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ANN Distance Protection for Transmission Lines

Aaron Don M. Africa, Isaiah Kyle A. Naco, John Joseph M. Castillo, Victor Antonio R. Valdes, Shawn Reece T. Wu

Department of Electronics and Communications Engineering
De La Salle University, Manila
2401 Taft Ave., Malate, Manila 1004,
Philippines, aaron.africa@dlsu.edu.ph

ABSTRACT

When using transmission lines, faults often happen during the flow of signals. One way to protect transmission lines is to use distance protection relays. These types of relays, however, are still affected by fault resistance. Fault conditions often follow a certain pattern. Having a relay that recognizes these patterns can help improve performance. This paper presents a method to implement this using an artificial neural network (ANN). An ANN is one of the many applications of machine learning, which in meaning, is the algorithms that give the ability to computers to obtain knowledge through data and adapt to make certain deductions and choices. This paper will only consider the effect of the fault resistance of a single line-to-ground type of fault. The ANN should be programmed to identify numerous patterns that each correspond to different fault conditions. This will help in identifying and classifying unknown patterns detected in the transmission lines.

Key words: artificial neural network, distance relay, fault resistance, transmission lines, algorithms.

1. INTRODUCTION

Transmission lines can become victims of faults or abnormal electric currents. There are four types of faults; single line-to-ground, line-to-line, three-phase, and line-to-line-to-ground. When faults occur, severe damage can be inflicted on the equipment. There are plenty of ways to protect transmission lines from faults. One way is to use distance protection. When a fault occurs, the current rises by a significant amount, and the voltage decreases by a significant amount. When using this method, a distance relay or impedance relay uses the voltage and current applied to it to measure the impedance of the line. When the impedance determined by the relay is within the setting of the relay, it will operate. The operation of a distance relay, however, can be affected by fault resistance. When the fault has resistance, it causes an error in the relay's calculation of the impedance of the line since it adds another parameter that affects the impedance. This causes the distance relay to operate even when the actual impedance is below or above the relay settings [1]. This paper introduces the utilization and manipulation of artificial neural network (ANN) to deal with this problem. ANNs are simply artificial brains that imitate the way an actual human brain works. The reason why ANNs would prove to be useful when applied to distance relays is that they are excellent at identifying patterns. Since a distance relay determines the impedance based on the voltage and current that is applied to it, and that faults drastically alter the amount of current and voltage, we can use an ANN to recognize and identify the patterns [2, 3]. ANNs also have generalization capability, noise immunity, robustness and fault tolerance. Because of these characteristics, a distance relay that uses an ANN will not be heavily affected by any variation to system parameters.

2. BACKGROUND OF THE STUDY

Transmission lines are a major component in an electric power system. The chances of experiencing faults are higher in transmission lines than any other component in an electric power system because of its exposure to the environment [4]. Faults in a transmission line can be caused by trees, lightning, animals, weather, and faulty equipment. Since electricity is so important in this day and age, it is important to be capable of detecting a fault in a transmission line and protecting said transmission line [5].

To protect a transmission line from faults, distance protection can be used. This method of protection uses distance or impedance relays. A distance relay or impedance relay uses the voltage and current applied to it to measure the impedance of the line. Distance relays have three "zones" that offer different levels of protection to the transmission line. Zone 1 provides high-speed protection to a large part of a transmission line. Zone 2 protects the rest of the line and also provides backup protection for the remote end bus. Zone 3 is the backup protection for all the lines. When the impedance determined by the relay is within the setting of the relay, it will operate. When a fault causes the current to rise and the voltage to drop significantly, the relay stops operating to protect the transmission line.

A fault resistance will affect the operation of a distance relay. Fault resistance consists of arc resistance, tower footing resistance, and resistance of the ground. A distance relay only considers the current and voltage applied to it, so an added impedance from the fault resistance will affect the determined impedance and affect the relay performance, causing to overshoot or undershoot.

Artificial Neural Network, in the simplest way of explaining, is a replication of the human brain. A human brain has the capacity to learn, think, and adapt to its environment. It is able to make decisions based on the judgments it makes [6, 7]. An artificial neural network, while far from the capabilities of an actual brain, even an animal's brain, performs the same way. It is very useful in understanding and recognizing complex objects and patterns, essentially being able to learn on its own. They generally consist of an input layer and an output layer. Most of the time, a hidden layer or layers are included [8]. These layers are between the input and output layers, and they transform the input into something the output layer can use.

Implementing this to something like the distance relay of a distance protected transmission line will not only bypass the issue caused by a fault resistance but also allows the distance relay to operate without the constant supervision or the manual operation of a human operator.

3. STATEMENT OF THE PROBLEM

Transmission lines were widely used to cover large-scale distances of electrical traveling during the early '90s. The initial structure was located in North America and functioned with a voltage value of 4000. It generates electrical travel from Willamette Falls and Chapman Square, Oregeon, having a distance that covers approximately thirteen miles. Covering that far of a distance, electric currents must be stable and unfaulty to obtain optimal electric generation and safety to the electricity's receiver but through the course of time system efficiency and damage might occur. The most prominent defects are known as line faults or fault currents. They are any known abnormalities of electric flow in the transmission lines. This paper aims to implement an artificial neural network in the distance relay of a distance protected transmission line using MATLAB. Faults in transmission lines are very dangerous to not only the electric system but to people working on them as well.

4. SIGNIFICANCE OF THE STUDY

Using an Artificial Neural Network (ANN) for distance protection in transmission lines is important for our society today because it is one of the efficient and effective ways of resolving line faults in transmission lines. Line faults are stray electric currents that are unwanted in the system. These line faults can be caused by several factors such as harsh weather, faulty equipment, and even human error. There are several types of faults that may occur in a transmission line system and the purpose of the ANN is to detect and locate the line that contains the fault no matter what type they may be. It is important to resolve line faults in transmission lines because they may cause damage to equipment, harm to operators, and avoidable loss of electricity. Line faults can make a system largely inefficient which may have drastic economic effects. With the modernization of society, the need for electrical power is abundant and the supply from transmission lines is needed [9]. Highly efficient systems are needed in order to bring electricity to societies and an ANN protection system for transmission lines would greatly help in making a system more efficient. This study would serve as research into the direct effects of an ANN in a transmission line system and how the system could be further [10].

5. DESCRIPTION OF THE SYSTEM

The system that the group is evaluating is a common transmission line system. The system is supplied with 220kV of electricity that flows through the transmission lines to the fault breaker and the circuit breaker. The substation in the system is the source of the electricity in the system and the distributed parameters block is the controller for the parameters for the system. The parameters that would be put upon the system is a fault and a healthy parameter.

6. METHODOLOGY

The system that the researchers will evaluate is a system that transfers three-phase energy through transmission lines. The tests that the researchers will run will be set on different conditions or parameters where the line may or may not have fault [11]. The system is designed to show the researchers the differences that faults may put to the system. Additionally, the researchers should be able to see the line parameters of the transmission line system. After this, the researchers will see if the ANN would be able to detect whether or not the line has a fault. The ANN should be able to see if there is a fault in the system through training and the acquisition of data about the line parameters.

7. REVIEW OF RELATED LITERATURE

There many types of faulty, which would result to many making of paper, journal, etc about faults on overhead lines are an unusual condition, brought on by climate conditions, human mistakes, the smoke of flames, hardware letdowns, for example, pivoting machines and transformers, and so on. One research paper uses the Pattern Recognition Approach for Fault Identification in Power Transmission Line. this research paper uses wavelet multire solution analysis is said to be suitable for extracting information or data from a transient fault signal. [12,13,14,15]. In this paper, it also shows that most fault line occurs in 2nd or 3rd harmonics; hence using the wavelet MRA style or technique, the presence of faults in a certain phase from the summation of detailed magnitude gotten. The general algorithm used for wavelet MRA generally for independent fault location or it is impedance or even an inception angle. The next research paper is the Fuzzy Logic Based On-Line Fault Detection and Classification in Transmission Line. This research paper uses programmable

automation and controls technology-based national instrument compact Reconfigurable input and output devices [16, 17]. This approach is determining the fault detection and also give automatic protection in real life. The application use says in the paper that it is reliable, secure, and fast, which makes the use of Fuzzy logic with application useful. The next research paper is about the Fault Detection and Location in Power Transmission Line Using Concurrent Neuro-Fuzzy Technique. The paper used the concurrent Neuro-fuzzy technique for fault classification, fault location, and fault detection. This technique is adapting and predicting the future possible error to occur in order for when the next faulty will come [18, 19, 20]. Next is a paper entitled Application of Artificial Neural Network to Transmission Line Faulty Phase Selection And Fault Distance Location by writers Anamika Jain, V.S.Kale, A.S.Thoke, introduces the use of an artificial neural network to detect faults and their locations. The ANN does this by using the current signals to find the relationship in the input patterns. The results of their study show that ANNs are capable of generalizing and classifying different faults from the patterns provided to the network [21,22]. The next paper is ANN Based Distance Protection of Long Transmission Lines by Considering the Effect of Fault Resistance by authors A.P. Vaidya and Prasad A. Venikar. They also use ANN to protect transmission lines from faults. However, they only consider the effects of fault resistance for a single-line-to-ground type of fault. To train their ANN, they used the Levenberg-Marquardt algorithm. They determined that using the algorithm to train the ANN requires fewer epochs, but it takes longer to train. The next paper is Classification of Single Line to Ground Faults on Double Circuit Transmission Line using ANN written by Anamika Jain, A. S. Thoke, and R. N. Patel. This paper provides further applications for artificial neural networks in transmission lines [23, 24, 25]. They discuss the potential use of the artificial neural network in detecting and classifying single line and ground faults on circuit transmission lines with remote end infeed [25, 26, 27]. The problem here is due to the mutual coupling of two circuits during different fault conditions. They also use the Levenberg-Marquardt algorithm. Based on their simulation results, single phase-to-ground faults can be detected and classified quickly after the fault starts. The algorithm they used proved to be not affected by the effects of remote end infeed, fault locations, mutual coupling, fault inception angle and fault resistances. The next paper is the New Design of a Neural Network Algorithm for Detecting and Classifying Transmission Line Faults by S. Vasilic and M. Kezunovic. The authors also discuss the introduction of artificial neural networks in the detection and classification of faults. The researchers used the Alternative Transient Program (ATP) to model the power network, and they used MATLAB to implement the protective algorithm [29, 30]. The results of their study also show that the algorithm of the proposed neural network has better detection and better protection for transmission lines. It also has more benefits over the previous algorithm, like the easy selection of fault scenarios and patterns, better algorithm training achieved through generating and combining cluster structures. The new algorithm is trained for every possible fault angle value, which is an improvement from the previous algorithm, which was only trained for particular fault angle values. These values are placed in a database [31, 32].

8. THEORETICAL CONSIDERATIONS

When writing this paper, the group had to gather enough information on transmission lines and artificial neural networks in order to understand it first then implement it into a simulation in MATLAB. The code sequences are patterned in the researches of [33,34]. One thing to be considered is that although artificial neural networks are complex and useful for they act like a human brain, it is important to remember that they do not actually function in the same exact way that a human brain does. The program structures of the system follows [35,36,37]. The neurons in an ANN are different from the neurons from an actual brain. When it came to artificial neural networks, the concepts of competitive learning models had to be understood before implementing ANNs. One theory the group considered is a theory for artificial neural networks called Adaptive Resonance Theory (ART). ART processes new data by checking for any similarities between new data and data already learned previously. If there is a close enough match, the new data is learned. If there is no match, this new data is stored as a "new memory".

9. ANALYSIS OF DATA

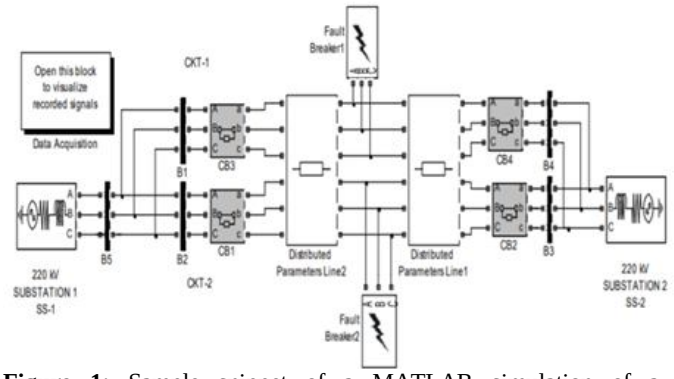

Figure 1: Sample snippet of a MATLAB simulation of a transmission system

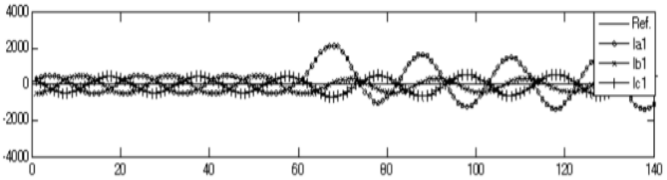

Figure 2: Sample snippet of the line current in a transmission line with the fault

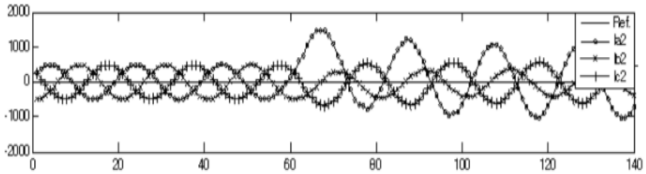

Figure 3: Sample snippet of the line current in a transmission line without fault

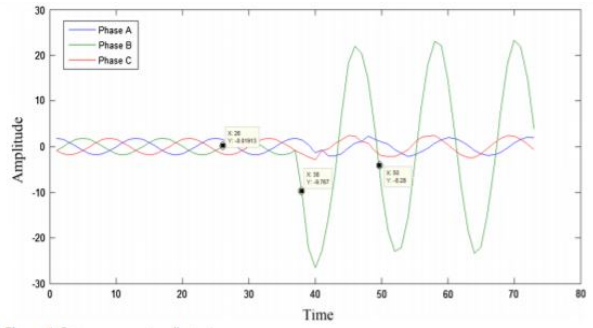

Figure 4: Sample snippet of the ANN model using SIMULINK

10. ANALYSIS OF DATA

An Artificial Neural Network was chosen to be applied for line fault detection in transmission wires due to the fact of it having a programming style which is perfect for solving the problems easily. Based on the data and simulation shown, the neural network was given six inputs while the fault detection process is ongoing. The method used was making the three-phase voltages and currents to act as the inputs in regard to the neural network. Another technique that was utilized was the Back-Propagation Neural Network Architecture. Through the simulation, an Artificial Neural Network was proved to be very optimal for line fault detection. The fault is the undesired broken circuit that happens between wire and ground.

The Artificial neural Network holds key to processing, mapping, memory and learning abilities. This specific Network having a wide range of usage and optimal outcomes makes it an effective and efficient way of detecting faults in an electrical system.

The snippet shown in figure 1.2 portrays the proposed ANN model which what simulated with the use of MATLAB. The certain toolbox utilized was divided into a set of three distinct parts.

To apply to the test, the first part of the three was the training data set. It was used for the sole purpose of training the said network into computing and distinguishing faults and value errors of network coverages. The second part is known as the validating data set which is utilized by the network while the training process is ongoing. The faults in the validating process for all of the validating sets are observed during the training process. The process ends once overfitting the given data is happening because validation errors will increase, so it basically ends to avoid further clustering of a limited set of data points. The third set is the testing set, which is not specifically used for the training process but to give the final judgment in terms of the performance and efficiency of the developed neural network.

11. CONCLUSION

The research that the group has conducted is about how an ANN can be used for distance protection in transmission systems. A transmission system is prone to some common errors and faults. There are several different types of faults that a system can be put under and these faults have many possible causes. If a system has a fault, this may deem the system to be ineffective and inefficient. Additionally, these faults can have effects on society and to the personnel operating the transmission line system. The objectives of the group through this research are to investigate the effectiveness of an ANN is detecting faults in a system, find ways to improve the transmission of electricity through large distances, learn more about ANN, learn about the different ways to remedy the different types of faults, and to learn more about Simulink in MATLAB.

To simulate the research properly, the group first needed to know more about transmission lines and why they experience faults. Also, before the group can research further into the topic, the group needs to learn more about ANN. ANN, or Artificial Neural Network, is a model that can be trained to know what the common input and the common output is which enables the model to find anomalies in a system. For this research, the group aims to implement the purpose of an ANN in a transmission line system for them to be able to find anomalies in the system. Once the group acquired simulation results, the group observed the effects that a fault has on a system. Also, the group learned how an ANN detects these faults in the system and identifies them. Overall, through the research, the group learned a lot about the use and the purpose of an ANN and the reason that it is implemented on transmission line systems. At the end of the research, the group reached their goals and realized the effectiveness of an ANN on the transmission line system.

12. RECOMMENDATIONS

The recommendations here in this project mostly are where the distance after detected can also be used as a reference for the future idea and also can also be a reference for predicting other possible faulty which will even the chance of reducing error. This idea is generally for wavelet or for fuzzy, but if combined with the idea of predication and technique of fuzzy, then the chance of ever coming back will be like preventing it most of the time due to the idea where it will know where mostly a faulty happen. There is a recommendation where this faulty are natural, so maybe if the location is right, the only that must be preventing are only small natural faulty that at least would be less hassle and will benefit the idea that lessening the cost as well for other faulty that will be unnatural to occur in a location that is close to impossible to happen. Another idea is how about make a tank circuit that will prevent the surge of strong current or voltage to pass through, then regulate it then also fix the data then allowing to transfer again. That said that the tank circuit idea was meant for just preventing other hardware from broken due to the high surge of current or voltage. Another recommendation would be why not make use of the future nanotechnology of a self-fixing idea, that way, if faulty happen, it will just be like a bump, then automatically readjust and fix while on the way to the destination. Another recommendation is to make

something that is immune to this faulty or multiple faulty at once, so that you may focus on other faulty that might harmful. Another recommendation is to make the transmission line absorb the faulty possibilities, thus making it immune physical faulty that will affect it.

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