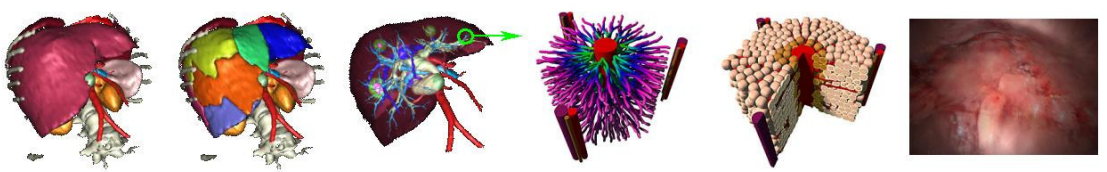
eHealth

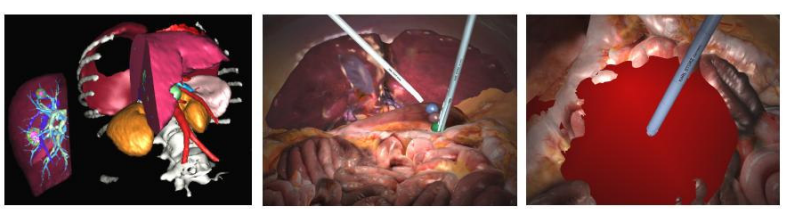
PASSPORT

Patient-**S**pecific **S**imulation for **P**re-**O**perative **R**ealistic **T**raining of Liver Surgery

Patient Specific data acquisition



Patient Specific Modelling



Planning *Education* *Simulation*

FP7, ICT-2007.5.3

ircad ETH TUM UCL Imperial College London INRIA IZBI Inserm CNRS ulp STORZ KARL STORZ – ENDOSKOPE

European Commission Information Society and Media

PASSPORT

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

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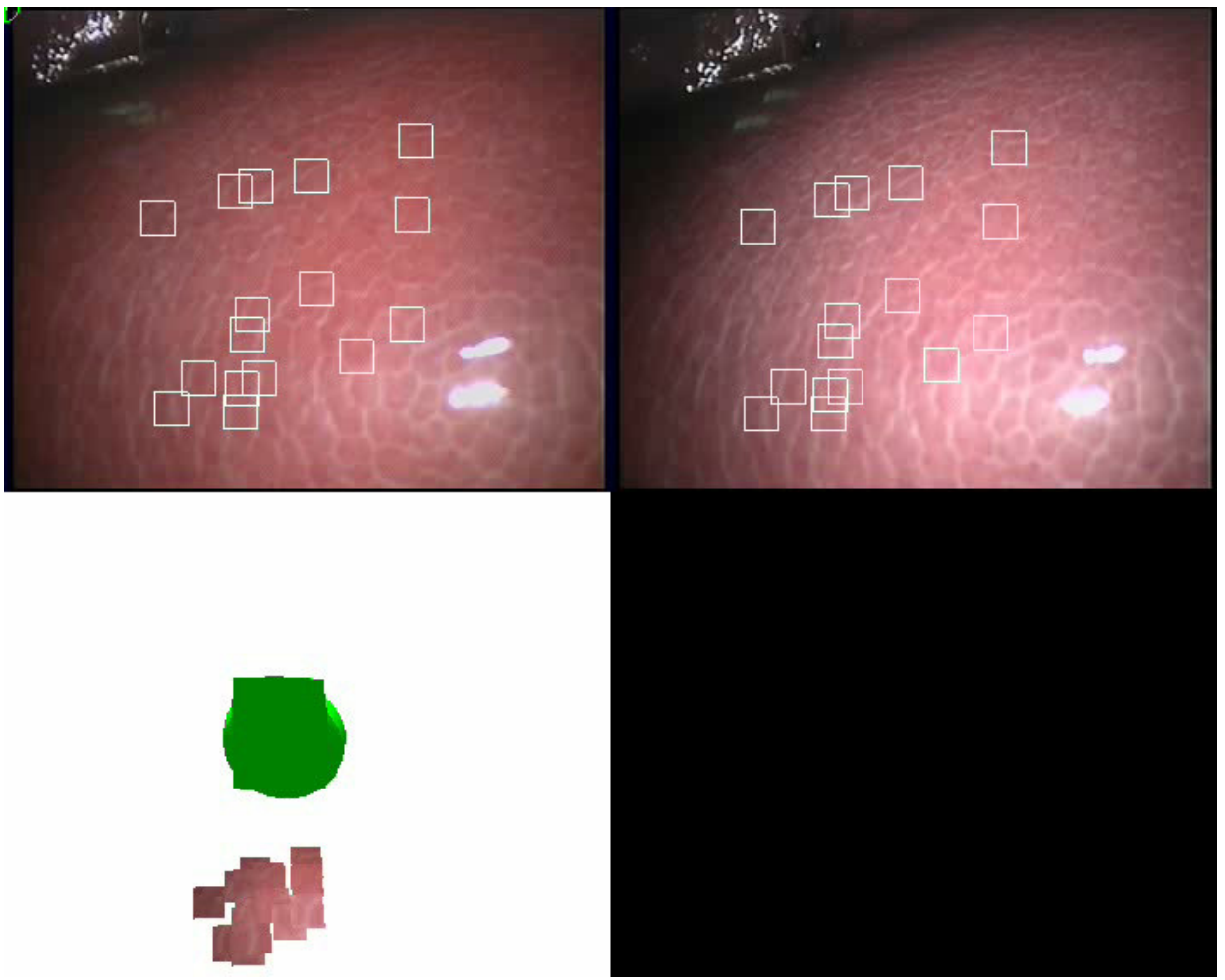
Extract motion models for points on the surface of the liver

- 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



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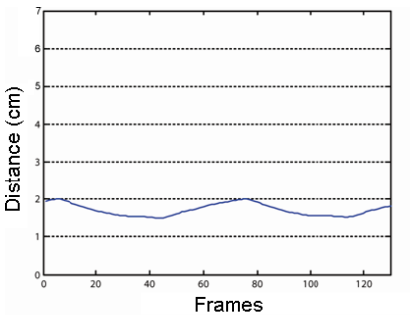
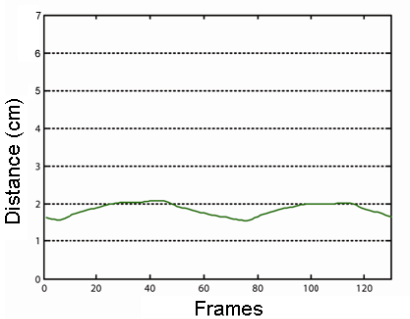
3D Tissue Motion to Respiration Model

3D Motion

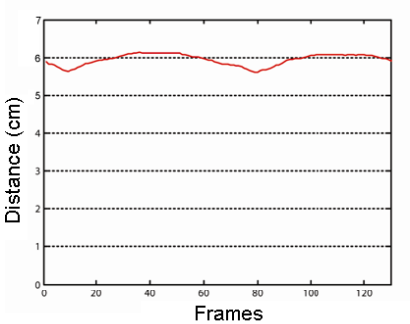
X axis



Y axis

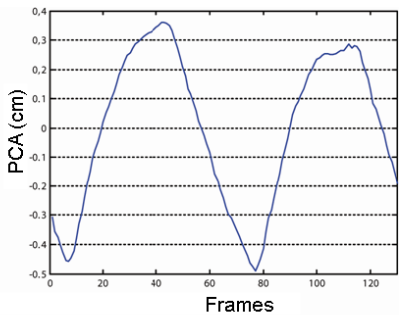


Z axis

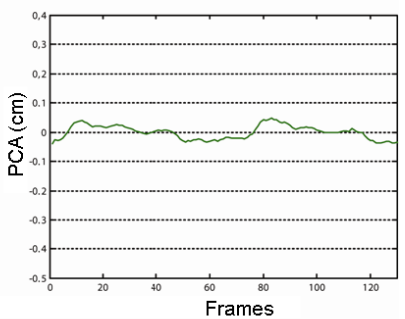


Components of Motion

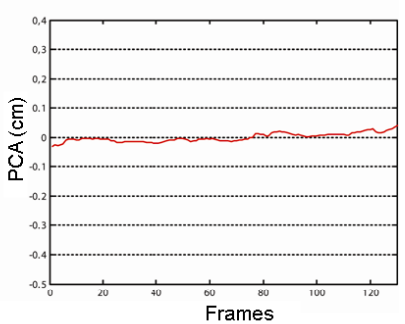
1st



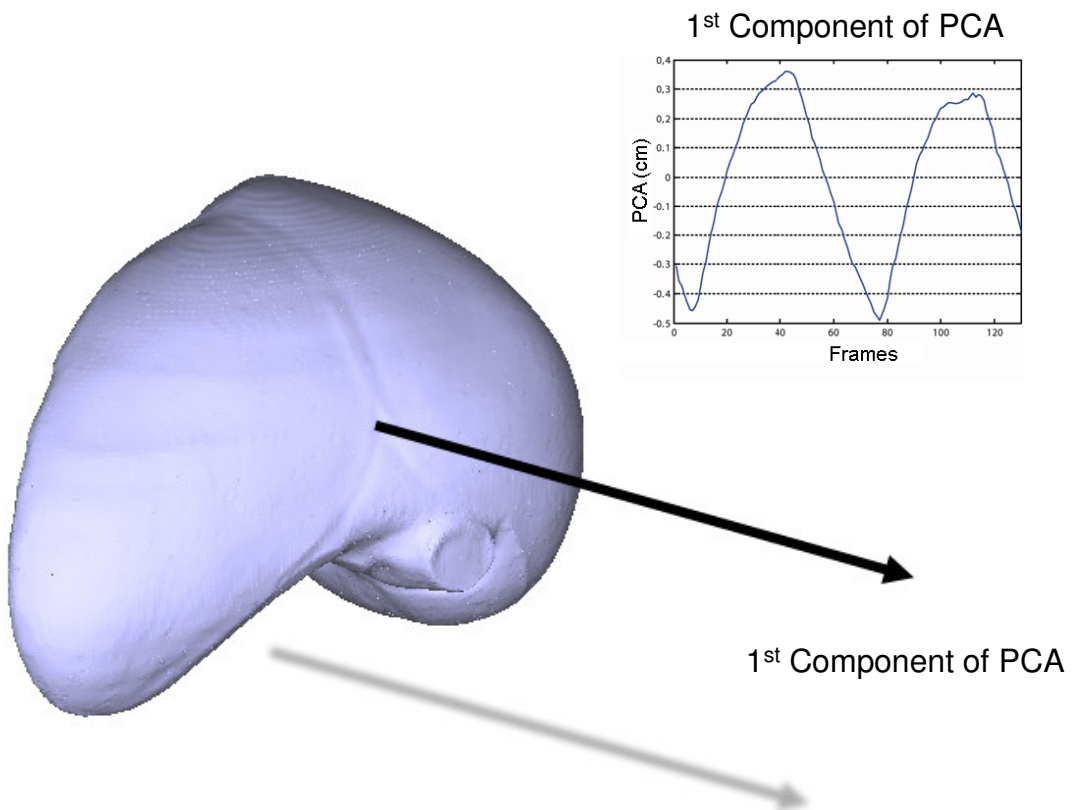
2nd



3rd

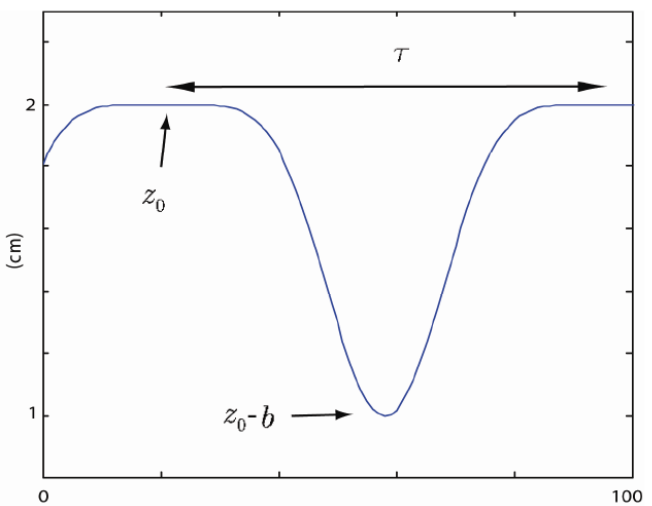


Principal Component of Motion



Respiration Model

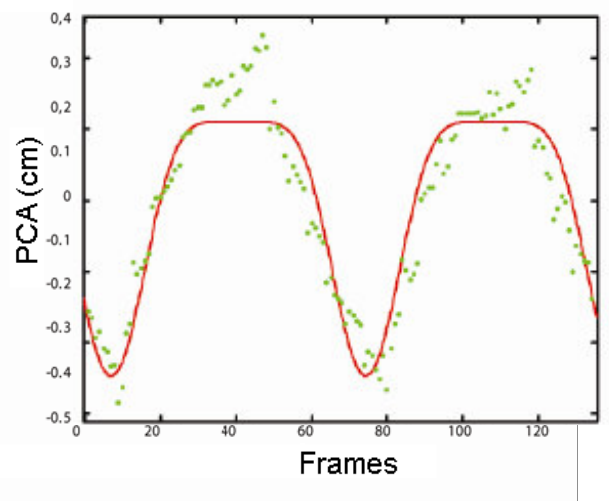
$$z(t) = z_0 - b\cos^{2n}\left(\frac{\pi t}{\tau} - \phi\right)$$



Lujan A.E., Larsen E.W., Balter J.M., Haken. R.K.T. A Method for Incorporating Organ Motion due to Breathing into 3D Dose Calculations. Medical Phisics. (1999);26(5):715 720.

Model fitting

Fit Observed Data to Model using
Levenberg-Marquardt Algorithm

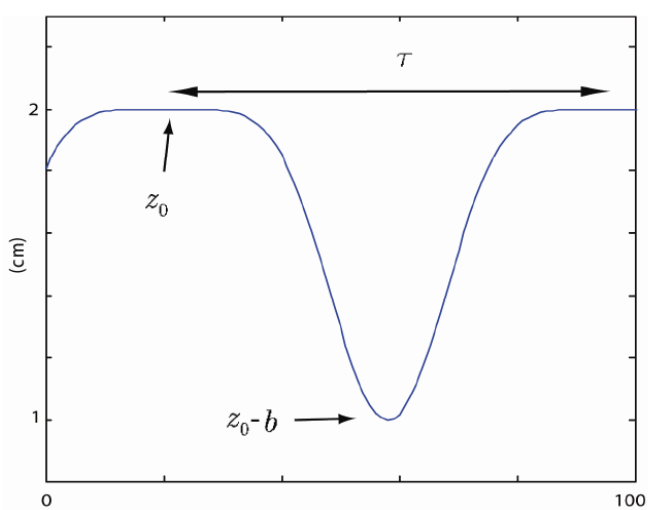


Green – Observed Data

Red – Respiration Model

Tracking/Predicting Motion

Extended Kalman Filter (EKF) for Tracking and Prediction



$$\mathbf{h}_i^R = (\mathbf{eig}(z_0 - b\cos^{2n}(\alpha)) + \overline{\mathbf{y}}\ )$$

$$\frac{d\hat{\mathbf{m}}}{d\alpha} = \mathbf{eig}(nb\sin(\alpha)\cos(\alpha)^{n-1})$$

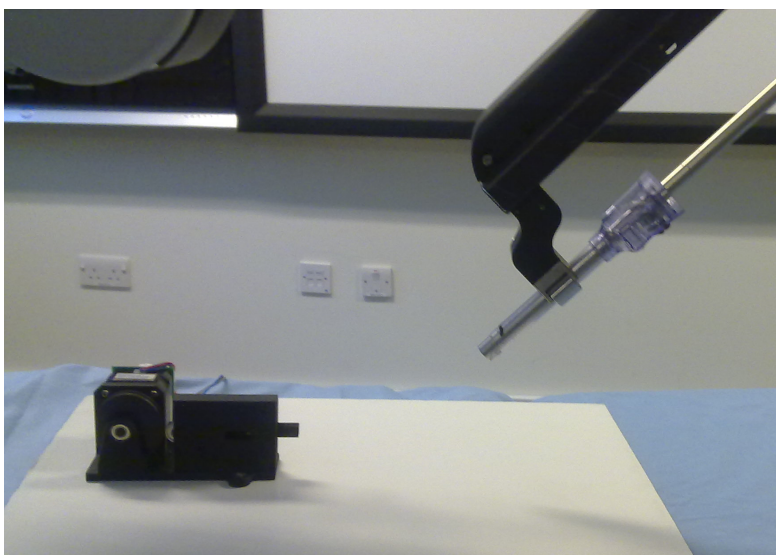
$$\frac{d\hat{\mathbf{m}}}{d\tau} = 0$$

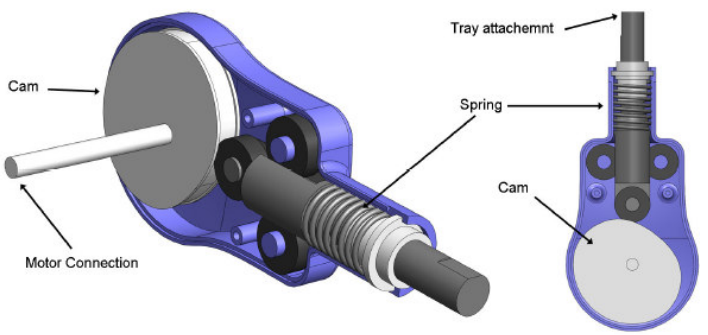
$$\frac{d\hat{\mathbf{m}}}{db} = \mathbf{eig}(\cos(\alpha)^n)$$

$$\frac{d\hat{\mathbf{m}}}{dz_0} = \mathbf{eig}$$

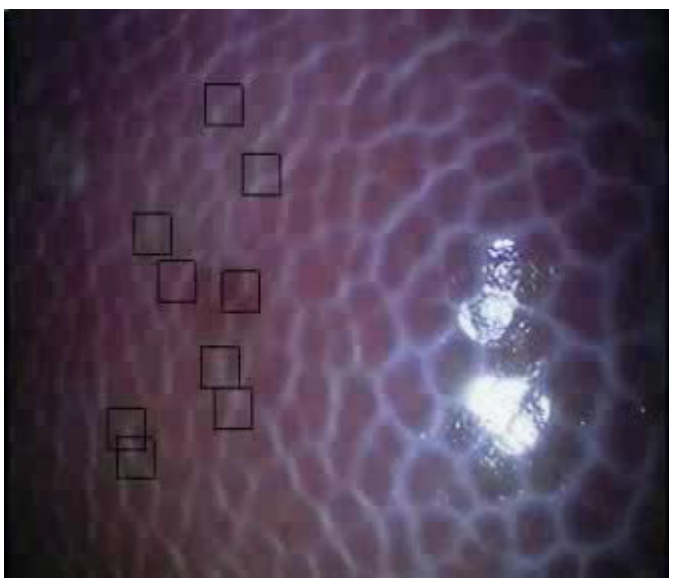
Results

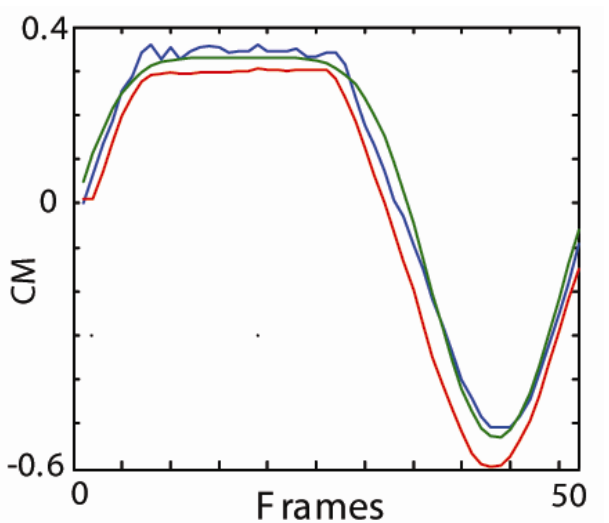
Experimental Set-up for Validation



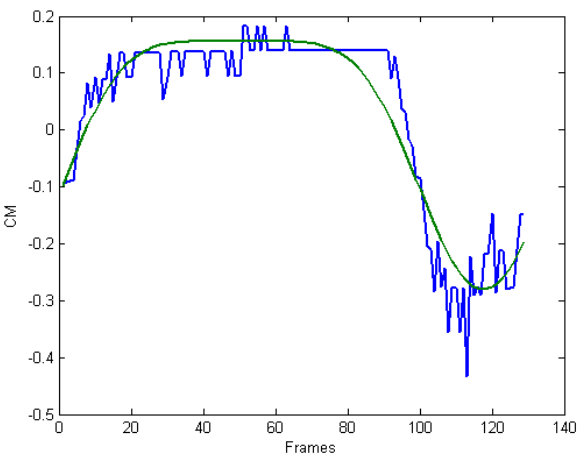


Results *Ex Vivo*

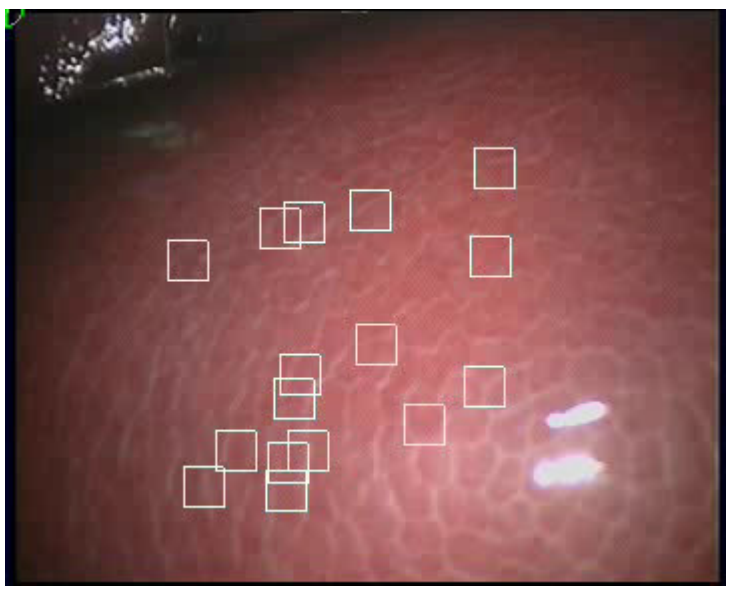


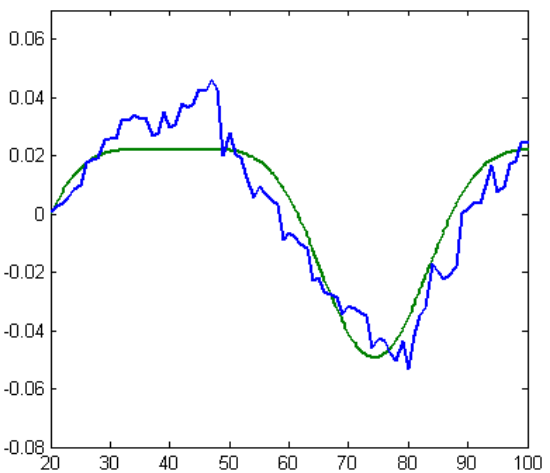


Results *In Vivo*



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