Algorithms for Nocturnal Hypoglycemia Detection using Wearable Data

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Introduction

Diabetes Mellitus is a chronic metabolic disease that causes high blood glucose levels due to the body's inability to produce insulin. Hypoglycemia is a condition in which blood glucose levels fall below the normal range (glucose < 3.9 mmol/L), which can occur due to an overly aggressive insulin regimen or inadequate glucose intake, disrupting the body's energy balance [1]. People with diabetes must remain vigilant about preventing hypoglycemia. During sleep, hypoglycemia can occur without noticeable symptoms, increasing the risk of serious complications. Continuous Glucose Monitoring (CGM) systems provide real-time feedback on glucose levels; however, they are invasive, may cause discomfort, may have a time lag, and are expensive. Therefore, this thesis aims to develop a non-invasive and scalable warning system for nocturnal hypoglycemia using consumer-grade smartwatches and artificial intelligence.

Materials and Methods

In a pilot-study conducted at UDEM, Inselspital, physiological data was gathered from people with diabetes using a Fitbit Sense 2 and a Garmin Venu 2 smartwatch. CGM was used as ground truth for identifying hypoglycemic states. 15 participants experiencing at least two nocturnal hypoglycemic episodes were included in the analysis. Four diffrent algorithms (see Figure 1) based on Random Forest Classifiers were developed, trained, and validated.

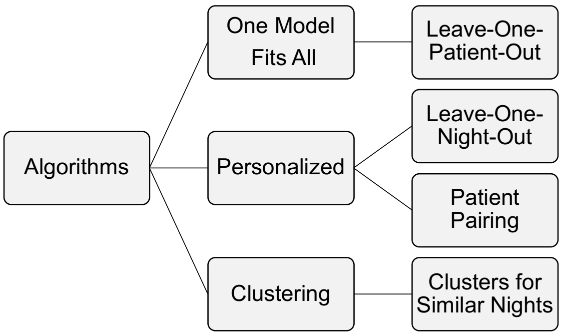

Fig. 1 Overview of algorithm frameworks to train and validate Random Forest Models for nocturnal hypoglycemia detection.

To assess the generalizability of the One Model Fits All, we used Leave-One-Patient-Out (LOPO) cross-validation (CV). For the personalized models, we followed two CV strategies: 1.) Leave-One-Night-Out (LONO), in which each model was trained on an individual patient for all except one night and tested on the remaining night. 2.) Patient Pairing, in which each model was trained on all individual patients, except for one. The remaining patient was first paired to the best fitting model before evaluating the model's performance. Lastly, a clustering approach aggregated nights into clusters with similar physiological responses. A Random Forest model was trained for each cluster.

Results

Compared to the One Model Fits All and the personalized models, the night clustering approach yielded the highest accuracy in detecting nocturnal hypoglycemia.

Algorithms	AUROC	Sensitivity	Specificity
LOPO	0.53	0.05	0.98
LONO	0.46	0.09	0.89
Patient Pairing	0.61	0.45	0.64
Clusters for Similar Nights	0.70	0.72	0.72

Tab. 1 Performance of the four Random Forest models.

Discussion

Our results suggest that clustering nights by similar patient physiology allows for more accurate detection of nocturnal hypoglycemia and holds promise for a potential non-invasive alternative to CGM to prevent people with diabetes from experiencing nocturnal hypoglycemia.

References

[1] Elizabeth R. Seaquist, J.Anderson, B.Childs, P. Cryer, S.Dagogo-Jack, L.Fish, S.R Heller, H. Rodriguez, J. Rosenzweig, R. Vigersky; Hypoglycemia and Diabetes: A Report of a Workgroup of the American Diabetes Association and The Endocrine Society. *Diabetes Care* 1 May 2013; 36 (5): 1384–1395.

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