Non-Rigid Monocular SLAM

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Abstract

Navier's equations modeling linear elastic solid deformations are embedded within an Extended Kalman Filter (EKF) to compute a sequential Bayesian estimate for non-rigid monocular Simultaneous Localization And Mapping (SLAM). The scene is represented as a Finite Element Method elastic thin-plate solid, where the discretization nodes are the sparse set of scene points salient in the image. It is assumed a set of Gaussian normalized forces acting on solid nodes to cause incremental scene deformation

Contributions

Recovering simultaneously non-rigid 3D objects and camera trajectory:

- Sequential method at 30 Hz
- No prior data association
- Full-perspective camera
- Dealing with isometric and elastic scene deformations

Future Work

- Exploit biomechanical priors
- Textureless materials: extend to shading and silhouettes
- Exhaustive validation in medial imaging

Acknowledgments

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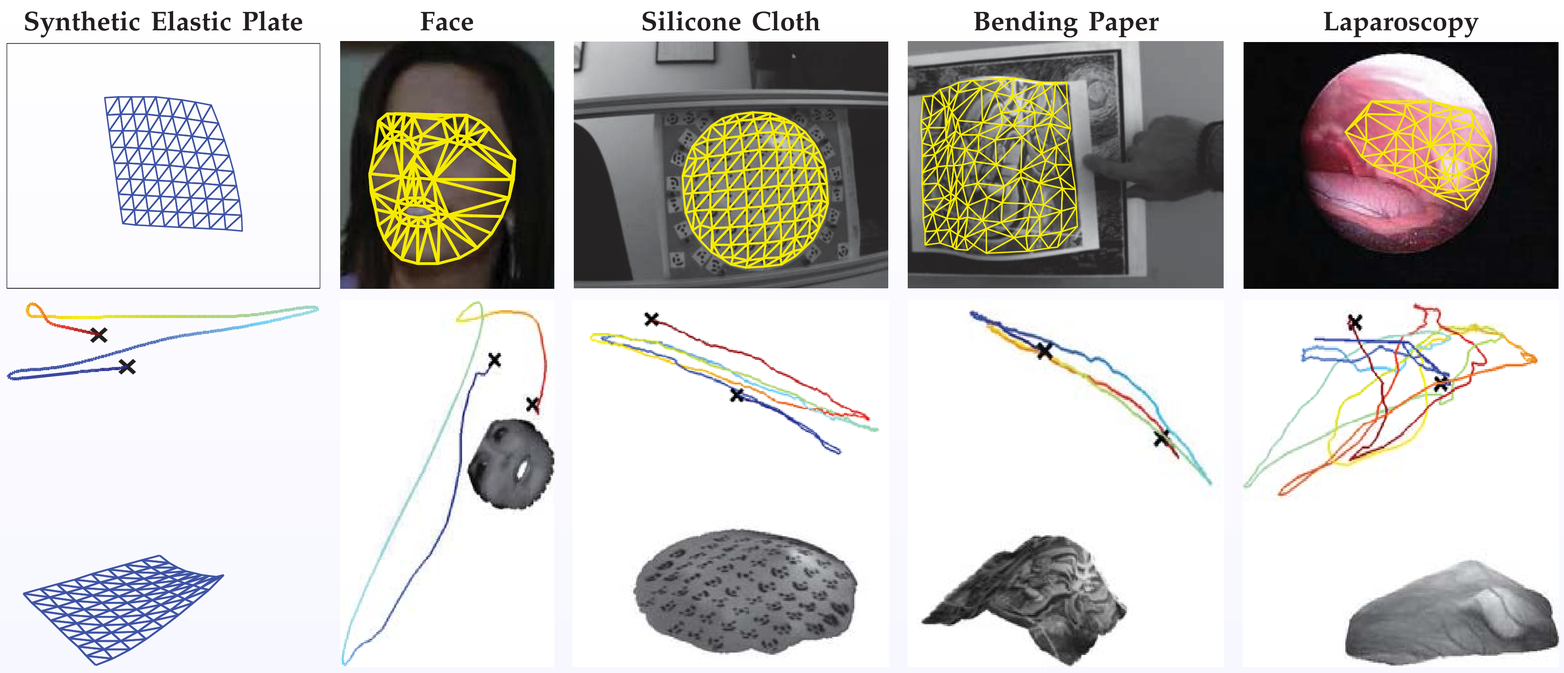
References

[1] Agudo A., Calvo B. and Montiel J. M. M. FEM Models to Code Non-Rigid EKF Monocular SLAM. In *Workshop on Dynamic Shape Capture and Analysis at ICCV 2011*

[2] Agudo A., Calvo B. and Montiel J. M. M. Finite Element based Sequential Bayesian Non-Rigid Structure from Motion. In *IEEE Conference on Computer Vision and Pattern Recognition (CVPR) 2012*

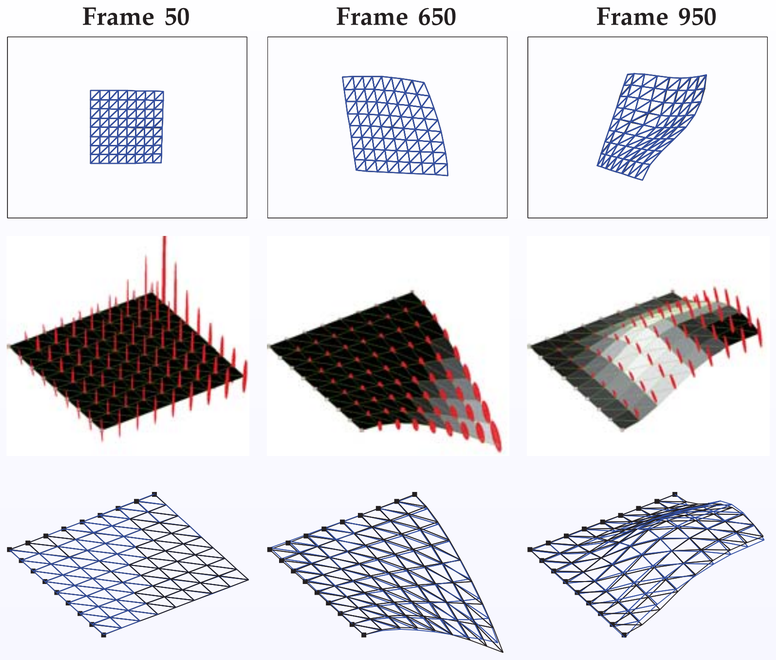
Our Approach



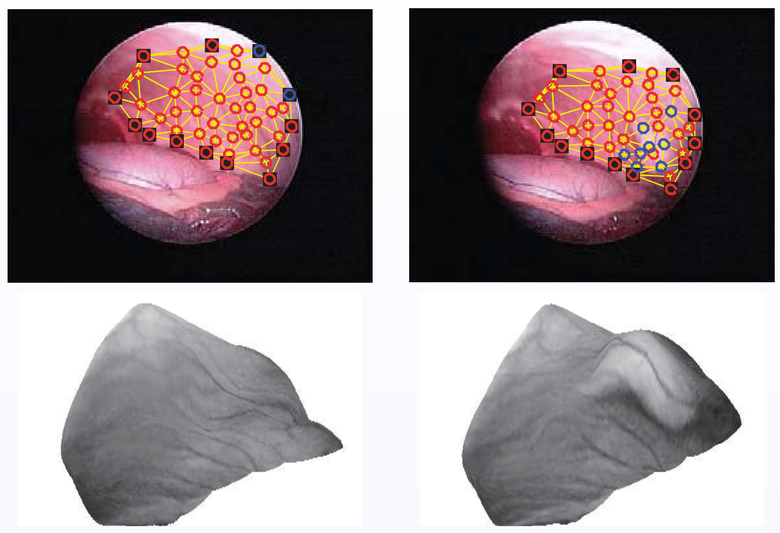
- EKF estimation processing every single frame in an online manner
- Non-rigid scene is modeled using elastic triangular finite elements
- Only normalized forces need to be tuned: account for material properties + external forces. The tuning does not need to be accurate
- Feature extraction and data association is embedded within EKF prediction-update loop
- Smoothness priors to camera motion and non-rigid deformation
- Sequential solution in real-time at 30 fps for small maps, $\mathcal{O}\left(n^3\right)$

Experimental Results

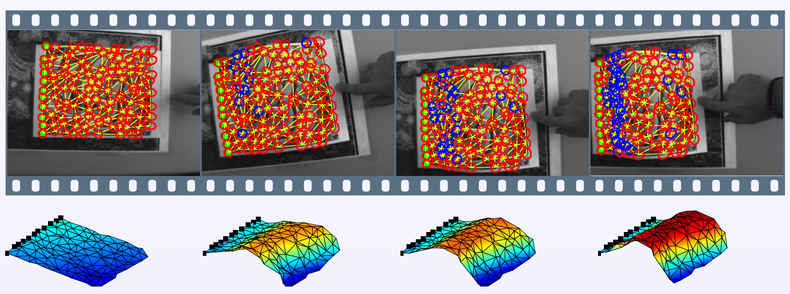
Elastic Synthetic Sequence



Laparoscopy Sequence



Bending Paper Sequence



- Measurements natural landmarks
- Static or moving camera
- Able to handle missing data

Actress Sequence