Synergy of Reinforcement Learning and Classical Data Analysis Approaches in Adaptive, Personalised Insulin Basal/Bolus Optimisation

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A Mobile Platform for Personalization of Insulin Delivery based on a Patch Pump and Reinforcement Learning

Background and Aims

Artificial intelligence (AI) is shaping the field of diabetes self-management. The reinforcement learning (RL) based adaptive basal-bolus algorithm (ABBA) [1] provides a holistic approach to personalised glucose control for diabetic patients with either

- self-monitored blood glucose (SMBG), or
- continuous glucose monitoring (CGM) device.

Each day, ABBA outputs one basal rate (BR) and three bolus doses. This study aims to enhance the performance of CGM version of ABBA in the announcement of disturbances during the day.

Methodology

The established version of ABBA provides for the following day

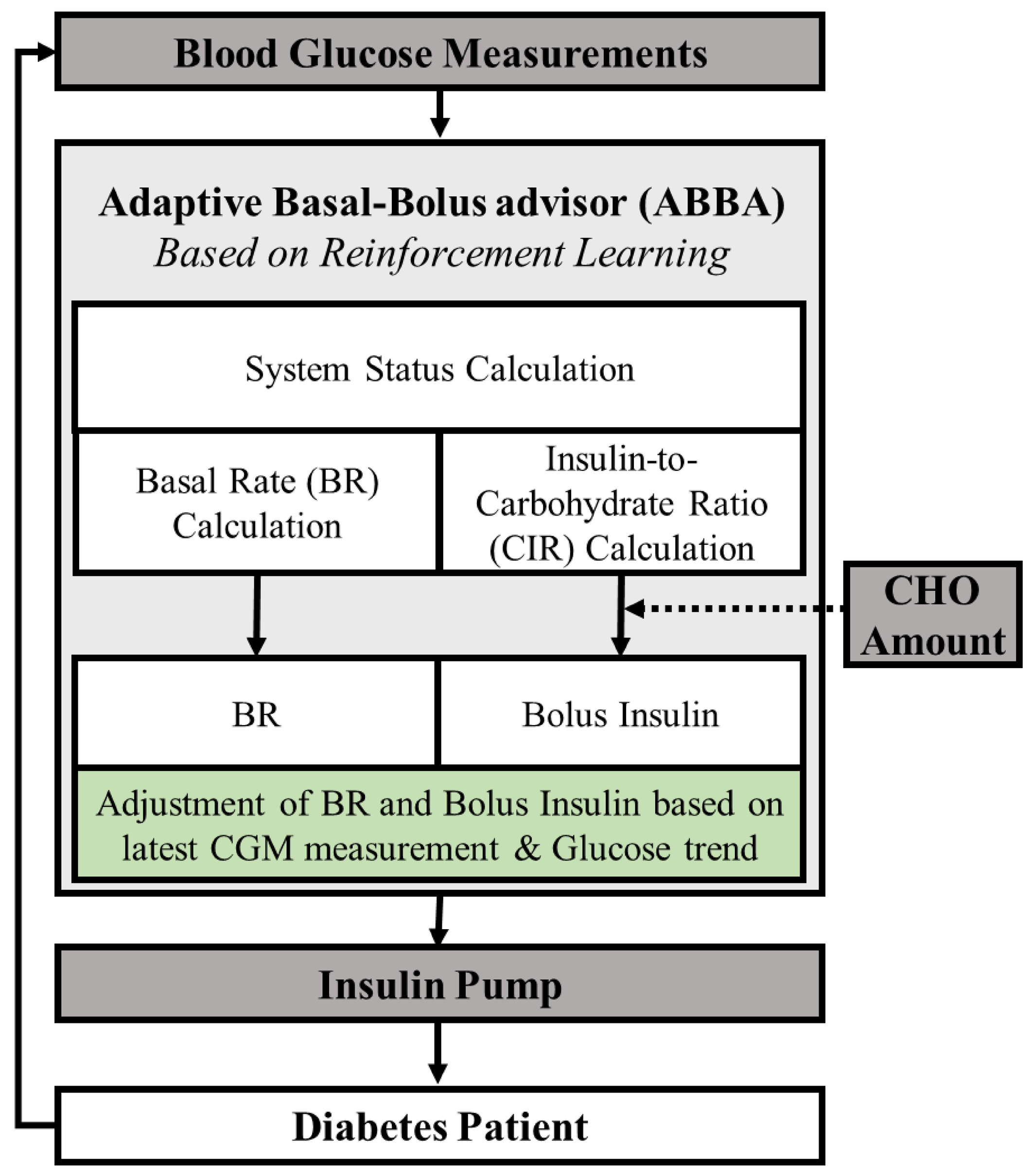
- one basal rate (BR) and
- three Carbohydrate-to-Insulin ratios (CIRs).

In an attempt to make ABBA more responsive and efficient in compensating errors in the disturbances, an additional module has been integrated. This module is triggered on the basis of:

- the latest glucose measurement and
- the glucose trend.

The proposed approach has been evaluated *in silico* with the FDA-approved UVa/Padova T1DM Simulator v3.2 - with 33 virtual subjects for 15 simulation days. Different variabilities and uniformly distributed uncertainties were considered.

The results of the ABBA with and without the insulin adjustment module were compared.



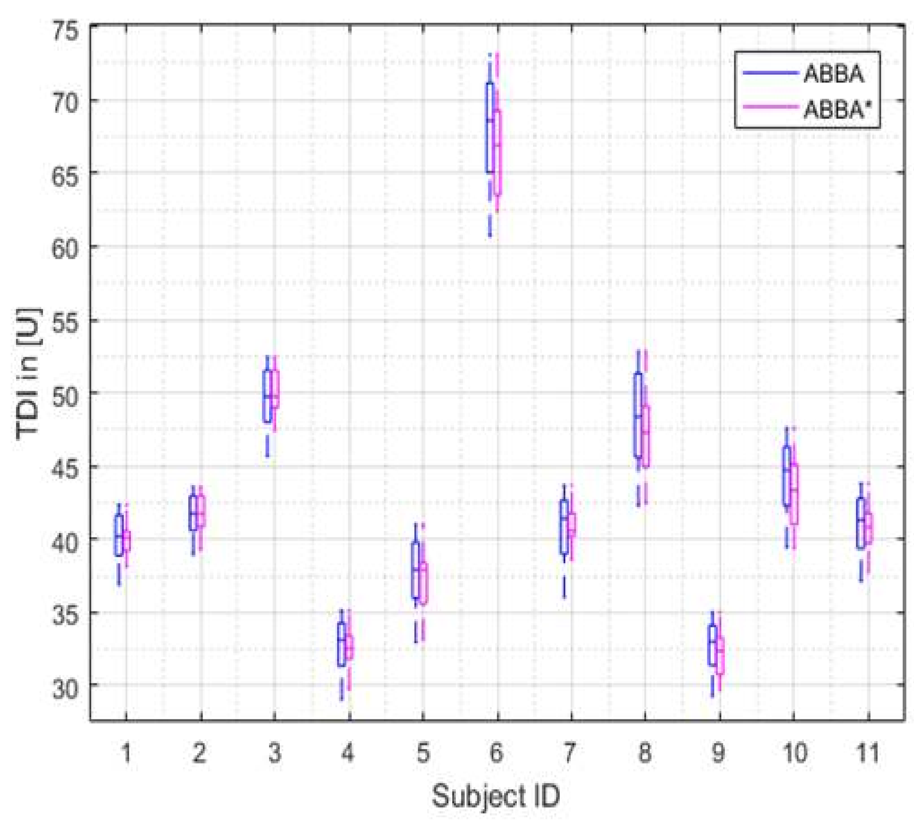
Structure of ABBA with additional module (in green)

Results

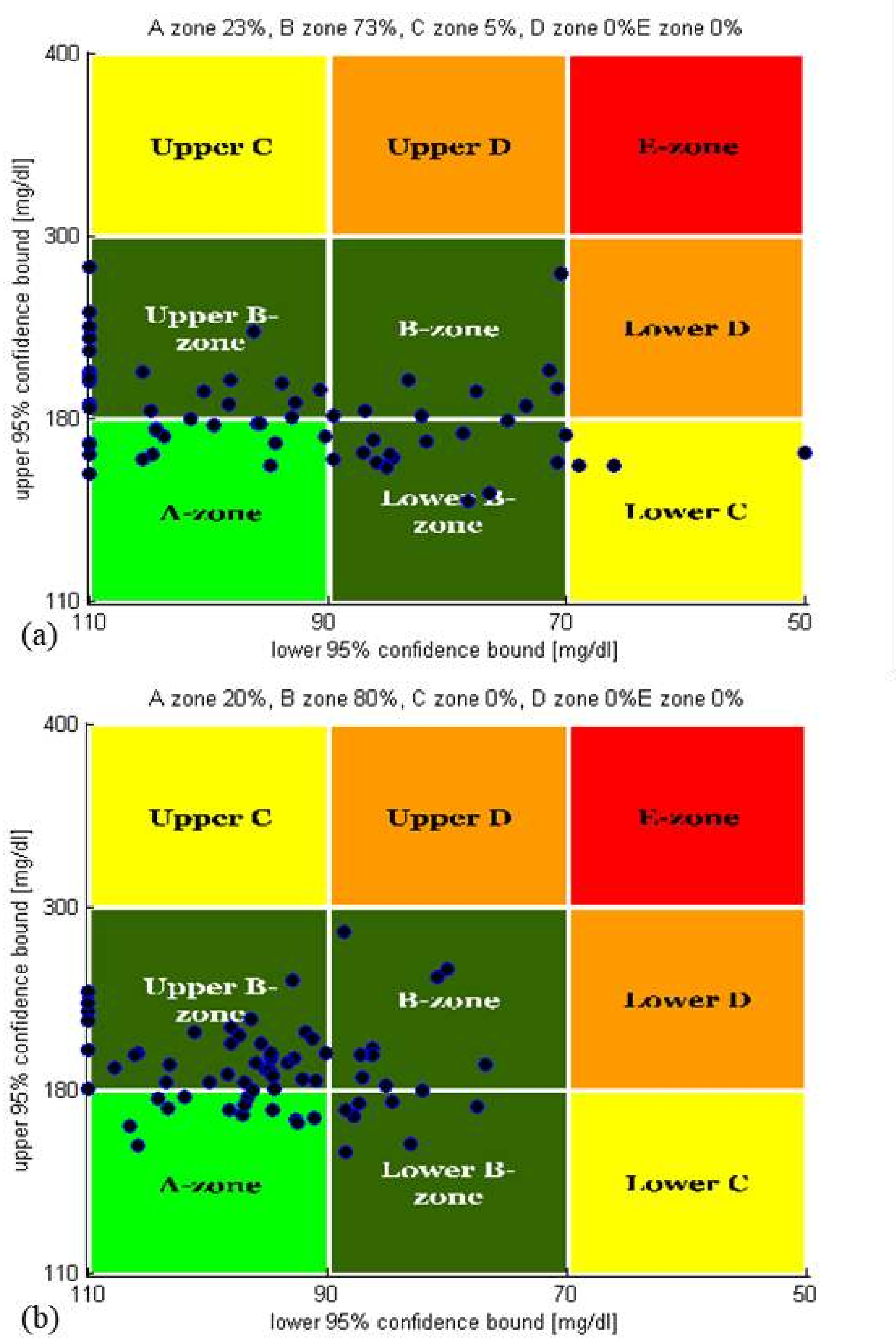
- Table 1 shows that the enhanced ABBA achieved better performance, in terms of percentage of time in all glycaemic ranges,
- CVGA plot visualises the improvement of the performance of ABBA with the additional module,
- Box plot shows the decrease of total daily insulin (TDI).

	BG Mean	% in range 70-180 mg/dL	% < 70 mg/dL	% > 180 mg/dL	TDI
A. Adults					
ABBA	138.8±14.5	88.9±13.0	0.5±0.8	10.6±12.7	42.13±9.46
ABBA*	137.6±9.7	**89.2±8.6**	**0.0±0.1**	**10.8±8.6**	41.76±9.20
B. Adolescents					
ABBA	153.1±12.6	73.4±13.1	0.6±1.0	26.0±13.2	30.36±7.28
ABBA*	146.0±11.1	**79.6±13.8**	**0.3±0.3**	**20.1±13.8**	31.16±7.43
C. Children					
ABBA	155.0±7.5	72.1±8.2	0.5±1.1	27.5±8.0	15.03±3.31
ABBA*	151.7±8.7	**73.6±10.4**	**0.0±0.0**	**26.4±10.4**	14.92±3.46

Table 1. Blood glucose control performance of day 9 to day 15
ABBA*: ABBA with additional adjustment module



Total daily insulin (TDI) of ABBA and ABBA*, during day 9 to day 15



The control-variability grid analysis(CVGA) plot for a) ABBA, b) ABBA*, during day 9 to day 15

Conclusions

The preliminary results are promising. The enhanced CGM version of ABBA not only learns from the user's daily patterns and habits, but is also able to react to new, not necessary repeated, disturbances. The concept may be extended to other kind of disturbances, e.g. exercise.

Reference:

1. Q. Sun, *et al.*, A dual mode adaptive basal-bolus advisor based on reinforcement learning (In Press). *IEEE J Biomed Health Inform*, 2018 (10.1109/JBHI.2018.2887067)

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