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Full Length Article

Modern optimization algorithms for fault location estimation in power systems

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ABSTRACT

This paper presents a fault location estimation approach in two terminal transmission lines using Teaching Learning Based Optimization (TLBO) technique, and Harmony Search (HS) technique. Also, previous methods were discussed such as Genetic Algorithm (GA), Artificial Bee Colony (ABC), Artificial neural networks (ANN) and Cause & effect (C&E) with discussing advantages and disadvantages of all methods. Initial data for proposed techniques are post-fault measured voltages and currents from both ends, along with line parameters as initial inputs as well. This paper deals with several types of faults, L-L-L, L-L-L-G, L-L-G and L-G. Simulation of the model was performed on SIMULINK by extracting initial inputs from SIMULINK to MATLAB, where the objective function specifies the fault location with a very high accuracy, precision and within a very short time. Future works are discussed showing the benefit behind using the Differential Learning TLBO (DLTLBO) was discussed as well.

1. Introduction

Nowadays, it becomes so critical and crucial to supply different customers by stable, sustainable, reliable and continuous electricity. Which by return is enhancing the investment capabilities. Transmission lines are exposed to faults which are caused by many reasons such as storms, snow, insulation breakdown and short circuit for any reason. Specially, that transmission line faults are the reason for most of faults within the grid. So, special dedication should be applied to transmission line system protection and service reliability. The ability of maintenance crew to detect fault location quickly will help them to clear the fault as fast as possible, and will not cause long duration of outages on the customer side [1,2].

Different techniques discuss the calculations needed to find the exact fault location on transmission lines explained in [3] which used travelling wave-based fault location for two and three terminal networks and it was concluded that the method is unaffected by noise or spurious changes in line because it used a time-average integral function, also It achieved an error of 3.2%. Also, in [4] a microprocessor fault locator is described which is used to improve accuracy. The main feature of the used method is that it considered the effect of remote-end infeed of the lines. While in [5] an accurate method of series compensated transmission-line was proposed. This method takes the advantage of only half cycle of post fault currents and voltages. Results calculated errors was almost 0.5% which is not good and will affect the fault detection and will have a bad effect on the maintenance team ability to know the fault location along the line. Also, in [6] impedance-based fault location method was discussed which proved to be simple and of low cost, while it is affected by several sources of errors and will have bad accuracy with different types of transmission lines and different models and is affected also by the line length which reduces the accuracy and mislead the maintenance team. And it was shown that, fault resistance, fault location, source impedance and the transmission line model can negatively affect the performance one terminal impedance-based method which will increase the cost of fault detection because more time will be needed to know the exact location. On the other hand it was shown that if the source impedance is available because of techniques of adaptive protection, a fault location method free from current transformer errors can be developed, but this method is depending on many parameters that which will take more time to get the exact location which affect the fault clearance process and will lead to more damage to equipment and ultimately will lead to more cost to fix those damaged equipment. This method is valid for un-transposed lines not for transposed ones which is a disadvantage as lines will be affected by mutual field between phases. In [7] it proved that if redundant measurements are available, it's

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feasible to design an approach for fault location detection. In [8] it was concluded that a two-terminal approach for fault location estimation using un-synchronized post-fault phasors. While in [9] a new accurate technique for locating faults was discussed and two-terminal line case has been considered. In [10] a fault location approach using "phasor matching" based on genetic algorithm, but it takes a long time which cause problem in detecting the fault in a proper time and cause a problem also that can damage more equipment within the grid. While in [11] an accurate method is used for two terminal transmission lines based on time-domain distributed model. In [12] genetic algorithm was used in fault location; the method is based on digital measurement of short circuit current which can be sometimes misleading and cause inaccuracy which lead to locating a wrong fault position along the line. In [13] fault location method was used presenting Field Programmable Gate Array (FPGA) using Artificial Neural Networks (ANN) theory. This method was developed as generic as possible with the aim of using it to develop similar applications. While, in [14] some useful features extracted from Single-Line-to-Ground (SLG) using harmonic spectrum of one-end voltage. This method was conducted on the un-transposed transmission line. In [15] another fault location method was discussed; this method takes loads into effect. This method also eliminated problems of conventional methods. As if the load behaves as constant impedance, fault location can be determined from the pre-fault data. While for a variable impedance load, the fault location requires prior knowledge of the load model which is not available all the time, and this causes inaccurate results and mislead the team and lead to wrong location estimation. This method results are three fault locations for three fault types and then choose the most appropriate distance or distance.

While in [16] showed an expert system in fault section identification, it also showed that combination of numeric and data base algorithms is essential to many developments in expert system application for power systems. It concluded that expert system offers good promise for many applications in utility. While at this era, the use of expert system wasn't mature enough and may cause some issues and has cost associated activities. Those methods have many differences in between, especially in the below points:

1- The model of transmission Line.
2- Some of them measure needed variables from one side, and some use both sides.
3- Optimization techniques utilized to obtain the best results.

Power system protection is designed originally to detect faults, and isolate only the faulted zones without disturbing the performance of other functioning zones. Some of other advanced methods investigated in recent decades used voltages and currents measured from both ends of transmission line. In [3–5] it utilizes measurements from local terminal only, and illuminate the need for data transfer between both local and remote terminals, but unfortunately those methods have major drawback, as they are affected by fault resistance and source impedance [6]. Other methods used in [7–11] utilize measurements from both ends. Those methods are more accurate in locating the fault location due to the larger data amount available in those methods. Recently, more intelligent methods are utilized in this aspect to detect fault location in transmission system where fault location is not achieved directly from equations linking currents and voltages. Also, optimization techniques joined recently this field of study adding more intelligence such as Genetic Algorithm (GA) [12,13].

Genetic Algorithms are the heuristic search and optimization techniques that mimic the process of natural evolution. This introduces three main definitions within GA [17].

1) Selection: This process determines which solutions should be preserved and allowed to reproduce and which solutions deserve to decay. Select the best solutions and discard the rest.

To evaluate solutions, a fitness function is needed and by using the value of this function, the optimality of the solution can be quantified.

2) Crossover: This is used to create new solutions from existing available solutions after applying selection operator.
3) Mutation: This is the occasional introduction of new features into the solution string to maintain diversity in the population.

Fig. 1 shows classes of search techniques, and allocate GA among those techniques.

Recent researches proved that GA has many advantages. It doesn't need a continuous search space as it jumps from point to point in search space; this allows it to escape from the local optima in which other algorithms may fall. Another advantage is that GA

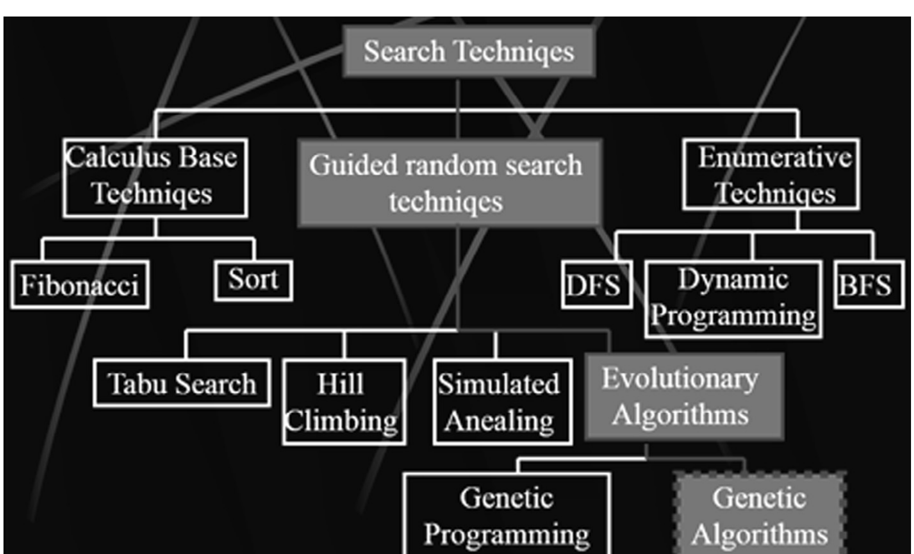

Fig. 1. Classes of search techniques.