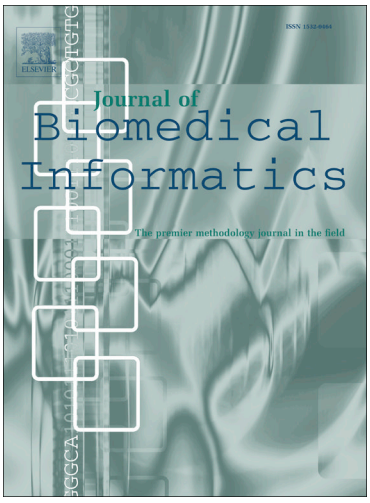

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CHI: A Contemporaneous Health Index for Degenerative Disease Monitoring using Longitudinal Measurements

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Abstract

In this paper, we develop a novel formulation for contemporaneous patient risk monitoring by exploiting the emerging data-rich environment in many healthcare applications, where an abundance of longitudinal data that reflect the degeneration of the health condition can be continuously collected. Our objective, and the developed formulation, is fundamentally different from many existing risk score models for different healthcare applications, which mostly focus on predicting the likelihood of a certain outcome at a pre-specified time. Rather, our formulation translates multivariate longitudinal measurements into a contemporaneous health index (CHI) that captures patient condition changes over the course of progression. Another significant feature of our formulation is that, CHI can be estimated with or without label information, different from other risk score models strictly based on supervised learning. To develop this formulation, we focus on the degenerative disease conditions, for which we could utilize the monotonic progression characteristic (either towards disease or recovery) to learn CHI. Such a domain knowledge leads us to a novel learning formulation, and on top of that, we further generalize this formulation with a capacity to incorporate label information if available. We further develop algorithms to mitigate the challenges associated with the nonsmooth convex optimization problem by first identifying its dual reformulation as a constrained smooth optimization problem, and then, using the block coordinate descent algorithm to iteratively solve the optimization with a derived efficient projection at each iteration. Extensive numerical studies are performed on both synthetic datasets and real-world applications on Alzheimer's disease and Surgical Site Infection, which demonstrate the utility and efficacy of the proposed method on degenerative conditions that include a wide range of applications.

Keywords: Risk monitoring, longitudinal measurements, degenerative disease, machine learning, convex optimization

1. Introduction

Although there is no universal definition of the concept "patient condition", it has been