Patient-Specific Simulation for Pre-Operative Realistic Training of Liver Surgery

Patient Specific data acquisition

Patient Specific Modelling

Planning  Education  Simulation

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Extract motion models for points on the surface of the liver

T5.4: Breathing modeling from endoscopy

Peter Mountney
Guang-Zhong Yang

Imperial College
London
Extract motion models for points on the surface of the liver

- Introduction
- Estimating 3D liver motion from an endoscopic camera
- Modelling respiration from 3D liver motion
- Developing a validation setup
- Applying the model to the SOFA framework
- Results – *in vivo* and phantom
- Augmented reality
Tracking the Surface of the Liver
3D Tissue Motion to Respiration Model

3D Motion

Components of Motion

X axis

Y axis

Z axis
Principal Component of Motion

1st Component of PCA

1st Component of PCA
Respiration Model

\[ z(t) = z_0 - b \cos^{2n} \left( \frac{\pi t}{\tau} - \phi \right) \]

Fit Observed Data to Model using Levenberg-Marquardt Algorithm

Green – Observed Data
Red – Respiration Model
Extended Kalman Filter (EKF) for Tracking and Prediction

\[ h^5_i = (\text{elg}(z_0 - b \cos^2(\alpha)) + \bar{y}) \]

\[ \frac{d\hat{m}}{d\alpha} = \text{elg}(nb \sin(\alpha) \cos(\alpha)^{n-1}) \]

\[ \frac{d\hat{m}}{d\tau} = 0 \]

\[ \frac{d\hat{m}}{db} = \text{elg}(\cos(\alpha)^n) \]

\[ \frac{d\hat{m}}{dz_0} = \text{elg} \]
Results

Experimental Set-up for Validation
Results *Ex Vivo*
Results *In Vivo*
Results *In Vivo*
Augmented Reality
Future work

Model hysteresis

Investigate the use of splines to model motion

Incorporate into SOFA

Registration (non rigid) for Augmented Reality