014-2018

Scopus Preview	Author search	Sources	⑦	Create account	Sign in
Source details			Fe	edback 🗲 Compare	sources >
Journal of Telecommunication, Electronic and Computer Engineering Scopus coverage years: from 2014 to 2018			CiteScore 2017 0.2		
(coverage discontinued in Scopus) Publisher: Universiti Teknikal Malaysia Melaka ISSN: 2180-1843 E-ISSN: 2289-8131 Subject area: (Engineering: Electrical and Electronic Engineering) Computer Science: Computer Networks and Communications) Computer Science: Hardware and Architecture Source type: Journal				sjr 2019 0.152	
				SNIP 2020 0.516	