PhD Proposal 2017

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Title: Advanced artificial intelligence algorithms and their applications to renewable energy generator
Scientific field: Electrical Engineering and Computer sciences
Key words: Artificial intelligence, power systems, renewable energy, modeling, control, optimization; prediction, diagnosis, data clustering

Details for the subject:

Background, Context:

POWER SYSTEMS

An electric power system is a network of electrical components used to supply, transmit and use electric power. Power systems engineering is a subdivision of electrical engineering that deals with the generation, transmission, distribution and utilisation of electric power and the electrical devices connected to such systems like generators, motors and transformers.

ARTIFICIAL INTELLIGENCE

Artificial Intelligence (AI) is a term that in its broadest sense would indicate the ability of a machine or artifact to perform the same kinds of functions that characterize human thought. The term AI has been applied to computer systems and programs, which can perform tasks more complex than straightforward programming, although still far from the realm of actual thought. AI consists of two branches, i.e., expert systems and artificial neural networks. Logic programs called expert systems (ES) allow computers to "make decisions" by interpreting data and selecting from among alternatives. Expert systems take computers a step beyond straightforward programming, being based on a technique called rule-based inference, in which pre-established

rule systems are used to process the data. Despite their sophistication, systems still do not approach the complexity of true intelligent thought.

NEED FOR AI IN POWER SYSTEMS

Power system analysis by conventional techniques becomes more difficult because of:
(i) Complex, versatile and large amount of information which is used in calculation, diagnosis and learning.
(ii) Increase in the computational time period and accuracy due to extensive and vast system data handling.

The modern power system operates close to the limits due to the ever increasing energy consumption and the extension of currently existing electrical transmission networks and lines. This situation requires a less conservative power system operation and control operation which is possible only by continuously checking the system states in a much more detail manner than it was necessary. Sophisticated computer tools are now the primary tools in solving the difficult problems that arise in the areas of power system planning, operation, diagnosis and design. Among these computer tools, Artificial Intelligence has grown predominantly in recent years and has been applied to various areas of power systems.

NEED FOR ARTIFICIAL INTELLIGENCE IN INTEGRATION OF RENEWABLE ENERGY SOURCES

Renewable Energy Integration must be self-sustainable, fault tolerant, reliable, secure and with good power quality. To achieve these objectives, efficient, fast, and scalable optimization and control algorithms are required. These algorithms should be capable of processing information intelligently and taking critical decisions dynamically. Though conventional techniques are successful in solving most of the problems, there are situations where they lead to unsatisfactory results. These include:

- Various forecasting tasks, like renewable energy forecasting, storage forecasting and demand forecasting, that need intelligent rules.
- The use of new equipment like storage systems, where monitoring and mapping of faults to different fault conditions of the equipment is difficult.
- The use of new equipment like power electronic interfaces, where monitoring and mapping of faults to different fault conditions and development of control mechanisms is challenging.
- The inclusion of renewable energy sources, for which the calculation of generation units to be committed and the economic scheduling of these units for optimal operation is highly complex.

Hence the conventional way of modelling the algorithms for these types of situations needs to be augmented or replaced with intelligent techniques that are robust and fault-tolerant.

Research subject, work plan:

RESEARCH SUBJECT

The research subject consists in using artificial intelligence to maximize the output of renewable energy sources while attaining an optimized and cost-effective solution. Developed algorithms will be applied to the design and the control of a muti-source power system with renewable energy sources integration and storage. To achieve these objectives, several sub models have to be implemented and many aspects such as renewable sources prediction, energy supervision, system control, big data processing, etc. have to be studied.
Based in case studies with renewable energy systems integration, the PhD student will attempt to apply AI to:

(i) Operation of power system like unit commitment, hydro-thermal coordination, economic dispatch, congestion management, maintenance scheduling, state estimation, load and power flow.
(ii) Planning of power system like generation expansion planning, power system reliability, transmission expansion planning, reactive power planning.
(iii) Control of power system like voltage control, stability control, power flow control, load frequency control.
(iv) Control of power plants like fuel cell power plant control, thermal power plant control.
(v) Control of network like location, sizing and control of FACTS devices.
(vi) Electricity markets like strategies for bidding, analysis of electricity markets.
(vii) Automation of power system like restoration, management, fault diagnosis, network security.
(viii) Applications of distribution system like planning and operation of distribution system, demand side response and demand side management, operation and control of smart grids, network reconfiguration.
(ix) Applications of distributed generation like distributed generation planning, solar photovoltaic power plant control, wind turbine plant control and renewable energy resources.
(x) Forecasting application like short term and long term load forecasting, electricity market forecasting, solar power forecasting, wind power forecasting.

WORK PLAN

1) Understanding power systems and artificial intelligence
2) State of the art
3) Application of AI for design and control optimization of a multi-source power system with renewable sources integration : proposing innovative solutions
4) Validation of developed algorithms and proposed solutions.

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