Drivy *drive with confidence*

A drowsiness prevention device

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Major Project

Design Process Journal

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Summary

This project is about the exploration of the possibility of having a reliable Drowsy Prevention System in automobiles, especially for private vehicles. From studies, it was found that nearly 25% and 37%of all road accidents in the UK and the US respectively are due to sleepiness on the wheels [1]. Further, in the USA more than 1.2 million car accidents occurred in 2019 alone [2] because of sleepy drivers. Thus, to mitigate such occurrences, in this project, a number of methods were explored with their effectiveness. A solution was developed upon a thorough study of currently used technologies by the automobile industry and sleep scientists along with consideration of drivers' preferences.

This project underwent a lot of changes and updation throughout the project timeline following user testing, but the exploration has provided a worthwhile solution. To prevent drowsiness and to keep the driver alert was the main objectives of this project.

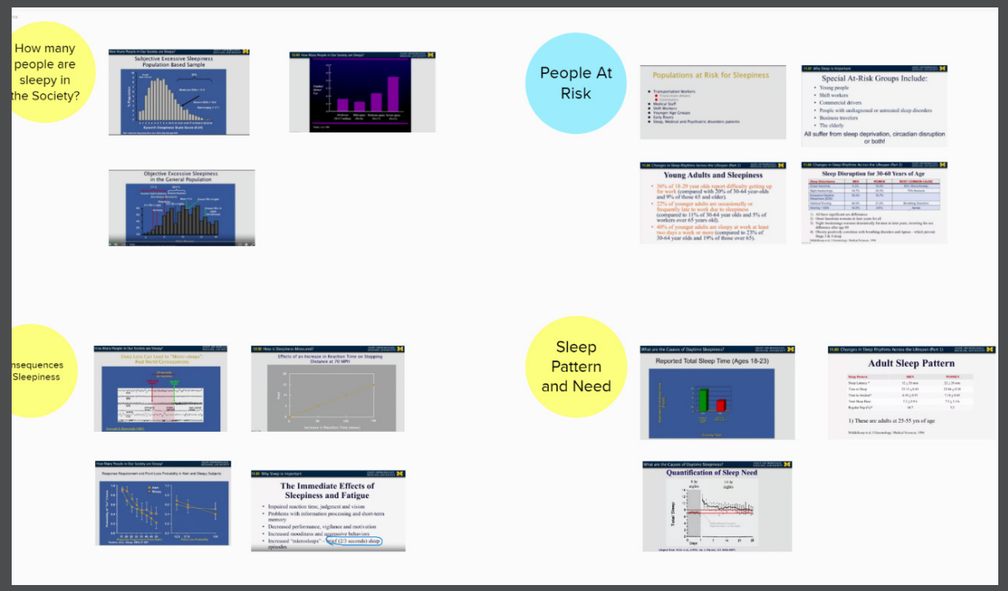
At last three main solutions emerged to help achieve the objectives namely; Drowsiness Detector using blink rate, eye closure and head movement; An alarm to alert the driver; and finally essential oils such as peppermint, lemon-grass, etc. to stimulate the driver and keep them alert and awake.

To reach the conclusion various design tools were used such as journey mapping, primary and secondary research. User scenario board, design thinking, technical considerations and more.

Contents

Discover and Define

This project started an Alarm issue. One day for an important deadline I got late because I remain asleep since the alarm didn't work for me, it wasn't enough. Later after understanding sleep and how it works, I came to realise that it was because of my sleep debt I couldn't wake up that day. Hence, I thought to explore this problem as my major project. Later after reviewing technology and talking to a sleep expert at University of Glasgow it became evident that proper evaluation of Sleep Deprivation is limited to a clinical setting only. Then, I moved on to further explore other problems caused due to sleep deprivation and happened to find drowsy driving, which is a big and concerning problem.



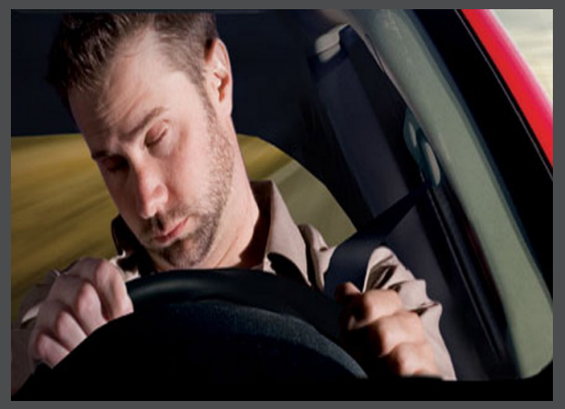
Exploring the problem and using mural to document the findings

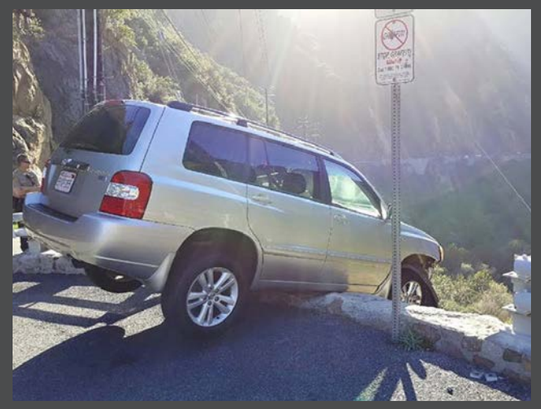
Mural Link for a detailed account of research:

https://app.mural.co/invitation/mural/mscpdestudio/1660473163839?sender=u7868c-193da0011c8a3fb1105&key=46ffa140-5742-4344-84e4-ea0c70e8f06d

Background

Sleepiness while driving is a well-known and universal fact. Though there are a number of reasons for sleepiness [3] such as sleep deprivation, monotonous and boring rides, fatigue, sleep apnoea, daytime sleepiness and sleep onset at specific times, and weather conditions. The symptoms of drowsiness are much the same [4] : people tend to take micro-naps, observable changes in blink rate and pupil dilation, changes in a brain wave pattern etc. Further, alone in the USA about 37% of the population reported experiencing excessive sleepiness at least a few days each month [1], and a study of fatal 204 road accidents in the UK concluded that 24% of these accidents were due to the drivers falling asleep on the wheels [5].





People At Risk: Target group [6]

New parents
Shift worker
Over time worker
Young adults (18-29)
The elderly
Untreated sleep disorder
Commercial drivers and
The business travellers

As a wide group of people are at risk for sleepiness thus targeted age group for this project is 18-64 is more appropriate. However, it is observed that in general when people rarely travel long distance the chances of occurrence of drowsiness is much more in that condition.

Existing Technology

Methods Used by Automakers [7]

- Lane detection
- Steering wheel movement
- Driving time
- Eye closure analysis (by DS)

Besides, there are various limitations on this system such as road conditions and driving speed. Some of the existing Driving Alert System works only when the vehicle is running at 65 km/h or more. Further, only certain model are having driver alert system that alerts the driver if they found sleepy.

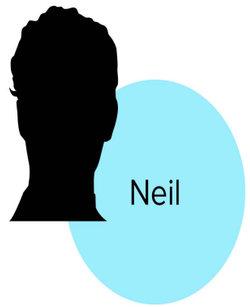
Methods Used by Sleep Scientists to assess Sleepiness [8][9][10][11]

- Rolling Eye Movement
- Blink Rate (BR)
- Electroencephalogram (EEG)
- Electrocardiogram (ECG)
- Psychomotor Vigilance Test (PVT)
- Heart-rate Variability Test (HVT)
- Sleep Propensity Test
- Multiple Sleep Latency Test
- Maintenance of Wakefulness Test

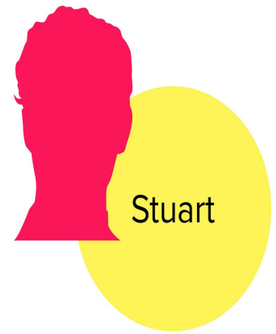
Gap and Opportunity

- Not many car company are using the human recognition method to detect sleepiness
- There’s no external product that addresses this challenge
- Only a few car models having a drowsiness detection system and usually available in expensive models!
- Commercial trucks and private vehicle market

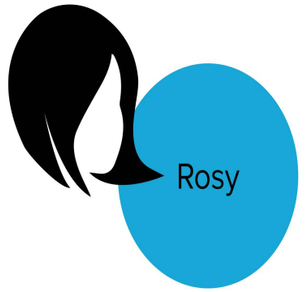
Discussions with Users



"I was travelling to south of india for an urgent reason and I missed the my train. I had to hire a rental car at 12am and the driver was very sleepy I got scared. I asked him to take some rest"



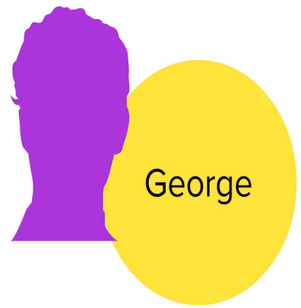
Because of late night study for the exams, I was tired and while driving from Edinburgh to Glasgow I experienced micro-naps. I was horrified. I slow lown the car and try to remain vigilant



I was driving on a motor way and started feeling sleepy.

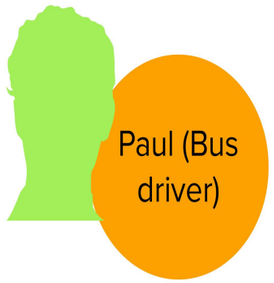
Why? Cause there's not much happening around me, it was a monotonous ride.

I put on the loud music



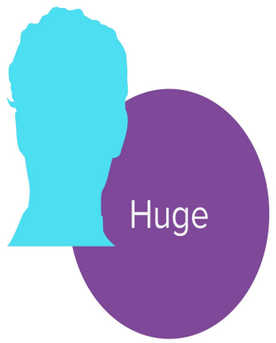
While travelling to home on the way lost steering control because of late night work. He anitipated that he might be sleepy while driving.

After the incident he tries not to do over shift, or not drive when it's late.



Very tired, no proper break between drive time. No proper sleep.

There's a system in bus that detects sleepiness, and vibrates the seat.



Try to scream out of the window. Put windows down to let some fresh air in!

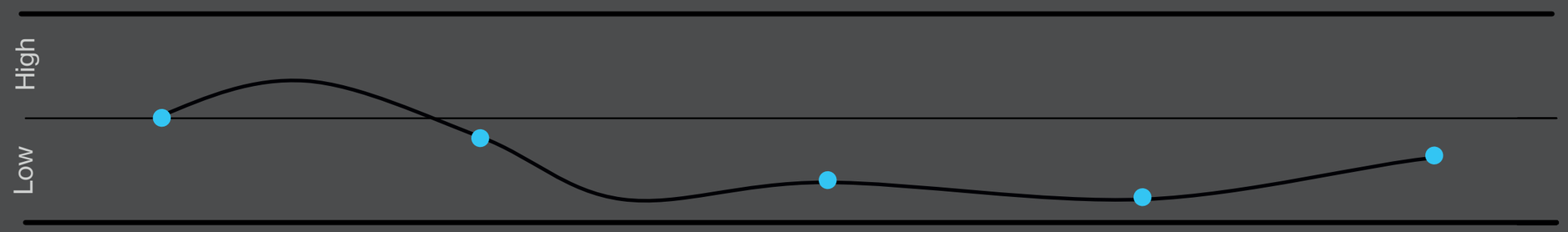
Here only a few discussions were shown. During the project more people were consulted and interviewed and the complete account of which can be found in the mural (link is provided in the page 3).

Journey Mapping

Mike, a new Father

- Mike works in a manufacturing firm, Mon - Friday from 9-5 pm.
- Now, he has a new daughter to take care of so, he constantly wakes up throughout night to check his daughter.
- During working days he becomes excessively tired, especially due to lack of sleep
- He struggles keeping his focus on the road while driving home.
- During weekends he tries to recover his lost sleep.
- He reported 2 near misses in previous month.
- He tries to be cautious while driving.
- Though his family considering to get a new car with extra safety features but, they could barely afford it.

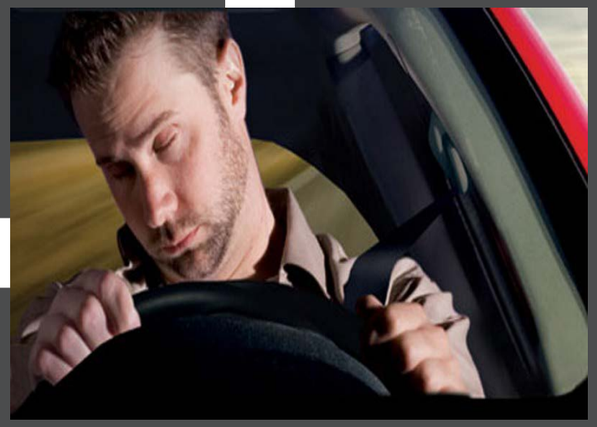
Sleep Loss	Tired during work hours	Commute back home	Asleep on wheels	
1	2	3	4	5
• Sleep interruption because of baby caring during night • Insufficient sleep	• Exhausted and sleepy • Wants some rest • Can't wait to go back home • Fears driving but that is the only option	• Riding home now • Tries to take the fast lane • Head starts nodding off • Can't think of anything except to reach home	• Taking a micro-nap on wheel!! • Almost had a near miss....Horrified, stops the car! • Waits a few minute • Considers coffee but don't want to get late	• Embarrassed on getting asleep while driving • Don't want to share this experience with family/-friend • Considers a new safer car but that is too expensive



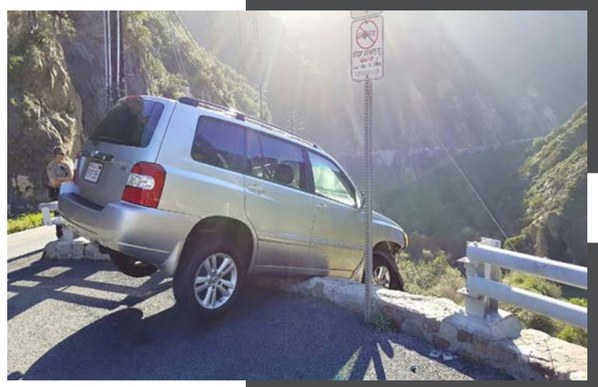
Mike is tired and sleep deprived

Time to go home

Drives well untill..



Started taking micro-naps on the wheel



An accident possibly

Car out of lane and control

Current User Scenario

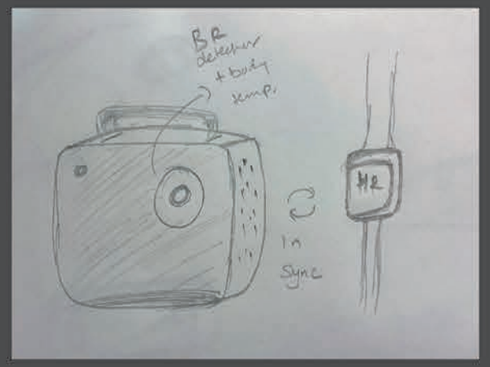
Pain Points and Insights from the user journey and storyboard

- The drive doesn’t know when or if they will engage in micro-naps.
- The monotonous ride causes sleepiness, also because the user is sleep deprived
- Even when they find themselves sleepy they are reluctant to stop if the destination is close
- The challenge is to stay awake throughout driving

Defining design requirements and product functions to address the issue

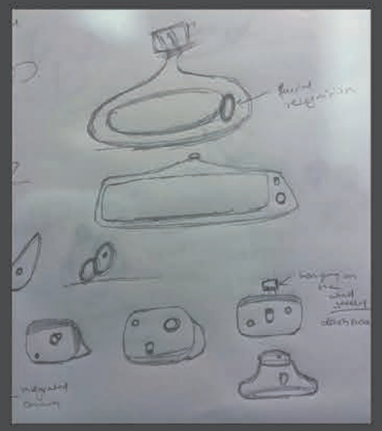
- Sleepiness detector using Blink Rate and Eye Closure
- Product should fit any car easily
- Provide stimulant to keep the driver alert (smell, music, a talk buddy etc.)
- A product that delivers driving confidence

Concept Ideation

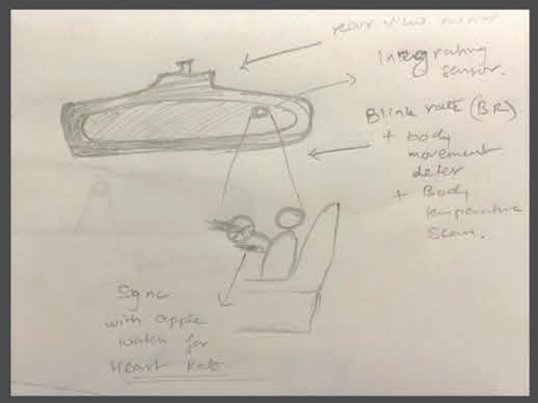


Drowsy detector with smart watch for alert using vibration

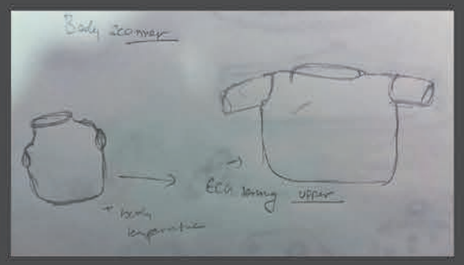
Drowsy detector on the steering wheel



Smell diffusers for stimulation with BR (blink rate) detector

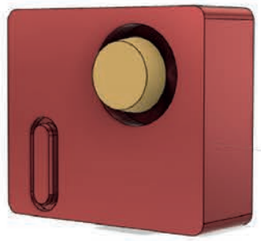


Drowsy detector on rear view mirror + sound alarm in context with the driver



Drowsy detector vest with a vibrational unit for alert

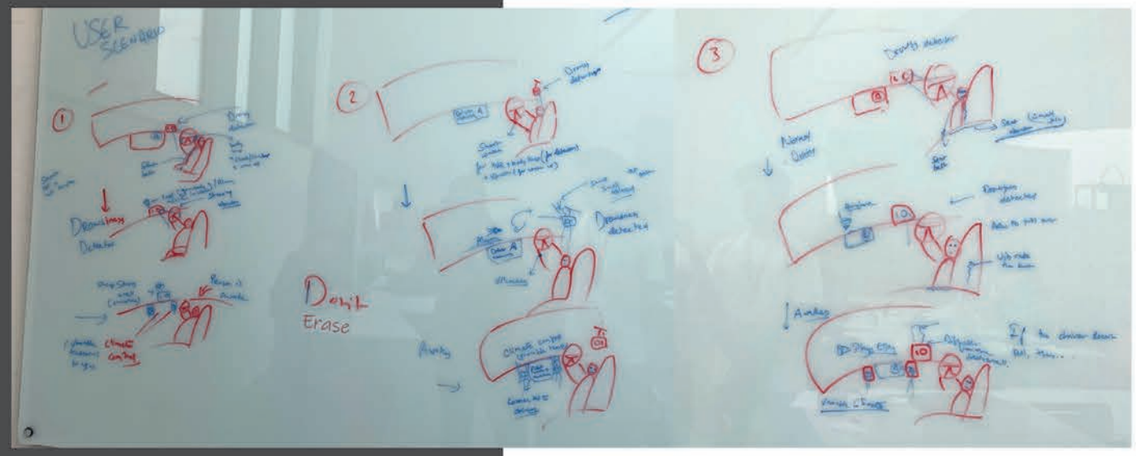
1. Sketches were drawn for discussing ideas



A drowsy detector that can be placed on the windshield

A vest with embedded ECG and vibration unit

Drowsy detector mounted on the rear view mirror



3. User scenarios were drawn based on different concepts to define how the product should work

2. Quick 3D sketches were made to visualize the ideas in context of a car

Concept Evaluation

Prototyping and testing an integrated steering wheel that contains the required features

Driver's were consulted again to evaluate the ideas from the user scenario and to identify any combination of sub solution they might prefer.

Upon discussion, steering wheel emerged as a potential solution since it can combine all the required functions.
However, after user testing the result was completely opposite. Many concerning facts emerged (more detailed provided in the journal) such as the position of the Air-bag and Camera. Also, how the oils would be refilled and concern with the oil leaking, and thus, reconsidered the ideas.

Prototyping and testing an integrated steering wheel that contains the required features

Examined the interior of a car for new retrofit-table device concepts. The windshield seemed to be a more appropriate position since some cars have a speaker system on the dashboard or a screen. Though, it will be tested again during the user testing of the new model.

Various retrofit-table models were designed using Autodesk Fusion 360 but only two final concepts were presented in the next page. And only one was selected for further development.

Prototyping and User Testing

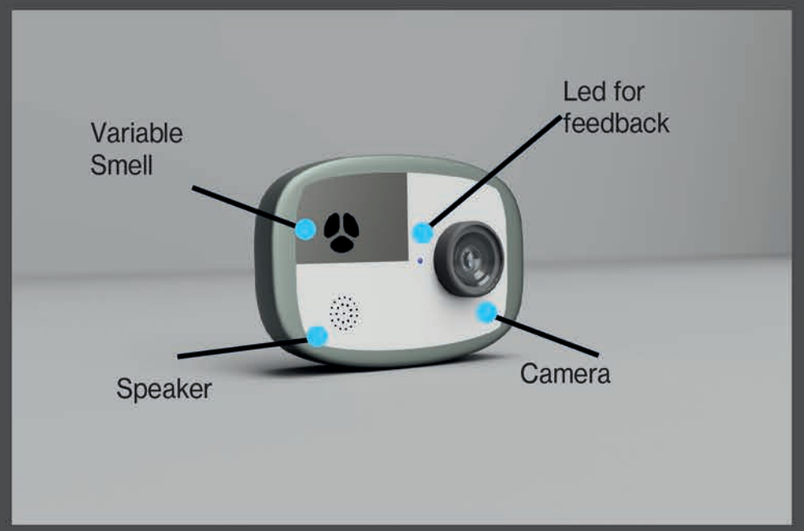
Final concepts

Option A; with a mount (common for both models) and uses a vibrational unit

3D printed option B

These final two concepts were discussed with peers and drivers to obtain their viewpoints. Some liked both the options but some liked option B more because it was less box like design and the front covers fewer visuals. However, they recommended changing the colour. Moreover, this is not an interactive device that the user will be holding or touching at any point except installation. Thus, it is justifiable to judge the product based on size and its appeal and function.

3D printed the 2nd option after discussions with the user group based on suitability of use and convenience. Follow next page for a brief discussion about the vibration and use of sound for alerting the driver.



Option B; uses sound to alert the driver

Comparison of peppermint oil and Ambipure room freshener

User Testing for smell effectiveness

The smell of peppermint (the green small bottle) is strong and uplifting but is not intense from a distance. While the Abmipure on the right picture, is more effective at a short distance as it is uses a heating coil. In addition, the desired effect is a more intense smell so that driver stays alert during his drive time. Thus, heating vaporisation is preferred over natural vaporisation to activate the oils.

Testing the position for the device

The size of the product is validated by the users in context of use with in a car (only one user is shown here). The product does not hinder their field of view. Also, the “position 1” (upper left corner) of the device is best suited for all the tested users. It is because of the eye height level and the fact that the product can be able to detect user movement since it is placed near the rear-view mirror. As the driver frequently needs to check the rear-view mirror.

“Human factors considered: different position of the device within the car was tested to find the optimal position.”

Test for vibration was also performed but it is not shown in here as there were some flaws with using that concept, however, on initial tests that seems to be working but after attaching it on the steering wheel users gave unexpected reviews thus changed to the sound model. The main problem was many users were not willing to stick a foreign item on the steering wheel and due to the fact its vibration may initiate the air-bag or might confuse the user with systems inherent feedback was the concern.

A detailed discussion is available in the design journal.

Note: After having concerns about the effectiveness of the vibration, a quick brainstorming was conducted with the test users. And the sound came as the best alternative, we then tried to simulate the experience of sound vs vibration in a controlled settings using an iPhone. Indeed users reported that the gradually increasing sound is much more effective than the use of vibration. In addition, it would not be required to attach to the steering wheel as well.

“Pictures were not taken of this experimentation”

User Journey

1. Chen is visiting a distant city

2. Long monotonous ride

3. She is sleepy, taking a micro-nap

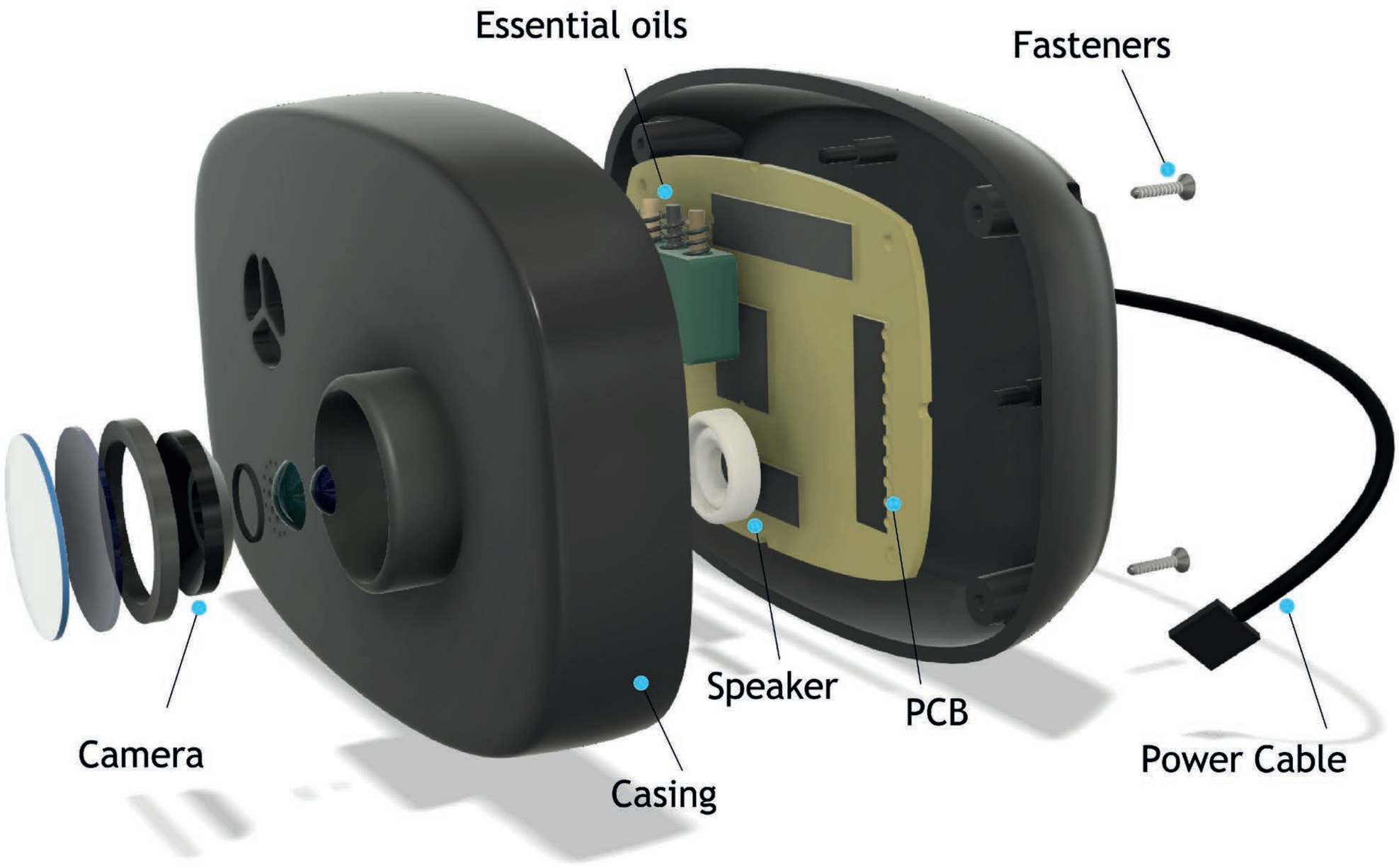
4. Drowsiness detected: the device alerts Chen using an alarm

5. Essential oil is released to keep her awake with variable stimulating smells

6. Chen now safely finds a place to rest

Product in Context of Use

Exploded view



References

[1] What Causes Excessive Sleepiness? | Sleep Foundation

[2] Walker, Matthew, Why We Sleep : the New Science of Sleep and Dreams (Penguin, 2018)

[3] Causes of Excessive Sleepiness: Sleep Apnea, Narcolepsy, RLS (webmd.com)

[4] Microsleep: Symptoms, Causes, and Safety Risks | Sleep Foundation

[5] MAYCOCK, G. (1996), Sleepiness and driving: the experience of UK car drivers. Journal of Sleep Research, 5: 229-231. https://doi.org/10.1111/j.1365-2869.1996.00229.x

[6] https://www.coursera.org/learn/sleep/lecture/tTQMA/12-03-how-many-people-in-our-society-are-sleepy

[7] Driver drowsiness detection - Wikipedia

[8] Freedman, N.S. (2007). Determinants and Measurements of Daytime Sleepiness. In: Pagel, J.F., Pandi-Perumal, S.R. (eds) Primary Care Sleep Medicine. Current Clinical Practice. Humana Press. https://doi.org/10.1007/978-1-59745-421-6_6

[9] Cluydts R, De Valck E, Verstraeten E, Theys P. Daytime sleepiness and its evaluation. Sleep Med Rev. 2002 Apr;6(2):83-96. doi: 10.1053/smrv.2002.0191. PMID: 12531145.

[10] 12.02 - How is Sleepiness Measured? - Unit 12 - Society: Daytime Sleepiness and Sleep Need - Thomas Roth, Ph.D. (Standard Track) | Coursera

[11] T. Danisman, I. M. Bilasco, C. Djeraba and N. Ihaddadene, "Drowsy driver detection system using eye blink patterns," 2010 International Conference on Machine and Web Intelligence, 2010, pp. 230-233, doi: 10.1109/ICMWI.2010.5648121

Note: All the used references is not provided here, most of the technical and detailed references are available in the technical report of the project.