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The Hungarian artificial pancreas project. Results and perspectives.

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Introduction: Individualized control therapies provide better and better results in the artificial pancreas researches. However, due to neglected dynamics the robustness of the methodologies is still a challenge. The Physiological Controls Group of the Obuda University together with the Hungarian Diabetes Association has designed a robust control algorithm by the joint work under the Hungarian Artificial Pancreas Working Group (MAP). The algorithm is capable to extend the limitations of the individualized algorithms. Results were presented at different domestic and international conferences (ATTD 2010-2014, MGYT 2009-2013, MDT 2010-2012) and journals (CMPB, JDST).

Aim: Based on our preliminary results we have focused on a larger patient cohort to test and validate our algorithm, but we have started to develop an adequate hardware and extend our concepts in telemedicine direction as well.

Methods: Based on literature guidelines (formulated by the JDRF community) and glucose-insulin models we have refined our controller and built an in-silico simulator. Including dynamic glucose absorption profiles identification of the virtual patients is based on data received from continuous glucose monitors (CGMS).
In the second step, the methodology of the developed algorithm has been extended: a designing template has been created to take into account environmental aspects of the control algorithm, and tested them based on literature metrics of the individualized algorithms. The algorithm was validated on other virtual patients, and target hardware (insulin pump panel) and software has been developed.
In the third step, during the development a telemedical system (DAQit) has been created separately, able to combine implementation, monitoring and visualization through a single information system.

Patients: Validation tests were done on 85 type 1 diabetic patients (aged between 6-52 years) equipped with Medtronic insulin pumps. The datasets (min. 1 week) were obtained from classical CGMS or IPro2 sensors. In case of 40 patients (20 children, 20 adults) dataset containing three different weeks (continuous or separated in time) were also tested. Moreover, model-free validation tests were carried out on the well-known Cambridge in-silico simulator.

Results: Hypoglycaemia is efficiently avoided and hyperglycaemia is reduced with more than 75% to the real datasets. Moreover, during the in-silico test we have proven that with correspondingly identified initial conditions the hypoglycemic and hyperglycemic episodes can be seriously reduced even in model-free environment.

It was also demonstrated that the algorithm can be implemented in a target hardware, while from telemedicine point of view we have started to implement a corresponding prototype able to integrate different types of measurement devices under a standard platform.

Conclusions: The research showed that there is a real hope to develop a general control algorithm that is able to globally manage patients and increase the reliability of the individual therapies (like model predictive control methodology criteria used by the JDRF). Moreover, even in model-free environment it is possible to achieve correct results. However, further research is required on the parameter identification method as the present system is sensitive to initial values and 1-2 days of patient dataset is needed as a priori information.

Further work: We plan to validate the algorithm on further datasets, but also to tune the identification algorithm and to develop the telemedical prototype. Fault detection analysis of different life situations (like stress, physical activity) is also required. Further aim is to test our results on FDA approved simulator(s) and combine our framework with individualized control protocols in order to be able to start clinical trials.