Doubly-online changepoint detection for monitoring health status during sports activities

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We provide an online framework for analyzing data recorded by smart watches during running activities. In particular, we focus on identifying variations in the behavior of one or more measurements caused by changes in physical condition, such as physical discomfort, periods of prolonged de-training, or even the malfunction of measuring devices. Our framework considers data as a sequence of running activities represented by multivariate time series of physical and biometric data. We combine classical changepoint detection models with an unknown number of components with Gaussian state space models to detect distributional changes between a sequence of activities. The model considers multiple sources of dependence due to the sequential nature of subsequent activities, the autocorrelation structure within each activity, and the contemporaneous dependence between different variables. We provide an online expectation-maximization (EM) algorithm involving a sequential Monte Carlo (SMC) approximation of changepoint predicted probabilities. As a byproduct of our model assumptions, our proposed approach processes sequences of multivariate time series in a doubly-online framework. While classical changepoint models detect changes between subsequent activities, the state space framework, coupled with the online EM algorithm, provides the additional benefit of estimating the real-time probability that a current activity is a changepoint.

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