



A computational intelligence-based suite for vulnerability assessment of electrical power systems

Ahmed M.A. Haidar^a, Azah Mohamed^b, Federico Milano^{c,*}

^a University Malaysia Pahang, Pahang, Malaysia

^b University Kebangsaan Malaysia, Selangor, Malaysia

^c University of Castilla-La Mancha, Ciudad Real, Spain

ARTICLE INFO

Article history:

Received 14 September 2009

Received in revised form 14 December 2009

Accepted 16 December 2009

Available online 14 January 2010

Keywords:

Contingency analysis

Vulnerability assessment

Control

Computational intelligence

Artificial neural networks

Fuzzy logic

ABSTRACT

This paper discusses the feasibility of implementing computational intelligence algorithms for power system analysis in an open source environment. The scope is specially oriented to education, training and research. In particular, the paper describes a software package, namely Computational Intelligence Applications to Power System (CIAPS), that implements a variety of heuristic techniques for vulnerability assessment of electrical power systems. CIAPS is based on Matlab and suited for analysis and simulation of small to large size electric power systems. CIAPS is used for solving power flow, optimal power flow, contingency analysis based on artificial neural networks and fuzzy logic techniques. A variety of illustrative examples are given to show the features of the developed software tool.

© 2010 Elsevier B.V. All rights reserved.

1. Introduction

1.1. Motivation

Electrical power systems are the biggest and most complex systems ever built by man. In recent years, electrical power systems have faced a deregulation process that has further increased the complexity of common operations such as monitoring, security assessment and emergency control. Due to the huge number of variables and scenarios that have to be taken into account for a proper security assessment of electrical power systems, heuristic techniques based on computational intelligence (e.g., fuzzy logic, artificial neural networks, etc.) are of increasing importance [1]. This paper describes a modular approach for power systems vulnerability assessment based on heuristic techniques. In particular, the paper focuses on a software package, namely Computational Intelligence Applications to Power System (CIAPS). This tool is oriented to education as well as practitioner training and research.

1.2. Literature review

The term *computational intelligence* (CI) generally refers to a group of techniques that attempt to mimic certain aspects of human brain or nature behavior. These include several techniques such as Artificial Neural Network (ANN), Fuzzy Logic (FL), Genetic Algorithms and Particle Swarm Optimization [1]. AlRashidi and El-Hawary [2] provide an extensive bibliographic

* Corresponding author. Tel.: +34 926295219.

E-mail addresses: ahmedm@ump.edu.my (A.M.A. Haidar), Federico.Milano@uclm.es (F. Milano).

review of recent applications of CI to power system analysis with particular regard to the optimal power flow problem. This paper focuses on ANN and FL, which have proved to be promising methodologies for solving certain complex problems in power systems, where conventional methods have not achieved the desired speed and accuracy.

ANN techniques have been used since late 90s for solving power system security-related problems [3–9]. In recent years, an ANN model known as *radial basis function neural network* (RBFNN) has become increasingly popular due to its structural simplicity and training efficiency. RBFNN has been used for solving power system problems such as for protection of transmission lines [10], locating faults in transmission lines [11] and transient stability assessment of power systems [12].

Fuzzy logic and fuzzy expert systems are also widely used for solving power system security assessment, power system protection and automation systems. Relevant bibliography on this topic is [13–25]. Fuzzy expert systems have also been used to assess voltage stability control and the optimum amount of load shedding [26]. Furthermore, fuzzy logic is also used for power system control and stability (e.g. [27]).

Despite the abundance in the literature of proposals of CI-based techniques for power system analysis, there is a lack of a common benchmark software tool that can function as a general-purpose board for CI-based algorithms. This paper addresses this issue through a variety of ANN and FL-based examples.

1.3. Software development environment

In the last decade, the Matlab language and scientific environment has become a standard tool for flexible technical computing [28]. Matlab incorporates a large number of domain specific toolboxes such as fuzzy logic toolbox, neural network toolbox, control toolbox real-time workshop, matrix-oriented programming, excellent plotting capabilities, etc. Furthermore Simulink offers a set of tools for modeling, simulating and analyzing dynamic systems [29].

These features make Matlab/Simulink an attractive choice for power systems research and education. Further details on the pros and cons of developing educational power system software applications in Matlab language can be found in [30,31]. As a matter of fact, a number of Matlab-based proprietary toolboxes, as well as open source research and educational power system tools have been developed. These are Power System Toolbox (PST) [32], MatPower [33], Voltage Stability Toolbox (VST) [34], MatEMTP [35], SimPowerSystems [36], Power Analysis Toolbox [37], and the Educational Simulation Tool [38], and PSAT [39]. Among these, MatPower, VST and PSAT are open source and can be freely downloaded.

None of the Matlab-based tools cited above includes AI techniques.

1.4. Contributions

Due to the lack of publicly-available software packages that provide computational intelligence techniques for power system analysis, this paper proposes and describes the software suite CIAPS. This tool has been developed using Matlab and mainly focuses on vulnerability assessment. The main purpose of CIAPS is education and practitioner training. At this aim, CIAPS comes with a complete graphical user interface that eases assessing power system vulnerability, ANN-based vulnerability relief and FL-based controlled load shedding.

With education in mind, CIAPS is not intended as a closed software package, but rather as a main board for future development and extension of CI algorithms and methods for power system analysis, thus not limited to vulnerability assessment.

The paper also introduces a novel technique for data reduction based on weight extraction using ANN.

1.5. Paper organization

The paper is organized as follows: an overview of the proposed software tool as well as of models and algorithms is given in Section 2. Section 3 illustrates simulations and discusses results of the proposed tools through small and large size power systems. Finally, Section 4 presents relevant conclusions.

2. Outlines of the proposed tool and algorithms

CIAPS is a package of Matlab scripts for solving power flow, optimal power flow, contingency analysis, vulnerability assessment based on ANN and FL simulations. CIAPS is intended as a simulation tool that is easy to use for students and educators. CIAPS was developed based on some of the available Matlab programs for power system analysis [39,33,40] and computational intelligence toolboxes [41,42].

CIAPS is launched at the Matlab prompt using the command `ciaps`. Afterwards, all main structures are initialized and the main window GUI is displayed (see Fig. 1). The main window works as a hub from where the user can solve available AI analyses. In particular CIAPS currently includes the following tools:

- (1) Power system vulnerability assessment (see Section 2.1).
- (2) Artificial neural networks-based vulnerability assessment (see Section 2.2).
- (3) Load shedding control based on fuzzy and neuro-fuzzy logic (see Section 2.3).

متن کامل مقاله

دریافت فوری ←

ISIArticles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات