

INTERNSHIP REPORT

Savonia University of Applied Sciences



SAVONIA
AMMATTIKORKEAKOULU

Student name: Alexey Tukalo,

Student number: 67687,

Group: EFA12SF,

Type: The internship Information Technology,

Duration: 4 months and 1 week or 720 hour (07.07.2015-18.11.2015)

The day of the report: April 30, 2016

Contents

1 Company

I carried out my summer practice at Institute of Data Processing and Electronics, which belongs 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 Karlsruhe¹. 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 staff is over 10 000 and over 7000 of them is academic staff. 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 - responsible for image processing and data management
- Michael Zapf - responsible 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 school 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

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

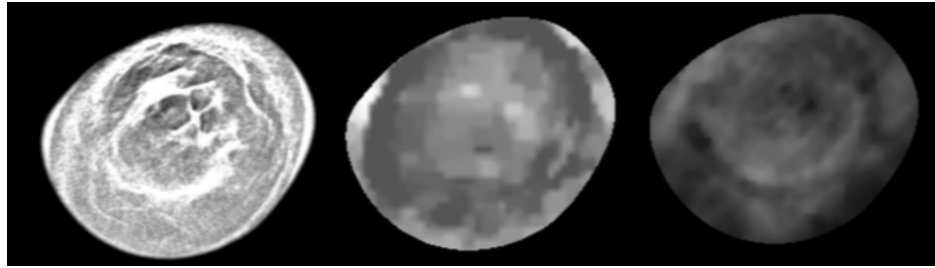


Figure 1: Examples of reflection, sound speed, attenuation images

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. 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 ??), while the reflection one allows them to define the structure. An essential part of the image processing is to fuse the three different images into a single one in order to give an intuitive access to the multimodal information at a glance and it was my main task of my internship.

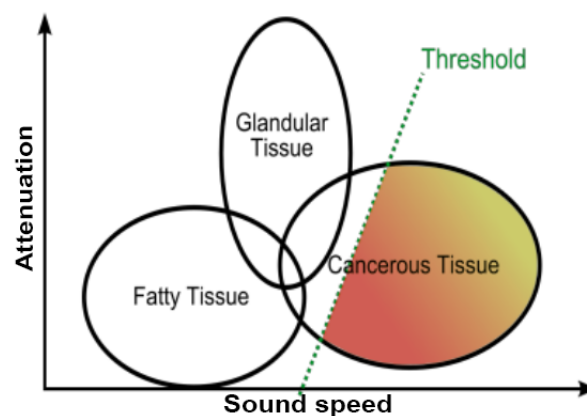


Figure 2: Tumor classification based on sound speed and attenuation [?]

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 aim of my internship was to explore new intuitive ways of multimodal data visualization, create the prototype of the methods and implements the visualizations 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.[?]

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

- Improve skills on object-oriented programming with Java² 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, which 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 techniques for 3D USCT images under supervision of Dr. Hopp. During the first week I made a literature research and came up with several ideas for realization of the fusion. After that I created prototypes for three promising approaches 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 the HSV color model. The model divides the color of every pixel into three separate components:

- Hue - keeps chromatic information (if 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 far away is the color from gray)



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

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

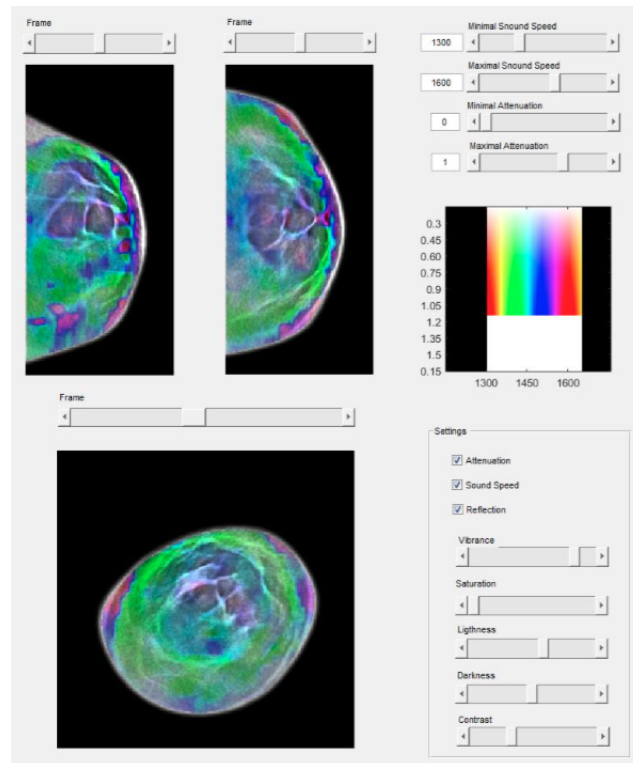


Figure 3: MATLAB prototype for HSV Fusion

The components are shown in figure ???. The color space of the model can be represented as cylinder, where: altitude is the value, saturation is radius from the center and the angle is hue, see figure ??.

To get the final result of the fusions. The algorithm transfers the image from HSV to RGB color model. The visual representation of the conversion is shown in figure ??. The picture is very easy to read because the data is separated over three different domain natural for human vision.

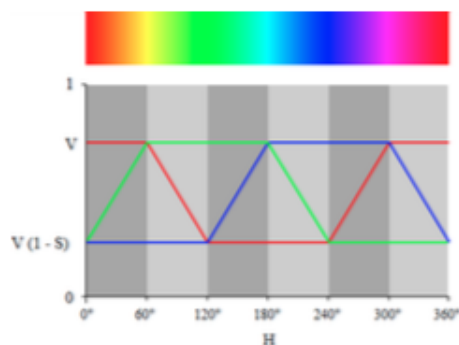


Figure 5: Visuale representation of HSV to RGB conversions

3.3.3 DICOM Viewer realisation

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

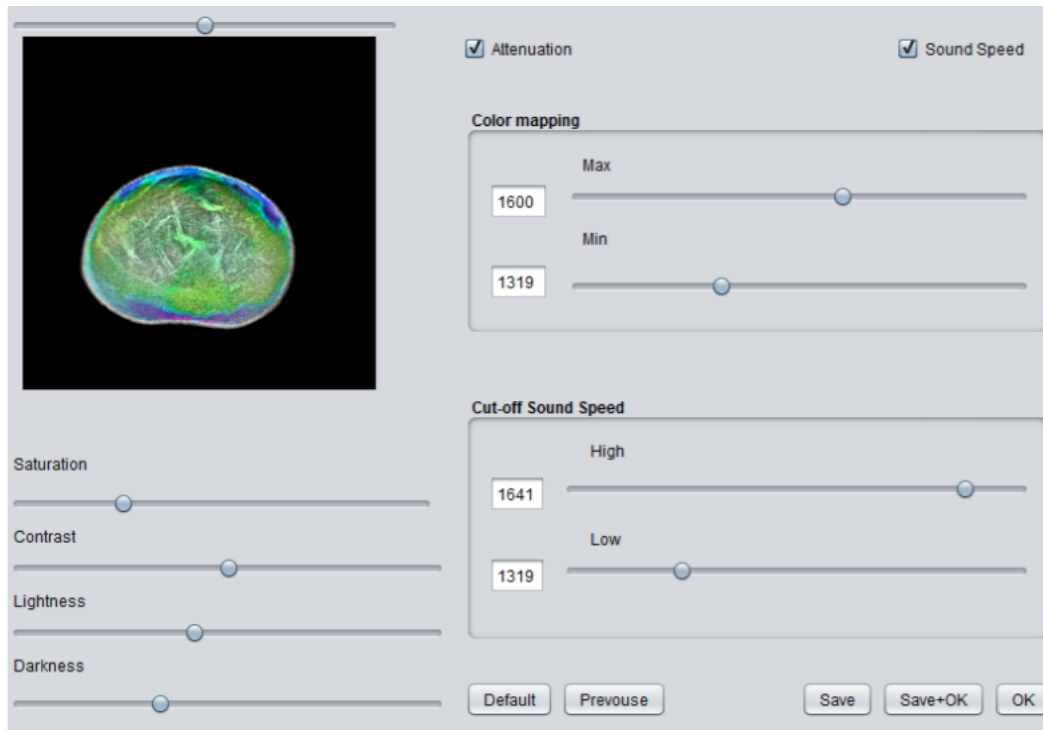


Figure 6: DICOM Viewer HSV Fusion Menu

The DICOM realisation has a simpler user interface than the MATLAB implementation, to make it better understandable for an end user. Sound speed thresholding were added to the final version of fusion, figure ??.

3.3.4 Re-slicing

DICOM Viewer kept three separate stacks of images for the different slicing directions along the x, y and z axis. Yet, thereby the same information needs to be stored three times as every of this three stacks contains enough information for visualising of all three slicing directions.

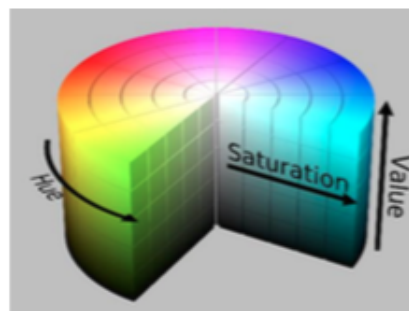


Figure 7: Model of HSV color space

My task was to implement the slicing algorithm, which allows to recalculate all three slicing directions from any of them directly within the DICOM viewer. If the image resolution along 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 image database by a factor of three and it will give an opportunity to also browse different slice directions of MRI images, which are usually used for comparison with USCT images in the same DICOM Viewer.

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 responsible for development of the project and the last part of my internship I did under his control.

The vizualisation is based on Tomoraycaster 2³. The aim was to modify the framework to make it works with USCT data well and develop a sci-fi graphical user interface for better representation of the visualisation.

My work started with deployment of an 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. This allowed me to integrate the image fusion, but I also added severl other features to the realisation. The visulisation was quite slow on weak machines when I started my developments. That's why I also worked on optimization of the code.

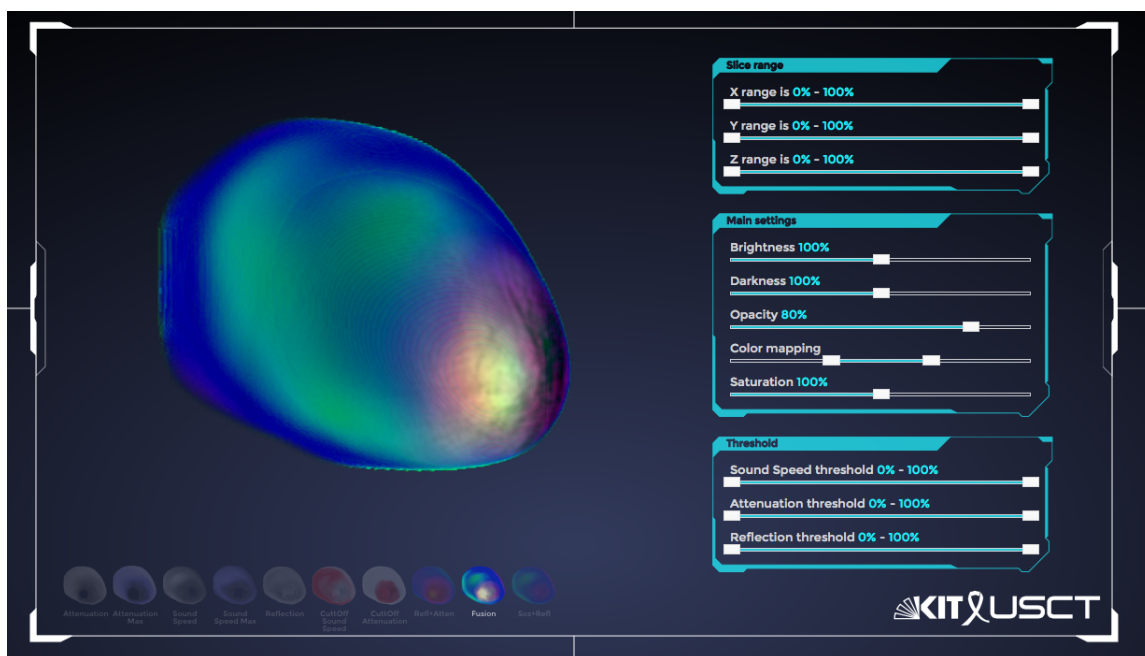


Figure 8: Web visualization for 3D USCT

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 a very complex animation and design. That's why I decided to draw the entire website inside a dynamic SVG image. I used Snap.SVG library to draw SVG images dynamically inside the webpage. Tomoraycaster and jQuery UI sliders were added to the SVG image as foreign objects.

The final result of the work is a 3D visualization of the USCT data with ten different modes and eleven sliders with different parameters, see pic. ???. The visualization is available at <http://ipepc57.ipe.kit.edu:10002>

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

3.4 Working place communication

During the most part of my internship I worked under direct supervision of Dr. Torsten Hopp. I received the task from my supervisor, asked him for help when I have had problems and reported about the current progress. My work on the modifications of the 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. Finally my branch was merged with the main repository.

Every Wednesday the USCT group had a meeting. The meeting starts with a discussion about current news related to the project. After that we have had a so called "weekly round", during which every team member reported about his/her progress during the last week in front of USCT team. During the report everyone was able to request help or advise from others 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. Therefore 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 perfect chance to improve my knowledge in the field of web development.

During the development of the visualization I worked in close cooperation with my mentor. We had discussions about the key issues of the project and made the key decisions together. He checked my code and taught me a lot about using Git as versioning system 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. Michael also 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 accordance with the position goals during the internship I developed a new way of visualizing for multimodal USCT data. During the implementation of the prototype for the algorithm in 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 in DICOM Viewer and development of the 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 tools for team cooperation such as the Git version control system. I also studied in 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 understanding of JavaScript much deeper.

I am very thankful to KIT for this experience, because I want to build my career in the field of digital image processing, visualization 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 Presentation by Dr. Nicole Ruiter
- [2] Position proposal from Dr. Torsten Hopp

5 Appendix



CERTIFICATE

Mr. Alexey Tukalo, born on 21/07/1994, has worked from 07/07/2015 to 18/11/2015 as an intern at the Institute for Data processing and Electronics (IPE) of the Karlsruhe Institute of Technology (KIT).

His work was focused on the following topic: "Visualization of multimodal 3D Ultrasound Computer Tomography (USCT) volume images".

Mr. Tukalo was very good organized and worked target oriented to achieve the goals of the internship. He managed to first of all get familiar with the existing methods for image fusion of 3D USCT images and then he started to make substantial extensions and improvements by developing a prototype for a novel image fusion method using the HSV color space. He integrated his developments into the USCT DICOM Viewer application. Developing the software, Mr. Tukalo made extensive use of MATLAB and Java. He furthermore developed a web-based rendering of multimodal USCT data in a WebGL ray casting application.

To demonstrate the functionality of the developed software, Mr. Tukalo presented his work in the working group seminar and tested the application with several user tests. The obtained results were evaluated and discussed with the imaging experts during the weekly USCT project meeting. The DICOM viewer application as well as the WebGL volume visualization is currently in use in a clinical study with USCT respectively in a public relations campaign for USCT.

The developed methods pave the way for the analysis of different image fusion methods in a radiological reader study. The contributions of Mr. Tukalo are very useful for the USCT team and the visualization research community.

We thank Mr. Tukalo for the very good work he did in the short time of his internship, demonstrating solid knowledge of medical image processing and software development. He easily learned how to work with new tools and techniques like WebGL. His profound and broaden expertise and his scientific curiosity facilitated the success of his work. It was a pleasure to discuss and work with him. We wish him all the best in his professional development and personal future.

Karlsruher Institut für Technologie (KIT)

Karlsruhe, 7th December 2015

i. A. Michael Markert

i. A. Alina Berger

Karlsruher Institut für Technologie (KIT)
Kaiserstraße 12
76131 Karlsruhe

Präsident: Prof. Dr.-Ing. Holger Hanselka
Vizepräsidenten: Dr. Elke Luise Barnstedt, Dr. Ulrich Breuer,
Prof. Dr.-Ing. Dettel Löhle, Prof. Dr. Alexander Wanner

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UST-IdNr. DE266749428

Baden-Württembergische Bank, Stuttgart
BLZ 600 501 01 | Kto. 7495501296
BIC: SOLADE33
IBAN: DE18 6005 0101 7495 5012 96

INTERNSHIP PLAN (Must be filled before Internship 1 (using word processing) and returned to your training supervisor.)

STUDENT

| | |
|----------------|---------------|
| Name | Alexey Tukalo |
| Student Number | 67687 |

EMPLOYER

| | |
|---------------------|---|
| Organisation | Karlsruhe Institute of Technology (KIT) Institute for Data Processing and Electronics |
| Address | Hermann-von-Helmholtz-Platz 1 |
| Post Code and Place | D- 76344 Eggenstein-Leopoldshafen |
| Field of Business | Education and research |
| Contact Person | Dr. Torsten Hopp |
| Phone | +49 721 608 2 5990 |
| E-mail | torsten.hopp@kit.edu |

INTERNSHIP

| | |
|---|--|
| Time | 07. 07. 2015 - 31. 11. 2015 |
| Number of weeks | Total of 19 weeks |
| Working hours | 760 |
| How does the coming internship <u>strengthen</u> my curriculum and career planning? | The work placement will help me to improve my knowledge in object-oriented and functional programming and get an experience in field of digital image processing which is also very interesting for me. |
| Characteristics and knowhow required at the chosen field of business. | I will be a part of team responsible for visualization of the information collected by the 3D USCT. The visualization will be made via ImageJ framework with different image processing technics for 3D and 4D visualization. |
| I have the following characteristics and knowhow relevant to my field. | I studied object-oriented at Java, MATLAB and digital signal processing during last two years at University. My dream is career of Data Sciences and visualisation is one of the fields related with this specialisation. So, I also have spent a lot of my spare time for learning of a basics of visualization technics and I think that the work placement will help me to improve my knowledges at the area. |
| I have the following <u>shortcomings</u> in the characteristics and knowhow relevant to my field. | I have no experience with ImageJ framework and my knowledge of MATLAB is not excellent, so hope that I will significantly improve it. |
| The main learning objectives for this internship period. | 1.Object-oriented programming and Java 2.Functional programming and MATLAB 3.ImageJ framework 4.Digital image processing |



| | |
|--|---|
| | 5. Visualisation technics |
| | 6. Experience in development of medical equipment |

Date and Place

22.06.2015

Student's Signature

Jykan



INTERNSHIP CONTRACT

to be drawn up in three copies

STUDENT AND INSTITUTION

| Surname | Given Names | Social Security Number |
|---------|-------------|------------------------|
| Tukalo | Alexey | 210794-291U |

| Address |
|--|
| Taivaanpankontie 14 A 14/1, 70200, Kuopio, Finland |

| Telephone | Email | Group code |
|--------------|---|------------|
| +79535441714 | alexey.a.tukalo@edu.savonia.fi (must be used during the work placement period) | EFA12SF |

| Degree Programme | Completed Credits | Degree |
|------------------------|-------------------|-------------------------|
| Information Technology | 181 cr | Bachelor of Engineering |

| Supervising Teacher | Telephone and Email |
|---------------------|--|
| Arto Toppinen | +358447856222 Arto.Toppinen@savonia.fi |

EMPLOYER

| Name of the Company | Business ID |
|--|-------------|
| Karlsruhe Institute of Technology (KIT) Institute for Data Processing and Electronics | |

| Address, Postal Code | Telephone |
|--|--------------------|
| Hermann-von-Helmholtz-Platz 1 D- 76344 Eggenstein-Leopoldshafen | +49 721 608 2 2027 |

| Supervisor | Telephone and Email |
|------------------|---|
| Dr. Torsten Hopp | +49 721 608 2 5990 torsten.hopp@kit.edu |

| Contact Person (if not the same as above) | Telephone and Email |
|--|---------------------|
| | |

INTERNSHIP

| Aims |
|---|
| <ul style="list-style-type: none">• Get an experience of object-oriented and functional programming in real-life project• Improve knowledge of image and sensor signal processing• Take part in the development of the medical device |

Duties



- Literature research for 3D/4D visualization techniques and supporting software packages for Java and/or MATLAB
- Development of prototypes for combined 3D USCT volume data visualization
- Development of prototypes for 4D information visualization
- Implementation of the data visualization in our customized DICOM viewer including the data handling and user interface design.
- Evaluation in cooperation with radiologists

Validity of Contract and the amount of Study Credits

Working Hours

| | |
|--|----------------------------|
| / 200 - / 200 | 5 month or 19 week or 760h |
| How many study credits student will get after this internship period (will be marked by the supervising teacher) ? | |

Pay excluded

☐

Pay included

☒

Amount 511 euros /month

The Student has presented the Aims and Objectives of a BSc Student's Internship (Appendix of this Contract) to the Employer.

Yes

☒

No

☐



OTHER TERMS

Supervision of the internship:

The internship is supervised by a representative of the employer in cooperation with the tutoring teacher at Savonia University of Applied Sciences.

The trainee is covered by the accident insurance of Savonia University of Applied Sciences during working hours if the student's official place of residence is in Finland, while the employer is responsible for arranging the liability insurance during the work placement period. If case of paid traineeship, the official work contract is made between the employer and the trainee. The employer will be responsible for meeting the terms and regulations governed by the legislation (e.g. insurance) of the work placement country.

The labour law applicable in this case is _____

The employer has liability and/or accident insurance for the trainee in case of accident in the workplace or on the work business: _____

The minimum terms and conditions of employment guaranteed by the applicable law are to be observed throughout the training period. This applies e.g. working hours, health and safety but excludes regulations concerning wages and salaries.

Data Registration:

Savonia Engineering and Technology has the right the register employer's contact information for the client registry and use the date for internship communication and marketing.

14.07.2015

Tykanen
Student

J. Hepp
Employer's representative

Anto Toim
Supervising Teacher