Section: **Validierung**

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Abstract-Title:
RAPID PROTOTYPING ANATOMIC MODELS FOR VALIDATION OF MEDICAL ROBOT SYSTEMS

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Purpose
Dedicated robot systems are more and more becoming a valueable tool in medical procedures. One of the most cited benefits resulting from the employment of complex mechatronical devices is the achievable precision of these systems in the micrometer range. On the other hand, the raw mechanical precision is of little significance, as limited resolution and distortions in CT imaging, segmentation and registration steps have a heavy impact on the overall tolerance chain.
In order to verify the precision of a medical robot system regarding the target application, a test scenario should be developed. The purposes of this test bed were to simulate realistic and reproducible surgical conditions and to allow a straight-forward interpretation of the test results.

Method
As a first step, three scenario settings where choosen: First, the milling of an implant bed for the insertion of the supporting electronic device of an auditory cochlea implant. By means of this scenario, the capability of a robot system to resect a fitting implant bed under protection of the dura mater should be evaluated. As a second scenario, the removal of the complete inner mastoid tissue was chossen. Here, the challenge was to remove all segmented tissue without violation of relevant risk structures like blood vessels or facial nerves. Third, a direct access to the middle ear in respect of the correct position and angle for the insertion of a bone anchored hearing aid (BAHA) should be milled.
As starting point for all scenarios, a CT data set of the lateral skull base was recorded. Based upon this data set, the regions to be resected by the robot system as well as relevant risk structures where segmented manually. As a second step, STL (Stero Lithography) surface geometry data was extracted. Using the STL data, rapid prototyping models with well-known characteristics were generated. Here, regions to be resected where coloured green, risk structures red, tolerance regions surrounding the resction regions by 1mm yellow and neutral tissues white.
The medical robot system was employed to mill the planned regions, the results were

inspected manually.

Results

The robot assisted milling of the rapid prototyping models showed that the material of the employed RP procedure is compareable to the real bone tissue regarding the milling time, which is closely associated with the density of the resected tissue.
Also the reproducibility of the test bed performed very well, as different iterations of the procedure showed the same results. Thus, the test bed is suitable to identify optimal paramter settings for milling forces or feeds.
The false colour representation of the resection, neutral, risk and tolerance areas prooved to be very useful for the estimation of the performance of the robot system.

Conclusion

We intoduce a generic model based upon a rapid prototyping false-colour test bed for the evaluation of medical robot systems performing milling tasks. Employing the test bed, mecatronic systems for the resection of bone tissues can be evaluated very close to realistic anatomical conditions. The described procedure is especially valuable for the optimization of registration and resection parameters, as a reproducible model is available at low price. Further steps, e.g. the geometric measurement of the resected volume, could increase the significance of the performed tests even further.

Literature

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