Project plan

Project #36
Software development for a wireless electrocardiogram

Date: 27.01.2018

Antti-Juho Nieminen
Miri Piironen
Claes Alexander von Numers
Thomas Jan von Steuben
Information page

Students
Antti-Juho Nieminen
Miri Piirainen
Claes Alexander von Numers
Thomas Jan von Steuben
Firstname Surname

Project manager
Jan von Steuben

Official Instructor
Ilkka Laakso

Other advisors
Support in relation to regulatory requirements, including medical safety, electrical safety, radio and EMC

Starting date
4.1.2018

Approval
The Instructor has accepted the final version of this document
Date: 27.01.2018
1) History

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1.0</td>
<td>2018-01-27</td>
<td>original</td>
</tr>
<tr>
<td>V2.0</td>
<td>2018-03-25</td>
<td>Change of roles for HW and embedded SW development between Miri and Jan. This was necessary to catch up on the schedule.</td>
</tr>
</tbody>
</table>

2) Background

In Biomedical instrumentation lectures, the Taipei Trading CO., LTD’s True Sense Kit is used for educational purposes. Based on feedback received from users of the product, there are areas of improvement related to hardware and software. The aim of this project is to design a user friendly interface for the Taipei Trading CO., LTD’s True Sense Kit. The software must be able to run on Windows, Linux and iOS. This kit is an educational kit for a wireless electrocardiogram. The current version in use is supplied by the manufacturer.

There are also some hardware related things that could be improved and will be taken into consideration during the project. As this is a commercial product there is no documentation of the hardware available. Sample code and instructions on how to receive the data from the TrueSense Kit are available.

Based on feedback received from users of the product, there are areas of improvement related to hardware and software. The option of a full redesign will be considered and carefully evaluated as the given time frame might result in a non-satisfactory result.

3) Expected output

The target use of this product is for educational purposes in the biomedical field and used to measure, record and visualize electrocardiograms. The expected result is a portable, user friendly product, with an easy to use interface and support of 3 to 5 electrodes to be connected. Furthermore, the the measurement data shall be stored to a edf file for further processing. Moreover, the product must be wireless for an easy setup of experiments, comply with regulatory requirements related to patient safety (IEC60601) as well as the European radio directive (RED). European regulations are sufficient, as this is only used at Aalto University for educational purposes. The software needs to be designed so that the patient is not recognizable from the gathered data and that the software is safe for the host computer.

The final product should include an intuitive GUI for connecting the measurement modules to a PC over a wireless connection, display the information in graphical form on the screen for multiple electrodes and record the data. In addition, the software implementation should include different filters to reduce the noise on the measured signals, also removing the 50Hz mains humming that is present in the current system.
The implementation of the new hardware, will be based on the Texas Instrument’s TIDA00096 demo board. Furthermore, safety will improved compared to the existing system and standard electrodes will be used. The application software for the PC is designed in the project. There should be at least 20 measurement modules assembled, supporting 3 to 5 electrodes each (support for 2 electrodes would be nice for a simpler test setup, but if the hardware does not support this, 3 electrodes are accepted). The hardware should function for a minimum of 1h, with 48h preferred. Primary batteries (non-rechargeable) will be used. Data logging is not required if all necessary data can be sent over a wireless link in real time.

4) Phases of project

Prestudy (2018-01-25)
Understanding the requirements for the application and understand the current hardware better to evaluate if the current equipment is sufficient or if a redesign is feasible or necessary. Furthermore an investigation of commercial electrodes and the wiring as such. In this phase the tools and roles are decided too.

Project plan ready (2018-01-29) (Milestone 1)
The project plan needs to be finalized by the 2018-01-29. This work should be done with the support of the instructor as a customer to ensure the project develops the right product.

Concept development (2018-02-05)
During the concept development phase, The project is considered from a big picture view, with a rough GUI layout definition and the functions to be implemented. The hardware functionality, shape and performance criteria will be defined.

Tools and learning
In order to make a successful product, the requirements for medical applications including measurements need to be understood. In addition, as these are wireless devices, the related regulatory requirements should be understood as well. The tools to implement the design need to be learned, e.g. PC software development (Python is a candidate), 3-D CAD software, schematic and layout tools.

PC software development: GUI (Milestone 2, 2018-02-16)
Designing and developing of the PC GUI, ensuring cross platform compatibility. Interfacing the hardware and data management, to store, display and post process the measured values. The milestone 2 is used to show the principle operation of the GUI presenting dummy data.

Measurement module design revision A (Milestone 3 2018-02-15)
Based on TI’s TIDA00096 demo board, a similar hardware development, component selection, schematic and layout are done. Prototype boards to be ordered by 2018-02-15 (MS3). Estimated delivery time for the PCB is 2 weeks from China. Components to be assembled are purchased during this time too. A suitable 3-D printed enclosure is designed.

PC software development, low end (Milestone 4, 2018-03-16)
Developing of the interface to the measurement module over a wireless link, and data storage. The milestone 4 requires some communication, but at that time, full functionality is not required.

Development of the embedded software (Milestone 4, 2018-03-16)
While the hardware is developed, the embedded software can be started by utilizing development boards for the chosen processor (CC2650 is a good candidate). In this way
there is a minimal delay due to hardware development. As the PC and the module must work together, the same milestone 4 is applicable for the embedded software

**Verification of the hardware and embedded software**

In this phase the hardware is tested to ensure proper operation and the signal quality is as expected. This can include EMC tests if possible.

**Testing with users (Ilkka and assistants)**

Using the products with the customers (students in the lectures) and get direct feedback for the user interface, is it intuitive, are any faults are found that we missed in our testing and if there is any functionality missing.

**Measurement module design revision B (hopefully final) (2018-04-15) (Milestone 5)**

There will be a need for a second revision to improve the found features. A new version of the enclosure might be required too.

**Mass production**

Ordering of the material for 20 or more pieces. These units must be assembled, this can be done by the project group, or if a service is used the costs should be considered.

**Finalizing the PC software (Milestone 6 2018-04-24)**

All features are implemented, feedback has been taken into consideration and implemented as feasible. After this stage, only bug fixes will be done, no new features.

**Finalizing documentation**

In this phase, the documentation is finalized, so that there are clear instructions on how to use the equipment and software. Furthermore the manufacturing documents of the boards, including assembly instructions must be ready and stored in the right place (Ilkka to define where). The software packages and the source code are provided to the right place (GITHUB?) so that further improvements can be directly based on that.

**Deliverables:**
- schematic
- layout
- gerbers
- Bill of Materials (BoM)
- source code and installation packages to Aalto version control
- User documentation
- a page on aaltowiki can contain all the documents

**Presentation**

Finalize the presentation material to be used in the final Gala latest by 2018-05-11, so that adjustments can still be made

**Final Gala 2018-05-15 (Milestone 7)**

Present the developed hardware and software in the final gala.

**Project ending**

Handover to the Instructor. Project completed and a small celebration!
5) Work breakdown structure (WBS)

6) Work packages and Tasks of the project and Schedule

6.1)  Work packages and estimated hours

Even though each package has one leader, the overall workload itself, or in case of unforeseen challenges, the work is shared among the team members, to achieve an overall equal balance, as well as the project’s goals. Learning is included in the work packages and taken into consideration with the amount of hours.

WP1 Project management (50h)
Jan von Steuben is responsible for this work package. This includes following the progress of the tasks as well as ensuring all tasks are assigned and balancing of the workload. Moreover, arranging meetings and preparing documentation related to the project

WP2 Pre-study (20h)
Alexander von Numers is responsible for this work package
This work package includes the following tasks:
Task 2.1. Feedback analysis. Feedback from the users has been received and must be evaluated (8h)
Task 2.2. Evaluation of the existing hardware vs a complete redesign. (12h)

WP4 PC software development lower layer (150h)
Alexander von Numers is responsible for this work package
This work package includes the following tasks:
Task 4.1. Learn Python (40h)
Task 4.2. Interface to the Bluetooth module in the PC (50h)
Task 4.3. Interface the measurement module via Bluetooth (40h)
Task 4.4. Data management, read and write the received data into an .edf and or csv file. (20h)

WP5 PC GUI development (150h)
Antti-Juho Nieminen is responsible for this work package. This work package includes the following tasks:
Task 5.1 Learn Python (40h)
Task 5.2 Graphic design. This is the overall layout of the PC software interface. (30h)
Task 5.3. Digital filter design, that can be chosen and applied to the measured data (30h)
Task 5.4. Represent the data as a graph. (30h)
Task 5.5. Display the measurements module’s battery level. (20h)

WP6 Hardware development and verification (130h)
Jan von Steuben is responsible for this work package. This work package includes the following tasks:
Task 6.1. Design and verification of the electronics for the measurement module including schematic, layout design and production documents. (80h)
Task 6.2. Design of the mechanics for the measurement module. (50h)

WP7 Embedded software (120h)
Miri Piiroinen is responsible for this work package and it includes the development of the measurement module’s firmware to read the signals from the ADC and forward them over a wireless link to the PC.

WP8 Business aspects
Jan von Steuben is responsible for this work package. This requires to look at the project business minded, including regulatory requirements for commercialisation and a pitch.

WP9 Dissemination (85h)
Jan von Steuben is responsible for this work package, but each group member must provide the part for his own work. This work package includes the following tasks:
Task 9.1. Project plan, this document (25h)
Task 9.2. Final report, closing the project and provide all information on possible shortcomings of the implementation and how to improve it. (40h)
Task 9.3. Final Gala presentation. (20h)
6.2) Detailed schedule
7) Work resources

7.1) Personal availability during the project

Table 1. Number of hours available for the project (excluding lectures and seminars) per week.

<table>
<thead>
<tr>
<th>Week</th>
<th>Antti-Juho Nieminen</th>
<th>Miri Piirainen</th>
<th>Alexander von Numers</th>
<th>Jan von Steuben</th>
</tr>
</thead>
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<td>21</td>
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<tr>
<td>Total</td>
<td>194</td>
<td>194</td>
<td>200</td>
<td>202</td>
</tr>
</tbody>
</table>

7.2) Personal goals

Antti-Juho Nieminen

Digital services and solutions are my goal expertise I aim with my studies. So far I have dealt with hardware and mechanical aspects of the matter and gained some knowledge of for example radio electronics. During this course I pursue to gather proficiency in the software side of digital product design. I am starting from near-zero, and that challenge excites me most.
Another field of embedded systems design I am highly interested in is project management, which I will gather all the skills, tools, and methods I can find. I am involved other great and growing projects in the fields of technology, art, business, and fun-having (and a combination of all of those) where I can and will make use of the skills I have achieved during this course.

Miri Piironen
My plan is to become an embedded system specialist after my studies. Currently I have a fairly good knowledge and understanding about the software engineering, but still find my hardware skills lacking. This project has given me a chance to learn hardware design and get to know the tools needed for designing PCBs and drawing schematics. During the process I will hopefully become better at reading data sheets and finding the needed information from them.
Since I am quite familiar with the software design I will try to help our software developers to the best of my capabilities, and hope to also learn something new from that area as well.
The project functions as a great platform in binding together what I’ve learned through my engineering studies.

Alexander von Numers
I have been studying automation technology, where there is not a lot of hardware or hands on exercises. Therefore, this project work will help me understand the basics in developing and assembling a ECG system from scratch and understanding the logic behind the component choice and why some are better suited than others. Moreover, I have never programed a UI or any kind of and look forward to learning and coding that part of the project.
Since I have only recently changed my major study path to health and wellbeing, this is exactly the kind of project that I might work on in the future. Therefore I want to understand every aspect of the project and have a good understanding of our choices.

Jan von Steuben
Having been involved in product development projects over the past 10 years, stepping into the project managers role will provide me with more insights into planning and executing of projects. Gaining a better understanding of different ways of working and how to combine them and how to make a good and motivated team will be a valuable skill in the modern work environments. As I do have experience in the field of electronics design, I chose not to do the electronics, but embedded software instead, and rather advice. The gained knowledge and understanding when writing the embedded software will help in my work, when collaborating with the embedded software engineer.

8) Cost plan and materials
In order to support the hardware development, the following costs estimates are expected to occur.

<table>
<thead>
<tr>
<th>item</th>
<th>price</th>
<th>comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrodes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prototype round 1</td>
<td>290</td>
<td>5 to 10 units to be made, some spare to break them</td>
</tr>
<tr>
<td>Prototype round 2</td>
<td>290</td>
<td>5 to 10 units to be made</td>
</tr>
<tr>
<td>production run of 20 pcs</td>
<td>580</td>
<td>20 units</td>
</tr>
<tr>
<td>Prototype round 3 (just in case)</td>
<td>280</td>
<td>This is a reservation in case a third revision is required</td>
</tr>
<tr>
<td>other material or licenses?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
9) Other resources

- A room for group work (possible weekends), Maarintalo is open 24/7
- 3-D printer,
- Lab access with an oscilloscope and a soldering iron
  - Otakaari 3 (Ilkka has a key)
  - ele lab Anti-Juho with the key for the lab (Otakaari 5I, Otaniemi, 02150 Espoo)
- consulting in regulatory requirements (Raimo Sepponen)

10) Project management and responsibilities

**Project Manager**

The project manager's role is to ensure all tasks have been assigned and proceed as planned. It is the project manager's responsibility to follow the progress and keep the schedule. In addition, the project manager arranges the meeting with the group and the instructor, as well as organizes the tools and funding required from the instructor.

**Instructor**

The instructor is acting as a customer to the project team and offers advice on the implementation and fields of his expertise. Furthermore, the instructor is responsible of providing funding for the necessary hardware and handles the purchasing of required materials.

**Work Package Leaders**

**Hardware**

The hardware work package leader is responsible for the design of the schematic and layout for the measurement module. The design or selection of the enclosure is part of this package.

**Embedded Software**

The embedded software work package leader is responsible for the measurement module's software and that all necessary functions are implemented.

**PC hardware interface software design**

The PC software design package leader is responsible for the lower level of the PC software, interfacing with the hardware and data storage related features.

**User GUI design**

The GUI design work package leader is responsible for the development of visual aspects of the PC software

**Business aspects**

The business aspects work package leader is responsible for the business plan and the pitch. This work package includes also the regulatory requirements.

11) Project Meetings

Regular project meetings are on a weekly basis in period 3 they are Mondays 14:00 to 16:00. In period 4 and 5, meetings schedule might be adjusted, depending on the project’s members schedule. Additional meetings are arranged as needed. Group work will be done in workshops, one day a week. The day is changing, depending on the availability.
- Memo Keeper: Jan  
  - The meeting memo is stored on google drive
- General meeting agenda as below, changes as needed, and to be provided prior the meeting by the project manager.
  - summary of achievements, 5 minutes each, maybe a small Demo
  - Plans for the next week
  - what is stopping the progress (e.g. waiting for another function to be completed)
  - distribution of workload (some tasks might be estimated wrong, or new tasks came up)

12) Communication plan

The following tools are in use for communication:
- weekly meetings face to face, including the instructor, availability to be confirmed
- one day a week workshop for group work
- unscheduled meetings with the instructor will be called in severe cases that can affect the project outcome
- ad-hoc meetings among the team as needed
- Google drive is used for file sharing (instructor has access too)
- for ad-hoc discussions a Telegram group has been established, also the instructor is present
- Trello (Kanban) is used for task listing and progress monitoring.
- email

13) Risks

The following risks have been identified.

<table>
<thead>
<tr>
<th>Risk</th>
<th>Description</th>
<th>Likelihood</th>
<th>Impact</th>
<th>Mitigation action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group member cannot complete</td>
<td>Due to illness, other responsibilities or underestimating the effort for a</td>
<td>high</td>
<td>high</td>
<td>not too large tasks and early identification and response.</td>
</tr>
<tr>
<td>task on time</td>
<td>given task can lead to that an assignment not being completed in time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group member leaving</td>
<td>for any reason a group member quits</td>
<td>low</td>
<td>high</td>
<td>re-evaluation of the project scope</td>
</tr>
<tr>
<td>knowledge gap (tools and</td>
<td>learning of limitations of chosen ideas and tools will become obvious when</td>
<td>high</td>
<td>medium</td>
<td>try to plan early on and communicate the challenges asap, so a new way/workaround</td>
</tr>
<tr>
<td>medical)</td>
<td>they are needed, not during the planning phase</td>
<td></td>
<td></td>
<td>can be found</td>
</tr>
<tr>
<td>Not enough funding</td>
<td>further proto rounds are required, but no funding anymore available.</td>
<td>medium</td>
<td>high</td>
<td>Review the work, to spot the flaws, review also the demo board design (especially</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>layout). Include the regulatory aspects right away (especially safety)</td>
</tr>
</tbody>
</table>
Breaking parts or damaging parts | short circuit, breaking or other malfunctions | medium / low | medium | Replacing the part, affecting the budget and additional delivery time add on

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14) Quality plan

The concept and progress will be evaluated by the project team and the instructor as a customer to ensure the final outcome meets the expectations and requirements. Parts which are defined in this plan represents what will be implemented. Any additional requests or changes must be evaluated and might cause other features and functions to be removed in order to reach the goal with in the given timeframe and budget. All finished tasks and documentation will be reviewed by at least one peer, to ensure continuous delivery of quality in software and hardware. The software must be well documented. The design must also be discussed and reviewed by an expert in the field of medical safety.

The project manager is responsible to monitor the progress of the project and ensure that the work is evenly distributed, to reduce the risk of “rushed” designs. For this Trello is used. Any upcoming quality problem, depending on the severity should be informed either in the weekly meeting or called for immediate attention.

For the assembled batch of 20 units to be delivered, every single unit must undergo full functional testing by the project team prior to delivery.

15) Changing this plan

In the case of unforeseen problems or a change of scope, the project plan needs to be updated. In order to change the content of this document after acceptance, the entire group and the instructor must come to a common conclusion. The change will be documented and the new revision of this document must be approved by the instructor.

16) Measures for successful project

The project’s outcome will be evaluated in the following way:

- Did we achieve all the set goals
- The system works on all three major platforms (Windows, Linux and iOS)
- Is the UI design satisfactory
- Is there an improvement to the hardware’s robustness
- What is the quality/stability of the code
- Is the code well documented
- Is the projects outcome documented well

The projects process will be evaluated in the following way:

- did we adhere to the schedule
- Communication and documentation practices, including tool utilisation (meeting efficiency, memos, trello board)
- Staying on budget
- Overall team satisfaction
- Individual learning outcome, compared to the set goals