Chapter 13
A Novel Neural Fuzzy Approach for Diagnosis of Potassium Disturbances

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ABSTRACT

In this paper, a neural fuzzy system for the diagnosis of potassium disturbances is presented. This paper develops an adaptive neuro-fuzzy expert system that can provide accurate diagnosis of potassium disturbances. The proposed diagnostic approach has many attractive features. First, it provides an efficient tool for diagnosis of K^+ disturbances and aids clinicians, especially the non-expert ones, in providing fast and accurate diagnosis of K^+ disturbances in critical time. Second, it significantly reduces the time needed to accomplish precise diagnosis of K^+ disturbances and thus enhances the healthcare standards. Third, it is capable of diagnosing the different types of potassium disturbances using a hybrid neural fuzzy approach. Finally, it has good accuracy (higher than 87%), specificity (100%), and average sensitivity (83%). The performance of the proposed diagnostic system was experimentally evaluated and the achieved results confirmed that the proposed system is efficient and accurate in diagnosing K^+ disturbances.

1. INTRODUCTION

Severe potassium disturbances are medical emergencies that disturb the function of different biological organs specially the cardiovascular system (Kamel, Quaggin, Scheich, & Happerin, 1994;

Young, Lin, & McCabe, 1995; Hulting, 1981; Lummc & Jouncla, 1986). These disturbances are usually caused by cardiovascular, neuromuscular, renal, and metabolic clinical manifestations (Srivastava & Young, 1995; Nordrchaug, Johannessen, & von der Lippc, 1985; Ascherio et al., 1996; Barri & Wingo, 1997; Steiness & Olesen, 1976; Dyckner, 1990; Farquharson & Struthers, 2002;

Fransc, Di Bari, Somes, Cushman, & Applegate, 2000; Macdonald & Struthers, 2004). Of course, the fast and accurate the diagnosis is made, the less the complications are. Thus, there is a clinical need for a computerized intelligent approach that can provide accurate and rapid diagnosis of potassium disturbances.

The conventional clinical procedure for diagnosis of potassium disturbances is based on routine measurement of potassium concentration in blood and classifying the result based on the clinician's experience into three main categories: hypokalemia (if $K^+ < 3.5$ mEq/L), normal (3.5 mEq$\leq K^+ \leq 5.5$ mEq/L) and hyperkalemia ($K^+ > 5.5$ mEq/L) (Giebisch & Wang, 1996; Sterns, Cox, Fieg, & Singer, 1981; Either, Kamel, Magner, Leman, & Halperin, 1990). In addition, an assessment of electrocardiogram (ECG) should be carried out because many electrocardiographic changes are associated with K^+ disturbances. Hypokalemia (HPO) produces sagging of the QT interval, depression or flattening of the T wave and slight widening of the QRS (Tolins, Hostetter, & Hostetter, 1987; Nora & Berns, 1989; Marriott, 1988; Gennari, 1998). Hyperkalemia (HPR) is characterized by increased PR interval, widening of QRS complex, peaked T wave and shortening of the QT interval (Wrenn, Slovis, & Slovis, 1991; Acker, Johnson, Palevsky, & Greenberg, 1998; Aslam, Friedman, & Ifudu, 2002; Pastor, Castellanos, Moleiro, & Myerburg, 2001; Shiraishi et al., 2004; Montague, Ouelltte, & Buller, 2008; Nemati & Taheri, 2010).

The proper treatment of the potassium disturbances depends not only on the existence of changes in the ECG waveform but also on the value and direction (increasing or decreasing) of these changes with respect to the normal values (Montague, Ouelltte, & Buller, 2008; Nemati & Taheri, 2010). The accurate and fast extraction of these changes require computational device because the visual inspection of patient's ECG as done in conventional diagnostic procedures (CDPs) will not result in precise and rapid di-

agnosis of K^+ disturbances. The CDPs require large time to extract the ECG features and do not relate the diagnosis with different changes in these features. Thus, the need for a computerized intelligent approach to simplify and speed the diagnosis process is very essential for assessment of K^+ disturbances.

In the last decades, many soft-computing techniques such as neural network, fuzzy logic and genetic algorithms were used as decision making approaches to enhance the accuracy and speed of clinical diagnosis for different diseases (Ganesan, Venkatesh, Palani, & Palani, 2010; Uncu, 2010; Brause, & Friedrich, 2000; Hong, Lin, Huang, & Lin, 2008; Jan, Sun, & Mizutani, 1997; Binaghi, 2007). However, in the diagnosis field of potassium disturbances, very little references were published. Wu et al. (2003) proposed a two-staged artificial neural network for predicting of hyperkalemia. Although the proposed approach represents a good step toward the application of artificial intelligence techniques for diagnosis of K^+ disturbances, it has many shortcomings. First, it is limited for diagnosis of only one type (hyperkalemia) of K^+ disturbances. Second, the use of only artificial neural network for designing medical diagnostic system lacks the capability to include the uncertainty existed in the medical data. Finally, the diagnosis accuracy (62.5%) and sensitivity (35%) achieved in Wu et al. (2003) need significant improvement.

In this paper, a novel neural fuzzy approach using NEFCLASS (NEuro Fuzzy CLASSification) for diagnosis of K^+ disturbances is proposed. The alternative neuro-fuzzy approaches are: adaptive neuro-fuzzy inference system (ANFIS), neuro-fuzzy function approximation (NEFPROX) and genetic-based neuro-fuzzy generator (NEFGEN) (Nauk, D., Klawonn & Kruse, 1997; Rahmoun & Berrani, 2001; Jang, 1993; Nauck & Kruse, 1997; Nauck, Nauck, & Kruse, 1995; Nauck, Klawonn, & Kruse, 1997). According to the results presented in Rahmoun and Berrani (2001), the NEFGEN has better performance than ANFIS and NEFPROX

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