Personalised adaptive basal-bolus algorithm using SMBG/CGM data

Qingnan Sun1, Marko V. Jankovic1,2, Christoph Stettler3, Stavroula Mougiakakou1,3

1ARTORG Center for Biomedical Engineering Research, University of Bern, Bern, Switzerland
2Department of the Emergency Medicine, Bern University Hospital “Inselspital”, Switzerland
3Division of Endocrinology, Diabetes and Clinical Nutrition, Bern University Hospital “Inselspital”, Switzerland

An essential component of the diabetes management plan is the glucose monitoring using either meters for self-monitoring of blood glucose (SMBG) or more recently continuous glucose monitors (CGM).

The main objective of the study is the simultaneous personalisation of the basal and bolus insulin to be delivered by a pump independent of the used glucose monitoring device (SMBG or CGM) using a newly proposed adaptive basal-bolus algorithm (ABBA).

ABBA is based on reinforcement learning (RL), a branch of artificial intelligence algorithms, that “...allows the system to learn its behaviour based on feedback from the environment”

After an initialization phase of seven days using patient’s CGM and insulin pump data the ABBA estimates the basal and bolus independently if he/she is using CGM or SMBG.

<table>
<thead>
<tr>
<th>BG (mg/dL)</th>
<th>% in target range</th>
<th>% in Hypo</th>
<th>% in Hyper</th>
<th>Total daily insulin (U)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults</td>
<td></td>
<td></td>
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<tr>
<td>ABBACGM</td>
<td>140.9 ± 18.4</td>
<td>87.5 ± 16.1</td>
<td>1.0 ± 1.1</td>
<td>11.5 ± 15.4</td>
</tr>
<tr>
<td>ABBASMBG</td>
<td>143.5 ± 18.9</td>
<td>86.9 ± 16.7</td>
<td>0.6 ± 0.9</td>
<td>12.5 ± 16.0</td>
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<tr>
<td>Adolescents</td>
<td></td>
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<tr>
<td>ABBACGM</td>
<td>148.1 ± 11.5</td>
<td>75.7 ± 12.2</td>
<td>2.4 ± 2.0</td>
<td>21.9 ± 12.3</td>
</tr>
<tr>
<td>ABBASMBG</td>
<td>145.8 ± 9.3</td>
<td>77.8 ± 13.6</td>
<td>2.6 ± 2.2</td>
<td>19.6 ± 12.7</td>
</tr>
<tr>
<td>Children</td>
<td></td>
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</tr>
<tr>
<td>ABBACGM</td>
<td>149.3 ± 9.0</td>
<td>75.0 ± 9.8</td>
<td>1.8 ± 1.6</td>
<td>23.2 ± 8.8</td>
</tr>
<tr>
<td>ABBASMBG</td>
<td>150.5 ± 10.8</td>
<td>75.2 ± 12.4</td>
<td>1.1 ± 1.3</td>
<td>23.7 ± 11.5</td>
</tr>
</tbody>
</table>

No statistically significant difference was observed between ABBACGM and ABBASMBG, α=0.05

Target range: [70 180] mg/dL; Hypo < 70 mg/dL; Hyper > 180 mg/dL

Conclusions

ABBA, the proposed RL algorithm, demonstrated its ability to achieve
• glucose control in an in silico population using a complex scenario characterized by a high degree of variabilities and uncertainties,
• comparable performances for both CGM and SMBG, without affecting the total daily insulin dose.

Next step
ABBA within the framework of a clinical study

Background and Aims

The training version of the FDA accepted UVa/Padova T1DM Simulator v3.2
• The scenario lasted for 98 days (Days 2-8 for initialization; Days 9-98 for control).
• Three meals (breakfast, lunch and dinner) were considered with variabilities in the announcement of mealtime (±15 min) and carbohydrate amount (±10g for main meals and ±5g for snack). In addition, an uncertainty in the order of ±50% was introduced to simulate the error of patient’s carbohydrate content self-estimations.
• Variable insulin sensitivity (dawn phenomenon -50% from 4:00 AM to 8:00 AM and interday variability in the order of ±25%).

Both variabilities and uncertainties follow uniform distributions.

In silico evaluation and daily scenario

Results

ABBA within the framework of a clinical study