# Measurement-based Cell-DT Method for Power System Transient Stability Classification

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***Abstract*—In this paper, a combined Characteristic Ellipsoid (CELL) and Decision Tree (DT) method for fast classifying the transient stability of power systems after a large disturbance is proposed. The proposed two-stage method involves projection of the PMU measurement data after the disturbance on a multidimensional space to form the CELL and then classification of the transient stability using DT which takes the characteristic attributes of CELL under different fault scenarios as input features. The dynamic behaviors after a disturbance for both stable and unstable situations are identified from the variation of the CELL's shape. The database, composed of the geometrical properties of the CELL such as volume, eccentricity, center and change rate of volume, is used to train a DT for transient stability classification. Case study on a IEEE 39-bus system demonstrates the feasibility of the proposed method. Investigations show that the proposed method requires less information from the system to fast classify the transient stability with high precision.**

***Index Terms*—Characteristic ellipsoid, classification, data mining, decision tree, transient stability.**

## I. Introduction

As the growing demand for electricity, power systems in different areas have been connected together, which increases the potential occurrence probability of accidents. So, the secure operation of power systems has gained increasing attention in recent years. One of the most important issues that need to be assessed in a security assessment is the transient stability, i.e. a fast assessment of the transient stability condition is greatly needed after the occurrence of large disturbances.

Transient stability analysis (TSA) is used to fast evaluate the stability type of system operation by selecting the serious fault which created the most threats to the transient stability and then providing available preventive controls [1]. So far, many methods have been proposed in TSA. In [2], a new mixed numerical integral algorithm was presented. It integrates the advantages of both implicit trapezoidal integration with fixed time steps and the Gear variable time step algorithm. [3] proposed an approximate boundary method using the credible region and transient energy function. The boundary was obtained from the union of the credible region and the constant energy surface at the related point of the fault-on trajectory. The Artificial Neural Network (ANN) was applied in TSA [4]. The post-fault transient features were selected as characteristic quantities and fed into an improved BP algorithm for training. Based on different modes, the sample space was classified and the selection of transient characteristic quantities was proved to be effective and accurate. With regard to high dimensionality in power system transient stability assessment, [5] set up an original feature set which was not limited to system scale and proposed a dual-stage feature selection approach based on a support vector machine. In the first stage, the features which had little influence in classification results, were eliminated and a group of dimension reduction features were obtained. For the second stage, a near-optimal feature subset was gained by using a best-first search. In terms of the classification of transient stability, an ANN-based multilevel classification approach is proposed for fast transient stability assessment of large power systems. The stability index for security classification is obtained by using some general abstract post-fault attributes in ANNs [6], [7]. Reference [8] introduces a general Bayesian framework for obtaining sparse solutions to classify predicting and the practical model "relevance vector machine (RVM)," which is applied in power system transient stability assessments. In [9], the characteristic ellipsoid (CELL) method to monitor dynamic behaviors of a power system is proposed. Decision tree techniques are used to link the CELL's characteristic indices and the system's dynamic behaviors and to determine types, location and related information about the dynamic behaviors.

We used this approach since the CELL method is capable of monitoring power system dynamics and ultimately increasing wide-area visibility of the system as well as situation awareness for power system operators [10]. This paper applies the combined CELL and decision tree (DT) method in fast classifying the transient stability of power systems. The CELL, generated by the projection of measurement data from PMU on the multi-dimensional samples space, contains the dynamic behaviors information of the disturbed-system. By tracking the continuous variation of the CELL's shape and orientation, the evolution process of the dynamic system can be reflected. The geometric properties of the CELL such as volume, eccentricity, center, and change rate of volume, provide a quantitative

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