UNIVERSITEIT TWENTE.

# SMART ENVIRONMENTS PROJECT

## DOCUMENTATION REPORT

**22 Enschaton Averted**

Just Baselmans
David van Dijk
Julius Meetsma
Luuk Welling

UNIVERSITEIT TWENTE.

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## Chapter 0: Introduction

More than thousands of people die yearly because of disaster, natural or infrastructural. Many of these disasters are things we can't prevent, but we could try to minimise the amounts of deaths that occur because of these circumstances. One thing which is responsible for a substantial amount of deaths and injuries every year, is traffic. In this paper we will try to find a method that uses smart technology to reduce the amounts of accidents caused by traffic, specifically fatigued driving. We hope to find a solution that could potentially reduce the amount of accidents caused by it, which according to the ANWB is currently responsible for about 700 to a 1000 severe car accidents in the Netherlands annually. In this paper we are going to discuss a smart solution that mainly uses your heart rate to detect when you become tired, and it notifies you to take a break. This way we hope to find a solution that would reduce the accidents occurring.

# Chapter 1: Literature Review

In chapter 1 we found 20+ meaningful publications on the general subject of disasters.

1. Pet flea treatments poisoning rivers across England, scientists find.(Carrington, 2020)

Summary: Highly toxic insecticides used on cats and dogs to kill fleas are poisoning rivers across England. The toxin found is called fipronil and the amount found in the rivers is 38 times above the safety limit. This endangers a wide range of birds, insects and fish found in the 20 rivers where samples were taken from. If the delicate balance of animals gets disrupted, the ecosystem in these rivers might collapse. This is something that shouldn't be allowed to happen.

2. Storm Alex: Floods and landslides hit France and Italy. (BBC News, 2020)

Summary: Storm Alex caused major landslides in the Northern villages of Nice in France. The severity of the storm combined with insufficient support beams for the ground underlying the village, caused the ground to break away. Because of this there are at least 2 deaths and over 20 people missing.

3. Storm Alex: Floods and landslides hit France and Italy. (BBC News, 2020)

Summary: A flood occurred in the city of Piedmont in Italy after 640mm of rain fell within 24 hours, a record high since 1954. A section of a recently renovated bridge collapsed, killing multiple people. Cars with people together with nearby lying houses were swept away. Hundreds of rescue troops were deployed to aid in the extremely critical situation.

4. Taal volcano eruption poses deadly dilemma.(Jorgio, 2020)

Summary: The sleeping Taal volcano in the Philippines erupted on the 12th of January 2020, wiping out an entire village and leaving little remains. Heavy charcoal-like ash rained down on towns and villages, blanketing everything. Houses and trees buckled under the weight of it. Affected areas had no power or freshwater. By the following Saturday more than 70,000 people had sought shelter in 300 temporary evacuation centers. Many more are staying with relatives or friends in other provinces.

5. Pre- and post-disaster negative life events in relation to the incidence and severity of post-traumatic stress disorder.(Maes et al., 2001)

Summary: A study on PTSD from motor accidents and a flash fire in a ballroom. This study looks at the relationships between PTSD and pre- and post-disaster life events. There were highly significant relationships between the cumulative number and event severity of post-disaster negative life events and the incidence rate and severity of PTSD. The post-disaster life events were significantly more related to the avoidance–depression dimension than to the anxiety–arousal dimension of PTSD.

6. The Death Toll from Natural Disasters: The Role of Income, Geography, and Institutions.(Kahn, 2005)

summary: A paper viewing deaths from disasters in 73 nations from 1980 to 2002, Though richer nations do not experience fewer natural disasters than poorer nations, richer nations do suffer less death from disaster.

7. Comparison of avalanche survival patterns in Canada and Switzerland.(Haegeli, 2011)

summary: "Data for survivors and nonsurvivors of complete avalanche burials from Oct. 1, 1980, to Sept. 30, 2005, from Canadian and Swiss databases. The probability of survival fell quicker with trauma-related deaths and in denser snow climates. Poorer survival probabilities in the

Canadian sample were offset by significantly quicker extrication (median duration of burial 18 minutes v. 35 minutes in the Swiss sample; $p < 0.001$)."

8. Consequences of climate-driven biodiversity changes for ecosystem functioning of North European rocky shores(2009)

Summary: A study investigating the impact of climate change on biodiversity on rocky shores in northern Europe. The temperature of the sea has been rising around these shores. "In a warming climate, the balance between grazers/suspension feeders and fucoids is likely to alter." With biodiversity, small changes in the amount of one organism, can have influence on all the other organisms in the ecosystem.

9. Climate Change Indicators: Wildfires. (United States Environmental Protection Agency, 2020)

Summary: Wildfires have been increasing in acreage burned compared to 20 years earlier. Wildfires are unplanned burning where the response is to put the fire out. Wildfires harm people, infrastructure and nature. It also has an affect on the cleanliness of air, due to the smoke.

10. Scientists are trying to save coral reefs. Here's what's working. (Gibbens, 2020).

The coral reefs around the world will have to adapt to higher temperatures faster than ever before. This due to climate change and paired with climate change there is a lot of pollution in the oceans too. The corals might not be able to evolve to deal with these changes.

11. Five Air Pollution Risks Caused by Natural Disasters.(International Environmental Technology, 2019)

A lot of natural disasters can have an impact on the air quality of the surrounding area. Dusts, toxic materials and bacteria will make the air less breathable and more dangerous.

12. Exploring the effects of a serious game-based learning package for disaster prevention education(Tsai et al., 2020)

Summary: A study that aims to develop a game-based package for education about disaster prevention. Because disaster education has proven to be an effective process in disaster management.

13. BIM integrated smart monitoring technique for building fire prevention and disaster relief(Cheng et al., 2017)

Summary: The study uses Building information modeling to construct an intelligent system for fire prevention and disaster relief.

14. Application of Internet of Things in Smart Grid Power Transmission(Ou et al., 2012)

Summary: The paper talks about using Internet of Things in a smart grid to speed up the information of the power grid system. And about how it would make it easier to ensure better disaster prevention as sensors could prevent natural disasters from damaging the power system.

15. Harnessing the Crowdsourcing Power of Social Media for Disaster Relief.(Gao et al., 2011)

Summary: The paper discusses the advantages and disadvantages of crowdsourcing applications tied to disaster relief. It also discusses the challenges to make it a better system.

16. WEF - The Global Risks Report 2020

It assesses risk using 5 critical aspects: economic, environmental, geopolitical, societal, technological. They talk about having about a decade left to get existential climate threats under control and the dangers of accelerated biodiversity loss. Another chapter focuses on the societal consequences of digital fragmentation.

17. Challenges in Scaling Up Biofuels Infrastructure(Richard, 2010, p. 794)

This paper addresses the challenges we will have to overcome as we transition towards greener energy production methods. As is, the agricultural industry is not ready to replace the petrol industry. The paper proposes a transition towards decentralization of supply chain and the specifics of certain biological processes that could work at scale in that networked industry.

18. Urban flood disaster management.(Tingsanchali, 2012, p. 34)

This paper describes concepts, policy and operational plan in 4 steps to prepare before and efficiently manage floods. The Total water cycle management concept diagram is particularly interesting thinking of where could sensors be placed to monitor useful information.

19. Public Perceptions of Private Space Initiatives(Platt et al., 2020, p. 101358)

The paper focuses on the perceptions in regards to space travel and such, namely Perceptions of space exploration, Perceptions of space tourism. The reasoning behind the approach taken by this research team is concerned with the necessary approval and trust of society in the players who lead the human space exploration project..

20. Distracted driving: prevalence, problems, and prevention.(Overton et al., 2014)

Article on car accidents in relation to using phone while driving. A study about car accidents in America related to phone use.

# Chapter 2: Identification of General Problems and Challenges

In chapter 2 we identified 8-10 general problems & challenges from the list of publications in Chapter 1.

### Small scale problems:

People dying of avalanches, with a higher decay of life expectancy when having trauma.

Mapping scientifically useful information of coral reefs or other shallow waters. (mapping sea life around windmill marks)

Car accidents because of being distracted, for instance by phone use while driving or sleep deprivation.

Modern buildings have diverse building environments, making fire hazards difficult to control and manage.

### Large scale problems:

Chance on disappearing underwater biodiversity, like the coral reefs.

Toxins used to help against certain diseases or illnesses affecting life in other areas. Indirectly affecting drinking water and which toxins we consume.

Erupting volcanoes polluting nearby rivers and making fertile ground inaccessible for a long period of time.

Fragmented cyberspace and differing technological standards could hinder economic growth, exacerbate geopolitical rivalries and further divide societies.

Biorefineries need to rethink their supply chain configurations to achieve economies of scale.

Power grids can get damaged by natural or infrastructural disasters, causing loss of power and damage to the economy.

Disasters, natural or caused by humans, can drastically increase air pollution over a short time in areas.

# Chapter 3: Identification of Relevant Problems

Identify 5 new problems you find relevant, urgent and interesting, not yet been addressed effectively

### House Fires

Home fires may be specifically fires that start in the kitchen. This is a problem because out of the 74,000 disasters the red cross responded to, 93% where homefire. This is a problem which is still growing every year.
https://www.redcross.org/content/dam/redcross/atg/PDF_s/Preparedness___Disaster_Recovery/Disaster_Preparedness/Home_Fire/FireFAQs.pdf

### fatigued / drowsy driving

14.5% of people participating in a research done by Ward Vanlaar, Herb Simpson, Dan Mayhew and Robyn Robertson admitted that they have nodded away or fallen asleep while driving within the last year. nearly 2% of those people ended up with an accident.
(Vanlaar et al., 2008, p. 306)

### Loneliness epidemic

During the corona quarantine, loneliness has suddenly risen a lot. Being lonely for extended periods of time has serious mental health consequences. From April to May in a month-long UK study, 30% of people have experienced loneliness and outside quarantine still a lot of the elderly population has had a massive loneliness problem.

Seeing someone through Teams, Skype or Facetime is not the same as seeing someone in real life, as you cannot make eye-contact with each other, an important way humans socialize with each other.

Microsoft already talks about this when releasing their “together mode” for microsoft teams.
(Large, 2020)
(Ryon, 2020)

### Food safety

All kinds of disasters can cause prolonged power outages, these are dangerous for various reasons. One of them has to do with food safety, because your fridge no longer works. There are some solutions but it would be beneficial to create a smart solution that makes it a non issue.
(Food Safety During An Emergency, 2020)

## Social media addiction

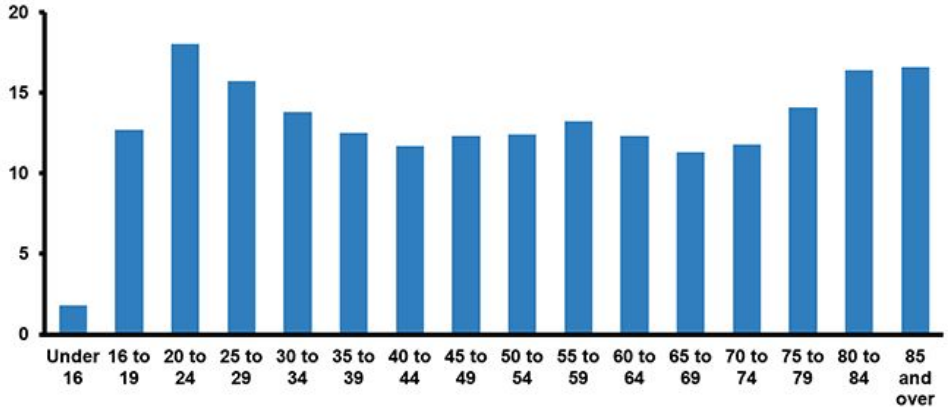
With the recent release of “The Social Dilemma” the problem of social media affecting our lives has truly gone mainstream. With people spending so much time on it in their life, the health consequences should be looked into more. Even though there might be mental consequences to social media for some people, you have to use it in this world, for work and for friends, especially in corona times, people are spending more and more time on social media.
(Hilliard & Parisi, 2020)

# Chapter 4: Problem Selection and Motivation

### The problem we choose

Of the 5 problems we identified in the previous step we have selected the car accidents to work with. We do this because this is still a giant problem - even though the amount of fatal car accidents have declined a lot when looking at a few dozen years ago.

According to multiple sources (Business Insider, 2019; Pines, 2013) the leading cause of car accidents is distracted driving, followed by speeding and drinking while driving. This is a giant problem that affects all ages




Motor Vehicle Deaths Per 100,000 Persons By Age, 2018 source (Insurance Information Institute, n.d.)

“Approximately 1.35 million people die each year as a result of road traffic crashes.” (WHO, 2020)

Car crashes as a whole is ofcourse a enormous problem but we hope we are able to create a realistic solution to a part of this problem to bring those deaths down.

“8 percent of fatal crashes, 15 percent of injury crashes, and 14 percent of all police-reported motor vehicle traffic crashes in 2018 were reported as distraction-affected crashes.”(National Highway Traffic Safety Administration, 2020)

We want to target distracted driving or sleepy driving as our main problem.

# Chapter 5: Potential Solutions

The five solutions to solve the problem that we choose (distracted driving/sleepy driving) are:

1. A smart system that can track your usual driving habits, this way if you start swaying more than usual, or otherwise deviate your car could give you a warning to rest.
2. Eye-tracking, this can be used at different levels. The easiest way is to look if your eyes are open and look at the amount you're blinking to determine how tired you are. but this could also be used to look how far away you are looking on the street the farther away you look the better focused you are on driving.

3. Using a heartRate monitor this could be a wearable or can be integrated into the steering wheel. By tracking heart rate you could determine how sleepy someone is. you would first have a period of calabriton to look at what the standard heart rate is and set a threshold accordingly. If your heart rate drops a X amount you should maybe take a rest. If your heart rate increases a X amount there is maybe something wrong with the road.
4. Using the location of a vehicle and combining it with the data of a smartwatch you can get better knowledge of where problems are on the road. All this data retrieved of different drivers using an app , like heart rate and vehicle speed can give very useful information to city planners. If for example, a lot of people on a specific road or intersection have a higher heart rate and their speed decreases significantly, there might be unclear infrastructure. A lot of people have a specific intersection in mind if you were to ask them about bad infrastructure around their city. This would be a way to see problematic roads before an accident has to happen.
5. A dash cam that uses a neural network to detect if there is a crash happening. If there is a detection triggered, the footage gets sent to rescue services that can assess immediately the type of service required, without the inconvenience of people calling in shock without being able to describe the situation clearly. If a neural network would be too difficult to implement, due to energy constraints and such, you can just use a big button that sends the past so many seconds of being pressed to the rescue services, making the driver or passenger do the work of the neural network instead.

# Chapter 6: Solution Selection

The solution we will work out is fatigued driving because we believe this is a manageable chunk of a giant disaster.
We will solve this problem by monitoring the heart rate of a person while driving. The heart rate is a very useful indicator for when a person is getting tired or even is falling asleep. “It is generally accepted that heart rate decreases during a shift from wakefulness to sleep in man as well as in animals” (Chouchou & Desseilles, 2014) So if it is possible to detect a reduction in heart rate it is also possible to warn a person by for instance sending a phone message and giving an audible warning.

“A majority of drivers (58.6%) admitted that they occasionally drive while fatigued or drowsy. Of greater importance, 14.5% of respondents admitted that they had fallen asleep or “nodded off” while driving during the past year. Nearly 2% were involved in a fatigue or drowsy driving related crash in the past year.” (Vanlaar et al., 2008)

**Waking state**
During sleep a slow heartbeat with rates around 40–**50 bpm** is common and is considered normal (MedlinePlus, n.d.).

ECG of 46,129 individuals with low risk for cardiovascular disease revealed that 96% had resting heart rates ranging from 48-98 beats per minute (Mason et al., 2007).

Seeing as it is possible for a person to have a resting heart rate of 48-50 beats per minute, and seeing that this is also the average for a sleeping person it will either not be possible for people with these resting heart rates to make use of our product, or we will have to figure out a way of finding their sleeping heart rate. However, these low heart rates are not very common. People with a resting heart rate lower than 60 have a condition called Bradycardia.

For the majority of people however, a simple check of whether a person’s heart rate is rapidly approaching the 40-50 range will create a clear indication of their waking state.

The US Centers for Disease Control and Prevention reported in 2011 that 15.2% of adult males and 6.9% of adult females had clinically-defined bradycardia.

**Sleep deprivation and crashes.**

Sleep deprivation has caused numerous accidents that could have been prevented if the driver was more awake.

A 2018 article researched the consequences of sleep deprivation in traffic and concluded that being deprived of sleep generates a higher risk of being involved in a traffic accident.

“Among 3201 evaluable participants, 222 (6.9%) reported at least one motor vehicle crash during the prior year. A higher apnea-hypopnea index ($p < 0.01$), fewer hours of sleep ($p = 0.04$), and self-reported excessive sleepiness ($p < 0.01$) were each significantly associated with crash risk. Severe sleep apnea was associated with a 123% increased crash risk, compared to no sleep apnea. Sleeping 6 hours per night was associated with a 33% increased crash risk, compared to sleeping 7 or 8 hours per night. These associations were present even in those who did not report excessive sleepiness. The population-attributable fraction of motor vehicle crashes was 10% due to sleep apnea and 9% due to sleep duration less than 7 hours.” (Gottlieb, Ellenbogen, Bianchi, & Czeisler, 2018)

## The Basic scenario:

The basic scenario consists of creating an app that will connect to a heart rate sensor linked to arduino integrated into a steering wheel. The heart rate sensor will measure over time and set a “normal” heart rate. If the heart rate drops a certain percentage under the “normal” heart rate a bluetooth signal will be sent to the user's phone that displays a message and gives a sound warning.

## The Ambitious scenario:

The ambitious scenario consists of everything from the basic scenario but does have a few additions. These additions consist of a few sensors and a few upgrades to the app, the app will not only work as a sleep warner but also as a navigation tool because most people nowadays already use google maps on their phone for navigating. The app will add to this so it can not only help you navigate but can also give you a more meaningful warning. For instance the app could lead the user to the closest place to rest or get something to eat when it is measured that a person is fatigued. because of this the app will also be able to access GPS and therefore it will be able to link heart rate to the roads. We hope we can find a correlation between how many accidents happen in a specific area and the heart rate that is measured there. It could for instance be that a very high heart rate on a specific intersection can correlate to a unclear and unsafe situation for the driver. By gathering mass data on this we hope we can prevent accidents by foreseeing dangerous situations because of the change in heart rate.

Within our team we will work on different modules.
Possible modules that have to be worked on:
Hardware (implementing the electronics, make durable and safe)
Software (create working electronics, energy efficient)
Research & dataAnalytics (look into theory, investigate what can be done with the data and test this)
Marketing/presenting (make project presentable)

The first goal we work towards is a working prototype after this, the roles are going to be changed, when needed it is also possible to change roles within this period of time. If that is the case you can find here down below who did what which week.

### Just Baselmans

Because of having quite some experience in programming arduino already, I will be working mostly on hardware, and the interaction between hardware and software. I will be testing the best way to sense heart rate. I will also be playing a big role in making this project presentable and finished in time. As a team leader however I hope I can oversee and help with all the different modules.

### Julius Meetsma

As the most experienced programmer of the group I will be responsible for the software goals and deadlines. This will include making the app work functionally, but not necessarily make the app look good or design aspects of it. I will work closely with hardware as the communication between the devices is key to the success of this project. I will also help with data analytics by giving more context of the numbers and graphs, data analytics will help me with narrowing down to the more interesting data representations.

### David van Dijk

Because of my previous experience building and using 3d-printers I will be working on combining and implementing hardware and software into one product. I have previous experience modeling in Fusion 360 which will help me in designing and prototyping this final product. Since I also have previous experience using Aruino's and Raspberry Pi's I will help create a back-end for the software.

### Luuk Welling

As a generalist I looked at what still needed to be done. I decided to work together with Julius on the app. I will support him both with the programming part, because I want to learn more about this. But I will also make sure the app looks decent and has an understandable interface for people who are not involved in the project. I will also help with the research, but I will focus most on supporting Julius with developing the application.

### Jorge Deurhof

I will focus on the dataAnalytics and Research part of the project.

| Date | Hardware | Software | DataAnalytics & Research | Project |
|---|---|---|---|---|
| 11-12-2020 | find all sensors that have to be used | Find a platform to make the app on. | Research heart rate in combination with tiredness | Documentation chapter 6 & 7 |
| 18-12-2020 | Get all sensor up and running | Make an hello world app | Research a way of finding heart rate anomalies<br>Set thresholds. | Documentation chapter 0 |
| | Hardware | | | |

| | | | | |
|---|---|---|---|---|
| | working | | | |
| 08-01-2021 | | Make the app show graphs and import some data. | analyse the first batch of data. | re-define methodology based on your experience up to now |
| 15-01-2021 | Hardware presentable | First version app working. | Display first batch of data for presentation | Documentation chapter 7,<br>3 - minute **presentation** of a first prototype |
| 22-01-2021 | | | Analyse and display all data for final documentation | Documentation Chapter 8<br>**Final version of documentation** delivered |
| 29-01-2021 | Hardware done and polished | Final version app working and usable | | **Final demonstration** |

Select 1 solution. Motivate your choice. Explain why you selected this solution over the other candidate solutions you found

# Chapter 7: Methodology

### Which equipment you need:

Android phone
Arduino OR Smartwatch

### Sensors we want to use:

GPS (already inside mobile phone )
ECG (Heart rate sensor) (amazon.nl, n.d.)

### Programming tools to use:

Android Studio, coding in Java, arduino

### Data collection method

In the first instance we will use Arduino in combination with multiple sensors to collect the data.
The first sensor we will address is the heart rate sensor and this sensor comes in a few variations:

| | | |
|---|---|---|
| Optic | Consists of a LED and a photodetector, when the LED shines light through your skin the light will scatter off your blood vessels into the photodetector. The volume(and thus the heart rate ) effects on how the light scatters resulting in a waveform signal that gets detected. |  |
| Electric | Consists of multiple electrodes placed on the body which measure the electrical current (polarity of the cell membrane), enlarge this signal and translate it into something that can be read by a computer or microprocessor (Davies & Scott, 2013). |  |

The one we will use is the optic version because this one is by far the cheapest and we don't think that we need the extra precision that the electric one provides.
The heart rate sensor will give an analog signal that with the right threshold and smoothing algorithm will provide a pretty good idea of what the heart rate of a person is.
Next to this the GPS signal from the users phone will be used to monitor where the person is, and at what speed the person is traveling. The location of the person is useful in a personal context for mapping the data, so someone knows the spot in a trip where he gets drowsy, as location is way easier to remember than the specific time. It can also help with seeing what type of roads may lead someone to drowsiness. The speed at which someone is travelling most likely has an impact on the heart rate and thus has to be taken into account, it might also indicate some special cases where heartrate alone is insufficient in giving context to the data, right after a moment or near miss, someone will have a sudden rise in heart rate. In a societal context location will be a very useful tool in locating roads that have excessive inattentiveness. Or with the addition of the heart rate monitor hopefully we can tell where accidents almost happen, and prevent accidents from happening.

## The personal app

The app is an important part in making the process of gathering personal data easy and hands off. The app will be developed in Android using Android studio. The data will be gathered using the arduino and the phone itself, following the scheme in figure 7.2.

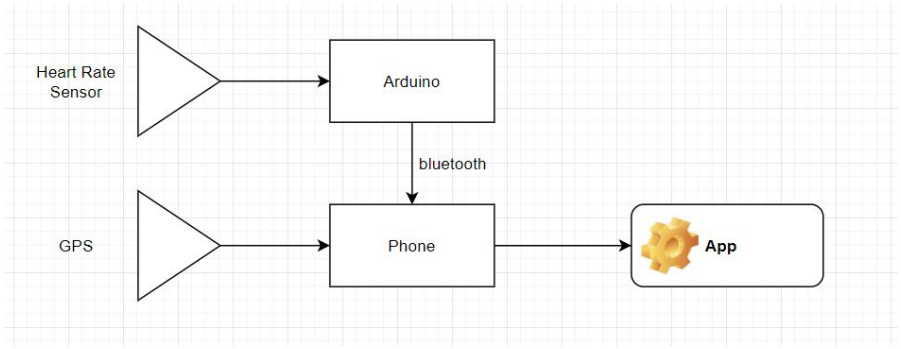



**figure 7.2** : Scheme on flow of information

To store the data the SQLite library will be perfect, as it will store the data locally on the phone on which the app is installed. In the most basic version of the app, only time and the beats per minute will be stored.

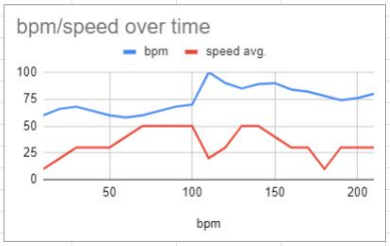
| | ID | TIMESTAMP | BPM |
|---|---|---|---|
| | Filter | Filter | Filter |
| 1 | 1 | 1610637749865 | 50 |
| 2 | 2 | 1610637754889 | 50 |
| 3 | 3 | 1610637759909 | 50 |
| 4 | 4 | 1610637764955 | 50 |
| 5 | 5 | 1610637770006 | 50 |
| 6 | 6 | 1610637775055 | 50 |

**figure 7.3** : Basic Version Database

Figure 7.3 shows the columns of the database and how it is stored, the BPM in this image has not yet been connected to the Arduino, thereby giving a basic value. In later versions of the app, speed and GPS will become separate columns in the database. To add data to the database, a background process is created to add a row every x amount of time, 5 seconds is the time delay we use as visible in Figure 7.3, as time is stored in milliseconds.
The background process runs independently from the application running, your phone can thus be used for other purposes like navigation at the same time. This is to make it more user friendly and less distracting, as distractions should be minimized during driving.

The following figure 7.3 shows some of the applications of some fake data by showing the correlation between speed and bpm. These will be the first charts to be made for the app.

| bpm | time(10s) | speed avg. |
|---|---|---|
| 60 | 10 | 10 |
| 66 | 20 | 20 |
| 68 | 30 | 30 |
| 64 | 40 | 30 |
| 60 | 50 | 30 |
| 58 | 60 | 40 |
| 60 | 70 | 50 |
| 64 | 80 | 50 |
| 68 | 90 | 50 |
| 70 | 100 | 50 |
| 100 | 110 | 20 |
| 90 | 120 | 30 |
| 85 | 130 | 50 |
| 89 | 140 | 50 |
| 90 | 150 | 40 |
| 84 | 160 | 30 |
| 82 | 170 | 30 |
| 78 | 180 | 10 |
| 74 | 190 | 30 |
| 76 | 200 | 30 |
| 80 | 210 | 30 |



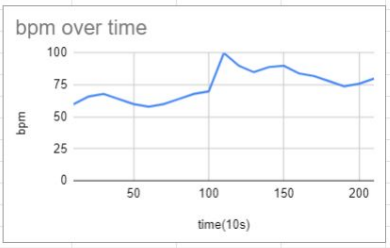




**figure 7.4:** Mockup data

With the GPS location added too, the google maps API can be used to show at what points in the city, a person might have some problems driving, either due to bad infrastructure or fatigue. All the data collected is for personal use only for now, the data will be stored on the device. But this will only be implemented for the ambitious plan, and not the basic plan.

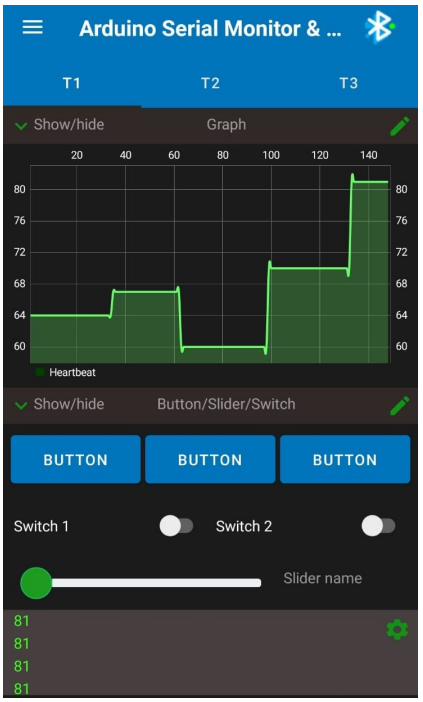
## Ambitious plan

Once the personal app is finished, it can be extended by implementing a button that sends data to a server. If lots of people use this app, the data can be shown on a map, where heart rate is too high or too low, thereby giving city planners useful information about area infrastructure by having a heat map of roads showing potentially dangerous areas. The legal and social matters do need to be investigated as people have privacy rights, but for our tests it will only be our personal test data.

## Testing

Obviously we need a way to test our product. During development we will test our heart rate sensor by comparing it to one of a smart watch while driving, to make sure the data is accurate.
When we have our prototype ready for real testing we are planning to use a simulated car environment using a steering wheel hookup up to a computer. We would compare the data in different situations: One where the driver is sure to be ‘awake’, we could do this by using coffee and testing it in the middle of the day.
We also need a situation where the driver is tired, this should be done either late at night or early in the morning after not having had too much sleep. Using this method we could see if the heart rate sensor gathers data that would allow the app to properly function.

# Chapter 8: Results and Conclusion



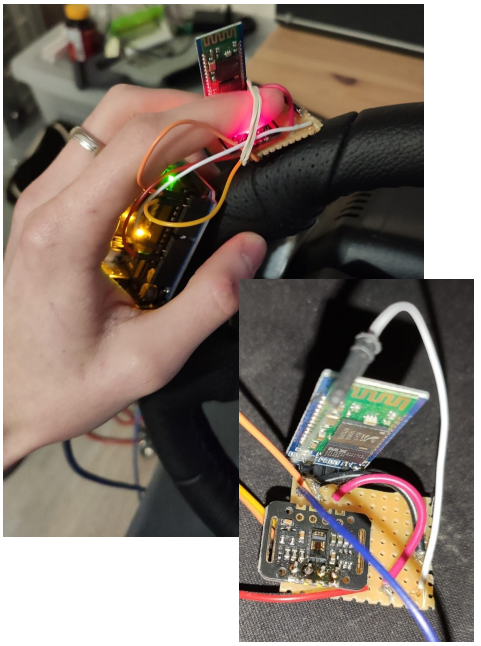

## The Hardware

The hardware consists of an HC-06 bluetooth transceiver, a MAX30102 heartrate/sPO2 sensor and an arduino uno.

The code on the arduino is pretty straightforward and based on the “Heartrate graphing” example by Adafruit. A few unnecessary features, such as the IR value have been removed from the code. A function to send the serial over bluetooth via the HC06 has been added to the code.

A way to measure if the connection was working was by using this simple app that records the serial input over bluetooth.

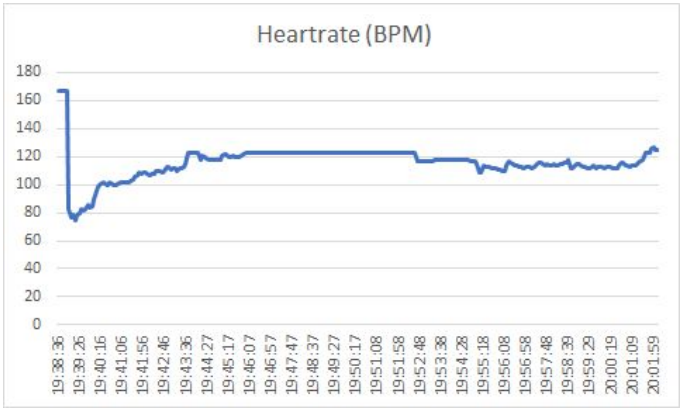
For the sensor to work a constant pressure has to be applied to it by the user’s finger. If no finger is detected, the code simply ignores the heart rate. This helps keeping the measurements accurate as no extremities will be recorded.



We wanted to test this hardware safely, when sleepy and wide awake. Now it obviously isn’t safe to go driving when extremely tired, which is why we created a simulator.

To test this hardware we created a simple testing environment using a Logitech G920 racing set, an Oculus Rift S and Eurotruck Simulator 2.

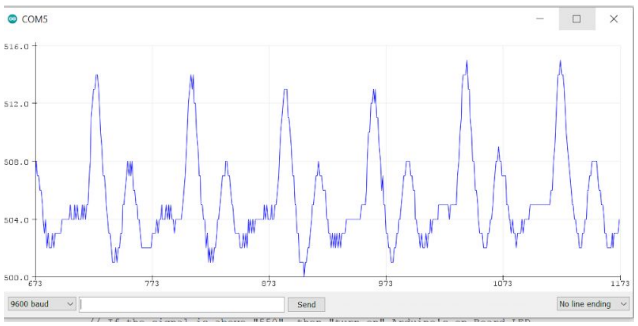
Here are the results:




*Awake*

*Note: I (David, the tester) have a very high natural heart rate, which is why the values might seem high.*

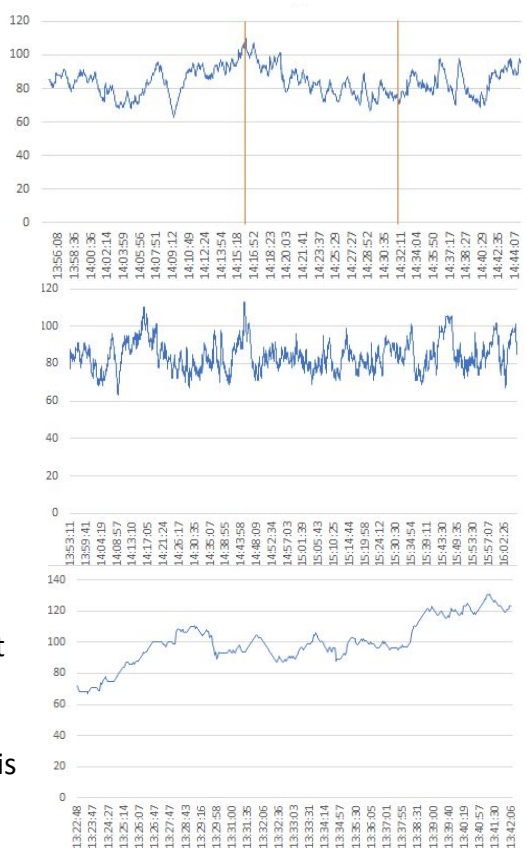
## Results




Eventually we decided to stick with the basic plan as the ambitious plan was simply too ambitious, these results are for the basic plan.
Getting the heart rate sensor to work is easy in theory. It is nothing more than analogRead a pin and set a “threshold” that is between the high bumps and the low bumps. But the difficult part about this is that this sensor picks up noise from about everything. It took multiple attempts to get the signal from the picture above just because my laptop was charging at the same time I was trying to get the sensor to work and this already caused too much noise to get a clear reading.

The next step after setting up the sensor was to determine when someone is tired and about to fall asleep. In chapter 6 it is explained that the heart rate can show when someone is tired but how this worked in practise still had to be tested. Below are a few of the results showing heartRate(Y-axis) measured over a certain time period(X-axis). All graphs below are results of using the mi band 3 using driving.
The first graph is driving on a familiar road from 22:08 till 22:28. In this period there was no fatigued or extremely stressed feeling. The only notable thing in this ride was that on 22:12 the car was stopped because something had to be picked up resulting in a short break while the driver remained seated. Decrease and later rise in heart rate at this moment is clearly noticeable.

Graph 3A and 3B are driving between Oirschot and Enschede from 14:00 till 16:05. The first vertical line in graph 3A shows the heart rate at a moment when driving between two trucks (14:16) and feeling stressed and the second vertical line shows a moment where feeling sleepy (14:32). These changes in heart rate are noticeable but at the same time many others were not like:
(13:58) where the person realised he was driving the wrong direction while on the acceleration lane.
(15:05) feeling very tired again while driving on “De Veluwe”.



Graph 4 shows the heart rate of a person driving to an exam which is very interesting to see, and does show that heart rate does tell something about the state of a person but this graph in particular does not tell a lot about driving while feeling tired.



The graphs above combined show that our hypothesis does not hold. We expected that we could base on only the heart rate if a person is feeling sleepy or is wide awake.
But the results we have gathered clearly show that only heart rate is not enough to tell that. Sometimes it does look like heart rate corresponds to how the user is feeling but there are many high and low peaks that are not explainable with the information we have. This is probably because heart rate depends on much more than only tiredness. It also depends on if you are listening to music or not, if you are in a conversation or not and many more. We did just not expect that it would have so much impact that the reading of only the heart rate appears to be useless on itself without further context.

## Discussion

Our project is not completely finished yet. We still have to do some of the testing and combine everything together in a working prototype. During this project so far we have ran into a few obstacles and issues.
One issue that arose is one that is also discussed above in the results, while it's possible to theoretically do all of the sensing with only a heart rate to detect the fatigueness, in reality it lies a bit more complicated. While you can generally explain why the heart rate fluctuates, it's not consistent enough to make sure the system works accurately. The heart rate fluctuations can be explained by a multitude of factors. For a future project it would be recommended to use multiple sensors in combination with that heart rate sensor to detect the fatigueness more accurately.

Another issue arises in our description for our ambitious scenario. We planned to use the heart rate data collected from consumers, combined with their GPS location to see if there is a correlation between certain locations and the mental state of the driver. However, this requires storing both the GPS location and the heart rate of consumers on an external server. The issue becomes larger when you realise that we would need to trade that data with people working in traffic to see if those locations could be made safer. The privacy laws of different countries and nations should be researched and looked into in great depth before making such systems. However, according to the GDPR, the General Data Protection Regulation of the European Union it should be possible to legally use this data collection if you make sure to follow all of their guidelines and if the consumer has given consent.

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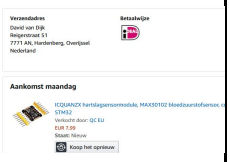
## Costs:

| Date | Product | Link | Total costs | amount | Person | |
|---|---|---|---|---|---|---|
| 06-12-2020 | ICQUANZX Hartslagmeter Pulsmonitormodule DIY voor Arduino | https://www.amazon.nl/gp/product/B07VJ9XB7T/ref=ppx_yo_dt_b_asin_title_o00_s00?ie=UTF8&psc=1 | 20,97 | 3 | Just |  |
| 18-12-2020 | ICQUANZX hartslagsensormodule, MAX30102 bloedzuurstofsensor, compatibel met STM32 | https://amzn.to/3p8AYih | 7,99 | 1 | David |  |
| | | | | | | |

# Script:

## Reason/theory: Luuk/Just

*The following is voice over with text word for word on the screen, and shots in the background*
"14.5% of respondents admitted that they had fallen asleep or "nodded off" while driving during the past year. Nearly 2% were involved in a fatigue or drowsy driving related crash." (Vanlaar et al., 2008)
"Approximately 1.35 million people die each year as a result of road traffic crashes." (WHO, 2020)
And we want to reduce this number specifically those caused by fatigued driving.
and I can see you thinking. "How?"

## Hypothesis: David

When someone is sleepy, they become less coordinated and more easily distracted.

"8 percent of fatal crashes, 15 percent of injury crashes, and 14 percent of all police-reported motor vehicle traffic crashes in 2018 were reported as distraction-affected crashes."
Now we can't say that all these crashes were caused by drowsiness, but it's fair to assume that a portion of it is. But how do we measure if a user is fatigued?

Heart rate is directly related to a user's fatigue. If they are sleepy their heart rate will be significantly lower than if they are wide awake. Obviously there are multiple factors that affect one's heart rate, but as a general rule of thumb we can state that a sleepy driver has a lower heart rate than one who is wide awake.

## Product: Just

Well the product that we made can be broken up into 2 parts: the processing part and the sensing part and let's start with the later.
*The Sensing part:* For the sensing part we tested multiple heart rate sensors but ended up with this one(tadaaa). we hooked this sensor up to a Esp32 to be able to send the gathered data via bluetooth to the user's phone and that looks a bit like this. Next up the processing part.
*The processing part:* and no not processing as in the program because most work actually went into android studio. And with work we mean something like (high pitch list of things we done) and this made us end up with an app that can receive data, convert the data into something useful, store the data and alert when the incoming heart rate is too low or too high. but how do you determine when the heart rate is low or high? We did that by testing. We tested in a car with a heart rate monitor but to be able to test when you are so tired you almost fall asleep. Therefore we used a car driver simulator which looks something like this.

## Results: Julius

Explaining what we gathered and interpretation.

*Some video part showing David putting on the thing on his wrist.*
The process is quite simple, you just put the sensor on your (wrist?finger?) and turn on the app to make connection and start gathering data.
*Simulator footage both screengrab and of the whole setup.*
Now we can see what we get in data.
*Show some graphs of driving.*
This data can give individuals data on the effect of their level of attention over time. And it can show us (results here)
This graph shows this, this graph shows that.

## Future: Luuk

Unfortunately our product doesn't work perfectly like planned. In theory it should work, but in reality it's more complicated. You can certainly detect and explain some patterns in the data, but it's not consistent and accurate enough to make a system that can pinpoint exactly when the driver is fatigued.  This is because the heart rate can also change by multiple other factors to be taken into account. To make sure this product works in the future it would be smart to use multiple sensors besides the heart rate sensor to get a more accurate state of mind of the driver.

## Feedback

Week 1:
Chapter 1:
The articles depicted by you for this research are well. The structure is clear and the sources are reliable. However, many of your articles are about disasters that happen in a very specific area that, often, has a clear cause already. Whether this is the regional temperature or the position compared to the tectonic movement of the earth's surface. Although all these combined to a set of disasters, I do think there are better articles to set you to investigate and get familiar with. This is not meant in a negative sense, but rather the opposite of this. The work you delivered is good for this chapter, but do think of other possible slow/fast global disasters as well. Try to think in different directions, neglecting that disasters only come in the form of co2 emission, earthquakes etcetera.

Disasters get caused by and happen in many different types. Types of which you would not even think. Types that are closer to us that you would imagine, and types of disasters that get caused so far away, that people would not even think of considering those as one of the possible causes. Think of mental stability due to addiction causing a disruption in people's habits, causing more abrupt changes in the environment or the dangerous influence of a nearby star or supernova, Betelgeuze, that slowly but steadily makes the earth deviate from its current position and disrupting the corresponding spacetime and gravitational pull, bringing the earth into a catastrophic position within the upcoming few million years.

Of course the latter example is a bit overdone, for now, but these are definitely not factors that may be left out as, within the upcoming few million years, these will have a huge impact on our solar system and therefore on our life on earth.

Chapter 2:
The problem statements defined were concise and clear. Often a bit too short, so a bit more elaboration on them might have been useful.
Another advice I want to give you is to perhaps start thinking of the different ways each of these problem statements, or a fraction of these statements, can be solved within a possible project you can conduct. This will open your mind for creative solutions and will help you later in the project.

General notice:
As stated before the structure of the document looks good and the information seems reliable. The one source I had some doubts about, was the youtube url. Youtube is technically a social media platform and therefore very vulnerable to misinformation, a clear example of this was discussed in Zondag met Lubach regarding the misinformation of Lange Frans. Do make sure that you use at least 99% reliable sources as this is the base of your project.

Week 2:
Chapter 3: All problems are relevant indeed. You could have added few more details for each problem, e.g. severity, importance, etc.

Chapter 4: Problem selected is valid, relevant to the theme. You also added some statistics that show the severity of the problem, which is welcoming.

Week 3:
Ch5:
S1: Good idea!
S2: Another good idea, could be combined with S1 (perhaps an ambitious version of it).
S3: Makes sense, or the other way around if someone is too stressed might have high heart rate. Again, could be combined with S1 and S2.
S4: Privacy issues here, I do not think this could scale anywhere beyond a simple demo.
S5: Dash cam could be replaced by noise sensor actually. Cheaper and much easier to detect noise of cars crashing. It is quite specific noise, no? Camera could be activated too, but more to see whose fault it is. Useful for insurance companies.

Week 4:
Chapter 6: Problem is good and well accepted, we discussed this already. Chapter is a bit incomplete though, because it does not indicate how you will address fatigued driving. You actually re-mention the problem, not the solution.
I appreciate the division in tasks and the time plan. Where are the other team members? What are they supposed to do? About the time plan, how do you intend to test/validate your solution? How will you convince us that it works?
Chapter 7: How will the accelerometer/gyroscope indicate fatigue? How does the speed relate to fatigue? It is too vague. I do not see a plan here. How is speed and bpm correlated? Finally, I guess the map fits under the ambitious scenario? You did not clearly differentiate between a basic and an ambitious scenario.
Overall, I consider your work incomplete.

Week 5:
Chapter 0: A bit too basic, you do not provide enough info on why this is an important and timely problem (some stats perhaps?) plus what exactly you aim to do. Describe your solution in 2-3 sentences. Chapter 7: Methodology has been improved, I am satisfied from what I read. We have discussed ways to assess/validate your solution (under the covid circumstances) and I expect you to update this chapter this week accordingly. Perhaps the GPS functionality might be difficult to test/assess? The ambitious plan idea is really nice, but privacy data might arise. You need to discuss those in your final documentation (this is for next week).

Week 6:
Your chapter 7 looks really good. You have done impressive research and the product you have described is complete, in my opinion. Do take in mind the way to deploy applications on the google market, as this will take some time. Good to see that you have included real time testing as well in your product. To make the product work even more stable and extend the features of the application, you might want to include a Firebase database and connect this to your application. I have little to no feedback on your progress. Well done. Antoine

## Code

**activity_main.xml**

```xml
<?xml version="1.0" encoding="utf-8"?>
<androidx.constraintlayout.widget.ConstraintLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:app="http://schemas.android.com/apk/res-auto"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    tools:context=".MainActivity">

    <Button
        android:id="@+id/settingsButton"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:text="Settings"
        app:layout_constraintBottom_toBottomOf="parent"
        app:layout_constraintEnd_toEndOf="parent" />

    <androidx.recyclerview.widget.RecyclerView
        android:id="@+id/lv_itemList"
        android:layout_width="367dp"
        android:layout_height="427dp"
        app:layout_constraintBottom_toBottomOf="parent"
        app:layout_constraintEnd_toEndOf="parent"
        app:layout_constraintStart_toStartOf="parent"
        app:layout_constraintTop_toTopOf="parent" />

</androidx.constraintlayout.widget.ConstraintLayout>
```

**activity_settings.xml**

```xml
<?xml version="1.0" encoding="utf-8"?>
<androidx.constraintlayout.widget.ConstraintLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:app="http://schemas.android.com/apk/res-auto"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    tools:context=".Settings">

    <Button
        android:id="@+id/backButton"
        android:layout_width="119dp"
        android:layout_height="42dp"
        android:text="Back"
        app:layout_constraintBottom_toBottomOf="parent"
        app:layout_constraintStart_toStartOf="parent" />

    <LinearLayout
        android:id="@+id/linearLayout"
        android:layout_width="match_parent"
        android:layout_height="match_parent"
        android:orientation="vertical"
        app:layout_constraintTop_toBottomOf="parent"
        tools:layout_editor_absoluteX="16dp">

        <Button
            android:id="@+id/dataCollectionButton"
            android:layout_width="match_parent"
            android:layout_height="107dp"
            android:text="Start Data Collection" />

        <EditText
            android:id="@+id/edit_dbName"
            android:layout_width="match_parent"
            android:layout_height="wrap_content"
            android:ems="10"
            android:inputType="textPersonName"
            android:text="DataBase" />

        <Button
            android:id="@+id/bluetoothConnectButton"
            android:layout_width="match_parent"
            android:layout_height="97dp"
            android:text="Connect Bluetooth" />

    </LinearLayout>

</androidx.constraintlayout.widget.ConstraintLayout>
```

**MainActivity.java**

```java
package com.example.timeandgps;

import androidx.appcompat.app.AppCompatActivity;
import androidx.recyclerview.widget.RecyclerView;

import android.content.Intent;
import android.os.Bundle;
import android.view.View;
import android.widget.Button;

/*
Main screen class

 */
public class MainActivity extends AppCompatActivity {


    RecyclerView recyclerView;

    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_main);

        recyclerView = (RecyclerView) findViewById(R.id.lv_itemList) ;


        configureSettingsButton();
    }

    private void configureSettingsButton(){
        Button nextButton = (Button) findViewById(R.id.settingsButton);
        nextButton.setOnClickListener(new View.OnClickListener(){

            @Override
            public void onClick(View v) {
                startActivity(new Intent( packageContext: MainActivity.this,Settings.class));
            }
        });
    }

}
```

**DataBaseHandler.java**

```java
package com.example.timeandgps;

import android.content.ContentValues;
import android.content.Context;
import android.database.Cursor;
import android.database.sqlite.SQLiteDatabase;
import android.database.sqlite.SQLiteOpenHelper;
import androidx.annotation.Nullable;
import java.util.ArrayList;
/*
Class that describes the SQLite database interaction
 */
public class DataBaseHandler extends SQLiteOpenHelper {


    public static final String BPM_TABLE = "BPM_TABLE";
    public static final String COLUMN_TIMESTAMP = "TIMESTAMP";
    public static final String COLUMN_BPM = "BPM";
    public static final String COLUMN_ID = "ID";

    SQLiteDatabase myDatabase;
    ArrayList<DataEntry> allData;

    public DataBaseHandler(@Nullable Context context, String dbName) {

        super(context, dbName,  factory: null,  version: 1);
    }


    @Override
    public void onCreate(SQLiteDatabase db) {
        String createTableStatement = "CREATE TABLE " + BPM_TABLE + " (" + COLUMN_ID +
                " INTEGER PRIMARY KEY AUTOINCREMENT, " + COLUMN_TIMESTAMP + " INT, "
                +  COLUMN_BPM + " INT)";
        db.execSQL(createTableStatement);
    }

    @Override
    public void onUpgrade(SQLiteDatabase db, int oldVersion, int newVersion) {

    }

    public boolean addOne(DataEntry de){

        SQLiteDatabase db = this.getWritableDatabase();
        ContentValues cv = new ContentValues();
        cv.put(COLUMN_TIMESTAMP, de.getTime());
        cv.put(COLUMN_BPM, de.getBeatsPerMinute());

        long insert = db.insert(BPM_TABLE,  nullColumnHack: null, cv);

        if(insert == -1){
            return false;
        }else{
            return true;
        }
    }

    public String getLastN(int N){
        SQLiteDatabase db = this.getReadableDatabase();

        Cursor cursor = db.rawQuery( sql: "SELECT * FROM " + BPM_TABLE,  selectionArgs: null);
        //long time = cursor.getInt(0);
        int bpm = cursor.getInt( columnIndex: 1);
        return Integer.toString(bpm);
    }
}
```

**Settings.java**

```java
package com.example.timeandgps;

import androidx.appcompat.app.AppCompatActivity;
import android.os.Bundle;
import android.util.Log;
import android.view.View;
import android.widget.Button;
import android.widget.TextView;
import java.util.Date;

/*
Class for the settings page, also needed to start background process
*/

public class Settings extends AppCompatActivity {


    private static final String TAG = "MainActivity";
    private String dataBaseName;

    private boolean paused;
    private boolean running;

    BackGroundRunnable bgr;

    TextView dataBaseNameTV;

    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_settings);

        dataBaseNameTV = (TextView) findViewById(R.id.edit_dbName);

        // Start background process paused
        paused = true;
        running = true;
        bgr = new BackGroundRunnable();
        new Thread(bgr).start();

        //configure buttons
        configureBackButton();
        configureStartBackgroundProcessButton();
    }

    // Back to main Activity
    private void configureBackButton(){
        Button nextButton = (Button) findViewById(R.id.backButton);
        nextButton.setOnClickListener(new View.OnClickListener(){
            @Override
            public void onClick(View v) {
                finish();
            }
        });
    }
```

```
    // The button that stops/starts the backgroundProcess
    private void configureStartBackgroundProcessButton(){
        Button nextButton = (Button) findViewById(R.id.dataCollectionButton);

        nextButton.setText("Start background process");
        nextButton.setOnClickListener(new View.OnClickListener(){
            @Override
            public void onClick(View v) {
                if(paused) {
                    nextButton.setText("Stop background process");
                    UnPauseBackgroundProcess();
                }else{
                    nextButton.setText("Start background process");
                    PauseBackgroundProcess();
                }
            }
        });
    }

    private void UnPauseBackgroundProcess(){
        paused = false;
    }

    private void PauseBackgroundProcess(){
        paused = true;
    }


    //Class that describes the Background Thread that logs the time and bpm in a local database
    class BackGroundRunnable implements Runnable{
        @Override
        public void run() {
            Log.d(TAG,  msg: "running");
            while(running) {
                //It is either running and saving to dataBase
                if (!paused) {
                    Log.d(TAG, new Date(System.currentTimeMillis()).toString());
                    addOneToDataBase( dbName: dataBaseNameTV.getText().toString() + ".db");
                }
                //Or doing nothing and sleeping
                try {
                    Thread.sleep( millis: 5000);
                } catch (InterruptedException e) {
                    e.printStackTrace();
                }
            }
        }
    }

    // Add one entry to dataBase given the input
    private void addOneToDataBase(String dbName){
        DataEntry dataEntry = new DataEntry(System.currentTimeMillis(),  beatsPerMinute: 50);

        DataBaseHandler dbh = new DataBaseHandler( context: Settings.this, dbName);
        dbh.addOne(dataEntry);
    }
}
```

**DataEntry.java**

```java
package com.example.timeandgps;

/*
Class that describes one entry in the database

 */
public class DataEntry {

    // Variables
    long time; // in millis
    int beatsPerMinute;
    // GPS location
    // float speed

    // Constructors
    public DataEntry(long time, int beatsPerMinute) {
        this.time = time;
        this.beatsPerMinute = beatsPerMinute;
    }

    public DataEntry(){

    }

    //toString
    @Override
    public String toString() {
        return "DataEntry{" +
                "time=" + time +
                ", beatsPerMinute=" + beatsPerMinute +
                '}';
    }

    // Getters & Setters

    public long getTime() {
        return time;
    }

    public void setTime(long time) {
        this.time = time;
    }

    public float getBeatsPerMinute() {
        return beatsPerMinute;
    }

    public void setBeatsPerMinute(int beatsPerMinute) {
        this.beatsPerMinute = beatsPerMinute;
    }

}
```