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Development and Evaluation of a Web Based Platform to Assist the Segmentation of Medical Images Using Crowdsourcing

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INTRODUCTION

Medical imaging is a vital field in today's medicine. The automatic segmentation of medical image data is one of the most important research topics in this field. It is rather easy for a physician to identify and classify different anatomical structures in an image. The same task, however, can become massively more complex for a computer system. In order to automatically segment image data, computer systems often have to be trained. This training depends on training data sets which must be segmented by hand. Unfortunately, the process of manually labeling a specific region in a volume data set is a very cumbersome task.
In recent time several online platforms which offer the possibility to solve so called human intelligence tasks have emerged. Human intelligence tasks are tasks which can be solved easily by humans, but are hard problems for machines. These platforms connect requesters having a specific task, with crowd workers who can solve the respective task. The idea now was to build a similar platform which allows the segmentation of medical image data with the help of crowd workers.

This project covers the design, the implementation and the evaluation of a crowd based segmentation platform for volumetric medical images. In order to evaluate the platform a user study was conducted.

CONCEPT

The developed system consists of several sub-components. An application server, which is mainly responsible for the management of users, data sets and projects. It responds to incoming HTTP requests and handles database transactions.
The data itself is stored in multiple ways. The raw image data is stored in the file system of the host server and managed by the operating system. Image meta data, user information and project information is stored in a relational database. Session management specific data structures and parameters, such as authentication tokens and inactive-intervals, are saved and cached in a fast key-value database.

The user interface is given in form of a single page application. This SPA communicates with the application server over a REST API.

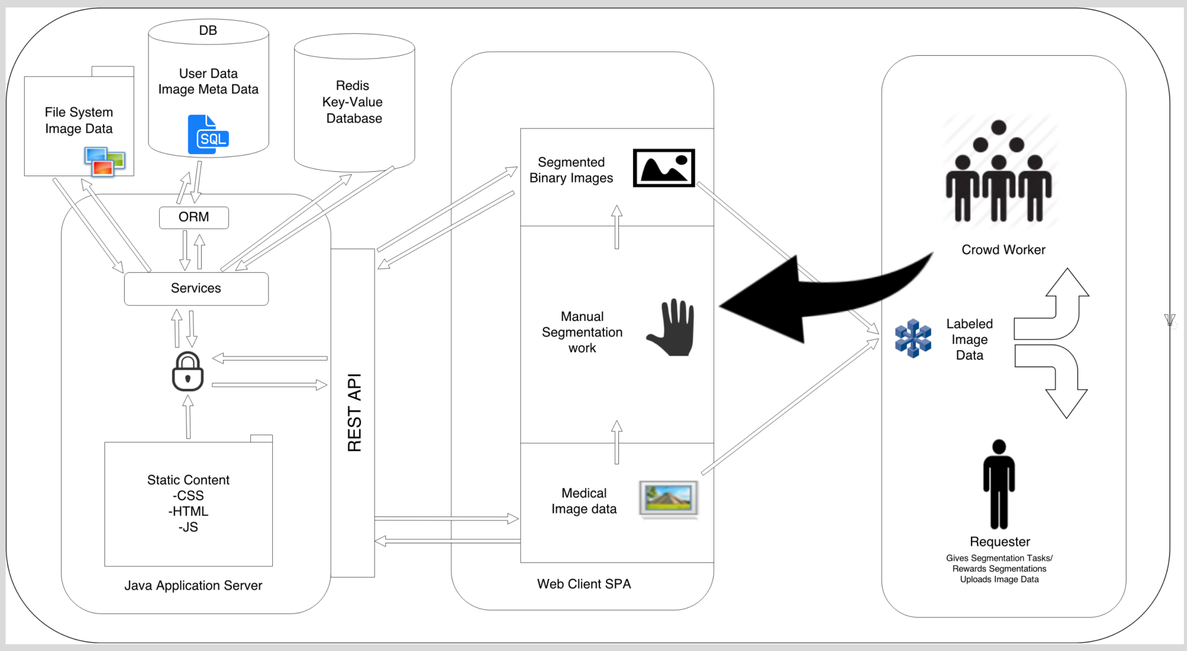


Fig.1: System Architecture

RESULTS

The functionality of the platform and the resulting segmentations were evaluated in form of a user study. In this study 13 non-expert users manually segmented three slice images of a human vertebra.
The platform ran stable throughout the whole study. The users were pleased with the interface and the functionality of the web application. The application provides users with several manual tools which they can use to manually label medical image data. These tools include, a simple brush, a polygon and a threshold based flood fill tool. The tools can be utilized from an axial, sagittal as well as coronal view.

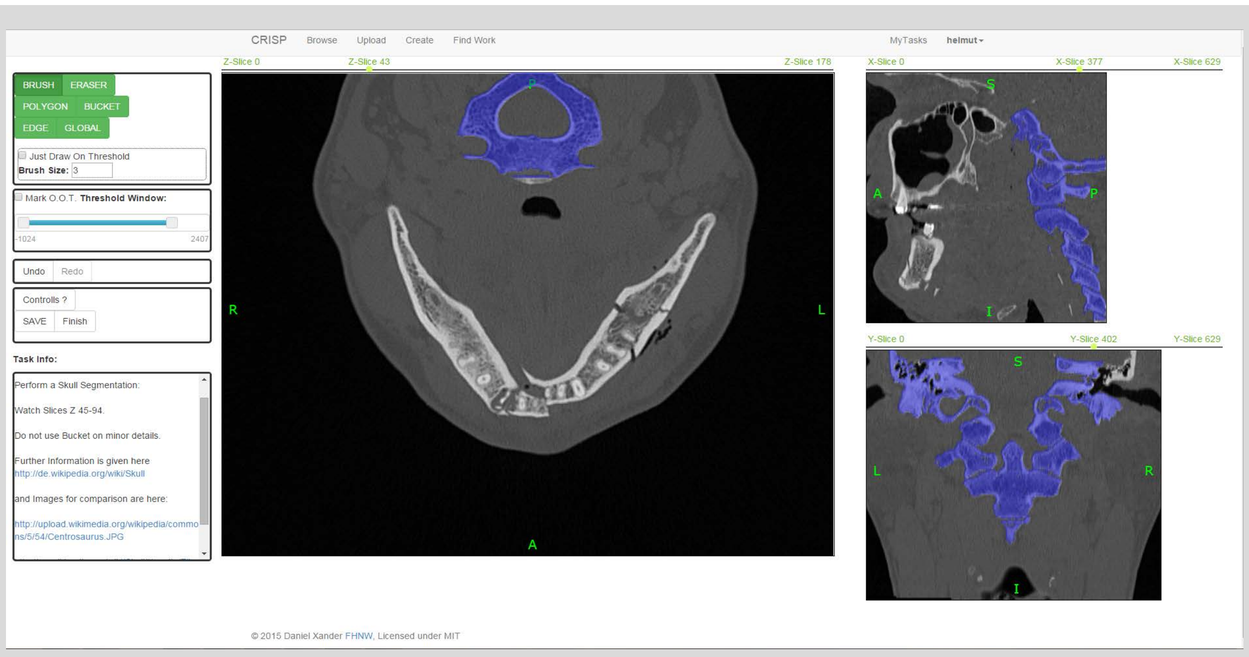
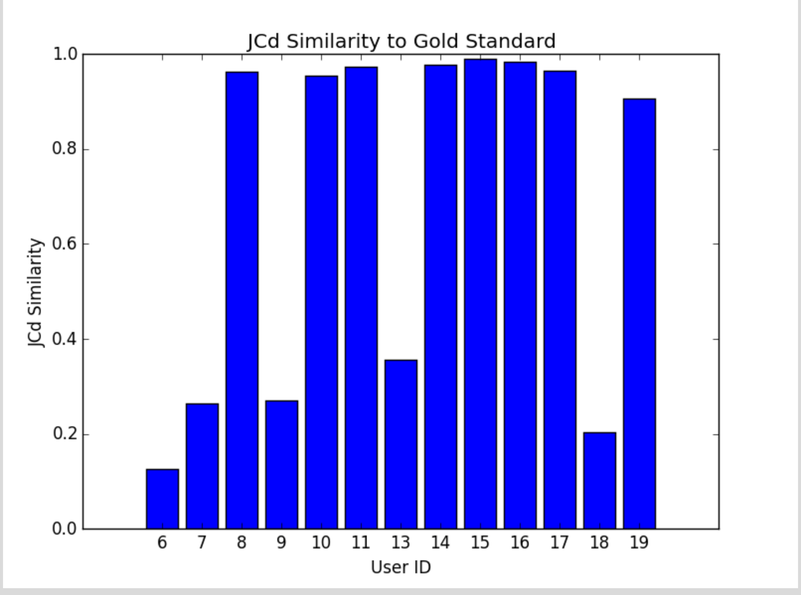


Fig.2: Segmentation User Interface

The segmentations performed by the users were compared to a gold standard segmentation using a distance enhanced variation of the Jaccard similarity coefficient[1]. The resulting segmentations showed promising similarity values. The majority of them exceeding the 95% mark.

A few segmentations however, were erroneous or incomplete due to a misunderstanding of the task by the corresponding user.



ID	JCd
6	0.12540393
7	0.2648974
8	0.9634239
9	0.27144048
10	0.95434225
11	0.97387356
13	0.35686523
14	0.97664607
15	0.9898798
16	0.9828729
17	0.9659882
18	0.20441084
19	0.86388355

Fig. 3 : JCd Similarities compared to Gold Standard Segmentation

It was discovered that it is possible to filter such erroneous segmentations by aggregating the different segmentations into one final consensus segment using logical operators. With the help of these operators false-positive and false-negative segmentations could be ruled out and the resulting segmentation reached an excellent similarity metric close to 99%.

CONCLUSION

In conclusion it can be said that a platform which enables the outsourcing of segmentation work to crowd workers is technologically feasible and can become a beneficial tool for the medical image segmentation community. The conducted user study demonstrates that segmentations performed by crowd workers can reach satisfactory results which qualifies them as potential training data sets for knowledge-based algorithms. The study also showed that the most important part of the system is the characterization of the task towards the crowd worker. This task description is less important if the worker is an expert or at least knowledgeable in the field. But it is of vital importance in order to gain correct results if the worker is a non-expert.

REFERENCES

[1] Ruben Cardenes, Rodrigo de Luis-Garca, and Meritxell Bach-Cuadra. *A multidimensional segmentation evaluation for medical image data*. Computer Methods and Programs in Biomedicine, 96(2):108 124, 2009.