Tracking Fatigue and Health State in Multiple Sclerosis Patients Using Ubiquitous Sensing

Catherine Tong[†], Matthew Craner[‡], Angela Chieh[*], Otmane Bellahsen[*], Matthieu Vegreville[*], Eva Roitman[*], and Nicholas D. Lane[†]

[†]Department of Computer Science, University of Oxford
[‡]Nuffield Department of Clinical Neurosciences, University of Oxford
[*]Withings

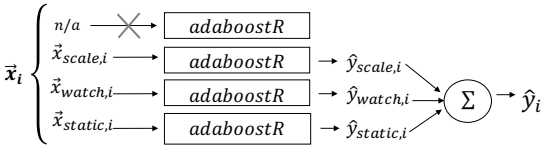
Multiple Sclerosis requires long-term disease management, but tracking patients through the use of clinical survey instruments is hindered by the high costs and patient burden involved. In this work, we investigate the feasibility of using data from ubiquitous sensing to predict MS patients' fatigue and health status, as measured by the Fatigue Severity Scale (FSS) and EQ-5D index. We collected data from 198 MS patients who are given connected wellness devices (smart watch, weighing scale, in-bed sleep tracker, and phone app) for over 6 months.

In predicting the reported FSS and EQ-5D scores per patient, we propose a method based on an ensemble of modality-specific AdaBoost regressors (Fig. 1). This method adequately handles the multimodal and missing data issues presented in the dataset. In predicting for both FSS and EQ-5D, we are able to achieve errors aligning with the instrument' standard measurement error (SEM), as well as strong and significant correlations between predicted and ground true values.

We also explore two different adaptation methods for personalized predictions: one based on residual error adjustment and another based on Maximum A Posterior (MAP) adaptation developed in [Reynolds et al., 2000]. We show that the simple residual-error adaptation method greatly reduces prediction errors through the use of just 1 user-supplied ground truth datapoint. For FSS (SEM 0.7), the universal model predicts weekly scores with MAE 0.99, while an adapted model predicts with MAE 0.51. For EQ-5D (SEM 0.093), the universal model predicts weekly scores with MAE 0.091, while an adapted model predicts with MAE 0.052.

Our study represents the first sets of results on tracking fatigue and health status of MS patients using ubiquitous sensing, which gives promising prediction performance with errors aligns with the accepted range of error in the widely used clinically-validated questionnaires. Future extensions and potential applications of our results can positively impact MS patient disease management and support clinical research.

Figure 1: An Ensemble of Modality-Specific Adaboost Regressors. Each component regressor takes in features from one source, so the model is able to handle missing data from some sources.



References

[Reynolds et al., 2000] Reynolds, D. A., Quatieri, T. F., and Dunn, R. B. (2000). Speaker verification using adapted gaussian mixture models. *Digital Signal Processing*, 10(1):19 – 41.