**Faculty of Electrical Engineering**

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<tr>
<th>Name</th>
<th>Title</th>
<th>Supervisor</th>
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| **4** | **Ahmad Ihsan Mohd Yassin** | **Nonlinear Auto-Regressive Model Structure Selection Using Binary Particle Swarm Optimization Algorithm** | Prof. Dr. Hj. Mohd Nasir Taib (MS)  
Assoc. Prof. Dr. Ramlan Adnan (CS) |
| **5** | **Mohamad Zhafran Hussin** | **A New Technique In Evaluation Of Stabilisation For The Design Of Amorphous Silicon Photovoltaic Modules In Grid Connected System Under Equatorial Climate** | Assoc. Prof. Dr. Hj. Zainal Azlan Md Zain (MS)  
Assoc. Prof. Dr. Sulaiman Shaari (CS)  
Assoc. Prof. Dr. Ahmad Malik Omar (CS) |
| **6** | **Muhammad Asraf Hairuddin** | **Automated Vision Recognition For Classifying Nutrient Deficiencies Based Of Elaeis Guineensis Leaf** | Associate Prof. Dr. Hjh. Nooritawati Md Tahir (MS)  
Prof. Datin Dr. Ir. Shah Rizam Mohd Shah Baki (CS) |
| **7** | **Nur Fadilah Ab Aziz** | **New Techniques Incorporating Computational Intelligence Based For Voltage Stability Evaluation And Improvement In Power System** | Associate Prof. Dr. Zuhaina Hj. Zakaria (MS)  
Prof. Dr. Hjh. Titik Khawa Abdul Rahman (CS) |

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(CS) = Co Supervisor

System Identification (SI) is a control engineering discipline concerned with the discovery of mathematical models based on dynamic measurements collected from the system. It is an important discipline in the construction and design of controllers, as SI can be used for understanding the properties of the system as well as to forecast its behavior under certain past inputs and/or outputs. The NARMAX model and its derivatives (Nonlinear Auto-Regressive with Exogenous Inputs (NARX) and Nonlinear Auto-Regressive Moving Average (NARMA)) are powerful, efficient and unified representations of a variety of nonlinear models. The identification process of NARX/NARMA/NARMAX involves structure selection and parameter estimation, which can be simultaneously performed using the widely accepted Orthogonal Least Squares (OLS) algorithm. Several

The use of thin-film photovoltaic (TFPV) technology is becoming more important with the increasing demands on PV installations in the full humid equatorial climate (Af) country such as Malaysia. There is a lack of literature on performance characterization of the grid-connected photovoltaic (GCPV) systems as well as a method in identifying the instability behaviour in TFPV technology, especially in this region. In this study, research on amorphous-Silicon (a-Si) based single-junction (SJ) TFPV technology was undertaken to find out the environmental suitability of the GC systems in Af climate. Three objectives have been identified: influence of Af climate on a-Si SJ TFPV technology on system performance, method of assessing the stabilization stages due to light-induced degradation (LID) phenomenon, designing on TFPV derating factor in matching of an Inverter-to-Array Power (IAP) ratio. This study includes field-test and analytical work on a newly installed GCPV system using a-Si SJ TFPV technology. The GC SJ TFPV system installed was 0.9 kWp, free standing on a concrete walkway.

Automated vision recognition has been widely implemented for various fields such as automobiles, manufacturing, medical, agricultural sector, etc. However, automation recognition specifically in oil palm or scientifically known as Elaeis Guineensis industry is still lacking. To the best of our knowledge, automatic detection device for nutrition-lacking disease based on appearance of symptoms on leaf surfaces is unavailable since at present, the disease is inspected by human experts depending on the knowledge and experience possessed. Hence, this thesis proposed to automate the nutritional disease detection due to nutritional deficiencies namely nitrogen, potassium and magnesium instead of manual visual recognition. This is because automation process is necessary to lessen error and reduce cost due to human experts as well as to increase speed of disease detection. Generally, the proposed automation disease detection of oil palm involves three modules namely feature extraction based on image processing technique, statistical analysis as feature selection and classification.

Recently, there are still many cases of voltage collapse incidents occur all around the world. This is due to the reason that most power systems today are being operated very close to their stability limits because of the exponentially growing demands, the desires to obtain maximum economic benefits and environmental constraints. Therefore, this thesis presents novel techniques for voltage stability evaluation and enhancement in power system. Firstly, a new bus voltage stability index named as Voltage Stability Condition Indicator (VSCI) was developed. The competency of VSCI was corroborated in three tasks; weak bus identification, automatic line outage contingency ranking and weak area identification. In addition, a new method to detect weak areas in a system termed as Weak Area Clustering Margin (WACM) was also developed. In the first part of study, all methods were tested on IEEE 30-bus and IEEE 118-bus test system. Secondly, a new voltage stability prediction technique utilising state of the art machine learning, Support Vector Machine (SVM) was developed. At this stage, two popular SVM selection parameter methods, trial and error and cross validation were investigated and compared. The developed technique used VSCI as the voltage stability indicator to be predicted. The performance of SVM was also compared with the performance of Artificial Neural Network (ANN). To enhance the SVM performance, an outstanding
criticisms have been directed towards OLS for its tendency to select excessive or sub-optimal terms. The suboptimal selection of regressor terms leads to models that are non-parsimonious in nature. This thesis proposes the application of a stochastic optimization algorithm called Binary Particle Swarm Optimization algorithm for structure selection of polynomial NARX/NARMA/NARMAX models. The algorithm searches the solution space by selecting various model structures and evaluating its fitness. A MySQL database was created to analyze the optimization results and speed up computations of the optimization algorithm. The proposed optimization algorithm was tested on several benchmark datasets, namely the Direct Current Motor (DCM), Mackey-Glass Differential Equation (MG) and Flexible Robot Arm (FRA). The DCM motor was the least complication dataset, followed by the FRA (medium complexity) and MG (most complexity). The results suggest that the proposed method can reduce the number of correlation violations down to between 28.57% and 69.23% at the expense of increased model size (requirement of additional regressor terms to explain the behavior of the system).

With all parameters monitored in high resolution data, in five-minute intervals, for the duration of two consecutive years. The field datasets were analyzed and evaluated using established standards and guidelines: MS IEC 61724:2010 and IEA-PVPS Task 2. Analytical work on the performance revealed that the system showed a very high energy yield, final PV system yield and performance ratio at 3.05 kWh/d, 3.39 kWh/kWp.d, and 81%, respectively under the Af climate region. In this work, a new procedure and technique to assess the stabilization stages of the SJ TFPV modules has been discovered, whilst determining the stabilization period. This new P-G technique involved four steps: (i) prediction DC powers based Initial and Stabilized condition, (ii) linear correlation approach (LCA), (iii) outdoor’s validation field-test condition, and (iv) comparison of prediction accuracy and computation time. For the second and third part with artificial intelligence. Firstly, the diseased-frond leaf surface image is captured at ambient environment. This uncontrolled processing environment approach implemented for disease detection based on leaf surface appearance is considered new and can be regarded as significant contribution in this research field. Next, the captured leaf image is transmitted to the host computer database for further processing. Further, the processor formulates its judgment through machine learning that is able to infer decision similar to human thinking. Here, the performances of several machine learning classifiers are compared. Once the processing stage is completed, the image will be retrieved online through the portable device of Apple’s Operating System (IOS) (ipod/iphone/ipad tablet) technology. Results demonstrated that support vector machine (SVM) of radial basis function (RBF) outperformed other classifiers in recognizing the disease types from the leaf surface. Furthermore, it was also found that SVM-RBF is the most suitable method for classifying the disease in terms of accuracy and processing speed. Feature selection via Analysis of Variance (ANOVA) and Multiple Comparison Procedure (MCP) enhanced classifier prediction capability, thus resemble original features as closest as possible without compromising the accuracy rate. Results revealed that higher recognition rates attained with classification based on SVM-RBF along with appropriate feature selection that yields accuracy from 91.11% to 91.81%.

hybrid Artificial Immune Least square Support Vector Machine (AILSVM) that integrates SVM with Artificial Immune System (AIS) was introduced in voltage stability prediction. For comparison, another new hybrid algorithm incorporating ANN and AIS called as Artificial Immune Neural Network (AINN) for voltage stability prediction was also developed. It was found that AILSVM has outclassed AINN significantly in terms of prediction accuracy and computation time. Thirdly, new techniques for load margin improvement were developed. Initially, a superior performance of AIS named as Fast Artificial Immune System (FAIS) to estimate the maximum load margin of a system was developed. FAIS offers a better performance of AIS since several available approaches for cloning, mutation and selection have been explored and compared. The combination of these approaches that delivered the best performance in terms of accuracy and time was utilised in FAIS. Later on, another novel technique that incorporates FAIS and AILSVM known as Fast Artificial Immune Support Vector Machine (FAISVM) for maximum load margin improvement via RPP optimisation was developed. The integration of FAIS and AILSVM has resulted to a very fast and accurate prediction of maximum loading point (MLP) as the objective function for Reactive Power Planning (RPP) optimisation. The proposed technique employed the predetermined support vectors from AILSVM. VSCI was used as the indicator for the MLP of load buses. Another new hybrid algorithm that used Evolutionary Programming (EP) termed as Evolutionary Support Vector Machine (ESVM) was also developed for comparative study. The results showed that FAISVM has outperformed ESVM significantly in terms of load margin improvement, prediction accuracy and computation time. For the second and third part of the study, the developed techniques were tested on IEEE 30-bus test systems. In conclusion, this thesis has developed a new voltage stability index, VSCI and novel techniques known as AILSVM and FAISVM for voltage stability prediction and maximum load margin improvement that utilised biological optimisation method.