INTERNSHIP REPORT

Savonia University of Applied Sciences

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Student number: 67687,
Group: EFA12SF,
Type: The internship information technologies,
Duration: 4 months and 1 week or 720 hour (07.07.2015-18.11.2015)
The day of the report: December 5, 2015

Contents

1 Company

I carried out my summer practice at Institute of Data Processing and Electronics, which belonges to the Karlsruhe Institute of Technology (KIT). The organisation's visitor address is Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany and mailing address is Karlsruhe Institute of Technology (KIT) - Campus North, Institute for Data Processing and Electronics (IPE), P.O. Box 3640, 76021, Karlsruhe, Germany. The phone number is +49 721 608 2 2027, an e-mail address is info@ipe.kit.edu, ipe.kit.edu is the webpage of the organisation. I worked under supervision of Dr. Torsten Hopp. His e-mail address is torsten.hopp@kit.edu and the phone number is +49 721 608-25990. The internship period was from the 7th of July to the 18th of November.

1.1 General Information

Karlsruhe Institute of Technology is one of the largest research and education organisations in Germany. In 2009, University of Karlsruhe merged with Research Center Forschungszentrum Karlsruhe[1]. The institute has leadership in the Engineering and Natural Sciences in Europe, ranking sixth overall in citation impact.

The total budget of KIT is €844 million, the total number of stuff is over 10 000 and over 7000 of them is academic stuff. There are 24500 students, 12600 of them are undergraduates ones, 8300 are postgraduate and over 800 are doctoral students.

1.2 Stuff

I was a part of the 3D Ultrasound Computer Tomography (USCT) team. USCT and the Big Data research group together form the Software Methods group of IPE. The Head of the Software Methods group is Dr. Rainer Stotzka. The permanent part of USCT team consists of:

- Dr. Nicole Ruiter - the head of 3D USCT
- Dr. Torsten Hopp - responsable for image processing and data management
- Michael Zapf - responsable for hardware and software integration
- Prof. Dr. Hartmut Gemmeke - former head of IPE, now advisor of 3D USCT

Other team members are students who are doing internship or these at the institute.

2 History

2.1 KIT History

A polytechnic school of Karlsruhe was founded on the 7th of October 1825. In 1865, the schooles was raised to the status of an institution of higher education. Since 1885 the organisation was called institute of technology. In 1967, it started to be called University. Karlsruhe Nuclear Research Centre was opened in 1956.

University of Karlsruhe opened a central computer laboratory and became one of the leading German institutions in computer science, in 1986. Karlsruhe Research Centre and Karlsruhe Institute of Technology merged together at 1 October 2009.

2.2 IPE History

IPE was founded as a part of Institute for Neutron Physics and Reactor Technology in 1959. It evolved to the Centre of Data Processing Department Laboratory Automation in 1967-1971. In 1973, the Computing Centre Data Processing and Laboratory for Electronics and Measurement Instrumentation merged in Department for Data Processing and Instrumentation. In 1991, the Department Data Processing and Electronics became independent from the Department

[1] Based on national nuclear research center opened in 1956 and called Kernforschungszentrum Karlsruhe, or KfK

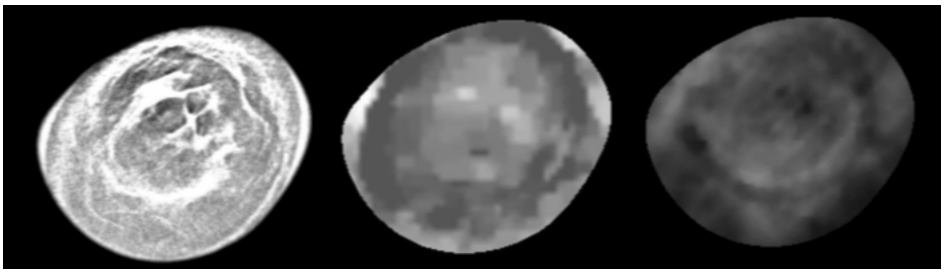

Figure 1: Examples of reflection, sound speed, attenuation images

for Data Processing and Instrumentation. Since 2001, the organisation is called Institute for Data Processing and Electronics.

3 Work description

3.1 Project description

I worked in a project called 3D Ultrasound Computer Tomography, shortly USCT. The main goal of the project is to develop a new imaging methodology for early breast cancer detection. This type of cancer is one of the most common and dangerous ones among women. A breast is not a vital organ, so the majority of patient dies of metastasis. A tumor with a size less than 5mm has very low probability of metastasis. That's why, an early diagnosis of breast cancer significantly increases the survival probability of the patient. The USCT team's aim is detection of the tumor with an average size smaller than 5mm.
The USCT system is able to produce three different types of images (Pic. 1):

1. Reflection - contains general structure by imaging tissue surfaces
2. Sound speed - map of the sound speed distribution
3. Attenuation - map of the sound wave's amplitude attenuation

The sound speed and attenuation images give doctors an opportunity to classify lesions precisely (Figure 2), while the reflection's one allows them define type of the structure. I worked on fusion of this three different images into the single one, because it makes an analising much easier.(Figure 2

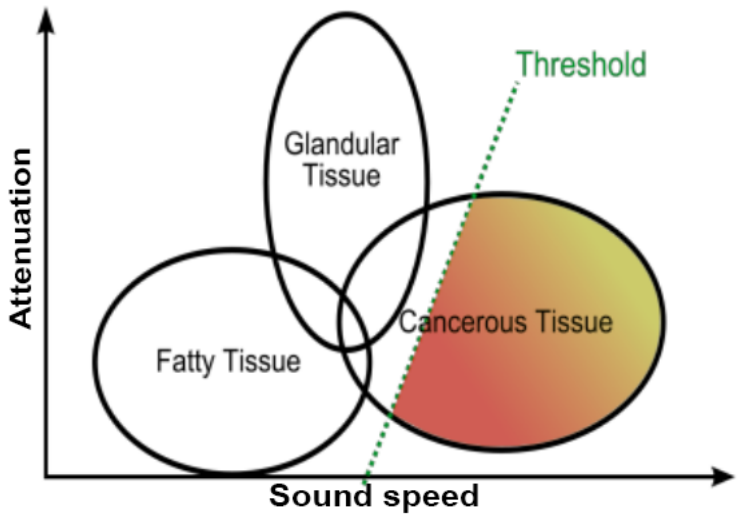

Figure 2: Tumor clasification based on sound speed and attenuation [1]

3.2 Position description

3D USCT volumes are converted into stacks of 2D images along specified standard slicing directions used in radiological workflows. They are presented to radiologist using USCT's customized edition of DICOM Viewer, which is based on the ImageJ Framework and the Tudor DICOM Viewer. The position title is Visualization of multimodal 3D USCT volume images. So, the aim of this internship is to explore new intuitive ways of multimodal data visualization, create the prototype of the methods and implements the visualisations in the customized DICOM Viewer. The software should be extended accordingly to allow interactive access to the visualization, e.g. to allow user specified input for setting thresholds, choosing projection directions etc.[2]

I also have had my personal goals related with the internship:

- Improve skills on object-oriented programming with Java[2] and improve knowledge of MATLAB
- Gain an experience in digital image processing
- Get an experience in team work on real-life project
- Learn software development workflow

I did not have any experience in digital image processing before the internship, but I have had deep understanding of color theory, visual art and raster graphics, the knowledge helped me a lot.

3.3 Work description

3.3.1 Prototyping

The most part of my internship I worked on development of new fusion technics for 3D USCT images under supervision of Dr. Hopp. During the first week I made literature research and came up with several idea for realisation of the fusion. After that I made a prototypes for three best of them in MATLAB. The picture **??** demonstrates prototype of HSV Fusion, which was chosen as the best solution.

3.3.2 HSV Fusion

The algorithm is based on HSV color model. The model divides color of every pixel into three separate components:

- Hue - keeps chromatic information (how the pixel is red, green, blue etc.)
- Value - keeps grayscale information (how bright is the pixel)
- Saturation - keeps an information about saturation of the hue (how the color far away from grayscale)

Figure 4: Components of HSV image from to top: Hue, Value, Saturation.

The components are shown on the figure 4 The color space of the model can be represented as cylinder, where: altitude is the Value, saturation is radius from center and angle is hue, look at figure 7.

[2]Java is one of the main languages studied in my program at Savonia UAS

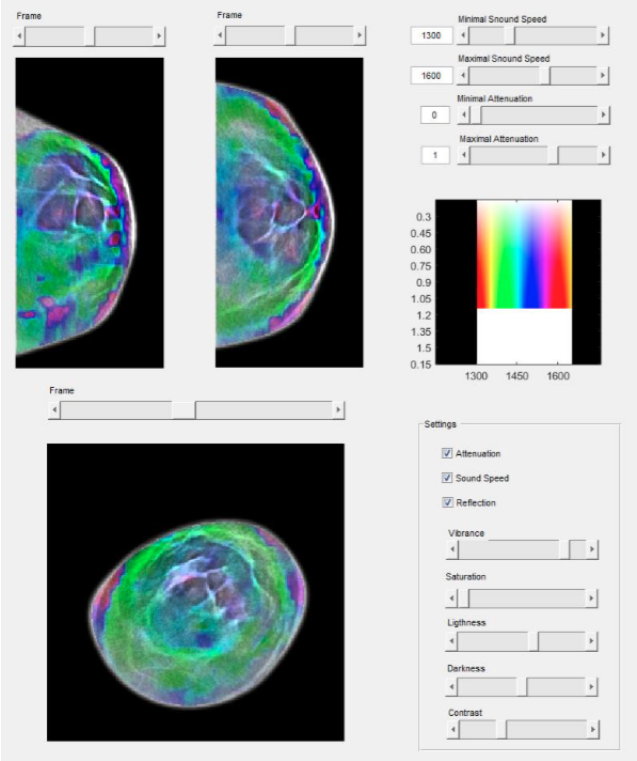

Figure 3: MATLAB prototype for HSV Fusion

To get the final result of the fusion the algorithm transfer the image from HSV to RGB color model. The visual representation of the conversion shown at figure 5.

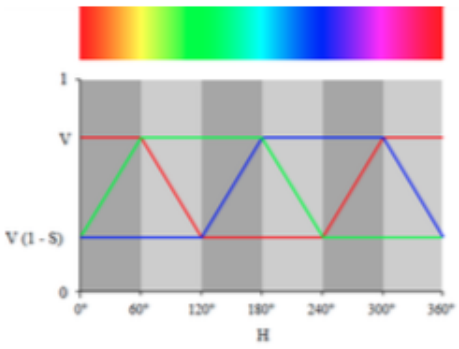

Figure 5: Visuale representation of HSV to RGB convertions

3.3.3 DICOM Viewer realisation

The prototype was presented to the Software Methods groupe of IPE. The realisation get positive feedback from the team and I started the realisation of the algorithm in DICOM Viewer with ImageJ.

The DICOM realisation has a little bit more simple user interface, to make it more understandable for an end user. Sound speed thresholding were added to the final version of fusion, figure 6.

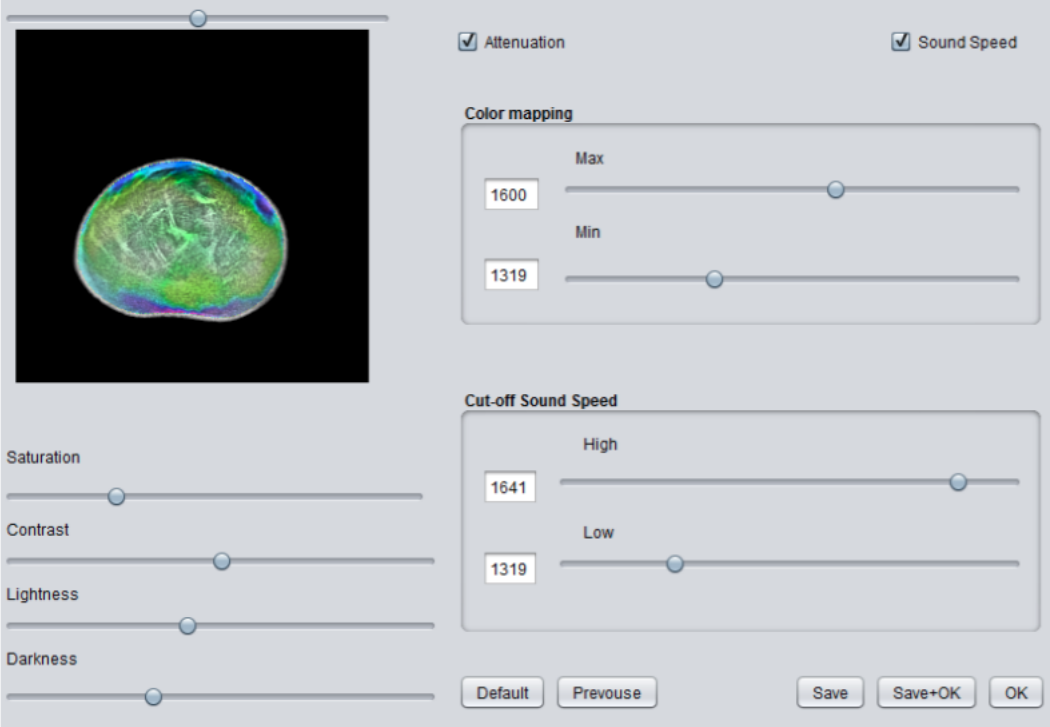

Figure 6: DICOM Viewer HSV Fusion Menu

3.3.4 Re-slicing

As I mentioned before DICOM Viewer keeps three different stacks of images with different slicing directions for a breast, but every of this three stacks contains enough information for visualising of all three slicing directions.

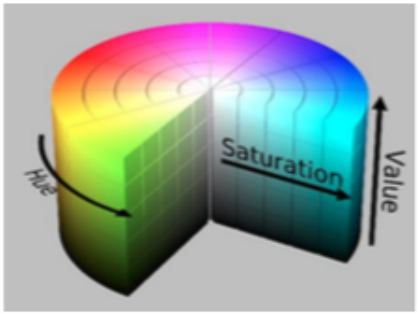

Figure 7: Model of HSV color space

My task was to implement the slicing algorithm which allows DICOM Viewer to recalculate all three slicing directions from any of them. If density a long different axis is not uniform the algorithm also had to perform interpolation of the data.

Re-slicing is very useful feature for DICOM Viewer, because it will three times reduce the size of the database and it will give an opportunity to browse different slice directions of MRI images[3].

[3]Usually, MRI images has only one slicing direction

3.3.5 WebGL Visualisation for USCT

I was volunteer to take part at development of 3D WebGL Visualisation of USCT data and Dr. Hopp allowed me to join the team. Michael Zapf was responsable for development of the project and the last part of my internship I did under his control.

The vizualisation is based on Tomoraycaster 2[4]. I had to modify the framework to make it works with USCT data well and develop sci-fi graphical user interface for better representation of the visualisation.

My work started from deployment of example for Tomoraycaser 2 with USCT data, the example was able to show the breast structure from reflection image. After that I started to make an adoptatoin of the shaders to give them an opportunity to handle multimodal data, basicaly I used very same idea as in Fusion, but I also added severl other features to the realisation. The visulisation was quite slow on weak machines, that's why I also worked on optimisation of the code.

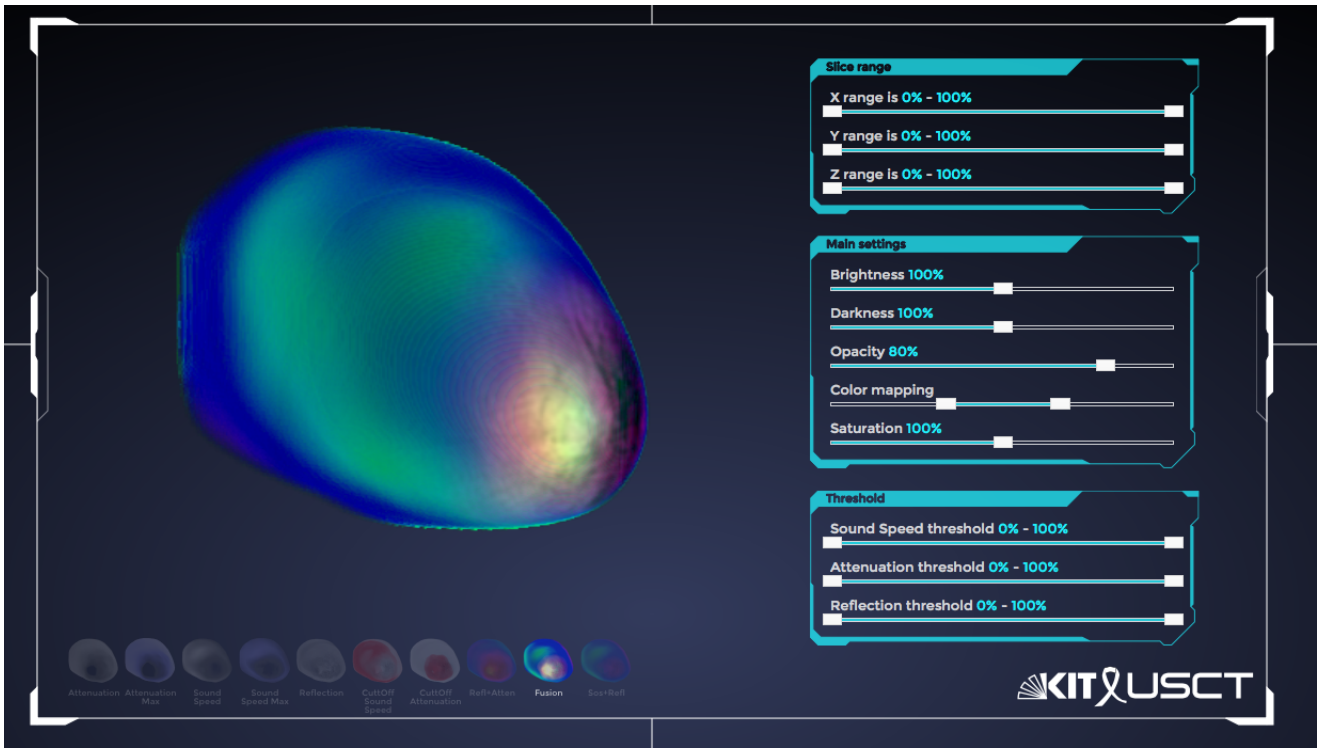

Figure 8: Web visualisation for 3D USCT

When I finished my modifications for Tomoraycaster, I started to write the actual graphical user interface in according with skeleton of the project provided to me by Nicolas.

Our GUI has very complex animation and designe, so we decided to draw entire website inside huge dynamic SVG image. I used Snap.SVG library to draw SVG images dynamicly inside the webpage. Tomoraycaster and jQuer UI sliders were added to the SVG image as foreign object.

Final result of the work is 3D visualisation of the USCT data with ten different modes and eleven sliders with different parameters, pic. 8. The visualisation is avaible on this address http://ipepc57.ipe.kit.edu:10002

[4] JavaScript framework for visualisation of 3D data, developed in IPE

3.4 Working place communication

During the most part of my internship I work under direct supervision of Dr. Torsten Hopp. I recieved the task from my supervisor, asked him for a help then I have had problems and report about current progress. My work realise with modification of DICOM Viewer was organised via SVN version control system, so I worked in my own branch to prevent any additional bugs in the main repository, Dr. Hopp was always able to get my latest stable result, to check the code style and report about bugs. Every new feature implemented in DICOM Viewer was checked by Dr. Hopp and fixed by me in according with his feedback.

Every Wednesday USCT group have a meeting. The meeting starts from discussion about current news related to the project. After that we have had so called ”weekly round”, during the ”round” every team member has to report about his/her progress for last week in front of USCT team on a meeting, during the report the everyone was able to request help or advise from other ones or help somebody him/herself.

At the last part of my internship I worked in cooperation with Nicolas Tan, he is an experienced web developer responsible for development and maintenance of Tomoraycaster 2, so he was assigned as my mentor for the task. I was very happy to have an opportunity to work under his mentoring, because it was prefect chance to improve my knowledge in field of web development.

During the development of the visualisation I worked in close cooperation with my mentor. We had had discussions about the key issues of the project and made the key decisions together. He checked my code and tought me a lot about using of Git and writing a good code. The requirements for the project were developed and controlled by Michael Zapf. Sometimes three of us had a small meetings to make key discussions. Sometimes Michael visited my working place to check current progress, point to bugs and give some advises.

4 Conclusion

I was very satisfied with the internship because I reached my personal goals and in my point of view the task assigned to me was sorted well. In according with the postion goals during the internship I developed new way of visualizing for multimodal USCT data. While implementation of the prototype for the algorithm at MATLAB, I improved my knowledge of MATLAB. After that I gained an experience in object-oriented programming with Java and digital image processing, during integration of the algorithm with DICOM Viewer and work under development of reslicing. I also learned in practise the software development workflow from idea, to prototype and from prototype to implementation and testing.

During the second part of my internship I got an experience in team work on real-life project, I improved my knowledge of tool for team cooperation such as Git version control system. I also studied in a practice the web development workflow and web development tools like browserify and sass, improved my system administration skills during deployment of the application. Nicolas' guidance helped me to improve my coding style and made my undestanding of JavaScript much deeper.

I am very thankful to KIT for this experience, because I want to build my career in field of digital image processing, visualisation and computer graphics, the work placement gave me first industrial experience in this fields, so it means a lot for my future career prospects.

I am very thankful to all the people I met during the internship, to the Software Methods group of IPE and especially to Dr. Hopp, Nicolas Tan and Michael Zapf for the mentoring and knowledge provided by them.

References

[1] USCT Presentaion by Dr. Nicole Ruiter

[2] Position proposal from Dr. Torsten Hopp