Generation of Personalized Computational Phantoms Using Only Patient Metadata

Xia Zhong[1], Norbert Strobel[2], James Chester Sanders[1], Markus Kowarschik[2], Rebecca Fahrig[2], Andreas Maier[1,3]

[1] *Pattern Recognition Lab, Friedrich-Alexander University Erlangen-Nuremberg, Germany*

[2] *Siemens Healthcare GmbH, Erlangen, Germany*

[3] *Erlangen Graduate School in Advanced Optical Technologies (SAOT), Friedrich-Alexander University Erlangen-Nuremberg, Germany*

Introduction

- Computational phantoms have found widespread use for
  - Optimization of acquisition settings and workflow for diagnostic CT [1]
  - Skin dose monitoring and positioning of interventional X-ray system [2]
- Existing approaches include template deformation using
  - Scaling factors from anatomical measurement [3]
  - Scaling factors from body mass index [4]
- We generate personalized computational phantoms including internal organs using **a learning based approach**

Materials and Methods

- **Training data**
  - Patient surface models: avatar database (standing)
  - Segmented 3D diagnostic scans: Visceral Anatomy3 (supine) [5]
- **Internal body cavities**
  - Minimal convex hull around selected organs
  - Modeled individually, e.g. for thorax and abdomen
- **Patient-dependent boundary determination** (Fig. 1a)
  - Learn a joint subspace linking patient metadata with patient surface model in standing pose based on the avatar database
  - Estimate for each CT scan a surface model using associated metadata and align the estimate with segmented surface
  - Calculate gravity deformation field to adjust the estimates from standing to supine pose
  - Learn a joint subspace linking patient metadata with surface models in standing pose, gravity deformation fields, and cavities model.
- **Internal organ model filling** (Fig. 1b)
  - Estimate internal cavity based on associated patient metadata
  - Select N closest datasets from database matching metadata
  - Non-rigid registration between estimated and selected cavities
  - Propagate the segmentation of selected ground truth to the estimates
  - Merge and extract segmentation using popular vote

Results and Discussion

- Evaluation data
  - Validation dataset: Visiable Human [6] and Golem [7].
  - Test dataset: 9 full-body CTs
- Organ volume estimation error: 30.6 $\pm$ 15.0 % (Fig. 2a)
- Mean center of gravity error over all organs: 23.5 $\pm$ 8.3 mm (Fig. 2b)
- High inter-patient variation for organ mass and dimensions
- Planned: convert computational model to attenuation maps and evaluate for attenuation correction

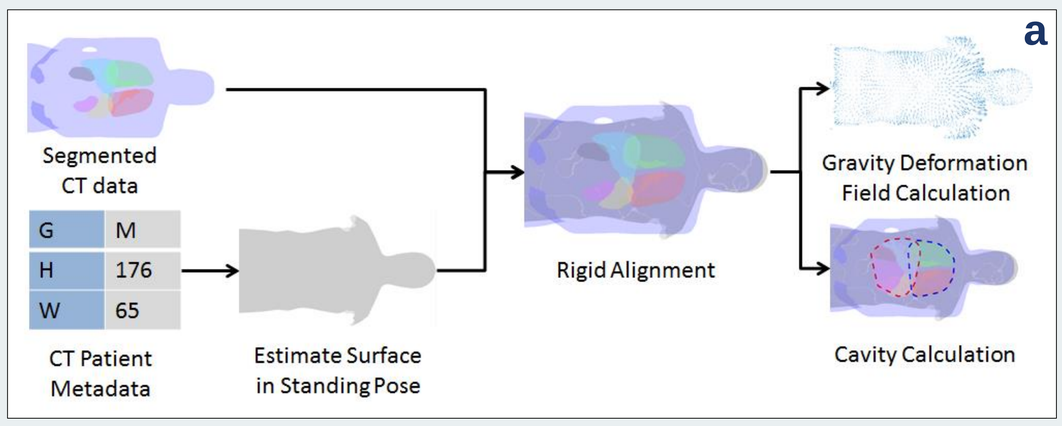
Conclusions

- We proposed a learning based method to estimate personalized computational phantoms (including organs) using patient metadata only.
- Good accuracy for organ localization

Contact

✉ xia.zhong@fau.de

www5.cs.fau.de/~zhong



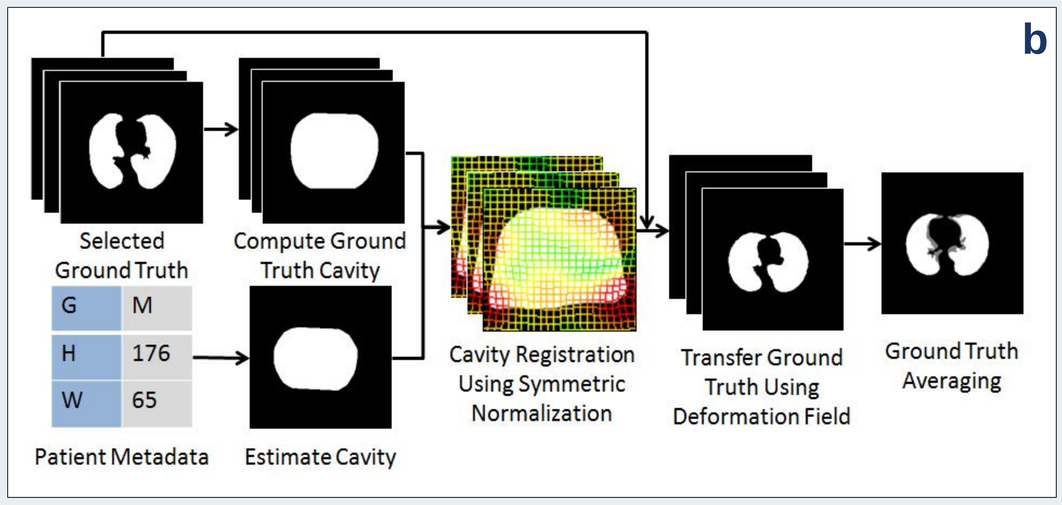
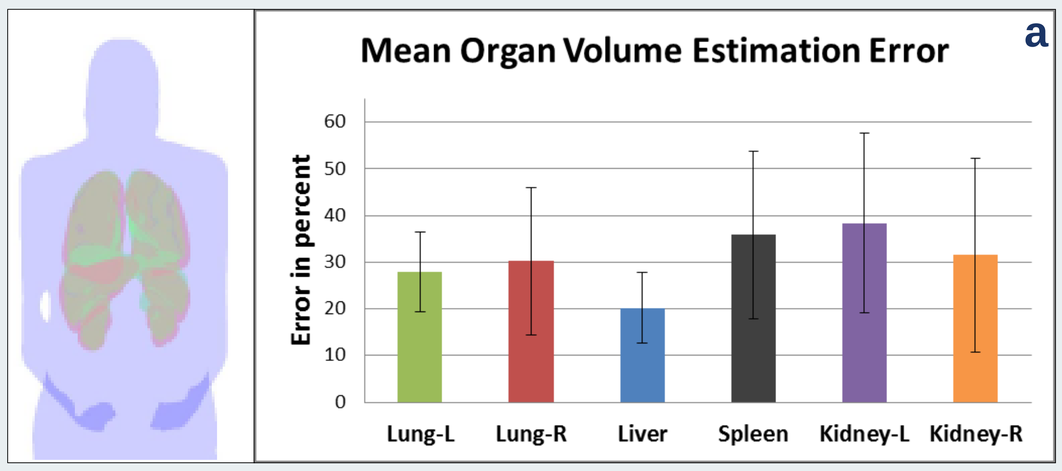


Figure 1: Workflow for generation of personalized patient model. (**a**) Estimation of gravity deformation field and cavities. (**b**) Internal organ estimation via cavity determination.



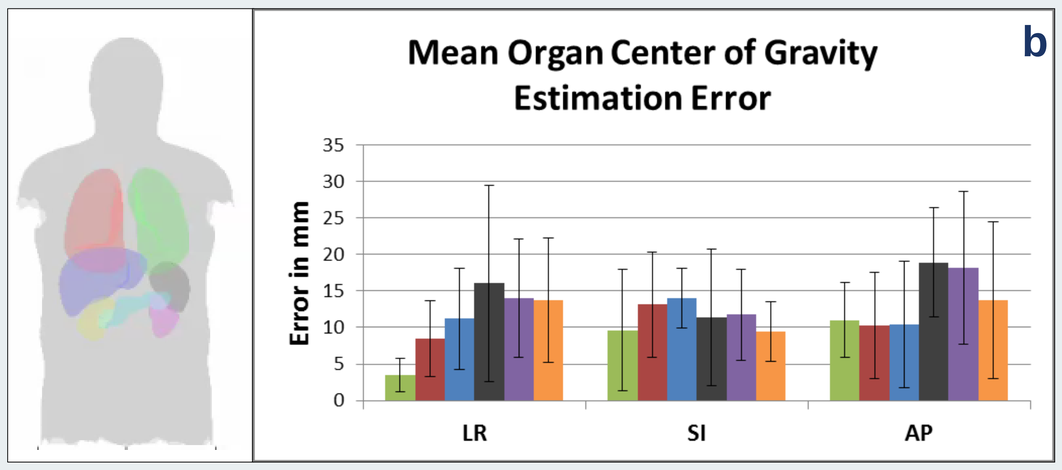


Figure 2: Evaluation results of proposed algorithm. **(a)** Internal organs of the Visible Human (green) and estimated corresponding model (red) overlaid in AP view (left). Organ volume estimation errors (right). **(b)** An example of personalized computational phantom estimate (left). Mean organ center of gravity displacement error from evaluation dataset (right).

References

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