**An ensemble approach for accurately predicting hypoglycemia**

Wonju Seo¹, Jiho Lee¹, Seunghyun Lee¹, Sang-Man Jin², Sung-Min Park¹*

¹Pohang University of Science and Technology (POSTECH), Republic of Korea
²Samsung Medical Center, Sungkyunkwan University School of Medicine, Republic of Korea.

**Introduction:** Diabetes is a metabolic disease in which the blood glucose level remains high due to insufficient secretion or usage of insulin. Although intensive insulin therapy is required to prevent serious diabetic complications, concerns on potential hypoglycemia (glucose level less than 3.9 mmol/L) [1] limits insulin dosing to be conservative. Therefore, there is a strong clinical demand for an algorithm that accurately predict hypoglycemia in advance to prevent the clinical consequence and enhance the insulin dosing. In this study, we develop and validate an ensemble learning model that accurately predict hypoglycemia with a large retrospective patient data.

**Materials and Methods:** We retrospectively analyzed 107 CGM cases from 104 patients (type 1: 52, type 2: 52) from the Samsung Medical Center (Seoul, Republic of Korea) between 2014 and 2015 (Institutional Review Board (IRB) of the Samsung Medical Center (IRB File number SMC 2016-05-058-001). Commonly used machine learning models were used to construct the ensemble learning model. The model was ran based on 5 consecutive continuous glucose monitoring (CGM) measurements (t - 20 min ~ t min) as an input and predicted an occurrence of a hypoglycemia alert value (glucose level less than 3.9 mmol/L) at a 30 min prediction horizon from the time of prediction (t min). We evaluated the performance of our ensemble model with 5-fold cross-subject validation by computing the following statistical metrics for the predictions of the occurrence of a hypoglycemia alert value: sensitivity, specificity, and F1 score.

**Results and Discussion:** After 5-fold cross-subject validation, the proposed ensemble model showed the average sensitivity of 89.5%, specificity of 93.2%, and F1 score of 0.723 for the occurrence of a hypoglycemia alert value. Figure 1 shows a result of hypoglycemia predictions on an example CGM case. As shown in Figure 1, the ensemble model completely predicted hypoglycemic events in that case.

![Figure 1. An example of hypoglycemia prediction in a CGM time-series data sampled on 1st cross-subject validation with the trained ensemble model. Blue line, CGM time-series data; Red points, the predictions of hypoglycemia by the ensemble model (0: non-hypoglycemia, 1: hypoglycemia); Transparent green box, hypoglycemic events.](image)

**Translational Impact:** In this study, we proposed an ensemble-based model with the machine learning algorithms to accurately predict hypoglycemia. If this algorithm is embedded in compact devices such as CGM or an artificial pancreas, patients with both types of diabetes can obtain a great help to manage their glucose level.

**Disclosure Statement:** We have no relevant financial or nonfinancial relationships to disclose.

**Acknowledgements:** This research was supported by the MSIT(Ministry of Science and ICT), Korea, under the “ICT Consilience Creative program” (IITP-2018-2011-1-00783) supervised by the IITP(Institute for Information & communications Technology Promotion), the Technology Innovation Program (or Industrial Strategic Technology Development Program)(20001841, Development of System for Intelligent ContextAware Wearable Service based on Machine Learning) funded By the Ministry of Trade, Industry & Energy(MOTIE, Korea), and the Bio & Medical Technology Development Program of the NRF funded by the Korean government, MSIP(2017072380).