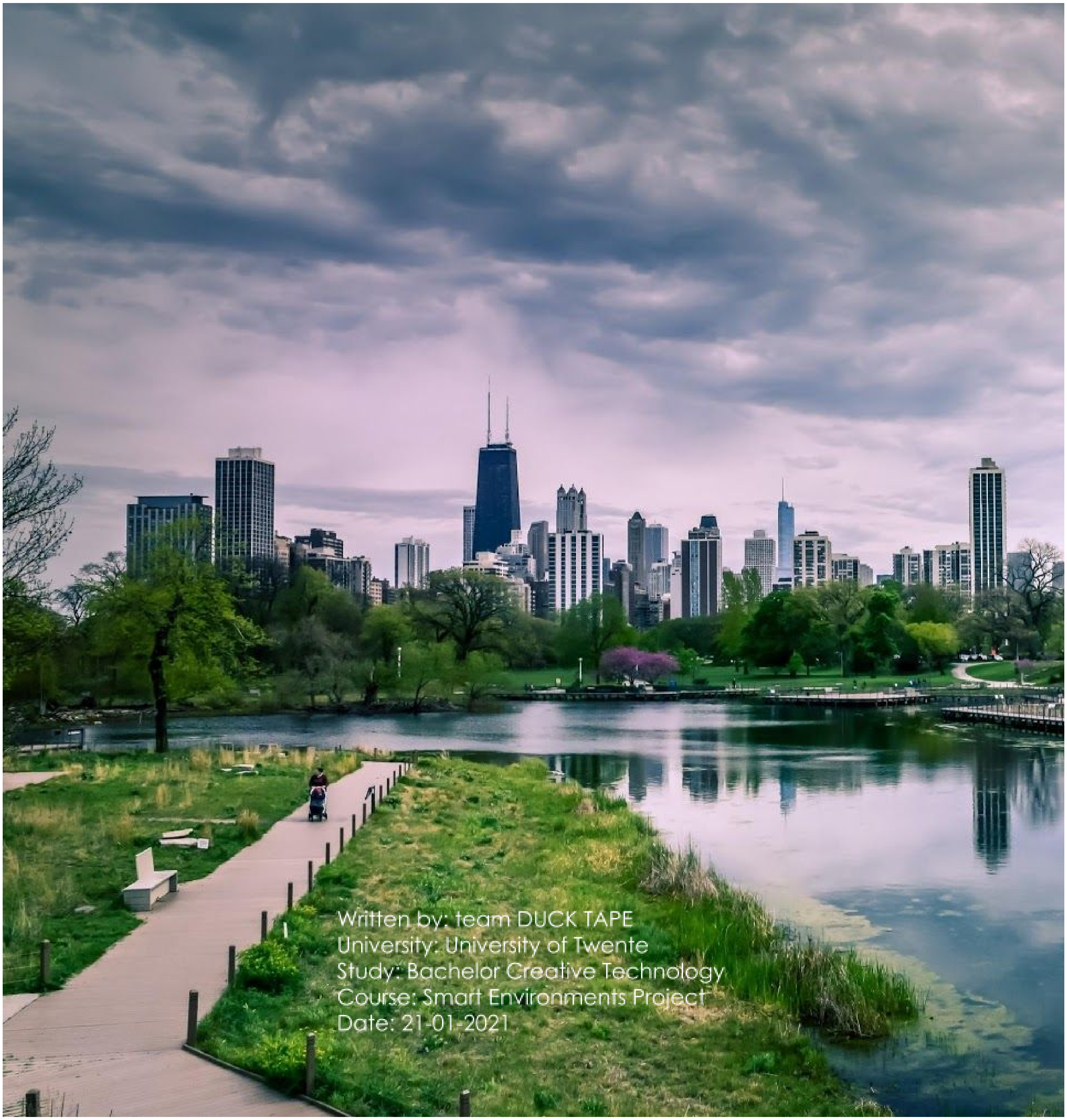
UNIVERSITEIT TWENTE.

SMART ENVIRONMENT PROJECT



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Chapter 0: Introduction

We are a group of 7 Creative Technologists, excited to ideate, create and test our Smart Environment project.
For this project we decided to focus on the problem of fatal accidents caused by the fatigue of car drivers. It came to our attention due to the research we did that this is a problem that causes a lot of fatalities all around the world, at the same time there are not that many real-life products on the market that contribute to concrete solutions.
Because of the acute nature and the many possible causes of accidents it is difficult to define and measure the sleepiness in these situations. However, in The role of driver sleepiness in car crashes: a review of the epidemiological evidence, written by Jennie L. Connor, it is estimated that 15-20% of all car crashes are related to the sleepiness of the driver.
In the United States, the NHTSA (National Highway Traffic Safety Administration) states that there were 91,000 motor vehicle police-reported crashes involving drowsy driving which claimed 795 lives in 2017. This, however, is most likely an underestimation of the impact of drowsy driving.
Our goal is to, with a combination of sensors, come up with a way to alarm the driver of their current driving ability and hopefully prevent some fatal accident from happening. We will be using an Arduino (mega) in addition to a self-made breathing monitor and a heart-rate monitor. When these two have reached an alarming value, the driver will be alerted by a visual notification, in the form of a light or some text on a small screen, and an audible notification.
The combination of these sensors makes for an achievable system with components available for arduino.

Jennie Connor, Gary Whitlock, Robyn Norton, Rod Jackson (2001). The role of driver sleepiness in car crashes: a systematic review of epidemiological studies, 10.1016/s0001-4575(00)00013, 0Accident Analysis & Prevention, 31 - 41
https://link.springer.com/chapter/10.1007/978-3-7643-9923-8_12

Drowsy Driving, (2019, July 22), NHTSA
https://www.nhtsa.gov/risky-driving/drowsy-driving

TEAM DUCK TAPE

We would like to introduce to you our team consisting of:

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Jelle Gerritsen	s2578018	j.w.s.gerritsen@student.utwente.nl **-team leader-**
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Jelle Gerritsen (team leader): J. Gerritsen is our team leader. His skill set consists of good leading and teaching techniques, experience in sound design and has a nag for visualising and realising ideas.

Kim de Weger (innovator): K. de Weger's skills consist of being a talented researcher, a great creative thinker and good at being able to realise realistic ideas.

Marije Kok (innovator): M. Kok is great at being a creative designer, thinking outside of the box and is the optimistic drive in the group.

Andrei Zdrobau (innovator): A. Zdrobau has experience with Arduino and is also quick to adapt to new situations.

Myungwon Youn (analyst): Researching is also one of M. Youn's skills. Furthermore, he is good at designing, prototyping and he knows how to work with Arduino.

Sven Sonneveld (executive): S. Sonneveld is our backbone of coding. He is a hard worker and a strategic thinker.

Mehar Askari (explorer): What M. Askari is good at is mainly the design. Other things M. Askari is good at are presenting and creative thinking.

Chapter 1: Literature Review

M. Youn

1. the contribution of alcohol to night-time crash risk and other risks of night driving

In terms of crash involvement per distance, driving at night is riskier than during the day. The risk associated with alcohol was shown to decrease with increasing age. The overall effect of alcohol was shown to contribute almost half of weekend night time risk for drivers aged under 40 on lower volume roads, but to contribute little to overall risk on higher-volume roads, consistent with other research showing that higher-volume roads are not favoured by drinking drivers. Roads with illumination at night are less risky at night relative to during the day than roads without illumination.

Keall, M. D., Frith, W. J., & Patterson, T. L. (2005). The contribution of alcohol to night-time crash risk and other risks of night driving. Accident Analysis & Prevention, 37(5), 816–824. https://doi.org/10.1016/j.aap.2005.03.02

2. Integration and Dissemination of Citizen Reported and Seismically Derived Earthquake Information via Social Network Technologies

Social network technologies are providing the general public with earthquake hazard information before scientific information has been published. The United States Geological Survey (USGS) rapidly reports the information to National and international agencies. Published scientific alerts can take between two and twenty minutes to produce. In contrast, people in near earthquakes are publishing information within seconds via social networking technologies.

Guy M., Earle P., Ostrum C., Gruchalla K., Horvath S. (2010) Integration and Dissemination of Citizen Reported and Seismically Derived Earthquake Information via Social Network Technologies. In: Cohen P.R., Adams N.M., Berthold M.R. (eds) Advances in Intelligent Data Analysis IX. IDA 2010. Lecture Notes in Computer Science, vol 6065. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-13062-5_6

3. Advances in Remote Sensing for Oil Spill Disaster Management: State-of-the-Art Sensors. Technology for Oil Spill Surveillance

Advances in remote sensing technologies can help to identify pollution and minor spills before they cause widespread damage. This paper examines the characteristics and applications of different sensors. Laser fluor sensor were found to be the best available sensor for oil spill surveillance.

Jha, M., Levy, J., & Gao, Y. (2008). Advances in Remote Sensing for Oil Spill Disaster Management: State-of-the-Art Sensors Technology for Oil Spill Surveillance. Sensors, 8(1), 236-255. https://doi.org/10.3390/s8010236

K. de Weger

4. Rapid assessment of disaster damage using social media activity

(Kryvasheyeu et al., 2016)

As a result of climate change, natural disasters are not only more likely to occur, but also become more intense and subsequently more costly as they destroy property, cause political stability, and lives are lost. The authors of this article describe how you can use posts on Twitter (number and content via keywords) to assess a disaster's gravity and how they aid in disaster response and damage assessment.

"Social media improves situational awareness, facilitates the dissemination of emergency information, enables early warning systems, and helps coordinate relief efforts" (Kryvasheyeu et al., 2016, p. 1). The authors hypothesized that "the spatiotemporal distribution of disaster-related messages helps with the real-time monitoring and assessment of the disaster itself" (Kryvasheyeu et al., 2016, p. 1). In their assessment, they focus on hurricane Sandy and they verified their findings for a wide range of in total 12 other natural disasters.

Thanks to the scale, Twitter[1] is very useful during disasters. Twitter offers the geographical and personal information of its users. The authors found that the region's proximity and Twitter activity are related to the hurricane's path. "Activity drops as the distance from the hurricane increases; after a distance of approximately 1200 to 1500 km, the influence of proximity disappears" (Kryvasheyeu et al., 2016, p. 7).

Data shows that areas close to the disaster generate more original content than the number of retweets. The tweet count is higher in the aftermath of the disaster than during the peak, which proves that social media is a viable resource for preliminary rapid damage assessment in the time after a disaster. The authors suggest that: "during a disaster, officials should pay attention to normalized activity levels, rates of original content creation, and rates of content rebroadcast to identify the hardest-hit areas in real-time. Immediately after a disaster, they should focus on persistence in activity levels to assess which areas are likely to need the most assistance" (Kryvasheyeu et al., 2016, p. 7).

The results of the research described in the article, show that real threats and physical disaster effects/damage can be observed through the intensity and composition of Twitter messages. With continued monitoring of social media, the researchers think that they can draw up disaster-specific predictive models for each particular type of natural disaster.

Kryvasheyeu, Y., Chen, H., Obradovich, N., Moro, E., Van Hentenryck, P., Fowler, J., & Cebrian, M. (2016). Rapid assessment of disaster damage using social media activity. Rapid Assessment of Disaster Damage Using Social Media Activity, 2(3), 1–12.
https://doi.org/10.1126/sciadv.1500779

5. Help from the Sky: Leveraging UAVs for Disaster Management

(Erdelj et al., 2017, p. 24)
"When a disaster occurs, the most important issue is preserving human lives." (Erdelj et al., 2017, p. 24) The first 72 hours are critical: search and rescue (SAR) operations must be organized and conducted very quickly and efficiently. But these are hindered by a lack of communication and knowledge about the local situation during a disaster. First responders often must improvise with the potential loss of efficiency. This article presents the results of a survey of the latest advances in unmanned aerial vehicles (UAVs) for network-assisted first response to disaster management and it identifies gaps.

Even though different regulations apply to the usage of UAVs, most countries allow flying devices to help first responders assess the situation in case of a disaster. Think of information on which structures were affected and the extent of the damage, the state of the infrastructure, and the potential number of casualties.

UAVs have already been used in many different disaster management situations like monitoring, forecasting and early warnings, information fusion and sharing, situational awareness and logistics, and evacuation support, as standalone communication systems, SAR missions, and damage assessment. According to the authors, UAVs could also enhance efficiency of several other activities such as media coverage, supply medicine, and (re)construction of infrastructure.

It is very important that the UAV network supports/accommodates the launch of UAVs for this particular purpose. As the authors state "naively launching multiple UAVs won't guarantee a successful SAR mission" (Erdelj et al., 2017, p. 25). They point out that e.g. the flight time of most off-the-shelf UAVs is limited to 15-20 minutes so their flight must be highly optimized (optimize energy-effectiveness).

The authors outline an example scenario/network architecture of UAV usage for disaster monitoring in combination/collaboration with existing wireless sensor network(s) (WSN).

They identify three stages of a disaster and the UAVs all have different roles in these three (1. pre-disaster preparedness, 2. disaster assessment, and 3. disaster response and recovery).

Furthermore, the authors classify three disaster stages and possible related activities based on the disaster type: A) geophysical, B) climatological and C) meteorological.

In stage 1, the role of UAVs is limited compared to that of WSN, whilst in stage 2, the role of UAVs becomes more important. In stage 3, the UAVs will play a critical role in communication about e.g. safe areas and evacuation routes.

The authors identified several open issues and challenges in case of type A and B disasters and type C disasters, concerning the relay network, in-network data fusion and handover issues (deal with data transfer), and resistance to weather conditions respectively. In addition, automating network maintenance and UAV charging, increasing UAV network security and robustness, ensuring privacy and trust, and handling UAV failures need further attention. The authors "hope" that their "new perspective for classifying disasters and developing suitable network architectures is just the start when it comes to UAVs for disaster management, as disaster victims will be increasingly looking to the sky for relief" (Erdelj et al., 2017, p. 31).

In short: the author's advice authorities (how) to classify disasters and arrange for network architectures based on interaction between UAVs and WSNs, to improve disaster management based on these classifications.

Erdelj, M., Natalizio, E., Chowdhury, K. R., & Akyildiz, I. F. (2017). Help from the Sky: Leveraging UAVs for Disaster Management. IEEE Pervasive Computing, 16(1), 24–32.
https://doi.org/10.1109/mprv.2017.11

6. Automatic identification of eyewitness messages on twitter during disasters

(Zahra et al., 2020,)

More and more people use social media platforms such as Twitter and Facebook to share information on (ongoing) disasters. Moreover, social media tend to break stories and events (much) faster than many other traditional information or news sources (Zahra et al., 2020, p. 1). The information shared at those platforms can potentially be very useful for disaster response for law enforcement agencies and first responders, but it is important that the information is first-hand and credible. According to the authors "Humanitarian organizations look for timely and trustworthy information that is directly observed from the disaster-hit areas to better estimate the severity and scale of damage, and the amount of aid required to help save lives and fulfil the urgent needs of affected people." (Zahra et al., 2020, p. 2) The most straightforward approach is to gather geotagged information from people in the direct area of the disaster, e.g. Twitter messages (tweets). However, not all information shared is redundant information, e.g. through sharing the same news article or video and only 1–3% of tweets are geotagged and in addition not all tweets from the disaster-struck area automatically come from eyewitnesses. "Many social media platforms allow the user to enter a home location manually in the user profile, but research has shown that at least in the case of Twitter it is very noisy and inaccurate, and it does not indicate location of the source at the time when a tweet is made…" (Zahra et al., 2020, p. 2). In their research, the authors tried to tackle the above issues and develop a method to process potentially millions of tweets and identify eyewitnesses reliably.

Several other researchers already tried to identify tweets from eyewitnesses using e.g. linguistic or meta features, topics of tweets and semantic features but none of them used a combination of expert-driven and data-driven feature engineering, nor differentiated between particular types of eyewitnesses. The authors designed an eyewitness reports taxonomy focusing on the needs of disaster response agencies during natural disasters that consists of three different subtypes of eyewitnesses i.e., direct, indirect and vulnerable direct eyewitnesses. Subsequently, the authors explored different types of features associated with tweets (using manual analysis of a set of data followed by crowdsourcing) to train machine learning models for the automatic classification of tweets. The authors used earthquake, foreshock, aftershock, flood, inundation, extensive rain, heavy rain, hurricane, cloud-burst, forest fire, and wildfire keywords to collect in total 25 million tweets related to earthquakes, hurricanes, floods, and forest fires from the Twitter Streaming API to collect data from July 2016 to May 2018.

Unfortunately for many tweets it was not possible to determine whether they were posted by eyewitnesses or not. But the manual analyses did show that it is possible to categorize eyewitness reports into direct, indirect, and vulnerable direct eyewitnesses. Direct eyewitnesses tend to use words related to perceptual senses such as seeing, hearing, feeling. Whilst indirect eyewitnesses merely express emotions such as thoughts, prayers, worry. And the vulnerable category mostly shares warnings and alerts about an expected disaster situation. With the information that was available, the performance of the machine learning models in identifying the different types of eyewitnesses was low. However, the authors managed to train several machine learning classifiers using the identified characteristics of the different types of eyewitnesses and labelled data. They are confident that the combination of domain-expert features and textual features leads to better classification performance.

They mention one other limitation of the study: language. Depending on the language structure, some of our features, e.g. first-person pronouns, might not work.

Zahra, K., Imran, M., & Ostermann, F. O. (2020). Automatic identification of eyewitness messages on twitter during disasters. Information Processing & Management, 57(1), 1–15. https://doi.org/10.1016/j.ipm.2019.102107

S. Sonneveld

7. SAR. Drones: Drones for Advanced Search and Rescue Missions

In this publication there was research about a framework to use autonomous drones to search the area for hazardous substances in an area and provide a Wi-Fi network to send this data to the rescue teams. For the paper different exploration schemes were tested where the Wi-Fi-signal strength and covered area was considered; the drones moving in a squadron or independent. The result was that the independent movement had better Wi-Fi coverage in the area while the squadron movement had better Wi-Fi strength in the area covered. The conclusion which the paper came to was that the advantages of independent movement was bigger than the ones of squadron movement. This has been tested in the real world with 4 drones and is proven to be effective.

Rémy, G., Senouci, S. M., Jan, F., & Gourhant, Y. (2013). SAR. Drones: drones for advanced search and rescue missions. *Journées Nationales des Communications dans les Transports*, *1*, 1-3 Link: https://bentley.u-bourgogne.fr/jnct2013/proceedings/JNCT13_Remy-UB.pdf

8. Inelastic Earthquake response of tall buildings

In this publication there was research done to have a better understanding of the behaviour of structures during earthquakes. This was analysed using an IBM 7090 computer program. The analysis consisted of 4 repeated steps: First the stiffness of the structure is analysed at the appropriate and start time, then the changes in displacement of the structure are computed, then the incremental displacement are added to the deformation state at the start of each test to obtain a total amount of deformations and last the appropriate stiffness coefficient is computed for the next interval based on the deformations. In the conclusions it was found that the maximum displacement in nonlinear (inelastic) structures was bigger than the displacement of (relative) elastic buildings; things moved more in the nonlinear building. It was also found that ductile deformations tend to vary throughout the building and that providing for an essentially elastic response in the column, while absorbing the earthquake energy in plastic deformation to be an effective approach to the earthquake-resistance of a tall building.

Clough, R. W., Benuska, K. L., & Wilson, E. L. (1965, January). Inelastic earthquake response of tall buildings. In *Proceedings, Third World Conference on Earthquake Engineering, New Zealand* (Vol. 11). Link: http://www.iitk.ac.in/nicee/wcee/article/vol2_II-68.pdf

9. Earthquake Damage Assessment of Buildings Using VHR Optical and SAR Imagery

In this publication the feasibility of certain methods of rapid damage assessment is looked at. Those methods are VHR (very high spatial resolution) and SAR (synthetic aperture radar) to get vital information from their ability to map an area. Before the disaster, an image is made and after a disaster and compared. This is to check if a building is intact or not.

Brunner, D., Lemoine, G., & Bruzzone, L. (2010). Earthquake damage assessment of buildings using VHR optical and SAR imagery. *IEEE Transactions on Geoscience and Remote Sensing*, *48*(5), 2403-2420. Link: https://ieeexplore.ieee.org/abstract/document/5411791

10. Crowdsourcing earthquake damage assessment using remote sensing imagery

This paper describes the evolution of recent work on crowdsourced remote sensing imagery, that from high resolution aerial images. This is to provide a rapid and reliable assessment of the damage the disaster caused, with in particular earthquakes. This is helpful if it is fast, accurate and reliable. Crowdsourcing can be used as a mechanism to help disaster assessment and management. In the future this type of crowdsourcing analysis of remote sensing imagery can be improved by having a larger platform to reach a larger audience to assist in this type of crowdsourcing. With this there will be a faster analysis and a more efficient way to collect this data.

Barrington, L., Ghosh, S., Greene, M., Har-Noy, S., Berger, J., Gill, S., Lin, A., & Huyck, C. (2012). Crowdsourcing earthquake damage assessment using remote sensing imagery. *Annals of Geophysics, 54*(6). doi:http://dx.doi.org/10.4401/ag-5324 Link: https://www.annalsofgeophysics.eu/index.php/annals/article/view/5324

M. Kok

11. Trends in Fatalities from Distracted Driving in the United States, 1999 to 2008

This article examined the trends in distracted driving fatalities and their relation to cell phone use and texting volume.
After declining from 1999 to 2005, fatalities from distracted driving increased 28% after 2005, rising from 4572 fatalities to 5870 in 2008. Crashes increasingly involved male drivers driving alone in collisions with roadside obstructions in urban areas. By use of multivariate analyses, they predicted that increasing texting volumes resulted in more than 16 000 additional road fatalities from 2001 to 2007.
Distracted driving is a growing public safety hazard. Specifically, the dramatic rise in texting volume since 2005 appeared to be contributing to an alarming rise in distracted driving fatalities. Legislation enacting texting bans should be paired with effective enforcement to deter drivers from using cell phones while driving.
In 2008, approximately 1 in 6 fatal vehicle collisions resulted from a driver being distracted while driving. The causes of distraction have recently been debated, and several studies implicated the use of cell phones or sending text messages while driving. Several studies suggest that, relative to non-distracted drivers, those drivers are 23 times more likely to crash. Laboratory and naturalistic studies also showed that distracted drivers are at a 30% higher risk of collision than non-distracted drivers.
Concern among safety experts, industry leaders and communities are rising as a growing number of them are considering and implementing regulations and bans for cell phone use while partaking in traffic.

Fernando A. Wilson, Jim P. Stimpson, 2010, American Journal of Public Health, Trends in Fatalities from Distracted Driving in the United States, 1999 to 2008, 2213 – 2219
https://ajph.aphapublications.org/doi/full/10.2105/AJPH.2009.187179

12. Driving performance during concurrent cell-phone use: are drivers aware of their performance decrements?

This study examined the extent to which different driver groups, male, female, younger drivers, older drivers are aware of their performance while driving. It compares the confidence rated by the drivers to their actual driving performance in the presence of a cell-phone task.
The study showed that in male drivers a confidence rating resulted in better driving performance. As confidence ratings increased, the size of the distraction decreased. This trend did not continue for females, however. For older females, as confidence increased, performance decreased. Older females also had a significantly higher brake responds, of 0.38s, whereas it was 0.10s for young males and females and 0.07 for older males.
In general females rated the driving task as less demanding than the male drivers, even though their performance was more often affected by distraction.
These results suggest that many drivers may not be aware of their decreased performance while using cell phones. It might be useful to target educational campaigns on driving distraction towards females as they tend to be less aware of their driving ability while distracted.

Mary F Lesch, Peter A Hancock, 2004, Accident Analysis & Prevention, Driving performance during concurrent cell-phone use: Are drivers aware of their performance decrements? 471-480 https://www.sciencedirect.com/science/article/pii/S0001457503000423

13. Emergency medical rescue efforts after a major earthquake: lessons from the 2008 Wenchuan earthquake

This study looks at the 16 earthquakes, from 2001-2011, that took place that led to more than 1000 casualties each and looks at the medical disaster relief efforts and distils learning points from them.
These are the lessons learned from the Wenchuan earthquake:
Preparation and management

- Disaster relief reinforcements in the form of back-up medical and military teams, risk awareness, and disaster prevention measures should be intensified in earthquake-prone areas
- Multilateral cooperation and local management improve the efficiency of emergency medical rescue

Supportive medical forces

- Allocation of supportive medical forces should meet the demands in the disaster area
- Military medical forces play an important part at the disaster site and should be considered as the leading force in earthquake emergency medical rescue efforts
- Volunteers are an important force, but the management of non-governmental organisations needs urgent improvement

Casualty evacuation

- Simplified, rapid evacuations by several means are thought to be the best way to evacuate casualties
- Aeromedical evacuation has an irreplaceable role in the rapid transportation of patients from the disaster area to rear hospitals

Casualty treatment

- Effective triage criteria are crucial to improve the efficiency of first aid
- Further development of portable medical equipment might improve diagnosis and treatment in the field
- Early treatment of crush injuries and other chronic diseases improves prognosis

Prevention of infectious diseases

- Rapid and multistage continuous assessments of public health issues should be done
- Comprehensive coverage of the population and focused disease prevention should help to prevent disease outbreaks
- Mobile phones can partly compensate for the destruction of computer-based infectious disease reporting systems

Effects on mental health and society

- Post-disaster psychological assessments should be staged and graded, immediately after the event and for some time afterwards
- Placation of survivors, post-disaster reconstruction of education facilities, and readily available rescue information to rebuild social self-confidence should be emphasized

Lulu Zhang, Xu Liu, Youping Li, Yuan Liu, Zhipeng Liu, Juncong Lin, Ji Shen, Xuefeng Tang, Yi Zhang, Wannian Liang, 2012, The Lancet, Emergency medical rescue efforts after a major earthquake: lessons from the 2008 Wenchuan earthquake, 853-861
https://www.sciencedirect.com/science/article/pii/S014067361161876X

M. Askari

14. Texting while driving: A study of 1211 U.S. adults with the Distracted Driving Survey

Emily Gliklich, Rong Guo MS, Regan W. Bergmark MD

This study was conducted to show how often distracted driving happened and self-reported accident rates under different demographics and groups. Distracted driving can include texting or reading texts while driving, drunk driving, being on social media, watching videos etc. The test group consisted of about 600 men and 600 women from all over the US. The age range of 18 to 72 so the mean age was 42. Out of all the participants 60% had admitted to driving with a distraction in the past 30 days. 18 to 24-year olds reported the highest rate of social media use while driving. The study also found that the most common use of the phone was for writing text messages and using the GPS. Higher mobile distraction rates were directly correlated to age and to higher self-reported crash rates.

Source: Gliklich, E., Guo, R., & Bergmark, R. W. (2016). Texting while driving: A study of 1211 U.S. adults with the Distracted Driving Survey. *Preventive Medicine Reports, 4*, 486-489. doi: 10.1016/j.pmedr.2016.09.003

15. 13th Annual Road Safety Performance Index (PIN) Report

In 2018 25,047 people died in road accidents in Europe. This is 1% less than the year before and 4% less than that entire year. A target was set to reduce road accidents by 2020 however by the looks of it this goal shall not be reached. To still reach that goal a reduction of 20% must be made between 2019 and 2020 which is highly unlikely.

Source: SemiColonWeb. (2019, June 19). Publications. Retrieved November 17, 2020, from https://etsc.eu/13th-annual-road-safety-performance-index-pin-report/

16. Drink-driving deaths in the UK have not decreased since 2010

The numbers of deaths by drunk driving in the UK in 2016 were about 203, which is very similar to the rates in 2010. Also, in 2016 the number of accidents where one or more occupants of the car had a high alcohol percentage was 6,070, which is a 6% rise

Source: SemiColonWeb. (2018, September 2). News. Retrieved November 17, 2020, from https://etsc.eu/drink-driving-deaths-in-the-uk-have-not-decreased-since-2010/

A. Zdrobau

17. There's No Such Thing as a Natural Disaster

In this publication it is stated that, whether a natural event is a disaster or not depends ultimately, however, on its location. But even among climatic events, natural causes are not entirely divorced from the social.

The refusal to tackle global warming is rooted in the global power of the petroleum and energy corporations which fear for their profits and which, not coincidentally, represent the social class roots of the Bush administration's power; the New Orleans population were vulnerable not because of geography but because of long term class and race abandonment – poverty – the incompetence of FEMA preparations expressed cocooned ruling class comradery, cronyism and privilege rather than any concern for the poor and working class; and the reconstruction looks set to capitalize on these inequalities and deepen them further.

The world has recently experienced dramatic warming, which scientists increasingly attribute to airborne emissions of carbon, and around the world Katrina is widely seen as evidence of socially induced climatic change.

A large earthquake in the Hindu Kush may spawn no disaster whatsoever while the same intensity event in California could be a catastrophe.

The images ricocheting around the world of a crippled United States, unconcerned or unable to protect its own population, receiving offers of aid from more than 100 countries, only reaffirmed for many the sense, already crystalizing from the debacle in Iraq, of a failing superpower.

Smith, N. (2006). There's No Such Thing as a Natural Disaster. There's No Such Thing as a Natural Disaster, 1–7.
http://blogs.ubc.ca/naturalhazards/files/2016/03/Smith-There%E2%80%99s-No-Such-Thing-as-a-Natural-Disaster.pdf

18. Neck sprain—a major cause of disability following car accidents

In this publication, it is stated that one hundred and thirty-seven patients attending hospital following road traffic injuries have been contacted concerning ache withinside the neck among 1 and 2 years later.

Eighty-five (sixty-two according to cent) said they had suffered ache withinside the neck for a while following their twist of fate in comparison with 42 (30.6 according to cent) who have been mentioned to have pain in the neck while tested quickly after the accident.

Thirty-one patients (22.6 according to cent) nevertheless felt occasional ache 1 year after the twist of fate and five had non-stop pain at 1 year.

Pain withinside the neck befell no matter the route of effect however become disproportionately common in rear effect injuries.

Patients wearing seat belts skilled pain greater often than unbelted sufferers.

Deans Magalliard Kerr Rutherford, GTJNMWH (1987). Neck sprain — a major cause of disability following car accidents. Injury, 1, 10–12.
https://www.sciencedirect.com/science/article/abs/pii/0020138387903755

19. Natural disaster management planning: A study of logistics managers responding to the tsunami

In this publication, the author aims to discuss the findings of a humanitarian logistics manager field study on response activity concerning the 2004 tsunami disaster in terms of what should have occurred and to present a comprehensive hindsight-analysis case for a model placing natural disaster response activity clearly within the context of local-nation-led, holistic and inclusive natural disaster planning.

The analysis of the findings in the light of tsunami-hindsight “effective disaster management” themes of recent academic literature and multi-agency reports and the development of the holistic, inclusive planning model.

That natural disaster response activity needs to be viewed holistically in the context of a disaster management planning continuum that ideally starts well before the response action is required and of which locally led inclusiveness is a crucial component.

Perry, M. (2007), "Natural disaster management planning: A study of logistics managers responding to the tsunami", International Journal of Physical Distribution & Logistics Management, Vol. 37 No. 5, pp. 409-433. https://doi.org/10.1108/09600030710758455

J. Gerritsen

20. Wireless Sensor Networks and Multi-UAV systems for natural disaster management

This scientific publication tells us about all the ways that WSN’s (Wireless Sensor Networks) and multi-UAV (Unmanned Aerial Vehicle) systems can improve or add to the quality of natural disaster management. After all the research the authors (M. Erdelj et al.) conclude the following: WSN and multi-UAV systems can help with:

1. the pre-disaster phase (Monitoring the area, use forecast input to predict and use early warning systems)
2. Fusing and sharing disaster information
3. Raising awareness, organizing the logistics and evacuation
4. Being used as communication tool
5. Assist search & rescue missions
6. Assessing the damage on the area

The paper also mentions the biggest obstacles that must be solved before applying this technology:

1. Coverage, mobility & Connectivity (practical/technical issues)
2. Robustness & Reliability (physical issues)
3. Security, privacy & safety (digital issues)
4. Inner operability (autonomous issues)
5. Quality of Service (Effectiveness issues)

Erdelj, M., Król, M. ł., & Natalizio, E. (2017b). Wireless Sensor Networks and Multi-UAV systems for natural disaster management. *Computer Networks*, *124*, 72–86. https://doi.org/10.1016/j.comnet.2017.05.021

21. Vehicle accidents related to sleep: a review

This article reviewed the relation between sleepiness and vehicle accidents. The article is a literature research where different, already published, articles were used to generate a conclusion about the relation between sleepiness and vehicle accidents, and what could help against vehicle accidents. After researching the publications, the following was concluded: sleepiness is significantly related to vehicle accidents
The following things can help reducing the amounts of sleepiness related vehicle accidents:

1. Raise awareness (too many people were fighting against sleep). The driver must realize that he/she/it is sleepy.
2. Try to take a rest (and preferably a nap) a soon as possible
3. Combine a rest with coffee (with around 150mg Caffeine) (still: Rest > Caffeine)

The most important is still the awareness of when people are too sleepy and should stop driving. The research concludes that too many people are fighting sleep instead of taking a rest.

Horne, J., & Reyner, L. (1999). Vehicle accidents related to sleep: a review. *Occupational and Environmental Medicine*, *56*(5), 0–294. https://doi.org/10.1136/oem.56.5.289

22. Incidence of alcohol and drugs in fatally injured car drivers in Norway

This article is about a research that looked at how car fatal accidents relate to usage of drugs and alcohol. The research was conducted in Norway which has very strict laws on alcohol while driving. The research was conducted by analysing the blood of people that had died in a fatal car accident. After doing the research they found the following things:

1. Even though the laws on alcohol are very strict, 28.3% of all people who died in a car crash had alcohol inside in their blood. This is nearly the same rate as their neighbour countries Sweden & Finland (25%-29%).
2. Drugs were also influential but significantly less than alcohol: 16.3%.
3. The drugs most common were: benzodiazepines & tetrahydrocannabinol.
4. It is realistic to regard these figures as minima because the samples were taken some time after the crash and not at the moment of the crash. This means that alcohol and drugs could have disappeared. This is also the case because, to keep the research doable, only a limited number of drugs were tested.

Gjerde, H., Beylich, K.-M., & Mørland, J. (1993). Incidence of alcohol and drugs in fatally injured car drivers in Norway. *Accident Analysis & Prevention*, *25*(4), 479–483. https://doi.org/10.1016/0001-4575(93)90078-b

Chapter 2: Identification of General Problems and Challenges

List of the problems and challenges

Small Note: due to miscommunication we came up with a little bit more than 8-10, but we decided that it is more fair to keep everything in.

1. The WSN (Wireless Sensor Networks) and multi-UAV (Unmanned Aerial Vehicle) are not yet able to cover a big area for natural disaster management
2. The WSN and multi-UAV are not easy to move and connect to each other
3. The WSN and multi-UAV systems are big and unreliable (eg. multi-UAV's that crash or WSN's that will not function correctly if the get a little bump)
4. The WSN and multi-UAV systems can comprise privacy and are, still, too easy to hack
5. The WSN and multi-UAV systems are not intelligent enough. Too many people must pay attention to the WSN's and UAV's
6. The WSN and multi-UAV systems are not able to provide quality data that is useful for natural disasters (sensor range and quality is not high enough to be useful)
7. People are not aware enough that they are too sleepy to drive
8. People are not aware enough of the fact that being sleepy during driving is dangerous
9. Alcohol and Drug regulations do not seem to be effective in reducing alcohol and drug presence at fatal car accidents
10. People are not aware enough of the fact that alcohol and drugs are extraordinarily dangerous when combined with participation in traffic
11. A huge issue of distracted driving seems to be the use of mobile phones while driving, mainly under young adults.
12. Even though steps are being taken to reduce distracted driving, they are not working fast enough.
13. People are not aware enough of their decreased driving abilities when distracted
14. There has not been much research done with actual drivers in real life situations
15. Fatal accidents related to distracted driving have increased over the last couple of years
16. Not only should there be more research done in short-term disaster relief, but also long-term help
17. A challenge for us in the Netherlands is that we are very mildly affected by earthquakes, so researching its effects might become difficult
18. Better laws, bans and regulations should be set in place to reduce the number of fatal car accidents related to distracted driving
19. In the US fatal car accidents have increased, as well as texting volumes

20. We should learn from previous earthquakes to see where we can improve upon the responses. It takes officials to long to get to the hardest-hit areas, which results in more casualties
21. Lack of communication and knowledge about the local situation during a disaster results in loss of efficiency
22. How much time does it cost to check an area with these drones?
23. Are the building designs representative?
24. Does every earthquake have the same effect on the building every time?
25. How accurately is a computer able to tell the difference between the images?
26. How difficult is to get the damage assessment using VHR and SAR set up for an area?
27. How reliable is the crowdsourcing for the damage assessment?
28. How is the information used in crowdsourcing reliably and efficiently spread?
29. Restrictions on drinking and night driving are poorly regulated.
30. Drivers, aged under 40, do not take the risk of drinking driving seriously
31. The risk of crashes related to driving at night can be reduced just by illumination on the road
32. Social network technologies provide early evacuation to report general public of disaster hazard.
33. Remote sensing can help management of damage from the oil spill disaster, even though it is not accurate

Chapter 3: Identification of Relevant Problems

5 Relevant problems

1. When an oil spill disaster happens, the monitoring is not effective
2. Too few people that live next to the area that is hit by a natural disaster are informed well. Most times there is nearly no communication with their neighbouring areas, which means there is no real preparation to assist the people in and from the area that was hit by the natural disaster
3. It costs too much time to scan the whole area that is hit by a natural disaster with UAV's, which makes them not effective enough to use
4. Most big buildings in cities that have a risk of earthquakes are not stable enough to survive a heavy earthquake.
5. People are not aware of the decrease of their driving ability when they are sleepy or distracted

Chapter 4: Problem Selection and Motivation

The problem we chose:

People are not aware of the decrease of their driving ability when they are sleepy.

Motivation

The first and main reason we chose this specific problem is that sleepy driving ranks second in biggest causes of traffic accidents. The same goes for the cause of fatal accidents, only alcohol and drugs are more deadly in traffic. We would like to contribute to a solution to this deadly problem.

There is also lots of research done on this topic. Because there is already so much known about this problem, its causes and effects, we can target our solution more precisely. Even though there has been a fair amount of research done on this topic already, we learned there aren't many real products to counter this issue which is why it is crucial to find and create a solution for it.

We also chose this, because the subject is very global and at the same time extremely close to people. Nearly everyone in the world partakes in traffic on a daily basis, which means the product might find a lot of uses in the future.

We as a group are excited to start working on this project and are looking forward to finding useful solutions to this problem.

Chapter 5: Potential Solutions

List of potential solutions

1. Give drivers adrenalin or energy shots.

   To improve the alertness of the driver, they could be stimulated to take some sort of energizer, like caffeine, or adrenaline. This however could be far too chemical and is not very smart environment oriented.

2. Alarm the driver (With levels of severity) by measuring heart rate, eye movements + blinks, CO_2 in air, audio in the car & detecting yawns).

   To alert the driver of their sleepiness, we would measure their sleepiness with a variety of sensors like heart rate monitors and breathing sensors. These sensors in combination with an app could sense the amount of sleepiness of the driver. The driver could then be alerted when their sleepiness is considered too high/dangerous by for example a light, sound or vibration. These sensory indicators will increase in severity to notify the driver, and encourage them to take a break.

   Sensing options:

   a. Heart-rate monitor
      When a person is fatigued their heart-rate fluctuates more than usual. In general the heart-rate lowers as well. This could be a clear indicator for fatigue and a reason to alert the driver to take a break.
   b. Measure driving time and encourage the driver to rest.
      To avoid people from driving sleepy, we could measure their driving time and encourage them to take a break after a certain period of time. This is a straightforward and easy to implement way of alerting the driver.
   c. Measure driving pattern of the driver to find if the driver is sleepy
      When the fatigue of the driver increases their response time and driving style changes. We could use this to our advantage and use sensors to rate their driving ability over time. The driver could be alerted when their response time changes and their driving ability degenerates.
   d. Breathing-rate monitor
      When a person is fatigued their breathing slows down. With a band around the driver's chest that senses their breathing patterns we can notice when a driver is becoming sleepy and alert them before it causes accidents.

   Alarming options:

   a. Car itself responds to sleepy behaviour and takes over driving.
      Similarly to point 2 we would use a variety of sensors to detect the driver's sleepiness. Instead of alerting the driver of their driving ability so they can act on it themselves, the car would take over the driving. The car would

automatically lead the driver to a save spot to take a break and restore their energy level.

b. Sensory notification
   A light will start blinking, with increasing severity to alarm the driver or a little screen will tell the driver to take a break or notify them of their fatigue.
c. Audible notification
   A little speaker will alarm the driver of their sleepiness with a beep or jingle.
d. Vibrating steering wheel
   To notify the driver but at the same time not distract the driver with visual or audible input, we could make the steering wheel vibrate. This way the driver cannot miss the notification as they are always holding the wheel.

3. When the car senses sleepy behaviour navigation locks your original route and navigates you to the closest parking lot to rest there. (Pitstop Mode)
   When the driver becomes sleepy and the car senses this, we could re-route the car. The navigation system would be connected to the sensors. As soon as the level of fatigue of the driver becomes dangerously high, the car's navigation is automatically re-routed to the nearest rest place to encourage the driver to take a break.

Chapter 6: Solution Selection

Solution

Alarm the driver (with levels of severity) by measuring heart rate, eye movements + blinks, breathing pattern and detecting yawns.

Motivation

There were many factors that played a role in deciding on our solution. The first reason being the amount of previous research done on this topic.. Already a lot of research was done on all different parts of the project which means combining knowledge to create a real product would become a lot easier.
It also is a project that is diverse and customizable, it has a lot of different sensors and can be tailored well to its maximum performance. If one sensor doesn't work (properly) we can adapt the product and then still run validation tests.
We should definitely not forget to mention that the goal seems really achievable which means we could actually create a solid end result while also being able to validate the products' effectiveness easily.
The last reason why we chose this solution, is that it is really applicable and if our project becomes successful, the technology could actually be implemented into real cars. It would be amazing to actually solve a dangerous problem in today's society.

Gathering knowledge

However, we did already divide tasks roughly for gathering the knowledge. There are three main things we must work on for our project. The output, the input and conversion of the valuable information to something that will determine whether the Arduino needs to send signals to the driver. We divided the group like this:

Input/Sensors	**Output/feedback**	**Mathematical Conversion**
K. de Weger	M. Askari	A. Zdrobau
M. Kok	S. Sonneveld	M. Youn
		J. Gerritsen

Division of all tasks

Task	***People working on it***
Ordering & Car sim	J. Gerritsen
Presentation: Movie	K. de Weger & M. Kok
Documentation	M. Kok & J. Gerritsen
Demo Host	M. Askari & A. Zdrobau
Heart rate monitor	A. Zdrobau & M. Youn
Breath rate monitor	K. de Weger & M. Askari
Screen & Speaker	S. Sonneveld & M. Kok
Algorithm app, App functions & interaction	S. Sonneveld & J. Gerritsen
Main Design of prototype & logo	M. Askari
Research; Design the test+data+conclusion	M. Youn, K. de Weger & J. Gerritsen
Configuration of the setup	A. Zdrobau, S. Sonneveld & J. Gerritsen
Getting the stuff from the scrapyard	K. de Weger & M. Kok
Make a purchase list	***Whole Group***
Assembling everything	***Whole Group***

Chapter 7: Methodology

Purchase list

Thing	**Amount**	**Who can get it?**
GTA Game	1	S. Sonneveld & A. Zdrobau
Game Steering Wheel: Logitech momo racing wheel	1	SmartXP
Heart rate sensors: PulseSensor (SEN-11574)	6	Alfred

Duck tape	1 roll	M. Askari & S. Sonneveld
Electrical tape	1 roll	S. Sonneveld
Long Solid Coil wire (1.5 meter)	20	Alfred
Arduino uno	1	Proto kit
Bluetooth module hc-05	1	Alfred
Mobile phone for the app	1	M. Askari (Samsung S10)
Piezo Speaker	1	S. Sonneveld
1.8 TFT 128x160 v1.1 (screen)	1	Alfred
Usb cable a to mini b	1	Alfred
Resistor 100 Ohm	1 little Bag	Proto Kit
Resistor 100k Ohm	1 little Bag	Proto kit
Infrared emitter, 15°	1	Alfred
Photodiode, 20°	1	Alfred
Capacitor 10nF	1	Alfred
Conductive stretchable wire	1 meter	K. de Weger & M. Askari

Insight on data collection and project calibration

How to collect the data

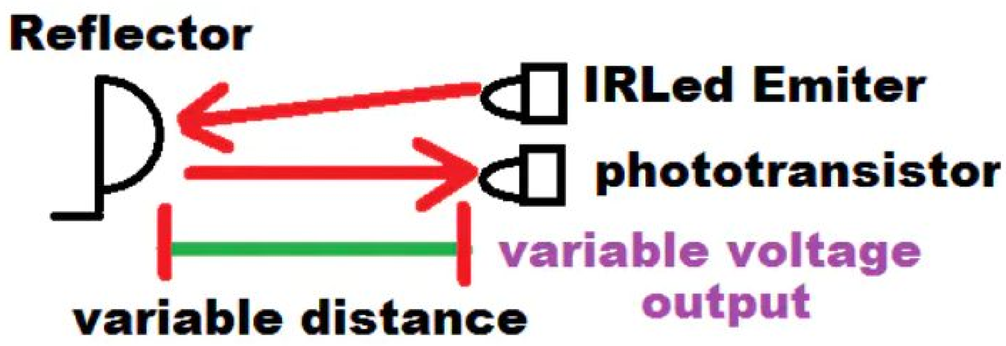
Heart rate monitor

For the system to function properly, the heart rate monitor will collect the data from a sensor placed on the steering wheel. When the driver puts his hands on the wheel and has at least one finger on the sensor, the sensor will determine the driver's heart rate and the data will be sent to the Arduino, where it will be processed and sent to the cell phone through Bluetooth.

Breathing monitor

Variant A

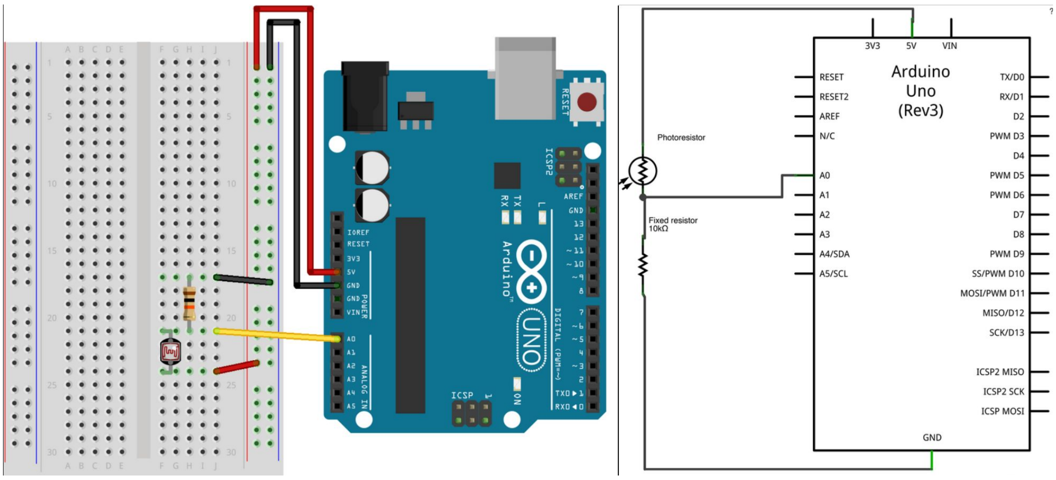
To make everything work, the breathing monitor will collect the data from a stretchable band that is around the driver's stomach. In our case, this will be measured by sending an IR-light to a reflector and receiving them via a phototransistor. This will give a value which can be calculated to be the breathing rate. This data will be sent to the Arduino.
We decided not to use this method in the end.



Breathing Sensor 1 Respiration Sensor. (2020). Arduino Project Hub.
https://create.arduino.cc/projecthub/marco-polo-sauza-aguirre/breathing-sensor-1-respiration-sensor-1b18de

Variant B

Like variant A, the breathing sensor will collect data from a stretchable band around the driver's stomach. As the band expands, the magnetic flux will change, changing the resistivity of the sensor. This gives input to the Arduino, which we can use to calculate the breathing rate.
We built this variant, but sadly we were not able to use it during the testing phase.



Instructables. (2020, 11 augustus). DIY Breath Sensor With Arduino (Conductive Knitted Stretch Sensor). https://www.instructables.com/DIY-Breath-Sensor-with-Arduino-Conductive-Knitted-/

Sending this data

We have all this data, now we need to do something with it. The collected data from the sensors will be sent to an cellphone app, coming from the Arduino, where the data will be processed and securely stored. The data will be sent via a bluetooth module to a cell phone where it will be analysed and the sleepiness value calculated. The Arduino has a high enough processor frequency to be able to process the data and make it effective for real time driving.

Calibrating the project

Sensor calibration

The data from the sensors can be made into a value using an algorithm. Different algorithms can be used for this, like an exponential or linear one where it looks at the difference between the value given and the average value. This way the data can be calibrated to be as accurate as it needs to be for the next algorithm.

App calibration

The value of the sleepiness can be calibrated by modifying the algorithm it will use. A possible algorithm could be one which assigns a weight to each value. This way it can be accurately calculated by changing the weight of the different sensors. The data which will be more accurate would be assigned a higher weight, and the data which indicates less accurately on the sleepiness will be given a lower weight. An example for this would be *sleepiness value = heart rate value * 0.6 + breathing value * 0.8*.
This value can be used to trigger the different ways to alert the driver on their level of sleepiness.

Different setups for the Arduino

Setup 1:

This setup uses 6 parts:

1x Bluetooth 4 (BLE) HM-10 (The kind of bluetooth module doesn't matter much)

1x IR receiver diode (Used for the breathing monitor)

1x IR LED (Used for the breathing monitor)

2x A transistor

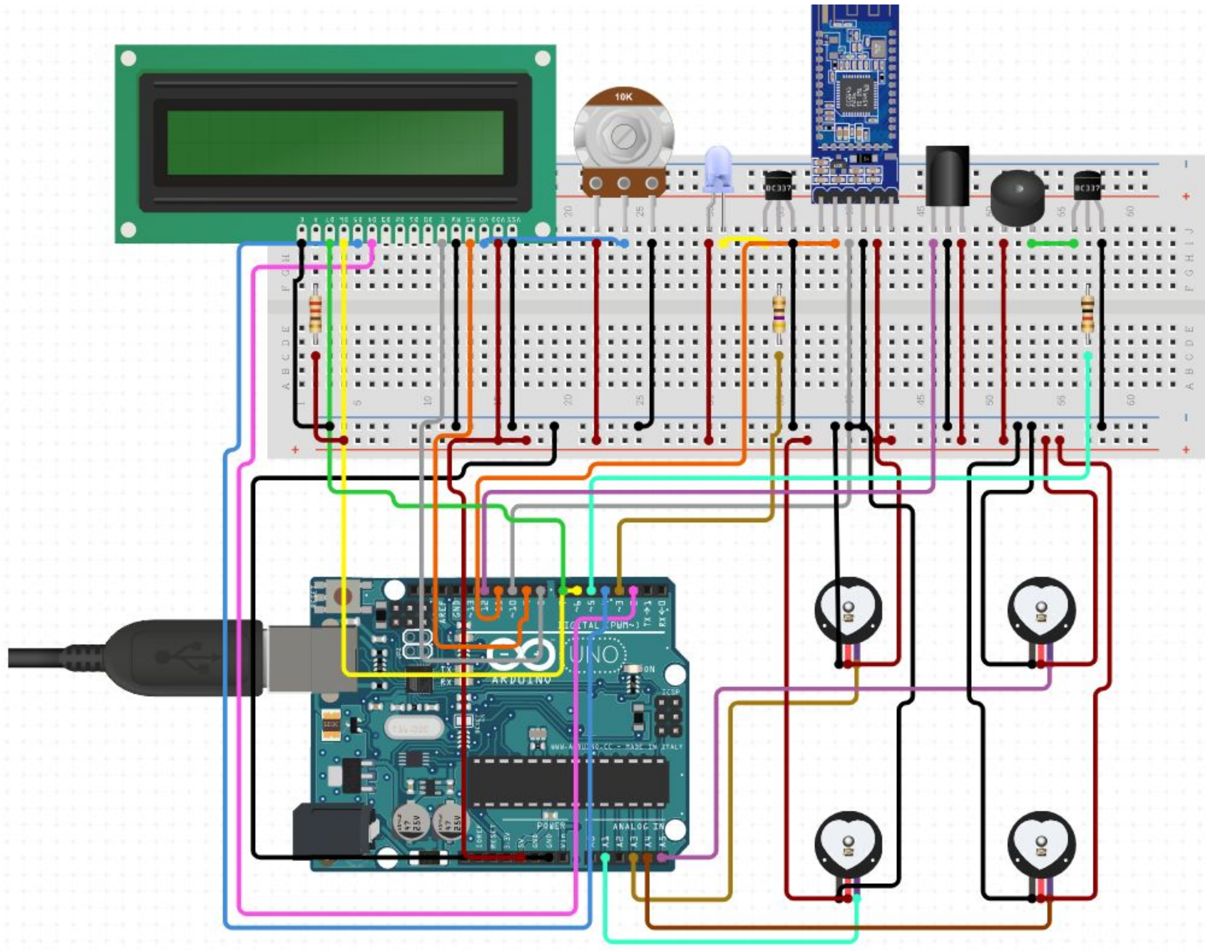
3x A resistor

4x A heart rate pulse sensor

1x LCD screen

1x potentiometer to configure the screen brightness (I think only needed once)

1x piezo speaker



Setup 2:

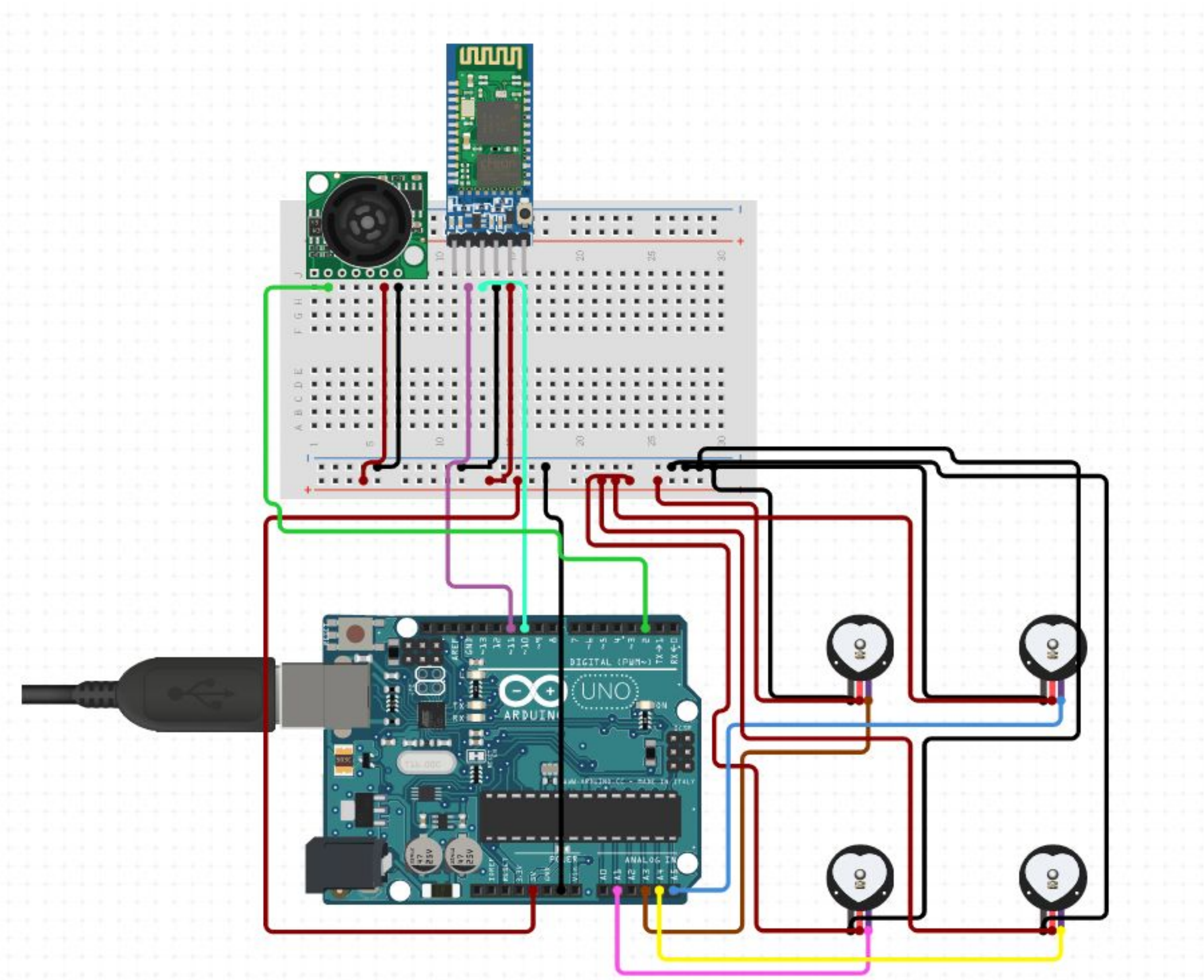
1x Half-Size Breadboard

1x Arduino UNO

4x Heart Rate Pulse Sensor

1x LV-MaxSonar-EZ1 - Ultrasonic Range Finder

1x HC - 05 Bluetooth Serial Module



Setup 3:

This setup uses multiple breadboards to have the different sensors on different places.

1x Arduino uno

2x breadboard tiny (can be smaller)

1x breadboard (can maybe be smaller)

1x Bluetooth 4 (BLE) HM-10 (The kind of bluetooth module doesn't matter much)

1x IR receiver diode (Used for the breathing monitor)

1x IR LED (Used for the breathing monitor)

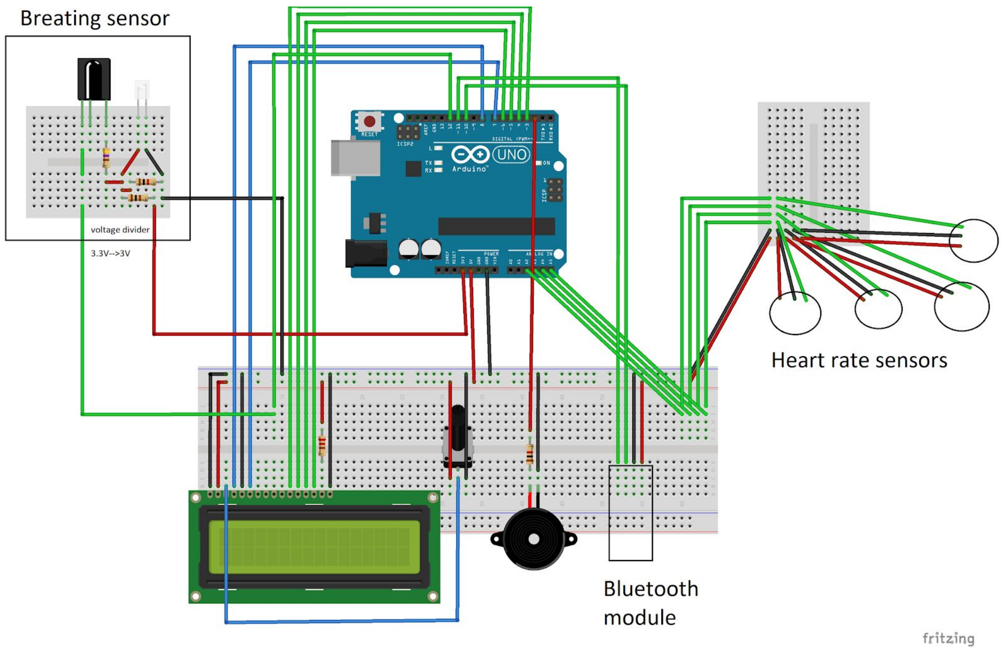
5x Resistors

4x Heart rate pulse sensor (more can easily be added)

1x LCD screen

1x potentiometer to configure the screen brightness (I think only needed once)

1x piezo speaker

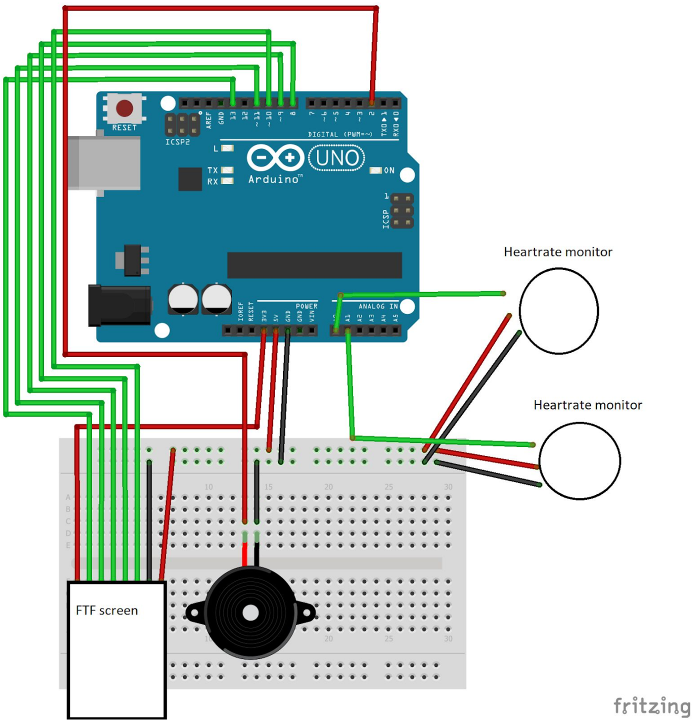


Configuration

Arduino + main breadboard: middle dashboard
Breadboard heart rate sensors: dashboard behind the wheel
Breadboard breathing sensor: right side of car seat

Final Setup

The setup we decided on using is:



This setup uses:
1x Arduino uno
1x 1.8 TFT 128x160 v1.1 (screen)
1x piezo speaker
2x heart rate monitor

Building a heart rate and breathing sensor

We implement the way of building and attaching sensors by the methods written on the arduino site.
https://create.arduino.cc/projecthub/Ingeimaks/diy-heart-rate-sensor-a96e89
https://create.arduino.cc/projecthub/marco-polo-sauza-aguirre/breathing-sensor-1-respiration-sensor-1b18de

Testing our product

Intention

We want to make this test as valid as possible, so we will find many people willing to try our project and maybe bribe them with food.
We do not need people with a driver's license, but we have to test if the sensors still work when you shift in your seat.
We want to test if our product helps keep you alert enough to guide you to the nearest parking place, so the driver can rest up and continue their trip in the safest way possible.

Hypothesis

We assume that the amount of car crashes is reduced when using our product and that the time between when they should stop driving and the moment they actually stop driving becomes less.

Before the testing

Before we can test it on people, we need to test the sensors individually, and when they work on their own, we need to try if they work/can turn on while connected to the monitor/screen. *(a week before (hopefully) the final test)*

The test

The group does three tests. The first test the group is fully awake. Here we just test to see if the product is working on them correctly. The last two tests are done while the group is sleepy. The second test, the product is active, the third test the product is not.

Testing round 1

Drive when normally awake and see if the system doesn't give feedback for invalid reasons

Testing round 2

For this round, we measure heartbeat and breathing rate, but we don't give feedback on whether they are too sleepy. We ask them to stop driving as soon as they feel sleepy.

Testing round 3

For this round, we do exactly the same as testing round 1, but we attach our feedback system and drivers get alarmed. We don't tell the drivers that they should obey this system.

Building the algorithm

Main idea

We will be making an algorithm that makes use of a sampled base and a lower boundary. The average sampled base will be created by taking the average of the heart rate/breathing rate. The lower boundary will be a value we set (for example 60 bpm).

We thought of different methods to build this algorithm. We are going to test which one is the most accurate.

Method 1

Sampled base = 0 (%) & lower boundary 100 (%)
Create a linear function that has these coördinates.
y=ax+b

Method 2

Sampled base = 0 (%) & lower boundary 100 (%)
Create a logarithmic function that has these coördinates.
y = e^(ax) + b

Method 3

Sampled base = 0 (%) & lower boundary 100 (%)
Take point for the percentage where the steps start (e.g. step 1=40%, step 2=60%, step 3=80%, step 4=100%)
y=ax+b

Choice

We eventually chose method 2, because logarithms are significantly better in displaying the true functions/graphs in nature and human behaviour. Also the working with steps didn't seem really realistic.

Ambitious plan

If we are very motivated, ambitious and have some time left we can work on an ambitious plan version. This version is an extension of the main plan, therefore everything that is written in the main plan is also applying to the ambitious plan.

We could add an extra camera that detects extra eye movements which can help in detecting sleepiness. That would result in more accurate data.
We could also do some more research in making it possible to add vibration to the alarm. At the first sight we scrapped this idea, because it might scare drivers. However if we do some more research we might be able to add this in a way that doesn't scare the driver.
The app could also keep track of how sleepy the driver is while driving and determine if the app is improving this or not.
It would also be interesting to add a "navigate to close parking space" function into our app that works together with Google Maps. This would also help the driver to stop driving.

If we are really ambitious we could add a camera that works together with a deep learning AI. This might be a little too difficult, because it would require a lot of new knowledge.

Chapter 8: Results, Conclusion & Discussion

Execution

We decided to first finish our basic plan before we started on our ambitious plan as we wanted to make sure we could finish everything in time. As it turned out our basic plan already gave us some difficulties in its execution. We managed to implement most of the ideas from our basic plan into a prototype.

We divided our tasks up into different pieces, related topics together. We had a couple of things people were working on at the same time. When everything was finished we would put everything together to create a working prototype.

We tested out the screen we got from Alfred and wrote the code so that it would change color as the input data from the other sensors changed. We, however, when we ordered the screen, didn't realize it was a shield to go on top of the Arduino. If we were to use this we couldn't add any other sensors and actuators to the setup. We also didn't realize the shield does not fit onto a (larger) breadboard due to the way the pins are arranged. Therefore, we decided to use a different screen, a smaller and more manageable 1.8 TFT 128x160 v1.1 screen. This screen did fit nicely onto the breadboard and allowed us to connect the piezo buzzer and the heart rate sensors to our setup as well.

We tested out the piezo buzzer and made sure everything was working the way it should. We played around with different frequencies, we even made it play "Slaap kindje slaap" a Dutch lullaby. Because it was difficult to alter the volume of the piezo buzzer we decided to work with the pitch of the notes the buzzer was playing to alarm the driver. In addition, we varied the amount of beeps the buzzer was making. When the driver was not very tired only one beep would be produced, whereas if the driver was showing real signs of sleepiness, the buzzer would beep 3 or 4 times.

We tested out the heart rate sensors and wrote code which was compatible with the rest of the set up. We decided to attach the heart rate sensors to two fingers, rather than to the steering wheel, which was our original plan. This was because of two main reasons. The first reason was that we didn't own the steering wheel so it would have been difficult to attach the sensors securely but at the same time temporarily to the wheel. The second reason was that the sensors already had velcro attached to them to wrap around a finger.

The breathing sensor turned out to be a larger struggle than we anticipated. We ordered conductive, and elastic wire which we would knit into a band. As the band would expand and contract as the person wearing it would breathe in and out, the resistance would change due to changing magnetic flux. We were hoping this would result in a visible change in resistance which would then indicate the breathing pattern of the person.

Firstly, half of the wire we ordered didn't come in and secondly, the wire we got wasn't elastic. We still tried if knitting it into a string would give us any results. Unfortunately, it didn't. The code we wrote for the breathing sensor, however, did work and gave us results indicating a change in resistance when it occurred. This, however, didn't happen when we attached the breathing sensor.

We decided to put a halt on the breathing sensor for a while as we were assembling the other components to the setup. We got the heart rate sensors to work with the screen and piezo buzzer. When the heart rate sensor detected that you were sleepy they notified the screen and buzzer to give a certain output.

To generate our test results we set up a driving simulator consisting of a steering wheel, pedals and a game of GTA on a desktop screen. A laptop monitored and captured the changing heart rate and the screen of the GTA game was recorded.
Some testers did get to see the screen and hear the buzzer while others played until they indicated their tiredness.

Questions Asked

Name of test subject:	Kim de Weger	Jelle Gerrits-en	Myung-won Youn	Nikki Warries	Wouter Bleker	Ben Ligthart	Marije Kok	Ilse de Haan	Sven Sonne-veld
How long did you sleep last night?	7 hours	7.5 hours	7 hours	3.5 hours	7.5 hours	7 hours	9 hours	7 hours	6.5 hours
Do you have a healthy sleep rhythm?	Probably not	Yes	Yes	No	Probably not	Yes	Yes	Yes	Yes
Are you legally allowed to drive?	Yes	No	Yes, but not in NL	No	No	No	Yes	No	Yes
From 1 to 10 how sleepy are you now?	6	4	5	4	4	2	3	5	4
Are you a morning or evening/night person?	Evening	Morning	Both	Night	None	Evening	Evening	Evening	Night
Did you notice that you got sleepy during the drive?	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
Did the subject drive	No	No	No	Yes	Yes	Yes	No	Yes	No

with the feedback system?									

Graphs

Graph 1 - Heart rate

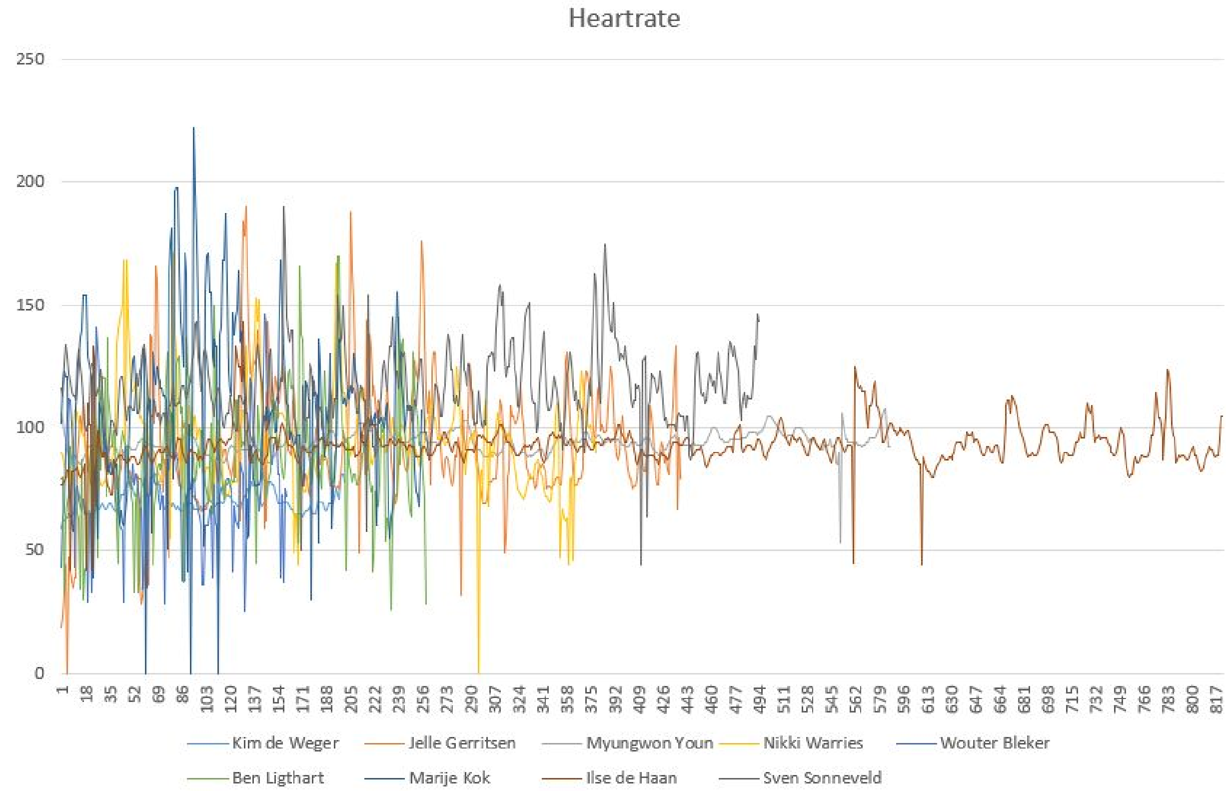


Figure 8.1
Lower bpm = sleepier driver
The heart rate is on the y-axis and the amount of test on the x-axis

Graph 2 - Sleepiness

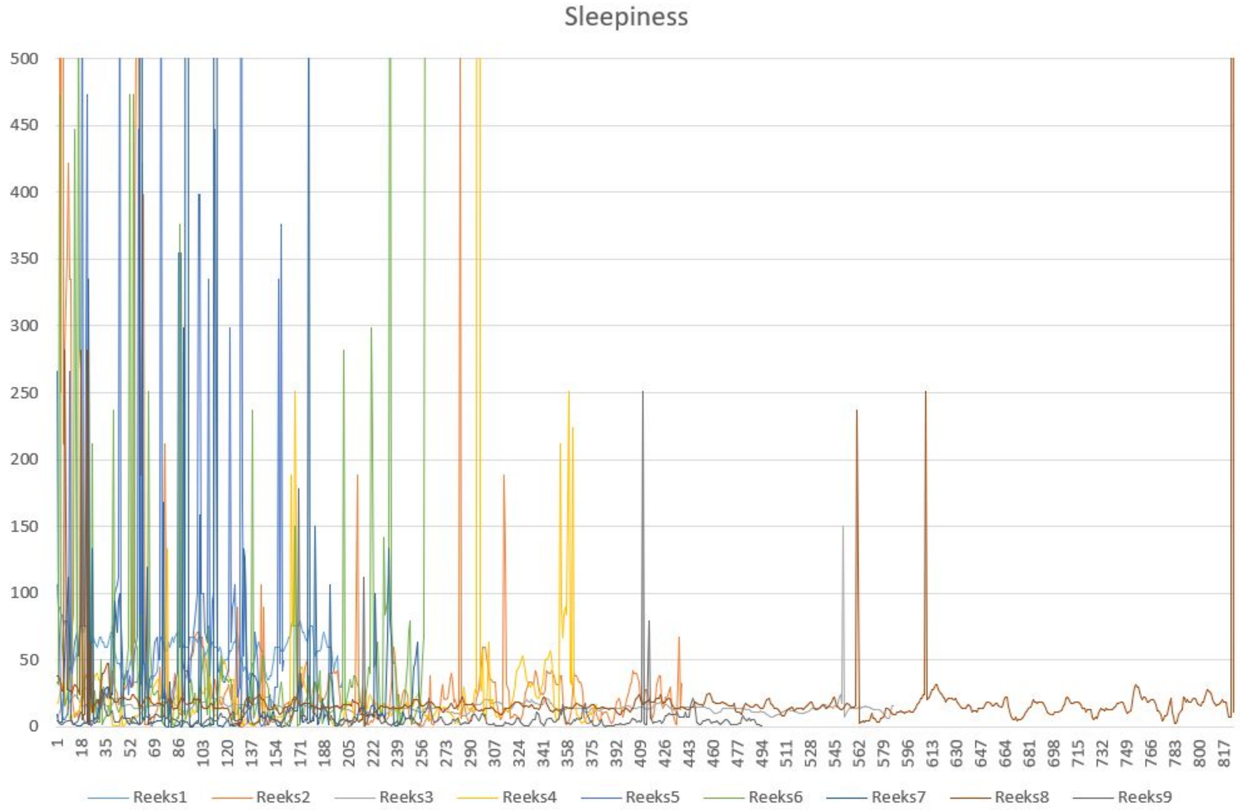


Figure 8.2
A lower sleepiness value mean the driver is more awake
This is graphed with the sleepiness on the y-axis from 0 to 500 and the amount of heart rates read on the x-axis

Graph 3 - Sleepiness Corrected

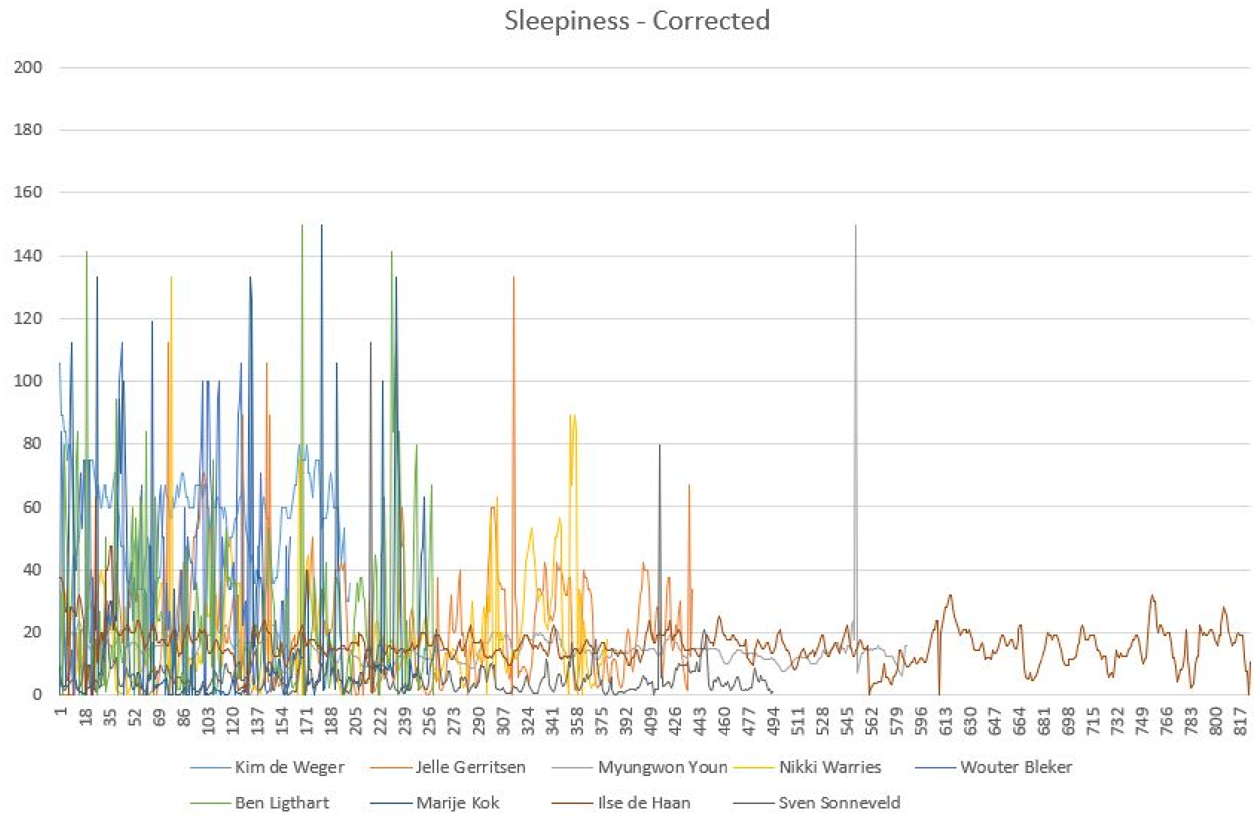


Figure 8.3
For this graph the values have been edited by removing every sleepiness value above 150 (bpm lower than 53) to try to give a better result by removing many possibly faulty readings. This was done to be able to give a better conclusion.

Graph 4 - Sleepiness Separated

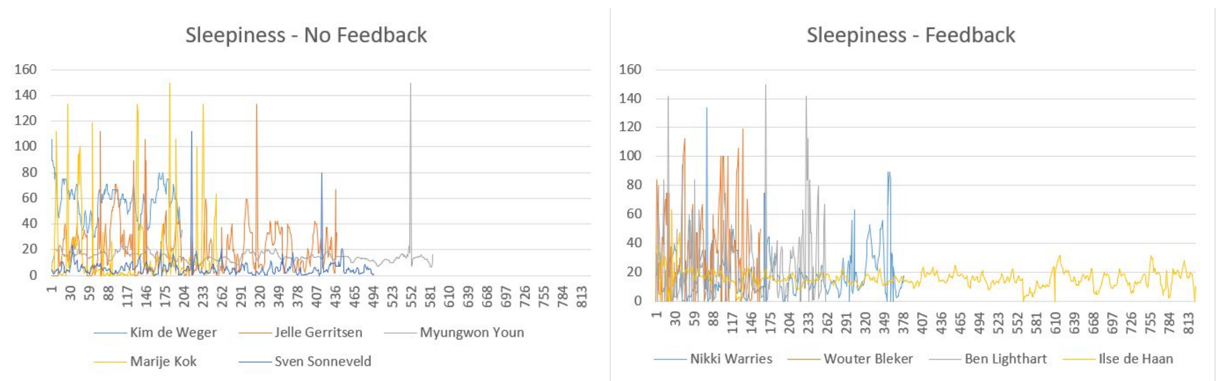


Figure 8.4
For these 2 graphs the corrected sleepiness has been separated into the participants who did get feedback from the prototype and people who didn't. This way it is easier to see the differences between them.

Results

It can be seen that in these graphs the participants who had less fluctuation in their sleepiness value have been able to be tested for a longer period of time. This was because the participants had been asked to stop driving when the values calculated indicated that they were sleepy.
There can be seen in the graph that the participants who had a bigger fluctuation were tested for a shorter period of time for the same reason.
In figure 8.4 it can also be seen that there is more fluctuation in the sleepiness value between those that got feedback and those who didn't with the participant who did have feedback having a higher fluctuation.

Conclusion

For Module 2 the task was given to create a device that would help, in case of, or prevent a disaster. The goal was to, together, create a prototype of a Smart Environment that would contribute to prevention or a solution.

Annually far too many people get into accidents that were caused by fatigue behind the wheel. People are not aware enough of their decreasing driving abilities when sleepy. The dangers of sleepy driving also aren't as commonly known as hazards such as intoxicated driving which has fatal accidents as a result. We found this to be small scale enough that it would be achievable, yet large scale enough that it could make a difference.

When starting this project, the main goal was to create a product that would measure the sleepiness of the driver and then make them aware of their current state. It was decided upon to use a heart and breathing monitor, and a screen with an app to relay the information. We had created a set up we could use to test it out, and had the sensors build. However, due to issues that shall be discussed in the discussion, our experiment did not work the way it should. We had some issues, due to corona as well as our own planning, creating the prototype. We like to believe that if the situation were different we would've been able to create a fully working prototype.

From the results we see that the heart rate monitor gave a reasonable reflection of the sleepiness of the driver. Of course, due to it being the only monitor we had set up at the time of testing, it was not a perfect indication. So we can conclude that the heart rate was a decent reflection but it was not completely reliable on it's own.

There are some things that can be said about the correlation between the graphs and the given sleepiness given by the participants. The sleepiness given by the participants are similar to the values that can be read from the graphs. Because it's difficult to estimate how tired you are on a scale from 1 to 10 the values given by the participants can be a bit inaccurate. Some have indicated that they were a bit tired, but had gotten lower values for the sleepiness than others who indicated that they weren't very tired.

It is definitely possible to create a product that would detect a driver's fatigue and tell them to pull over. Sadly, due to circumstances out of our hand, we as a group could not create a fully working prototype. Singular pieces did work as intended.

Discussion

In almost every project, some things go wrong. An essential part of making mistakes is admitting to them. We tested our product a couple of times, but we also ran into a couple of hiccups along the way.

The setup

The Covid-19 safety measures were one of those hiccups. We were not able to meet in person that often. Instead, we met on discord. We still managed to meet the appropriate amount of times so we could get the best product possible, given the circumstances. But with the unstable wifi of teammates and the short attention span, meeting in person would have resolved a lot. After the Christmas break, we were in a lockdown. This meant that assembling the sensors and testing had to be done differently. We could not get a car simulation, so we had to use a video game (Grand Theft Auto). This is, of course, less realistic. This means that you might not have moved as much as you would do when driving on the road. We realize that the test results could be less accurate. Also, the number of testers could not be as large as we would have wanted. But we managed to get the results we needed with a limited number of testers.

Another hiccup was that we ran into a couple of problems the week before the final deadline. For instance, we underestimated the breathing sensor. Our original plan was to make, let's call it variant A, but this turned out to be more complicated than foreseen. We looked for another, variant B, and the problem with variant B was that the belt. For this sensor to work, we needed a conductive belt around someone's stomach. We bought a conductive wire, but we didn’t receive the right wire. We did manage to build a working prototype, but the results were not optimal. We only got a result when the two alligator clips were in contact with each other. Also, the belt was a safety hazard, as we got sparks. So we decided to exclude the breathing sensor from testing. This hiccup could have been resolved if we had ordered the parts for the sensor earlier.

We were planning on using a Bluetooth module to connect the Arduino to the app, but we ran into some problems. The Bluetooth module got results, but the issue was that when you do something in the app, the connection between both was lost. The Bluetooth module code was not able to run in the background, which caused the app to stop responding which was a shame because now we couldn’t use the Bluetooth module or the app.

We did not consider the change in breathing patterns when someone is talking or singing in the car. We could have also used someone's health (weight, age, etc.) for some more accurate measurements to see if the results were abnormal.

The research

First, we should mention that due to Covid-19, we have a meager amount of test subjects. We conclude out of too little and insignificant data, which means our conclusions aren’t accurate enough to use in further research. Secondly, due to sensors not working, we couldn’t test all the aspects intended. If the breathing sensor had worked, we might have gotten different results. Third of all, the members of team DUCK TAPE were testers too. We know what kind of results we expected and were rooting to get. This means that the outcome is not as valid as we would have wanted. Fourth, while testing we noticed that there are some inconsistencies in the measurements of the heart rate sensor. As you can see in the graphs in the eighth chapter there are a couple of high peaks. Unfortunately, we were not able to find out why we got these inconsistencies. We also didn't take the resting heart-rate into account when testing which may have led to inaccurate readings. And finally, we were not able to acquire a realistic car simulator. This means that the testers could have gotten distracted and not notice they were tired. Their heart rate could have spiked when they got excited while playing the game.

But despite the hiccups mentioned above, we still managed to conclude: it is, in our opinion, possible to measure someone's sleepiness while driving and alert them of their sleepiness. We hope this will contribute to better sleepiness awareness in drivers and prevent (fatal) accidents related to driving.