A Novel Infusion Failure Detection Paradigm Based on Fluid Pressure and Supervised Learning

Luis E. Blanco, B. ChE; John C. Gray, B. ChE; John H. Wilcox, B. Bio; Marzia Cescon, PhD

Diatech Diabetes, Inc.
Memphis, TN, USA
LBlanco@DiatechDiabetes.com

Objective:
To develop a novel insulin infusion failure detection model for pump therapy using fluid pressure, exploiting supervised learning techniques for binary classification.

Method:
Three independent preclinical animal studies were conducted over a period of 24 months. Six non-insulin dependent female swine were anesthetized and infused using a 50/50 mixture of contrast and saline. In total, 503 boluses across 142 sites were administered and viewed under fluoroscopy using a Siemens Artis Pheno. Fluid pressure and flow rate were collected for every infusion using in-line sensors spliced into the infusion set. Infusions were performed using a MiniMed Paradigm (n=5), Harvard Apparatus Pump 11 Elite (n=131) and Medtronic 770G (n=289). Post study, 425 boluses (20.7 µL ± 3.11 µL) were accepted and manually labeled as normal (n=299) or malfunction (n=126), using the available x-ray scans. All malfunctions were observed within 30 mins of insertion. Python scikit-learn library was used to train/test (70/30) Support Vector Machine (SVM), Random Forest (RF), and Logistics Regression (LR) models. Hyperparameter tuning was done using GridSearchCV function with 10-fold 3 repeats stratified k-fold cross validation, F2-measure was used for scoring. Adaptive synthetic sampling was performed during training on minority class.

Result:
From the fluid pressure data, 221 features were created; later reduced to 28 using recursive feature elimination. Overall, the best classification performance was obtained with SVM showing 96.9% accuracy on the test set, Matthew's Correlation Coefficient of 0.927 and weighted F2-measure of 0.97. This was followed by LR (95.3%, 0.893, 0.952) and RF (93.7%, 0.857, 0.94).

Conclusion:
This study showed that bolus infusion malfunctions can be detected with high accuracy using fluid pressure data only, without the need for elevated blood glucose levels.