An exhibition on biomedical engineering for Vattenhallen Science Center LTH

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Abstract

This thesis contains the basis for an exhibition about biomedical engineering due to be displayed at Vattenhallen in the summer of 2013. The aim of the exhibition is to inspire and interest the children and adults that come and visits Vattenhallen. Hopefully at least one child will feel interested at study at LTH in the future. The basis contains 13 experimental stations and a short description of a potential laboration. Apart from these 13 stations three experiments have been constructed as well. An EMG-controlled prosthetic hand, an ultrasound phantom in the form of a 13 week old fetus and a software program for an experiment about MR/CT imaging.

The experimental stations are:

At the hospital
Tissues
MR
Ultrasound
The way through the stomach and bowel system
Key hole surgery
Your fantastic body
The EMG controlled hand
ECG
Tinnitus
Dialysis
Microfluids

The laboration:

Servoventilator

Preface

In order to inspire children and show that technology can indeed be a lot of fun, LTH used to have something called Experimentörerna, located on the fifth floor in the E-building at campus. Experimentörerna was a low scale project and from it the idea of Vattenhallen sprung. In 2009 Vattenhallen opened at LTH. It is located in the V-buildings old water tank room which were used to simulate port conditions, hence the name Vattenhallen. At Vattenhallen children and adults alike can indulge in a range of experiments. Vattenhallen does also feature thematic exhibitions with experiments. The next exhibition to be featured will be about biomedical engineering and science. Hopefully this will show children how science and technology have developed medical treatment and also how much medical technology has been developed in Lund.

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Chapter 1

Introduction

In this report the description of the journey that has been undertaken producing the base for an exhibition on biomedical engineering. The aim and goal for the thesis was to produce an exhibition with content and experiments designed to inspire and interest children from between ages 5-20. It began with the notion of creating one of the experiments in order to give the thesis technical height. The experiment in question would be constructing an electromyographic (EMG) control for an electrically controlled hand prostheses. Apart from constructing this experiment the assignment was also to provide the base for the rest of the exhibition, i.e. decide on what biomedical engineering should be included and design experiments around the different technologies. It was also in the assignment to provide all the informative material to each station and figure out a good experiment that would interest the children and have relevant meaning to the field of technology chosen. The red line in the exhibition is research and science from Lund.

The difficulty in this thesis was that we were only providing the base. The exhibition will open in summer 2013 and the deadline is in February 2013. This put some limitation to our work since a lot of the material for the experiments will not be available to us until after the thesis deadline. Therefore we decided to focus on our prosthetic hand experiment, finish all the informative material and then get as much work done on the other experiments as possible.

As it were, the prosthetic hand was given a lot of focus, producing an electromyographic controlled prostheses is not by any means a novelty. Luckily they are already commercially available and have been for some decade. There is also

a lot of research going on on how to improve this type of prostheses in order to make it more lifelike and feel more like a real hand to the owner. However, making it fit for a science center is a bit different than making it fit as a prostheses. Only when satisfied with the hand we started to work on the other experiments, such as the ultrasound phantom and the MRI tube.

This theses include several different fields of technology. The report is divided into sections featuring the exhibition as a whole, the hand experiment, the ultrasound phantom and the MRI tube. The reason for this is that these three experiments have actually been constructed by us and does therefore deserve a little more attention. Note the chapter featuring the MR tube is not quite as elaborate as the chapters about the hand and the phantom. The reason for this is simply because there was no greater need for understanding every detail of MR when constructing the program for the experiment. Every section is a small report in itself with an introduction, method, result and discussion. The information that will be displayed on the different stations in the exhibition will be on posters, which can be found in the appendix of this report. The report is then concluded by with an overall conclusion and discussion.

Chapter 2

The Exhibition

2.1 Introduction

The goal with this thesis is to produce a design and base for an exhibition that is going to be displayed in LTH's Science Center Vattenhallen during 2013. It will open in summer 2013 and be on display for a year. The aim is to construct an exhibition featuring biomedical engineering. The exhibition will consist of stations showing different fields of science and include an experiment that connects with the field displayed. The exhibitions aim will be to inspire children to be more interested in technical fields and chose that path when later in life deciding their education. Vattenhallen is LTH's own science center and was founded in 2009 by Monica Almqvist. The goal was to inspire young people about science. It features shows and experiments and has grown steadily during the years. Last year the center had 34 000 visitors[1].

As stated earlier, the aim with the exhibition is to inspire and interest the visitor. Hopefully when the children leave they do it with the feeling of having seen something fun, exciting and educating. If they leave feeling that they want to spread the experience to others, then it has been a job well done.

In order to reach this goal the exhibition needs to feature exciting, simple and funny experiments and stations that are connected to biomedical engineering. Since there has been a lot of research in Lund about the subject, it was only natural that this should have its certain place in the exhibition. Therefore the red line through the whole exhibition was chosen to be research from Lund. This means that every experimental station should include some research about the subject. It might give the visitors a sense of pride to know how much have been done so

close to them, and how much still can be done. It might also help to interest them in actually becoming students at LTH in the future.

The exhibition is meant for children between ages 5-20. This is something that had to be taken in consideration when designing the experimental stations and gathering the information. No five year old child will be interested in reading line after line of text about technology, likewise will not a twenty year old be very much interested in a text meant for a five year old. With this in mind the posters has been done with a lot of pictures and limited amounts of text. Though some posters' content are a lot more technically advanced so that the interested one can divulge in them.

Each experimental station is supposed to have some sort of experiment, posters containing information about the biomedical engineering and information about the connecting research from Lund. Not all information will be on posters though, some will also be displayed as videos on screens. The exhibition is also supposed to include a couple of laborations that will take about 20-30 minutes to complete.

2.2 Method

The work started out just brainstorming about what kind of experimental stations were possible to have and what good experiments could be done. Finding subjects was not very hard, however finding a good experiment to match them proved more difficult.

For inspirational purposes visits were made to Livets Museum. It is a museum about the body and our life owned by Region Skåne. The visit was for inspiration. As Livets Museum focuses more about the biological aspects than the technical, it was deemed that it was safe to continue on with the thoughts and ideas that had already been brainstormed. The first draft for stations was as follows:

1. The EMG-controlled hand
2. The MRI-tube
3. The ultrasound
4. At the hospital
5. Your fantastic body
6. The way through the stomach and bowel system
7. Keyhole surgery
8. ECG
9. Microfluids

10. Dialysis
11. Tinnitus
12. Kinect
13. Servo ventilator
14. Tissues

This draft was presented at a meeting where different scientists, engineers, teachers and a pedagogue from LU and SUS were invited. The purpose of the meeting was to get feedback, ideas and help with gathering text and image information to the different stations. There was also a hope to get help finding material that could be used for the different experiments. This meeting is henceforth referred to the reference group meeting.

The stations above are also written in priority order. Since the time was limited, the experiments would be constructed in this order, as many as possible in the given time. The hand was the main priority. Even if there wasn't time to construct all the experiments, the information that the stations would display would be completed for each station.

Finding information has been a mix of reading literature, browsing the internet, interviewing physicians and scientists and looking through lecture material. It was decided that the information would be displayed on posters, and in some cases, video on screens if such material was given. Posters may not be the best medium, since it require the visitor to stop and stay for a while to read. However, it would not be much of an exhibition if there were no information about the technology presented through the experiment. Also since there can't be a guide telling the information to each visitor, posters was decided upon. The posters let the visitors decide on how much they want to read, what they want to read or just look at the pictures. Constructing the posters meant finding a path where the information was conveyed in a technical way without being too heavy or hard to understand. The text on the posters was divided into smaller pieces connected to an image. Hopefully this layout will inspire the visitor to at least read some parts, and maybe feel interested to read it all.

2.2.1 Constructing the experiments

The following will describe the work gathering information to the stations and designing the experiments as it was planned from the beginning. The three first have their own sections in this report and will therefore not be discussed much here.

1. The EMG-controlled hand
The experiment would be the EMG-controlled hand prostheses. The visitors would put on the electrodes and be able to control the hand by flexing the right muscle. The information at the station would be about EMG and EMG controlled prostheses. The research part would be about the smart hand project, and this information was gathered with the help of Ph.D Christian Antfolk and the Smart Hand webpage. More information about how the experiment was constructed can be read in chapter 3.

2. The ultrasound
There was already an ultrasound station at Vattenhallen before this work started. In the exhibition it will be more about diagnostic ultrasound and how it is used for both heart and fetus diagnosis. The experiment is to use a new ultrasound phantom modelled of a 13 week old fetus. This fetus is one of the experiments that was constructed by the authors and more on about how this was done can be read in chapter 4.

In order to gather images and information that could be displayed on the station, visits to the hospital in Lund were made. These visits resulted in interviews with biomedical analyst Bodil Andersson who works with cardiac ultrasound and biomedical analyst Ann Turing who is specialist at measuring blood flow in fetuses. The research part was derived from interviews with Magnus Cinthio and Tomas Jansson, both scientists at LTH.

3. The MRI-tube
This will be the largest experiment in the exhibition. It will be a real CT shell, that will be slightly modified to simulate an MRI tube. So the visitors will roll themselves in it and see MRI and CT images, as if they scanned themselves.

4. At the hospital
At this experimental station the visitors can do health control. When the information was gathered about this station it was found that in order for it to be worth doing, several different health controls had to be merged into one. It is for exam-

ple not standard procedure to measure blood pressure on children, nor is doing a hearing test.

Kristina Olsson, a certified audinom; was consulted in order to make sure that the hearing test will be as correct as possible.

5. Your fantastic body

The aim of this station was showing how mathematical units are included within the body, such as numbers, pressure, speed, volumes and sizes. Having knowledge of these things are essential when designing biomedical engineering. You can't build an artificial heart without knowing how much blood it needs to pump around every minute. The information gathered has also been given good comparisons so that the visitor can get a grasp of how heavy, how many, how big a pressure of something is, etc. The station consists of two posters with different facts and comparisons. The facts were derived from different medical websites and literature.

6. The way through the stomach and bowel system

This station is about wireless capsule endoscopy. The material was gathered from Ervin Tóth who is the chief physician at Endoskopienheten at SUS Malmö. He provided an interview, lots of film material, images and four fake capsule cameras. Mr Tóth provided images and film material.

Left was figuring out a good experiment. Since the camera travels through the bowel system it is almost as if it travelled in a labyrinth. Therefore the idea of making a labyrinth behind glass and attaching the camera to a magnet came up.

7. Key hole surgery

Here the visitors can try on key hole surgery. The experiment will consist of a box with hidden contents, surgical instruments, a camera that films the inside of the box and a screen that displays what the camera sees. The instruments will be special instruments that are used for key hole surgery. A request has been sent to Lars Forsberg who works at the medical equipment department at SUS if he might donate material to this station (and others). A poster has also been made with material found on medical websites.

8. ECG

For these ECG station there was an idea of constructing an experiment where a person held in two iron rods and got to see her own heart rate. To put it simple,

an ECG. At LTH there has been much research about ECG and signal processing and therefore professor Leif Sörnmo at EIT LTH was asked to contribute with information about various projects. He also verified that it should be possible to construct the aforementioned experiment.

9. Microfluids
This station was put in to the agenda rather late and it was decided to only display posters showing research. This since the research projects needs to explain how microfluids work in order to be understandable. There is also a huge amount of different ways in how to execute microfluids. In order to get facts about different projects going on at the university Ph.D Per Augustsson was asked if he could help contribute. He in turn asked around colleagues and they gathered a substantial amount of information on different interesting projects about microfluids connected to biomedical engineering. They also helped figuring out experiments that would suit Vattenhallen.

10. Dialysis
For the dialysis station a visit to Gambro was made. Gambro is an international company founded in Lund. It manufactures hemodialysis machines, or artificial kidneys as they are also called. Here information on hemodialysis was received. The problem about this station was figuring out a good experiment. At Gambro engineer Anders Felding gave us tip that the principal for osmosis can be showed by dissolving the egg shell of a whole egg in white vinegar, and then putting the egg in different solutions. A sugar concentrate would dehydrate the egg whereas water would expand it. This experiment was tried out.

11. Tinnitus
The thought of this experimental station was to give the visitors a chance to feel how it is like to have tinnitus since it is a very common symptom these days. Maybe the experiment can prevent some children from being careless with their hearing and ears. A headphone will hang on a wall and when the visitor put them on they will hear a monotonous tone. Tinnitus is not curable but there is also some rather interesting research about the subject. In Lund, a method called the THA-method has been developed and this was included in the poster.

12. Kinect
This station was not supposed to include any information on posters. It is not really connected to biomedical engineering. More that it could be possible to make

a program where the visitor stands in front of a screen with kinect and sees him or herself as a skeleton. It was thought to be a good station to have since it could in some sense be connected to x-rays. This station has been given quite little attention.

13. Servo ventilator
Since the servo ventilator is an invention born in Lund, it was thought appropriate to have a station concerning it. The first idea was to have something that the visitors could blow in and get a measurement of their lung capacity. At the reference group meeting protests were made against this experiment since it is a liable source of air born infection spreading. The station was thus removed but the idea has stayed and been made into a laboration instead.

14. Tissues
The original idea of this experimental station was to have fake organs that would feel like real organs. The would have the same size, be as heavy and have the same structure. The purpose was the give the visitors an idea how things felt inside the body. The point about this station was that the organs would be handled by the visitors and this means durable organs. There are websites that makes props for movies and sell props to the public. Maybe these could be purchased for Vattenhallen. Another idea is to purchase an anatomical model so the visitors can get an understanding on where in the body the organs are located and their approximate size. An anatomical body might do for a good experiment too since it can act as a puzzle.

The experimental stations was also arranged so that they would be in a specific order. The order has been chosen with the intention to make the connection between the stations a bit more obvious and natural.

The exhibition starts with **At the hospital**, where the visitor makes a quick health examination in order to get ready for the rest of the exhibition. From there he/she proceeds to the **Tissue** station in order to get an understanding of various organs in the body and where they are located. Following tissues are some different image modalities. First the **MR-tube**, the **Ultrasound** and then **Kinect**. The idea is that now the visitor will have grasp on what is inside of the body, and what different technologies are available to study them noninvasivly. After this comes two invasive techniques, **The way through the stomach and bowel system** and **Key hole surgery**. The next experiment in line is **Your fantastic body** where he/she

may learn about different units in the body. Next is the **EMG-controlled hand** and the **ECG** station. These two are about signals in the body and how they may be used. From ECG one moves to another experiment about signals, the **Tinnitus** station. The next station will be **Dialysis** and closely after **Microfluids** since they can both be used to clean blood.

2.3 Result

The final list of experimental stations are as follows:

1. At the hospital
This station does not contain any more information than instructions concerning what the visitors are supposed to do. They will receive a paper and a pen, and are then asked to weigh themselves, measure themselves, do an eye sight test, try and take their blood pressure, listen to their own hearts with a stethoscope and do a hearing test. The poster can be seen in appendix 1.

2. Tissues
The result of this station is a collection of links to various homepages that sells anatomic models and props. The station will probably consist of an anatomical model with internal organs that can be removed. The organs will not feel like real organs, but their size and placement in the body will at least be accurate. For the collection of links see appendix 2.

3. The MRI-tube
The tube is not built, but the software program has at least almost been completed. The program will have to be modified when the sensors are implemented in the tube. Apart from the experiment, the station will also consist of a poster providing information on how an MRI machine scan actually works. More about MR and the program constructed can be found in chapter 5.

4. The ultrasound
Two phantom fetuses has been made. One of them lacks umbilical cord and the other has a slightly strange profile. However, the result in the ultrasound machine is quite nice since the images produced look rather realistic. More about the phantom experiment are on page 44.

Three posters has been made, one containing facts about ultrasound in general,

one about how the machine works. The research project poster contains information about the longitudinal movement in blood vessels. There is also a movie of the heart. The posters can be found in appendix 3.

5. Kinect
Very little has been done at this station. It is a part of the result because the authors would really like to see it at the exhibition. However it has not been possible to find information on how to construct the experiment.

6. The way through the stomach and bowel system
Chief physician Ervin Tóth was kind enough to donate four dummy cameras. These can hopefully be used in an experiment. It should not be difficult to construct a labyrinth behind glass and then attach a magnet to the camera. The goal will then be to direct the camera through the labyrinth with the aid of a magnet on the outside.

The posters provide information about endoscopy and research from the university. There is also a short movie made from actual footage from a camera that has travelled the way through the stomach. For posters see appendix 4.

7. Keyhole surgery
At this station there will be a black box containing something that can be operated on with the help of key hole surgery operating tools. Since it is key hole surgery, the only way to see what is in the box is by looking at the screen. The screen is showing what a camera inserted inside the box is recording. The content of the box can be replaced with different things. For example, sewing in dish cloths has the feeling of sewing in real tissue. Pearls and a pearl plate takes some concentration and shows how hard it can be to operate when you are not actually seeing what you are doing.

Permission has also been given to show actual surgery movies from a webpage meant for medical students. The link to this page, together with poster about key hole surgery can be found in appendix 5.

8. Your fantastic body
The station consists of two posters with different interesting facts and comparisons about the body. This station can be developed further by having objects that the visitors can use in order to get even more understanding. For example, there could be a spring that can be compressed with the same pressure that is in the

blood vessels. Or a piece of rope the same length as the intestines. Why not a sheet the same size as the skin? The possibilities are many. The two posters can be seen in appendix 6.

9. The EMG-controlled hand

For result on this experiment see page 29 about the EMG experiment. For the two posters about EMG and the Smart hand see appendix 7.

10. ECG

The result of this station is three posters and a concept for an experiment. Two of the posters feature facts about ECG and how it works. One is about research projects going on at the Department of Electrical and Information Technology at LTH. Professor Leif Sörnmo was kind enough to provide with the poster.

He also verified that the ECG experiment was possible. Thus it can be constructed at Vattenhallen. The posters are located in appendix 8.

11. Tinnitus

The result is a poster featuring facts about tinnitus and some of the Lund research about the THA-method. The experiment will be putting on a headphone and receive a signal into the ear that will have tinnitus character. The poster can be seen in appendix 9.

12. Dialysis

Dialysis is something with a lot of connection to Lund and the university, so it felt wrong not to include it in any way. Unfortunately it was very hard to come up with a good experiment picturing dialysis that would be quick and easy to do. Therefore it was decided to make posters containing information about dialysis and the research done here in Lund. The station features a poster about hemodialysis and a poster made by Anders Felding, engineer at Gambro, telling a tale of a day in a hemodialysis machines life.

The egg experiment was tried, and it provided a satisfying result, but since it took about two or three days before anything could be seen at all it was deemed not fit for the exhibition. The problem is that osmosis is a slow process but it is the process that is used for hemodialysis. However the experiment was done and the result was put on the poster. Professor Leif Sörnmo also kindly contributed by doing a poster about dialysis research. Posters can be found in appendix 10.

13. Microfluids
This station will contain an experiment that could show the principles of laminar flow and separation of particles, or it will be about how particles can be ordered into patterns by exposing them to certain sound waves. There are many different experiments that show the principles of microfluids, some examples are Kundts tube and the Chladni plate. The poster features two different research projects from the University. The poster can be found in appendix 11.

14. Servo ventilator
The experiment for the laboration would consist of breathing through a straw and thereby giving the feeling of not being able to breath effortless. The idea was developed slightly. Also added was blowing up a balloon with one draught of air. The balloon can then be submerged into water and the volume of the balloon calculated. Thus the lung capacity can be decided. The laboration will be about breathing and lungs. This might give rise to question as to what can be done if one get troubles breathing on one's own and lead to discussions about the servo ventilator.

2.4 Discussion

Constructing the base for the exhibition has been quite interesting but also difficult. The aim was to construct interesting posters containing more images than text. Finding images that work proved more difficult than initially thought. Keeping the text limited but still informative and understandable for those who does not have five years of engineering in their luggage was also a challenge. Our hopes were high when we had the reference group meeting since so many were incredibly keen to help out. Unfortunately keenness and will does not always make up in time. Therefore a lot of material that we were promised has failed to appear. It has also been difficult to handle the experiments that we wouldn't build or construct. How do you make a description of an experiment if you haven't verified that it works. We have found possible experiments, but we don't know how or if they will work out at Vattenhallen or if their construction will be easy. The three experiments that we have worked on proved tricky for us. It might be taken in consideration as well that we did not have access to any budget. If Vattenhallen manages to find good sponsors the experiments will have every potential to become great. We do feel that our material is well written and the posters are interesting. In all cases we have not succeeded in having less text than images,

but hopefully the format of how the text is spread over the posters will still invite to some reading.

We also had great hopes for displaying research from Lund since this would be our red line through the exhibition. We have been very well met by those scientists and physicians we have asked for help and we really hope that our posters will inspire children to become engineers in the future.

In hindsight we would have liked a closer cooperation with Vattenhallen in order to get more feedback on the material we have gathered and put together. We also would have liked to have more discussions and inputs about the different experiments and how they could be constructed. It is also understandable that constructing this kind of base for an exhibition is a ongoing process and things might be added or removed. But we feel like the line up we have in this thesis will be a good base for the exhibition. Nothing is set in stone, this is just our suggestion and contribution.

Chapter 3

Electromyography - EMG

3.1 Introduction

In the body signals travel from the brain down to the muscles by electric impulses. The muscles are connected to nerves. In the nerves the action potential provides the nerve impulse which in turn sets off an action potential in the muscle cells and this makes the muscle contract. The action potential is the very fast reversal of the cell membranes electric polarization. The procedure takes about a microsecond. The action potential itself can travel through the body at a speed from 1 to 100 m/s [2]. These signals are crucial to our movement. The mechanics of the action potential is a report in itself and will therefore not be discussed much deeper in this paper.

We do not have a singular type of muscle in our bodies. Depending on its functionality and purpose the muscles can be categorized into three different types: skeletal, smooth or cardiac. Skeletal are the types of muscle we can control by will, they are the larger muscles of our bodies, and they are attached to the skeleton. The smooth muscles are the muscles that we cannot control by will, they are instead controlled by our autonomous nervous system. They are typically found in our intestines and blood vessels. Cardiac is the heart muscle and although we do not control its contraction by will it is not a smooth muscle. The cardiac muscle builds the wall of the heart and is responsible for the systole and diastole of the heart[3]. Electric signals derived from the heart are known as electrocardiography – ECG.

As stated earlier the muscle contraction is the consequence of a cells answer to stimuli. In the skeletal muscles the action potential is transmitted through the

body with the help of the motor neurons that originates from the either the brain or the spinal cord. The motor neuron ends at a muscle and is connected through a special synapse which is rather large at about 2000-6000 μm^2 known as the neuromuscular junction[4]. This synapse makes it possible for the action potential to stimulate the muscle into a contraction. The muscle fibers forms together with the connected motor neuron something that is called a motor unit (figure 3.1), which is the representation of a functional contracting unit. Depending on its purpose, the motor unit can control just a few muscle fibers, or more than a thousand[5]. When a potential is generated at the nerve-muscle synapse it will often result in a

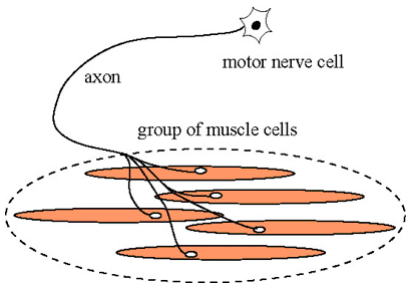

Figure 3.1: A motor unit [I].

muscle fiber action that travels from the synapse to the end of the muscle fibers. This is known as the motor unit action potential, MUAP, and its the result of spatial and temporal summation of the individual action potentials that travels along the muscle fiber. The electrical current associated with this phenomena it is known as electromyogram (sprung from the word myo which means muscle) or EMG for short[6]. It is the summation of the different MUAPs within an electrodes detecting area that is received as the EMG signal. The signal passes on information about the controller function in the muscles central and peripheral nervous system. EMG has shown very useful since the signal properties varies a lot with how much the muscle is activated[7].

As with so many scientific inventions and discoveries it is hard to denote who was the first to notice the electrical potential in muscles. Worth mentioning is Jan Swammerdam who lived between 1637-1680. He discovered that when the innervating nerve of a frogs muscle got stroked, the muscle would contract. In 1666 Francesco Redi (1626-1698) documented that the electric eel had a very specialized muscle that generated electricity. He was also the first to make the connection between muscles and generation of electricity[8]. But perhaps the most famous

experiment when dealing with electric signals in the body was carried out by Luigi Galvani in 1791. In his experiment, he touched a frogs leg muscle with metal rods, there by depolarizing them and making them contract. Later on Galvani also found that the muscles could contract if the free end of a nerve was placed across it. It showed that the contraction could happen without the intervention of metals[9].

Many scientists has been involved during the centuries to develop understanding of EMG signals, but it took until the 1960's until EMG became widespread in clinical use. The technology to record the signals has during the last decades improved immensely. Therefore the interpretation of the signal has become more accurate over the years. The quality of the signal, and the amount of MUAPs that are gathered depends on what type of electrode that is being used. When a muscle is to contract, the central nervous system will initiate motor unit recruitment in order to control the force of the contraction. The motor unit recruitment is a spatial and temporal recruitment of muscle units, and is a very fundamental muscle process. If the force of contraction needs to increase then more spatial recruitment is needed. If instead the frequency of the contractions need to be greater, the temporal recruitment needs to increase. If the temporal recruitment is too much and the fire rate of the action potentials gets to 50 Hz or faster, the responding EMG signal will take on a noiselike appearance since the individual MUAPs no longer can be discerned because of temporal superimposal of the signal[10].

3.1.1 Needle EMG

EMG is an extracellular recording type, which means that the electrodes are placed outside the cell and the difference in potential is measured between them[11]. The electrodes used to gather the EMG signal can either be invasive or noninvasive. Invasive means that the electrodes is submerged into the muscle inside the body. Noninvasive means that surface electrodes positioned on the skin above the muscle are used to gather the information. Using a needle electrode submerged into the muscle enables gathering information from individual muscle fibers. This gives high resolution and local description of the muscle, the detection signal can be rather weak and it is fairly easy to reposition the electrodes over a new area in the muscle, but the down side is that it is painful for the patient[12]. Needle EMG is often used clinically for diagnostic purposes. Needle electrodes can be of different types as well. The most common types are the monopolar (figure 3.3) and the concentric (figure 3.4). The monopolar needles have a teflon coating over the shaft. The coating function as insulation. The needle has only one lead wire extending from its tip. The needle requires that a reference electrode is placed

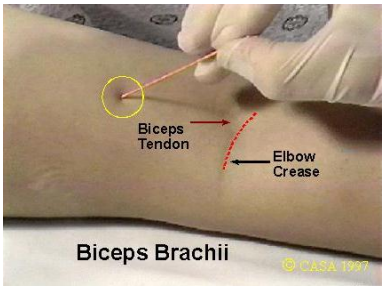

Figure 3.2: Insertion of a needle electrode into biceps [II].

on an electrically neutral zone, across bone for example, away from the measuring electrode. The requirement of a reference electrode is because the EMG machine is in basic only a differential amplifier. It needs to compare the electric activity produced in the muscle around the needle electrode with a zero value[13]. The concentric electrode however does not need the reference electrode since the

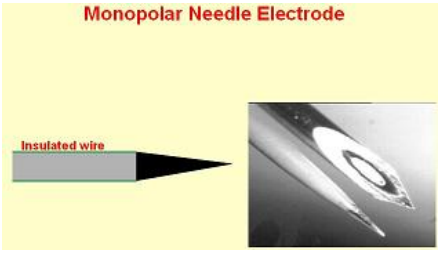

Figure 3.3: Monopolar needle electrode[III].

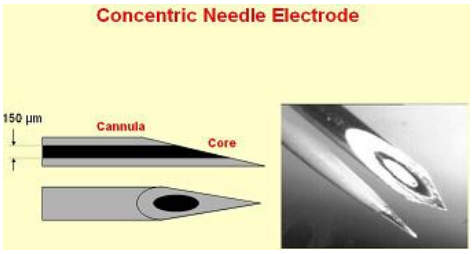

Figure 3.4: Concentric needle electrode[IV].

reference comes from the between the electrodes active surface and the needles cannula[14]. The needle has two wires, one attached to the active area, and one to the cannula. The effect of having the reference closer to the electrode is that the amplitude of the motor units will decrease. The concentric needle also tend to make all electrical activity appear smaller than in the monopolar case. But is has also shown to reduce noise[15].

3.1.2 Surface EMG

Surface EMG, often written as sEMG, on the other hand is not at all painful, but will provide a lower resolution of the signal. It is not possible to discern the indi-

vidual fibers as in needle EMG since it reflect the gross activity of multiple motor units. Surface electrodes can be either passive or active. The passive consists basically of a detection surface and electrode will only pick up the current from the muscle through its skin-electrode interface. The active electrode on the other hand is built so that the input impedance is much greater thus it is less sensitive to the impedance of the electrode-skin interface[16]. This will reduce the occurrence of noise to the signal such as the 50/60 Hz coupling, artefacts coming from electrode or cable movement, distorted signals and general background noise[17]. Most surface electrodes that can be bought today will also have some sort of signal filtration and processing built in. Placing a surface electrode involves having

Figure 3.5: Surface electrodes[V].

Figure 3.6: Active electrodes[VI]. The gain of the signal can be changed on the electrode and the signal is filtered.

knowledge of the muscle fibre orientation and anatomical landmarks. It is also important to place the electrodes so that the electrical cross talk from other muscles is minimized, they mustn't be placed to close to each other[18]. It is important that the contact between the electrode and the skin is good, otherwise the measurements will be affected. Pressure must be applied to the electrode and in some cases the contact is increased by using saline gel or paste which is applied between the electrode and the skin. To further increase the contact the skin should be washed so that the dead surface layer of it is removed along with its protective oils, removing these will lower the electrical impedance. The need for some sort of lubricant between the electrode and the skin is only necessary for the passive electrodes since they do not account for the skin impedance. The active electrodes

however are often referred to as dry electrodes, or pasteless electrodes since they have addressed the issue about the impedance[19].

The surface EMG is generally used when the time of the activation and the signal amplitude contains the information desired. Usually this is the case for different applications controlled by EMG such as certain limb prosthesis. For these types of application active electrodes are typically used.

The surface EMG can also be recorded at lower sampling rates than the needle EMG. This is because the tissue between the motor unit and the recording electrode act as a lowpass filter of the electrical signal. Most of the spectral power of the surface EMG is located at 400-500 Hz, so a sampling rate at about 1 kHz is needed. This due to the Nyquist theorem stating that the sampling frequency should be at least twice the highest frequency contained in the signal. In the case of needle EMG, the frequencies can be as high as 10 kHz, because of that a sampling rate of 50 kHz is often used[20].

3.1.3 EMG control of upper limb prostheses

The first mention of using EMG for control of upper limb prostheses comes from the German Reinhold Reiter who described it in a patent from 1945. Later in the 1960's the real break through came when a group of Russian scientists presented a design of a prosthetic hand controlled by muscular signals[21]. Since then the development of EMG controlled hand prostheses has taken place in several countries world wide.

Simple EMG controlled models will only enable the handler to open or close the hand by contracting the right muscle. The electrodes that are used to record the signal can either be placed on one or two muscle sites. Depending on how they are placed the control may differ some. On one site placement the control can either be two state or three state control. Two state control means that if the signal crosses a threshold, the prostheses will open, and if the signal goes below the threshold the prostheses will automatically close again. In three state control there is instead a low threshold and a high threshold. When the signal is between the high and low threshold the prostheses will be closed. It opens when the signal surpass the high threshold and shut down when it is lower than the low threshold.

It's quite common to use a two site, two state placement. In this type one electrode at one site will function as opening electrode and another at the other site will be the closing electrode. So if the opening electrode picks up a signal passing the threshold the hand will open, and stay open until the closing electrode picks up a signal large enough to pass the threshold and thereby closing the hand.

Using two site, two state also makes it possible to control the speed which the fingers on the prostheses moves[22].

3.2 Experiment – The EMG-controlled hand prostheses

3.2.1 Goal

The goal for this experiment was to see if it was possible to create an experiment consisting of controlling the robotic hand with EMG signals. Also to construct the experiment so it is durable enough to survive rather rough handling at Vattenhallen for maybe over a year.

3.2.2 Equipment

- Prebuilt robotic hand together with special made data acquisition card

- LabVIEW program that controlled the hand, also already made

- Four electrodes from Otto Bock, of type Myobock Electrode 13E200=60

- National Instruments data acquisition card USB-6008

- Oscilloscope

- LabVIEW

3.2.3 Method

The first step was getting familiarized with the hand that were to be used for the experiment. The hand was build for the Art Hand project that later developed into the Smart Hand project[23]. Then the goal was to turn it into a durable experiment that could be displayed and used at Vattenhallen. The hand itself consists of six motors. Five of them controls the flexing movement of the fingers, and one is for controlling the in and out movement of the thumb. The motors in their turn are controlled by a special designed acquisition card taking its directive from LabVIEW. The hand is powered with six and nine volts. The motors need six volts and the micro controller on the card needs nine volts. Since the hand was controlled

by LabVIEW from the start it was decided to use this programming language in order to control the hand with EMG. Four active electrodes from Otto Bock were received. The electrodes requires voltage supply between 4.7 and 16 V. They are complete with filters that filter the EMG raw signal into smoother curves.

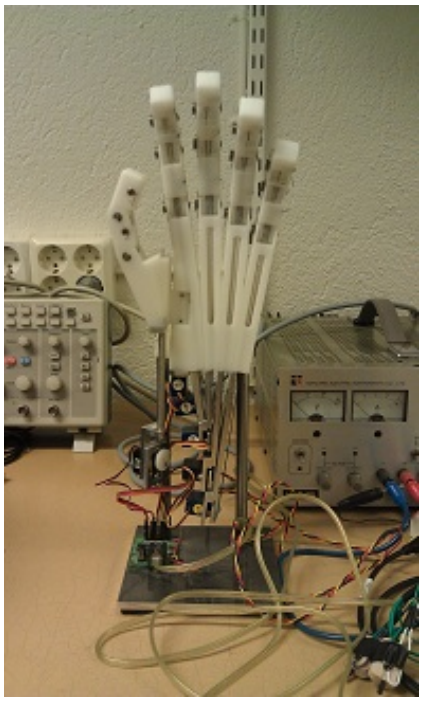

Figure 3.7: The hand.

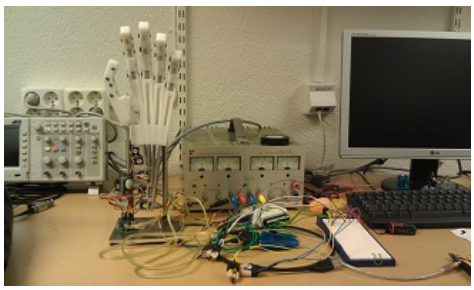

Figure 3.8: The hand set up.

Since they had already been used for other experiments their condition was not mint. They had first to be repaired since the cords that are supposed to be attached to the electrode and supply power and output were missing. It was done by soldering on new cords and connection points. When the cords were in place the next task consisted in verifying that all of them worked. This was easily done by connecting them to an oscilloscope and testing their output when they were put on a flexing muscle. On the oscilloscope the electrodes gave very nice outputs. One idea at first was to let the electrodes control one finger each. So if the user bent a finger then the corresponding finger on the prostheses would bend as well. This idea was quickly discarded since that kind of control would require needle electrodes, since the muscles for the different fingers can't be discerned with surface

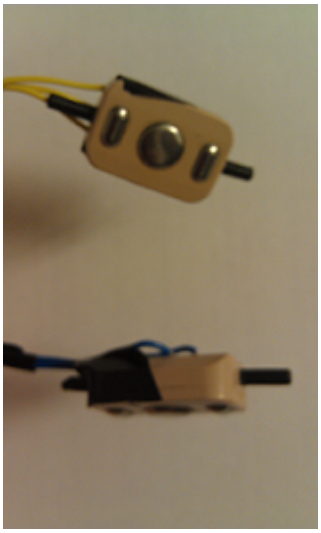

Figure 3.9: The electrodes used for the experiment.

electrodes.

When both hand and electrodes had been received the task of designing the control program started. The hand itself is not a real prostheses and is quite clumsy and fragile. It is not a toy and that was taken in consideration when designing the program. The idea is based on the two site, two state method but with some changes. In that method, one electrode is used for opening and one for closing. But since this will be an experiment for children (and other visitors to Vattenhallen) it was thought it might be more interesting to the children controlling the hand if they could do a few more movements than just opening and closing. Therefore states were introduced to each electrode. Figure 3.12 shows the state machine.

In that way one electrode can be used for opening and closing. If the electrode detects a signal higher than the set threshold the hand will open(light on), and stay open(lit) until there is again a large enough signal to pass the threshold(light off). In that case the hand will close(off). By introducing these states we have made it possible for each of the four electrodes to control a certain grip. It is important that the fingers on the hand and the different grips do not collide since this put unnecessary strain on the motors, and will lead to dysfunction if it occurs too often. This was experienced during the design process and has also been dealt with. In order to avoid collision each grip has been assigned a number corresponding to a

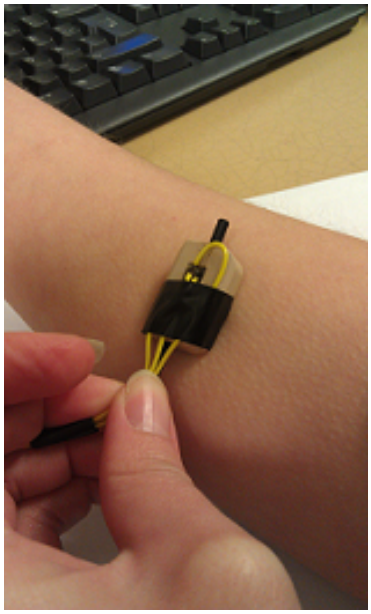

Figure 3.10: Testing the electrodes functionality.

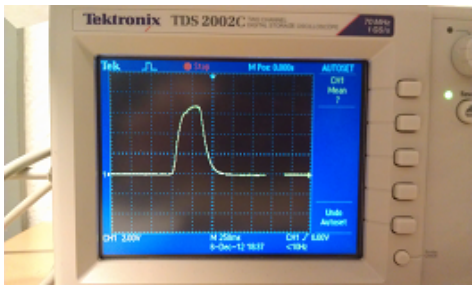

Figure 3.11: The signal corresponding to hand movement.

priority, when the grip is called upon the number will be stored in a vector. If the same grip is called again the number will be removed from the vector. Depending on what is already in the vector the grip will be carried out or not. If there is something with higher priority, then the grip will not be carried out since there is a risk of collision. This system forces the user to empty the vector of the grip with highest priority when a new grip with lower priority is wanted.

It was also experienced that the signal from the electrodes could go very high if the contact between skin and electrode was bad. Because of this a START/STOP button was implemented. The button enable the program to run so that the muscle signals can be observed without the hand moving. When it has been determined that the contact is good the START/STOP button may be pressed thus activating the hand. The reason for this is again to avoid unnecessary strain on the motors.

It was also noticed when more electrodes were added to the program that the noise level increased and that the signal would often get stuck on a certain voltage level. This had to do with noise from the signal generator and was avoided by supplying the voltage by battery instead. Each electrode gets its power supply from a 9 V battery. When the electrodes are in place and they are not being

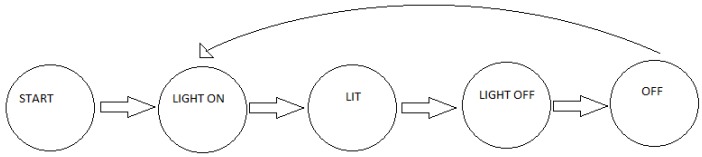

Figure 3.12: The states originally only controlled lamps, therefore they have been named accordingly.

touched, they work as intended.

However, during testing and construction of the experiment it became obvious that the hand would not last long with continuous use at Vattenhallen. Therefore a new idea was introduced. The hand would only be used for demonstration purposes and laboratories, and for the every day usage the physical hand would be replace with a digital virtual hand since such a program already existed from the Art hand project. The virtual hand functions just like the robotic hand but there is no risk of ruining motors when operating the virtual hand. The new task became thus to merge the existing virtual hand program with the robotic hand program that had been constructed for the experiment.

It was also noted that the 9 V batteries that was originally intended to be used as power supplies for the electrode were too large and had to be replaced with smaller batteries of the type CR 2032.

The electrodes were then sewn onto velcro in order to both create a way to easily fasten them on oneself and construct a stable connection between skin and electrode. The contraption however proved not to be stable enough, nor big enough to hold the batteries. It was also of concern that it was to easy to ruin.

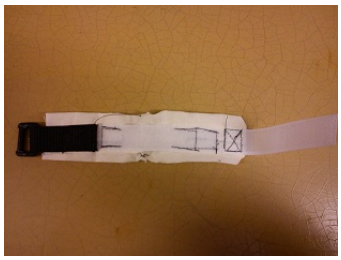

Figure 3.13: The first electrode holder.

Instead of fabric, small boxes were bought. A hole was cut into the box so that the electrode could come through and have skin contact. Then both electrode and battery was put in the box since it minimized the use of long cables and increased the movement ability of the wearer and the durability of the construction. It also kept the electrodes and cables more secure and protected from curious hands that wants to pull at everything. The lid is screwed on the boxes and can thus be easily removed when the batteries need changing.

Figure 3.14: Electrodes and batteries inserted into boxes.

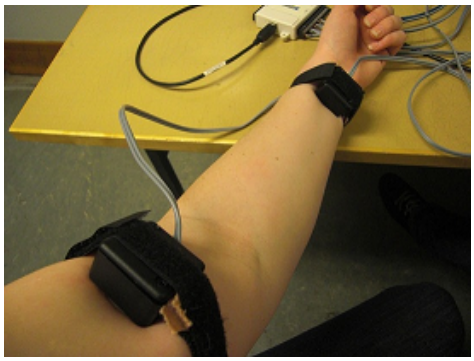

Figure 3.15: Electrodes attached to the arm.

3.2.4 Result

The result of this experiment is both a physical and a virtual hand that you can control to some extent with muscle contractions. The electrodes sends their signal

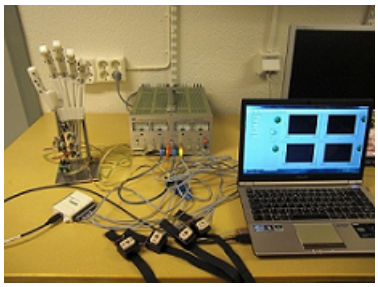

Figure 3.16: The finished set up.

into LabVIEW via an acquisition card where the program then decides on which grip will be executed. Each electrode has its own grip, the grips can be changed by a moderator. The program features a graphic panel that shows the four different signals from the electrodes. A lamp will light up if the electrode is activated, and turn off if it is deactivated. Activation happens when the muscle under the electrode contracts enough to produce a signal that exceeds the threshold value. It is deactivated when it again detects a large enough signal. Each electrode has two states, grip and open. Each grip has a priority assigned to it, and when it is activated the priority will be stored in a vector. The vector will feed the highest number to the hand which will execute the grip. Grips with lower number cannot be executed unless the higher number is put back to open state. The priorities has been chosen so that grips that could have potential to collide can not be executed directly after one another. As a further precaution the grips have been chosen so that they don't collide at all.

The virtual hand functions in the same way as the robotic, the only difference being that it is 100 % digital and not as sensitive to strain as the robotic one.

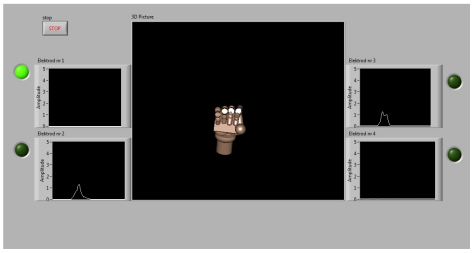

Figure 3.17: The virtual hand. Hand closed.

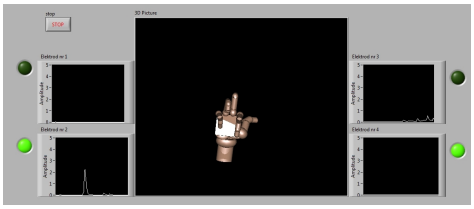

Figure 3.18: The virtual hand. Hand open.

3.2.5 Discussion

Constructing the hand experiment has been rather difficult. The one thing they told us at Vattenhallen was to keep the experiments really robust and durable since the visitors can be quite rough on them. When we received the hand we immediately understood that it would have to be kept behind some sort of protection, a glass cupboard for example. We did not, however, realise how incredible fragile the hand in itself was. During testing of our program we've managed to break it three times in total. One time one of the engines even burned. The burnt engine proved how fragile the hand was. This was something we took in consideration when we made the software.

Since we also noticed that the electrodes had a habit of giving rise to signals just by being touched we feared that the hand might take damage just by putting on the electrodes. With the program being as it were, the hand would start moving long before the electrodes were in place and we thought this to be an unnecessary strain on hand and engines. To come around this problem we implemented a START/STOP button and believed we had come around the problem. We thought so until it was clear that the visitors at Vattenhallen should not be allowed to operate the program themselves. The next idea was then to replace the digital START/STOP button with an analogue one. However, it still felt rather unsure on whether or not the hand would survive at Vattenhallen. This could perhaps be avoided if some sort of timer were implemented in the program. A timer that runs for 5 minutes and then you will have to press start again.

We do think it is a shame that the robotic hand could not be used permanent. It is a bit more fun to work with than the virtual hand. However, since it became evident during construction of the program that it would not be durable enough, we think that the virtual hand is the best solution. The robotic hand can still be on display in Vattenhallen since it looks rather interesting and would probably spark an interest. We do also hope that the electrodes will last, since they are still to be used with the virtual hand. They were old and some of them broken from start and we have noticed that the cables have a tendency to let go if not handled with extreme care. Putting the electrodes in a box together with the batteries helps insure that the cables won't have to endure unnecessary wear and tear. Should they break however, it might be wise to look up the possibility of getting new electrodes.

Chapter 4

Ultrasound

4.1 Introduction

Sound is the product of longitudinal waves moving through a medium. The waves are the product of vibrations. For example, a loudspeaker has a membrane that vibrates. The vibrations will push on the air molecules causing them to vibrate and push on adjacent molecules. The wave will the propagate through air and might hit an ear where the eardrum vibrates. The brain will then interpret the vibrations as sound. The speed at which the vibrations occur is called the frequency. The human ear can perceive frequencies in the range of 20 Hz to 20 kHz. Sound waves with frequencies above 20 kHz are known as ultrasound waves.

Ultrasound can be used for diagnostic medical applications since it can produce a real time image of the inside of the body[24]. Ultrasound consists of longitudinal waves. These types of waves will cause the medium they are travelling in to move in the same directions as the wave. They will easily propagate in solids, fluids and gases. This is why they are fit to enter the body as opposed to transversal waves which doesn't travel very far in liquids[25].

The history of ultrasound dates back to 1794 when Italian physiologist Lazaro Spallanzani discovered that bats navigate through the air using sound waves and echo location. This discovery lead to further research in the field. In the 1880's Pierre and Jacques Curie discovered the piezoelectric effect which can be used to produce ultrasound in a controlled way. A couple of decades later the catastrophe of Titanic inspires Dutch physicist Paul Langevin to invent the first hydrophone in order to detect icebergs and submarines. During the 1900's the use for ultrasound in medicine developed. In 1942 a neurologist by the name of Karl Dussik

used ultrasound to diagnose a brain tumour. This is regarded as the first attempt to use ultrasound for medical diagnostics[26]. In 1953 Swedish physician Inge Edler needed a way to look at the hearts mitral valve without having to resort to surgery. He hoped to find a noninvasive method to study the heart, thus enable a correct diagnosis before having to operate on the heart. At the same time as Edler was hoping to find this method, Carl Helmut Hertz was working as a graduate student at the nuclear physics department at Lund University. He had an interest in ultrasound and was therefore also studying that. Hertz and Edler met and together they borrowed an ultrasonic reflectoscope from Tekniska Röntgencentralen, a company based in Malmö. With that equipment they managed to obtain well defined echoes moving synchronously with the heart beat. There was also an interest to use ultrasound for obstetrics and gynaecology. Professor Ian Donald pioneered in this field when he in 1958 described how a echoscope could generate a two-dimensional display. This description sparked the interest of Bertil Sunden who made a three week visit to Donald in order to learn more. Sunden also studied if there could be any harmful effects by using ultrasound to supervise pregnancies. He did this by using ultrasound in pregnant rats. His conclusion was that there were no harmful effects. His resulting thesis constitutes the earliest textbook on ultrasonography in Obstetrics and Gynaecology[27].

4.1.1 Physics

Speed, frequency and wavelength are central parts of Ultrasound. The speed of sound is determined by the medium in which it is travelling. The speed in gases are considered low when compared to liquids, which is in turn low compared to the speed in solid material. Table 4.1.1 shows the speed of sound in different materials.

Table 4.1: Speed of sound in different materials[28].

Material	Speed [m/s]
Air	333
Average body tissue	1540
Water	1510
Bone	3190-3406

The frequency of the sound wave determines how many times the wave oscillates when passing a stationary observer during a certain amount of time. The

choice of frequency of the sound wave is very important when studying the insides of the body. A high frequency will not travel as far into the body as a low, but it will on the other hand return a better resolution. The wavelength of a sound wave is the distance between two amplitude peaks, or two similar points on a consecutive wave. The distance is often called λ.

The above three properties are closely connected. A wave with the length λ and the frequency f travels with the speed c. Thus:

$$c = \lambda \cdot f \tag{4.1}$$

and

$$\lambda = \frac{c}{f} \tag{4.2}$$

Other things that will have to be taken in consideration when dealing with ultrasound is absorption, scattering, reflection and acoustic impedance. The absorption of ultrasound by biological tissue increases with the frequency. Human tissue is seldom homogeneous so the ultrasound will propagate in a medium that consist of different type of tissue. When the beam goes from one type of tissue to another, e.g fat/muscle or muscle/bone, the sound will reflect a little but might not return to the transducer. The sound will scatter and the energy will be lost. This loss is known as scattering. The largest loss in human tissue is however caused by absorption. Sound wave makes the tissue move as it propagates. The movement takes energy from the wave and converts the kinetic energy to heat. This is the conversion that is known as absorption. The total energy loss from an ultrasound wave in tissue consists of both absorption and scattering. It is called attenuation. Absorption is however the leading loss of energy because about 75-95% of the loss in tissue consists of absorption[29]. Absorption is in most tissues linear with the frequency and the attenuation can thus be expressed in dB/cmMhz. The typical attenuation for human tissue is located in the range of 0,3-0,6 dB/cmMHz. Bone however have considerably higher attenuation at 22 dB/cmMHz.

Acoustic impedance (z) is a measure of how much response a particle in a medium will give to a wave of certain pressure. A mediums acoustic impedance is determined by the mediums density (ρ) and stiffness (k). The acoustic impedance is given by

$$z = \rho \cdot c \tag{4.3}$$

When a sound wave travels from a medium with acoustic impedance z_1 to a medium with acoustic impedance z_2 a conflict will arise. Since there is a difference

in acoustic impedance at the interface between the two mediums, the ratio of pressure to particle velocity must change abruptly across the interface. This will result in an extra wave travelling back into the first medium, a reflected wave. The sum of the pressure and the velocity of the reflected and incident wave is the same as the pressure and velocity of the original wave. From this the following can be derived.

$$\frac{P_r}{P_i} = \frac{z_2 - z_1}{z_2 + z_1} \tag{4.4}$$

The ratio between the reflected and incident pressure is often referred to as the amplitude reflection coefficient. This is an important coefficient for ultrasound imaging as is determines the amplitude of echoes produced at boundaries between different types of tissue[30].

4.1.2 Phantoms

Ultrasound phantoms are made in order to function as training equipment. The phantoms can be designed to resemble both normalities and abnormalities. They can be as advanced as an entire heart with all chambers and ventricles or a fetus with all internal organs, or as simple as a single blood vessel in tissue. They are commercially available, however they are expensive[31]. If one does not want to spend a fortune on a commercial phantom, one can construct it.

Phantoms for ultrasound are generally of two types. One is made to resemble tissue as much as possible. This means that acoustic properties such as speed, acoustic impedance, attenuation, etc. are mimicked as close as possible. The other type of ultrasound phantom is made to approximate the sonographic appearance of tissue. This type is also often used for biopsy training aid. Phantoms made to resemble tissue can be created from different materials. Some that are often used are Agar agar with particles of graphite mixed in it, polyurethane foam, and magnesium silicate gels[32].

As mentioned above agar agar is commonly used as the main ingredient in ultrasound phantoms. Agar agar is a substance derived from certain algae. It can function as a substitute for gelatin. It is cheap and rather easy to handle. Since it takes on liquid form when heated it can be molded into almost anything. The biggest asset is however its acoustic properties. The speed of sound in agar agar is 1516 m/s at 30^{o}C, which is in the same range as of that in tissue and water. The density is 1,05 kg/dm^3 (water has 0,9956 kg/dm^3)[33].

4.1.3 Obstetrics

When pregnant, parents may choose to undergo an ultrasound examination of the unborn baby. In Sweden it is customary to supply one examination for free, but Malmö and Lund chose to supply two. These two were performed in pregnancy week 17-18 and 32-33. However because of budget cuts and privatizing of health care this service might change in the future. It is however something that will not be discussed further in this report.

At the examination at week 17-18 [34] the fetus femur and skull is measured in order to determine how old the fetus is and when it will be born. Other things that can be seen are possible abnormalities in the fetus development such as missing extremities or split lips.

Doing the examination earlier than week 17 is not much use since the fetus is too small and the skeleton is hard to perceive. At 13 weeks the fetus is about 7 cm, extremities are developed[35] but it's hard to get a good view of the femur which is only about 13 mm large. At this age the fetus grows rapidly as well[36].

4.2 The ultrasound fetus

4.2.1 Goal

The goal of this experiment is to construct an ultrasound phantom in the shape of a fetus. The fetus shall look as life like as possible so that the children easily can identify it and learn something from it. It is also an aim to construct it so that it will last for at least a year.

4.2.2 Equipment

modelling clay
latex (formlatex)
agar agar
graphite powder
sodium bensoate
plastic chip for femur
plastic beads
balloon
latex string

4.2.3 Method

Figure 4.1: The model (to the left), the first molding (in the middle) and the second molding (to the right).

First a fetus model out of modelling clay was made. Since the containers at Vattenhallen holding the current ultrasound phantoms aren't very large it was decided to keep the phantom rather small. The finished model has the size and shape representing a fetus about 13-14 weeks old. When the model was done the task of painting it with layers of form latex started. The purpose of this was to create a latex molding that could be used to mold the phantom. The first mold was painted with 5 layers of latex and then let to dry for a day. The latex proved to be not completely dry so it stuck to itself in some parts of the molding. It was also noted that the models feet were to close together so the latex could not be removed without making damage to the feet. The model actually lost one leg when removing the molding. This leg was glued back on but with a slightly different angle separating the feet a bit more.

Since the first molding was not intact it was decided to make another one. Molding number two received 10 layers of latex and was left to dry for five days. The second molding was sturdier and easier to remove. After removal both molding and model were intact. The moldings together with model can be seen in figure 4.1.

The phantom would be created out of agar agar. The recipe was given by associate professor Tomas Jansson. A mixture containing 40 g agar agar per litre water was heated to 95^oC during rigorous stirring. It was then left to cool to a temperature of 45^oC and then poured into the first molding with thinner latex. After a couple of hours the latex could be removed. It proved difficult to remove the phantom from the molding and still keeping it in one piece. The hopes were that the second molding, which had kept its feet intact during the removal, would work better. A new attempt was made. This time 40 g of graphite particles per litre

Figure 4.2: Plastic femur, 13 mm long.

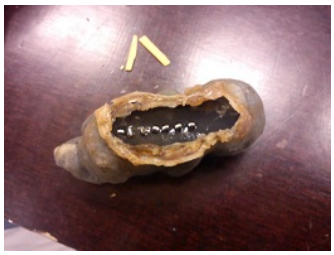

Figure 4.3: Beads inserted into the back.

water were added to the agar agar mixture. Adding the graphite ensures that the attenuation in the agar agar will be 0,4 dB/cmMHz, which mimics average human tissue[37]. When the mixture had cooled down, a couple of spoonfuls of sodium bensoate were also added in order to conserve the phantom. Both moldings were used. After a couple of hours it was attempted to remove the phantoms from the moldings. It was now noticed that although the second molding was of better quality, the thicker layer of latex made it increasingly more difficult to remove the phantom in one piece since the molding was so rigid. The legs fell of from both phantoms yet again. They were glued back on with warm agar agar.

It was quite clear that the phantoms were rather fragile, since they broke again during testing. They produced an ultrasound image, but they were sensitive to rough handling. In order to get around this problem further work on the design were made. New phantoms were molded, this time with a piece of plastic in their

thighs representing the femur (figure 4.2 and a string of beads to mimic a spine (figure 4.3. The phantoms was also given an umbilical cord (figure 4.4 and figure 4.5) of latex attached with warm agar agar to the navel (figure 4.6), and was then put in a balloon filled with water representing the womb.

Figure 4.4: Umbilical cord in the making. Four layers of latex.

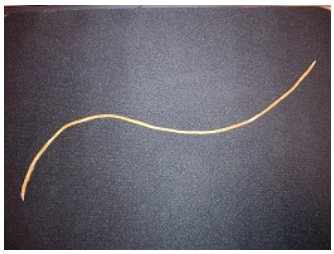

Figure 4.5: The finished umbilical cord.

Figure 4.6:]
Phantom with umbilical cord.

However, the first phantom with an umbilical cord to be put in the balloon unfortunately lost its umbilical cord and it was not possible to fasten it again without ruining the phantom. The second phantom kept its cord but when it was left to cool down it was placed head facing downwards. This resulted in a dent in its forehead and a slightly strange profile. The balloon was filled with water to the size of about a large grapefruit. The exact size of the womb containing a fetus of 13 weeks is hard to determine since it varies between individuals.

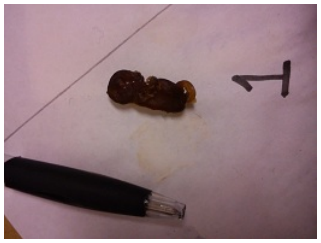

Figure 4.7: The first phantom after a couple of days.

4.2.4 Result

Phantom number 1 (figure 4.7) lacked both graphite and sodium bensoate. It was also left out in the open after it's making so it shrunk. After this attempt it was learned to have both graphite, sodium bensoate and to keep the phantom in water.

Figure 4.8: The two second phantoms. Notice the absence of legs.

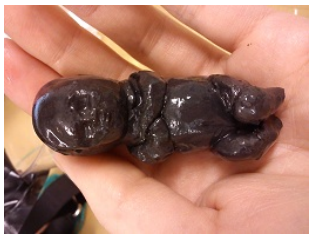

Figure 4.9: Legs have been glued back on but the feet's could not be saved.

The two second phantoms (figure 4.8) got air bubbles, and lost their legs. They were tested with the ultrasound machine and showed a good image. Their legs were glued back (figure 4.9) on with warm agar agar, but the mending proved weak against handling.

Phantom number 3 (figure 4.10) was put in a balloon for testing if it could be possible to get a good image through a balloon.

Phantom number four (figure 4.11) received a 13 mm long femur made of plastic (figure 4.2), a spine made of beads on a string (figure 4.3) and an umbilical cord (figure 4.4, 4.5 and 4.6) and was attached inside a seethrough balloon. The mixture used for the final phantom that hopefully will be used at Vattenhallen has the following recipe:

Figure 4.10: Phantom number three inside a balloon.

Figure 4.11: The finished phantom.

2,5 dl of water
10 g graphite particles
10 g agar agar
2 table spoons of sodium bensoate

The pictures for figure 4.12, 4.13 and 4.14 were taken at Vattenhallen using the ultrasound machine they have there. They show the final result.

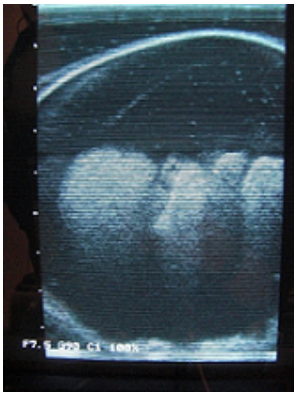

Figure 4.12: Profile image of the phantom.

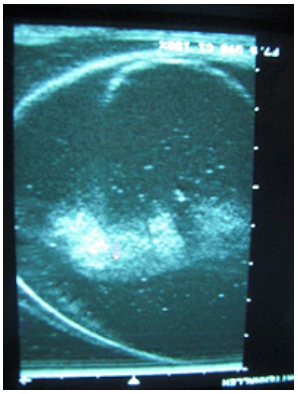

Figure 4.13: The umbilical cord is at the top of the image.

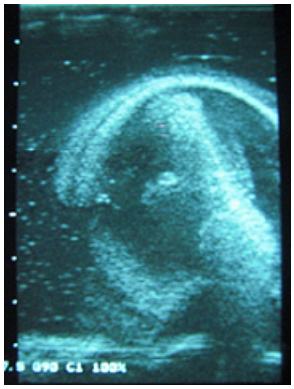

Figure 4.14: The spine are the spots in row at the right side of the image.

4.2.5 Discussion

This experiment started out as a trial and it was rather unsure whether or not we would have time to realize it. Therefore the clay model was made mostly as a test. In hind sight it might have been better to make a model of an older fetus about 17-18 weeks since this is the time when the real ultrasound imaging occur for pregnant parents. This could be more pedagogical for the children trying the experiment. However, keeping the model small also made it easy to keep extremities close to the body and thus making a better molding. Also keeping the molding as compact as possible ensures better robustness to the phantom. Research then showed that to mimic the acoustic properties of tissue with agar agar, graphite was needed. We were also slightly upset to see how easily it was to break the phantom. This worried us since we had hoped that they would survive at Vattenhallen for at least a year. Hopefully the balloon will protect the phantom a bit more, and will also give realism to the phantom since it now has a womb that can be seen on the ultrasound machine.

We cannot guarantee that the phantom will survive, but it is fairly easy to create new ones. Maybe the model can be redone as well as making it a bit older and keeping in mind how legs and arms are positioned. If the model and molding is to be redone, it is also recommended to keep the latex thin. Five layers means trickier handling (getting it off the model and handling the molding with liquid agar agar in it), but in the end it is far easier to remove the finished phantom. One must keep in mind to let the thin latex molding dry completely though since it will stick together at removal otherwise.

Fetus skeleton is soft and does not give rise to such high reflection as older bone. Therefore it was decided to use a piece of plastic. We were initially worried that the piece of femur and spine would be too clear and easy to spot on the screen, however this was not the case. They are visible but it can be a bit tricky to find them. We think this enhance the experience and makes it feel more real. It might also interest the visitors to try and find both the femur and the spine. If more visibility is desired perhaps chicken bone can be an option since it's highly reflective.

Giving the phantom these attributes, spine, femur, umbilical cord and womb proved to be a great idea since it really made the whole thing look and feel a lot more real. We also feel that the phantom is robust enough to survive Vattenhallen as long as it is kept safe in a tank of water.

When testing this experiment we found it to be quite interesting and fun. It was exiting trying to find the spine and the femur. The fact that the phantom

looks quite lifelike made it feel real. During testing it sometimes felt as if the phantom really moved. We feel that the effect became truly great. We do hope that the visitors trying the phantom out will feel just as excited as we did when we managed to get a good image of the fetus, see its womb and umbilical cord. We hope they will think it is fun trying to find the spine and the femur since it is quite hard, but not at all impossible. And of course we also hope that the phantom won't break.

Chapter 5

MRI

5.1 Introduction

Magnetic Resonance Imaging is a technique used primarily in medical treatment in order to receive high resolution images of the inside of the body. It is based on the principles of nuclear magnetic resonance.

The technique is not very old compared to others such as EMG measuring or ultrasound, but it has developed rapidly[38]. In 1946 Felix Bloch and Edward Purcell both independently discovered that when a certain nuclei was put in a magnetic field it would absorb energy in the electromagnetic spectrum and then release the same energy when put back in its original state. During the years between 1950 to 1970 nuclear magnetic resonance (NMR, was the old term for MR; later the nuclear was dropped) was developed for usage on chemical and physical molecular analysis. In 1971 Raymon Damadian showed that cancerous tissue had longer excitation time than normal tissue. Damadian believed he had found the ultimate way to detect cancer[39].

Magnetic resonance imaging was demonstrated for the first time in 1973 in small test tube samples by Paul Lauterbur. In 1975 it was proposed to use phase and frequency encoding and Fourier transform for magnetic resonance imaging. This technique is the basis for the one used today. Further development was made in 1977 when an echo-planar imaging technique was introduced. This introduction led to a development where images could be produced at video rate (30 ms/image)[40].

5.1.1 Physics

MRI records a radio frequent signal from the nuclei in the body. The most common nuclei would be hydrogen. The name nuclear magnetic resonance is, to be entirely correct, the name of the physical phenomena that is used in MR. Nuclear because it has to do with nuclei, magnetic since the nuclei is suspended in a powerful magnetic field and resonance comes from the fact that the nuclei will spin in the magnetic field according to the pulse that the MR camera is emitting, this will enable them to absorb the energy[41].

When a patient goes through an MRI she is put in a strong magnetic field. The strength of this field can be between 2000 to 60000 times stronger than the magnetic field of the earth. Then a short pulse of radio waves is directed from the MR camera into the patient. Inside the patient, some of the hydrogen nuclei will absorb energy from the radio pulse. Since the energy can't stay in the hydrogen for long they will induce a radio signal of their own, picked up by a receiver. The signal will weaken with time as the nuclei returns to its initial state. Several pulses will give rise to several signals that can be computed into an image[42].

5.2 The MRI experiment

5.2.1 Goal

This will be the largest experiment of the exhibition. The goal is to construct a software program that can later be integrated into the construction of the MR-tube. The tube itself will not be constructed during the time of this work.

5.2.2 Equipment

LabVIEW

5.2.3 Method

During the reference group meeting it was promised that images would be delivered so that they could be used in the MRI tube. Promises of an old CT shell were also made. Since the shell would not arrive until January at the earliest it was decided to only make the software for the experiment. Since the promise of the CT shell had been made, it was also decided to make the tube into a combined MRI/CT machine.

The idea is that when a person lay down on the slide and then slide herself into the tube it will start sounding like an actual MRI machine, although not as loud. Inside the tube there will be a screen showing either a MR image, CT image or a combined MR/CT image. There will be sensors in the tube monitoring where in the tube the slide is. The image that is displayed will correlate to the sensors and show pre-set images of the part of the body that is in front of the MR-camera at the moment. It is the program showing these images that has been constructed.

The program was made with LabVIEW. Since the tube doesn't exist at the moment it is hard to tell what type of sensor will work. It will probably be a sensor that give a voltage output. This output should change depending on where in the tube the slide is. A possible sensor for the job could be a potentiometer. With this in mind the software program were constructed with a control simulating the potentiometer. Sliding the control, slides the image currently displayed.

5.2.4 Result

The program works as intended. It should be easy to change later on so that the input comes from the sensors in the tube and not from the program. The images used currently has been taken from the net, but they can also easily be swapped into other images.

Figure 5.1: The finished program showing a MR image.

5.2.5 Discussion

During the reference group meeting the hopes for the MRI-tube got sky high since we were promised so much help with images, sound and information. Not to

mention the fact that we could get our hands on a real CT-shell. When we later tried to contact those who had promised to help, they did not have time to respond. The program in it self is quite simple (figure 5.1), but it does what it is supposed to do. It displays an image according to a specific input. We chose the bar since it scrolls between 0 and 10 with the intention that this bar could easily be substituted in the future with the sensor that is finally chosen for the tube. Had we had more time it might have been fun to build a small model of the tube with a sensor implemented. In the future the virtual buttons that are at the moment represented with boolean lamps will have to be replaced with physical buttons inside the tube.

We have not taken the sound in consideration when doing this program. However we feel the easiest solution for the sound would be to just connect it to the sensors. When the sensors output are above a certain level, indicating that the slide is in the tube, the sound goes on. When the sensors go below a certain level, indicating that the slide is outside the tube, the sound goes off. This should not be hard to implement if the sound is ever received.

We do believe that when this experiment is up and running, with a real CT-shell, real images and real MRI-machine sound, it will be a very memorable one.

Chapter 6

Overall conclusions and future work

Working on this thesis have been fun and challenging. We hope that Vattenhallen will find this thesis to be a good foundation on which to base the construction of the exhibition. We believe that our goals have been met when it comes to providing information and experiment ideas that the visitors will find fun and interesting.

It may be that not all of the material will be used. Or that some of it will be changed. Some posters could be replaced with power point slides and displayed on screens for example. The experiments that are not yet built might have to be changed completely or removed from the exhibition all together. The laborations has not been given as much time and can certainly be developed further.

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Appendix

1. At the hospital
2. Tissues
3. Ultrasound
4. The way through the stomach and bowel system
5. Key hole surgery
6. Your fantastic body
7. The EMG-controlled hand
8. ECG
9. Tinnitus
10. Dialysis
11. Microfluids

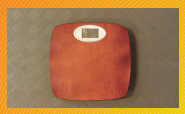
1. At the hospital

HÄLSOKOLL

När man går i skolan så får man regelbundet gå på hälsokontroller hos skolsköterskan eller på vårdcentralen. Dessa undersökningar är till för att hålla koll på barnets utveckling så att man i ett tidigt skede kan upptäcka eventuella onormaliteter hos barnet samt åtgärda dessa på bästa sätt så tidigt som möjligt. På dessa hälsokontroller brukar barnet få vägas och mäta sig samt genomgå ett syntest, ett hörseltest och en ryggkontroll. Man lyssnar även på hjärtat och lungorna samt tar blodtrycket. Gör man hälsokontrollen på en vårdcentral får man ibland även få ta ett blodprov.

Ta ett papper och en penna så du kan anteckna dina värden och testa sedan på hur det känns att göra en hälsokoll.

Oftast får barnet börja med att väga och mäta sig. Det är ju alltid roligt att veta hur mycket man vuxit från gång till gång och det är inte ovanligt att det finns en mätsticka hemma på väggen eller på en dörrkarm. På en hälsokontroll kollar man så att man växer normalt samt att vikten är någorlunda proportionerlig mot längden.



Uppgift 1:
Ställ dig på vågen och anteckna vikten på ditt papper.

Uppgift 2:
Ställ dig mot väggen vid mätstickan och mät hur lång du är. Skriv ner längden på pappret

I samband med att barnet får mäta sig så brukar man även kolla om ryggen är rak eller sned. Barnet får då ta av sig tröjan och luta sig framåt så att hela ryggraden syns tydligt genom huden. Om ryggen är sned kan man mäta hur mycket med en linjal. Det kan vara ganska vanligt att ett barn någon gång under sin uppväxt har en lite sned rygg. Detta beror på att man helt enkelt växer hela tiden och ibland växer man mycket på en och samma gång. Då kan ryggraden ha svårt att hänga med i svängarna och man får en sned rygg. Oftast så försvinner detta med åldern. Men detta har skötterskan koll på.
Sedan brukar läkaren eller skötterskan lyssna på hjärtat och lungorna med ett stetoskop. Detta görs för att kolla så att allt låter som det ska. Har man till exempel astma eller blåsljud på hjärtat kan man bland annat höra det med stetoskopet.

Blodtrycket kollas för att se så att barnet har ett normalt blodtryck. Blodtrycket varierar mycket med åldern och individ men ett någorlunda gränsvärde för en femåring ligger på 105/65, för en tioåring 110/70 och för en femtonåring 115/75 där enheten är millimeter kvicksilver (mmHg). Den högre siffran är det tryck som uppstår av att hjärtat drar ihop sig och pumpar ut blod i kroppen, det så kallade systoliska trycket. Den lägre siffran är det tryck som uppstår när hjärtat slappnar av och fylls med blod, det så kallade diastoliska trycket.

Uppgift 3:
Ta stetoskopet och lyssna på kompisens eller ditt eget hjärta.

Hur låter det?

Bild på blodtrycksgivaren

Uppgift 4:
Använd blodtrycksgivaren för att ta ditt eget blodtryck, se bild på hur du ska använda den (kanske behöver du lite hjälp att få på den).
Skriv ner ditt blodtryck på pappret.

Sedan brukar barnet få göra ett syntest och ett hörseltest. Syntestet går ut på att barnet får täcka för ett öga i taget och sedan läsa de bokstäver på en tavla som står ca 3 meter framför. Om barnet har någon synnedsättning brukar man få en remiss till en ögonläkare eller optiker. Hörselkontrollen kan göras på en mängd olika sätt. Vanligast är att barnet får ett par hörlurar på sig och får trycka på en knapp varje gång ett ljud hörs.

Bild på syntesttavlan

Uppgift 5:
Ställ dig på sträcket på golvet framför bokstavstavlan på väggen. Täck vänster öga med din hand så du inte kan se något med det öget. Läs sedan högt det som står på tavlan. Byt öga så att du nu täcker höger öga istället och gör sedan samma sak.
Ser du alla bokstäver?

Bild på hörlurarna

Uppgift 6:
Ta på dig hörlurarna. Du kommer höra ett antal pip under en minut. Räkna hur många pip du hör. Skriv sedan ner antalet pip på pappret.

Det vanligaste är att hälsokontrollerna görs på skolan hos skolläkaren eller skolsköterskan och då görs inga blodprov. Görs däremot hälsokontrollen på en vårdcentral eller om man blir sjuk får man göra ett blodprov. Blodprovet kan användas till en mängd olika saker. Till exempel kan man kolla blodgrupp och om det finns några infektioner eller inflammationer i kroppen men det är bara två av väldigt många funktioner ett blodprov kan ha.

Du slipper ta ett blodprov men var vänlig lägg tillbaka pennan där du tog den så nästa person kan använda den. Pappret med dina uppgifter kan du ta hem och spara.

2. Tissues

The following link collection shows where anatomical models can be found.

Anatomical models:
http://www.easyteach.dk/shop/torso-3c1.html
http://waldemarlarsson.se/products/category/organmodeller/
http://www.organum.se/index.php?page=shop.product_details
&flypage=flypage.tpl&product_id=113&category_id=21&
option=com_virtuemart&Itemid=1

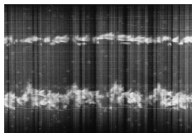
Movie props:
http://www.bjwinslow.com/

Contact information to the artist who created the model of a brain at Livets Museum.
Artist Mats Nilsson
Phone: 0760 931522

3. Ultrasound

ULTRALJUD

Vi människor har ett hörselområde mellan 20 och 20 000 Hz. Ultraljudet ligger på över 20 000 Hz vilket gör att vi inte kan höra det. Däremot kan bland annat fladdermöss och delfiner höra det och använder det för att kommunicera och hitta mat.

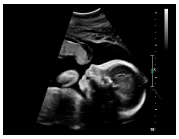


Det första ultraljudet av Inge Edler och Helmuth Hertz.

Ultraljudet i sig är ingen Lundensisk uppfinning, men däremot att använda ultraljud inom medicin, så kallat diagnostiskt ultraljud, är något som stammar från Lund. Inge Edler var hjärtläkare vid Lunds lasarett och efterlyste en metod att kunna undersöka hjärtat utan att behöva utföra kirurgi. Tillsammans med professor Helmuth Hertz från Lunds universitet utvecklade han 1953 ekokardiografin som blev den första kliniska användningen av ultraljudet.

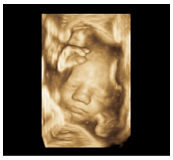
Hur fungerar ultraljudet?
För att förstå det måste man ha lite kunskap om ljud. Ljud består egentligen av vågor som breder ut sig i ett medium. När vi pratar vibrerar våra stämband, vibrationen ger upphov till en våg som sätter luftmolekylerna i svängning vilket ger ett ljud. De här vågorna beter sig lite olika beroende på vilket medium de breder ut sig i. Till exempel låter ju ljud i vatten annorlunda än i luft. Alla som har hört ett eko vet dessutom att ljudet kan studsa. Det händer när ljudvågen slår i ett hårdare medium än det som den rörde sig i från början, då studsar vågen istället för att absorberas. Pröva själv att prata i ett helt tomt rum eller i ett rum med mycket mattor och gardiner i.

Ultraljudet skickar med hjälp av transducern in ljudvågor i kroppen. Eftersom det inuti i kroppen finns vävnader med olika akustiska egenskaper (ljudet studsar, eller absorberas olika mycket) kommer ljudvågen att studsa tillbaka till transducern och med hjälp av lite bildbehandling kan dessa ekon omvandlas till en bild.

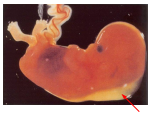


En sådan här bild var förmodligen en av de första bilderna din mamma och pappa fick se av just dig.

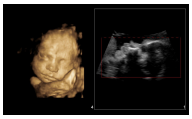
Ultraljud är en icke-invasiv metod, det vill säga man behöver inte öppna upp kroppen för att titta in, och är därför en undersökningsmetod som används mycket inom medicin. Med ultraljud kan man titta på i stort sett alla organen i kroppen, man kan titta på blodkärlens tjocklek, blodflödet, leta efter tumörer och titta på foster.



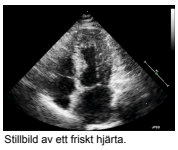
Tekniken har gått framåt vad gäller avbildning och idag kan man med lite tur få riktigt fina 3D bilder på insidan av kroppen.



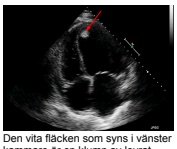
För att kolla om det finns en förhöjd risk för Downs syndrom kan man mäta bredden på den vätskespalt som finns vid fostrets nacke, det kallas nackuppklarning. En av många saker som kan kollas på på fostret får att se så att utvecklingen går framåt som den ska.



Till höger syns en profilbild av en bebis. De röda linjerna är det område som syns på 3D-bilden till vänster.



Stillbild av ett friskt hjärta.



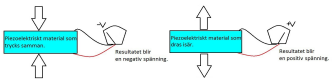
Den vita fläcken som syns i vänster kammare är en klump av levrat blod, en så kallad trombos eller blodpropp.

Hur fungerar ultraljudsmaskinen?

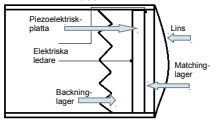
Den första frågan som man ställer när man vill förstå sig på tekniken bakom en ultraljudsmaskin är kanske:

"Hur uppstår ljudvågorna?"

Svaret är piezoelektricitet.
I ultraljudsmaskinens givare (som också kallas transducer) sitter det en rad med piezoelektriska element. Att ett material är piezoelektriskt innebär att det expanderar om en negativ spänning läggs över det, och kontraherar om en positiv spänning läggs över det. Effekten fungerar även på andra hållet, d.v.s. materialet genererar en positiv spänning om det utsätts för sträckande krafter och en negativ spänning om det utsätts för komprimerande krafter. Så genom att lägga en spänning över elementen i givaren kan man få dem att vibrera i önskad frekvens och därmed ge upphov till en ultraljudsvåg.



Givarens uppbyggnad



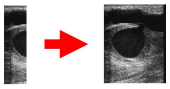
Det finns ett par olika typer av givare men gemensamt för dem alla är att de innehåller en piezoelektrisk platta, ett så kallat matching-lager och ett backing-lager. Backing-lagret fungerar som en dämpare i givaren. Den piezoelektriska plattan har en nackdel i att den har ungefär 20 gånger högre impedans i jämförelse med mjukvävnad. Det leder till att en stor del av ljudvågen reflekteras mellan vävnad och givare

Bara ca 20 % av vågens styrka tar sig igenom in i kroppen och resten reflekteras. Om inget görs åt detta kommer den reflekterade vågen att stanna kvar och skapa en massa ekon som stannar kvar längt efter det att spänningen på elementen upphört. Dessa ekon ger upphov till något som kallas ringning. Ringning gör att ultraljudsbilden får väldigt dåligt upplösning. Men backing-lagret tar effektivt hand om detta genom att dämpa det reflekterade ekot mellan vävnad och givare.

Så hur får man en bild då?
när ekot skickats in i kroppen kommer ljudet att sprida sig in i kroppen till ett visst djup beroende på den frekvens och våglängd man använder sig av. En hög frekvens har en kort våglängd och kommer inte så djupt in i kroppen men ger å andra sidan en bra upplösning av signalen. En låg frekvens har en lång våglängd och kommer längre in i kroppen men ger sämre upplösning.

Valet av frekvens styr hur de piezoelektriska elementen vibrerar och vilken typ av våg de skickar ut. När vågen gått in i kroppen kommer den att reflekteras mot olika vävnadstyper. Den reflekterade vågen skickas tillbaka till givaren där de piezoelektriska elementen komprimeras och ger upphov till en spänning som sedan ultraljudsmaskinen tolkar. Beroende på hur mycket av vågens utgångsintensitet som har reflekterats och hur lång tid det tog kan ultraljudsmaskien räkna ut var i kroppen vågen reflekterades och utifrån detta bygga upp en bild.

Ekot från efterföljande pulser adderas.



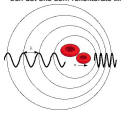
Färdig bild.

Varje element skickar ut en ljudväg.

Typer av givare

Det finns som sagt ett antal olika typer av givare som används beroende på vad och var i kroppen man vill titta. En linjär givare, till exempel, används när man vill titta på vävnader som ligger nära ytan i kroppen. Ett vanligt föremål är blodkärl. En linjär givare är ofta rektangulär i formen men den finns även i kurvformade varianter som ger en något större djup. Dessa givare används då man vill studera bukregionen. I en linjär givare skickas signalen från ett aktivt element i taget. När en puls har sänts iväg fungerar en grupp av andra element som mottagare. När alla ekon återvänt till den aktiva gruppen, flyttas ett element från denna grupp till nästa aktiva grupp och processen börjar om. En annan variant av givare är den fasade givaren. I denna givare sprider sig strålen alltid solfjäderform. Till skillnad från i en linjär givare så sändning och mottagning av ljudimpulsen av samma element i en fasad givare. Man kan även ändra fokus i en linjärgivare genom att styra när de olika elementen skall aktiveras.

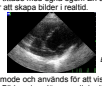
Dopplereffekten
Alla har nog märkt av dopplereffekten någon gång i sina liv. Det karaktäristiska lätet som uppstår när en ambulans kör förbi kan till exempel tillskrivas dopplereffekten. Dopplereffekten är förändringen i den observerade frekvensen från en ljudväg i rörelse i jämförelse med den utsända frekvensen från ljudkällan. Dopplerskiftet är det som uppstår när ljudkällan rör sig bort från detektorn. Då kommer avståndet mellan ljudvågorna att öka och den detekterade frekvensen blir lägre än den utsända. Storleksordningen på dopplerskiftet är proportionell mot hastigheten som ljudkällan rör sig. Tack vare detta fenomen kan man använda ultraljud för att mäta blodflöde. Man mäter helt enkelt skillnaden i frekvens från det utsända ljudet och det eko som reflekterats tillbaka från blodkroppar i rörelse.



Figuren visar principen för dopplereffekten. När blodkropparna rör sig mot källan ökar frekvensen (λ) och när de rör sig från källan minskar frekvensen.

A-mode, B-mode och M-mode.
Bilder kan återges i A-mode, B-mode, M-mode och 3D.

B står för brightness och innebär att de reflekterade vågornas intensitet anges genom att bilden som skapas får olika gråskalor, från svart till vitt. Ju mer intensitet som kommit tillbaka desto ljusare blir den återgivna punkten och tvärt om. B-mode bilder är mycket lika det man faktiskt skulle se om man gjorde ett tvärsnitt av kroppen och tittade med egna ögon. En annan fördel med B-mode är att det kan användas för att skapa bilder i realtid.



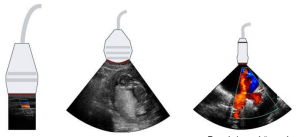
B-mode bild av ett hjärta.

M-mode står för motion mode och används för att visa de temporala förändringarna i ett eko. Bilden visas längs en linje där den ena axeln motsvarar ekots djup och den andra tiden. Det hela ger en uppfattning om hur vävnaden rör sig i förhållande till givaren.

Grafisk representation av M-mode.

A-mode står för amplitude-mode, och är den enklaste bildåtergivningstekniken. Det används dock sällan idag. Det kan användas för en noggrannare bestämning av ljudpulsens gång tid då den återkommande amplituden mäts. De tidigaste ultraljudsbilderna inom diagnostik avbildades i A-mode

Grafisk representation av A-mode.



Linjär givare, med färgdoppler.

Kurvformad linjär givare.

Fasad givare, här med färgdoppler.

Färgdoppler
Det finns även något som kallas färgdoppler. Då kodar man den uppmätta frekvensen med en färg. Vanligtvis låter man blått betyda att blodet är på väg bort från givaren och rött att det är på väg mot givaren.

Kontinuerligt och pulsad doppler.
Doppler kan sändas kontinuerligt eller i pulser. Kontinuerligt doppler innebär att man hela tiden sänder in en våg och får en lika dan tillbaka. Det kräver att man måste ha skilda delar för sändning och mottagning. Kontinuerligt doppler gör det möjligt att studera snabba flöden eftersom det inte finns någon hastighetsbegränsning, dock kan man inte begränsa djupet eller bestämma en exakt punkt man vill titta på. Kontinuerligt doppler återbildar allt i dess väg. Med pulsad doppler har man möjlighet att bestämma hur långt in i kroppen pulsen ska gå och var fokus ska hamna. Samma element kan användas för sändning och mottagning. Pulsad doppler innebär att man skickar in en puls i vävnanden och väntar på ekot innan man skickar in en ny. Detta ger begränsningar vad gäller hastigheter. Därför är det inte rekommenderat att använda pulsad doppler om man vill titta på flödeshastigheter eftersom mycket information hinner gå förlorad mellan pulserna.

4. The way through the stomach and bowel system

KAPSELENDOSKOPI

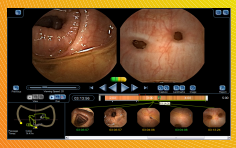
Kapselendoskopi heter det när patienten får svälja en kamera som bara är lite större än ett piller. Det finns två olika kapselkameror (eller pillerkameror som de också kallas), en kamera för undersökning av tunntarmen och en kamera för undersökning av tjocktarmen.

Kapselkamera för undersökning av tunntarmen med enbart en kamera. Kameran tar två bilder i sekunden under sin tid genom tarmarna.

Kapselkamera för undersökning av tjocktarmen. Har två kameror för att kunna ta fler bilder. Varje kamera tar 7 bilder i sekunden vilket totalt ger 14 bilder i sekunden.

Patienten får gå runt med en handdator som sitter i ett bälte och ha några elektroder fastsatta på kroppen. Dessa elektroder innehåller sensorer som fångar upp bilderna som kapselkameran tar under sin resa genom tarmarna. Elektroderna skickar bilderna till handdatorn och bilderna kan sedan föras över till en större dator så att läkaren kan analysera dem. Sedan behöver man inte bry sig om kameran utan den kommer ut den naturliga vägen och kan utan problem spolas ner i avloppet då den inte innehåller några farliga ämnen.

Att undersöka tarmarna på det här viset underlättar massvis för patienten. Efter att ha svalt pillerkameran kan patienten gå hem och leva som vanligt. Efter ca 10 timmar kommer patienten tillbaka till sjukhuset och lämnar tillbaka datorn så att läkaren sedan kan kolla igenom bilderna. Detta är betydligt behagligare än att få svälja en slang med en kamera, ett så kallat endoskop, eller att endoskopet förs upp i tjocktarmen. Dessa två undersökningsmetoder, tunntarmsendoskopi respektive koloskopi, är både smärtsamma och tidskrävande.

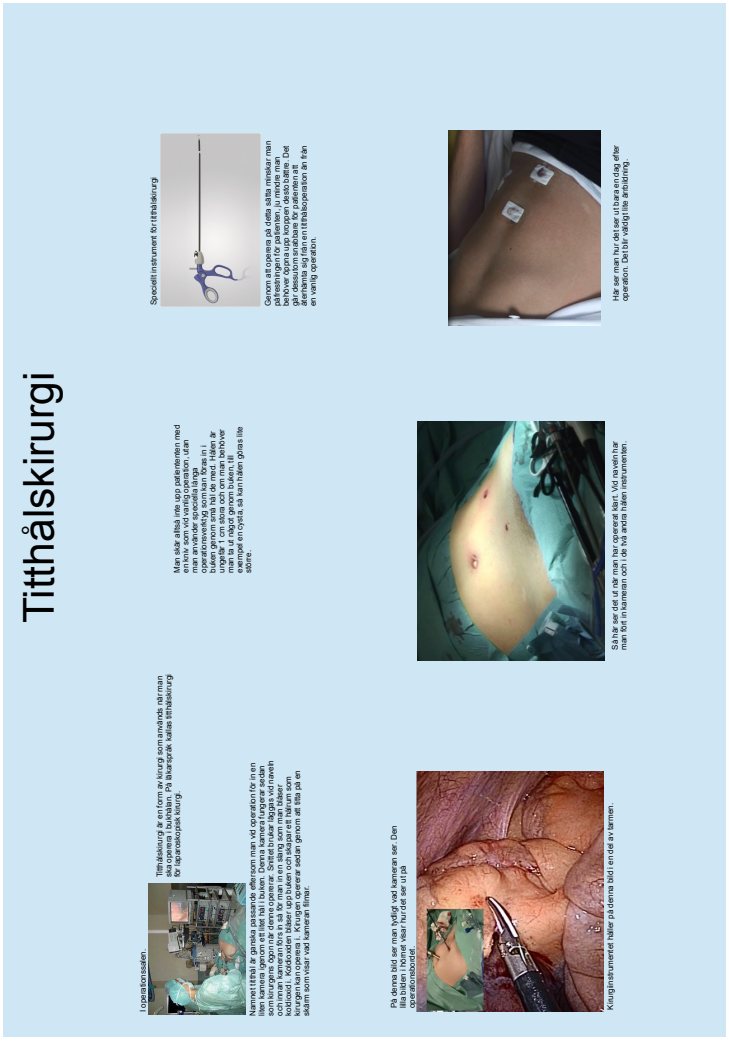


Hur det kan se ut när läkaren kollar igenom bilderna. Längst ner till vänster syns vägen genom tarmarna som kapseln har färdats.

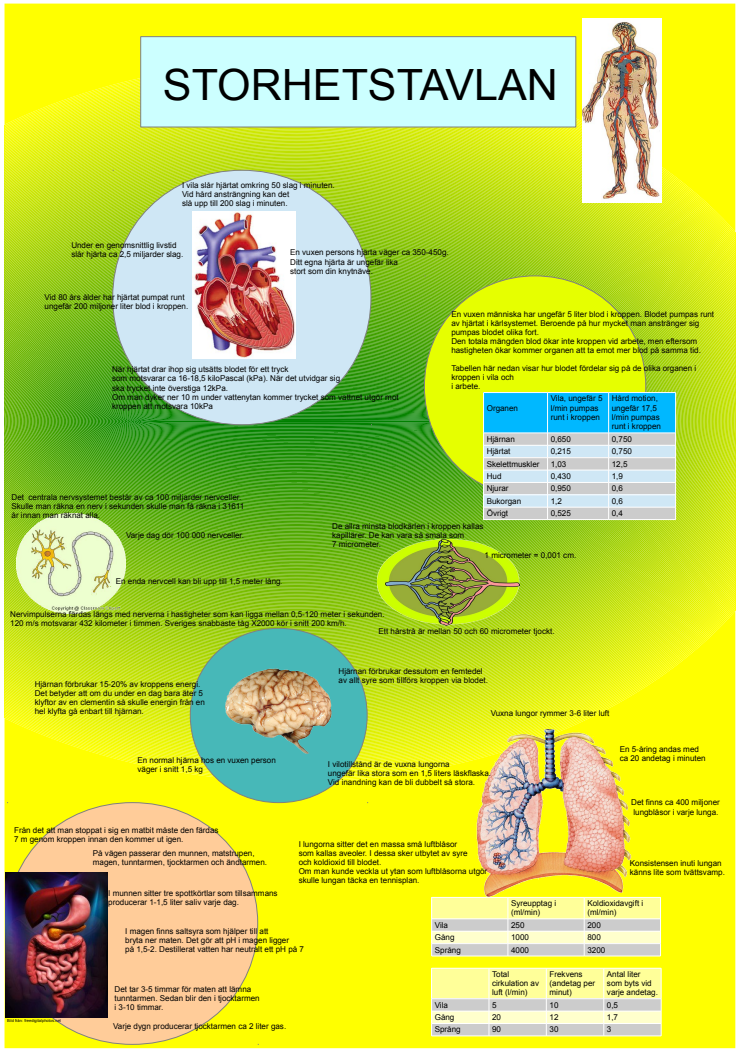
En nackdel med pillerkameran är att den kan fastna i en förträngning och i värsta fall måste den opereras ut. För att undvika detta får patienten svälja en testkapsel som innehåller en RFID-tag några dagar innan pillerkameran ska sväljas. För att kolla om testkapseln finns kvar i kroppen eller om den åkt ut används en handskanner. Om handskannern inte indikerar att testkapseln finns kvar i kroppen så kan patienten svälja den riktiga pillerkameran. Annars får man använda en annan metod för att undersöka tarmarna.

Det är överläkare Ervin Tóth, chef på Endoskopienheten i Malmö vid Skånes Universitetssjukhus, som påbörjade dessa undersökningar i början på 2000-talet. Nu har det gjorts ca 2500 undersökningar. Till en början var de begränsade till att enbart kolla tunntarmen men sedan 2006 görs även undersökningar av tjocktarmen och inom en överskådlig framtid är det nog även möjligt att göra behandlingar av tarmarna med hjälp av pillerkameran.

5. Key hole surgery



6. Your fantastic body

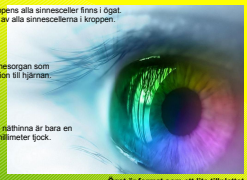


Organen	Vila, ungefär 5 l/min pumpas runt i kroppen	Hård motion, ungefär 17,5 l/min pumpas runt i kroppen
Hjärnan	0,650	0,750
Hjärtat	0,215	0,750
Skelettmuskler	1,03	12,5
Hud	0,430	1,9
Njurar	0,950	0,6
Bukorgan	1,2	0,6
Övrigt	0,525	0,4

	Syreupptag i (ml/min)	Koldioxidavgift i (ml/min)
Vila	250	200
Gång	1000	800
Språng	4000	3200

	Total cirkulation av luft (l/min)	Frekvens (andetag per minut)	Antal liter som byts vid varje andetag.
Vila	5	10	0,5
Gång	20	12	1,7
Språng	90	30	3

130 miljoner av kroppens alla sinnesceller finns i ögat.
Det är ungefär 70% av alla sinnescellerna i kroppen.

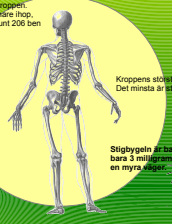


Ögat är det av våra sinnesorgan som
levererar mest information till hjärnan.

Ögats hinnor är bara en
halv millimeter tjock.

Ögat är format som ett lite tillplattat klot och har en diameter på 2,5 cm när man är vuxen.

Man föds med 300 ben i kroppen.
En del av dessa växer samåre ihop,
och som vuxen har man runt 206 ben
i kroppen.



Kroppens största ben är lårbenet.
Det minsta är stigbygeln som sitter inuti örat.

Stigbygeln är bara ca 3 mm lång, och väger bara 3 milligram. Vilket är ungefär lika mycket som en myra väger.

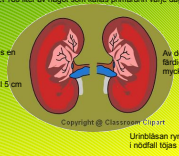
**I näsan har vi
20 miljoner luktceller.**

En hundnos däremot har
hela 220 miljoner luktceller.

På tungan sitter det 10 000 smakceller.

Dessa kallas smaklökar och lever
i ca 10 dagar innan de dör och byts
ut.

I njurarna som är kroppen eget reningsverk, produceras
det 180 liter av något som kallas primärurin varje dag.



Det manliga urinröret är hos en
vuxen 20 cm långt.

Det kvinnliga bara 3 till 5 cm

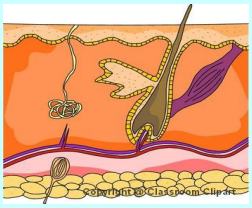
Av dessa 180 liter blir sidan 1,5 till 2 liter
färdig urin som man kissar ut. Mängden beror
mycket på hur mycket man druckit under dagen.

Urinblåsan rymmer 3-4 dl, men kan
i nödfall töjas ut till att rymma lite till.

Huden är kroppens största organ.
Om man skalar av huden och vecklar ut den,
skulle den kunna täcka en kvadrat som här
sidan 2 meter. Alltså 2 kvadratmeter.

I huden sitter det runt 5 miljoner hårsäckar.

Bara på huvudet finns det ungefär 1 miljon
hårsäckar. De långa hårstrån vi har på toppen
av huvudet är ungefär 100 000 st.



Hårstrånas längd bestäms av något som kallas hårcykeln.
Olika här på kroppen har olika långa hårcyklar.
Håret på huvudet har en cykel som är 2-5 år lång. Det betyder att
ett hårstrå på hjässan kan växa i 2-5 år innan det faller av och ett
nytt börjar växa i den tomma hårsäcken.

Huden hos en vuxen
väger omkring 4 kg.

Den tunna fjuniga håret som vi har över hela kroppen
har en hårcykel som är 27 dagar lång. Det är därför dessa
hår aldrig blir särskilt långa.

Håret växer ungefär 1 cm i månaden. Det motsvarar en hastighet på 0,000014 m/h. Kan jämföras med en snigel som kan krypa 10m/h i timmen.

Huden består av olika lager,
och dess tjocklek varierar över kroppen.
Tunnast hud finns på ögonlocken, den är bara 0,5 mm
tjock. Tjockas hud finns på hälarna, där är den 4 mm tjock.

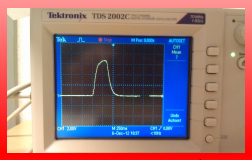
Naglar och hår består av samma material.
En nagel växer 1-2 mm i veckan, alltså 0,00001 m/h.
Lika snabbt som håret alltså.

7. The EMG-controlled hand

EMG och proteser

Elektroder som kan användas för att mäta EMG.

EMG, eller elektromyografi, som det står för är vad man kallar de elektriska impulserna som ger upphov till att musklerna drar ihop sig. Vi kan alltså inte spänna våra muskler om vi inte från hjärnan skicka en nervimpuls i form av en elektrisk signal till dem. När signalen nått muskeln kommer den att spridas och säga till alla muskelfiber att dra ihop sig. Detta i sin tur genererar en större signal som man enkelt kan mäta med hjälp av elektroder. Det fiffiga med den elektriska signalen som uppstår när en muskel drar ihop sig är att den varierar i styrka beroende på hur mycket kraft man använder för att spänna muskeln.



Oscilloskopet visar hur en signal som en elektrod plockat upp från en muskelaktivering kan se ut.

Just det här att musklerna skapar en elektrisk spänning när de aktiveras är något som flitigt används inom protesvärlden. Proteser kan antigen vara passiva eller aktiva. Passiva proteser kan inte själva grepppa om saker och de är mest ett stöd för den friska lemmen, eller en kosmetisk del. En passiv protes är så att säga en replika av den del man förlorat, men den går ofrast inte att styra. Det finns passiva proteser där man kan ställa fingrarna genom att böja dem med den friska handen.

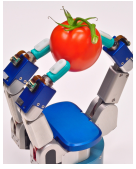
Kosmetisk protes.

Proteser med enbart gripfunktion.

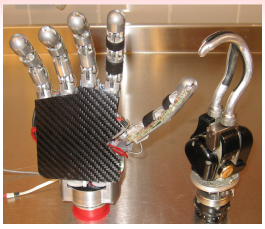
Aktiva proteser däremot kan man styra, antingen mekaniskt eller elektriskt. Styr man den mekaniskt är det ofta en kabel kopplad mellan protsen och en annan del av kroppen. När man drar i kabeln rör sig protesen på önskat sätt. För just handproteser kan det vara väldigt bra med aktiva proteser eftersom man då kan få tillbaka förmågan att greppa och hålla saker. En elektriskt styrd handprotes har små motorer som styr fingrar och ibland även vristen. Det är dessa typer av proteser man kan styra med EMG.

EMG-styrd protes med handske.

Elektroderna fästs på den delen av armen som är kvar och genom att spänna musklerna kan man öppna eller stänga sin protes. Beroende på hur pass avancerad protesen är kan man styra fler fingrar och skapa olika grepp. En del proteser har även sensorer som känner av om föremålet man håller i håller på att glida loss, när detta sker så stramar protesen automatiskt om greppet utan att man själv behöver göra något.



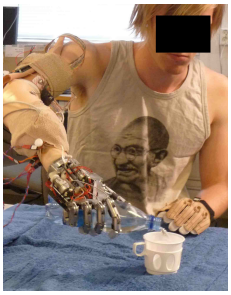
Aktiv protes med bra precision i greppet.



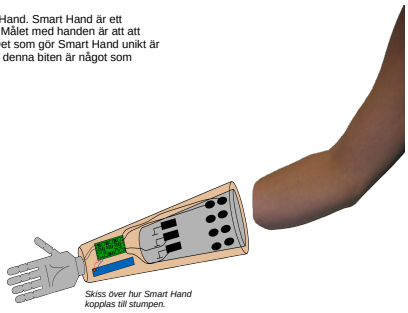
Båda är aktiva proteser men det är stor skillnad på hur pass avancerade de är.

Smart Hand, en smart protes

I Lund har det pågått ett forskningsprojekt som kallas Smart Hand. Smart Hand är ett EUprojekt och många internationella forskare är inblandade. Målet med handen är att att skapa en protes som ser ut och känns som en riktigt hand. Det som gör Smart Hand unikt är protesen ska kunna ge känsel feedback till användaren. Just denna biten är något som forskare här på LTH har utvecklat.



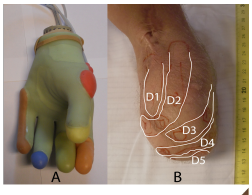
Smart Hand provas på riktigt.



Skiss över hur Smart Hand kopplas till stumpen.

Många som förlorat en hand känner fortfarande av något som kallas fantomsmärtor, Det innebär att man känner av smärta i den delen som inte längre finns. Man har upptäckt att det går att kartlägga var någonstans på stumpen som fantomsmärtorna är lokaliserade. Det betyder alltså att om man trycker på specifika delar av stumpen kan personen med en amuputation känna det som att man tryckte på ett finger eller en hand som inte längre finns. Just detta utnyttjar Smart Hand.

När man greppar något skickar handen signaler som kopplas till rätt del av stumpen och man upplever då känsel i sin protes. Just det här att protesen förmedlar känsel kan dels avhjälpa fantomsmärtor men även hjälpa personen som förlorat en del av sin kropp att ta till sig protesen som en ny del. Annars är det vanligt att man ser protesen som något främmande och aldrig en del av sin kropp.



På armstumpen har man kartlagt var känslen för fingrarna befinner sig

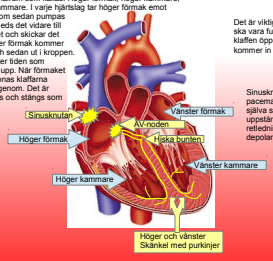
God dag, God dag!

8. ECG

EKG – Vad é de´?

EKG, eller elektrokardiografi som det egentligen står för är ett sätt att mäta aktiviteten i hjärtat. Som namnet antyder handlar det om att mäta de elektriska impulserna i hjärtat som får det att dra i hop sig i varje hjärtslag. Men hur fungerar det då?

Vi börjar med att titta lite på hjärtats anatomi och det elektriska retledningssystemet:
Ett hjärta är uppbyggt av fyra hålrum som kallas: Höger förmak, höger kammare, vänster förmak och vänster kammare. I varje hjärtslag tar höger förmak emot syrefattigt blod från kroppen som sedan pumpas till den högra kammaren. Där leds det vidare till lungorna som syresätter blodet och skickar det till vänster förmak. Från vänster förmak kommer blodet till vänster kammare och sedan ut i kroppen. Hjärtslaget är en process, under tiden som kamrarna töms fylls förmaken upp. När förmaket är fullt och kammaren tom öppnas klaffarna där emellan och blodet flyter igenom. Det är ljudet från när klaffarna öppnas och stängs som vi för som hjärtslag.

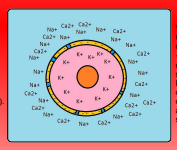


Det är viktigt att allt sker i ordning. Förmaket ska vara fullt och kammaren tom innan klaffen öppnas. Det är här **retledningssystemet** kommer in i bilden.

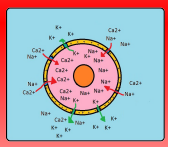
Sinusknutan i hjärtat är uppbyggd av något som kallas pacemaker celler. Dessa celler Kan depolarisera sig själva spontant utan någon retning. Retningen som uppstår i sinusknutan sprids sedan till resten av retledningssystemet så att alla celler går igenom en depolarisation.

Aktionspotential i cellen, hur uppstår den elektriska impulsen?

För att förstå hur den elektriska impulsen uppkommer ska vi titta på nervcellerna i hjärtat. En cell hålls ihop av något som kallas för cellmembran. I hjärtats celler ligger det en liten elektrisk spänning över cellmembranen som kallas för **vilopotential**. Denna spänning är negativ och ungefär 90 millivolt stor. I cellen finns det kaliumjoner (K^+) och utanför cellen finns det natriumjoner (Na^+) och calciumjoner (Ca^{2+}). I cellmembranet finns det även speciella kanaler som kan släppa igenom de olika jonerna.



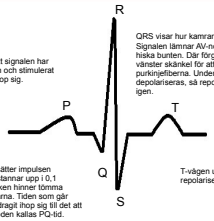
Vid en retning öppnas kanalerna för Na^+ och Ca^{2+} som då börjar strömma in i cellen och ändra dess elektriska potential. När spänningen stigit från -90 mV till ca +20 mV uppstår en urladdning av cellen och en elektrisk impuls har skapats. Det som nyss har hänt kallas för **celldepolarisation**. För att cellen ska kunna skicka en ny impuls måste den komma tillbaka till sin vilopotential på -90 mV, den måste alltså **repolariseras**. Detta uppnås genom att speciella kanaler som släpper ut K^+ ur cellen öppnas samtidigt som Na^+ och Ca^{2+} också läcker ut.



Ekg används som sagt för att undersöka hjärtats aktivitet. Det man kan se är hjärtats rymt, hur impulserna breder ut sig och om man har någon form av problem med hjärtmuskel. Med EKG kan man enkelt se om retledningssytemet fungerar som det ska.

När vilopotentialen är uppnådd stängs K^+ kanalerna. Även om kanalerna är stängda så läcker det in kalium i cellen tills den är tillbaka i utgångsläget och redo att **aktiveras** igen.

Den här figuren visar en typisk EKG-kurva. Har man något problem med hjärtat kan det visa sig på kurvan genom att visa toppar antigen försvinner eller förekommer flera gånger.



P-vågen innebär att signalen har börjat i sinusknutan och stimulerat förmaken att dra ihop sig.

QRS visar hur kamrarna drar ihop sig. Signalen lämnar AV-noden och färdas till hiska bunten. Där förgrenar den sig i höger vänster skänkel för att till sist gå ut i purkinjefiberna. Under tiden som kamrarna depolariseras, så repolariserar sig förmaken igen.

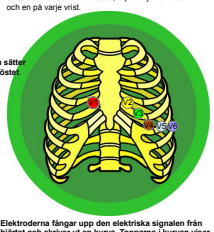
Från sinusknutan fortsätter impulsen till AV-noden där den stannar upp i 0,1 sekunder så att förmaken hinner tömma sig ordentligt till kamrarna. Tiden som går från det att förmaken dragit ihop sig till det att siganlen lämnar AV-noden kallas PQ-tid.

T-vågen uppkommer när kamrarna repolariserar sig igen.

De olika bokstäverna symboliserar hur den elektriska impulsen rör sig genom hjärtats retledningssystem.

Vanligen när man gör ett EKG på sjukhuset så sätts 6 elektroder över bröstet, 1 på varje handled och en på varje vrist.

Bilden visar hur man sätter elektroderna över bröstet.



Elektroderna fångar upp den elektriska signalen från hjärtat och skriver ut en kurva. Topparna i kurvan visar var i retledningssystemet den elektriska impulsen befinner sig.

Lite mer om avledningar

Det som registreras vid ett EKG är egentligen summan av potentialskillnaderna som uppstår när hjärtat depolariseras och repolariseras. Dessa summor blir resulterande vektorer. Att man på EKG kurvan får både positiva och negativa amplituder beror på att de resulterande vektorerna är riktade åt olika håll. En negativ amplitud innebär att vektorn är riktad från elektroden och en positiv amplitud betyder att vektorn är riktad mot elektroden.

Varför behövs det så många elektroder?

Fungergar som voltmetrar.

Elektroderna fungerar som voltmetrar och läser av den elektriska aktiviteten. För att man ska kunna jämföra EKG från olika person och även kunna följa upprepade mätningar från samma person är det viktigt att elektroderna placeras på samma ställe. För att man alltid ska sätta elektroderna på samma plats har man bestämt ett antal avledningspunkter

Unipolärt eller bipolärt?

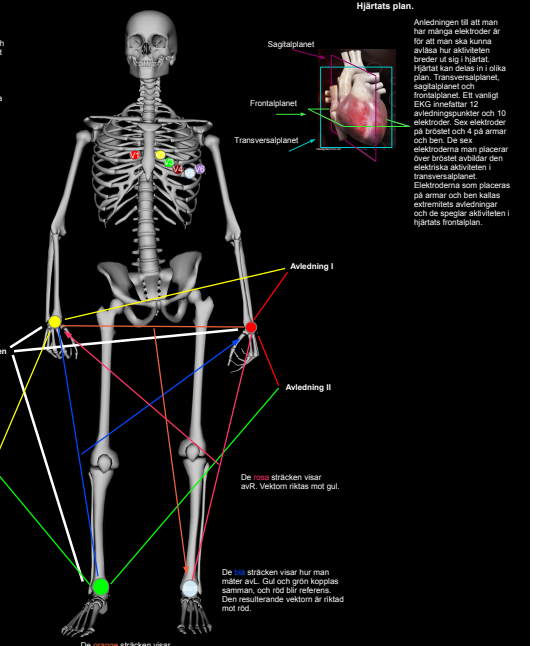
Avledningarna kan vara antingen bipolära eller unipolära. Unipolära avledningar registrerar aktiviteten i hjärtat som är riktad mot, eller ligger under elektroden, medan bipolära avledningar registrerar spänningen mellan två elektroder. De unipolära avledningarna jämför även skillnaden mellan hjärtas aktivitet och spänningen från en så kallad indifferent elektrod. Denna elektrod kallas Wilsonelektroden och består vanligtvis av sammankopplade avledningspunkter från armar och ben. Genom att koppla samman dessa får man en elektrod som inte har några spänningsvariationer trots att hjärtat har en elektrisk aktivitet. Därav namnet indifferent.

Elektrodavledningarna har egna namn.

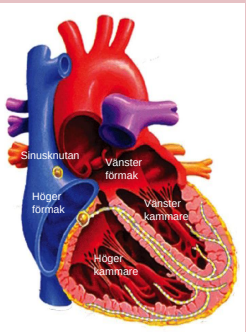
De tolv EKG avledningarna är internationellt standardiserade och har egna namn. De bipolära extremitetsavledningarna kallas I, II och III. De unipolära extremitetsavledningarna kallas avR, avL och avF, och bröstavledningarna kallas V1-V6.

Hjärtats plan.

Anledningen till att man har många elektroder är för att man ska kunna avlåsa hur aktiviteten breder ut sig i hjärtat. Hjärtat kan delas in i olika plan. Transversalplanet, sagitalplanet och frontalplanet. Ett vanligt EKG innefattar 12 avledningspunkter och 10 elektroder. Sex elektroder på bröstet och 4 på armar och ben. De sex elektroderna man placerar över bröstet avbildar den elektriska aktiviteten i transversalplanet. Elektroderna som placeras på armar och ben kallas extremitets avledningar och de speglar aktiviteten i hjärtats frontalplan.



Signalbehandling av förmaksflimmer



EKG

Ett hjärtslag startas av **elektriska impulser.** I ett normalt fungerande hjärta initieras dessa impulser i sinusknutan som sitter i högt uppe i höger förmak. Impulserna fortplantar sig sedan genom förmaken och vidare till kamrarna. Muskelcellerna i hjärtväggarna aktiveras av dessa impulser som får hjärtat att dra ihop sig och pumpa blod.

EKG-signalen, som registreras med elektroder på kroppsytan, visar hur den elektriska aktiviteten förändrar sig över tiden. Varje hjärtslag ger upphov till olika vågor som beskriver förmakens kontraktion (P-vågen), kamrarnas kontraktion (QRS-komplexet) och kamrarnas återhämtning (T-vågen).

Förmaksflimmer

Förmaksflimmer är den vanligast förekommande hjärtrytmrubbningen, och cirka 6% av alla över 65 år drabbas. Förmaken flimrar i stället för att dra ihop sig, vilket försämrar hjärtats pumpfunktion. Risken för stroke ökar också markant, eftersom proppbildning i förmaken är vanligt. **Behandlingen** av förmaksflimmer syftar till att återställa normal hjärtrytm genom medicinering, elchock eller mera sällan operation.

Orsaken till att förmaken flimrar är att de elektriska impulserna i förmaken är defekta. Det kan finnas **återkopplingsloopar** och/eller **ektopiska fokus** som tar över sinusknutans funktion i förmaken. Vid förmaksflimmer är P-vågorna ersatta av **flimmervågor**, sk f-vågor, vars rytm är oberoende av kamrarnas.

Målet

Att extrahera information från flimmervågorna i EKG-signalen som kan användas för att
- **utvärdera effekten** av olika läkemedel, eller
- **förutsäga vilken typ av behandling** som passar bäst för varje enskild patient.

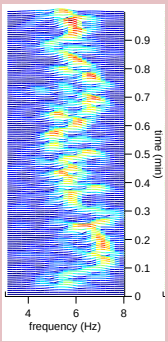
Flimmerfrekvensen är ett mått som rönt stort intresse på senare tid. För patienter med lägre flimmerfrekvens är chanserna större att förmaksflimret slutar spontant, och att behandlingen därmed lyckas.

Signalbehandling

Eftersom kammaraktiviteten har mycket större amplitud än förmaksaktiviteten är det nödvändigt att först separera dessa aktiviteter så att förmaksaktiviteten kan karaktäriseras på ett tillförlitligt vis.

Muskelaktivitet, kringliggande elektrisk utrustning och lossnande elektroder ger upphov till **brus** i EKG signalen. Därför är det viktigt att hitta **robusta metoder** för att bestämma flimmerfrekvensen och andra mått som beskriver flimmervågorna.

Genom **tid-frekvens analys** av flimmersignalen är det möjligt att beskriva hur förmaksflimmret ändrar sig över tiden. Figuren till höger visar hur flimmerfrekvensen hos en patient kan variera under en minut.



Medicinsk signalbehandling
Institutionen för elektro- och Informationsteknik
Lunds Universitet

CENTER FOR INTEGRATIVE ELECTROCARDIOLOGY AT LUND UNIVERSITY

9. Tinnitus

TINNITUS

Tinnitus är oljud i form av ringningar, brus eller tjut i öronen. Ljudet finns alltid där och kan vara väldigt jobbigt att gå runt med, framförallt när det är helt tyst runt omkring och ljudet blir mer framträdande. Tinnitus kan uppkomma om man vistas i miljöer med höga ljudnivåer. Men eftersom tinnitus är ett symptom och inte en sjukdom så ligger det ofta andra orsaker bakom ljudet. Det kan vara en skada i innerörat eller på hörselnerven men det kan lika gärna bero på stress eller en viss medicin.

Än så länge kan tinnitus inte botas men den kan lindras. Det finns en mängd olika metoder för detta, exempelvis tryckkammare, akupunktur, ginko biloba (naturläkemedel), silica (kosttillskott), antidepressiva medel, maskering, ljudstimulering, bettskena, laser, massage, hörapparat, psykologisk behandling, TRT-metoden (Tinnitus Retraining Therapy) osv. Det viktigaste att tänka på dock är att vi alla är olika så de olika metoderna fungerar inte på alla.

En metod utvecklad i Lund kallas THA-metoden, som står för Töjning, Hållning och Akupunktur. Den går ut på att förbättra hållningen på patienten som lider av tinnitus genom att stretcha överrygg, axlar och käke. Sedan får patienten öronakupunktur. Detta sägs iallafall hjälpa vissa av de som lider av tinnitus.

Det finns pågående forskning på att försöka bota tinnitus genom att operera in en elektrod kring vagusnerven som finns i nacken. Denna elektrod stimulerar vagusnerven med svaga elektriska pulser flera hundra gånger per dygn. Samtidigt får patienten, en gång per dag, lyssna på toner i frekvensområdet nära den frekvens tinnitusen har. Efter ca tre veckor sägs det att tinnitusen ska vara borta.

Skydda din hörsel med hörselskydd eller öronproppar

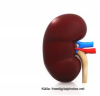
om du tycker det är väldigt hög ljudvolym!

Testa!
Ta på dig hörlurarna, lyssna och få en känsla över hur det känns att gå runt med tinnitus.

Borde egentligen vara en bild på hörlurarna som kommer användas!

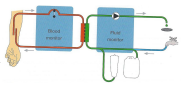
10. Dialysis

DIALYS



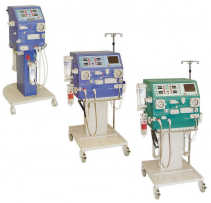
Hemodialys är ett sätt att rena blodet på patienter som drabbats av njursvikt, eller uremi som det också kallas. Njurarna är en del av kroppens eget reningsverk och de renar blodet och hela vätskevolymen i kroppen, som ju faktiskt är 50-60% av kroppsvikten, från restprodukter som kroppen inte behöver. Njurarna har även andra viktiga funktioner, till exempel bildar de vissa sorters hormoner, hjälper till att reglera blodtrycket, stimulerar produktionen av röda blodkroppar och aktiverar D-vitamin. Allt detta i ett organ som är ungefär 10-15 cm stort och format som en böna.

Tappar njurarna sin funktion måste man hjälpa dem antingen genom en njurtransplantation eller genom dialys flera gånger i veckan. Oftast använder man sig av dialys i väntan på en njurtransplantation.



Den konstgjorda njurens fader kan man nog säga är Nils Alwall som var professor i medicin vid Lunds universitet mellan åren 1957 till 1971. Alwall var övertygad om att det bästa sättet att behandla patienter med njursvikt var att använda dialys för att rena blodet. Alwalls första försök till att rena blodet genom dialys skedde under 40-talet. Hans första dialyspatient behandlades i Lund den 3 september 1946.

Nils Alwall (till höger) tillsammans med Holger Crafoord framför en spiraldialysator. De lade tillsammans grunden för företaget Gambro som startade under 1960-talet.



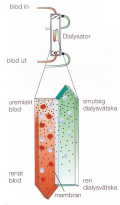
Dagens maskiner från Gambro.

Den första spiraldialysatorn från Gambro.

I hemodialys tar man även bort det överflödiga vattnet som bildas i kroppen när njurarna inte fungerar som de ska. Detta kallas ultrafiltrering och man gör det genom att skapa ett undertryck på den sidan av membranet med dialysvätskan. Undertrycket gör att vattnet pressas igenom membranet och in i dialysvätskan.

Experiment att göra hemma:
Ta ett ägg och lägg i ett glas med ättika. Låt stå ett dygn så att det hårda skalet lösts upp. Är det någon skillnad på storleken på ägget? Lägg sedan ägget i en sirapslösning (en del sirap och en del vatten) under ett dygn. Vad har nu hänt med storleken på ägget?

I bilden nedan är ägget till vänster ett helt vanligt ägg från kylen, ägget i mitten och till höger har legat i ättika ett dygn, ägget till höger har sedan legat ett dygn i sirapslösning.



Blodet pumpas ut ur kroppen till en dialysator, den konstgjorda njuren. I dialysatorn renas blodet och sedan pumpas blodet tillbaka in i kroppen. Själva reningen av blodet sker med osmos genom många halvgenomsläppliga membran som finns i dialysatorn. Halvgenomsläppligt betyder att de små slaggprodukterna i blodet, det vi vill bli av med, inte har några problem att ta sig igenom membranet men lite större produkter t ex blodceller är för stora för att kunna ta sig igenom. Så om blodet flyter på ena sidan om membranet och en speciell vätska, så kallad dialysvätskan, flyter på den andra sidan blir det en koncentrationskillnad av slaggprodukter mellan det orenade blodet och den rena dialysvätskan. Detta gör att slaggprodukterna i blodet tar sig igenom membranet och hamnar i dialysvätskan och på så vis är blodet som pumpas tillbaka in i kroppen fritt från slaggprodukter.

När ägget får ligga i ättikan löses skalet, som består av en stor del kalk, upp. Kvar blir den tunna hinnan som finns under skalet. Den kommer nu fungera som ett halvgenomsläppligt membran precis som i dialysatorn. Vattenhalten utanför hinnan är mycket högre än i ägget alltså kommer vattnet att vandra in i ägget vilket resulterar i att ägget sväller. När ägget sedan läggs i siraplösningen så är förhållandet det motsatta och vattnet kommer därför vandra ut ur ägget vilket gör att ägget krymper.

Förbättrad övervakning av hjärt-kärlsystemet vid dialys

Lunds universitet
Medicinsk signalbehandling, Institutionen för elektro- och informationsteknik
GAMBRO

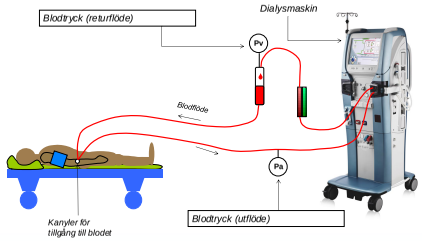
Vad är dialys?

Ordet kommer från grekiskans *dialusis* som betyder att lösa upp. Dialys är en livsuppehållande behandlingsform för personer som lider av kraftigt nedsatt njurfunktion, njursvikt. Om njurarna slutar fungera kommer vätska, salter, gifter och andra restprodukter att börja ansamlas i kroppen. Syftet med dialys är att **rena blodet**. Detta görs vanligen tre gånger i veckan med hjälp av en dialysmaskin. Maskinen renar blodet utanför kroppen innan det förs tillbaka till patienten.

Problem

Njursvikt påverkar blodkärlen och hjärtat på ett negativ sätt. Detta leder till obehagliga komplikationer, särskilt under dialys, eftersom förändringar i den biokemiska balansen riskera att gå för fort. För att förhindra yrsel, illamående och blodtrycksfall, behövs ny övervakningsteknik.

Den övervakning som finns tillgänglig idag kräver tyvärr extra utrustning som innebär ökad arbetsbörda för personalen och ökat obehag för patienterna, och därför görs inte övervakning rutinmässigt idag.



Forskning

Dagens **dialysmaskiner** mäter redan parametrar som avspeglar fysiologisk aktivitet. För att övervaka hjärt-kärlsystemet studerar vi de tryckmätningar som görs vid utflöde och returflöde i blodslangarna. Vår forskning har som mål att knyta tryckvariationer till status för hjärt-kärlsystemet.

Tillsammans med **sjukhus och industri** utför vi kliniska studier för att samla in data från både tryckmätarna i blodslangarna och från olika referens-instrument. Vi använder dessa data för att beräkna olika parametrar för bestämning av hjärtpuls, pulsens variationsmönster, förekomst av extraslag och arytmier.

Mål

- Övervakning av hjärt-kärlsystemet utan extra utrustning.
- Ökad patientsäkerhet under dialysbehandlingen.

11. Microfluids

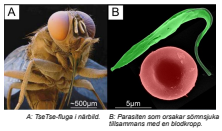
Mikrofluidik

-två spännande forskningsprojekt.

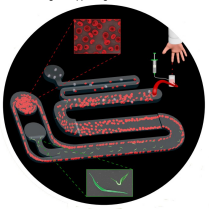
Att separera ut parasiter med hjälp av lab-on-a-chip.

Ett projekt av Stefan Holm, Dr Jason Beech och Dr Jonas Tegenfeldt från avdelningen för Fasta Tillståndets Fysik vid Lunds Universitet.

I Afrika finns det en fluga som kallas tsetse-fluga. Denna fluga biter och suger blod ifrån människor. Detta i sig är inget problem, men tsetse-flugan bär väldigt ofta på en parasit som ger den bitna människan något som kallas sömnsjuka. Sömnsjuka är en sjukdom som leder till döden om den inte snabbt behandlas. Problemet är att det är svårt att ställa en snabb och korrekt diagnos. För att kunna ställa diagnos måste man leta upp parasiten i blodet, och detta är som att leta efter en nål i en höstack. För att underlätta kan man centrifugera blodet och på så sätt få bort blodkroppar. Dock ger inte centrifugeringen en tillräckligt bra upprening från blodcellerna.

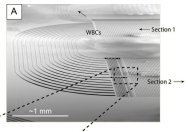


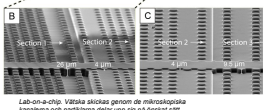
A: TseTse-fluga i närbild. B: Parasiten som orsakar sömnsjuka tillsammans med en blodkropp.



Separering av blod och parasiter.

Nu har en forskargrupp i Lund bestående av Stefan Holm, Dr Jason Beech och Dr Jonas Tegenfeldt från avdelningen för Fasta Tillståndets Fysik vid Lunds Universitet kommit på ett sätt som skulle kunna underlätta processen, med deras metod skulle vem som helst kunna hitta parasiter i blodet enkelt på bara några minuter. I deras metod använder man något som kallas mikrofluidik och lab-on-a-chip. Lab-on-a-chip är precis vad det låter som. Ett komplett litet laboratorium på ett chip. Mikrofluidik innebär att man låter vätskor passera genom väldigt små rör. De rör som används på miniatyrlab är oftast mycket mindre än ett mänskligt hårstrå i diameter. När man låter vätska passera i så små utrymmen beter det sig mycket annorlunda mot vad det gör om man låter det passera genom stora rör. I små rör radar partiklarna i vätskan upp sig och marscherar igenom som soldater på ett torg. Med ett sådant ordnat flöde kan man styra och påverka partiklarna mycket mer. Detta kallas laminärt flöde.





Lab-on-a-chip. Vätska skickas genom de mikroskopiska kanalerna och partiklarna delar upp sig på önskat sätt.

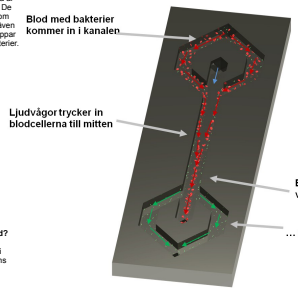
Detta forskningsprojekt är ännu inte helt klart och det finns mycket mer att göra inom området. Men med hjälp av dessa duktiga lundaforskare kanske man in framtiden kommer att kunna behandla och hjälpa alla de som drabbas av sömnsjuka, aids, malaria och cancer.

Forskarna i Lund har byggt upp chip som innehåller så kallade pelarskogar. På chippet har man då byggt en samling hinder som får partiklarna i blodet att dela upp sig på ett specifikt sätt. På grund av det laminära flödet kommer partiklarna att färdas i bestämda banor. Beroende på hur man väljer att bygga hinderbanan kan man sedan styra och separera ut specifika partiklar beroende på storlek, form och konsistens. På chippet kan man sedan sortera tusentals celler varje sekund.

Kan man hitta bakterier i blod med ljudvågor?

Ett projekt av Pelle Ohlsson, Klara Petersson, Andreas Lenshof, Ingbritt Åstrand-Grundström och Thomas Laurell från Lunds Tekniska Högskola och Skånes Universitetssjukhus i Lund.

Vad är blod?
Trots att blod ser ut som en vätska består det faktiskt till hälften av celler, så många som 5 biljoner i en liter blod. De flesta av cellerna är röda blodkroppar som transporterar syre. De är anledningen till att blodet är rött. Förutom de röda blodkropparna innehåller blodet även blodplättar som läker sår och vita blodkroppar som försvarar kroppen mot virus och bakterier.



Vad händer om man får bakterier i blodet?
Bakterier ska egentligen inte komma in i blodet, men om de lyckas ta sig in i blodet kan vi bli väldigt sjuka och riskera att dö av blodförgiftning. I så fall gäller det att snabbt ta reda på vilka bakterier som tagit sig in i blodet så att man kan behandla med rätt antibiotika. Det gör man idag genom att ta ett blodprov och låta bakterierna i det växa under en eller ett par dagar så att de blir tillräckligt många för att man ska kunna hitta dem. Vi håller nu på att utveckla ett sätt att sortera ut bakterierna direkt ur blodet med hjälp av ljudvågor för att kunna hitta dem direkt!

Hur hittar man bakterier med hjälp av ljud?
Vår metod går ut på att skicka blodprovet genom en smal kanal. I kanalen använder vi ljudvågor för att trycka in cellerna till kanalens mitt. Bakterier är för små för att påverkas av ljudvågorna, så de blir kvar vid kanalens väggar. När bakterierna väl är skilda från blodcellerna kan vi samla upp dem för sig.

Vad händer nu?
Metoden verkar fungera bra i forskarlabbet, så nästa steg är att testa den på blod från patienter. Om det funkar lika bra hoppas vi kunna bygga en bakteriesorteringsapparat som