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TEACHING AID FOR DIAGNOSING MOTORCYCLE DAMAGES USING BACK PROPAGATION ARTIFICIAL NEURAL NETWORK

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ABSTRACT

The challenge of learning media in the world within the next 1 to 2 years is Bring Your Own Device. It forces the learning paradigm to think quickly to follow the development of technology that can optimally use it. In the Control Systems II course, there are some stereotypes that some of the material is mainly an Artificial Neural Network (ANN) was limited to theory and simulations and is difficult to be applied. Teaching aids are interpreted as teaching material that is used to help teachers in carrying out the teaching and learning activities in the classroom. The purposes of this study are: (1) to create teaching aid for ANN material to diagnose motorcycle damage in the Control System II Course (2) to define the accuracy of the application of the teaching aid for the material of ANN in the Control System II Course. The prototyping approach model is used to generally define the teaching aid product that will be developed. In detail, the development methods include (1) listen to the customer, (2) build or revise a mock-up, and (3) customer test drives mockup. Teaching aids products are built in the form of application for the diagnosis of motorcycle damages using the Back-Propagation ANN. This application can detect four types of motorcycle damages based on the sample sounds of motorcycles included. The application can recognize the type of damage from 100 new sound data outside its knowledge-base with a 60% accuracy level.

Keywords: artificial neural network, backpropagation, teaching aids, motorcycles

INTRODUCTION

New Media Consorcium (NMC) Horizon Report 2015 of Higher Education Edition challenges the world's learning media will face over the next 1 to 2 years is BYOD (Bring Your Own Device) [1]. BYOD can be interpreted as the optimization of electronic devices such as laptops, tablets, smartphones, or other similar devices for teaching-learning activities. This forces the paradigm of thinking fast in learning to follow the development of technology so that BYOD can be implemented optimally. Such innovation should have attention from Yogyakarta State University, especially from the Faculty of Engineering, in preparing their alumni to be the educators in Vocational High Schools. 2014 Curriculum of UNY has been applied for 3 semesters, the changes occurred affect certain courses. In the course of Control System II, the competency ranges from the material of open system, loop system, artificial neural network to fuzzy logic. The interesting thing found about this course is the stereotypes occur among the students that some of the materials in the Control System II course are only limited to theories and simulations, it makes the course is hard to be learned. Moreover, the main difficulty in learning Control System II, especially the competence of Artificial Neural Network, is the observation results are assumed based on how far the students can master three main categories, namely; (1) complex mathematics material, (2) simulation domination, and (3) the ability of the students to imagine the implementation/

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application of the course in its practice. In the Educational Robotics Journal: New Challenges and Trends, it is stated that "shifting from 'black box' to 'white box' paradigm: learners as 'makers' rather than just consumers" [2]. It means that the learning process needs further mastery of strong theory and in practice, but the fact the mastery of complex concepts causes student apathy orientation.

Artificial Neural Network or ANN is an algorithm that allows machines to learn from experience. This algorithm is suitable to be applied to solve problems sourced from inputs and outputs, yet the processes of input and output are unknown [3]. In ANN, many methods can be used to solve problems, for example, to do the process of speech recognition. ANN is one of the artificial representations of the human brain that always tries to simulate the process that occurs in the brain [3]. The term artificial here is used because the neural network is implemented by using a computer program capable of completing several calculation processes during the learning process.

ANN is very mathematical and is related to Higher Order Thinking Skills (HOTs). HOTs is interpreted as a high-level thinking ability including critical thinking skills, analytical, logical, reflective, metacognitive, creative, and cooperative skills. ANN is a part of HOTs, reasoning ability is required in this thinking level. Reasoning and critical thinking are interconnected. This is in line with Stephen and Rudnick's [4] opinion, that reasoning includes basic thinking, critical thinking, and creative thinking. These last two levels of thinking (critical thinking and creative thinking) are included in high-level thinking skills that must be implemented in the Control System II learning activity. In the book Way of Learning [5], it is mentioned that the relationship between theory and practice are parts that are exponentially related. This means that the theory will be more attached to its retention when it is practiced. This relation theory can be produced from the results of research [5]. The researcher wrote about the team's experience in developing a voice recognition to visualize the numbers through the voice input/human speech, as part of the preliminary research.

Based on the Curriculum 2014 of Electronics Education study program [6], the teaching and learning activities of the Control System II course teach the students about backpropagation artificial neural network materials and its relationship with BYOD. About 85% of students have laptops with them. This proves that the implementation of BYOD based teaching aid is suitable for ANN materials. The teaching aids themselves according to the National Center for Vocational Education Research are interpreted as teaching materials or any form of materials used to assist lecturers/instructors in carrying out teaching and learning activities in the classroom [7]. Because of its nature, the development of teaching aids for the ANN material can provide good retention. The sample of teaching aid in implementing ANN materials can be applied in diagnosing motorcycle damage. The recognition process of motorcycle damage is following the method used by mechanic experts to detect damage through the sound.

Complex materials, minimum teaching aids, and the limited innovation of implementation of ANN in the Control System II course urged the researcher to find out the solution. Based on the explanation, the researcher felt the need to do research entitled "Teaching Aid for Diagnosing Motorcycle Damages using Back

Propagation Artificial Neural Network". The teaching aid of the Control System II course was developed in such a way to optimize the presence of BYOD in the department. The use of the teaching aid can be used to help the students to understand and implement ANN, especially in diagnosing motorcycle damage.

Durdanovic [8] has succeeded in analyzing how much influence teaching aids were used by instructors on the quality of teaching in providing music education. The teaching aids were applications provided on the computer and stored on CD for each class. His research concluded that teaching aids were very helpful for teachers in the process of learning music education. Brazdeikis & Masaitis [9] have also researched teaching aids that use the assistance of information technology in learning in Lithuanian Schools. Constraints that occurred in the implementation were limited funds to procure hardware. While the benefits obtained were to reduce the gap between the real world and the theory in school textbooks.

There are also several studies related to the speech recognition system [10]–[13]. This research will develop a teaching aid based on speech recognition, while the problem domain is motorcycle damage which will be solved using the Backpropagation ANN method. ANN Backpropagation is one of the main materials taught in the Control System II course in the Department of Electronic Engineering Education, Faculty of Engineering, UNY.

This study will provide a scientific contribution to the branch of artificial intelligence specifically about the combination of ANN that is suitable for detecting motorcycle damages based on its sound. The purposes of this study are: (1) to create teaching aid for ANN material to diagnosing motorcycle damage in Control System II Course (2) to define the accuracy of the application of the teaching aid for the material of ANN in the Control System II Course.

METHOD

The method used in this study is Research and Development that was conducted to develop prototype products or new products. According to Pressman [14], this method has 3 elements that are needed to be considered in developing software, they are the presence of students and lecturers, developers, and user trials (lecturers). The explanation can be seen in Figure 1.

The prototype method is a software development method that represents the working system of software which is not yet completely represented by user trials (lecturers). The developers coordinate and maintain intensive meetings with the users to accommodate the information that will be the basis of the design. The prototype of the software is then presented and the users (lecturers) are given the chance to give inputs/comments so that the resulting software will be completely under the expectation and the needs of the customer.

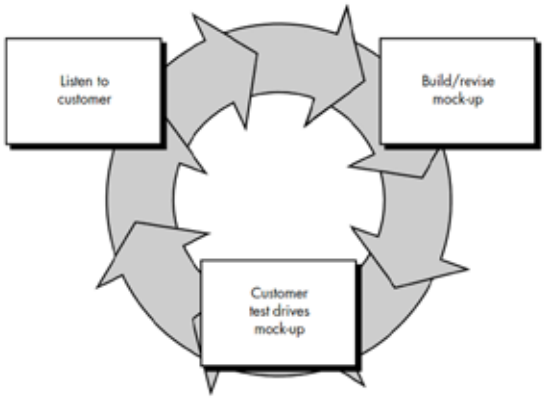

Figure 1. Prototype Model adopted from Roger [15]

The followings are the prototype development modeling stages: (1) Listen to Costumer. This stage is done by observing and interviewing the users, the students, and lecturers, to identify the weaknesses of the Control System II course. (2) Build or revise mockup. In this stage, the software for preprocessing (feature extraction) is built using Fast Fourier Transformation (FFT). Then followed by designing the software and implementing the Back Propagation Artificial Neural Network algorithm for diagnosing motorcycle damage. The backpropagation method includes an auto-associative type of network that the input range processed into the network is equal to the range of the results released [16]. In general, the application system follows the flow as shown in Figure 2.

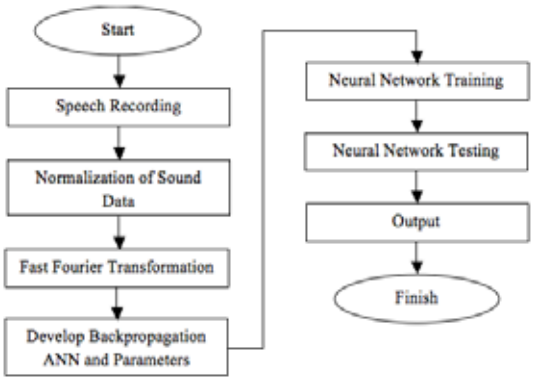

Figure 2. System Flow Diagram

The Customer Test Drives Mock Up is the evaluation stage, which is the act of collecting, processing, and analyzing the information systematically to obtain the real value of problem-solving. The evaluation stage is conducted through the collection of information from users (lecturers) who have used the application.

The evaluation stage consists of software testing. Software testing is needed [17] and important [18] in the software development stage. The evaluation was conducted using Alfa and Beta testing, which had previously been successfully applied in several other studies [19], [20]. Aspects tested include content, function, usability, navigation, performance, compatibility, and security. The alpha test aimed at identifying and eliminating as many problems as possible before finally reaching the users. The testing is done after the application is developed by the developers. The Alpha test instrument is required to ensure the validity of the application performance. The experts appointed in the Alfa test are software development experts and practitioners.

The Beta test is fully performed by potential users using the instrument by selecting three categories: potential users, average users, and slow learner users. The users are told the Beta test procedure, then they are asked to rate the application to obtain the data. The results of the Beta test will be subjected to the revision of the application products. The Beta test instruments are used after being validated by software development experts.

The subjects of this study were students and lecturers who used teaching aids in delivering the presentation material of backpropagation in the Control System II course in class. In this research, the sound samples were taken from different motorcycles types and manufacturers. The data collection method used in this research was Non-Probability Sampling. The data were collected by using a quota sampling technique, that the data were taken from three different motors. The data were in the form of sound data samples from motorcycle engines. The samples were taken through Matlab R2014a application. Each sound sample (in .wav file format) is taken with a normalization time of 1 second which is subsequently extracted into 10000 data.

RESULTS AND DISCUSSION

The first step of this research is to Listen to Costumer or through establishing communication with customers/potential users. The interviews were conducted with two lecturers of the Control System II course. The interviews were enacted in the form of discussion and questions and answers that focused on the problems that are faced in the process of teaching-learning activity of Control System II. In that course, the materials are divided into two main topics namely ANN and Fuzzy Logic. The result of the interviews was the gathered information about some stereotypes occur among the students about ANN which can be categorized in three basic assumptions, namely; (1) complex mathematical materials, (2), simulation domination, and (3) the students were hard to imagine the form of the implementation/application of the material. Therefore, a teaching aid is needed to internalize the concept of ANN. The type of ANN dominating in the course of the materials is backpropagation artificial neural network. Backpropagation artificial neural network is the most widely applied ANN in everyday problem solving, such as the pattern of recognition, medical diagnosis, image classification, code translation, and other patterns of recognition. So far, the students are only given the theory of the application without actually trying the application in practice.

After knowing the problems that have been faced in the Digital Technique II course, the next step was to determine the solution obtained from the results of question and answer with the lecturers of the course, namely: (1) Complex Mathematical Material. Complex ANN calculation is full of iterations up to thousands or even millions of times. The students will not be able to calculate the calculation of the ANN formula quickly. The calculations on ANN cannot be completed manually. The expected solution is the existence of a system/application that can do the calculation of ANN automatically, quickly, and accurately. (2) Simulation Domination. Until now, the students are only given examples of simulations of the ANN program, especially back propagation artificial neural network materials. The simulation represents a problem, but not for real, the input data entered is not based on everyday problems. The solution is to build a system/application that is capable to solve an everyday problem with real input data, so the output is also logical and is a workable solution for problem-solving. (3) Students Face Difficulties in Imagining the Implementation or Application of the System. The students have little experience in using the real application of the implementation of a backpropagation artificial neural network, which makes it difficult to imagine the real application in the reality. So far, the lecture is dominated by giving theories and simulations. The solution is to build an application that can be applied to solve problems in the real life. One of the problems to be considered is motorcycle damage because motorcycles are the most used vehicles in the community nowadays, and the damage is the problem that might be faced by society. In addition, motorcycle damage can only be repaired by certain people, namely motorcycle experts/ technicians.

The next step was analyzing the needs based on the problem and the solution that is going to be applied. In this stage, the researcher took sound data of motorcycle damages from Motorcycle Workshop, Department of Automotive Engineering Education, Faculty of Engineering,

Yogyakarta State University. The sound recording processes were done on July 1st, August 4th, October 13th, 2016.

The data of motorcycles' sound taken were as much as 400 sound samples in .wav file format, where 300 sound samples will be used as Training Data and 100 other sound samples as Testing Data. The tool used to record the sound was Digital Voice Recorder.

The type of damages from the motorcycles' sound samples obtained were four, namely: Rubber House Clutch, Compact Chain, Loose Valve Gap, and Damage Loker Bearings/Dearing/Noker Ass. On the other hand, the normal sound sample was also taken. dan Rusak Loker Bantalan / Dearing / Noker Ass. Figure 3, Figure 4, Figure 5, Figure 6, and Figure 7 respectively show the sound graph of the four types of motorcycle damage and a normal sound.

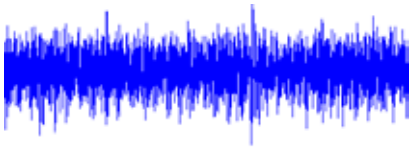

Figure 3. Rubber House Clutch Sound

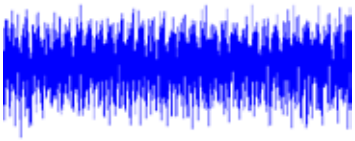

Figure 4. Compact Chain Sound

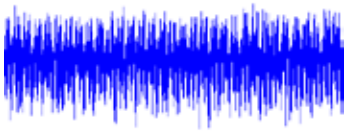

Figure 5. Loose Valve Gap Sound

Figure 6. Damage Loker Sound

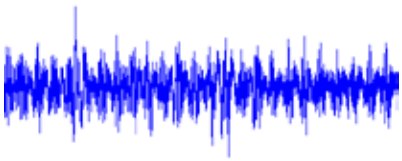

Figure 7. Normal Sound

After taking the motorcycle sound sampling for the ANN knowledge-base, the next step was sound recording for the network testing. The data recorded for the test was 160 sound recordings from different motorcycles. The Results Design Stage Build and Revise Mock-up is the application's interface presented in Figure 8. There are buttons used to Open and Play the file. Users can start diagnosing the sound by opening the previously-stored sound file on the database, by selecting the Open menu. After the users choose the sound file, the users can immediately see the graph as well as the identification result of the types of motorcycle damages. Besides, the file name that has been selected is also shown to make it clearer. If the users want to listen to the recorder, the users can select the Play menu. The result of the sound identification from REC001.WAV file, that was selected previously, can be seen in Figure 8. The type of motorcycle damage that has been identified is the Rubber House Clutch.

Figure 8. Motorcycle Diagnostic Application Interface

The next stage is the customer test drives mock-up results. In this stage, the information from the users (lecturers) using the completed application was gathered. The experts in software development were chosen to do the Alpha test. The total scored obtained from the Alfa test instrument was 4.6 out of 5, which is categorized as Very Good.

While in the Beta test, the test takers were potential users. The potential users were told the Beta Test procedure and then are asked to rate the application to take the data. The result of the Beta test would be subjected to the revision of the product application. The total scored obtained from the result of the Beta test instrument was 4.33 out of 5, which is categorized as Good.

The application of Motorcycle Damage Diagnosis was built with BackPropagation Artificial Neural Network by using 1 input layer, 1 hidden layer with 100 neurons, and 1 output layer. The activation function used is Tansig. There are two ways in determining the cessation of the ANN training process, namely: the number of iterations limitation or Mean Square Error (MSE).

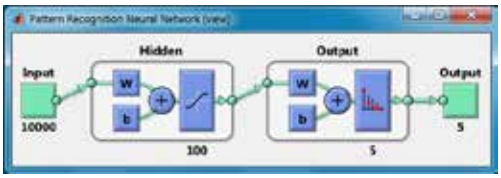

Figure 9. BackPropagation ANN Architecture

In the application, the number of iterations is limited to 1000, whereas MSE is limited to 1.00e-06. The result of the ANN training can be seen in Figure 10. The training process stops at the 129th iteration with a recorded time of 48 seconds. While the result of the ANN confusion matrix can be seen in Figure 11.

Figure 10. Results of JST Training

The conclusion drawn from the matrix is that the level of accuracy in determining the net output of the built application is 100%.

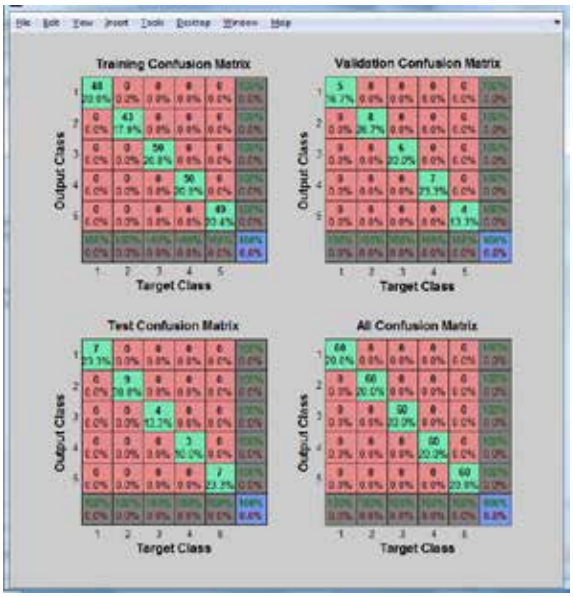

Figure 11. The Result of ANN Confusion Matrix

The application was built by using 300 damage sound data samples on motorcycles as the Training Data. Once the application is completed, it needs to be tested for its accuracy by trying to input new damage sound data besides the previously-stored knowledge-base. The new sound data tested are 100 data from the motorcycles that come from different types. The result is that the application can recognize 100 types of damage sound data with an accuracy of 60%.

CONCLUSION

Teaching aids in the form of application used to diagnose the motorcycle damages through backpropagation artificial neural network method as a teaching aid was built with the network architecture of 1 input layer, 1 hidden layer (100 neurons), and 1 output layer. The activation function used is Tansig. The training process stops at the 129th iteration with a recorded time of 48 seconds. The result of the ANN Confusion matrix indicating the level of accuracy in determining the network output of the constructed application was 100%. But this application can only recognize the type of damage sound from 100 new data outside its knowledge base with 60% accuracy level. Tests have been conducted on teaching aids that are built. The total score obtained from taking the Alfa Test instrument was 4.6 out of 5, which is categorized as Very Good, while the total score obtained from taking the Beta Test instrument was 4.33 out of 5, which is categorized as Good. In further research, the type of motorcycle damage can be added, so that the damage will be more varied. The application can also be developed to be portable and real-time. In addition, you can also compare the Back Propagation ANN method with other methods such as ANFIS (Adaptive Neuro-Fuzzy Inference System) to diagnose motorcycle damages.

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