PILOT STUDY OF EXPLOITING ABDOMINAL SOUND FOR EARLY MEAL ONSET DETECTION

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Background and Aim:

- A typical artificial pancreas depends on continuous glucose monitoring (CGM) for insulin dosing.
- Because of the slow dynamics of the glucose sensing, current CGM based meal detection approaches typically exhibit a delay of 10 to 40 minutes between actual meal onset and reliable detection [1,2].
- In contrast, the processes of ingestion and digestion produce sounds even before meal glucose enters the blood. [3]
- Therefore, the focus of the present work is towards the early meal onset detection based on abdominal sounds.

Data collection:

- Sennheiser MKE2 P-C condenser microphone was fixed in the chest-piece of a stethoscope for recording abdominal sounds.

- A digital audio recorder 722 was used to digitize the sound signals into samples with a sampling frequency of 32000 Hz and 24-bit precision.
- In in the present study, these signals are decimated to 4000 Hz to reduce the complexity.
- This assembly was attached to the upper right quadrant of the abdomen by medical tape.
- Abdominal sounds were recorded in a total of eight meals; four meals from each of the volunteers. Each recording lasts for approximately 80 minutes.

Fasting 20 minutes	Eating 15 minutes	Digestion 45 minutes

Experimental results:

Leave one out cross validation with the following metrics:

I. TPM: Four consecutive sound segments after meal onset are classified as meal-sound

II. FPM: Four consecutive segments before the start of a meal are classified into meal-sound

III. FNM: If there are no four consecutive segments after the start of meal classified as meal-sound

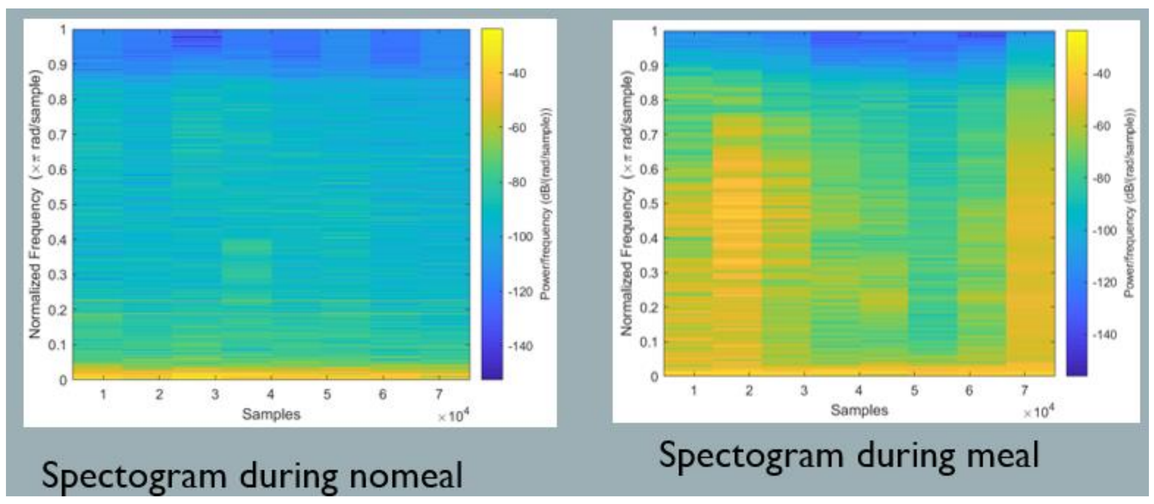
IV. RD: The time delay from actual meal onset to the time of detection by the proposed method.

Subject Number	TPM	FPM	FNM	RD
1 (Noise-free)	75%	25%	0%	6.6 min
2 (Noisy)	50%	50%	25%	2 min

This approach detects meal onset with an average delay of 4.3 minutes in our limited number of subjects. Importantly, it provides lesser delay than the state-of-the-art CGM based approach [1,2].

Method

- The sound signals are segmented into smaller segments each of 20 seconds with an overlap of 10 seconds between consecutive samples.
- Features: Mel-frequency cepstral coefficients (MFCC) and wavelet transform-based entropy features from each abdominal sound segment.
- The extracted features are combined by using simple feature concatenation technique to get a final feature vector representation.
- Classification: The final feature vector extracted from each segment is given to a feedforward neural network for discriminating meal and no-meal abdominal sounds.



Conclusion:

- Preliminary results indicate that the abdominal sounds-based approach may provide early meal onset information [3]. This can be exploited in an artificial pancreas through allowing earlier meal insulin boluses, resulting in improved glycemic control.
- It can also be useful in a meal reminder, as support for manual or hybrid closed-loop glucose control.

References

[1] E. Dassau, B. W. Bequette, B. A. Buckingham, and F. J. Doyle, III, "Detection of a meal using continuous glucose monitoring: Implications for an artificial β-cell," Diabetes care, vol. 31, no. 2, pp. 295–300, 2008. DOI: 10.2337/dc07-1293

[2] K. Kölle, T. Biester, S. C. Christiansen, A. L. Fougner, and Ø. Stavdahl, "Pattern Recognition Reveals Postprandial Changes in CGM Data: Non-Individualized Meal Detection in DM1", IEEE Journal of Biomedical and Health Informatics, Vol. 24, No. 2, pp. 594–602, 2020. DOI: 10.1109/JBHI.2019.2908897

[3] T. S. Kumar, E. Søiland, Ø. Stavdahl and A. L. Fougner, "Pilot Study of Early Meal Onset Detection from Abdominal Sounds," *2019 E-Health and Bioengineering Conference (EHB)*, Iasi, Romania, 2019, pp. 1-4. DOI: 10.1109/EHB47216.2019.8969901

Acknowledgements

- The first author, T. Sunil Kumar, a European Research Consortium for Informatics and Mathematics (ERCIM) Alain Bensoussan fellow at NTNU, would like to thank both ERCIM and NTNU for supporting this work.
- This project belongs to the Artificial Pancreas Trondheim research group (APT, apt-norway.com) and is supported by the Research Council of Norway (grant no. 248872 & 294828) through the Centre for Digital Life Norway (digitallifenorway.org).

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