A Semi-Automatic Markerless Augmented Reality Approach for On-Patient Volumetric Medical Data Visualization

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AGENDA

- Introduction;
- On-Patient Volumetric Medical Data Visualization;
- Volume Rendering;
- Results and Discussion;
- Conclusions and Future Work;

INTRODUCTION

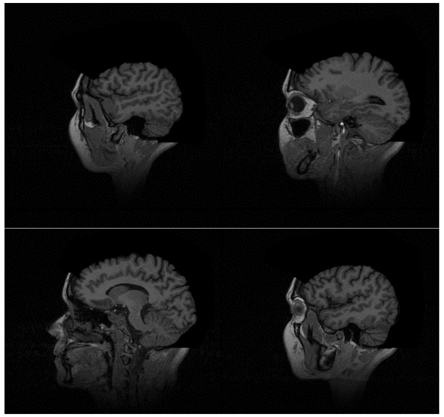
Context

- Problem: On-Patient Medical Data Visualization

3D Data

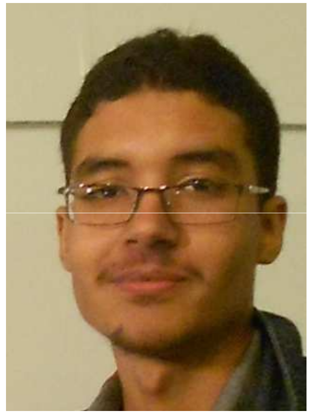
shown as

2D Slices



which must be composed on

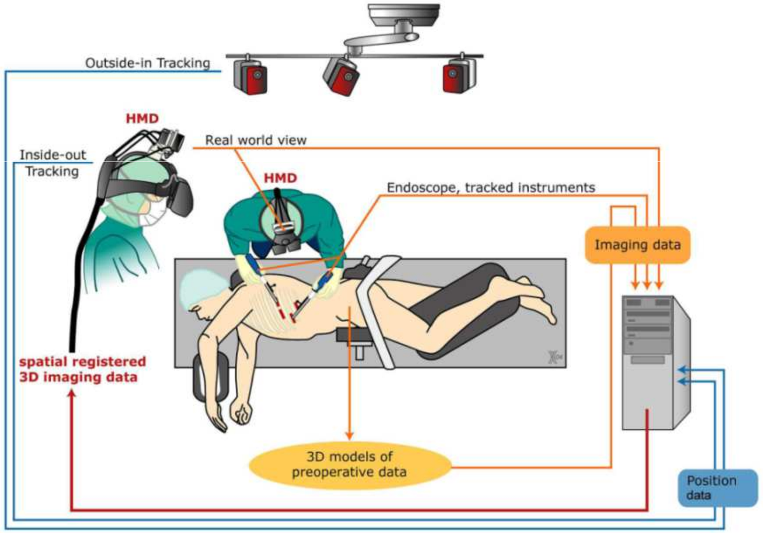
“Patient”



- Solution: Augmented Reality

CURRENT SCENARIO

- This issue is addressed by some medical AR systems.



Contribution

- Our main contribution is the evaluation of the applicability of standard volume rendering techniques in a markerless AR environment in real-time;

On-Patient Volumetric Medical Data Visualization

ENVIRONMENT SETUP

- The proposed approach is based on a RGB-D sensor and a computer with GPU:
  - RGB-D calibration;

Vertex and Normal map Generation

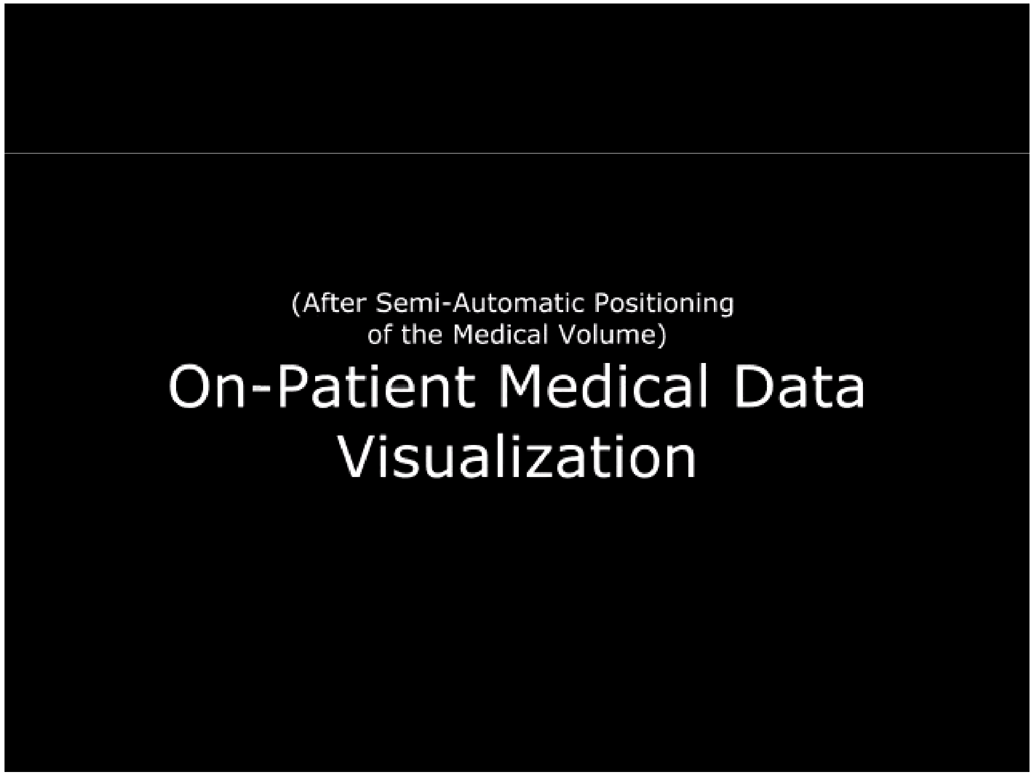
- Bilateral filtering;
- Depth background segmentation;
- Vertex Map = Depth Map * K (intrinsic calibration matrix);
- Normal Map = eigenvector correspondent to the smallest eigenvalue from a covariance matrix computed in the vertex map;

3D Reference Model Reconstruction

- Segmentation of the patient's ROI (region of interest):
  - Viola-Jones face detector;
- Detected window fixing;
- KinectFusion algorithm;

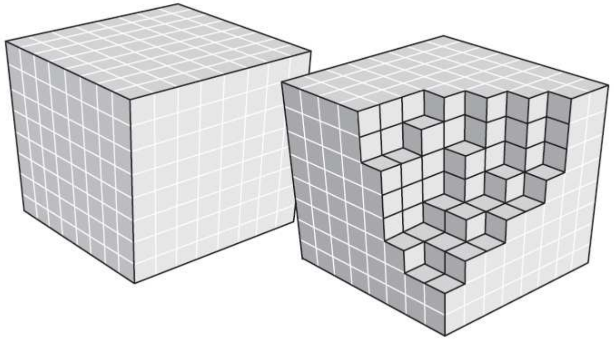
Live Tracking

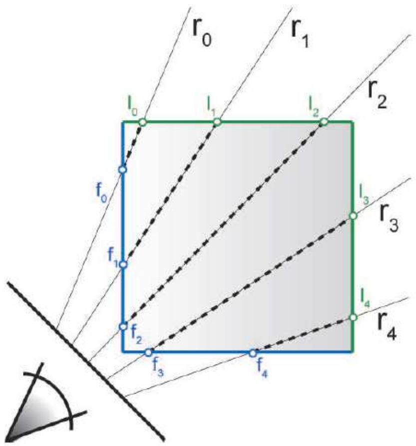
- Iterative Closest Point (ICP);
- Robust Real-Time Face Tracking;



Volume Rendering

VOLUMETRIC DATA REPRESENTATION





TECHNIQUES EMPLOYED

- To improve image quality:
  - Stochastic Jittering;
  - GPU-Based Tri-cubic Filtering + GPU Pre-filter for Accurate Tri-cubic Filtering;
- To improve performance:
  - Empty-Space Skipping of Non-Visible Voxels;
  - Early Ray Termination;
  - Adaptive Sampling;

Techniques Employed

- Additional features:
  - Pre-integrated Transfer Functions;
  - Blinn-Phong shading with on-the-fly gradient computation;
  - Non-polygonal iso-surface rendering;

INTEGRATION INTO A MAR ENVIRONMENT

- Blending:

$$I_{final} = \beta * I_{real} + (1 - \beta) * I_{medical}$$

- To solve occlusion, the depth maps of the 3D reference object reconstructed previously and the 3D object coming from the sensor's live stream are compared.

Results and Discussion

Experimental Setup

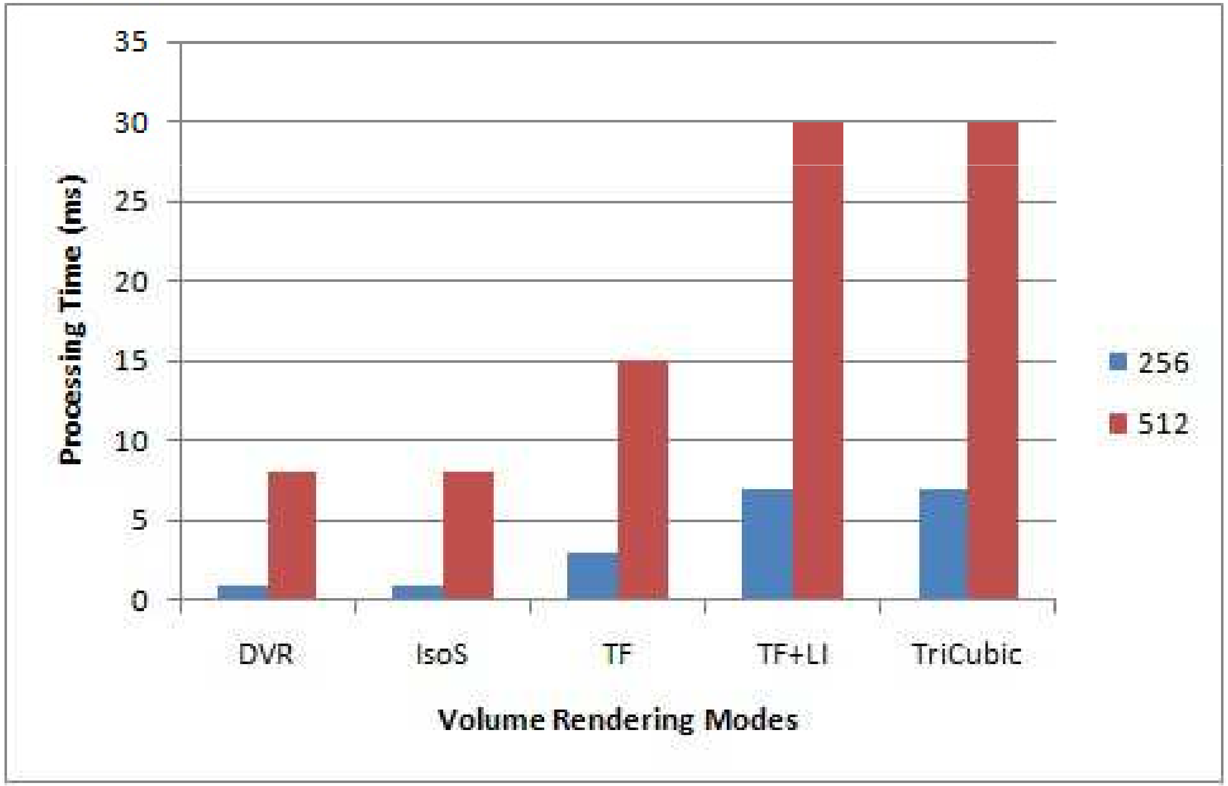
- Our approach is evaluated in a scenario where the patient's head is augmented with a generic CT volumetric dataset of a head.
- The medical dataset used is a CT volumetric data of a head of two different resolutions: 256^3 e 512^3;
- The reference human face was reconstructed with the KinectFusion using a grid with volume size of 70x70x140cm and resolutions of: 256^3 e 512^3;

EVALUATION

- The Kinect sensors provide data at 30 FPS;
- 3D reconstruction takes 23 ms per frame (43 FPS);
- 3D reference model requires ~15 seconds to be completed;
- User positioning the medical volume takes ~10 seconds;
- MAR live tracking takes 21 ms per frame (47 FPS);
- Our approach never dropped below 29 FPS independent of the volume resolution used (on the simplest volume rendering mode);

EVALUATION

- Average processing time for various volume rendering modes



Conclusions and Future Work

Conclusions

- We have presented a marker-free AR approach for on-patient volumetric medical data visualization;
- We have shown that, with a typical volume size, the proposed algorithm is capable to run in real-time;
- In addition, our approach supports occlusion;

Future Work

- Accuracy evaluation;
- Focus + context visualization;
- Noise reduction;

ACKNOWLEDGMENTS

- We are grateful to the PCL project for providing the open-source implementation of the KinectFusion algorithm;
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Thank you!

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