# AUTOMATIC SUPER-BOLUS AND BOLUS-SHAPING FEATURES FOR INSULIN PUMPS

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## ABSTRACT

This work presents a method for automatic insulin bolus shaping based on residual insulin or insulin-on-board (IOB) estimation as an extra feature for commercial insulin pumps. Among other potential applications, this methodology allows the pump to automatically generate the so-called super-bolus for the compensation of high glycemic index meals, which has been recently related to the best theoretical basal-bolus combination for the reduction of glucose excursions under open-loop treatment [1].

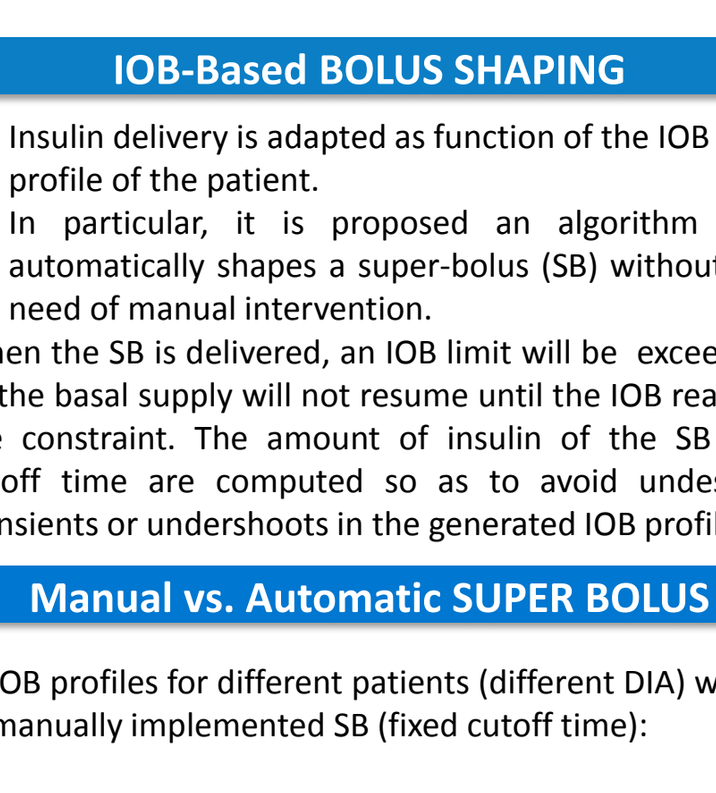
## IOB-Based BOLUS SHAPING

- Insulin delivery is adapted as function of the IOB profile of the patient.
- In particular, it is proposed an algorithm that automatically shapes a super-bolus (SB) without the need of manual intervention.

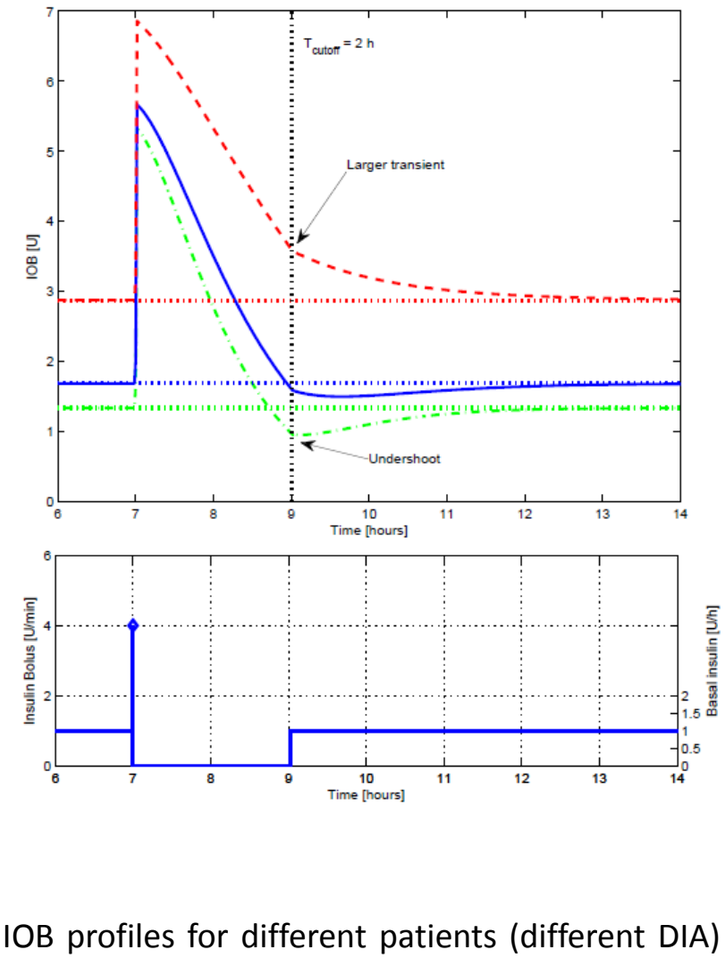
When the SB is delivered, an IOB limit will be exceeded, so the basal supply will not resume until the IOB reaches the constraint. The amount of insulin of the SB and cutoff time are computed so as to avoid undesired transients or undershoots in the generated IOB profile.

## Manual vs. Automatic SUPER BOLUS

- IOB profiles for different patients (different DIA) with a manually implemented SB (fixed cutoff time):




- IOB profiles for different patients (different DIA) with automatic SB:




## RESULTS

All *in silico* patients of the distribution version of the UVA/Padova metabolic simulator are considered for simulations.
The protocol employed for performance comparison vs. standard SB (not included in this poster) and standard treatment includes 4 meals: a high glycemic index (HGI) mixed meal of 25 g (bar of chocolate with peanut butter), a HGI mixed meal of 50 g (pasta with tomato sauce), a 75 g of CHO and 100 g of CHO meal.

**Reduction of time in hyper and hypoglycemia** achieved under the automatic SB with respect to the standard treatment (computed from total times):

| Meal | | Adults | Adolescents | Children |
|---|---|---|---|---|
| Mixed HGI 25g | Hypo | - | - | 37% |
| | Hyper | - | 24% | 50% |
| Mixed HGI 50g | Hypo | 100% | 100% | 65% |
| | Hyper | - | 89% | -13% |
| CHO 70g | Hypo | 17% | 34% | 81% |
| | Hyper | 79% | 36% | 1% |
| CHO 100g | Hypo | 42% | 67% | 44% |
| | Hyper | 37% | 14% | 14% |

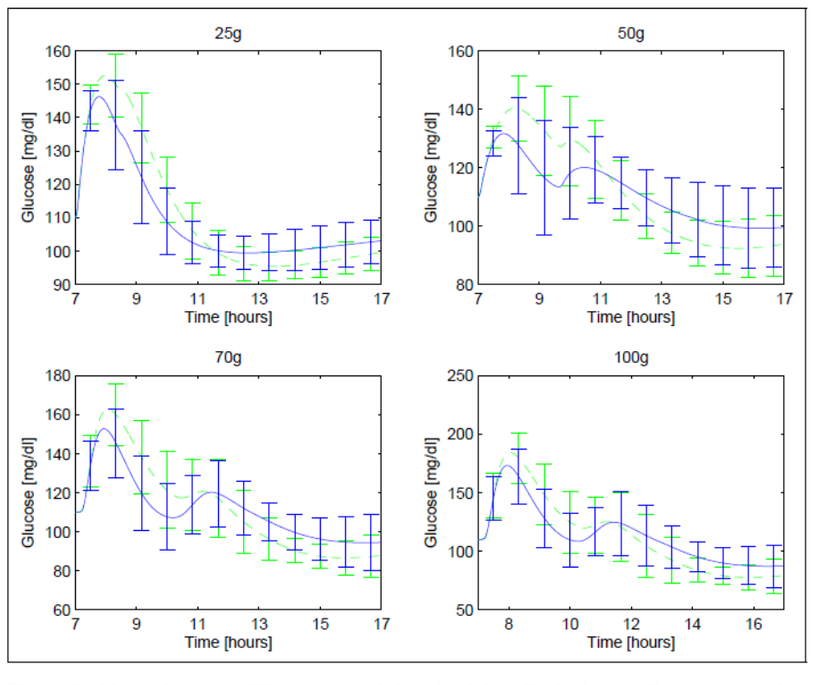



Figure 9: Mean glucose ± SD response of the 10 adults. Dashed-green line corresponds to standard treatment, solid-blue line to automatic SB

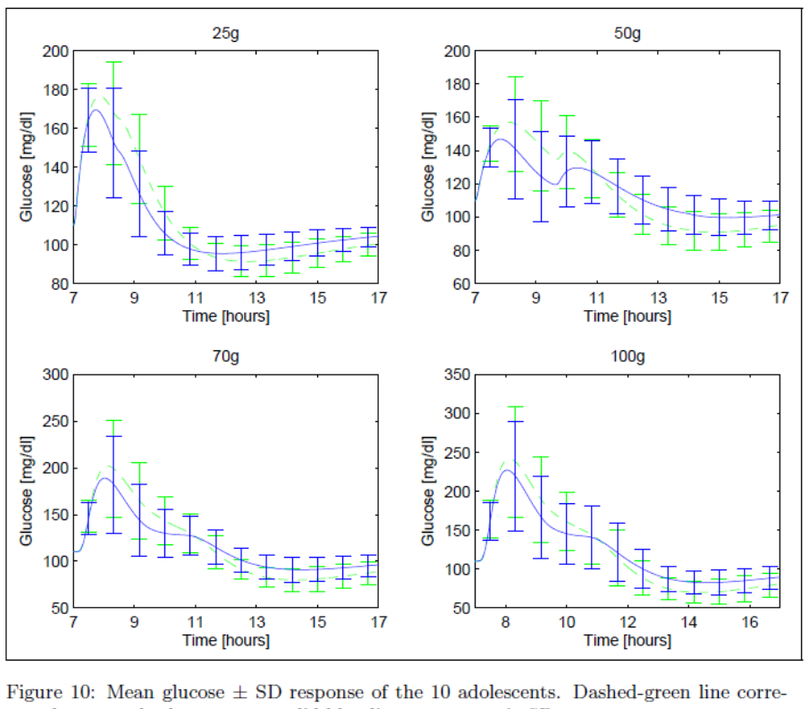



Figure 10: Mean glucose ± SD response of the 10 adolescents. Dashed-green line corresponds to standard treatment, solid-blue line to automatic SB

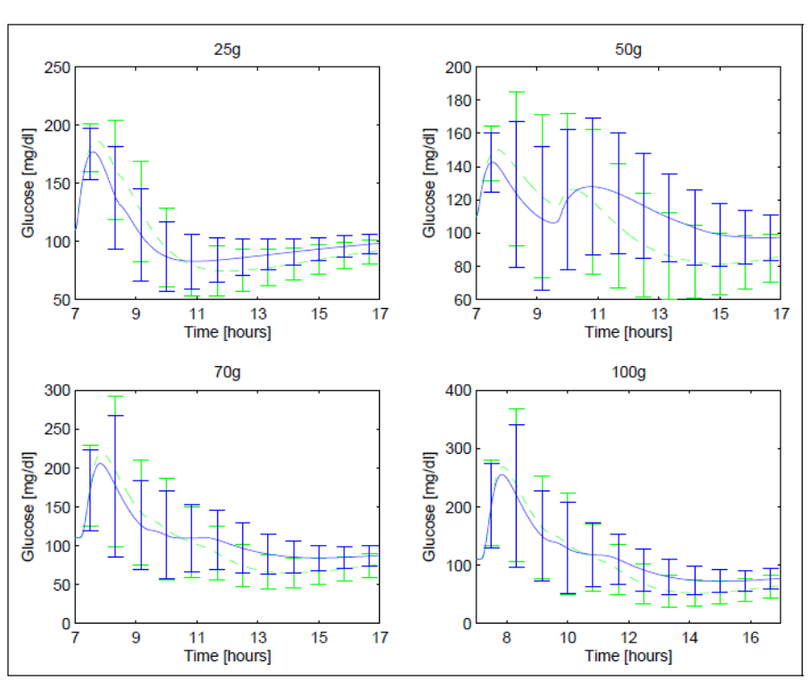



Figure 11: Mean glucose ± SD response of the 10 children. Dashed-green line corresponds to standard treatment, solid-blue line to automatic SB

## CONCLUSIONS

- Novel treatment for open-loop control.
- Easy-to-implement in current pumps software (patent requested [2]).
- Better performance facing a mixed HGI or large meals with regard to the standard treatment, using the same amount of insulin.

## REFERENCES

[1] G. C. Goodwin, A. M. Medioli, D. S. Carrasco, B. R. King, and Y. Fu, "A fundamental control limitation for linear positive systems with application to type 1 diabetes treatment," Automatica, 55, 73–77, 2015.
[2] PCT/ES2016/070051. F. Garelli, H. De Battista, J. Vehi, and F. Leon-Vargas, "Method and computer program for determination and time distribution of an insulin dose to a user", 2016.

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