WaveMeIn

WaveMeIn: Authentication via Brain Waves

188.407: Management von Software Projekten

Group: 10

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1 Synopsis

1.1 Project Idea

WaveMeIn is a research project to create a new type of secure login mechanism. It consists of a small device worn by the user at the ear which authenticates the user based on brain waves.

1.2 Why do we need it?

At the time of this proposal the most used ways for authentication are manually typed passwords or biometric authentication methods. However all of the previous methods have some security problems or are simply not user-friendly. Typed passwords are easy to spy out simply by looking at the keyboard of the user or the traces of the fingers on touch displays. In the case of biometric authentication, there are for example face recognition, iris or fingerprint scans. Face recognition software can easily be tricked by face masks or photographs and moreover depends on good light conditions, the quality of the images of the web camera and other factors. Fingerprint and iris scans are the most secure options of the authentication methods mentioned before. However they also have many disadvantages. Iris scans are not practical since the hardware required cannot easily be integrated into small devices and it is not user-friendly to require the user to place his eye very close to the scanner every time he/she wants to unlock a device. Fingerprint sensors are known to fail to recognize the fingerprint correctly quite often and it is also a not very user-friendly authentication method for handicapped people that may not reach the sensor or may not have any fingers at all.

1.3 How does it work?

Brain waves are a secure and user-friendly alternative authentication method. The idea is to create a small device, called Wavy, that can be worn at the ear of the user in the same style as bluetooth headsets are already worn for communication today. The Wavy measures the brain waves near the ear in case a login is required by a client device that is connected via bluetooth. It listens for a brain wave pattern that was previously trained by the user as a password. If the correct pattern was detected by the Wavy it transmits a OK signal back to the client device.

1.4 Why should somebody care?

Nowadays people are forced to type their passwords in public places which is a security risk and also not a very efficient way for authentication. Especially when typing in password on small devices such as mobile phones this authentication method is also very error prone due to the small keyboard interfaces. On the one side people are lazy and do not want to remember and enter long and complicated passwords, but on the other side they are also concerned about the security of their data and their privacy. So the users are in need of a more secure and easier way of authentication.

1.5 Who are the beneficiaries of the results?

Basically everybody can benefit from the WaveMeIn project since it is usable in the daily life. Especially for handicapped people it is a new and more easy to use option to log into their devices. Also it grants a higher level of security than existing authentication methods so it is also well suited for environments where higher security is needed, such as access authentication is modern research labs and government or military facilities.

For our product to succeed, we need to invest into research in the area of brain wave detection and analysis. This investment can improve our understanding of this topic. After a commercial success, we have to enhance our product. This means we have to invest further into brain wave

research. On the other side, we can make our world more secure. It makes hacking of accounts and password fraud more complicated.

1.6 Problem classification

The task of detecting brain waves it tightly connected to the research areas of Neuroscience, Pattern Recognition and Machine Learning. In the field of Neuroscience it touches the areas of not invasive brain computer interfaces and neural oscillation. Since detecting and reliably identifying brain waves at the location near the ears is still technically immature the project can be seen as basic research in this area. The following research questions have to be answered before a prototype can be developed.

- Detecting brain waves at the ears

- Recognize brain wave patterns

- Distinguish correct patterns from random signals

- Distinguish brain waves from different users

On the other hand if we take the Wavy into account, which should be the resulting product, this project is also an applied research project. It further touches the fields of computer security and privacy.

2 Introduction and problem description

WaveMeIn is a research project to show the potential of brain waves, a new method of electronic authentication via a small wearable device. Its aim is to investigate the usage of brain waves to replace passwords or other authentication methods. Therefore the properties of brain waves regarding uniqueness and reliability have to be explored. The project shall demonstrate via a small prototype that the recognition is possible without large sensors on top of the users head. A requirement for such a method of authentication clearly exists as demonstrated by the following use cases:

2.1 Use Case 1

Assume a user needs to log on to a device (e.g. a notebook) that contains sensitive information in public. Typing in the password is not an option as it can easily be monitored by another person. Fingerprints are also not a good alternative as they can easily be taken from any surface the user touched and be copied onto synthetic materials to deceive the fingerprint reader. Brain waves are (as of current knowledge) unique for each person even if two people are having exactly the same thought. If the intruder does not know the precise brain wave pattern of the user's pass phrase/thought it is impossible to duplicate.

2.2 Use Case 2

Assume an average user wants to unlock his/her smart phone in a crowded area such as the subway. Nowadays this is done by entering a pin or drawing a pattern on the screen. A person with the intention to steal a users phone just needs to observe its victim while entering the pass code or pattern. Afterwards it is easy to unlock the phone and steal the victims personal data or cause large costs while using it for phone calls and mobile data. Locking the phone via a brain wave authentication mechanism may not prevent the theft but the costs arising from the phone being used afterwards.

2.3 Current Authentication Methods

In theory brain waves will be rank among the most secure authentication methods, probably being the most secure one if the research proves successful. The particular brain wave of a user required to unlock a device can not be obtained easily other than strapping the user to a chair and forcing him/her to think his/her pass thought. Other authentication methods are password, drawing patterns, fingerprint, iris scan, voice recognition. Passwords and pattern drawing are the least secure ones as the user can be observed while typing or drawing without much effort. Fingerprint, iris scan, voice recognition may require more technical or social effort to obtain, but in the end all of them are features of a person that are always visible for the outside world and therefore copyable with more or less effort.

2.4 Unresolved Problems and Opportunities

The unknown factor of this research project is that no research has been done on measuring brain waves at other locations (e.g. the ears) of the body except directly at the users head. Additionally it is unknown if the brain waves of are person are distinctive enough to distinguish a pass thought of a user from other thoughts and if the brain waves of different users while thinking the same thought are distinctive enough.

At the time of writing this proposal there exists no device that is capable of the features mentioned above as well as being small enough to be worn as an accessory. Therefore this is an important area of research with practical future applications.

3 Project goals and deliverables

The following sections will provide an overview over the research questions and hardware questions associated with the project.

3.1 Research questions

- How can brain waves be detected by a small device at a single location?

- How reliable is the detection of individual brain waves of the same person?

- How reliable is unique identification of the brain waves of different persons?

- Is it possible to detect brain waves at other body locations than the head?

3.2 Hardware Design

- How can the required hardware be minimized to be small and practical (Wavy Device)?

- Are the existing sensors for measuring brain waves good enough for the projects requirements?

3.3 Expected Results

- Successful research on the identification of brain waves.

- Algorithms to reliably identify brain wave patterns.

- Creation of a small prototype device capable of reading brain waves.

At the end of the project it should be clear if:

- The detection of brain waves is possible at different locations of the body.

- The same thought produces a repeatable and reliable brainwave pattern. (Reliability)

- Different people have different patterns when thinking the same thought. (Uniqueness)

- Brain waves can be used as authentication method.

- The necessary can be integrated into a small device.

3.4 Non-Goals

- No mind reading device

- No client software (just the brain wave research, hardware and interface)

- No design or usability study (just a prototype that works and is small enough)

- No end-user/consumer product (just a prototype)

4 Scientific relevance and innovative aspects

WaveMeIn can be seen as an important step in the development of brain-computer interfaces used on a daily basis. Given the huge possibility, many private corporations as well as research institutes initiated promising projects. To get a quick overview see Section 5.

4.1 Simple step into real life

The use case of brain wave controlled interaction in WaveMeIn is still kept simple, as it is used only to unlock a device and no further commands have to be recognized. On success, following projects can base more sophisticated ways of interaction on results of WaveMeIns research. Even if this project covers a lot of ground work as well, the focus is to create a product usable on a daily basis. Therefore it goes a little further then most other project in this field, as they concentrate on mostly one specific aspect.

4.2 Brain wave recognition

In the field of neuroscience the main question will probably be, what kind of brain waves produce recognizable patterns of the same imagination. Another question is, under what circumstances do brain wave scans look similar. Does the pattern change if the context of the person changes, like a noisy environment, strong emotions or the effect of drugs? The link to pattern matching in computer science would be, how to match the original password-pattern, recorded in a probably neutral state and the input-pattern within a shifted context. This leads to the question, if a brain wave pattern can be normalized without knowledge of the specific context.

4.3 BCI improvement

In conjunction with electrical engineering the BCI itself should be revised. The goal is to shrink the scanner to a minimum so it does not disturb while wearing it for many hours in public. There not only size matters but the position of the scanner should be as flexible as possible. That said, a scanner with the proportions of a Bluetooth headset seems appropriate but not feasible at the moment. One task is to raise the level of detail of the scanners and in the same time to suppress undesired noise. It is still unclear what areas of the head are viable to work with an even improved non invasive BCI.

4.4 Device security

Since WaveMeIn is not only meant to simplify the unlock mechanism, but to raise the security of the procedure as well, this will be an important task in the area of computer science. The password itself is an interpretation of a specific thought and therefore never conventionally visible as maybe a fingerprint or a typed password. But still, it will be scanned, processed and the interpretation itself or at least a answer will be sent to the device that is waiting to get unlocked. The most vulnerable moment is during transport of the data. The security requirement should be comparable to wireless networks or Bluetooth connections and is therefore a well researched area already.

5 State of the art / current knowledge

5.1 What results and approaches have already been presented in this or related areas?

5.1.1 Berkeley researches replace passwords by measuring brainwaves as a biometric identifier

The US Berkeley represents an approach, which turns the brain activity of an user into a biometric identifier. To do this, the Berkeley researchers use a commercial EEG (electroencephalogram), which resembles a Bluetooth headseat with an electrode. This electrode is placed on the users forehead, over the brain's left frontal lobe. The electrode measures the users brainwaves and transmits them via a Bluetooth link to a Device. According to the Berkeley researchers this system has an error rate of below 1 percent.

To ensure that the brain waves of every single person are unique and that they provide enough information to authenticate the user's identity, the Berkley researchers performed tests with participants, which included different kinds of tasks. For example, the participants where asked to just sit and focus on breathing in and out, imagine moving their finger up and down and listen for an audio tone. The participants where also asked to focus on a personalized secret, such as singing a song of their choice. During this tasks, the participants where wearing the EEG which measured their brain waves. As result came out, that not only the measured brainwaves of personalized secrets, but also measured brainwaves of simple tasks, like sitting and focusing on breathing, provided a pattern which makes it possible to authenticate an identity.
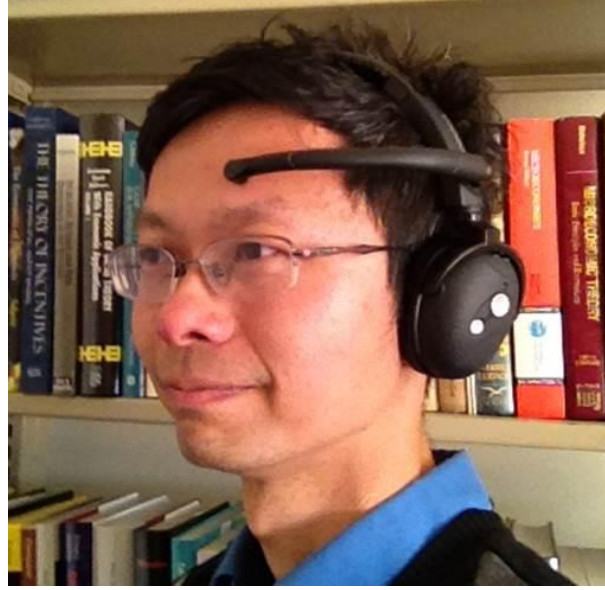
Figure 1: Professor John Chuang with the Neurosky MindSet brainwave sensor.

5.1.2 Using brain waves as a new biometric feature for authenticating user in real time

Using brain waves as a biometric feature for authenticating was proposed by Kusuma Mohanchandra, Lingaraju G M, Prashanth Kambli & Vinay in the International Journal of Biometrics and Bioinformat. In this work it has been proved that the brain-wave pattern of every individual is unique and the signals captured through the EEG can be used for biometric authentication. This research team used an EEG EPOC headset with 14 channels to measure the brain waves. The collected data, containing the fusion of delta, alpha, theta, beta and gamma brain waves, was merged with the aim to create a way to authenticate the user.

In Fladby (2008) three basic forms of authentication are identified: something-you-have, something-you-know, and something-you-are. According to Fladby (2008):"

- Something-you-have can be objects like a key or passport and people have to be very careful not to loose the object or get it stolen.

- Something-you-know is based on secret knowledge like passwords or PIN codes and the secret must never be written down, forgotten, or told to others.

- Something-you-are involves person specific features like fingerprints, voice, face, and gait. Authentication based on such features is called biometric authentication. Brain wave based authentication is a combination of something-you-know and something-you-are when the person involved has to think about something specific, but it can also be just something-you-are when the brain waves are used directly as a biometric.

The most important part of any authentication system is that true identities are verified and that false identities are rejected. In a password system the password is either right or wrong, but with biometric authentication there is an uncertainty involved because the equipment that measure the biometric feature rarely provide exactly the same data twice. The reason is that external parameters like finger placement, head rotation, facial hair, location etc are present. The challenge is to overcome these problems in such a way that even two slightly different sets of data can be verified to originate from the same person. There is usually a threshold that decide how different two different sets of data is allowed to be before they are rejected, and as

a consequence there is a chance that some clients are falsely rejected and some impostors are falsely verified. Biometric authentication therefore introduce two error rates: False Non-Match Rate (FNMR), the rate at which clients are falsely rejected by the system, and False Match Rate (FMR), the rate at which impostors are falsely verified by the system. As such the main problem in this thesis is two compare two or more EEG signals and decide whether they are from the same person or not, and get as low FNMR and FMR as possible."

5.1.3 Google Glass hack allows brainwave control

After Google has released his Google Glass, a company called "This Place", has developed an app to control the glass over brain waves. However, the app alone is not enough to control the glass with the power of your mind. Normally the Goggle Glass is controlled over voice commands or over a touchpad built into the side of the device. To control the device with brain waves "This Place" combined the Google Glass with a Neurosky MindWave headset. The Neurosky MindWave is an EEG-headset to detect brain waves. This is one of the first devices for consumers. Normally this headset will be used to train your brain and it will be delivered with a hand full games. After combining the two devices, the company begined with testing the different kinds of brain waves they could detect. For this reason they created a simple app which implemented a counter starting at 0. When the user concentrated, the app began counting upwards towards 50. When the user started to relax, the counter began returning to 0. After this successfull test, they created an app to show a real-world use, called MindRDR. It allows an user to take a photo and share it over Twitter only by using his mind. Very important to know is that the brain waves only activate the camera app at Google Glass and take a picture. The settings for Twitter were set before. They released their software for free, in hope that other developers can adapt it for other uses.

5.2 Relation to the international scientific work in the field (international status of the research)

The very beginning of the existence of brain wave based authentication systems dates back to the 1960's when Vogel discovered a connection between a person's EEG signals and his/her genetic code(DNA). It was proved that every person owns unique brainwaves and it possible to identify a person through his brainwaves. Identical twins where shown to have the same EEG patterns in the same situations and even changes related to aging were similar.

The brain consists of billions of brain cells called neurons. This neurons have to communicate with each other. For this communication the neurons use electricity called brain waves. This communication is producing a lot of brain waves, which can be detected using sensible sensors such as an EEG. The first person, who confirmed the existence of brain waves and performed the first tests was Hans Berger. There are five different kinds of brain waves and all of them are directly connected to what a person is thinking, doing and feeling:

- Gamma (27 Hz and up)

- Beta (12 Hz - 27 Hz)

- Alpha (8 Hz - 12 Hz)

- Theta (3 Hz - 8 Hz)

- Delta (0.2 Hz - 3 Hz)

This was also explored by Benedicenti (2001) in the year 2001. This researchers used EEG directly as a biometric and their work showed some promising results on this field.

EEG based person authentication was first proposed by Marcel and Millán (2005) in "Person authentication using brainwaves (EEG) and maximum a posteriori model adaption". They proposed the use of Power Spectral Density as the feature, and a statistical framework based on Gaussian Mixture Models (GMM) and Maximum A Posteriori Model (MAP) Adaptation on speaker and face authentication. The potential of their method is shown by simulations using strict train/test protocols and results.

In Poulos et al. (2001) Poulos, Alexandris and Evangelou performed person identification based on spectral information and presented their results in their work: "On the use of EEG features towards oersin identification via neural networks". To prove the connection between a person's EEG and genetically specific information, this researchers did experiments with the EEG data of healthy individuals. The proposed method has had a success rate of 80 percent to 100 percent showing that the EEG holds genetic information, which can be used for person identification.

Furthermore, a novel two-stage biometric authentication method was proposed by Palaniappan in Palaniappan (2008). Their results show that the combination of two-stage authentication with EEG features has good potential as a biometric as it is highly resistant to fraud.

5.3 Description and critical discussion of related scientific work

The approaches that have been discussed above have succeeded to prove the connection between a person's DNA and her/his brain waves. The approaches clearly show that every single person possesses unique brain waves, which can be used to identify a person. However, a large disadvantage of all of this approaches is that they require the user to wear a big headset with an electrode going across his/her forehead. None of this approaches has succeeded in measuring brain waves from different body parts in order to enable a smaller headset and therefore make it easier for the user to use it in their everyday life.

6 Method

6.1 How should the expected results be achieved?

In the first place some basic research about brain waves should be done in order to achieve the expected results and build a device for brain wave based authentication. The goal of the projects research part is to clarify the scientific requirements needed for the creation of the prototype. There are two main scientific questions that need to be answered. First, confirm the uniqueness of brain waves or define how specific brain waves of a person can be identified. This is important since we want to assure that the user can be identified as the same one later again. It should be guaranteed that thoughts provide a reliable identification method, therefore the research should give answers how reliably brain waves of a person can be identified. Second, besides confirming the uniqueness of a persons brain waves compared to the brain waves of others, another important factor is to confirm that the brain waves of a specific thought of a person are distinguishable from other thoughts of the same person. To prove our assumptions about the uniqueness of brain waves experiments will be conducted on human subjects in the empirical part of this project.

The research part consists of two phases – a theoretical and an empirical research part. The purpose of the theoretical part is to analyse existing studies and use the results for the project. Already existing studies confirmed the possibility of authentication via brain waves, but so far no study managed to measure brain waves from different head parts than the forehead. The studies showed theoretical approaches to measure brain waves using EEG electrodes placed at the users forehead. The goal of the theoretical research part is to use this approaches and sensor minimising methods in order to define requirements for building a small device, called Wavy.

Therefore, the goal to measure brain waves from different head or even body parts is a very important part of the research. The Wavy device should be as small as possible and designed in a way which allows the user to wear it in everyday life. The ears will be the primary focus of this research for measuring brain waves at positions less visible then the forehead. This will enable the Wavy device to be worn like an accessory on or behind the ear.

In the empirical part there will be some practical tests with human beings, where their brain waves will be measured with an EEG in different situations. The goal of this research part is to confirm the uniqueness of two peoples brain waves, even if they think about the same thing. The approach from UC Berkeley, which John Chuang presented at the 17th International Conference on Financial Cryptography and Data Security, is a good one to use for the project. In this approach the participants were asked to perform seven mental tasks. These were divided into two categories. For the first group of tasks - which was the same for all participants - the subjects were asked to do simple things, for example to focus on their own breathing, imagine moving a finger, or to listen for an audio tone and respond to that by focusing on a dot on a piece of paper. For the second group of tasks - which participants selected and performed individually without letting others know what they were doing - the subjects were asked to select from imagining performing a repetitive motion from their favourite sport, such as swinging a golf club; singing a song of their choice; watch a series of on-screen objects and silently count those that matched a color of their choice; or think of something for 10 seconds. Adhikari (2013) These tests will be repeated over several weeks to verify the critical uniqueness of a person's thoughts as mentioned above a prolonged period of time. With such tests the Berkeley researchers managed to ensure that brain waves provide enough information to authenticate the user's identity. This kind of tests will be also done with users in our empirical research part.

6.2 What methods will be applied?

The following methods will be used:

6.2.1 Theoretical study

The goal of the theoretical study is to gather information from existing studies on this field. Several different studies already investigated the possibility of using brain waves as access method. Their findings will be used as a start point for our research. Researchers in the field of neuroscience and computer science will be needed for this task which will be part of the first work packages at the beginning of the project.

6.2.2 Experiments

This part consists of performing practical tests with participants. During these tests the users will wear an EEG device and will be asked to think of some simple things as well as thinking of some personal memories or for example their favourite song. The experiments will define whether brain waves of every single person are unique and how reliable they can be measured from different body parts. The participants will have to be selected as heterogeneous group so that the experiments can be performed on people with different characteristics such as male/female, adult/children, etc. Neuroscience and computer science are the required fields of expertise for this part. The results of the experiments will also determine which sensors are best suited for the future prototype. The human brain produces a wide range of different brain waves with different frequencies. Some of these frequencies are more important to thought recognition than others. Available EEG devices can measure delta waves (0.5 to 3 Hz), theta waves (3 to 8 Hz), alpha waves (8 to 12 Hz), beta waves (12 to 38 Hz) and gamma waves (38 to 42 Hz). The experimental part will narrow down the range of waves that are best suited for our goals.

6.2.3 Prototype

In order to get to this project phase the first phase which includes the brain wave connected research part should be completed. The goal of this phase is to use the results from the research part and create the Wavy prototype and write a demo software. The Wavy should be as small as possible and communicates with the user's device via Bluetooth. It listens for a brain wave pattern that was previously trained by the user as a password. If the correct pattern was detected by the Wavy it transmits a OK signal back to the client device. A demonstration software shall be written to show how the Wavy device can be used. This work will require an hardware and a software engineer to work together with the researchers.

6.2.4 Scientific study

At the end of the project the security and usability of authenticating via the Wavy device will be compared to existing authentication methods. This study should generate a comprehensive report which can be published to show the advantages of this new authentication method and raise the public's awareness for it.

7 Detailed description of the workpackages

WP 1 - Basic research

- goal(s): The goal of the research part is to clarify the scientific requirements, needed for the creation of the prototype.

- description: This work package deals with the brain waves related part of this project.

- expected results: Thought identification, confirmation of the uniqueness of brain waves, measuring brain waves from different body parts.

- responsible person: Neuroscience researcher

- dependencies: none

- start date: 05.01.2015

- end date: 05.07.2016

WP 1.1 - Confirm uniqueness of a person's brain wave pattern

- goal(s): Confirm assumption of persons unique brain waves.

- description: Every person has an unique brain wave pattern for the same thought. This pattern can be used to identify the person.

- expected results: If the research shows unexpected results and it the uniqueness can't be proved, it will limit the security aspect of the project, but it still can be realised.

- responsible person: Neuroscience researcher

- dependencies: none

- start date: 05.01.2015

- end date: 05.07.2015

WP 1.2 - Reliable thought identification

- goal(s): Confirmation of our assumption, that a thought of a person can be identified again as the same.

- description: Research on how a specific brain wave of a person can be identified reliably.

- expected results: A person can be identified again as the same.

- responsible person: Neuroscience researcher

- dependencies: WP 1.1

- start date: 05.07.2015

- end date: 05.01.2016

WP 1.3 - Measuring methods of brain waves from different parts of the head

- goal(s): Existing studies showed theoretical approaches to gatter brain waves with in-ear or behind-ear EEGs. The goal is to use this approaches and define requirements for building a small device to measure brain waves.

- description: In this package we attempt to define requirements for building a small device.

- expected results: Prove that brain waves can be measured from different head-parts than the forehead.

- responsible person: Neuroscience researcher

- dependencies: WP 1.2

- start date: 05.01.2016

- end date: 05.07.2016

WP 1.4 - Survey of state of the art for sensors and devices for brain wave measurement

- goal(s): Analyse the hardware components of existing brain wave measurement and gather enough information to build a small device.

- description: There already exists a lot of sensors for detecting brain waves. Main part here is to look, if a device already exists or if we buy a existing one a make it smaller.

- expected results: Today do probably exist decent sensors, but none exactly as needed for the planned tiny device.

- responsible person: Hardware engineer

- dependencies: none

- start date: 05.01.2015

- end date: 05.01.2016

WP 2 - Hardware and software development

- goal(s): Develop prototype hardware and software for showing the success.

- description: To show that authentication over brain waves works, we have to develop a hardware prototype. There different kinds of software we have to develop. First an algorithm to ensure fault tolerance and an interface for the communication with the device.

- expected results: The developed application shows a successfully communication with the device.

- responsible person: Hardware engineer

- dependencies: WP 1.2

- start date: 05.07.2016

- end date: 05.07.2017

WP 2.1 - Reviewing of existing algorithms for detecting patterns in measured brain

- goal(s): To identify the thought of a person.

- description: It is possible that the same thought of a person can be shown different in the brain wave. For this case we need some patterns to confirm the measured brain waves.

- expected results: A working algorithm with good performance.

- responsible person: Computer science researcher

- dependencies: none

- start date: 05.07.2016

- end date: 05.10.2016

WP 2.2 - Develop new algorithms for detecting patterns in measured brain waves

- goal(s): Develop the needed algorithms.

- description: If there are no existing algorithms for detecting patterns in measured brain waves, which can be used in this project, then new ones need to be developed.

- expected results: Our algorithms need to be reliable and fast.

- responsible person: Computer science researcher

- dependencies: WP 2.1

- start date: 05.10.2016

- end date: 05.01.2017

WP 2.3 - Define the communication protocol and interface of the Wavy

- goal(s): A software interface for the Wavy

- description: Develop an software interface for other applications to communicate with the Wavy. This interface should operation system or other developers allow to handle their authentication over Wavy.

- expected results: A easy usable and reliable software interface implement for several programing languages.

- responsible person: Software engineer

- dependencies: none

- start date: 05.07.2016

- end date: 05.07.2017

WP 2.4 - Develop small sensors for brain wave measurement

- goal(s): Develop small sensors for brain wave measurement so they can be placed in the Wavy.

- description: Because the Wavy should be build as tiny as possible small sensors are needed.

- expected results: This work results in a tiny fully functional sensor for surement.

- responsible person: Hardware engineer

- dependencies: WP 1.4

- start date: 05.07.2016

- end date: 05.01.2017

WP 2.5 - Develop a microcontroller for the Wavy

- goal(s): A microcontroller to handle and identify brain waves.

- description: Develop a microcontroller thats manage the detection and identification of brain waves. It is working with the developed algorithm and sending it over a bluetooth interface to a chosen device. The communication with the controller is handled with the developed software interface.

- expected results: A working microcontroller.

- responsible person: Hardware engineer

- dependencies: WP 2.2, WP 2.3

- start date: 05.01.2017

- end date: 05.07.2017

WP 3 - Prototype development

- goal(s): A device that is similar than the device for the consumer.

- description: Develop a prototype which can satisfy all requirements

- expected results:

  - Wavy prototype
  - Demonstration software
  - A study confirming the superiority of our new method

- responsible person: Hardware engineer

- dependencies: WP 2

- start date: 05.07.2017

- end date: 05.07.2018

WP 3.1 - Create the Wavy prototype

- goal(s): Develop a wearable prototype.

- description: The Wavy prototype doesn't have to be the final product but it should function like specified above.

- expected results: working prototype (Wavy)

- responsible person: Hardware engineer

- dependencies: WP 2

- start date: 05.07.2017

- end date: 05.03.2018

WP 3.2 - Write a software prototype

- goal(s): Write a simple prototype including all essential features of WaveMeIn.

- description: The software prototype should implement the software, which is required for using the WaveMeIn Features.

- expected results: A small software to show how the Wavy device works (log in to an operation system).

- responsible person: Software engineer

- dependencies: WP 2

- start date: 05.07.2017

- end date: 05.03.2018

WP 3.3 - Comparing with existing authentication methods

- goal(s): certificate, publicity

- description: An external research comparison.

- expected results: Confirm that the safety of this authentication method is superior to any other authentication method.

- responsible person: Computer science researcher

- dependencies: WP 2, WP 3.1

- start date: 05.03.2018

- end date: 05.07.2018

8   Time plan (Gantt chart)

As specified in section 7, the project consists of three basic work packages (each of them having several sub-packages):

- WP 1 - Basic research

- WP 2 - Hardware and software development
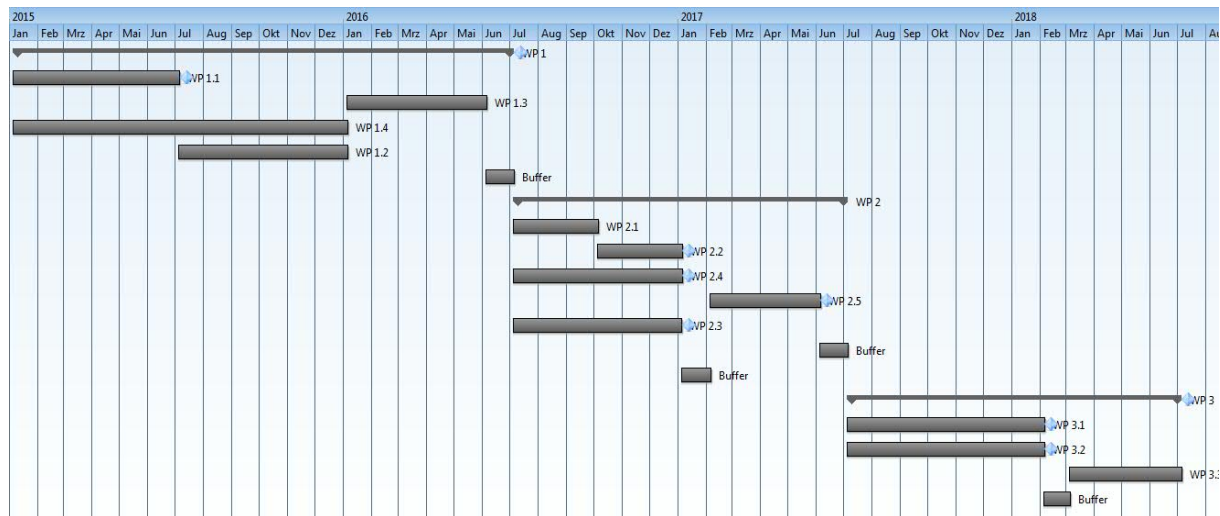
- WP 3 - Prototype development

Figure 2: GANTT Chart

Each of these packages consists of another sub-packages. Since the research part of the project delivers the basis for the whole project and therefore is the most important part of the project, it has a planned duration of 1,5 years. The planned duration of the hardware and software development package is 1 year and the duration of the prototype development package 1 year. Also there is a scheduled time buffer of one month in each package, which can be used in potential problematic situations and in cases of time delays appearances.

8.1 Milestones

The planned milestones of the projects are:

- 05.07.2015 - Confirmed uniqueness of a person's brain wave pattern

- 05.07.2016 - Research part completed

- 05.01.2017 - Hardware and Software for Microcontroller finished

- 05.06.2017 - Hardware Part Completed

- 05.02.2018 - Prototype Completed

- 05.07.2018 - Project Completed

8.2 Timeplan

The estimation of the schedule based on work packages:

8.2.1 WP1 - Basic research

- start date: 05.01.2015

- end date: 05.07.2016

- milestone: Research part completed

8.2.2 WP 1.1 - Confirm uniqueness of a person's brain wave pattern

- start date: 05.01.2015

- end date: 05.07.2015

- milestone: Confirmed uniqueness of a person's brain wave pattern

8.2.3 WP 1.2 - Reliable thought identification

- start date: 05.07.2015

- end date: 05.01.2016

8.2.4 WP 1.3 - Measuring methods of brain waves from different parts of the head

- start date: 05.01.2016

- end date: 05.07.2016

8.2.5 WP 1.4 - Survey of state of the art for sensors and devices for brain wave measurement

- start date: 05.01.2015

- end date: 05.01.2016

8.2.6   WP 2 - Hardware and software development

- start date: 05.07.2016

- end date: 05.07.2017

The Milestones for the work packages 2.2, 2.3 and 2.4 share the same milestone - Hardware and Software for Microcontroller finished and after this three work packages there is also planned a buffer of one month for eventual time delays.

8.2.7   WP 2.1 - Reviewing of existing algorithms for detecting patterns in measured brain

- start date: 05.07.2016

- end date: 05.10.2016

8.2.8   WP 2.2 - Develop new algorithms for detecting patterns in measured brain waves

- start date: 05.10.2016

- end date: 05.01.2017

- milestone: Hardware and Software for Microcontroller finished

8.2.9   WP 2.3 - Define the communication protocol and interface of the Wavy

- start date: 05.07.2016

- end date: 05.07.2017

- milestone: Hardware and Software for Microcontroller finished

8.2.10   WP 2.4 - Develop small sensors for brain wave measurement

- start date: 05.07.2016

- end date: 05.01.2017

- milestone: Hardware and Software for Microcontroller finished

8.2.11   WP 2.5 - Develop a microcontroller for the Wavy

- start date: 05.01.2017

- end date: 05.07.2017

- milestone: Hardware Part Completed

8.2.12   WP 3 - Prototype development

- start date: 05.07.2017

- end date: 05.07.2018

- milestone: Project Completed

8.2.13   WP 3.1 - Create the Wavy prototype

- start date: 05.07.2017

- end date: 05.03.2018

- milestone: Prototype Completed

8.2.14   WP 3.2 - Write a software prototype

- start date: 05.07.2017

- end date: 05.03.2018

- milestone: Prototype Completed

8.2.15   WP 3.3 - Comparing with existing authentication methods

- start date: 05.03.2018

- end date: 05.07.2018

8.3   Critical Areas

The critical areas of this project are in the research part, because if the research parts doesn't deliver the following results, the project will not fail but it won't lead to the planned project goals. The Work package 1.1 (Confirm uniqueness of a person's brain wave pattern) and 1.3 (Identify the methods to measure brain waves from different head parts) are the most critical parts of the project.

9 Human resources / team

9.1 Required Persons and Roles

- Project Manager
- Neuroscience researcher
- Computer science researcher
- Hardware engineer
- Software engineer

10 Costs

- *Length: 2-3 pages*

- Rough estimation of cost in form of calculation (table(s)) + descriptive text.

- Justification for the personnel and non-personnel costs (equipment, material, travel and other costs)

- An Excel template is provided as supplementary material to support budgeting.

- Personnel costs

    - Justification for the personnel to be assigned to the project (type of position(s), description of nature of work, length and extent of involvement in the project)

    - The application should include all persons who will be required for the proposed project (project lead, researchers, developers, advisory board, etc.). The available legal categories of employment are contracts of employment for full- or part-time employees (DV) and reimbursement for work on an hourly basis (GB). In addition, a part-time contract of employment (DV 50%, "studentische Mitarbeiter") may be requested for people who have not yet completed a Master or Diploma program (Diplom) in the relevant subject.

    - The justification of the requested personnel should contain:

        * description of type of work;
        * extent of involvement (part-time contracts are permitted).

    - Exact numbers of employment categories can be found on the FWF Website (http://www.fwf.ac.at/de/projects/personalkostensaetze.html)

- Equipment costs

    - Indicate reasons for equipment costs. The "scientific equipment" category includes instruments, system components, costs for the use of software required by the project and other durable goods provided the cost per item (including VAT) exceeds EUR 1,500.00.

- Material costs

    - This category encompasses consumables and smaller pieces of equipment where the cost per item is below EUR 1,500.00 including VAT. The calculation of requested material costs should be justified with reference to the schedule, work plan and experimental plan. Experience with previous projects should be taken into account.

- Travel costs

    - Funding may be requested for the costs of project-specific travel and accommodation, field work, expeditions, etc. Applicants are to provide a detailed travel (cost) plan broken down by project participant. For brief stays, the calculation of the travel and accommodation costs should be based on the federal regulations governing travel costs (RGV). The RGV rates governing Austria and abroad may be found in the FAQs on the FWF Website (http://www.fwf.ac.at/de/faq/reisegebuehrenvorschrift.html). For longer stays an appropriate and comprehensible cost plan should be prepared.

- Other costs

    - Independent contracts for work and services (costs for work of clearly defined scope and content assigned to individuals, provided that this is scientifically justifiable and economical)

    - Costs that cannot be included under personnel, equipment, material or travel costs, such as:

        * reimbursement of costs towards or for the use of research facilities, e.g. of large-scale research facilities (project-specific 'equipment time'). Applicants should obtain and submit multiple offers;
        * costs for project-specific work carried out outside the applicant's research institution (e.g. for analysis work performed elsewhere, for interviews, for sample collection, for preparation of thin slices etc.). Applicants should obtain and submit multiple offers;
        * honoraria for test persons;

11 Expected implications and risks

- *Length: 1-2 pages*
- Importance of the expected results for the discipline
    - To what extent does the proposed research address important challenges?
- Importance of the expected results for other areas
- What are possible risks of the project and how can they be alleviated?
    - What factors could lead to a failure of the project?
    - Which factors or persons could support the project and increase the chance for success?
    - What if important team members leave the project?

12 Ethical considerations & security issues

- *Length: 1-2 pages*
- Provide a brief explanation of the ethical issue involved and how it will be dealt with appropriately.
- Are there any security-sensitive issues that apply to your proposal?

References

Adhikari, R. (2013). Brainwaves could make passwords old school.

Benedicenti, L., K. Z. M. J. . P. R. (2001). The electroencephalogram as a biometric. In *Electrical and Computer Engineering*.

Fladby, K. (2008). Brain wave based authentication. *Master Thesis*.

Marcel, S. and Millán, J. d. R. (2005). Person authentication using brainwaves (eeg) and maximum a posteriori model adaptation. Idiap-RR Idiap-RR-81-2005, IDIAP. To appear in IEEE Transactions on Pattern Analysis and Machine Intelligence – Special Issue on Biometrics 2007.

Palaniappan, R. (2008). Two-stage biometric authentication method using thought activity brain waves. *Int. J. Neural Syst.*, 18(1):59–66.

Poulos, M., Rangoussi, M., Alex, N., and Evangelou, A. (2001). Person identification from the eeg using nonlinear signal classification. methods of info in medicine. In *Methods of Information in Medicine*, pages 41–64.

Abbreviations

MSWP Management von Software Projekten

WP Work Package