A MARKERLESS AUGMENTED REALITY ENVIRONMENT FOR MEDICAL DATA VISUALIZATION

Márcio C. F. Macedo (UFBA)
Caio S. B. Almeida (UFBA)
Antonio C. S. Souza (UFBA/IFBA)
Josildo P. Silva (UFBA/IFBA)
Antonio L. Apolinário Jr. (UFBA)
Gilson A. Giraldi (LNCC)

Mestrado/Doutorado em Ciência da Computação - UFBA
LABRASOFT – IFBA
Coordenação de Ciência da Computação - LNCC

AGENDA

- Introduction;
- Technique Overview;
- Medical Volume Rendering;
- Results and Discussion;
- Conclusions and Future Work;

INTRODUCTION

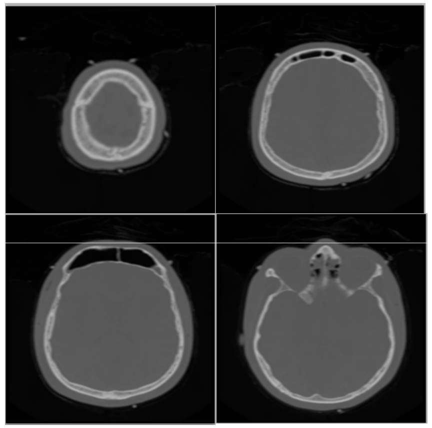
Context

- Problem: On-Patient Medical Data Visualization

3D Data

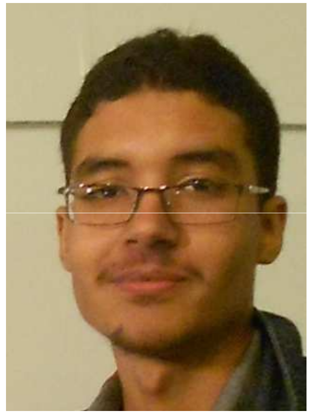
shown as

2D Slices



which must be composed on

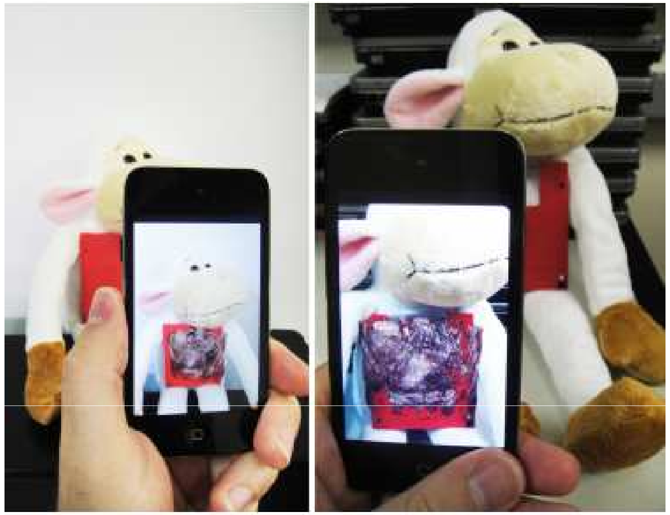
"Patient"



- Solution: Augmented Reality

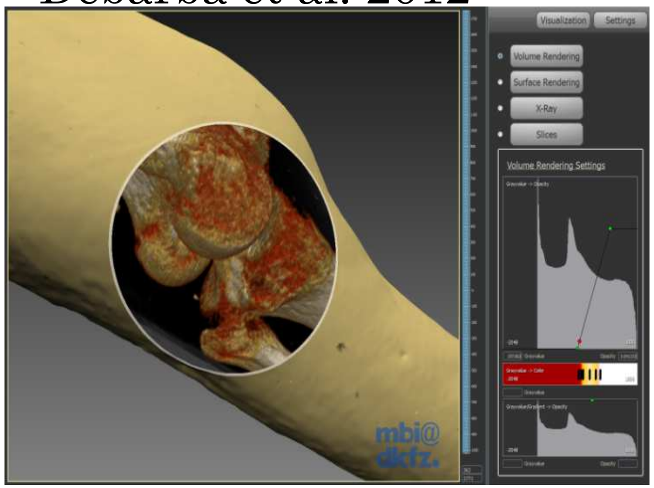
F+C Visualization

CURRENT SCENARIO

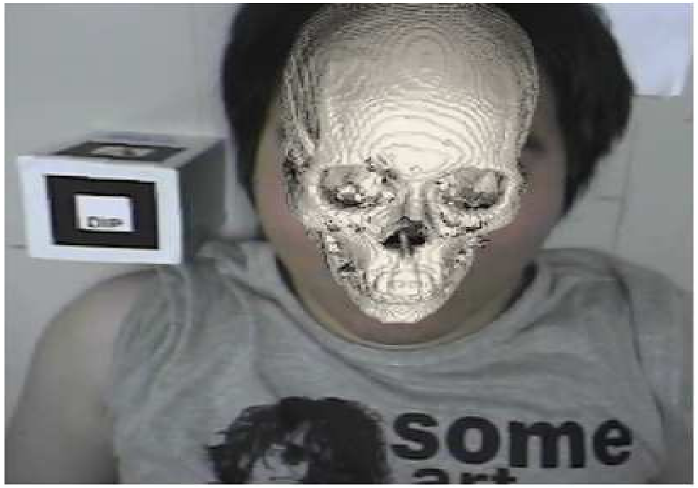


Debarba et al. 2012

Kutter et al. 2008



Maier-Hein et al. 2011



Lee et al. 2012

CONTRIBUTION

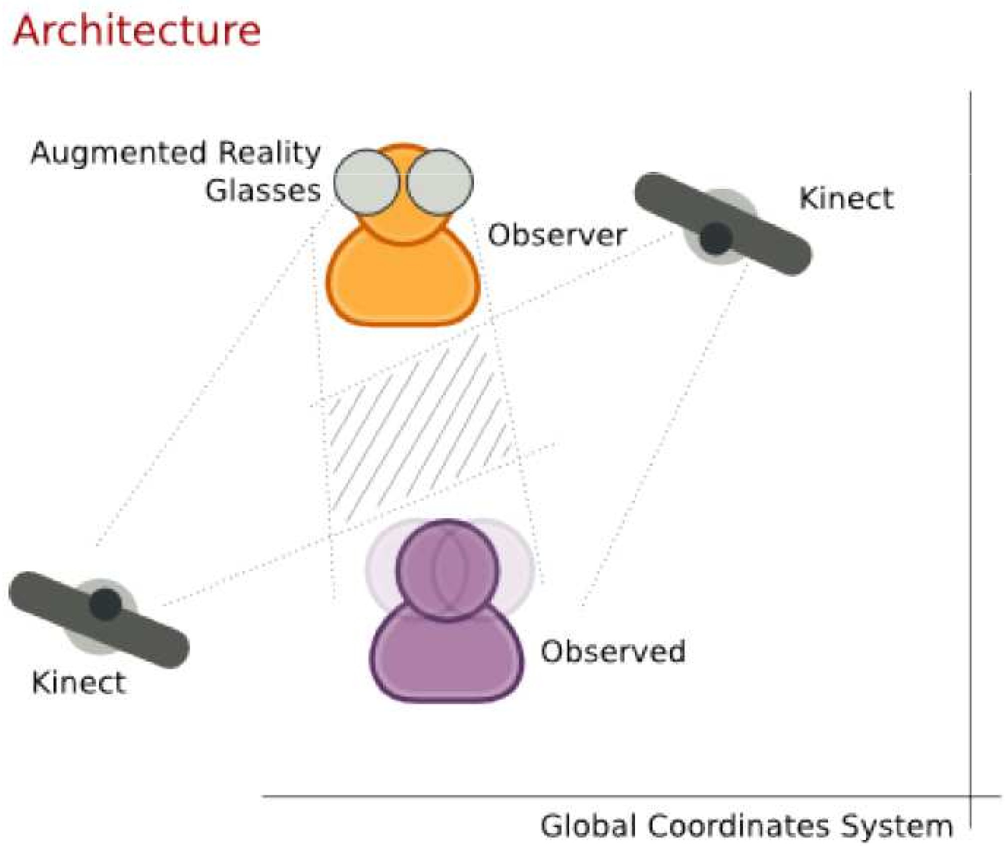
- Our main contribution is the proposition of a real-time markerless AR solution with support to:
  - On-Patient Medical Data Visualization by Volume Rendering;
  - Non-Rigid Registration;
  - Low-Cost Hardware Components;

- Motivation: Surgery simulation and prediction by craniofacial specialists;

Technique Overview

COMPUTATIONAL INFRASTRUCTURE ENVIRONMENT

- The computational infrastructure requires two RGB-D sensors and an AR glasses;

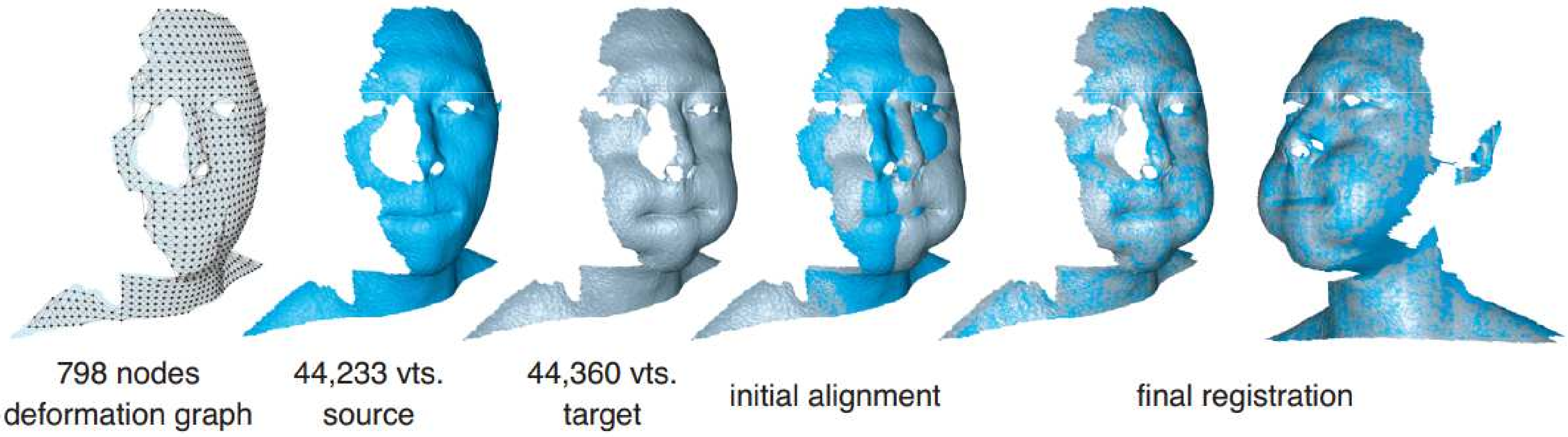


Markerless Tracking

- Markerless tracking is done based on a 3D reference model reconstructed from the patient's region of interest.

Deformation Model

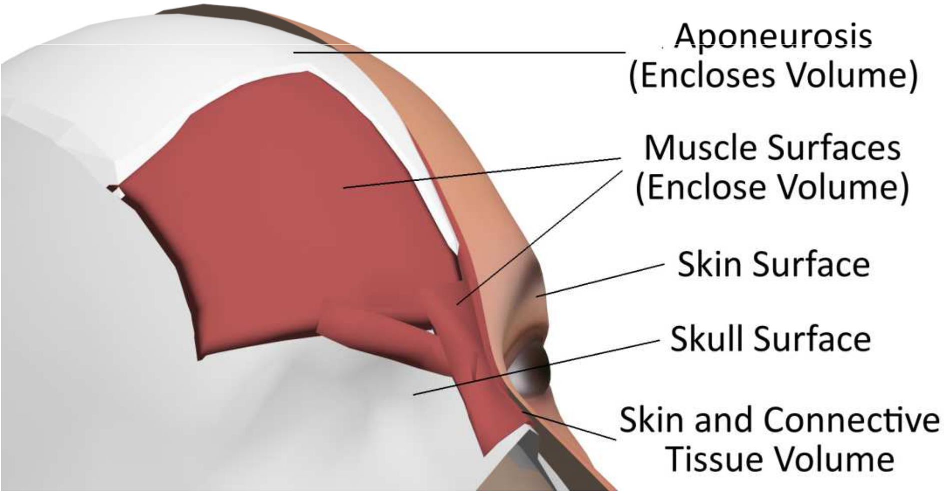
- Fast non-rigid registration is done by building a graph on the 3D reference model.

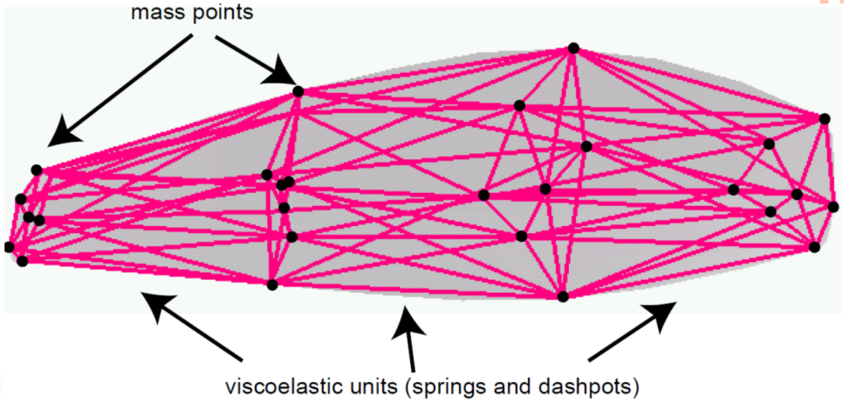


Li et al. 2009. Global Correspondence Optimization for Non-Rigid Registration of Depth Scans

Soft Tissue Deformation

- For surgery simulation, patient's soft tissue deformation can be simulated by using Mass Spring models.

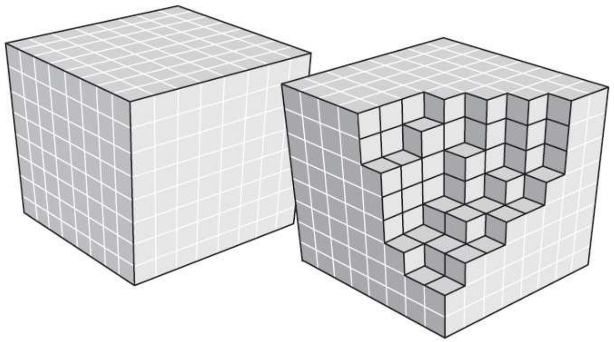


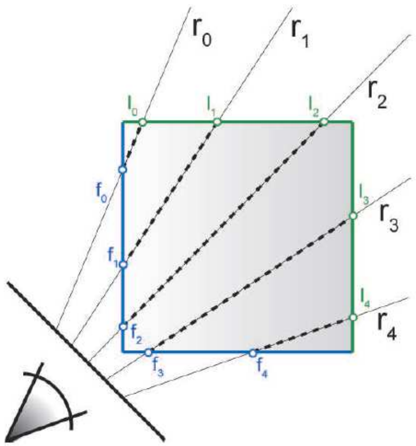


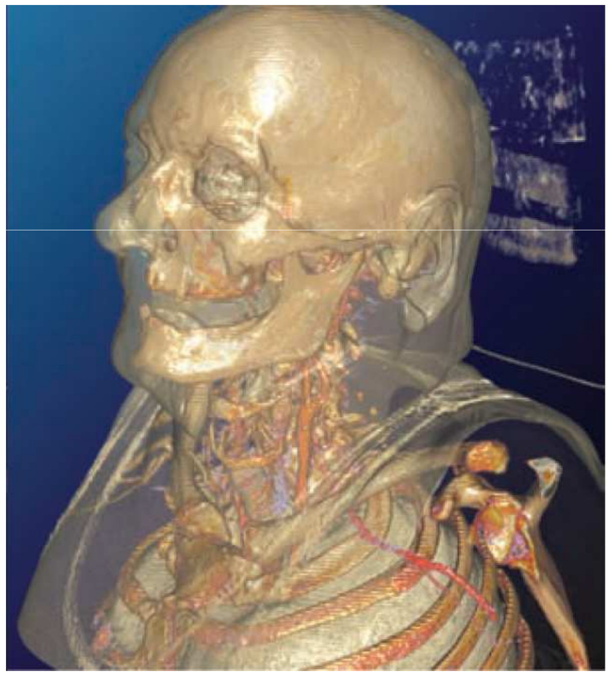
Warburton e Maddock (2013). Creating Finite Element Models of Facial Soft Tissue

Victor Ng-Thow-Hing (2001). Anatomically-Based Models for Physical and Geometric Reconstruction of Humans and Other Animals

Medical Volume Rendering



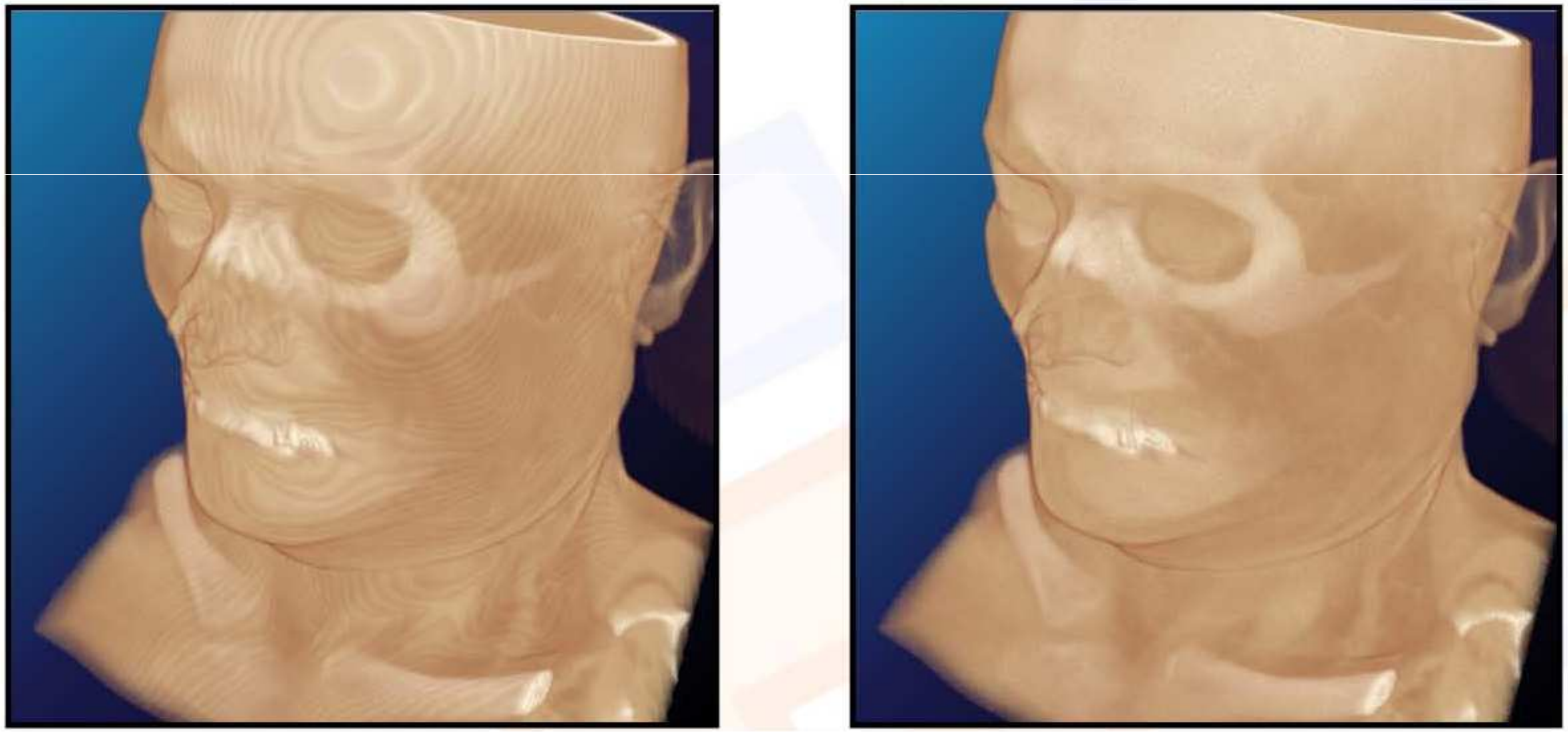




Hadwiger et al. 2006

TECHNIQUES EMPLOYED

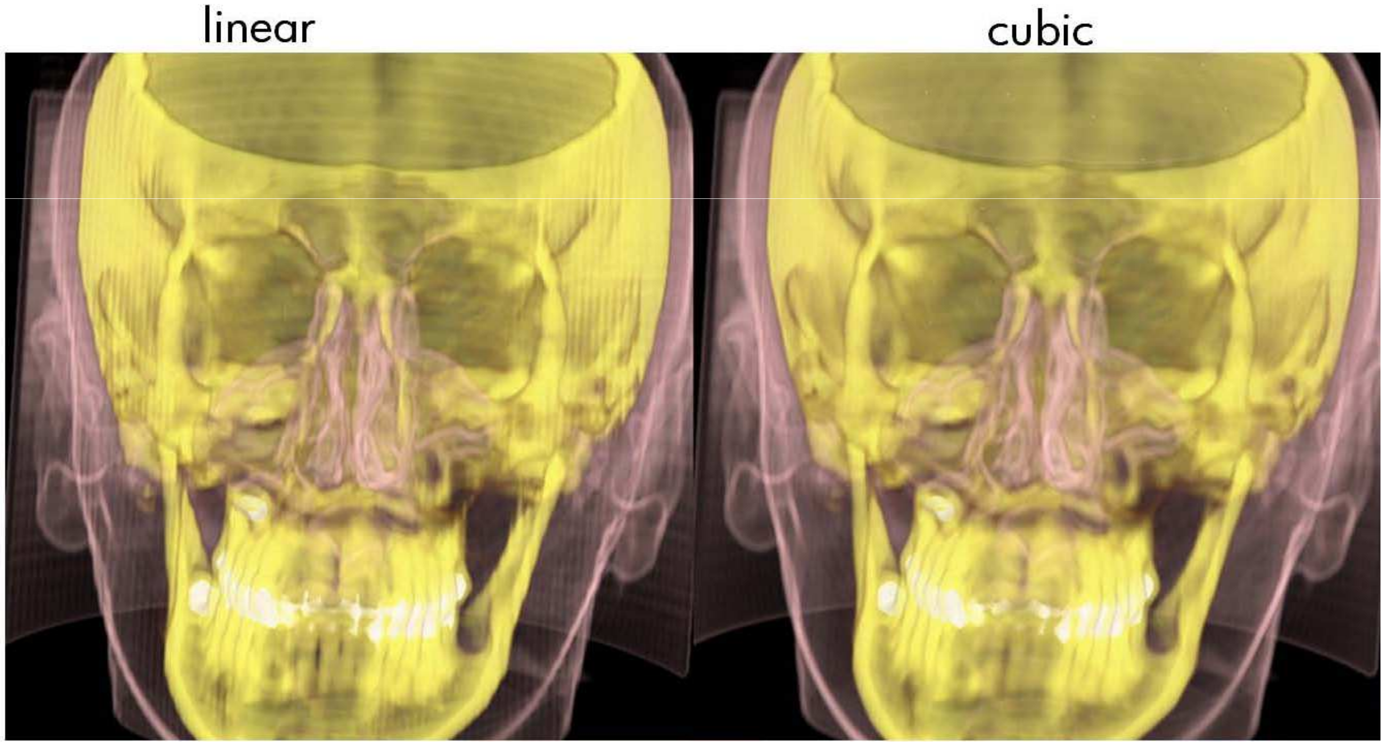
- To improve image quality:
  - Stochastic Jittering;



Hadwiger et al. 2006

Techniques Employed

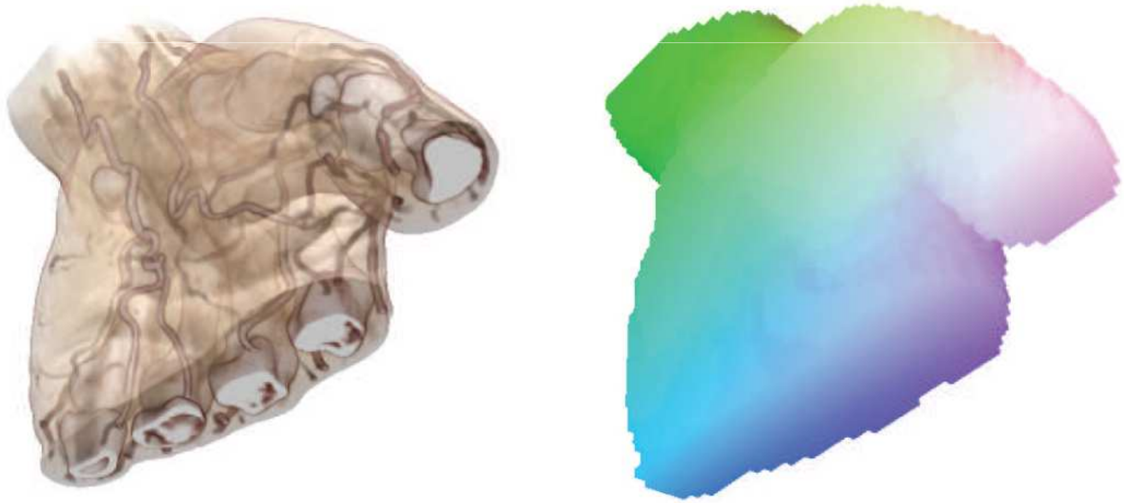
- To improve image quality:
  - Tricubic Interpolation;



Hadwiger et al. 2006

Techniques Employed

- To improve performance:
  - Empty-Space Skipping of Non-Visible Voxels;



Hadwiger et al. 2009

TECHNIQUES EMPLOYED

- To improve performance:
  - Adaptive Sampling;

Hadwiger et al. 2009

Techniques Employed

- Additional features:
  - Pre-integrated Transfer Functions;

Techniques Employed

- Additional features:
  - Pre-integrated Transfer Functions;
  - Blinn-Phong shading;

TECHNIQUES EMPLOYED

- Additional features:
  - Pre-integrated Transfer Functions;
  - Blinn-Phong shading;
  - Non-polygonal iso-surface rendering;

INTEGRATION INTO A MAR ENVIRONMENT

- Blending:

$$I_{final} = ß * I_{real} + (1 – ß) * I_{medical}$$

- The contribution of each image (ß per pixel) is dynamically defined by using focus + context visualization;
- 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

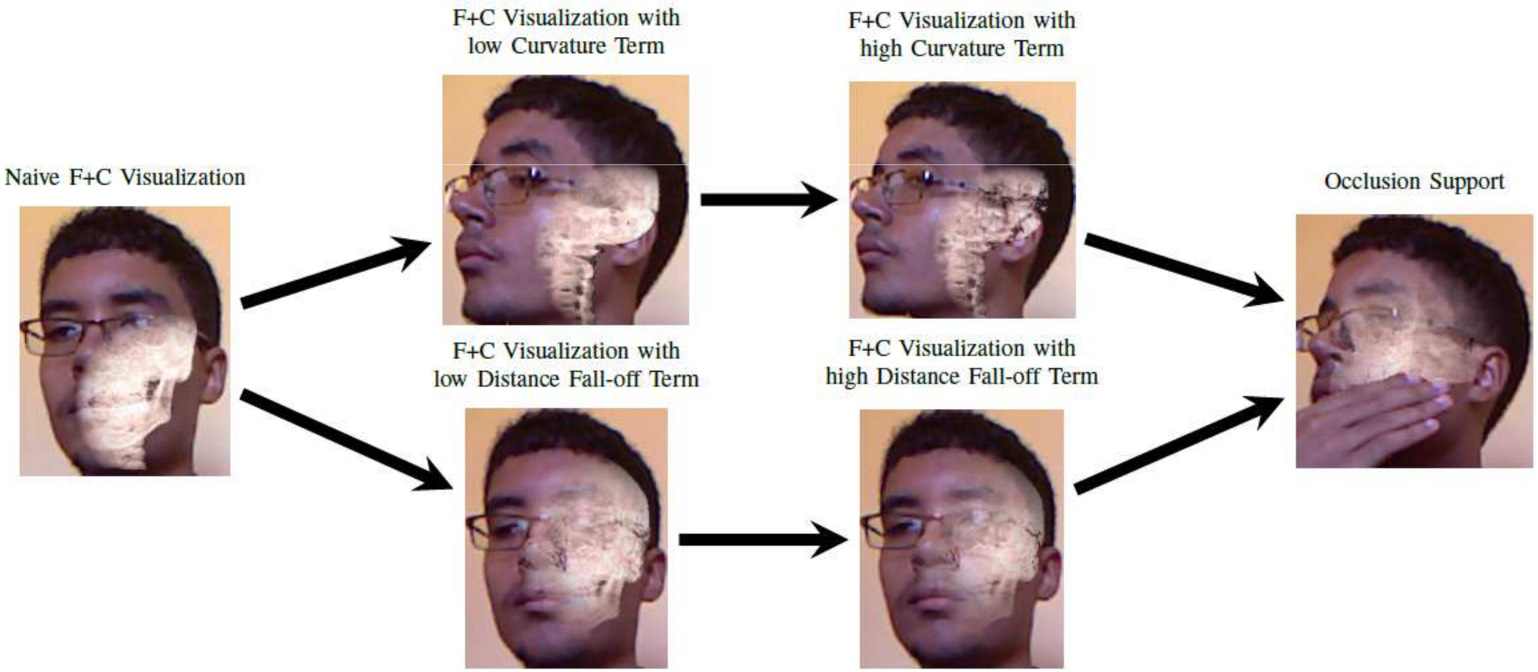
- The evaluation of the proposed approach is conducted in a scenario where the patient's head is augmented with a generic CT volumetric dataset of a head;
- The deformation model presented is evaluated in terms of performance and accuracy in a real situation;
- The medical dataset used is the CT volumetric data of the Visible Male's head of resolution 128 x 256 x 256;

Evaluation

- The 3D reference model reconstruction runs in 30 FPS;
- The on-patient medical data focus + context visualization based on markerless tracking runs in 20 FPS;

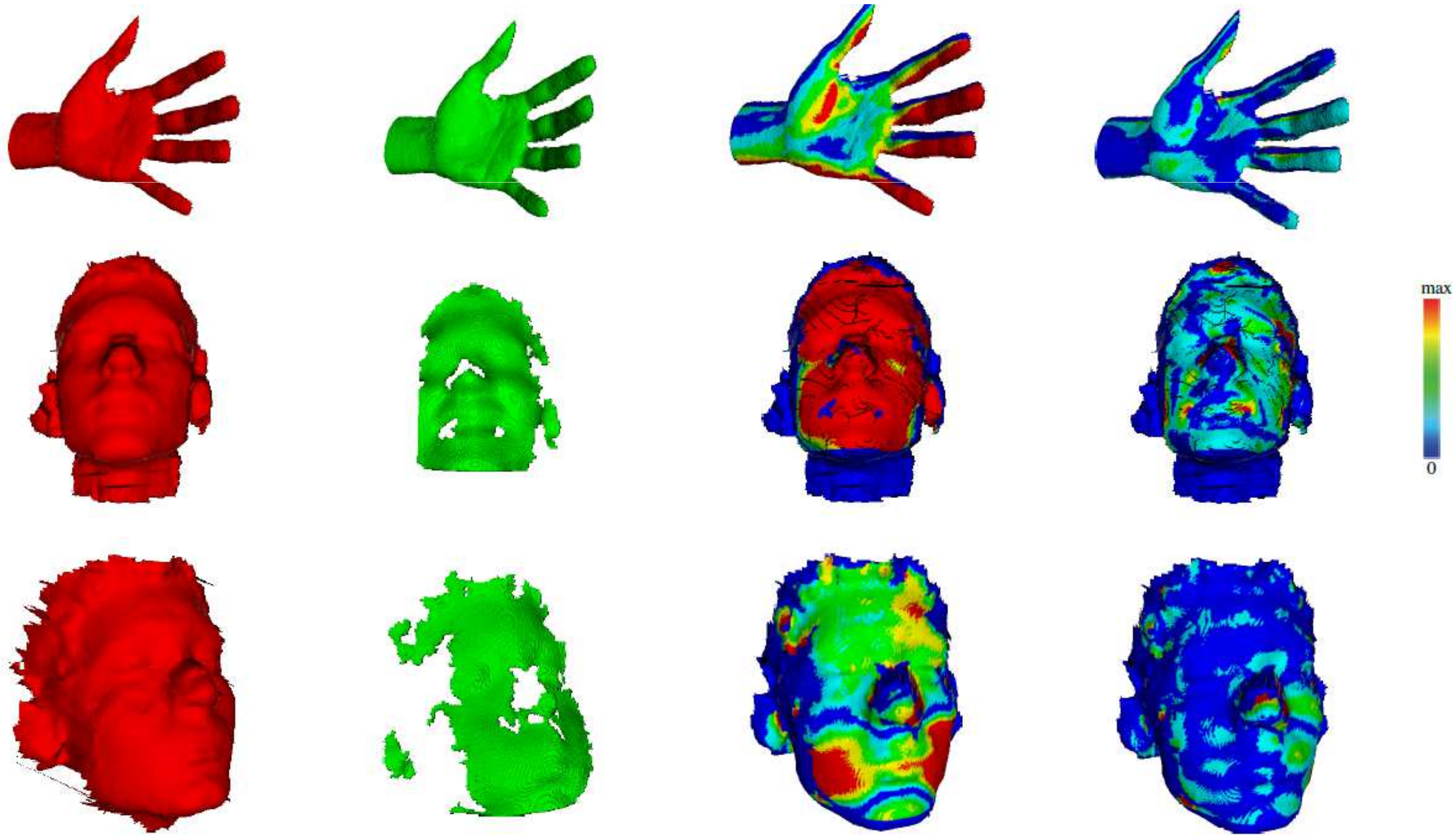
Evaluation

- Focus+context visualization enhances the human perception of the scene;



EVALUATION

- The deformation model was tested on a typical dataset captured by the Kinect sensor.



EVALUATION

- The computational infrastructure is almost finished. Currently, it has been integrated with the on-patient medical data visualization;
- Soft tissue deformation is not incorporated yet into our computational system. However, the first simulations show encouraging results.

CONCLUSIONS AND FUTURE WORK

Conclusions

- We have presented a multiview, marker-free augmented reality approach for on-patient volumetric medical data visualization;
- Markerless tracking runs in real-time;
- An algorithm for fast non-rigid registration of surfaces using GPU was presented;

Future work

- Improve realism by illumination;
- Multi-frame non-rigid registration;
- Accuracy validation;

ACKNOWLEDGMENTS

- We would like to acknowledge the support of FAPESB, CAPES and CNPq for this work. Also, we are grateful to the PCL project for providing the open-source implementation of the KinectFusion algorithm.

Thank you!

Márcio C. F. Macedo (marciocfmacedo@gmail.com)
Caio S. B. Almeida (caiosba@dcc.ufba.br)
Antonio C. S. Souza (antoniocarlos@ifba.edu.br)
Josildo P. Silva (josildo@dcc.ufba.br)
Antônio L. Apolinário Jr. (apolinario@dcc.ufba.br)
Gilson A. Giraldi (gilson@lncc.br)