An alternative technique for measuring respiratory motion in speech

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Motivation

- Evaluate alternative to measure breathing-related movement during speech
- Standard: Respiratory Inductance Plethysmograph (RIP)
- Is triaxial accelerometer a useful replacement / supplement?

Material & Method

- Speech Breathing
  - Orient-3 wireless sensor device
  - Freescale MMA7260Q three-axis accelerometer
- Location: lower costal margin, just below the ribs, attached using surgical tape.
- This location usually gives the clearest rotation measurement.
- Accelerometer outputs on the device had 35Hz second order analog filters. Sample Rate = 128Hz.
- Normal breathing was taken during the same session.
- Processing of accelerometer data following [1]

Background I: Respiratory monitoring

- Triaxial accelerometers: Measurement of accelerations in three dimensions, regardless of device or subject orientation.
- Extraction of a one-dimensional respiratory signal by tracking the major axis of breathing and calculating rotational rates about this axis.
- Integration in order to extract respiratory rate mm/s
- Previous Study - Monitoring Application [1]: Correlational Study. Rotational Rate of the abdomen can serve as proxy for respiratory airflow.
  → Almost perfect correlations of rot. rate with airflow measured by a nasal cannula connected to a pressure transducer (r=0.94).

Background II: Speech Respiration

- Objective: Maintainance of (almost) constant subglottal pressure. Achieved by a complex interplay of expiratory and inspiratory muscles.
- First comprehensive approach: Edinburgh model and modifications [2, 3] and its remodelling [4].

Qualitative Analysis

- Annotation: Handlabelled portions of audible acoustic inbreath.
- Top panels: Acoustic waveforms of representative utterances.
- Bottom panels: Integrated rotational rates (RR Int)
  → hypothesized correlate of lung volume (RR Integ).
- Middle panels: Rotational rate (RR) of the breathing sensor.

Replication of some key findings

- Inspiration Depth and Quantity of Speech have often been reported to be positively correlated.
  → Our data (from [5]): Weak positive correlation:

Speech breathing is irregular.
  → Distribution of inter-breathe intervals in normal and speech breathing as measured by our technique (see [5]):

Correlation between duration of audible inbreath and peak height of the integrated signal.

We have shown that accelerometer-based respiratory monitoring can be applied to speech breathing. We were able to replicate some of the most basic findings concerning speech respiration: Speech breathing is characterized by irregularity and reduced frequency in comparison to normal breathing. Further, the rotation maximum mostly coincides with audible inspiration and matches well with the place of expected maximum lung volume. However, the gradual decrease in lung volume over the course of the utterance is not perfectly reflected in the data. The exact reasons for that remains unknown but provides guidance for future research: It would be worthwhile applying several sensors measuring respiratory activation in parallel. For example, the accelerometers used here could also be supplemented with gyrosopes, measuring rotation directly. A further direction would be to carry out multi-method studies which using the combination of accelerometer/gyroscope with Respiratory Inductance Plethysmography (RIP).

Result Summary & Discussion

References:


Acknowledgments:

This research was funded by grants to the EPSRC (EP/EO130001/1, EP/EO18981/1).

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