TECHNICAL DOCUMENTATION

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Version 0.1

Status

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| Reviewed |  |  |
| Approved |  |  |

PROJECT IDENTITY

Project group number 2, MED3/term 7, RunKinect

Tekniska högskolan at Linköping University

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**Abstract**

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Document history

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| --- | --- | --- | --- | --- |
| **Version** | **Date** | **Eventual changes** | **Done by** | **Reviewed** |
| 0.1 | 2013-01-24 | First version | NB, MB, AB, ED, KR, JT |  |
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# Introduction

## Background

Every person has a different way of moving around, a different moving pattern. It is influenced from parents to their children and from other inputs that we are exposed to. Ways of doing a simple thing, as carrying a handbag, can vary a lot between different people. One way can seem simple and normal to someone while it seems odd and sometimes even painful to someone else.

By analyzing the movement pattern of an individual, interesting information can be gained. This information can help the individual to a better way of moving. A better way can be more relaxed, less painful or more efficient. These ways of moving can have impact on a persons heart rate and breathing pattern. But changing a moving pattern is changing a habit and that can be hard and feel unnatural. To establish a new pattern can take over 300 repetitions depending on how complex it is, which might seem quite remarkable. Also, the age of the individual has a big impact on the difficulty. It is easier for a young person, a child for example, to change his/hers behavior and way of moving, than for an adult.

Analyzing a movement and finding out if changing it is necessary can be hard to do, especially when the movement occurs in a high speed. The timing in the body segments stays the same no matter how fast the move is and that gives us the opportunity to slow down the movement and analyse it when it is easier to spot the issues and fix them. When the speed and the load of an imperfect movement increases, the more the imperfection will be shown. A good way to see this is by using a camera. A Kinect camera can take up to 30 frames per second and this can help spotting the imperfect movement. When a person is jumping right up it can be hard to see any imperfections but if you have several pictures of it, it is easier to see what is happening. With this way you can see if the person is knocking his/her knees together, which can be a sign of a weak hip. With this information, new helpful exercises can help the person and prevent injuries in the knees and back.

Analyzing the movement pattern can have huge impact on individuals. It can help them in their daily life by making different movements more efficient and preventing them from getting injuries

## Purpose and aim

The projects main purpose was to create a running lab where different running styles, related to the runners physical health, were exposed. The project should result in a model that could help analyzing and improving running movements. The aim was to set up a model around a treadmill with optical registration of body movements and wireless recording of physiological measures. These two was to be connected to one single system for easy usage for any operator. The result should be presented in real-time.

Important body movements was how different angles between joints in the body changed during running. The runners pulse and ECG were important  physiological measures and was shown in the program.

The projects outcome was uncertain because project group had such limited programming skills and that the project customer had little experience in these type of projects involving mainly software development. Nobody involved in the project knew how the problems were going to be solved and exactly what level of knowledge was required to solve them.

## Limitations

Limitations in the project, disregarding the project groups competence, were (among other things) limitations in the optical instrument. The number of instruments needed were limited to two and the instruments hardware and software also had limitations. The access of experts were limited and their knowledge as well. This depends on that the required knowledge was uncertain in the beginning. Other limitations were the maximum speed and incline of the treadmill. The sensitivity of the pulse band also contributed limitations to the project.

## Method

### Before phase

*The project didn’t have any given question but questions raised was if it was even possible to create such a system and in that case, what was the best way to do it? What optical instrument was the best to use? How could the runners pulse and ECG be presented in the most optimal way?*

Since the pulse monitor used Bluetooth for data exchange, a programming language with a Bluetooth standard library or a Bluetooth API would have to be chosen for the project. Suggested languages would then be C, C++, C#, Java, Python, VB.NET and many more. The customer suggested using Kinect sensors as part of the solution. After research of alternatives lead by the project developer manager, the Kinect sensor was chosen as part of the solution because of its superiority over other solutions by also providing depth and motion aside from a video feed (<http://www.microsoft.com/en-us/kinectforwindows/discover/features.aspx> 2013-05-07). Since parts of the Kinect project are closed source (<http://www.bit-tech.net/news/2013/03/13/microsoft-reveals-kinect-source-code/> 2013-05-07), the most effective way of programming with the sensors would be by using the official Microsoft Kinect SDK. This would limit the number of choices to the .NET languages C#, C++/CLI and Visual Basic .NET. The project developer manager then decided to write the code in C# because of its C-like syntax and familiar object-orientation seen in previous courses taken by the group members.

In the before phase of the project the group began with the creation of a group contract. This document defines the distribution of responsibilities among the group members and how the group works together and it can be seen in *appendix A*. There were meetings with the customer about the idea of the project and what the group was supposed to do. This resulted in the writing of a project plan , including a timeplan *(appendix B)*, a specification of requirements *(Appendix C)* and a design specification *(appendix D)*. These documents were approved by the customer and in certain cases the mentor.

### During phase

The during phase began with a literary study. Everybody in the group read about the c# language and did tutorials to learn how the programing language was build and how it functioned. Different tutorials were done to learn different code basics7.These included operators, types, classes and other vital basics*.* Then the group read about the hardware of the Kinect, how the camera is build, how it works and the basics concerning how to program it. The basics of the available SDK was studied with the help of the book *Beginning Kinect programming with the Microsoft Kinect SDK* by Jarret Webb and James Ashleyand the interesting parts were read more thorough. The group also studied how to connect two cameras into the same system.

Then the group discussed what different components that had to be developed to make a system that fulfilled the specification of requirements. A plan describing who would be working with which parts of the project was also formed and the group started working with different parts of the system simultaneously.

The group had a meeting with the customer and renegotiated some of the requirements. This was done late in the project, with only five weeks until deadline. Though it was necessary since the project group discovered that some requirements was impossible to fulfill depending on the equipment itself. Other changes in the requirements was the level of priority and relevance.

### After phase

After the project is finished the delivery of the product will take place, after which necessary documentation will be supplied to the customer. A technical report, a reflection report and a user manual will be written. The project will be tested in regard to the specification of requirements. The project is then finished after an evaluation by each of the group members.

## How a Kinect works

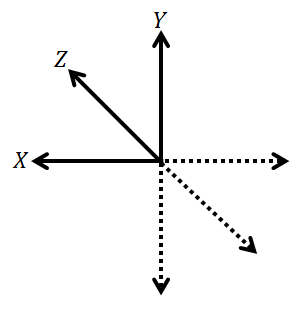
In november 2010 Microsoft first released, after years of speculations, rumors and a prereleases, a new accessory to the Xbox 360 that would change the way gamers played. This was a way to play that did not require a controller, instead you would control the game with your body. This new accessory was called Kinect. The Kinect camera uses a complex system of sensors, transmitters and cameras to detect and show how a person moves. This is done with the help of an infrared (IR) projector, two cameras and four microphones. Starting from the right, no 1 an IR projector which emits infrared light into the room. Second comes the color camera used to collect RGB-data. It functions as a regular webcam and supports a resolution of 1280 x 960 pixels. The third one is an IR-camera. This camera collects the depth data, it detects the infrared light when it bounces back towards the camera. It supports resolution of 640 x 480 pixels. The Kinect camera also has a microphone array that consists of four microphones placed on the bottom of the camera. One is underneath the IR transmitter and the other three is evenly spaced on the right side of the depth camera. However, the microphones were not used in this project.

The Kinect SDK

Microsoft have created a Software Development Kit (SDK). The SDK is a set of libraries that allow us to program applications with the Kinect as input. With the help of these libraries it is relatively easy to access the Kinect cameras image-, depth- and skeleton streams. With this data you can to develop any number of applications.

The Kinect skeleton space

From the Kinect camera’s point of view, the room coordinates  for the skeleton space looks like this:



The positive z-axis is pointing out of the camera, the positive x-axis is pointing to the left and the positive y-axis is pointing upwards. The boundaries (in m) are [-2.2, 2.2] for the x-plane, [-1.6, 1.6] for the y-plane and [0, 4] for the z-plane.

## The pulse band

Heart rate monitors

Our heart is, among other things, a complex electrical system called the cardiac conduction system. This system consists of three different parts: the sinoatrial node (S-V node), the atrioventricular node (A-V node) and the His-Purkinje system. These parts cooperate to create and spread the necessary electrical potential through the heart in the appropriate manner. The electrical signal begins with aThe heart contraction begins with an electrical build-up in the S-V node. The signal is then spread through the heart with the help of the A-V node and the His-Purkinje system that makes sure that the different valves and walls contract in the right order. (<http://www.bostonscientific.com/lifebeat-online/heart-smart/electrical-system.html> 2013-04-25)

The electrical signals in the heart can be measured in different ways e.g. electrodes attached on the person's body, a transmitter secured around the chest with a strap. The detected signal is then transmitted to a watch or some other equipment that can detect, process and display the desired data. (<http://wiki.answers.com/Q/How_does_a_heart-rate_monitor_work> 2013-04-25 eller <http://www.freescale.com/files/microcontrollers/doc/app_note/AN4059.pdf>)

*In our case the signal is measured with a heart rate monitor secured with a strap around the chest. The monitor then sends a signal to a bluetooth device that sends the signal to a computer program which manipulates the signal and extracts the interesting data. (mer detaljer kring hur det fungerar? Någon som vet hur det fungerar? Är detta rätt? Skriver en lite mer detaljerad beskrivning nedan -Nima)*

The pulse monitor provided to the group is a two-lead ECG-monitor secured with a strap around the chest. The leads are connected by wire to a pad where a module is placed. The module transmits the acquired signals via Bluetooth to a server/nearby computer. The ECG data is then, if necessary, filtered and presented on a chart by a program.  


*Image 1 - Back of pulse monitor with highlighted ECG leads*



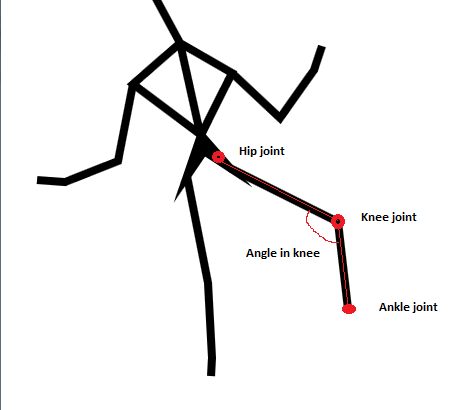
*Image 2 - Pad where transmitter module is placed*  


*Image 3 - Transmitter module*

# Result

In this project the group has solved different programming problems.

Finding angles in joints

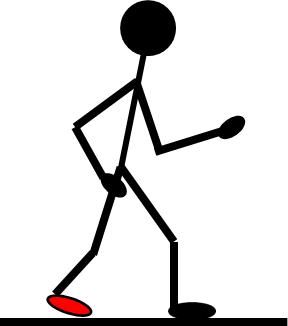
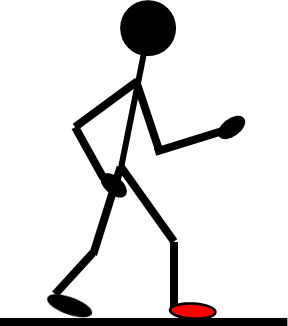
To find the angle between two joints in the runners lower body we used data from the Kinect skeletonstream.The data needed is the X, Y and Z position of three joints. If you e.g. want the angle in the knee you use knee, ankle and hip. There is a vector drawn between knee and ankle as well as knee and hip and scalar product is used to find the angle between the vectors. This is described in figure XX below

*Figure XX Image describing how the angle in the knee is found*

Drawing a skeleton

Finding the speed and incline of the treadmill

To find the speed and incline of the treadmill, the Kinect skeleton stream was used which allowed comparison of joint position between different frames. The development of the method for this purpose was based on the assumption that the feet have the same velocity as the band of the treadmill as long they are connected. Therefore it seemed feasible to determine the speed if knowing when and where a foot hits and takes off from the band during a step. The speed of the foot (and therefore the treadmill) should then be the distance between these two points divided with the time elapsed between their recording. The concept is illustrated below:



*Figure X. The starting position for the measurement is highlighted in red in the left figure. The same is done close to half a step cycle later for the right figure with the end position for measurement.*

The first approach was to determine momentaneous velocities by comparing the current frame with the previous frame. When the x-velocity of the foot under consideration turns positive, the foot should be moving backward (see section The Kinect skeleton space).This indicates that the foot is about to or has hit the band. When the y-velocity of the foot turns positive, the foot should be moving upwards. Which indicates that the foot is about to or has took off from the band. However, this approach gave unreliable, though reasonable, results. This probably because of the skeleton data being too “jumpy” for comparison between a frame and the preceding one. Since the time between frames are so short (mostly around 30 ms), even slightly misgiven coordinates might have indicated velocities that in reality would have the opposite sign.

The final approach was to base the decision of when to start and stop measuring by investigating the distance between the feet. This turned out to be a significantly more reliable solution.

## Presentation of test results

# Discussion

Alternative to Kinect – why is it more difficult?

**Other options**

One other method would be using a regular camera. Then the group would have to write a software that could recognize different parts of the body via some kind of object recognition. This software would have to be able to recognize body parts and specific joints in a persons body and be able to create a skeleton representation from this data.

Without the depthstream (IR transmitter and receiver) available in the Kinect it would be hard to create a 3D representation of a skeleton. To find how far away an object is you would have to detect shaded areas and how they move in respect to a known light source  This is very complicated due to several reasons, one being that the reference light always has to be the same for you to get a correct comparison.

## Development potential

* Hur långt har vi hunnit?
* Varför har det inte gått som vi tänkte oss?
* Hur kan man gå vidare med detta?
* Är det ett krav som vi inte lyckats uppfylla?

*Programming the pulse monitor*

*Making a 3D representation of the runner*

**Discussion**

* Is there a better way to approach/solve the problems in the project?
* What have we learned?

**Stroke rehabilitation - a development**

* Movement improvement - training balance and coordination
  + Make rehabilitation fun with Kinect games
* Help people who are unable to e.g. type to use computers.

# sources

## Printed sources

## Electronic sources