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Bayesian Classification of Falls Risk

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Abstract

Background: Prior research in falls risk prediction often relies on qualitative and/or clinical methods. There are two challenges with these methods. First, qualitative methods typically use falls history to determine falls risk. Second, clinical methods do not quantify the uncertainty in the classification decision. In this paper, we propose using Bayesian classification to predict falls risk using vectors of gait variables shown to contribute to falls risk.
Research Questions: 1) Using a vector of risk ratios for specific gait variables shown to contribute to falls risk, how can older adults be classified as low or high falls risk? and 2) how can the uncertainty in the classifier decision be quantified when using a vector of gait variables?
Methods: Using a pressure sensitive walkway, biomechanical measurements of gait were collected from 854 adults over the age of 65. In our method, we first determine low and high falls risk labels for vectors of risk ratios using the k-means algorithm. Next, the posterior probability of low or high falls risk class membership is obtained from a two component Gaussian Mixture Model (GMM) of gait vectors, which enables risk assessment directly from the underlying biomechanics. We classify the gait vectors using a threshold based on Youden's J statistic.
Results: Through a Monte Carlo simulation and an analysis of the receiver operating characteristic (ROC), we demonstrate that our Bayesian classifier, when compared to the k-means falls risk labels, achieves an accuracy greater than 96% at predicting low or high falls risk.
Significance: Our analysis indicates that our approach based on a Bayesian framework and an individual's underlying biomechanics can predict falls risk while quantifying uncertainty in the classification decision.

Keywords: Gait analysis, falls risk prediction, Bayesian classification, falls prevention

1. Introduction

Falls prevention efforts for older adults have become increasingly important and are now a significant health research effort. Unintentional falls are a leading cause of injury to those over 65 years of age and have significant societal and economic impacts [1]. One of the current trends in health informatics is the use of machine learning to predict adverse outcomes [2, 3]. Prior research has shown that machine learning can be used to analyze gait and classify older adults as a faller or non-faller, where a faller has a past history of falling [4, 5].

In supervised learning, a binary classifier maps an input vector to one of two labels, e.g. faller vs. non-faller. Labels for falls risk prediction are typically inferred from empirical data including the use of expert domain knowledge and are usually obtained using two methods. The first is through the use of questionnaires which assess, for example, an individual's history of falling, medication usage, and home environment all of which may increase an individual's risk [1]. The second method uses clinical mobility-based assessments to evaluate an individual's gait, strength, and balance which have also been shown to be indicators of falls risk. These assessments include but are not limited to the Timed Up and Go test [6], the 30-second Chair Stand [7], and the 4-Stage Balance Test [8].

There are two challenges with these methods for classifying falls risk. First, the questionnaires can be error prone due to their qualitative nature [4]. Additionally, they often use a threshold to place individuals into one of two categories, faller or non-faller. However, these labels are only indicative of the individual's falls history, fail to capture their level of risk [1], and do not account for biomechanical risk factors associated with a prospective fall. It has also been shown that mobility-based measures of falls risk are uncorrelated with falls risk assessments that use falls history, home environment, and medication to assess falls risk [1]. The second issue is that although clinical assessments have been shown to be successful at identifying older adults at risk of falling or those who have fallen in the

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