Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 82 (2016) 4 – 11

Procedia Computer Science

Symposium on Data Mining Applications, SDMA2016, 30 March 2016, Riyadh, Saudi Arabia

Fuzzy-Genetic Model for the Identification of Falls Risk Gait

Md Rafiul Hassan*[a], S M Arafat[a] and Rezaul K Begg[b]

[a]*Dept of ICS, King Fahd University of Petroleum and Minerals, Dhahran 31261, KSA*
[b]*Dept of Biomechanics, Victoria University, VIC 8001, Australia*

Abstract

This paper investigates the effectiveness of a hybrid genetic and fuzzy set algorithm for the recognition of gait patterns in falls risk patients. In a previous work, we have shown the usefulness of fuzzy set techniques for gait pattern identification. In this paper, we apply a genetic algorithm in conjunction with fuzzy logic rules to better select the optimal combination of pathological gait features for improved gait diagnostic capability. Gait features were calculated using minimum foot clearance data collected during continuous walking on a treadmill for 20 older adults. The subjects are composed of two groups, 10 individuals with normal gait, and 10 with a history of falls. Fuzzy rules were extracted from the gait dataset using subtractive clustering. The genetic algorithm was introduced in order to select the optimum combination of gait features. Using cross validation test data, the results indicated that the generalization performance, in terms of accuracy, for the hybrid system was 97.5%, compared to89.3% that was obtained using only the fuzzy system. The generalization performance of the gait classifier was also analyzed by determining the areas under the receiver operating characteristic plot. We observed that an improved gait classification performance became evident when the fuzzy system classifier used a small number of features that were selected by the genetic algorithm.

Peer-review under responsibility of the Organizing Committee of SDMA2016

Keywords: gait, falls risk; feature selection; genetic algorithms; fuzzy systems

1. Introduction

It is widely understood that the balance control mechanisms and the associated gait functions of the human locomotor system deteriorate with age. Some of these gait pattern changes can cause high health risks and can lead

* Corresponding author. Tel.: +966138607330.
E-mail address: mrhassan@kfupm.edu.sa

Peer-review under responsibility of the Organizing Committee of SDMA2016
doi:10.1016/j.procs.2016.04.002

to falls and injuries during movement. Falls during walking in older adults are a major social and health concern [1]. Also, falls risk have a close connection to gait degeneration and to altered gait balance that is due to ageing. Among the various types of falls, tripping and slipping account for the majority (i.e., more than 50%) of all fall cases [2].

Researchers have investigated potential parameters associated with tripping and falling risk of the elderly [3]. Such parameters include foot to ground clearance height during leg swing phase [4], minimum foot clearance [5], and lower limb joint angles [6].

One important parameter during the foot's flight (swing phase of the gait cycle) is the toe clearance, which is regarded as an important characteristic because it assists in adapting to uneven surfaces as well as avoiding obstacles. The toe comes very close to the ground during the mid-swing phase leaving a very small margin for error [7]. The minimum foot/toe clearance (MFC) during this event has been identified as the most critical factor that is associated with avoiding tripping, mainly because either a reduced magnitude or a highly varying MFC could lead to the increased risk of foot contact with obstacles [7].

One technique that could be applied for minimizing falls in older adults is to identify potential fallers through their modified gait characteristics, thereby engaging in intervention procedures to improve their gait function. Moreover, an objective model is necessary to link MFC information with falls risk individuals in an effort to determine MFC features that could be used to diagnose potential falls risk victims.

Due to the large intra-subject variation in gait [7], the task of identifying gait features that map potential fall risk patients is complex. One possible method is to develop nonlinear models based on computational intelligence approaches, in a bid to find relationships between MFC features and different falls risk categories (i.e., high risk or balance impaired individuals, low-risk or normal individuals with no-falls history, etc.). Such models can potentially have many applications to a number of fields including gait diagnostics, rehabilitation, assessment of at-risk gait, and other related areas.

In recent years, fuzzy inference models have emerged as powerful tools for solving many classification problems. Prior studies that applied fuzzy rules to classify gait types have shown success in detecting gait events, gait measurement [8], and classifying normal and ankle arthrodesis gait patterns [9]. In a previous investigation [10], we have demonstrated the effectiveness of fuzzy logic in classifying both healthy and falls risk gait patterns. In particular, we found out that subtractive clustering [11] for fuzzy rules generation using training data was quite useful and the trained fuzzy system was able to recognize the two gait types with 89% accuracy rate. In this paper, we investigate the use of a hybrid fuzzy genetic model in order to improve gait recognition. We have designed and implemented a genetic algorithm (GA) to select the optimal input feature combination for the fuzzy classification system. The objective of this hybridization was to achieve an improved accuracy rate in classifying at-risk gait in older populations. The performance of the hybrid GA fuzzy model was evaluated using accuracy rates as well as the receiver operating characteristics (ROC) curve. The remainder of this paper is organized in the following way: Section II offers an overview of the fuzzy genetic algorithm; Section III elaborates on the data, experiments, and results, and finally, Section IV concludes with a discussion and conclusion.

2. Overview of the model

A combination of GA and fuzzy logic system is proposed for gait pattern recognition and classification tasks. We applied subtractive clustering that was proposed by Chiu [11] in order to extract fuzzy rules from the dataset. GA was applied in parallel in order to select an optimal combination of input features that maximizes classification performance for both normal and falls risk gait subjects. The objective function used in the hybrid model maximizes classification accuracy. GA randomly selects input data features that are used to generate fuzzy rules. Next, the model predicts test cases that are evaluated using classification accuracies. Intuitively, GA selects the next generation that includes a combination of the well fitted input data features. Next, fuzzy rules are generated for the newly selected input data space for further testing. Thus the model includes three major steps:

1. Division of the training data into a number of clusters;
2. Generation of fuzzy rules for each of the clusters (as shown in Fig. 1);
3. Application of GA to select the best feature combination.