MULTIOBJECTIVE OPTIMAL POWER FLOW USING EVOLUTIONARY ALGORITHMS

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INTRODUCTION

With increased complexity and appearance of more concerns in the field of planning/operation of power systems new tools implying optimization techniques have been adapted to power systems. Among the new commonly identified needs is the Optimal Power Flow (OPF), which has, initially, started as an economical dispatch problem to optimize the fuel cost. Subsequently, other objectives were identified from the power systems field, and proposed/incorporated in the OPF such as active/reactive losses, power plant emissions, voltage profile and stability. This has extended the OPF from a single objective to multi-objective optimization problem. Initially, to facilitate the solution, multi-objective OPF problems were treated as single objective optimization problems using weighting factors. This requires changing these factors and performing several runs in order to obtain different nondominated solutions.

Recently, different evolutionary optimization techniques have been proposed/applied to OPF. These evolutionary techniques have the attribute of being population based searching algorithms and, hence, obtain several solutions in a single run. This makes them suitable to handle multiobjective optimization problems which normally have many optimal solutions. Generally, the population based evolutionary algorithms have shown promising success in solving multiobjective problems effectively.

This paper proposes a Differential Evolution (DE) based approach to solve a true multiobjective OPF considering a set of objective functions and several equality and inequality constraints. The proposed approach has been examined on 6-bus, 30-bus, and 118-bus standard test systems. The simulation results indicate the effectiveness of the proposed approach and its capability to result in several Pareto optimal solutions in a single run. The comparison with the literature confirms the superiority of the proposed approach to handle the multiobjective OPF problem with the examples considered.

MULTI-OBJECTIVE OPTIMAL POWER FLOW

Mathematically, a multiobjective OPF problem is formulated as follows:

$$\min/\max\ F(x,u)=\begin{bmatrix} f_1(x,u) \\ f_2(x,u) \\ \vdots \\ f_j(x,u) \end{bmatrix} \quad j=1, 2,\ldots\ldots\#\text{ of objectives}$$

Subject to $g(x,u) = 0$,
$h(x,u) \leq 0$,

where:

x : is a vector of dependent variables.
u : is a vector of control variables.
F : is a vector of objective functions.
g(x,u) : represents equality constrains.
h(x,u) : represents inequality constrains.

In this study, the following objectives were considered:

- Fuel Cost Minimization
- Active Losses
- Voltage Profile Improvement
- Reactive Power Reserve Margin
- Voltage Stability using L-index

THE PROPOSED APPROACH

In this paper, a multiobjective technique based on Differential Evolution is proposed to solve the formulated multiobjective OPF. The flowchart of the proposed approach is summarized in Figure 1.

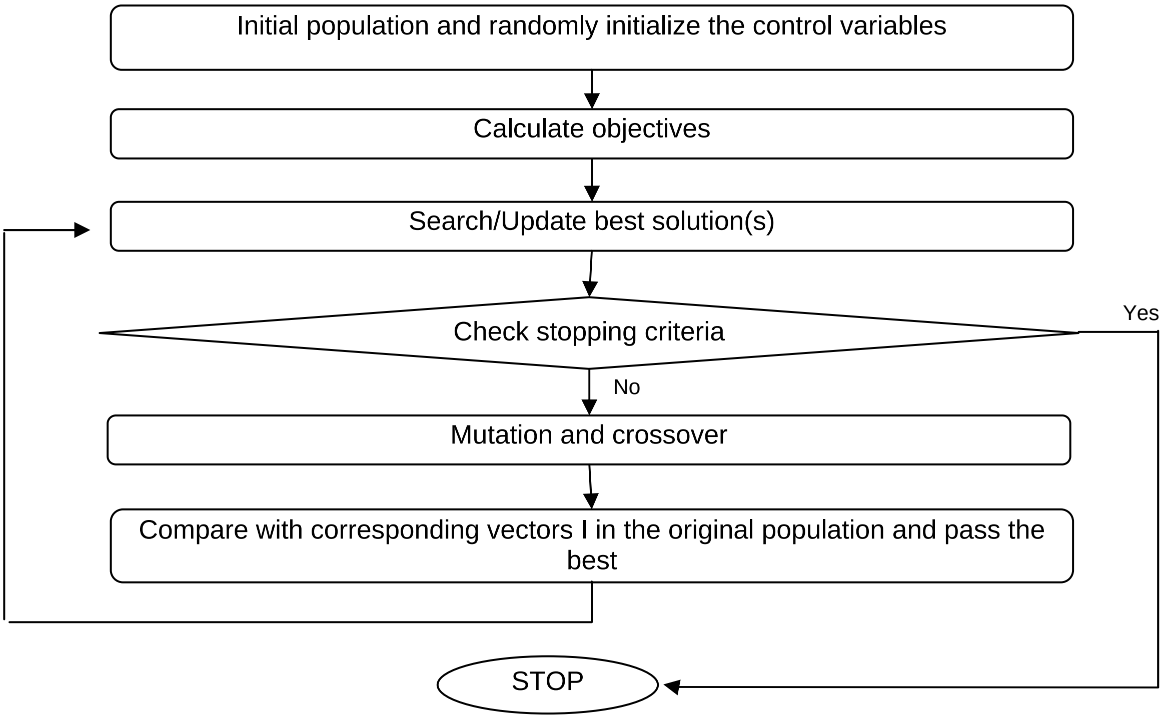

Figure 1: The proposed Differential Evolution based approach

RESULTS AND DISCUSSION

The formulated multiobjective OPF and the proposed DE based approach were tested on three standard test systems: 6-Bus, 30-Bus and 118-Bus systems. A sample of results is given in this extended summary as shown below. Figures 2 and 3 show the distribution of Pareto optimal solutions considering fuel cost and active losses as the problem objectives in IEEE 30-bus and 118-bus systems. The simulation results indicate the effectiveness of the proposed approach and its capability to result in several Pareto optimal solutions in a single run with satisfactory degree of diversity.

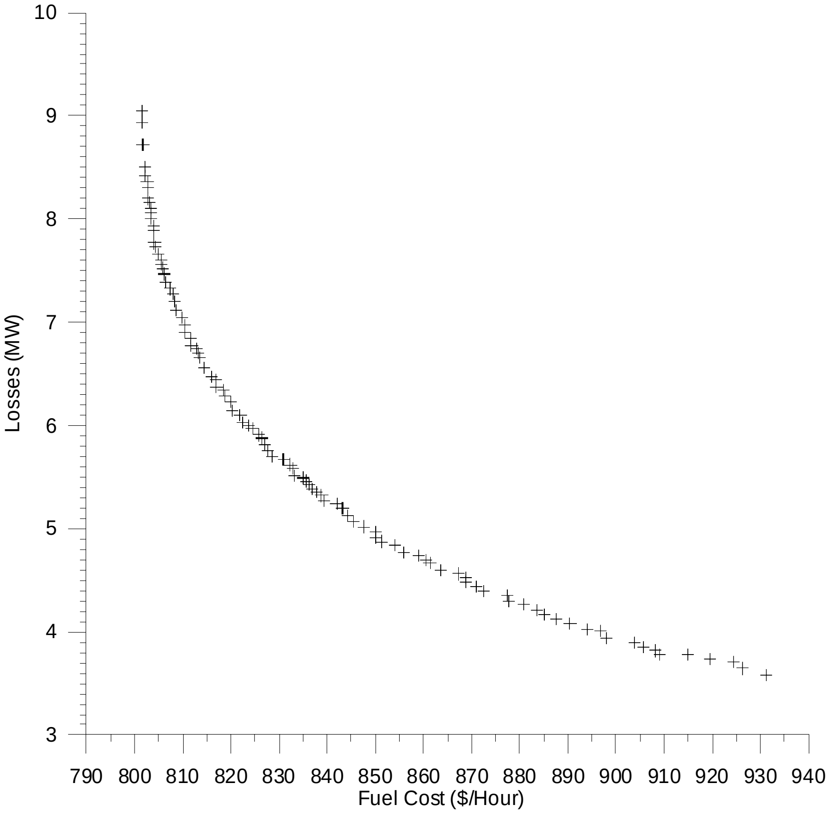

Figure 2: 30-Bus System, Fuel Cost and MW Losses Pareto Set

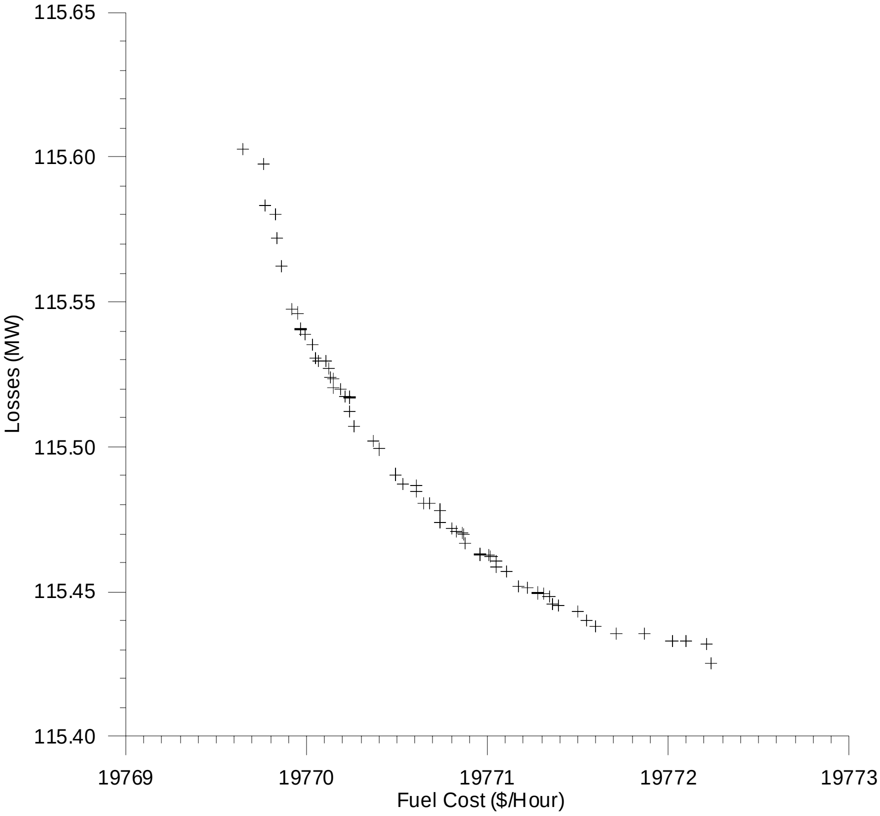

Figure 3: 118-Bus System, Fuel Cost and MW Losses Pareto Set