Customized immobilization face masks for radiotherapy using Incremental Sheet Forming

Treatment of head and neck tumours requires radiotherapy with high precision localized to the diseased area with the tumour [1]. Missing the desired area can lead to increased doses to sensitive body parts such as the eye or the spinal cord [1, 2]. Present immobilization systems for head fixation typically use masks made of PVC or thermos-plastic material such as Orfit masks [3]. A study conducted by Weltens et al. [1] showed errors larger than 4 mm in 6.2% cases where thermoplastic masks were used [1]. Furthermore, closed form, full head masks have a setup uncertainty of 2-3 mm and force patients to keep the eyes and mouth closed during daily treatment and may be uncomfortable for patients with claustrophobia [4].

To overcome the issues associated with the current fixation techniques in immobilization for head and neck radiotherapy, this project will seek to develop customized immobilization face masks using digital images of the patient and a flexible sheet prototyping process, Incremental Sheet Forming (ISF), available in the Faculty of Engineering.

The digital images of the patient will be processed to generate 3D point clouds. The reconstruction from images to point clouds will be based on identifying local features in the images which will be extracted and matched between images. The matches will be used to compute relative poses between image pairs and to triangulate a sparse reconstruction, following the work done in developing the web-based service Arc3D [5]. In addition, the accuracy of the generated point clouds will be evaluated by comparison with laser scanner based reconstruction. Once the algorithms for reconstruction from images are well validated, these point clouds will then be meshed using meshing routines such as Marching Cubes and the mesh will be used to generate toolpaths for incremental forming within a software tool created specifically for this project.

The manufacturing challenges within this project will involve assessing the suitability of specific alloys for making these masks and developing advanced toolpath strategies to form masks for a wide range of human faces. Typically, parts made using ISF tend to fail as the wall angle of the formed part exceeds a limit dependent on the material type and sheet thickness. In a face mask, failure is expected in the chin and nose regions where the wall angles are typically high. Optimized toolpaths that take into account part failure limits and inaccuracies in the formed part due to material springback and feature behaviour will be developed within the framework of this project. Specifically, the suitability of multi-step morphing strategies and use of feature based material specific generic compensation functions will be evaluated in detail.

The face masks formed in this project will be sent to collaborating clinics for evaluation with respect to alignment and positioning, patient comfort etc. Feedback will be used to calibrate and validate the technique for regular clinical use. This project will require interdisciplinary work involving close collaboration between manufacturing engineering, computer science and medical science.

References

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