Mapping Breathing Induced Liver Movement Using Ultrasound

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Introduction
The main purpose of medical simulation is to educate students and practitioners in the health sector by using high technology simulators. According to the records published by Institute of Medicine, approximately 44000 to 98000 deaths were recorded primarily due unexpected mistakes during treatments (Institute of Medicine, 2009). Due to increased complexity of medical treatments, it is essential to tailor these simulators to provide specific and accurate information to the users. Providing the necessary information to users will help them to understand the nature of what they are working with and also in the case of errors, to understand their mistakes. The long term goal of simulators has been to replicate certain health conditions that may have minimum level of tolerance for human errors during treatments. In fact having these simulators minimizes the intervention of human beings in the first place during training purposes.

Objective
- Formulate a method to track induced liver motion due to respiratory and cardiovascular system: that could be further used in patient simulator system.
- Use of ultrasound imaging techniques to locate position and movement of liver segments.

System Modelling

Motion modelling

\[ \delta(t) = \delta_{max} \omega \sin(\omega t + \phi) \]

\[ v(t) = -\delta_{max} \sin(\omega t + \phi) \]

\[ x(t) = \text{path taken by the system for each axis of motion and } y(t) \text{ is the velocity in that path, } \delta_{max} \text{ is the maximum distance the model will travel at a given time frame and ideally } \omega \text{ will be half of this value. Differentiating this equation yields velocity of the model at a given time; } \omega \text{ is the oscillation frequency.} \]

Respiratory system induced movement

Cardiovascular system induced movement

Motion of liver is affected by both respiratory and cardiovascular system

Physical Simulation Models

Conclusion
For verification, given the respiration frequency combined with the US imaging frequency and maximum lung displacement envelope, a prediction of over motion could be attained. Predicted data can be compared with the real-time US image based data for consistency and reliable accuracy. However, it is quite evident that induced motion of liver is dominated by the respiratory system. The motion component from cardiovascular system is relatively insignificant thus could be neglected in extreme conditions.

References


Ching-Kai Lin, Jeng-Chih Lin et al. Ultrasound Image-Guided Algorithms for Tracking Liver Motion In: International Conference on Advanced Intelligent Mechatronics, 2012 July 11-14, Taiwan

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