Exploring the Framework of Automotive Service Accuracy Problem Solving Skills Using Artificial Intelligence Technique

W. Sudsomboon
Graduate Program in Industrial Technology, Intelligence Automotive Technology Research Unit,
Faculty of Industrial Technology, Nakhon Si Thammarat Rajabhat University,
1 Moo 4 Thangew, Meuang, Nakhon Si Thammarat, 80280 Thailand

Abstract- **With the rapid growth of automotive mechatronics system, automotive service accuracy problem-solving skills has become standards continuously improve on customer demands, enhancing accuracy, reliability maintenance, safety, and maintenance cost. Artificial Intelligence (AI) technique have the potentially to perform operations for enhancing the learning and decision making by special emphasis on human cognitive processes. The objective of this research was to explore the framework of automotive service accuracy problem-solving skills based on artificial intelligence technique for Electronics Concentrated Engine Control System (ECCS) fault diagnosis as perceived by experts. The research methodology was qualitative research, which was conducted by focus-group interviews. The participants were 15 among automotive service experts from Nissan Training Center, Nissan Motors (Thailand) and Nissan Surat Piya (Nakhon Si Thammarat). Data was analyzed by the experts' explorations of three basic tasks of automotive service accuracy problem-solving skills using artificial intelligence technique in ECCS fault diagnosis. The research found that these four themes covered a total of 4 themes and 12 sub-themes. Moreover, the data-driven were complementarily of automotive service technicians and AI technique in real-world situations decision-making. The famous machine learning algorithms are dealing to combine ANN and SVM methods tend to perform better for new applications. The proposed ASAPSS framework demonstrated a significant performance improvement of automotive service technicians for Nissan Motor (Thailand) and among undergraduate mechanical engineering students.**

Keywords: Artificial Intelligence; Automotive Mechatronics System; Automotive Service Accuracy; Problem Solving Skills

I. INTRODUCTION

With the rapid growth of Automotive Mechatronics System (AMS), Automotive Service Accuracy Problem-Solving Skills (ASAPSS) has become standards continuously improve on customer demands, enhancing accuracy, reliability maintenance, safety, and maintenance cost. The AMS is among the most important equipment in modern automotive technology applications. The automotive service technicians' understanding plays important problem-solving skills in obtaining real-world situations for electronics concentrated engine control system (ECCS) which is automotive mechatronics complex to the solve problem needs.

The automotive mechatronics elements are sensors, electronic control module and actuators identification of the AMS conditions has become increasingly important [1]. Furthermore, different from the traditional diagnosis methods based on various signal processing techniques, intelligent diagnosis enhances to effectively analyze symptoms. The collected data and automatically are provide diagnosis results, which has become a new trend in the field of fault diagnosis [2]. Fault diagnosis of the AMS becomes the most critical aspect in system maintenance.

The problem of traditional diagnostics methods are usually performed based on a service manual task of the system by special emphasis on human cognitive processes around a nominal operating condition. Sudsomboon [3] states that the AMS is inherently real-world situation and dynamic for ECCS; therefore, the ASAPSS performance is decreased whenever the operating condition changes as shown in Figure 1. As a result, the traditional of AMS problem-solving process for ECCS fault diagnosis is currently operations in dealers, which is repeated a normal function is finished, therefore the outputs of enhancing accuracy, reliability maintenance, safety, and maintenance cost is multiplied by the waste times of the loop is repeated. The new paradigm for ASAPSS is changed. Therefore, crucially, fault diagnosis of the AMS can be stated as a pattern recognition problem-solving skill regarding the condition.

Due to develop the performance and effectiveness of the ASAPSS response signals, they are almost impossible to recognize fault diagnosis patterns directly. A common fault diagnosis system often consists of the AMS have two key important: data processing (feature extraction), fault recognition. Most common intelligent fault diagnosis systems are built based on the preprocessing by feature extraction algorithms to transform the input patterns. Moreover, they can be represented by AI technique feature for easier match and comparison. The AI approach have the potentially to perform operations for enhancing the learning and decision making by special emphasis on human cognitive processes [4].

Therefore, the ASAPSS using artificial intelligence technique for ECCS system depends on experts' perceptions chooses to provide in this research. This statement represent significant opportunities for automotive service quality problem-solving skills improvement according to AI technique in order to uncover fundamental patterns that can be used to explore optimal framework, reduce errors/costs, and better integrate research and appropriateness for practice [5]. The objective of this research was to explore the framework of automotive service accuracy problem-solving skills using artificial intelligence technique for electronics

 10.14416/c.fte.2020.03.034

concentrated engine control system fault diagnosis based on perceive their experts.

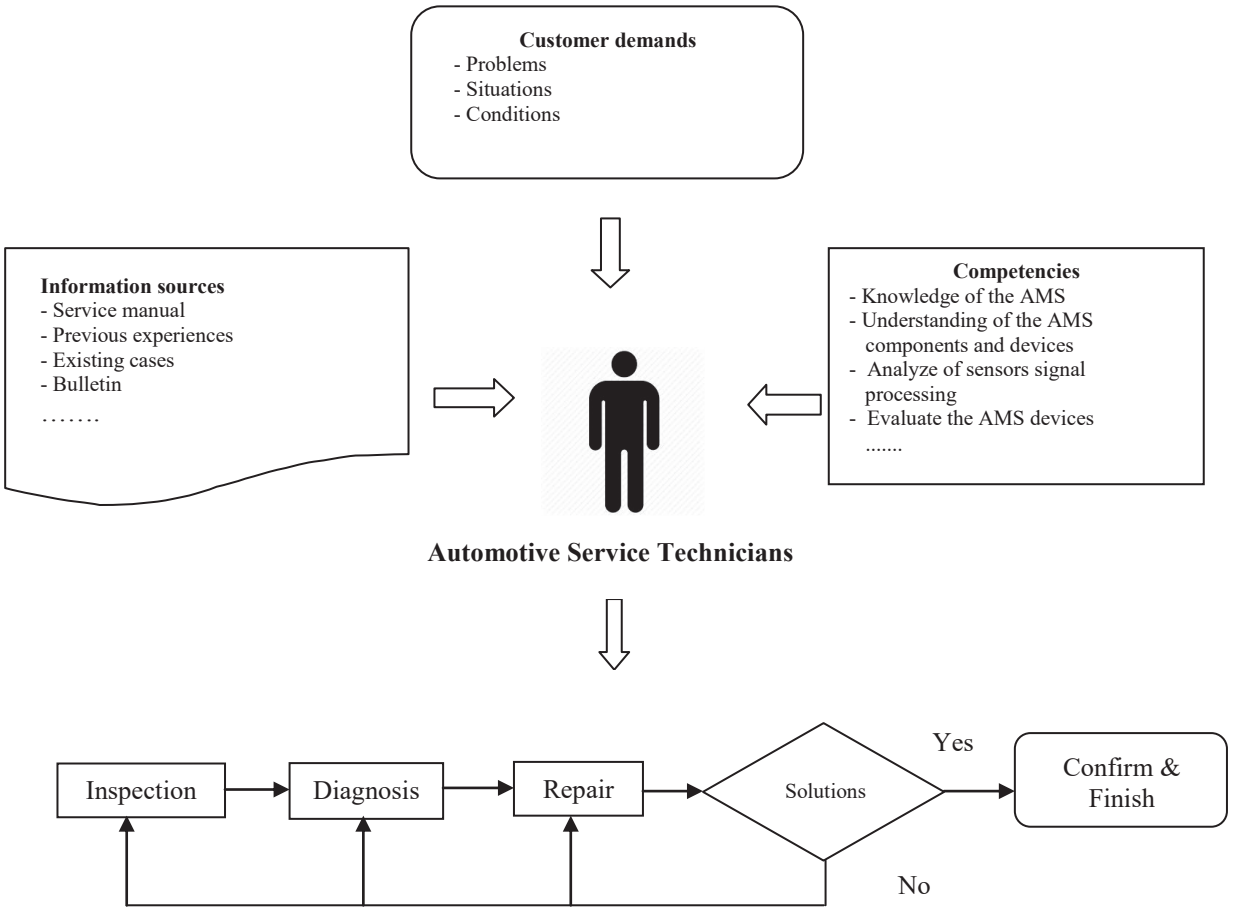

Figure 1. The traditional of AMS problem-solving skills process for ECCS fault diagnosis [2-3]

II. THEORETICAL FRAMEWORK

The AI is conceptualized as machine learning, automated solutions (i.e. intelligent agents, intelligent systems) to solve the problems which could develop the intervention of intelligence by humans [6]. In a context of ASAPSS, there are problems to be lacked that require this ECCS performance characteristic, which need human cognitive process (e.g., judgment, analysis, synthesis, interpretation, evaluation) perform to assess and solve the AMS problems for ECCS with guarantees of tasks success. These decisional situations frequently relate to strategic issues in tasks, where problems are far from being well-structured [7]. Developing and applying AI technique, due to their particular strengths, to process data processing (feature extraction), fault recognition and provide valuable information either with a data-driven or, especially, with a knowledge-driven approach, might be of increase to automotive service technicians potentially in their decision-making.

With this advantage, researcher has studied to promote, high-quality automotive service problem-solving skills contributions on AI technique to support the automotive service technicians of Nissan among dealers. As the traditional techniques, they used by service manual and or scan tool to support decision-making on quantitative problems, or the insufficient attention paid to operating applications in the AI field, among others. In this regard, the overall number of generated ideas, also considering more technical-oriented skills treating problems on AI/intelligent systems lacked to response signals, they are almost impossible to recognize fault diagnosis patterns directly [8].

A. The uncertainly of automotive service quality problem-solving skills

Uncertainty is stated as a lack of information about all alternatives or their consequences, which makes interpreting a real-world situation and decision making for more difficult. Uncertainty can stem from a lack of information about both internal and external environments of automotive service technicians (e.g., shortage of human resources, emergence of disruptive technologies, new markets and competitors). The AI can assist human decision makers with predictive analytics: (1) they can generate ideas through probability and data-driven statistical inference approaches and (2) identify

relationships among many factors, which enables human decision makers to more effectively collect and act upon new sets of information. One of the primary functions of predictive analytics is generating new information and improves about customer demands, enhancing accuracy, reliability maintenance, safety, maintenance cost, and operations [1], [3].

B. Knowledge acquisition and representation of AI technique

In this context, automotive service technicians as decision makers often build on knowledge acquisition and representation approach, leveraging insight and qualitative assessment that are rooted in knowledge acquisition and representation of tacit experience and personal judgment. It is very difficult to articulate the reasons behind these decisions beyond that they just do right and or do wrong according to alternative solutions. Both abstract thinking with knowledge acquisition and representation can promote creative decision-making situations. This inherent, inexplicable perception that comes from within is almost impossible to simulate with AI. This may be found in activities may involve higher levels of ambiguity and uncertainty. A large number of knowledge sources pertinent to ASAPSS are organized as database, engineering knowledge base, originality method, and existing case base. Theses bases become more important than support for the AMS problem-solving process [9], [10].

C. The AI techniques feature

In this research, AI technique defines an appropriateness model to deal with knowledge-driven database. The AI technique applications summarized as follow as [6]:

1) ANN is conceptualized as a computational model as well as mimics the human brain structure. ANN consists of simple processing elements connected in a complex layer structure which enables the model to approximate a complex non-linear function with multi-input and multi-output (MIMO).

2) Deep learning is conceptualized as an effective method to learn features automatically at multiple levels of abstraction, allowing learning complex input-to-output functions directly from data.

3) k-NN is conceptualized as an instance-based learning algorithm that delays the induction or generalization process until classification is performed. Compared with *k*-means, it only computes the instance of the nearest points instead of global distance.

4) Naive Bayes algorithm is conceptualized as the explicit underlying characterized by probability model.

5) SVM is conceptualized as an excellent performance in generalization, also with few training data and its appropriate nonlinear mapping using kernel functions.

III. METHODS

A. Design

The research methodology was qualitative research, which was conducted by focus-group interviews. This research was provided the range of ideas and insights held by individuals on ECCS fault diagnosis. As well as, the differences of experts in group and or individuals were analyzing to establish a ASAPSS framework.

B. Participants

The participants were 15 among automotive service experts from Nissan Training and Development Division at Nissan Motor (Thailand) and Nissan Piya Nakhon Si Thammarat, who were training managers, training instructors, and master technicians. They were selected by purposive sampling method. The expert focuses on ASAPSS to extract competences by identifying previously ECCS fault diagnosis. When perceives were sought on related topics during these interviews, the experts' answer started to exhibit differences for data collection.

C. Data Collection

Data was collected for 3 days in April, 2018. The experts were interviewed with a more open discussion about ASAPSS guidelines depend on experts' perceived. They were held the first interview followed by a more AI approach, and the second interviews were reviewed to confirm its application. Researcher generated the 6 interview questions in consideration of the ECCS fault diagnosis themes. After each question was discussed, the researcher inspected whether their understanding of the experts' perceived in the interview truly reflected the experts' experiences [11]. The interviews were recorded, field notes were taken and each tape-recorded interview was immediately transcribed verbatim.

D. Data Analysis

Thematic analysis was employed to enhance an understanding of the experts' perceived of ASAPSS based on AI approach. The data was generating initials codes and searching for themes. Then, review these themes by defining and naming them [11]. The analysis continued until a convincing task using the data could be formulated. To ensure the consistency and reliability of the data analysis, all of the data was analyzed by researcher. Finally, the experts reviewed the data-driven confirm were consistency.

IV. RESULTS

To explore the framework of automotive service accuracy problem-solving skills using artificial intelligence technique based on perceive their experts The thematic analysis of their experts' consensus revealed explorations of four basic tasks of ASAPSS using AI technique in fault diagnosis**:**

1) Analyzing whether the equipment is appropriateness or not;

2) Solving the malfunction of devices and its reason;

3) Suggestions the trend of fault development; and

4) Existing cases and storage knowledge-driven. These four themes covered a total of 4 themes and 12 sub-themes as shown in TABLE I.

 10.14416/c.fte.2020.03.034

TABLE I
THE THEMATIC ANALYSIS OF THEIR EXPERTS' CONSENSUS REVEALED EXPLORATIONS

Themes	Sub-Themes
1. Analyzing whether the equipment is appropriateness or not	1.1 Examining of the problem description. 1.2 Considering of the fault symptoms detection and setting the appropriate of hypothesis. 1.3 System identification of AMS. 1.4 Following the process of AMS. 1.5 Recognizing the appropriateness tools to solve the AMS problems.
2. Solving the malfunction of devices and its reason	2.1 Knowledge acquire, knowledge represent, reason, and human-machine interface of AMS problem-solving skills process. 2.2 Applying intelligent technology (Nissan CONSULT-III Plus) to measure and evaluate quality problem-solving skills.
3. Suggestions the trend of fault development	3.1 Describing of the intuitive problems/causes. 3.2 Presenting of the appropriate tools to solve the problems (e.g., hand tool, special tools, measurement equipment, instrumentation, accessory, standards kits) 3.3 Suggestions of the ASAPSS strategy as an AI technique (e.g., inspection, procedural knowledge, repair process, solving solutions, alternative solutions)
4. Existing cases and storage knowledge-driven	4.1 The data of knowledge acquisition is employed to collect all data in the cases via ASAPSS process. 4.2 The ontology library generated the fault symptoms, the immediate measure problem-solving process performance, and transforms the data into knowledge and knowledge-driven database.

V. DISCUSSION

From the results as shown in TABLE I, the experts reviewed the knowledge-driven data obtain to confirm reveal as a framework of ASAPSS using AI technique with the focus-group discussion. The ASAPSS using artificial intelligence technique for ECCS system have showed as results in TABLE 1, a total of 4 themes and 12 sub-themes. As briefly discussed first, automotive service technicians encounter a number of four basic tasks of ASAPSS using AI technique in fault diagnosis.

With implication of ASAPSS using artificial intelligence technique for ECCS system, a key of capacity of automotive service technicians was the ability to solve ECCS system. This required ANN & SVM feature extraction, which in turns serves as a cognitive process for linkage interpersonal skills into practice. In addition, ANN & SVM fault recognition [12], [13], which will be found the results in three inherent shortcomings:

1) The implications of ASAPSS using AI technique for ECCS system were complementarily of automotive service technicians and AI technique in real-world situations decision-making.

2) In order to accomplish for training program development, the ASAPSS using AI technique for ECCS System were typically enhance cognitive process implemented by the data-driven AI methods (e.g. uncertainly, complexity, and equivocality).

3) The collaborative between automotive service technicians and ASAPSS using AI technique for ECCS System can implement in two categories:

- Automotive service technicians and ASAPSS using AI technique for ECCS system can collaborate to deal with aspects of decision-making. They are likely to be well performed to solve complexity issues with systematic approaches as four basic tasks. Automotive service technicians can focus more on uncertainty and equivocality, using more creative and intuitive approaches for ECCS system (i.e. sensors, engine control modules, and actuators).
- Even the most complex decisions of which AI has a comparative aspects are likely to require automotive mechatronics elements of uncertainty and equivocality, which compels involvement. Therefore, automotive service technicians and ASAPSS using AI technique for ECCS system will play a combined role in almost all complex decision-making.

Furthermore, in the data-driven AI methods should the consideration of components and devices for AMS in ECCS system. As a result, procedural knowledge should be utilized and integrated closely to improve diagnostic performance [12], [14].

Additionally, ANN and SVM methods provide a way to integrate the feature extraction part and pattern recognition part into a system. Then, a complete integrated and automated diagnostic system should be gain more attention effectively to obtain real-world situations for electronics concentrated engine control system (ECCS) which is automotive mechatronics complex to the solve problem needs [12].

Additionally, ANN and SVM methods provide a way to integrate the feature extraction part and pattern recognition part into a system. Then, a complete integrated and automated diagnostic system should be gain more attention effectively to obtain real-world situations for electronics concentrated engine control system (ECCS) which is automotive mechatronics complex to the solve problem needs [12]. The structure of ANN can be performed by changing its applications; it can achieve good fault diagnosis performance in the AMS applications.

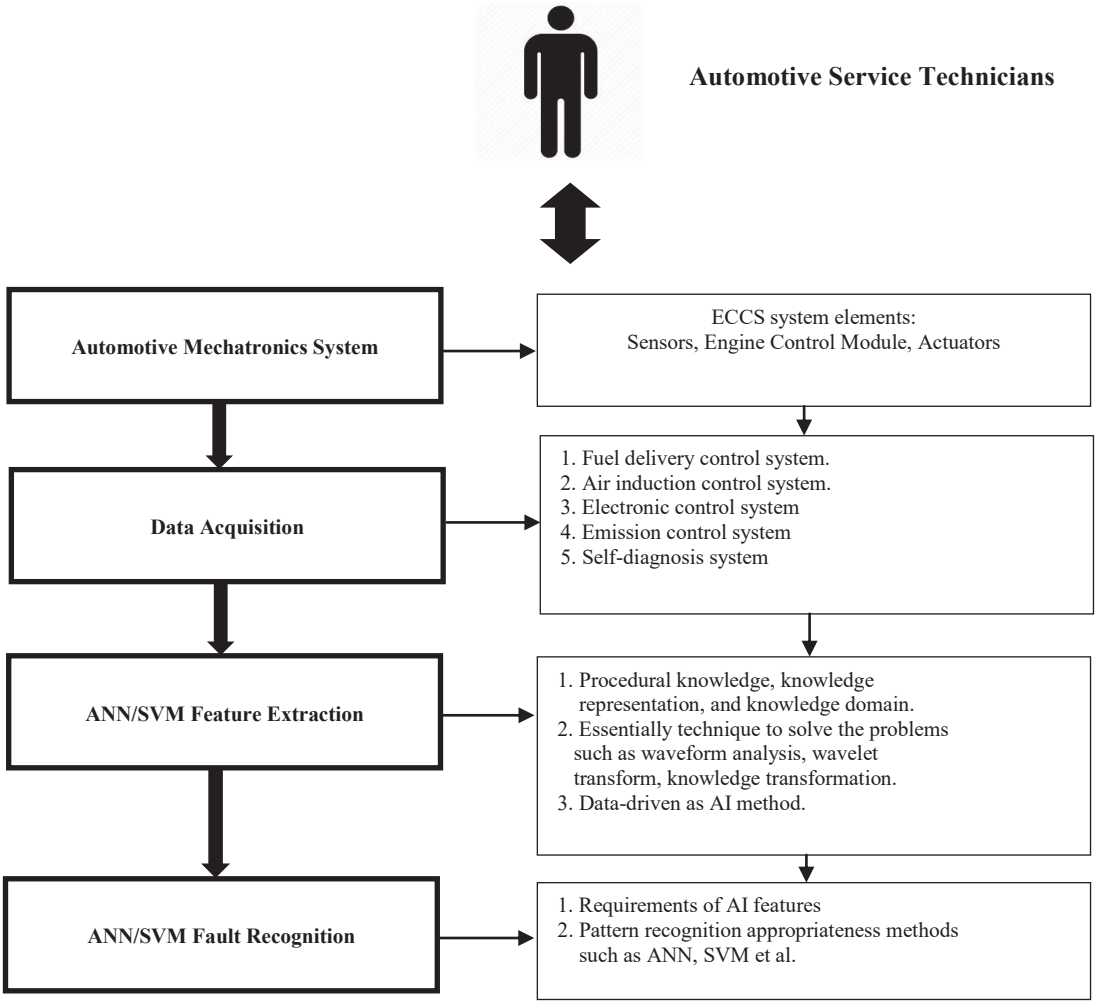

Figure 2. A framework of ASAPSS using AI technique

VI. LIMITATION

The primary limitation of this study was the choice of training course development to develop fault diagnosis via AI technique to solve the AMS problems for ECCS system, which were performed at Nissan Motors (Thailand). In addition, researcher proposed the guidance in perceptions of more experienced experts. The findings discussed in focus-group discussion. Therefore, a more detailed discussion of this research in knowledge-driven problem-solving system in the AMS for ECCS fault diagnosis according to AI technique should be addressed in future studies.

VII. CONCLUSION

This research primarily focused on exploring the framework of automotive service accuracy problem-solving skills using artificial intelligence technique for electronics concentrated engine control system fault diagnosis based on perceive their experts. The framework proposed a novel problem-solving skills process, name ASAPSS. The proposed ASAPSS was established based-on artificial intelligence technique, which was originally designed for Nissan ECCS fault diagnosis. The ASAPSS framework is simply and applied to fit directly involved 4 themes and 12 sub-themes as follow as: (1) analyzing whether the equipment is appropriateness or not; (2) solving the malfunction of devices and its reason; (3) suggestions the trend of fault development; and (4) existing cases and storage knowledge-driven. In this research, a number of AI techniques have been proposed four themes covered a total of 4 themes and 12 sub-themes.

This framework enabled a key of capacity of automotive service technicians for Nissan Motor (Thailand) and among undergraduate mechanical engineering students classifier to learn up-skills temporary automotive technology sequential patterns of the AI technique. The research finding was able to identify the datasets sequential problem-solving process depends on enterprise demands. The ASAPSS demonstrated that the strategic issues in tasks, where problems are far from being well-structured [7]. Both reliable and efficient of AI

technique, due to their particular strengths, to process data processing (feature extraction), fault recognition and provide valuable information either with a data-driven or, especially, with a knowledge-driven approach, might be of increase to automotive service technicians potentially in their decision-making.

This primary study was to implement for evaluating ASAPSS using AI technique for ECCS fault diagnosis when compared to traditional problem-solving process. The data-driven were complementarily of automotive service technicians and AI technique in real-world situations decision-making. The famous machine learning algorithms are dealing to combine ANN and SVM methods tend to perform better for new applications. The proposed ASAPSS framework demonstrated a significant performance improvement of automotive service technicians for Nissan Motor (Thailand) and among undergraduate mechanical engineering students.

In the next research, the researcher plan to conduct further to construct a quality problem-solving database pattern and a novel pattern of ANN and SVM artificial neural network methods for prediction of problem-solving performance. Then, to improve the ASAPSS is to generate knowledge-driven problem-solving system in the AMS for ECCS fault diagnosis, such as machine learning and or deep learning, respectively.

ACKNOWLEDGEMENT

This research was supported by the Nissan Motor (Thailand) Co.,Ltd contract no. NMT 010/2018 in March 23, 2018 and Memorandum of Understanding (MOU) between Nakhon Si Thammarat Rajabhat University and Nissan Piya Nakhon Si Thammarat according to July 14, 2018. The reference is contract no. MOE 0557.06/053 in March 7, 2018 and MOE 0557.06/137 in July 5, 2018.

The researcher would like to also express really sincere gratitude to Mr. Peter John Galli, Vice President of Communication, Mr.Thammanoon Sangkhawan, General Manager in Networking Division, Mr.Kullachat Chutichawakul General Manager in Training Division, Mr.Preecha Atthamanee, Manager in Training Division, and trainers from Nissan Motor (Thailand) Co.,Ltd for contribution. The researcher also would like to express really sincere gratitude to Mr.Supaphon Longduriyang, Executive President, Mr.Smith Longduriyang, Vice Executive President, Mr.Thanabordee Tanwattanaarree, Training and Development Manager from Nissan Piya Nakhon Si Thammarat Co.,Ltd for contribution. This research is a part of establishment of 'The Establishment Project of Nissan Automotive Technology Training and Technology Transfer Center in Southern Region: NATECS).

REFERENCES

[1] W. Sudsomboon, T. Muangmungkhun, W. Jinwan, W. Pansrinuan, S. Karakorn, W. Srinounpan, and S. Muenhat, "The Desirable Characteristics of Automotive Service Technicians in era of Thailand 4.0 as Perceived by Entrepreneurship," *The 4th National and International Conference on Curriculum and Instruction "Instructional Leadership: driving for professional learning community" (NICCI 2018),* February 9, AVANI Khon Kaen Hotel and Convention Center, Khon Kaen, Thailand, pp. 758-765, 2018.

[2] W. Sudsomboon, S. Sudsomboon, S. Sudsomboon, T. Muangmungkhun, A. Siripan, W. Jinwan, and S. .Karakorn, "Designing of a Competency Framework for Academic and Research Engagement on University-Industry Cooperation in Automotive Technology Knowledge Transfer," *The 11th International Conference on Educational Research "Innovations for Capacity Building and Networking" (ICER 2018),* September 8-9, Faculty of Education, Khon Kaen University, Thailand, pp. 607-613, 2018.

[3] W. Sudsomboon, "A Proposed of Automotive Direct Ignition Coil Fault Diagnosis through an Adaptive Fuzzy Logic Control," *The 7th International Conference on Sciences and Social Sciences "Innovation Research to Stability, Prosperity and Sustainability" (ICSSS 2017),* January 11-12, Rajabhat Maha Sarakham University, Thailand, pp. 643-648, 2018.

[4] A. K. Jardine, D. Lin, and D. Banjevic, "A review on machinery diagnostics and prognostics implementing condition-based maintenance," *Mechanical System Signal Processing,* vol. 20, no. 7, pp. 1483-1510, 2006.

[5] Xu. Zhaoguang, D. Yanzhong, and M. Peter, "Knowledge-driven intelligent quality problem-solving system in the automotive industry," *Advanced Engineering Informatics,* vol. 38, pp. 441-457, 2018.

[6] R. Stuart and Norvig. P, *Artificial Intelligence: A Modern Approach,* 3rd ed., New Jersey: Prentice Hall, 2010.

[7] M. Mrugalski, M. Witczak, and J. Korbicz, "Confidence estimation of the multi-layer perceptron and its application in fault detection systems," *Engineering Applications of Artificial Intelligence,* vol. 21, no. 6, pp. 895-906, 2008.

[8] G. Bin, J. Gao, X. Li, and B. Dhillon, "Early fault diagnosis of rotating machinery based on wavelet packets empirical mode decomposition feature extraction and neural network," *Mechanical System Signal Processing,* vol. 27, pp. 696-711, 2012.

[9] M. D. Prieto, G. Cirrincione, A. G. Espinosa, J. A. Ortega, and H. Henao, Bearing fault detection by a novel condition-monitoring scheme based on statistical time features and neural networks, *IEEE Trans. Ind. Electron,* vol. 60, no. 8, pp. 3398-3407, 2013.

[10] Y. Wang, Q. Ma, Q. Zhu, X. Liu, and L. Zhao, "An intelligent approach for engine fault diagnosis based on Hilbert-Huang transform and support vector machine," *Applied Acoustic,* vol. 75, pp. 1-9, 2014.

[11] M. Q. Patton, *Qualitative Research & Evaluation Methods: Integrating Theory and Practice,* Thousand Oaks, California: SAGE Publications, Inc.; 2015.

[12] Y. H. Hu and J.-N. Hwang, *Handbook of Neural Network Signal Processing,* CRC Press, 2001.

[13] Z. Zhou, C. Wen, and C. Yang, "Fault isolation based on *k*-nearest neighbor rule for industrial processes," *IEEE Trans. Ind. Electron,* vol. 63, no. 4, pp. 2578-2586, 2016.

[14] G. Soheil and T. Morteza, "Training qubit neural network with hybrid genetic algorithm and gradient descent for indirect adaptive controller design," *Engineering Applications of Artificial Intelligence,* vol. 65, pp. 346-360, 2017.

[15] K. M. He, X. Y. Zhang, S. Q. Ren, and J. Sun, "Delving deep into rectifiers: surpassing human-Level performance on Image Net classification," *IEEE International. Conf. Comput. Vis,* pp. 1026-1034, 2016.

[16] X. M. Jiang, S. Mahadevan, and Y. Yuan, "Fuzzy stochastic neural network model for structural system identification," *Mechanical System Signal Processing,* vol. 82, pp. 394-411, 2017.