3-D PRINTING BASED PRODUCTION OF HEAD AND NECK MASKS FOR RADIATION THERAPY USING CT VOLUME DATA: A FULLY AUTOMATIC FRAMEWORK

Shuqing Chen[1,2], Yanye Lu[1,3], Christian Hopfgartner[4], Michael Sühling[2], Stefan Steidl[1], Joachim Hornegger[1], Andreas Maier[1]

[1] Pattern Recognition Lab, Department of Computer Science, Friedrich-Alexander University Erlangen-Nuremberg, Erlangen, Germany
[2] Research & Development, Computed Tomography & Radiation Oncology, Imaging & Therapy Systems, Siemens Healthcare GmbH, Forchheim, Germany
[3] Department of Biomedical Engineering, Peking University, Beijing, China
[4] ISO Software Systeme GmbH, Nuremberg, Germany

FAU FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG TECHNISCHE FAKULTÄT

SIEMENS

Introduction

A fully automatic framework to construct and produce immobilization masks for radiation therapy of head/neck:

- Using 3-D printing technology along with image analysis approaches based on 3-D CT image data
- Including facial model construction and facial features recognition with atlas registration[1]

Methods

The general procedure *(Figure 1)* consists three main aspects:

- Construction of a facial statistical shape model[2] and a facial appearance model[3].
- Surface extraction of the anatomy regions of interest of a new image.
  - A variant of the chain code method[4] is applied for each slice to extract and fill the object contours.
  - A shape descriptor is used to classify and remove head support tools and instruments.
- Automatic facial features recognition using atlas registration.
  - PCA is applied to analyse the head major coordinates and to calculate an initial pose.
  - The active shape model[2] is applied to refine the alignment to achieve the optimum.
  - Multiple start poses of head are applied to enhance the accuracy of the registration.

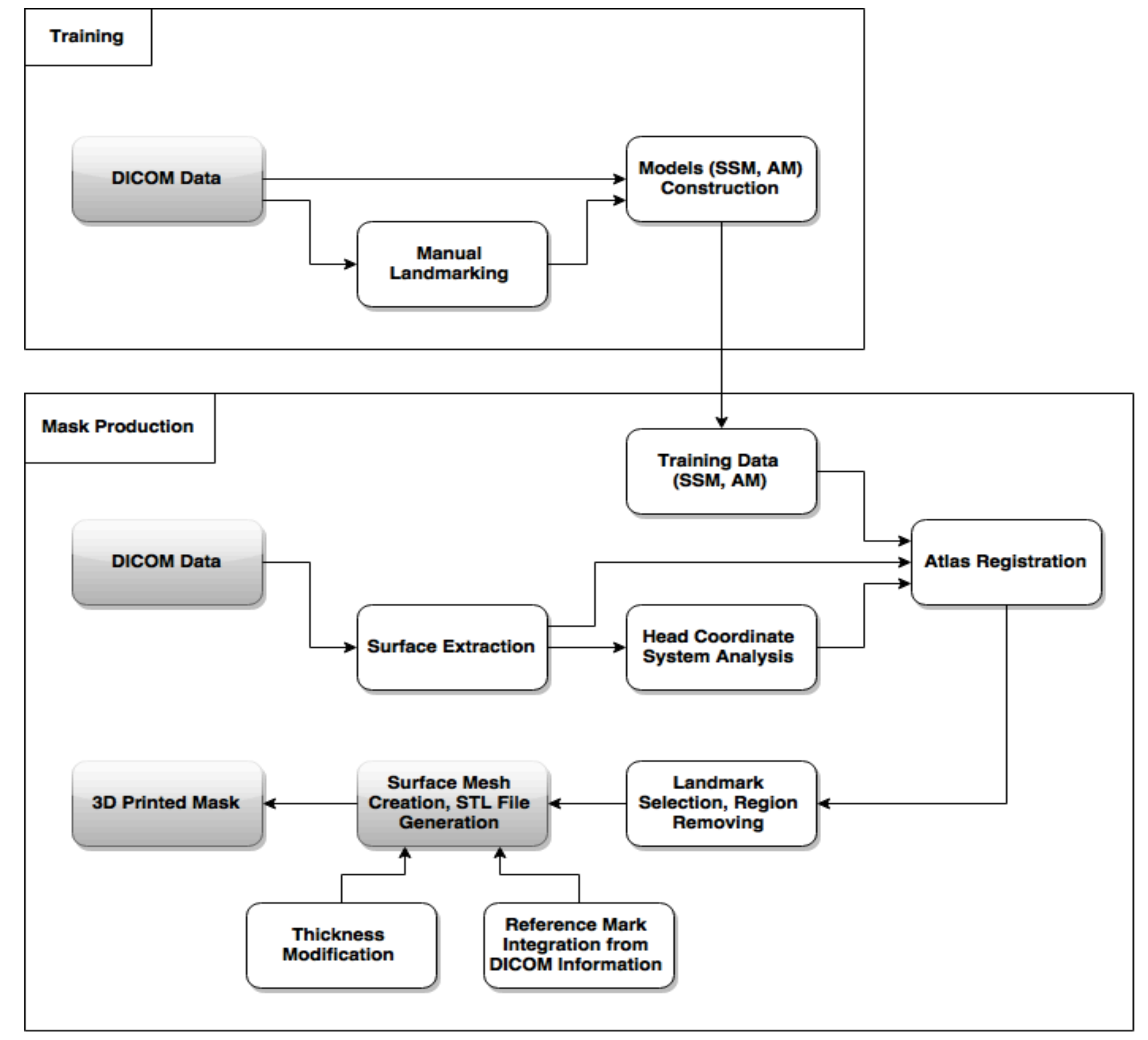

Figure 1: The general procedure flow chart. SSM: Statistical Shape Model. AM: Appearance Model.

Results and Evaluation

Result of the procedure

A surface mesh *(Figure 2 left)* is generated for 3-D printing, with the automatic removal of facial features.

Evaluation of surface extraction

10 volume images with manual segmentation from anonymized patients are used to evaluate the segmentation accuracy and the accuracy of facial feature recognition. The evaluation results *(Figure 3 left)* show that the segmentation method has a very low mean error of **0.4mm**, which enables a very high accurate mask production.

Evaluation of facial feature recognition

A cross validation test has been made based on these 10 data sets. For each test, the test data is aligned with the statistical shape model generated by the rest datasets. The Euclidean distance between aligned landmarks and their corresponding manual annotations is defined as registration error. The mean error of cross validation trails *(Figure 3 right)* is 11.78mm.

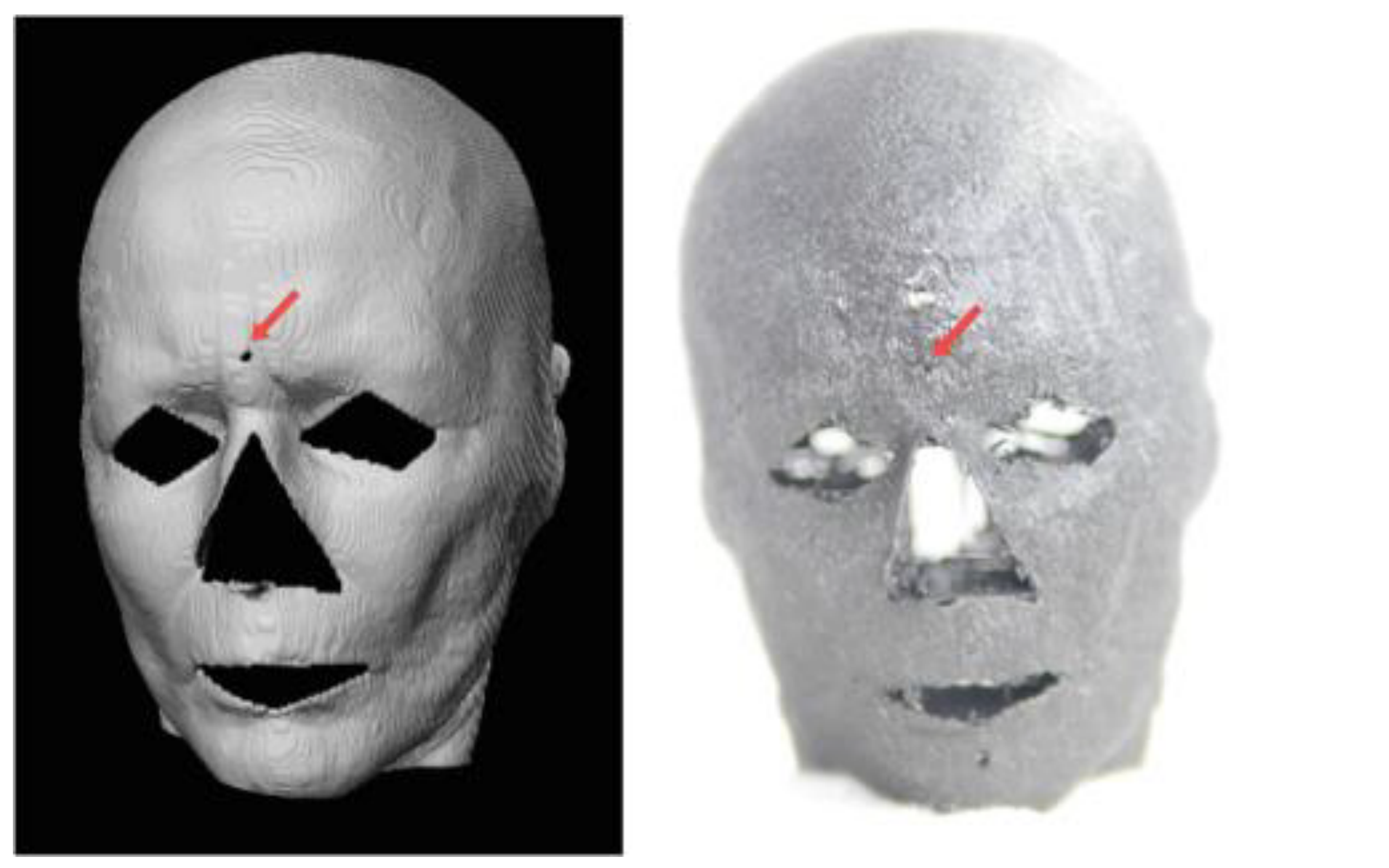

Figure 2: Left: an automatic generated final surface mesh after the surface extraction, the facial features recognition and removal, and the integration of one reference mark from the DICOM data of the radiotherapy plan. Right: the printed mask of the left mesh. Arrow: the reference mark.

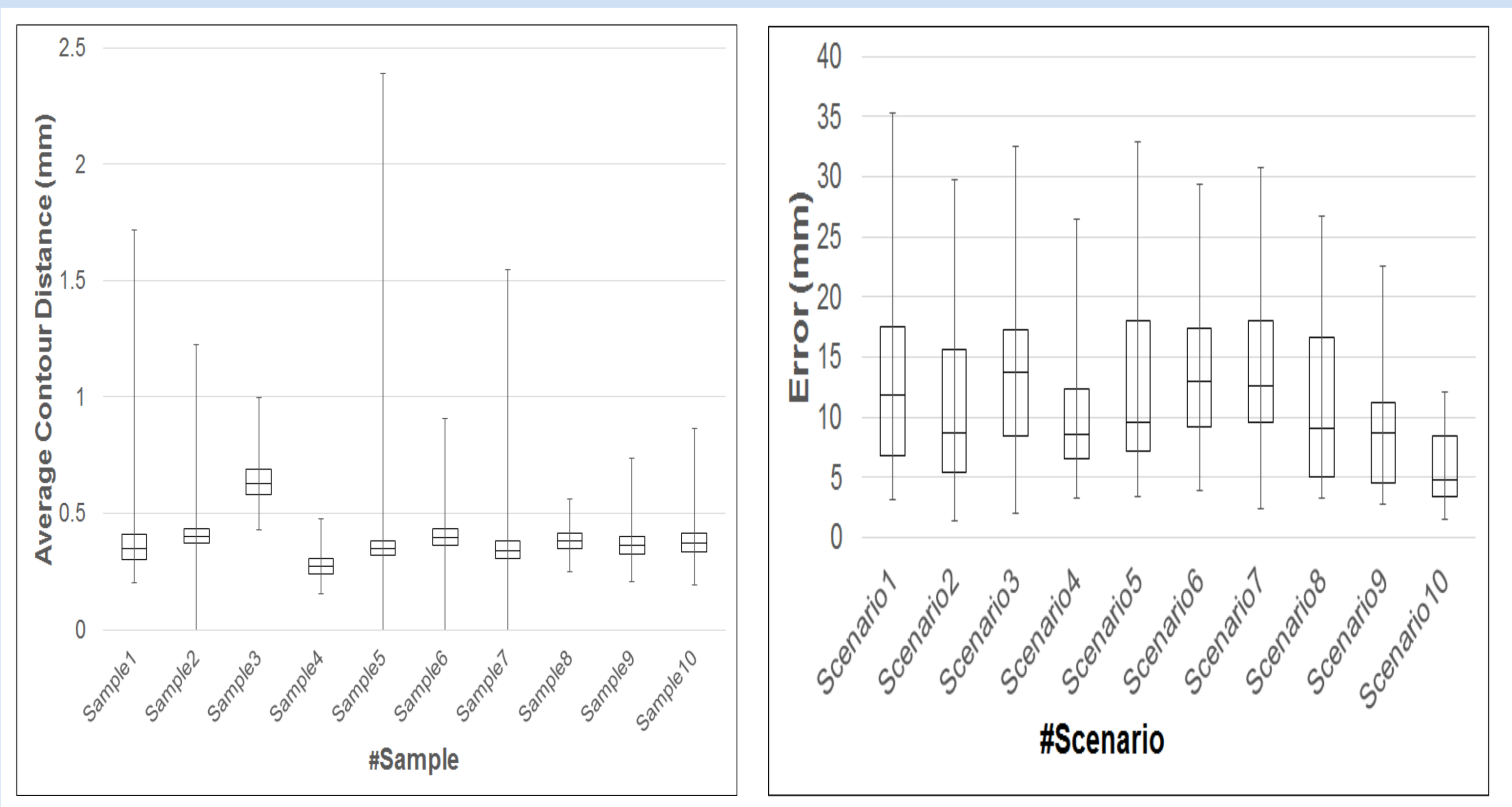

Figure 3: Left: average contour distances of the segmentation. Right: cross validation results of the registration.

Discussion and Conclusion

- A fully automatic framework for construction and production of radiation therapy mask
- Very high segmentation accuracy
- Automatic facial features recognition and facial features removal
- Feasible and robust for partially available images

References

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Contact
shuqing.chen@studium.fau.de
http://www5.cs.fau.de

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