INCORPORATION OF MODELS OF CGM SENSOR ERROR AND FAULTS AFFECTING CGM SENSORS IN THE UVA/PADOVA TYPE-1 DIABETIC SIMULATOR: ASSESSMENT ON CLINICAL DATA

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BACKGROUND AND AIM

Recently, a new model of the measurement errors in continuous glucose monitoring (CGM) sensor was identified for Dexcom® G4™ Platinum [1]. Furthermore, a model for the faults affecting CGM sensors (e.g. disconnections and compression artifacts (CA)) was proposed [2]. The inclusion of these two components in the UVA/Padova Type-1 diabetic simulator is critical for accurate in silico testing of CGM-based applications like the artificial pancreas. In this work, both models are incorporated into the most recent version of the simulator and simulated data are compared against clinical data [3].

DATABASE AND SCENARIOS

Subjects
108 traces of subjects wearing the Dexcom G4™ Platinum (DG4P) and undergoing an 1 day hospital admission are available. Blood glucose samples were collected every 15±5 min using YSI®. The accuracy of these CGM measurements was compared with the accuracy of the simulated CGM in 108 traces obtained replicating the clinical protocol from 72 in silico type 1 diabetic (TIDM) adults by using the UVA/Padova TIDM simulator [4].

METHODS

CGM Sensor Subsystem

Model of CGM Sensor Error [2]

Model of CGM Sensor Disconnections [2]

Model of CGM Sensor Compression Artifacts [2]

RESULTS

CGM Sensor Error

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Real Data</th>
<th>Simulated Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senses Traces (M)</td>
<td>13631</td>
<td>13429</td>
</tr>
<tr>
<td>Number of paired samples</td>
<td>13631</td>
<td>13429</td>
</tr>
<tr>
<td>%B (mg/dL)</td>
<td>81.6</td>
<td>77.3</td>
</tr>
<tr>
<td>MAD (mg/dL)</td>
<td>17.9</td>
<td>12.1</td>
</tr>
<tr>
<td>MARD (%)</td>
<td>13.1,12,5</td>
<td>13.1,11,5</td>
</tr>
<tr>
<td>CEG-Zone (%)</td>
<td>80.2</td>
<td>77.3</td>
</tr>
</tbody>
</table>

Table 1. Comparison of overall performance metrics between the results reported on [3] and simulated data.

Figure 1 and Table 2. Metrics of all matched pairs for each individual sensor was evaluated. Using a standard statistical test method, the nonparametric two-sample test, the differences between the real data distributions and the simulator data were found to be statistically significant. Only the differences on the MAD for the normoglycemic range was found to be statistically significant. Overall statistics are showed on the table and box plots.

CGM Sensor Disconnections

Figure 2. In total 99/100 disconnections occurred on real data vs. 100/100 on simulated ones. Figure shows the normalized histogram of the duration of the disconnections (each bar has height given by the number of occurrences divided by the total number of events). 72.6% (left) vs. 73.3% (right) of them consist of only one sample missing (10-min gap). 90.2% (left) vs. 89.1% (right) of them lasted <=20 min.

CGM Sensor Compression Artifacts

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Real Data</th>
<th>Simulated Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARD (%)</td>
<td>-0.86</td>
<td>-0.84</td>
</tr>
<tr>
<td>MAD (mg/dL)</td>
<td>15.3</td>
<td>13.1</td>
</tr>
<tr>
<td>MARD (%)</td>
<td>10.1</td>
<td>8.3</td>
</tr>
<tr>
<td>CEG-Zone (%)</td>
<td>0.12</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Table 2. Comparison of overall performance metrics between the results reported on [3] and simulated data.

Figure 3. Example of two compression artifacts obtained with the UVA/PADOVA simulator equipped with the two models.

CONCLUSIONS AND FUTURE WORK

• Results suggest that the UVA/PADOVA simulator equipped with the two models are able to reproduce the clinical trial observations.
• Next steps will include to complete the statistical analysis of real and simulated compression artifacts, in order to compare frequency, duration and amplitude. Furthermore, to test the UVA/PADOVA simulator equipped with the two models with other real datasets.

REFERENCES


ACKNOWLEDGEMENTS

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