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Performance Study of Novel Acceleration-enhanced Filters in the Prediction of Normal and Irregular Respiration Motion

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Purpose

To study the performance of the novel acceleration-enhanced (AE) filters in the prediction of normal and irregular respiration motion and compare them with those of traditional adaptive normalized least mean squares (nLMS) and adaptive neuron network (ANN) filters. This facilitates the real-time tumor tracking and dynamic delivery of radiation dose to the tumor.

Method and Materials

Respiration signals are collected from volunteers under IRB-approved protocol by respiration sensor, which is able to sense the expansion and contraction of the rib cage. One-dimensional respiration signal is used in this work for the evaluation of the performances from different prediction filters. The respiration signals are captured at a frequency of 256 Hz and sampled at 32 Hz. The prediction performances of the filters in the prediction of normal and irregular respiration are compared, including adaptive nLMS and adaptive ANN filters, as well as their AE versions, which use the accelerations derived from the predicted velocities for further corrections to the predicted positions.

Results

The adaptive ANN filter performs better than the adaptive nLMS filter in the prediction of normal respiration whereas the latter excels in predicting irregular respiration signals. The implementation of AE method prompts the performances of the traditional filters. For example, with a prediction time fixed at 250 ms, the ANN and nLMS filters gave percentage root mean square (RMS) prediction errors of 3.51% and 4.25% for normal respiration, and 8.85% and 6.17% for irregular respiration, respectively. AE-ANN filter gives a percentage RMS error of 3.45% in normal respiration prediction and AE-nLMS has a 5.87% RMS error in irregular respiration prediction.

Conclusion

The acceleration-enhanced method is able to improve the performance of the traditional filters. The AE-ANN and AE-nLMS filter give the minimum error in the prediction of the normal and irregular respiration, respectively.

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