Vision Goggle

Eye Care Product Concept Design For Computer Vision Syndrome

Degree project
Master of Industrial Design
Yongdong Long
Lund University
2020

LUND UNIVERSITY

Thanks to

Anders Warell

Claus-Christian Eckhardt

David Lightman
(Retinal surgeon, USA)

Hillevi Hemphälä
(Optometrist, PhD Visual Ergonomics BSc Optometry, Lund University)

All instructors in the workshop
And all the private contributors involved in this project.

Vision Goggle

Eye Care Product Concept Design For Computer Vision Syndrome

by Yongdong Long

Degree Project for Master of Fine Arts in Design
Main Field of Study Industrial Design
from Lund University, School of Industrial Design
Department of Design Sciences

Supervisor
Professor Anders Warell
Examiner
Professor Claus-Christian Eckhardt

Year 2020
ISRN: LUT-DVIDE/ EX--20/50492-SE

LUND
UNIVERSITY

Abstract

Vision Goggle is a concept smart eyewear that can remind user to use their eyes reasonably by detecting real-time eye condition.

This project is aimed at people's eye discomfort caused by prolonged computer use, especially for the user who spend more than 2 hours a day on computers. The symptoms caused by long screen time are referred to as Computer Vision Syndrome (CVS), and the two most common ones are dry eyes and eye strain. With further literature review and consultation with experts, the principles behind these two symptoms became clear. Then, I designed Vision Goggle as a smart eyewear to perceive the eye condition in real time and remind user to use their eyes reasonably, hoping to prevent eye discomfort through early means.

Vision Goggle can monitor the user's eye blink status, screen distance and gaze time, and remind the user in real time through different vibration feedback, whether to blink eyes (keep the eyes moist), or keep an appropriate screen distance, or take enough breaks, etc. Vision Goggle integrates miniature sensors in a stylish form, and its natural interaction makes it easy to use in work scenarios. This product at this stage is a concept design, I hope it will bring people's awareness of eye health and also bring inspiration to other designers.

Key Words:
Computer Vision Syndrome, screen time, eye strain, dry eyes, vision goggle

Contents

INTRODUCTION

RESEARCH

IDEATION & DESIGN

PROTOTYPING

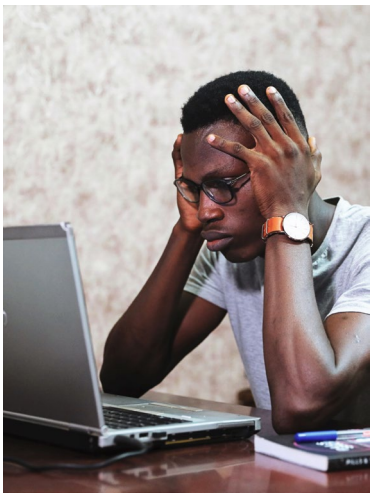
REFLECTIONS

REFERENCE

Introduction

Increasing Usage of computer

With the maturity of computer technology and the rapid development of the Internet, more and more people start to use computers. People use computers to study, work, recreate, socialize, and even do shopping and travelling. Computers have become one of the increasingly indispensable electronic devices. Of course, this is not limited to desktop computers or laptops, but also includes tablets, mobile phones, etc., but desktop computers and laptops are the main targets here. In fact, the average daily duration of people using computers is also increasing nowadays. Not only that, the age of computer users is also becoming younger and more childlike.



This is unprecedented, hence with prolonged use of digital screens, more and more people are experiencing different degrees of physical discomfort, of course, the main object here is eye discomfort. As a designer, I also always spend quite a lot time in front of computer screen, which really cause lots of issue with my eyes, I hope through this project we can have a profound understanding of what we are experiencing and devise something inspiring.

Computer Vision Syndrome

Basically, when people spend prolonged periods in front of digital screen, there are quite a lot problems related to eye and vision occurring, which are grouped together and so called Computer Vision Syndrome, or CVS, also referred to as Digital Eye Strain. It is a repetitive strain disorder defined by the American Optometric Association as the combination of eye and vision problems associated with the use of computers.

Computer Vision Syndrome (CVS) has become the number one occupational hazard of the 21st century, according to Torrey(2003) and Graney(2011) as cited in Akinbinu and Mashalla (2014).

The symptoms of CVS are summarized in the table below which is primarily based on the table arranged by Clayton Blehm (2005) in his research, as I added few symptoms that's been missing, such as headache, redness, and dark circle, and I also put eye-strain, tired eyes, eye fatigue into one place since they are basically the same meaning with different names.

This table would give a really clear view upon what CVS is, and the explanation of unfamiliar symptoms will be given in research part.

Table 1- Symptoms in Computer Vision Syndrome from Blehm et al., revised

Symptom Category	Symptoms
Asthenopic	Eye strain/Tired eyes/Eye fatigue
	Sore eyes
Ocular surface-related	Dry eyes
	Red eyes
	Watery eyes
	Irritated eyes
	Contact lens problems
Visual	Blurred vision
	Slowness of focus change
	Double vision
	Presbyopia
Extraocular	Headache
	Dark circle
	Neck pain
	Back pain
	Shoulder pain

Research

Targeting Symptoms

Asthenopic (Amblyopic) symptoms

Eyestrain or asthenopia is an ophthalmological condition that presents with nonspecific symptoms such as fatigue, pain in or around the eyes that are caused by reading or looking at a computer screen for too long (Gowrisankaran et al., 2012). The American Heritage Dictionary defines eyestrain as pain and fatigue of the eyes, often accompanied by headache, resulting from prolonged use of eyes, uncorrected defects of vision, or an imbalance of the eye muscles (The American Heritage Dictionary of the English Language, 2009)

Dry eyes

The dry eye in CVS is different from the dry eye syndrome commonly seen in elderly persons (Akinbinu & Mashalla, 2014). Dry eye may be a primary cause of ocular fatigue due to the decrease of blink rate when staring at digital screen, which is correlated with what I found in the first stage. Also several other factors contribute to the drying of the ocular surface besides reduced blink rate, such as dry air environment, increased surface area of eye exposed to the effects of evaporation, elder age, related systemic diseases, contact lens usage, localized dysfunction of the glands and cosmetics (Blehm et al., 2005). Students wearing contact lenses were 40.8% likely to develop dry eyes as compared to 22.3% of the non-contact lenses wearers (Logaraj et al., 2014).

Watery eye

Watery eye is due to so called reflex tears which actually does not help with ocular dryness, so dry eyes just keep produce more reflex tears, ending up with watery eyes (Akinbinu & Mashalla, 2014).

Blurred vision

The Online Medical Dictionary defines blurred vision as indistinct, fuzzy visual images or a lack of sharpness of vision resulting in the inability to see fine detail (Akinbinu & Mashalla, 2014).

Double vision

Double vision (diplopia) indicates weakness of one or more extra ocular muscles and several causes, which can occur monocularly or binocularly. Monocular diplopia happens when the unaffected eye is covered. Patients with monocular diplopia can see two slightly separated images where the extra image may be seen as a ghost image. Diplopia in CVS is likely to be attributed with extraocular muscles fatigue resulting from glaring on digital screen (Akinbinu & Mashalla, 2014).

Red eyes

Red eyes (or red eye) is a condition where the white of the eye (the sclera) has become reddened or "bloodshot." Red eyes can be caused by several different factors other than CVS, so if red eyes keep existing after enough time of relax, it would be better to go to see a doctor to see if it is caused by any other disease (Heiting, 2019).

Dark circle

Dark circles sit under the lower eyelids, which looks darker than other area of face skin. Dark circles make people look older and can be difficult to get rid of. Many factors can contribute to the form of dark circles and lack of relax and eye strain are among them, according to Anthony (2018).

The methodologies I used for research in this project were literature review and interviewing experts. The reason I chose literature review was because the question here involved a huge amount of people, basically other researchers would take it alone as a thesis study. It would be pointless for me to conduct a small quantitative research and have conclusions on that. In terms of interview, it will be valuable to hear from experts, and actually it was more of a consultation since I know very little about the topic, so I wrote emails instead of having a face-to-face meeting, which I think was less stressful and more effective.

What are the main symptoms people experience?

- First of all, some researches find that headaches are the most reported symptoms, however in this project I primarily looked at eye related symptoms rather than other types of symptoms.
- However, the major contributor to computer vision syndrome symptoms by far appears to be dry eye. (Blehm et al., 2005)
- According to American Optometric Association (n.d.), the most common symptoms associated with Computer Vision Syndrome (CVS) or Digital Eye are, eyestrain, headaches, blurred vision, dry eyes, neck and shoulder pain.
- A cross-sectional study done in United States in which three hundred and five (305) random undergraduate students were selected shows that 90.5% in total are positive to CVS, and headache showed 53.4%, dry eyes 24.6%, watering eye 49.2%, redness of eyes 44.9%, eye tiredness 60.7%, itching 34.8%, blurring of vision 34.4% and burning sensation 44.6%. (Hassan, Kashifq, Masud, Raza, 2017)
- Another cross-sectional study conducted at King Saud University obtained a sample size of 706, showing one of the most common ocular symptoms is dry eyes with a prevalence of 51.5% (mild, moderate, and severe), also burning eye sensation is reported most. Table 2 below is one of their findings (Layan, Sara, Leena, Tala, Siham, Shaik, 2018) .

Table 2. Prevalence of self-reported CVS symptoms.

CVS symptoms	No symptom, N (%)	Mild symptom, N (%)	Moderate symptom, N (%)	Severe symptom, N (%)	Total
Headache	239 (33.5)	300 (42.1)	157 (22.0	17 (2.4)	713
Burning eye sensation	297 (41.7)	260 (36.5)	136 (19.1)	20 (2.8)	713
Eye redness	422 (59.2)	194 (27.2)	87 (12.2)	10 (1.4)	713
Blurred vision	395 (55.4)	216 (30.3)	82 (11.5)	20 (2.8)	713
Dry eyes	346 (48.5)	194 (27.2)	133 (18.7)	40 (5.6)	713
Neck and shoulder pain	127 (17.8)	248 (34.8)	254 (35.6)	84 (11.8)	713

- There is confusion among study population when reporting on eye strain because in some cases eyestrain is reported as burning sensation (Akinbinu & Mashalla, 2014), so basically we can take burning eye sensation as similar to eye strain.
- According to Harvard Health Publishing (2017), eyestrain is another major problem people come across when it comes to staring at screen.
- In another study among undergraduate dentistry students, dry eye (reported by 64.52%) and eye strain (reported by 67.74%) were two of the most common signs next to headache and neck pain (Adrian et al., 2019).

EYE STRAIN

≈Asthenopia
≈Tired eyes
≈Eye fatigue

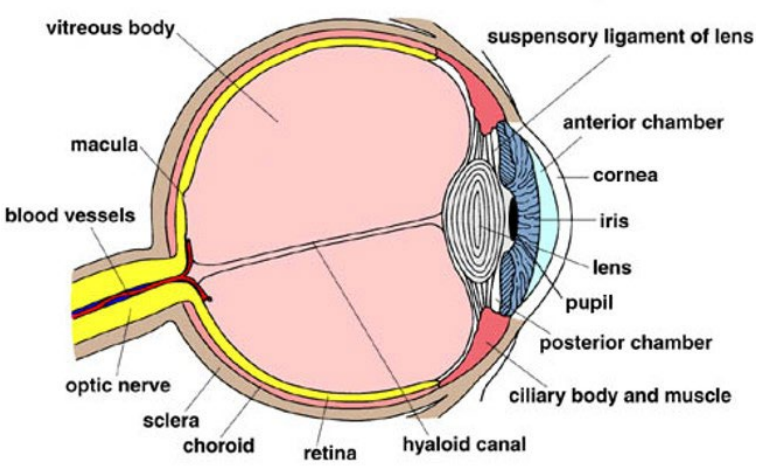
&

DRY EYES

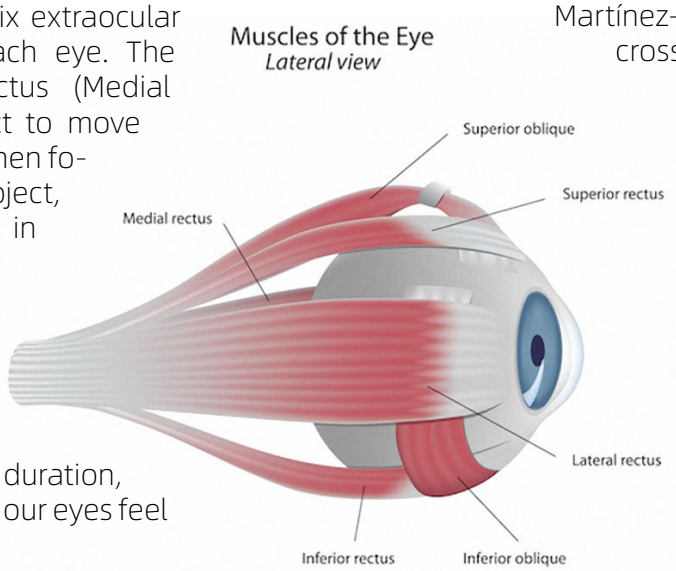
Eye Strain

Literature Review

Eye strain can be triggered by different things. First of all, when people conduct extended near work (at a close distance), the ciliary body is forced to contract overtime. The ciliary body is the focusing muscle that allows us to focus on near objects. When you stare at a near object, that muscle contracts and allows the lens to get thicker and increase the total power of the eye. Extended periods of contracting lead to fatigue of the ciliary body, which is basically why we have tired eyes.



Besides ciliary body fatigue, there is also extraocular muscle fatigue, which is another set of muscles that contract when doing near work (Can be found in the picture below). There are six extraocular muscles around each eye. The two horizontal rectus (Medial Rectus) will contract to move the eyes inwardly when focusing on a near object, to keep the image in focus and to prevent you from seeing double. Similarly, when those muscles contract for long duration, they get fatigue and our eyes feel strained.



Also, according to Mutti and Zadnik (1996). Accommodative effort during near work is thought to be a causative factor in the development of myopia (near-sightedness), which means prolonged work periods at a digital screen will cause eye fatigue which is further causative for myopia, or at least transient myopia. There is a cohort study in Spain which could probably be the first large longitudinal assessment in young adults showing that exposure to digital screen is associated with myopia (Fernández-Montero, Olmo-Jimenez, Olmo, Bes-Rastrollo, Moreno-Galarraga, Moreno-Montañés, & Martínez-González, 2015). In another cross-sectional study, VDT (Visual Display Terminals) users experienced a myopic shift of about −0.12 D after the work period compared with no change of refractive error of typists (Saito et al., 1994). Transient myopia was reported by Luberto et al. in 20% of VDT workers at the end of their work shift (Luberto et al., 1989).

Asthenopic symptoms do not refer to myopia, since usually, prolonged close-up working will cause myopia, but the distance from eyes to the screen may not be close enough, or as close as reading books and writing, but prolonged screen time does cause visual fatigue, which further increase the risk of myopia development or progression (Fernández-Montero et al., 2015).

Expert's Word

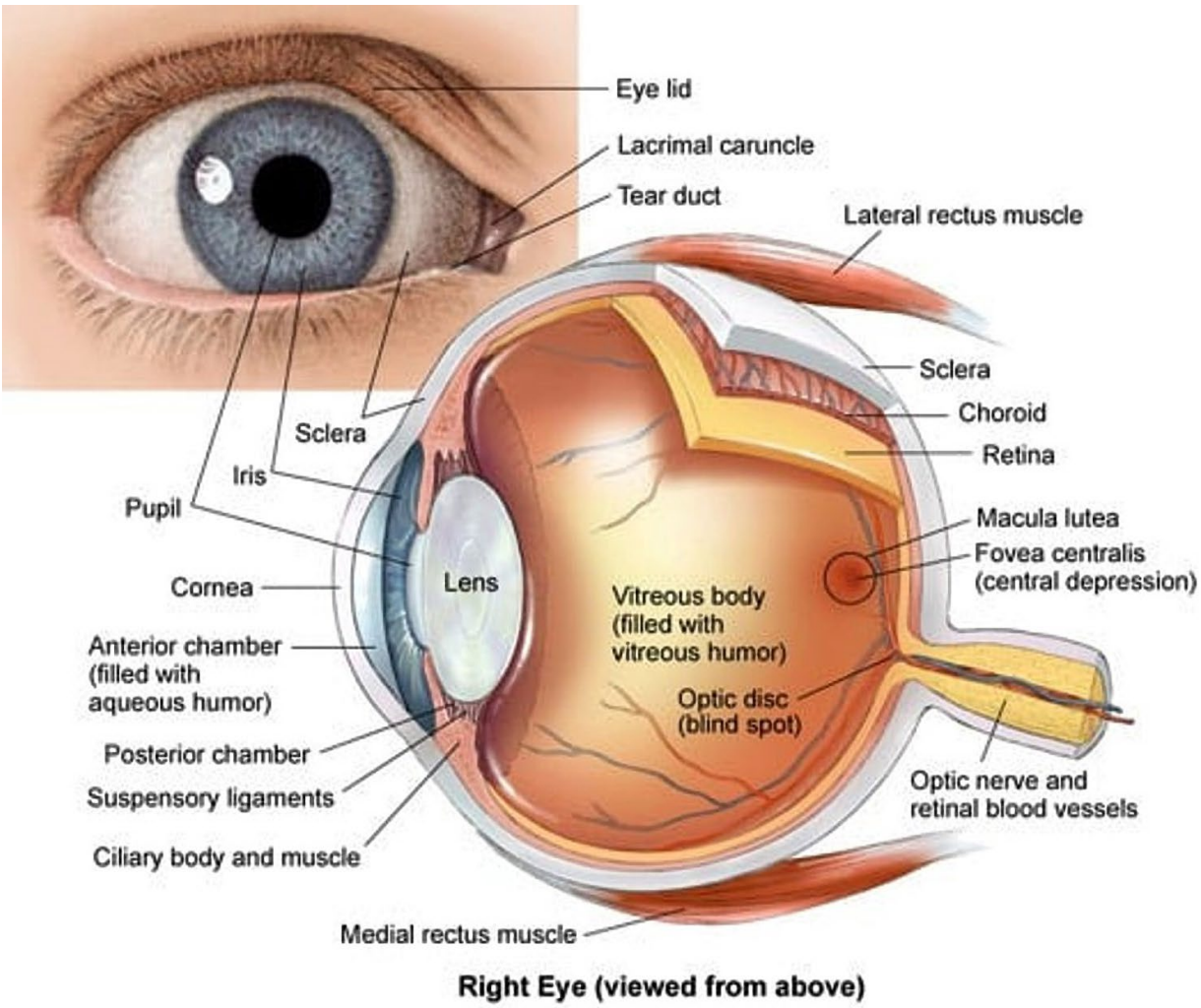
about Eye strain

The normal human lens (the crystalline lens) is responsible for focusing for near tasks like reading or looking at computer screens. When we look at something up close we initiate the accommodative reflex. The eyes turn inward, the pupil constricts, and the ciliary body contracts which makes the crystalline lens more powerful. The closer the near object of attention, the more we have to focus our lens.

If we are staring at a computer screen for a long period of time, our ciliary muscles are in a constant state of contraction which can make our eyes tired. Also, when we glance away from the screen, it may take a moment for our ciliary muscles to relax to focus at distance.

If someone spends a lot of time staring at a computer screen, he or she might want to invest in a pair of computer glasses specifically powered for the distance of their computer screen. The number of diopters of reading add depends on the focal distance of the screen. The formula is D = 1/f where D is diopters and f is the focal distance. So if the screen is 60 cm from the eye (0.6 m), one would need 1/0.6 or about +1.5 diopter reading glass.

——David A. Lightman (Retinal surgeon, USA)



Right Eye (viewed from above)

Dry Eyes

Literature Review

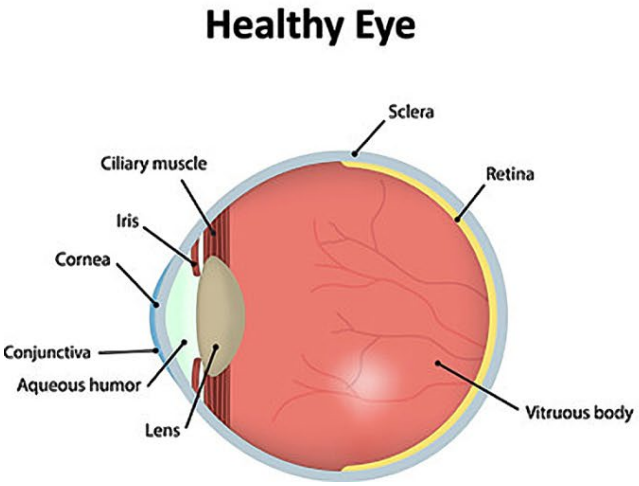
Dry eye may be a primary cause of ocular fatigue due to the decrease of blink rate when staring at digital screen. According to the American Academy of Ophthalmology (AAO) , staring at a screen automatically reduces the frequency of a person blinking eyes and can also result in incomplete blinks. Research shows that people blink an average of 14 times per minute under normal circumstances, but only one-third or one-half as often while staring at a screen. Dryness depletes what's called the tear film — the protective layer of moisture and oil that sits on top of the cornea. This, in turn, leads to dry spots on the surface of the eye which can cause irritation and even fluctuations in vision. When the tear film is depleted and you do blink, there's a potential that the friction on the eye's surface will create inflammation (Wisniewski, 2019).

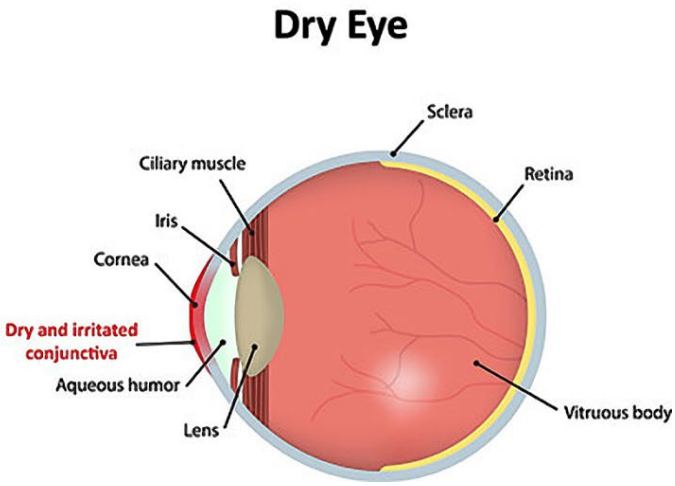
Normal blink rate is about 16-18 times per minute. Studies show that blink rate decreases to as low as 6-8 blinks per minute (about 1/3rd the normal rate). (Hassan, Kashifq, Masud, Raza, 2017) Diseases that widen the interpalpebral fissures or lid retraction, such as thyroid disease may lead to increased tear evaporation, thereby worsening dry eye symptoms (Izquierdo, García, Buxó, Izquierdo, 2007) .

Dryness that accompanies screen use can even change the chemical structure of tears. When people blink less, the moisture in tear film evaporates, leaving behind salt — a phenomenon called hyperosmolarity. The combination of less lubricant and high salt content leads to more inflammation, which in turn can clog the oil glands that prevent tears from evaporating in the first place, so this is totally a vicious cycle.

Also several other factors contribute to the drying of the ocular surface besides reduced blink rate, such as dry air environment, increased surface area of eye exposed to the effects of evaporation, elder age, related systemic diseases, contact lens usage, localized dysfunction of the glands and cosmetics (Blehm et al., 2005).

Another possible cause of dry eyes is the brightness or glare that comes from the electronic screen, especially if people have cataracts.





Expert's Word

about Dry eyes

I think the reason they have symptoms of dry eyes is because they are so engaged in their work or video games they forget to blink. Blinking is extremely important in uniformly spreading the natural tears across the cornea by the action of the lids. If one forgets to blink, the tear film evaporates, the cornea gets dry, and the surface becomes irregular. The irregular corneal surface blurs the vision (like smearing vaseline on your glasses) and also irritates the very sensitive corneal nerve endings resulting in ocular irritation (redness and burning).

Keep in mind the best lubricant for the eyes are our own natural tears.

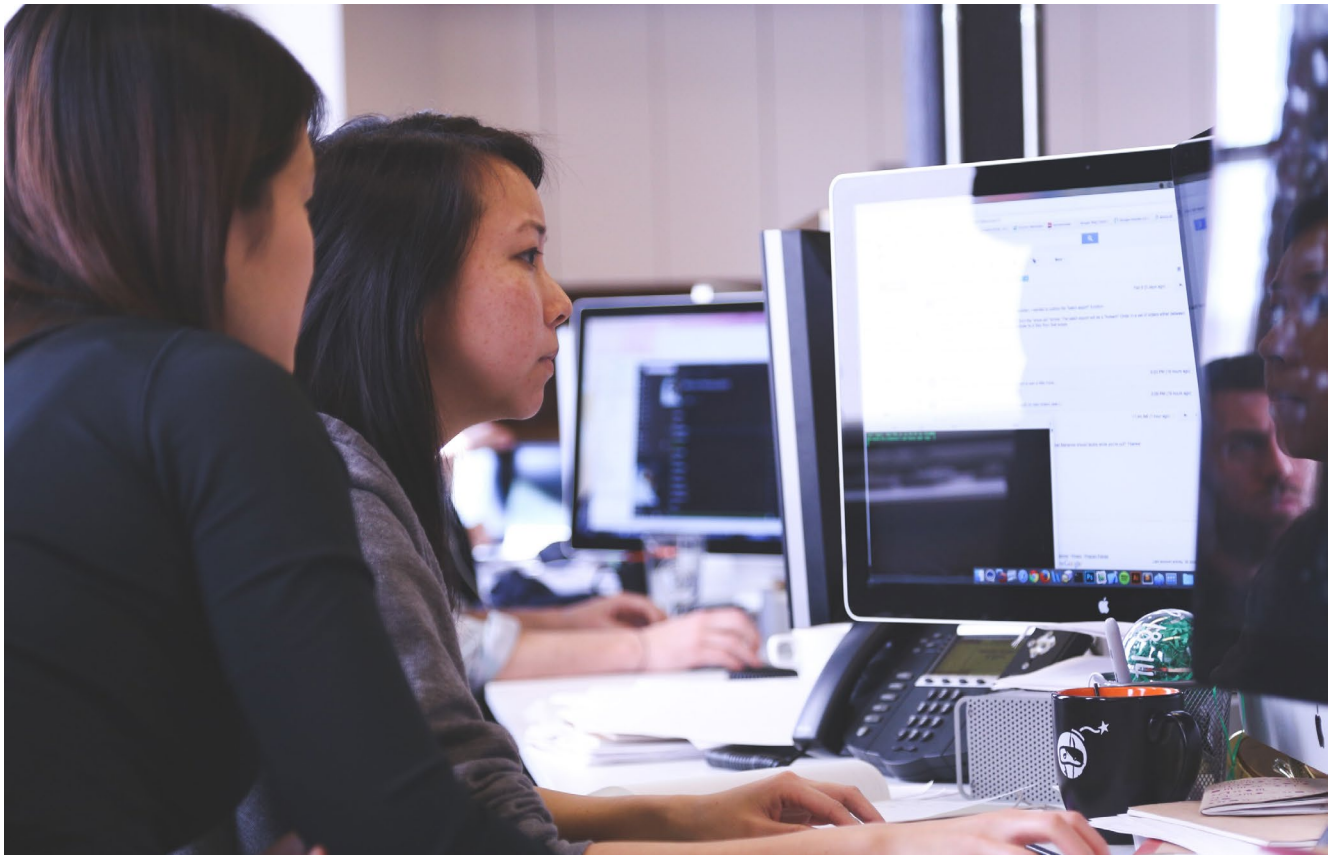
——David A. Lightman (Retinal surgeon, USA)

Dry eyes is usually caused by the blink rate being reduced while performing visually demanding work.

When you are doing visually demanding work by a computer screen that is mounted too high, your eyes are too open, and cannot cope with the reduced blink rate. It can also be caused by glare.

Especially when you have problems with the tear film, and clogged Meibomian glands. Then the steam mask helps to soften the clogged up Meibomian glands and improve the tear film.

——Hillevi Hemphälä (Optometrist, PhD Visual Ergonomics BSc Optometry, Lund University)



Target People

Literature Review

- CVS is regarded to affect all populations with broad access to digital display devices with different intensity levels. Due to the increase of computer use in our daily life the syndrome is at risk of becoming a major public health issue.
- Previous studies have estimated that the prevalence of CVS rangers between 64 to 90% among computer users (Hayes et al., 2007).
- About 70% of computer workers worldwide report having vision problems and there is an alarming increases in the number of people affected (Blehm et al., 2005).
- Studies among students have shown that the prevalence of CVS among engineering students was 81.9% as compared to 78.6% among medical students. This study also showed that a significantly higher proportion of engineering students (40%) used computers for between four and six hours per day as compared to 10% of the medical students, and this was why the students of computer engineering and technology had higher risk of developing CVS. It was concluded that students who used the computer continuously for more hours showed a greater number of symptoms of CVS, in comparison with students who spent less hours and took frequent breaks. Especially noteworthy was the observation that permanent damage was being caused to the eyes of students in extreme cases of excessive computer usage (Logaraj et al., 2014).
- In Malaysia, CVS prevalence reported among university staff was 68.1% (Rahman and Sanip, 2011).
- Keyboard users are equally affected, 59.5% prevalence of CVS was reported among keyboard users in Mauritius (Subratty and Korumtolee, 2005).
- Iwakiri et al.(2004) reported 72.1% CVS prevalence among office workers in Japan.
- The study group consisted of students of the first year of dentistry. Almost half (45,16%) declare, that their computer use do not exceed 2hr per day, but over 70% of respondents suffer from vision defect. Most use the computer in the range of: games/films, social media, study. (Adrian et al., 2019).
- A cross-sectional study conducted in the Khyber Medical University Peshawar at the Institute of Paramedics, Institute of Nursing and Institute of Physiotherapy in which amongst 305 who participated (65.8%) were male and 54.1% youngsters (18-24 years old). As a result, 90.5% of the participants were CVS positive (Hassan et al., 2017).
- Another cross-sectional study was conducted among female undergraduate medical and business students at King Saud University, Riyadh with a sample size of 706. Half of them suffered from dry eyes and nearly half of them showed burning eye sensation, which is one of asthenopic symptoms. Business students were 1.6 times as likely as medical students to suffer from computer vision syndrome (Layan et al, 2018).

Conclusions

1. Who has CVS symptoms ?

From the literature I studied, large proportion of engineering students, medical students, business students; University staff, keyboard users, office workers has CVS symptoms, in fact that most computer users have CVS symptoms to a certain point.

2. What is the proportion of positive CVS patients ?

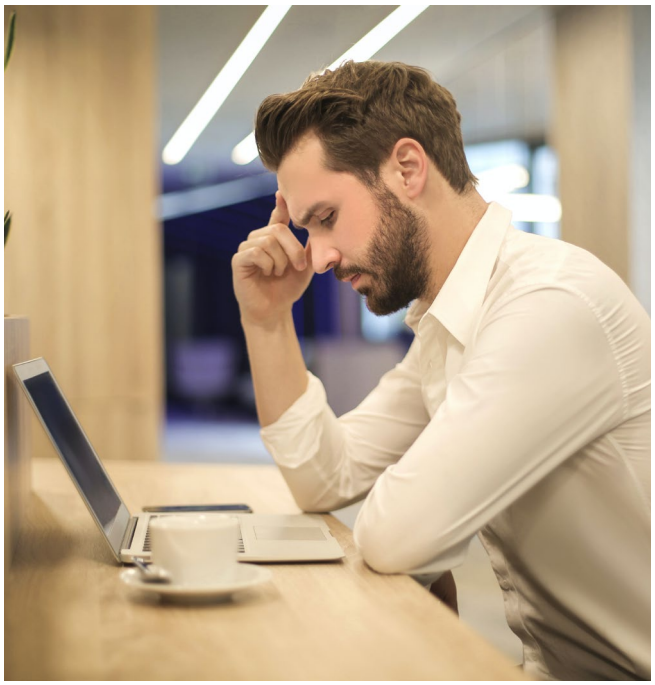
Up to 90% among all computer users has CVS symptoms to some degree.

3. Who are prone to CVS ?

People who spend more than 2 hours a day on average are prone to CVS symptoms, and the longer the worse, also less breaks the worse. People who do not have time to take care of themselves throughout the day when work with computer.
Gender does not matter, age does not matter, region does not matter.

4. What are my target user groups ?

From what we can assume that designer, engineer, software developer, programmer, office workers who are prone to CVS are my targets people; Professionals who use screen basically more than 2 hours a day for either studying or working, or entertainment (non-esports).
People who have a personal consumption level from medium to high and premium level as I prefer to design high quality products.
Not for people who have systemic or ocular disease, such as clogged Meibomian glands.



Personas

Name: Howard
Age: 25-45
Gender: M
Relationship Status: Single
Major: Electrical Engineer
Career Type: Employed
Career Stage: Professional level
Income Range: $40k-$100k / Year
Tag: PC gamer, medium to high level consumer

Experience: Very concentrated when working, play some first person view 3A games during free time. Usually work in the office, sometimes at home. Sometimes have irregular routine when work a lot, want to have good sleep everyday. Usually have CVS symptoms such as dry eyes and sore eyes.

Name: Jennifer
Age: 25-30
Gender: F
Relationship Status: Single
Major: Product and Service Designer
Career Type: Freelancer
Career Stage: Professional level
Income Range: $30k-$70k / Year
Tag: Photography enthusiast, high level consumer

Experience: Very concentrated on working, usually work at home, occasionally work in the public places like Café and library, and usually stay in front of computer throughout a day. Have bad sleep once in a while. Usually have CVS symptoms such as red eyes and sore eyes.

The personas here come from two of my friends I referenced.

Current Market

Category: Steam Mask

Single-use disposable steam eye mask

This type of eye mask is super light weight and convenient to use, the user only needs to take it out from the package and put it on the face, then the chemical reaction will start and generate heat to help improve blood circulation around the eyes. However, it won't be economical if you want to use them regularly.

USB powered hot compression eye mask

This type of eye mask is very light and soft, usually very thin too, since it does not have any battery inside, thus a power bank or charger is needed. Tethered style maybe inconvenient sometimes. It generates heat to improve blood circulation around the eyes, and compared to disposable eye mask, it could be more cost-effective.

USB powered hot steam eye mask

This type of steam eye mask is also very light, since it is USB powered, too. User is supposed to spray some water inside the eye mask, and then turn and wear it, the it will heat up and create a warm humid area to help with dry eyes as well as improving blood circulation.

Multi-purpose Steam Console

This type of steam mask has similar principle to the steam eye mask, but serves more function for different purposes. It usually uses a PTC heating chip to heat up water with a constant temperature to create water steam for soothing either face or eyes. Some uses ultrasonic vibrator to create water steam. It is a console style that can stand on table or be held when using.

Current Market

Cool/Warm Water-propelled Eye Massager

The world's first water propelled eye massager that can conduct both cool and warm compression. The cool compress helps to relieve the strains in eyes and alleviate conditions associated with inflammation. The warm compress can help with dry eyes and improve blood circulation. Claimed to be very comfortable, but separated water tank and pump makes it not so convenient in some cases. IF design award 2016 winner.

Air pressure hot compression eye massager

Breo iSee M, an air pressure eye massager with battery inside, there are 3 options of air pressure modes along with adjustable duration and temperature settings, allowing you to customize your own massage experience. Fabric covered body makes it feel comfortable and of high quality. Foldable design. IF design award 2019 winner.

Category: Eye Massager

Air pressure hot compression eye massager

Breo iSee4, an air pressure eye massager with battery inside, 3 modes of air pressure massage and heat compression, with good ergonomic design that fits both men and women alike. Ultra-soft hypoallergenic cover fabric construction provides ultimate comfort. Featured with a seamlessly integrated OLED display. Foldable design. IF design award 2014 winner.

Air pressure hot compression eye massager

RENPHO, an air pressure eye massager with heat compression, vibration and Bluetooth connectivity. 5 Modes of pressure massage for different situations. Built-in speakers with the recorded natural melodies that relieve you during relaxation. Foldable design.

Current Market

Air pressure hot compression eye massager

SKANDAS eye massager, 2020 model, an air pressure eye massager with heat compression, point massage, vibration. 4 types of pressure massage for different situations. 2 Built-in speakers provide a relaxing musical facial massage with your own songs. Foldable design. Can be used as power supply.

Magnetic vibration eye massager

This magnetic vibration acupoints eye massager has 22 finger shaped massage contacts (made of high-purity silicone), with highly effective medical health stone producing good magnetic flux, which can activate the magnetic field of human body and restore healthy power. Not easy to clean.

Category: Eye Massager

Detachable hot compression eye massager

SKG 4301, a hot compression eye acupoints massager, capable of 3 massager modes and music playing, featured with a detachable silica gel massage head, which is very convenient for cleaning after use.

Cool/Warm handheld Eye Massager

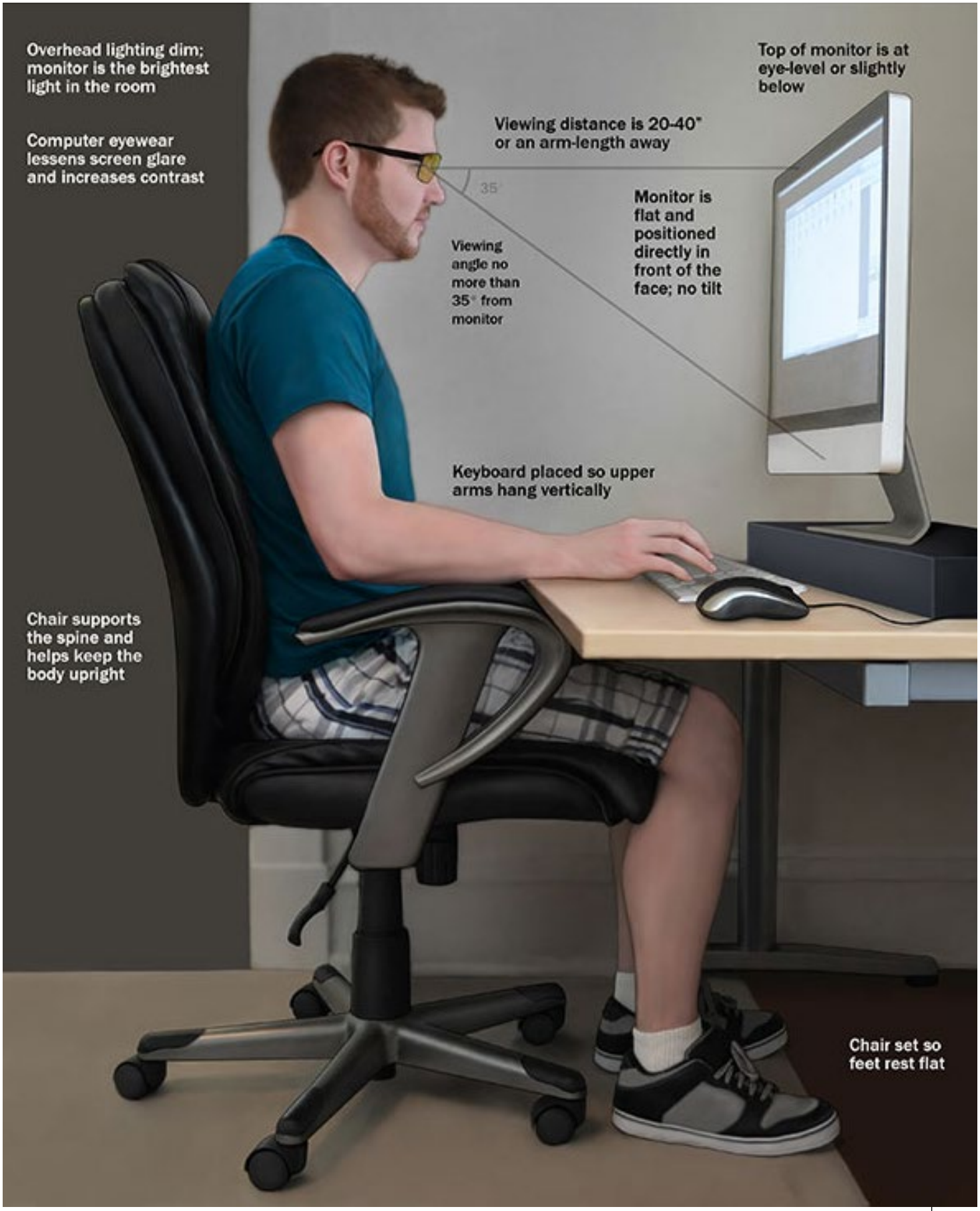
LEFAN, a hand-held eye massager that provide both hot and cool compression for either removing eye fatigue or decreasing edemas. On the back side of the massager, there is a silicone pad for a conventional vibration massage. It is lightweight and portable with one single button for easy control. But you need to hold it all the time while using.

Ideation & Design

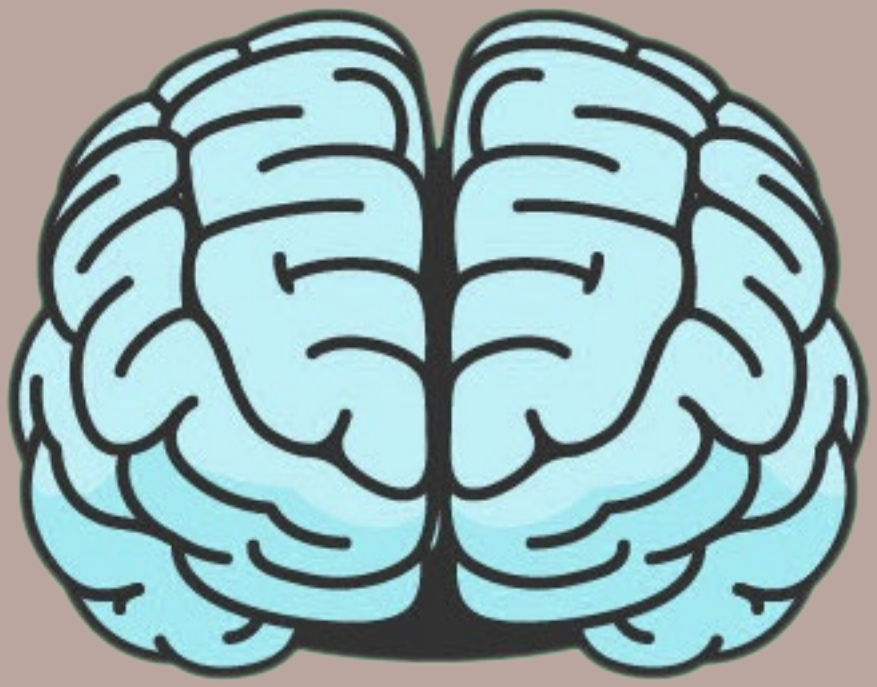
Suggestions

If there is something that people know, but not doing, or forget to do, that is this

- Variation in posture while sitting behind the computers can improve the symptoms associated with CVS.
- Frequent breaks with computer use have been shown to increase comfort and relax the accommodative system. Taking a smaller break for 5-10 min more frequently is better than taking a longer break every 2 or 3 hours. A 10-15 min break from the computer is recommended for every continuous 1-2 hours of computer use but is supported by limited evidence.
- Frequent breaks and looking at a distant object away from the computer terminal at least twice an hour was sufficient to prevent CVS symptoms (Cheu, 1998).
- Follow the 20-20-20 rule: take a 20-second break to view something 20 feet away every 20 minutes.
- Researchers have recommended a viewing distance between 30 and 70 cm as measure to reduce visual symptom (Bhandeni et., 2008; Chiemeke et al., 2007; Taptagapoorn et al., 1995).
- The digital screen should be placed at 50 to 60 cm away from the eyes, and the top of it should never be above the eye line; Optimally, the computer screen should be 15 to 20 degrees below eye level (about 4 or 5 inches) as measured from the center of the screen and 20 to 28 inches from the eyes.
- The room where the computer is should be well illuminated. Incandescent light should be preferred to other types of lighting;
- Avoid glare, particularly from overhead lighting or windows, If there is no way to minimize glare from light sources, consider using a screen glare filter. These filters decrease the amount of light reflected from the screen.
- Blink the eyes frequently. Normal blink rate is 14-18 times per minute.
- Keep the monitor screen always clean.


Overhead lighting dim; monitor is the brightest light in the room
Computer eyewear lessens screen glare and increases contrast
Top of monitor is at eye-level or slightly below
Viewing distance is 20-40" or an arm-length away
35°
Monitor is flat and positioned directly in front of the face; no tilt
Viewing angle no more than 35° from monitor
Keyboard placed so upper arms hang vertically
Chair supports the spine and helps keep the body upright
Chair set so feet rest flat

Traditional suggestions are focusing on preventions, while the market is interested in treatments.



The thing is there are so many different massagers, but they are all massagers, isn't it wired?

Aha!

Aha Moment

Instead of asking how to give treatments for CVS symptoms,

Why not prevent this from happening in the first place?

> **Keep in mind the best lubricant for the eyes are our own natural tears.**
>
> ——David Lightman (Retinal surgeon, USA)

In the beginning I was thinking of designing an eye massager which was a proven existing market, possibly with ultrasonic steam feature, and I did see plenty of those products. In fact, I used some of them before and they did have pros and cons, for example, some were difficult to clean after use, some had low battery life or it needed to plug in with a power bank. For most of the massagers, one thing was that you must spend around 15 minutes in darkness and enjoying the weird noise coming out of the device. Some products can see through, and some use water and separating the pump and mask. If I were going for the massager, I would probably end up making improvements on traditional products, which could be good, but honestly, I wanted to do something different as I realized that it came to a point to choose either design for recovery or design for precaution.

I remember one thing being stressed by David (the retinal surgeon I consulted) **is that "keep in mind the best lubricant for the eyes are our own natural tears"**, which means that instead of using artificial tears in extreme situations or having other massage treatments, the best way is to keep it healthy on our own, so is to adjust our behavior and go back to a healthy status.

Just imaging a babysitter device that tells us when we should take breaks or blink our eyes?

After some basic researching, **I was quite happy to find out that detecting eye blink condition and measuring distance between screen and eyes are not difficult**. And I also found those modules were small enough to be put into a goggle and had low power consumption, thus users can get real-time feedback of whether they blink too little or reaching too close to screen. By getting real-time feedback, people can blink their eyes and keep their eyes moisturized by natural lubricant of their own, and reduce eyestrain by either keeping enough distance or getting off the screen once in a while by the reminder from the smart goggle. Other things like glare, blue light, could be solved by lens coating as well. **In other words, it was possible to prevent users from getting dry eyes and tired eyes in the beginning instead of trying to have a massage afterwards.**

Therefore, why not design a pair of smart interactive eyeglasses that can help reduce chances of getting CVS symptoms to a maximum extent in the first place, even though there is no such product on the market yet.

Product Positioning I

I put current products in a positioning map like this, where the Y axis indicates prevention and treatment, the X axis indicating the extent of convenience. Even though the positioning is given by my thoughts, I will give my reasons here.

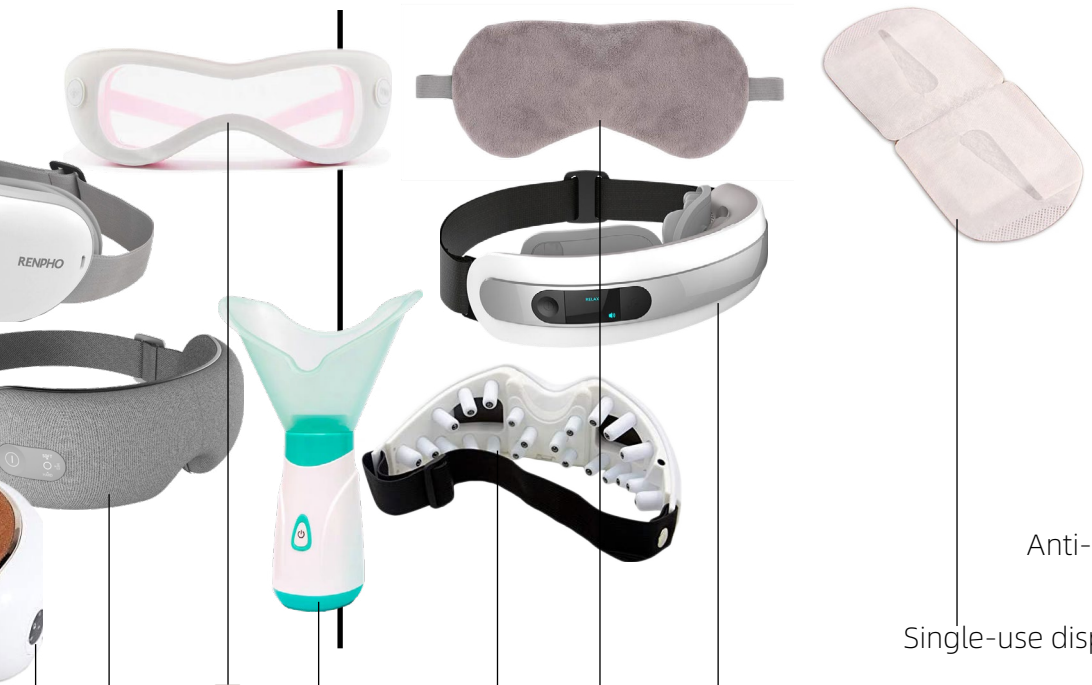
Let's start at the bottom left, the water-propelled eye massager was put here due to the tethered parts that user has to carry together, also the user needs to add water and clean for storage. The handheld one works for one eye each time, also the user needs to hold it along the usage. Moving from left to right, it becomes more convenient, the reason why these three air pressure massagers sit behind the ones on the right is that they are relatively uneasy to clean. The two steam masks are in the middle as they need to somehow add water but they are easy to clean as well. The detachable head massager is convenient to clean and the disposable one can be the most convenient.

However, we can see that all these masks and massagers sit in the area of treatments, while probably only one is for prevention, which is this anti-blue light computer glasses.

Prevention

Something we want

Convenient



Anti-blue light computer glasses

Single-use disposable steam eye mask

Detachable hot compression eye massager

USB powered hot compression eye mask

Magnetic Vibration eye massager

Multi-purpose Steam Console

USB powered hot steam eye mask

pression eye massager

Treatments

Product Positioning II

Since we blinks less, how can we remember to blink enough?

Also, as we usually get closer to screen when engaged and forget to take breaks, how can we remember to do all these?

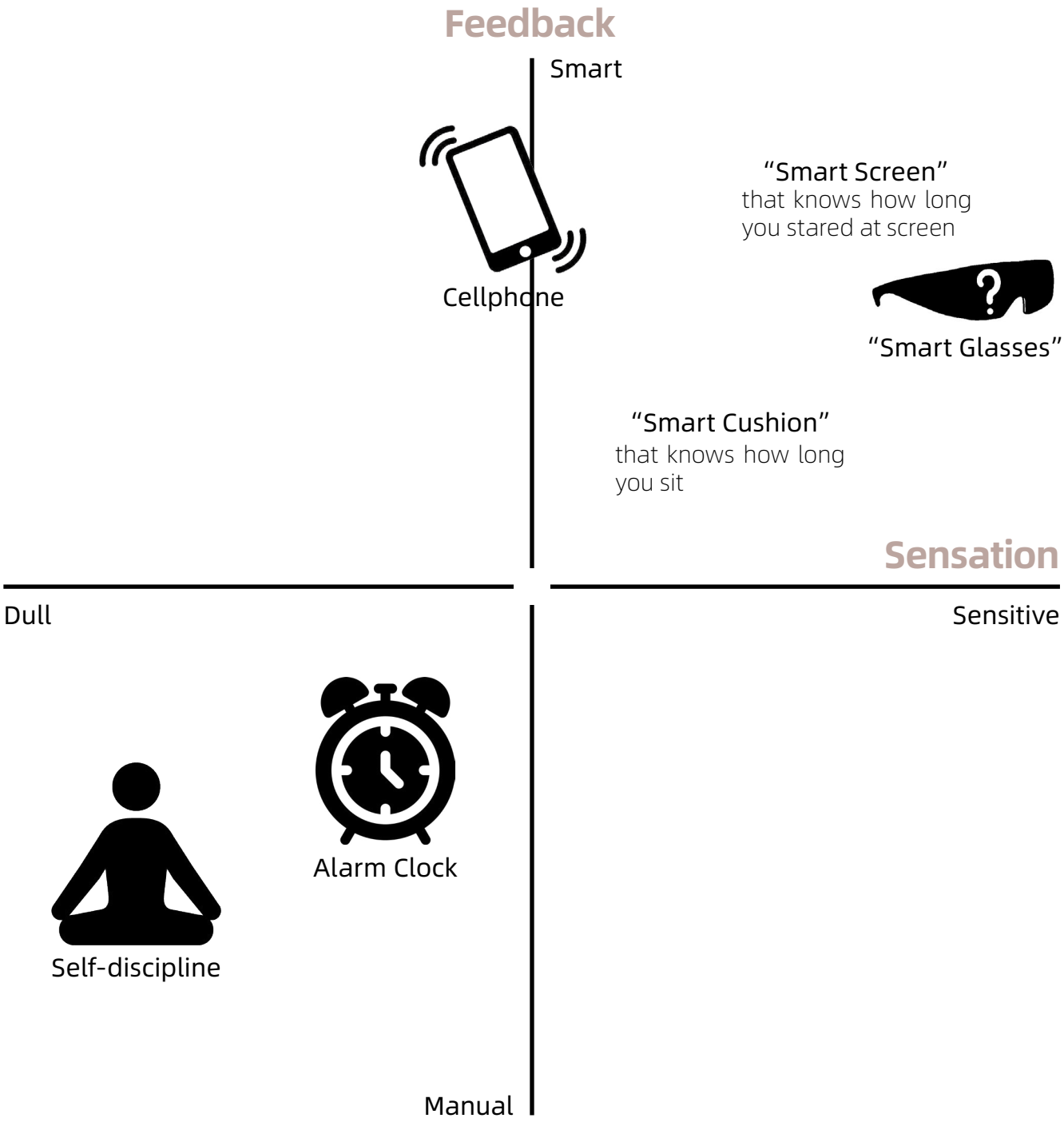
The easiest thing we can imagine is that we be aware and strict to ourselves, we can make rules and requirements on ourselves, telling ourselves to blink as much as possible and when to take a break, which is called self-discipline.

We can use an alarm clock to help as a reminder, it is loud enough to be noticed, however, usually it needs to be well set up every time, which can be of operating costs and psychological barriers especially if you are afraid of tedious things.

Of course, most of us have probably the smartest thing in our pocket nowadays and that is our cellphone. You can absolutely set up alarm clocks on a cellphone with different ring tone you like, and you can even find some interesting interactive applications hopefully and download them with a flick of finger, but no matter how subtle the feedback it offers, our cellphone is not designed to detect our eye condition, which means it is almost a blind to be your supervisor.

Things are getting interesting when talks about smart devices, and when referred to smart devices, I am stressing its sensations, because it is the ability to sense that makes it smart, not how fast the chip it has. I had some ideas in terms of smart devices, for example, what if a smart chair, or a smart cushion that can sense when people sit on it, and then it can calculate how long you are staying there and guessing that you possibly need a break. A pair of smart glasses that knows how long you use your eye and if you keep proper distance to the screen or not could be inspiring, since eyeglasses can be appropriate to perceive human eye's condition. As I mentioned in my Aha moment, I figured that it will be super interesting to further develop this idea, that's why I moved on with this idea.

As for the smart screen, actually it was thought about later, which can be interesting as well.


Feedback
Smart
Cellphone
"Smart Screen"
that knows how long
you stared at screen
"Smart Glasses"
"Smart Cushion"
that knows how long
you sit
Sensation
Dull
Sensitive
Alarm Clock
Self-discipline
Manual

Feasibility

Is this idea functionally possible in the foreseeable future?

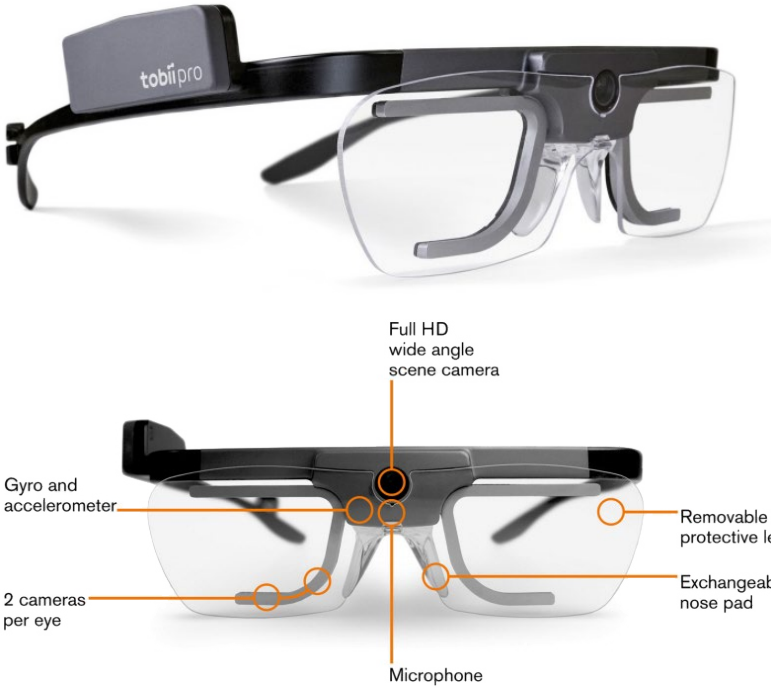
In my mind, the smart eyeglasses can detect whether the wearer blinks too little or reaching too close to screen in real time. Then it could give real-time feedback to the wearer, thus people can blink their eyes and keep their eyes moisturized by natural lubricant of their own, and reduce eyestrain by either keeping enough distance or getting off the screen once in a while by the reminder.

With little googling, we can find the technology to detect the condition of eye blink is actually not novel. Much more complex technology like eye tracking technology was already here on the market, but to detect eye blink was much more easily. By analyzing picture or video of the user's eye captured from a normal camera, it could tell whether the user blinked or not, and similarly, the frequency of eye blink can be calculated, or the gap duration between two blinks, because both blink rate and gap time are important in this case, but they were not hard to figure out. As for the distance detection between eye and screen, first thing came to my mind was rangefinder, and it did not take long time to find something that was small enough in this case.

Theoretically, all the functions involved here can be realized by the existing technology, the functional components were also small enough to be put onto a wearable device, and the performance of relevant electronic components can meet the design requirements as well.

Tobii Pro Glasses 2

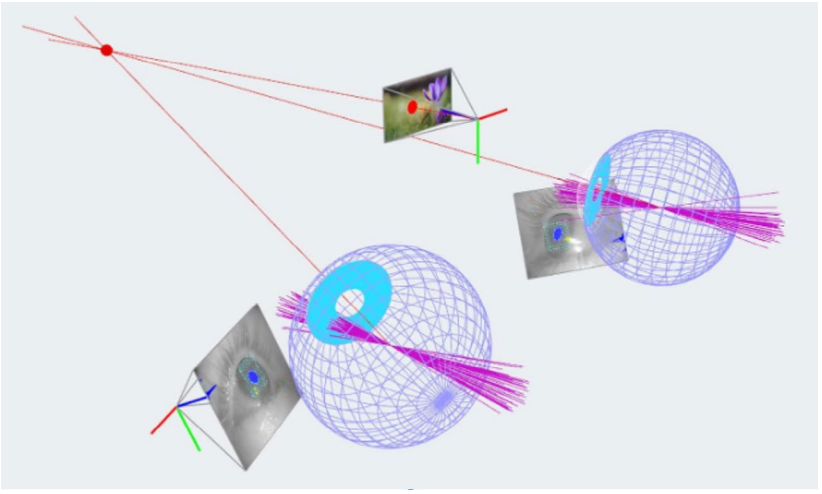
Wearable eye tracker from Tobii Pro, which is the world's leading provider of eye tracking research solutions. This glasses was designed to capture people's viewing behavior in any real-world environment while ensuring outstanding eye tracking robustness and accuracy.

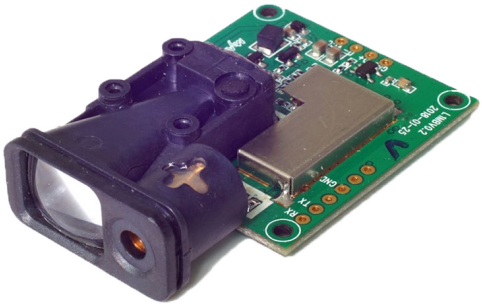


Pupil Core

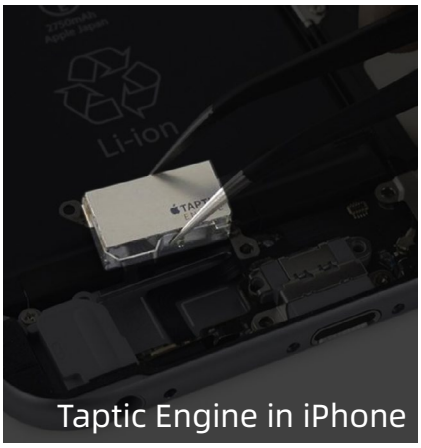
Eye tracking kit from Pupil Labs.

It is a developing plat form that is composed of an open source software suite and a wearable eye tracking head-set. It utilizes IR camera to track eye movement and get gaze data, which to my case is an overkill technology.





Laser Rangefinder Module
Invisible infrared laser 808nm, 980nm, 1064nm



Taptic Engine in iPhone

mEngine in MEIZU

Vibration Motor

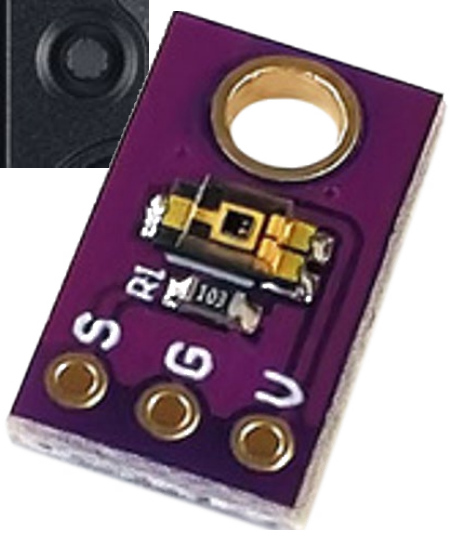
The taptic engine in iphone 7 is LRA (Linear Resonant Actuator) vibration motor that provides different instant vibration feedback to the user according to different interaction, which brought huge impact on user experience in every detail. High-end android cellphone brand like MEIZU was catching up using LRA vibration motor as well, which was called mEngine. One single LRA could provide different vibration patterns like dzzz, da, mm, etc., and has countless combinations.

Actually, traditional ERM (Eccentric Rotating Mass) vibration motor could also be qualified for the role here, and it is much cheaper. An array of ERM vibration motor could theoretically create different vibration pattern needed here, but it consumes more energy.

Eye Sensor in Fujifilm mirroless camera

It sits below the EVF (Electronic Viewfinder). When photographer put his/her eye to the viewfinder, it will turn on the viewfinder and turn off the LCD monitor, and taking off eyes will turn off the EVF.

It serves as an easy but critical sensor to make the camera smart. The same can be apply to detect whether the user is wearing the glasses or not, thus to control the power switch.



An ambient light sensor

Target Specification

Table 3. Target Specificatio

	Function	Value	
Blink Detection Module	Blink Rate	Average rate per Minute	Default reminde minute
	Gap time between 2 blinks	5 seconds	Default reminde
	Eye state	Staring/Closed	Detection is no
Rangefinder	Min-distance warning	Min-distance threshold	Directional vibra 30 to 40cm, you interval
	Continuous short-distance duration warning	Continuous short-distance duration threshold	Default reminde the duration of t
IR Sensor	Wearing condition	Wearing/Not wearing	Wear to trigger
Power Switch	Smart switch	/	Opening the tem mode, and fold t
Vibration System	Feedback	Different vibration patterns	ERM (Eccentric or LRA (Linear R
Lens	Anti-glare, anti-blue light	Lens Coating	Lenses prescrib of computer vie

Target specification were made through out the process to determine what the core features and functions of this concpet product should have.

It was edited many times and still under construction, since this deisgn was still at its conceptual phase. Details can not be determined until further investigation and real testing.

However, this target specification so far was still a good example of how it may work with the user.

n of smart glasses concpet

Details	Feedback Pattern
r trigger when under 14 times per	Vibration in the front of the frame: mm-mm / 2s until blink performed
r trigger once over 5 seconds	Vibration in the front of the frame: mm-mm / 1s until blink performed (similar to the one above)
longer measured when user close eyes	/
tion feedback exists by default from can set the specific value of this	Vibration from the front of the temples to its rear: mmm-mm-m (Directional pattern) Below the threshold, the closer the distance, the larger the vibration amplitude, the higher frequency
r once every 30 minutes, you can set ime	Vibration in the whole frame: mmm-mmm-mmm / until distance increased other feedback form: Reminder on smart devices
detection, stand by when not wearing	/
nples to switch on and in standby to shut down.	Vibration in the whole goggle: mm-mm-mm, a quick pattern indicating device switched on Vibration in the whole goggle: mm-mm-mm-mm-mm, a longer quick pattern indicating device switched off
Rotating Mass) vibration motor array Resonant Actuator) vibration motor	/
ed to meet the unique visual demands wing may be achieved	/

In terms of feedback methods, I chose physical vibration instead of sound or visual feedback, because vibration feedback was a proven technology, it was cheap as well, if it was visual feedback as you can imagine based on what you would find currently on google glass and other agmented reality glasses, it would be very expensive and complex, which would also consume a lot energy compared to only vibration. As for sound feedback, it could be way more disturbing especially when in public offices.

Naming

Naming is an important thing since it helps the definition of a product, or a service.

After creating the target specification, I had a basic understanding what this concept produt would be like, thus I can possibly give a proper name to it.

Not airbag eye massager, water-propelled eye massager, magnetic eye massager, infrared eye massager, XXX eye massager, steam eye mask, etc..

Not safety goggle, sports goggle, ski goggle, lab goggle, protective eyewear, reading eyewear, etc..

Since it was not an traditional eyewear, nor a prescription eyeglasses, it felt more of a goggle that you wear when you were engaged in a certain work situation, indeed working with computer screens.

I thought about eye-care goggle, sight-care goggle, screen goggle, etc., but they all sounded not powerful enough. I wanted the name to carry a bit impact with it.

Finally, I named it vision goggle. The word Vision comes from CVS, and goggle meant it was the thing that guards your vision.

Vision Goggle

Vision Goggle

Mood Boards

OAKLEY Flight Deck™ XM Snow Goggle

POC Crave Sunglasses

OAKLEY Fall Line XL Snow G

Breo iSee M air pressure hot compression eye massager

POC TECTAL Mountainbike Helmet

Goggles

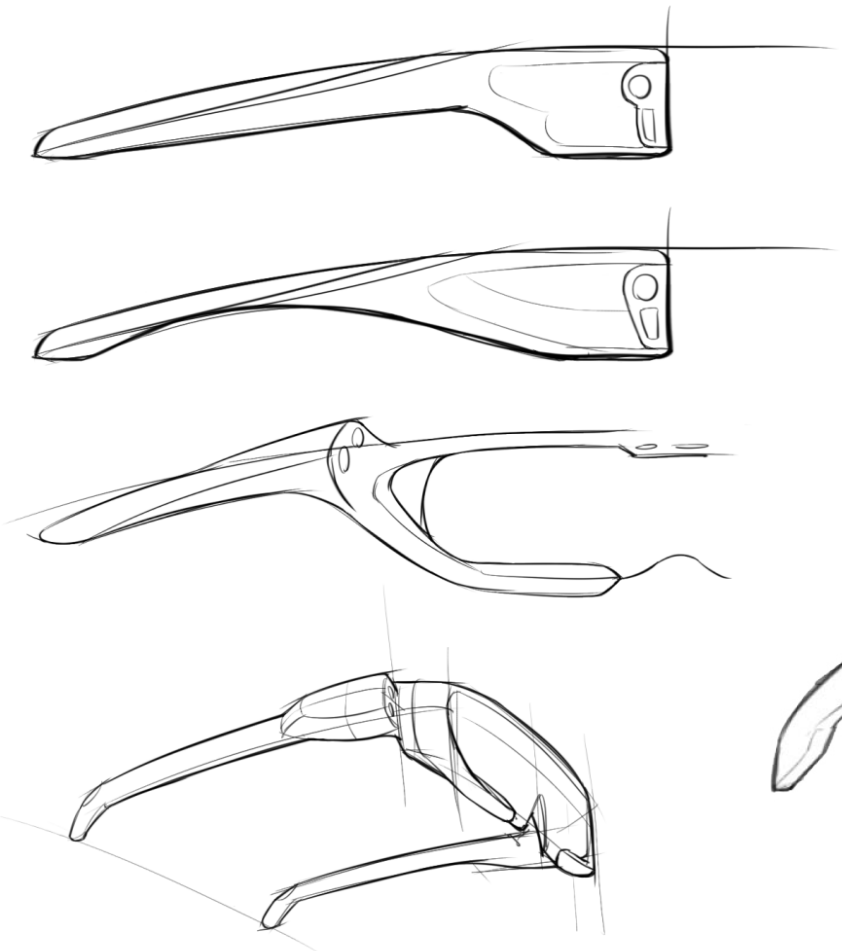
DJI MAVIC Mini Drone

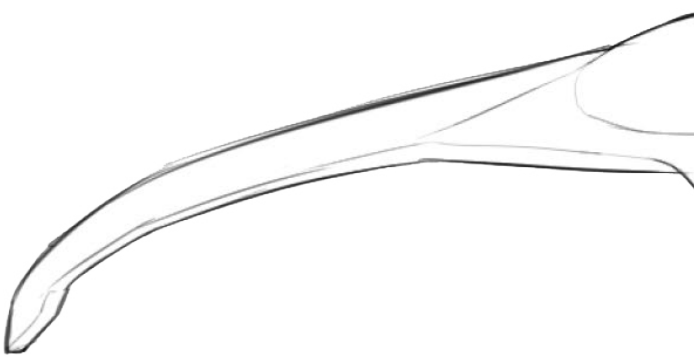
A mood board is a collection of images, materials, or pieces of textures intended to evoke or project a special style or feeling about a particular topic.

A mood board is created to give samples of what emotions of feelings the designer wants to convey. In this case, I wanted this concept to convey a feeling of professional style. I wanted it to be futuristic and smart, and necessarily it should project a comfortable feeling, not something too complicated like VR headset current on the market.

It should maintain good balance between simplicity and technology. All sample products here are greyish or white, since grey have little color tendency, it could easily match other clothes the user may have, and also the soft contrast would make it perfect to blend in most of the working scenarios without visual conflict. Furthermore, there was a sense of future among these products, which was also what I want to convey.

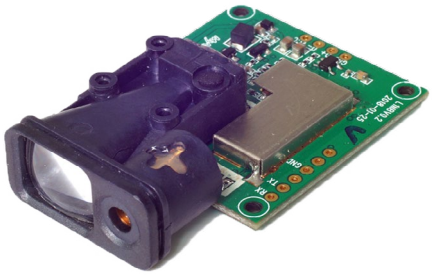
Primary Concept





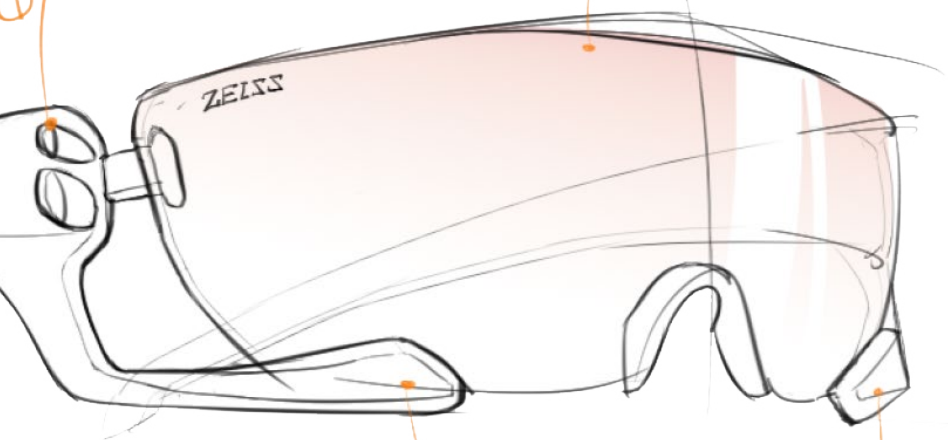
These are the primary concept sketches I drew based on the sensors I found. I just put the major components where I thought they were supposed to be. The Laser rangefinder was set on the temple, and the eye camera was on the lower side of the frame, which was similar to the eye tracking headset I looked at before.

This was a very early, imaginative sketch, aiming to be bold and create a good image of what this concept could be like. I did not draw a lot, but focused on one and tried to make it looks nice, because I knew the form of this concept product really depended on the components and the core value of this concept was not form itself, but the idea how this could work together as a whole to help prevent CVS symptoms.

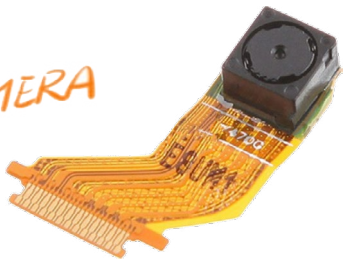


RANGEFINDER
LOW CONSUMPTION LASER

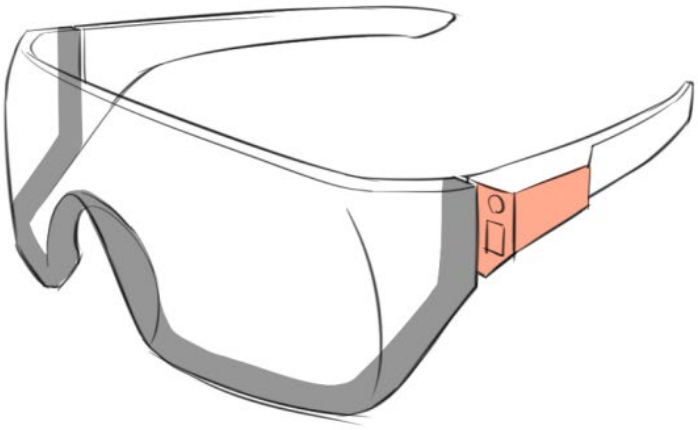
ANTI GLARE
ANTI BLUE LIGHT



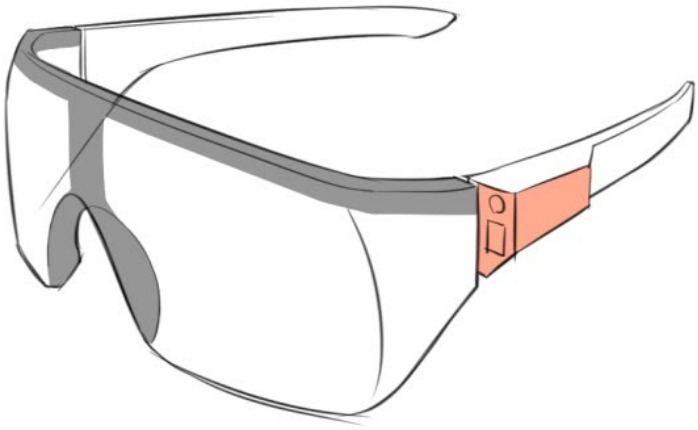
EYE BLINK CAMERA



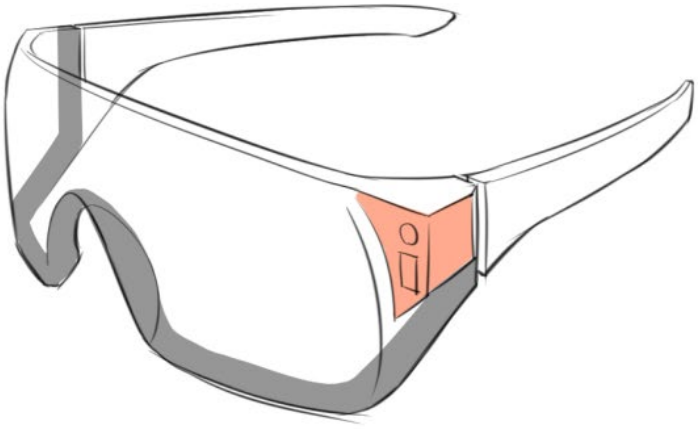
Combination



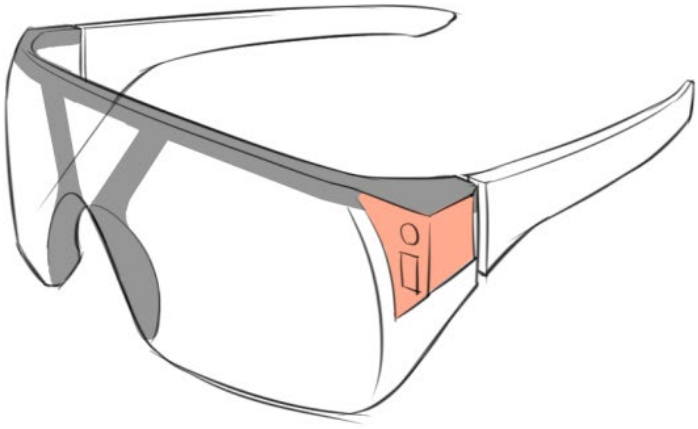
Lower half frame
Rangefinder on the temple



Upper half frame
Rangefinder on the temple



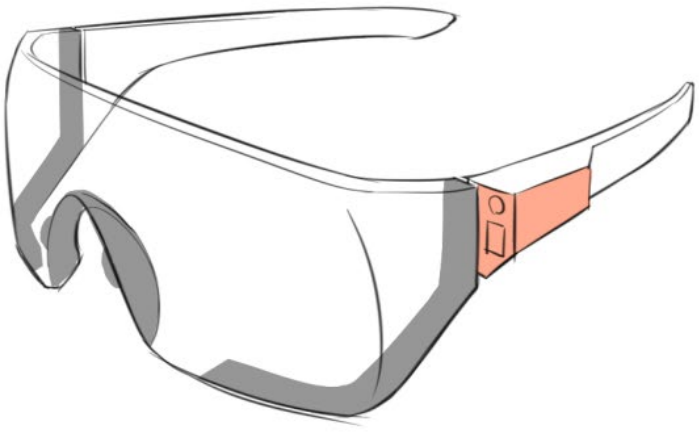
Lower half frame
Rangefinder on the frame



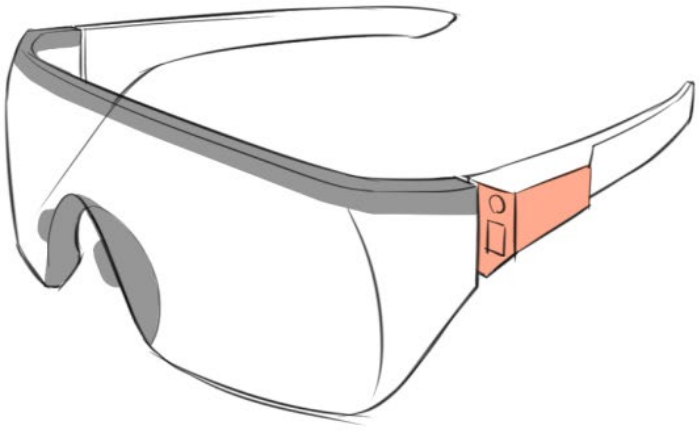
Upper half frame
Rangefinder on the frame

These were the analysis of different components combination, I made them to see what visual effect different arrangement would bring about.

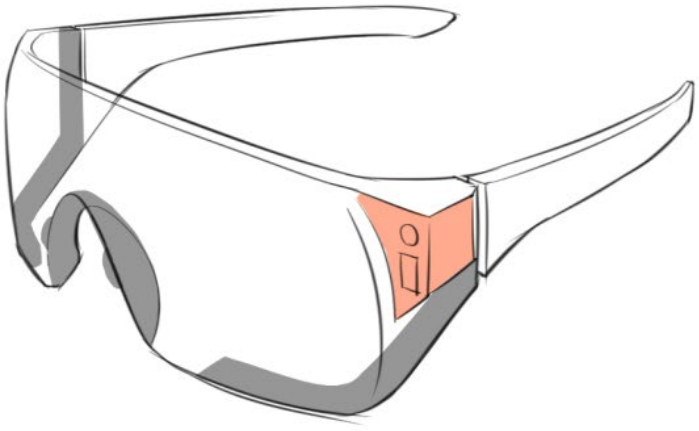
The rangefinder could either be placed on the temple or the frame, while the frame could be full frame or half frame and the eye camera would be on the frame. In fact, every one of these combinations would work out, what it affects was the form and product image to the user. In my opinion, it would be cooler and provide more immersive experience to be half frame.



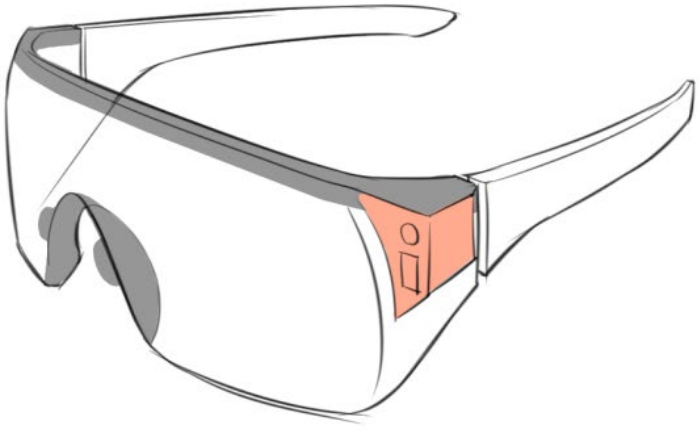
Lower half frame + separeted nose pad
Rangefinder on the temple



Upper half frame + separeted nose pad
Rangefinder on the temple



Lower half frame + separeted nose pad
Rangefinder on the frame



Upper half frame + separeted nose pad
Rangefinder on the frame

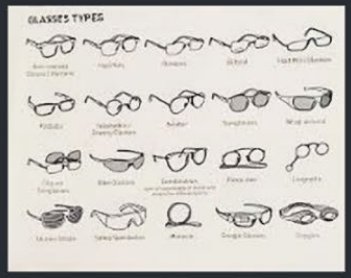
The nose pad needed to be connected to the frame traditionally, but I thought it was possible to separate it from the frame and be connected directly to the lens, which I realized even by myself (You can find this detail in the later parts of the documentation). I would further try and develop on some of the preferred ones to see how it looks on the paper.

What style

Sunglasses with names of th...
pinterest.com

After Consulting - Frame Styl...
itl.cat

Fashion in Infographics — Th...
fashioninfographics.com



GLOSSARY - Glasses & Fram...
stitchintimeandfilm.com

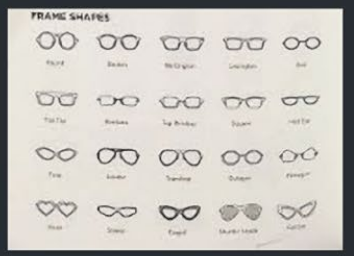
Where to Buy Glasses | Buy G...
popularmechanics.com

eyeglass fashion | Fashion vo...
pinterest.com

Behold the World's Most Fam...
pinterest.com

Infographics On Fashion Pict...
lovethispic.com

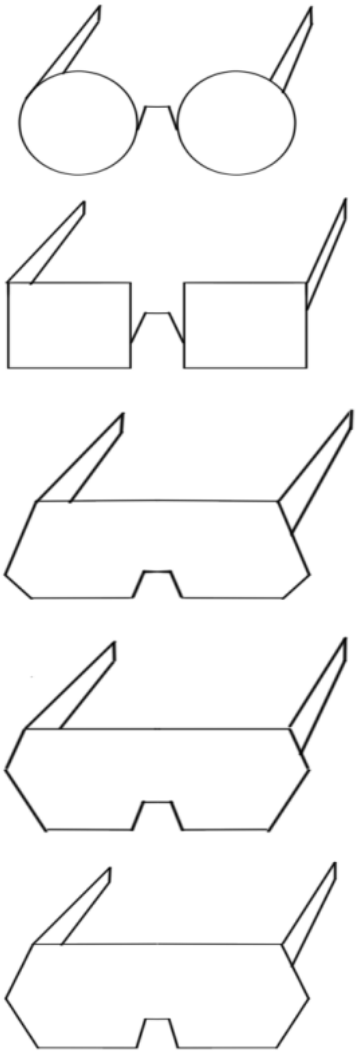
Eye Wonder Wholesale Men ...
aliexpress.com



GLOSSARY - Glasses & Fram...
stitchintimeandfilm.com

TYPE — SHINYA KAMATA
shinyakamata.com

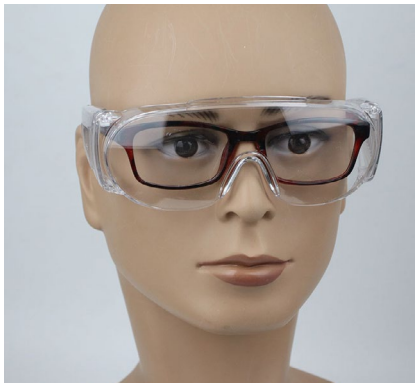
No Commitment Frames fro...
fashionwhipped.com



There were lots of different style of eye glasses, but in my case, I should not go for a specific style when it comes to form design, because vision goggle needed to be compatible with most of the optical eyeglasses, so it had to be somehow a big square version to be able to cover the most cases of different eyeglasses.

But still I believed, there were quite a lot chances to manipulate the form.

OTG style



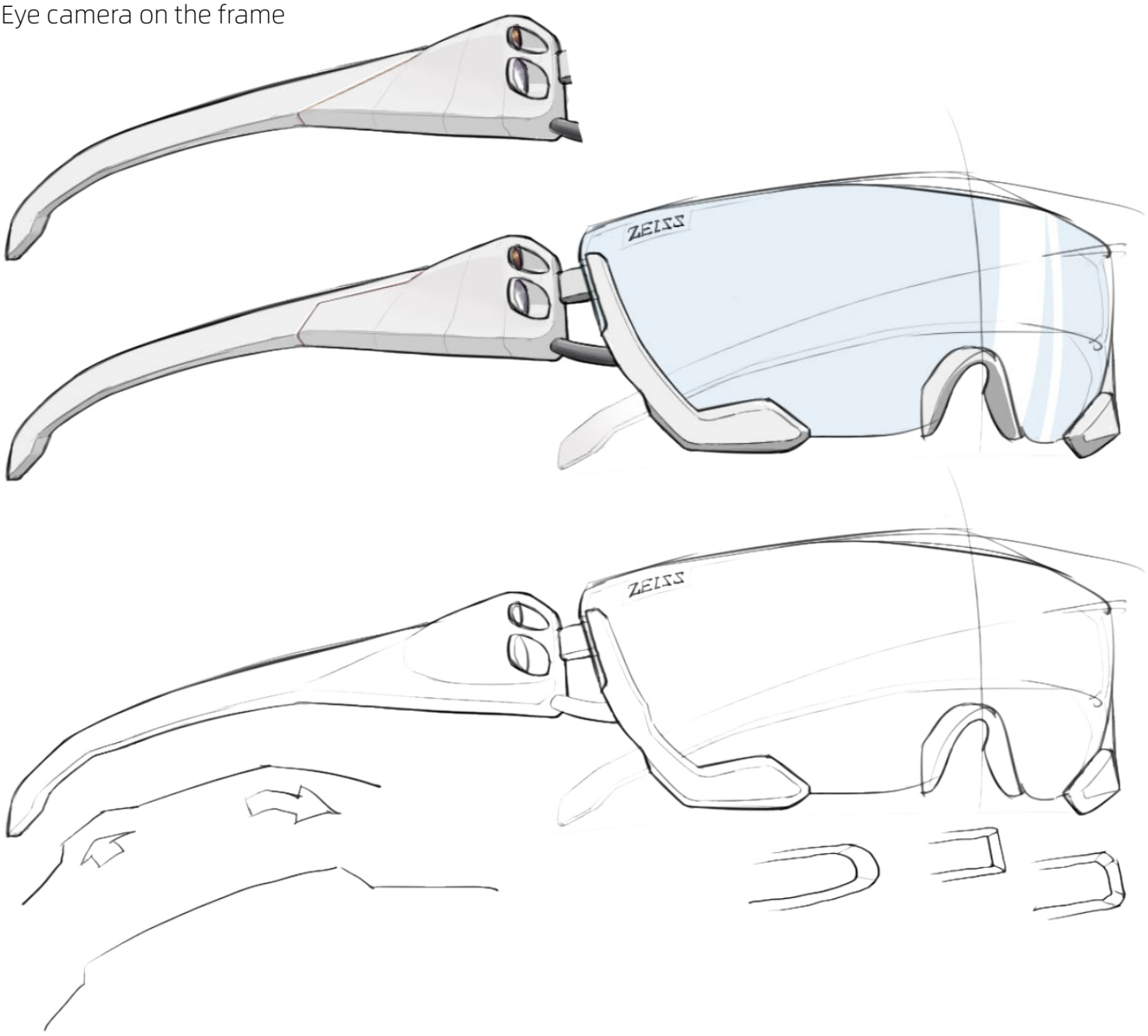
OTG stands for "Over the Glasses" that describes those frames that are compatible with optical glasses.

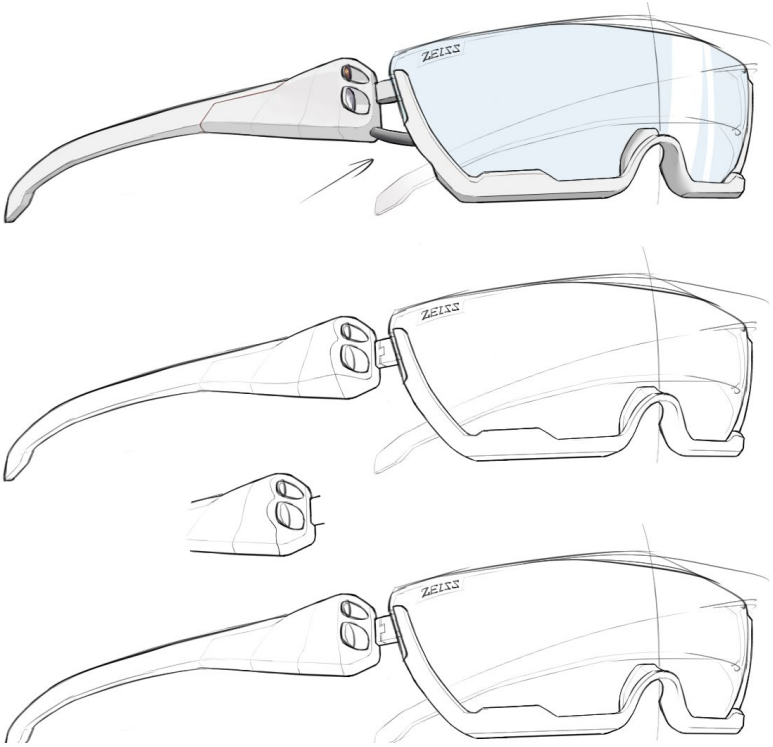
I reckoned this was a very important feature since lots of modern computer user was wearing a pair of optical glasses, so it would be a good idea to take this typical safety goggle as a base point to further explore design.

Sketches iteration

In the following sketching ideation process, I beginned with the previous imaginative concept sketch as I thought there was huge potentials.

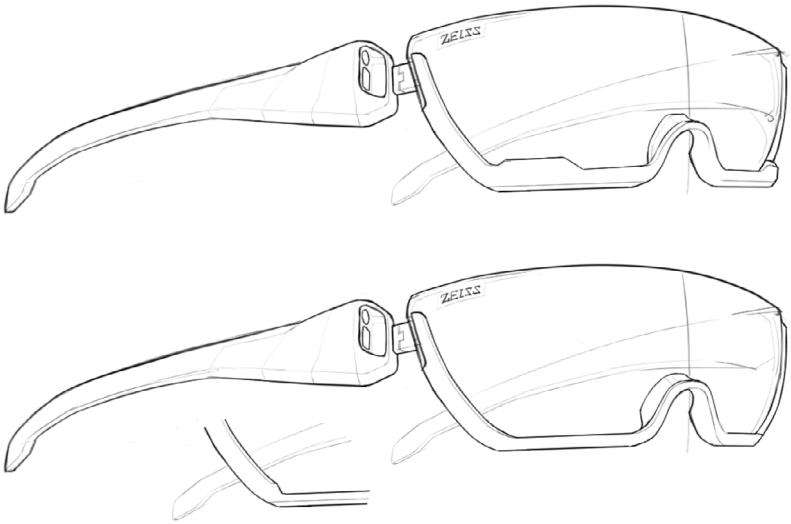
Half frame style
Rangefinder on the frame
Eye camera on the frame





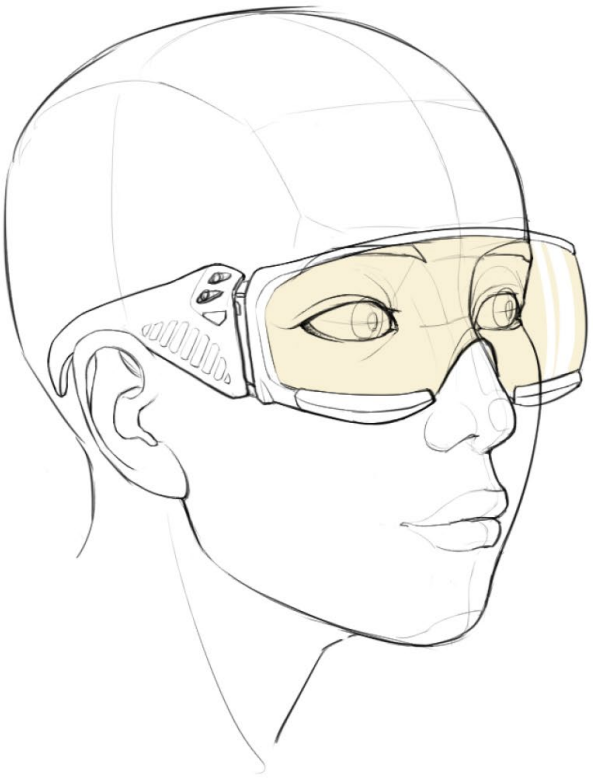
Then I drew this lower half frame version where the nose pad is connected to the frame in order to put the light sensor somewhere around the nose pad, and then I tried put it on a model's head and see how it looks.

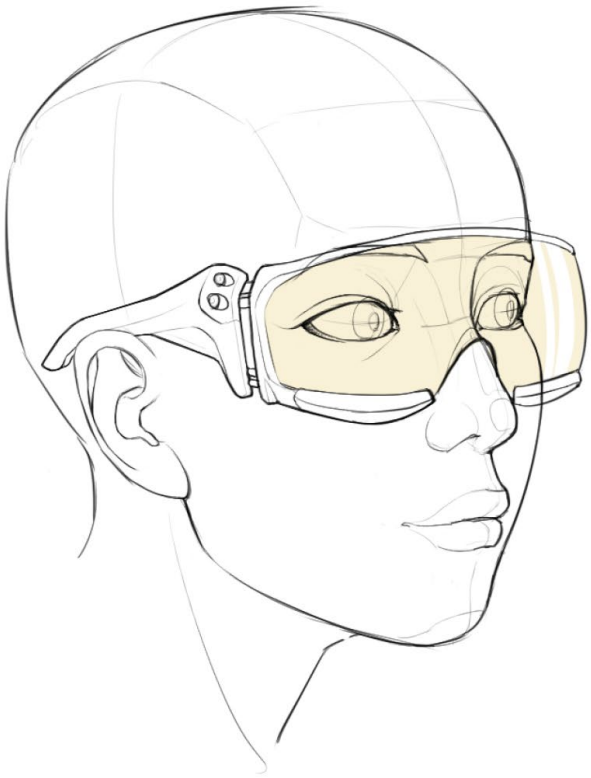
Then I realized it was not so elegant, it was too nerdy.

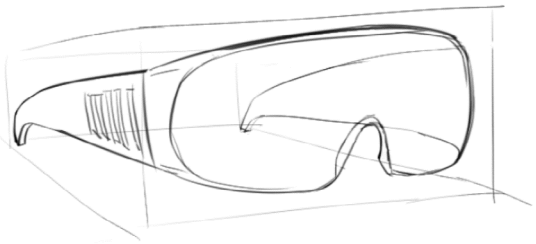


I tried to simplify this shape, for example, I removed all the raised shapes and made it as thin as possible, but it still looks strange. I realized that it was the lower half frame style that made it dull, so I gave up on this type of design.

Sketches



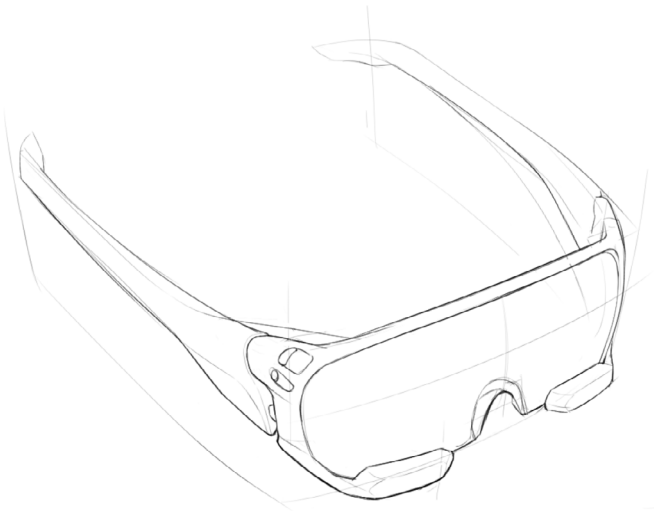


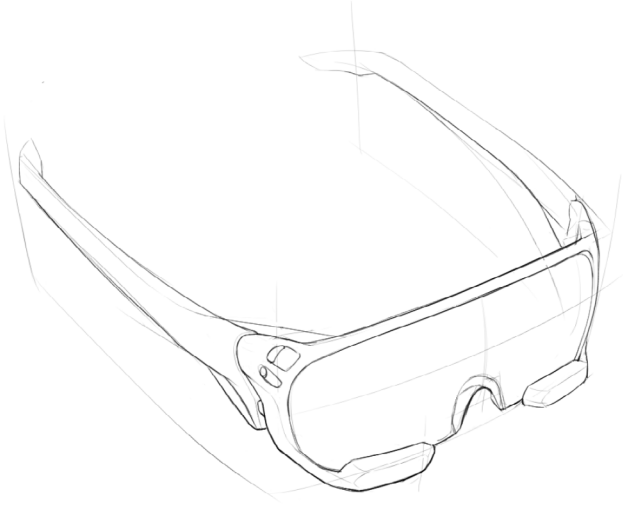


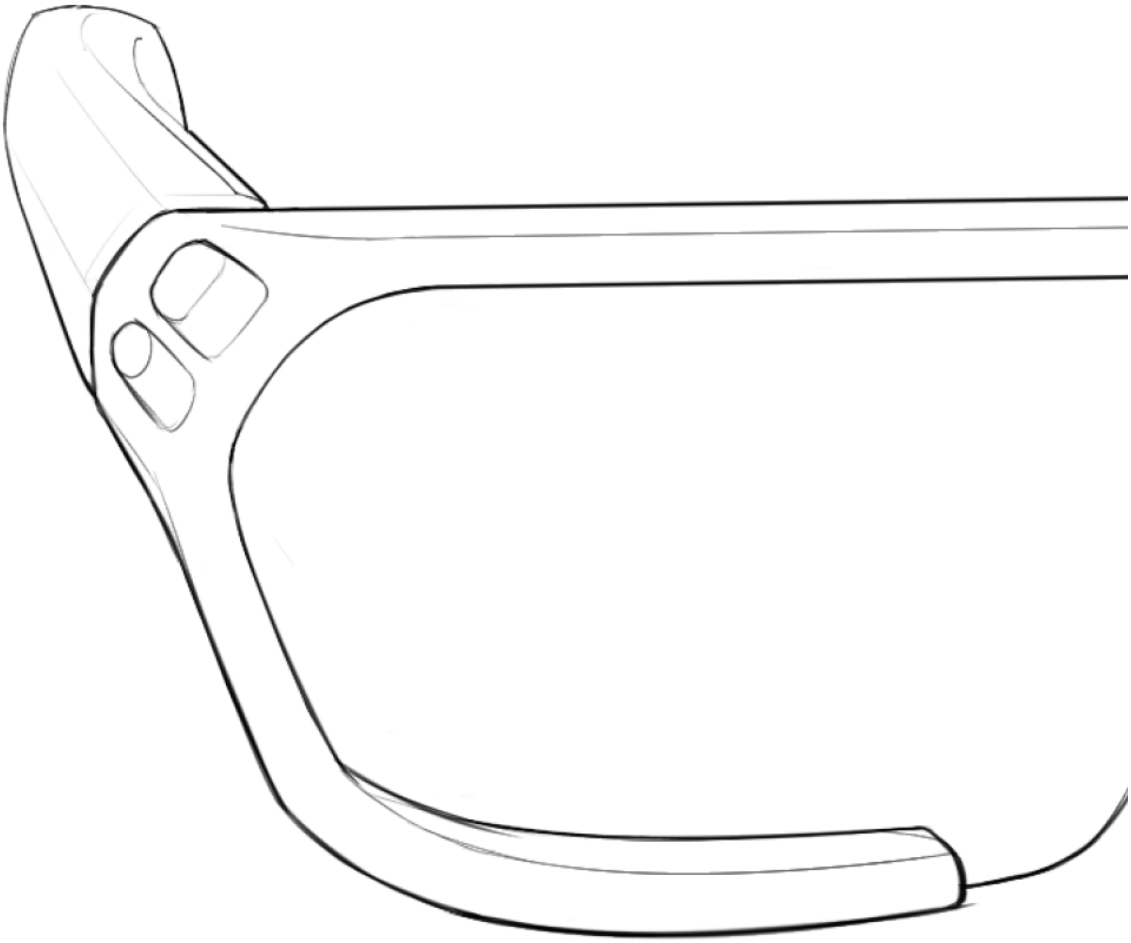
Full frame style
Rangefinder on the temple
Eye camera on the frame

These two sketches were drawn directly based on the safety goggle.

Full frame style
Rangefinder on the frame
Eye camera on the frame





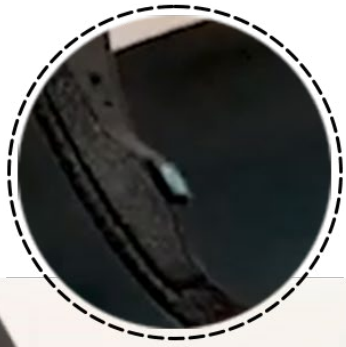


Emmmm...

Getting stuck here, it felt just like another google glass.

Pupil Invisible

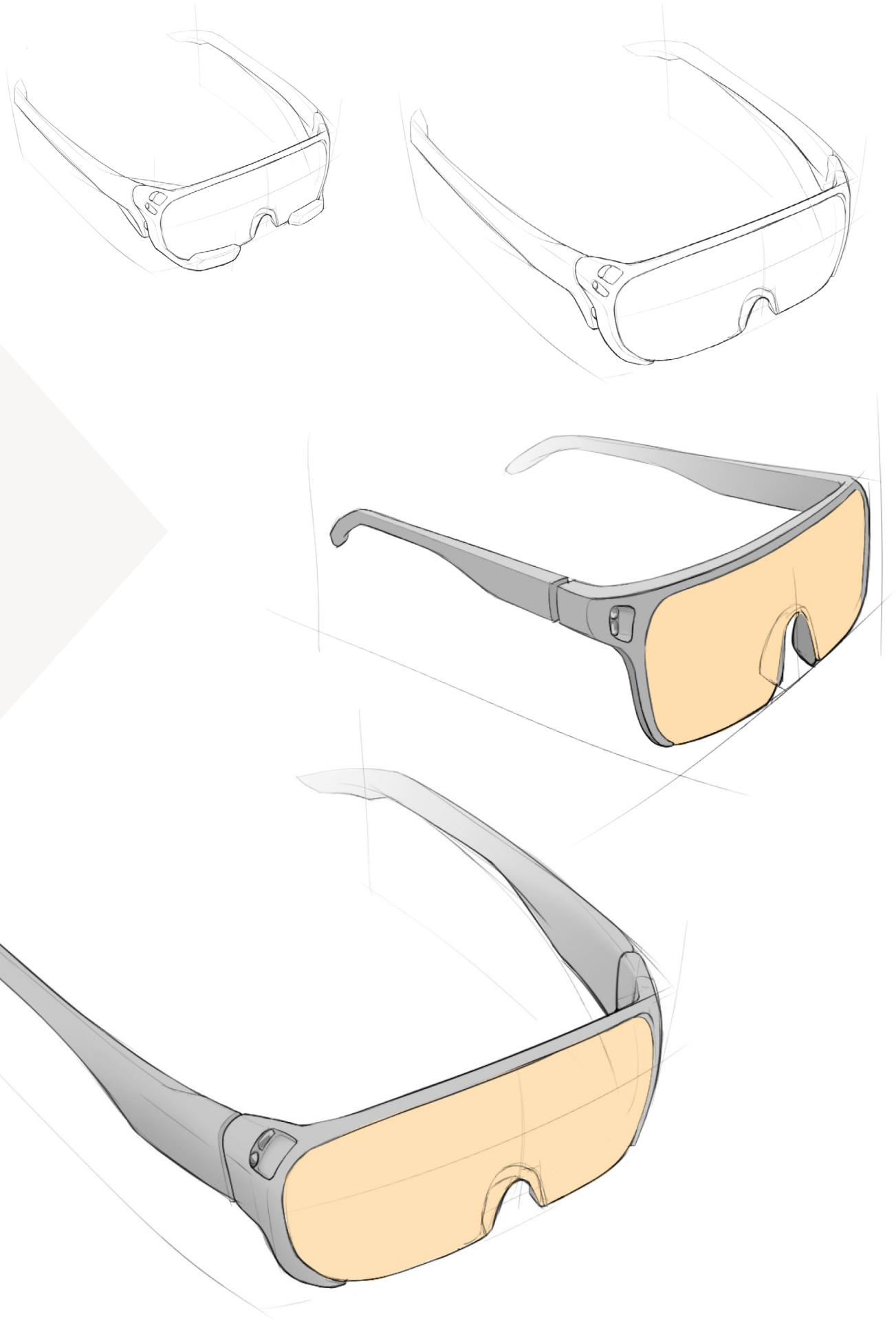
Eye-tracking glasses from Pupil Labs



Oh, I found this

This is an eye-tracking glasses from Pupil Labs, which is called Invisible. It is well designed and looks like a pair of normal glasses thanks to the miniature infrared illuminated eye cameras which sit on the inner side of the frame, as you can see from the image. Basically, the same hardware can be applied for blink detection as well.

iteration



TOF Camera

Time of flight Camera / Depth sensor

Oh again, I found this

A time-of-flight camera (ToF camera) is a range imaging camera system that employs time-of-flight techniques to resolve distance between the camera and the subject for each point of the image, by measuring the round-trip time of an artificial light signal provided by a laser or an LED.

It has been applied in smartphones in recent years to scan face or objects, and used by other decent AR applications. This TOF sensor I found has relatively smaller form factor than traditional laser rangefinder module, and have way enough detecting range that is needed for Vision goggle, which is currently a good choice in my case.

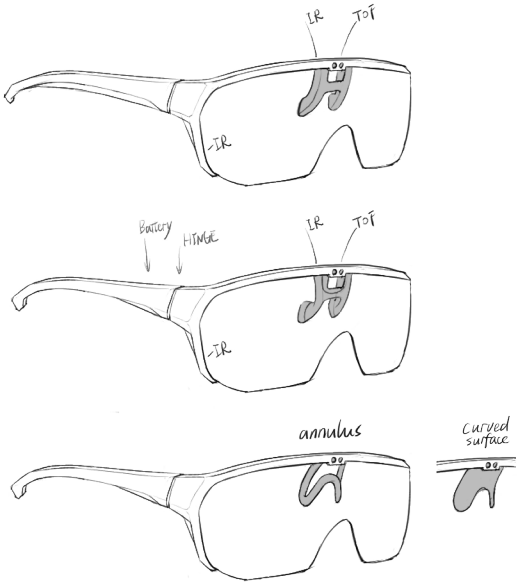
4.4x2.4x1.0 mm
Eye Safe

The VL53L0X from ST Microelectronics is a new generation Time-of-Flight laser-ranging module housed in the smallest package on the market today, providing accurate distance measurement whatever the target reflectances unlike conventional technologies. It can measure absolute distances up to 2m, which is just enough for my application.

The sensor has a miniature form factor down to 4.4 x 2.4 x 1.0 mm, and meets the Class 1 laser device compliant with latest standard IEC 60825-1:2014 - 3rd edition, which is a proof of eye safety. It is fast and of low power consumption.

This is just an example of what could be used to achieve the function I wanted for my concept design, or in other words, a proof of feasibility for this concept. The real product may or may not adopt this specific type of sensor.

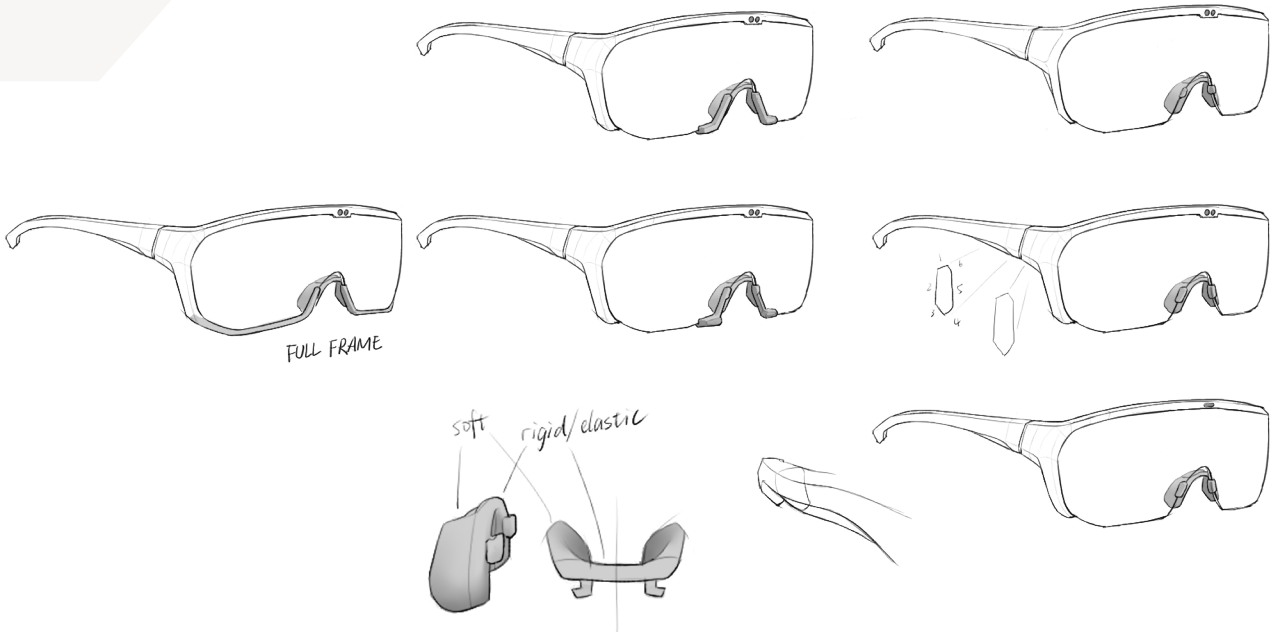
iteration



Half frame style
Rangefinder on the frame
IR sensor on the inner side of the frame

Top frame Mounted Nose Pad↑

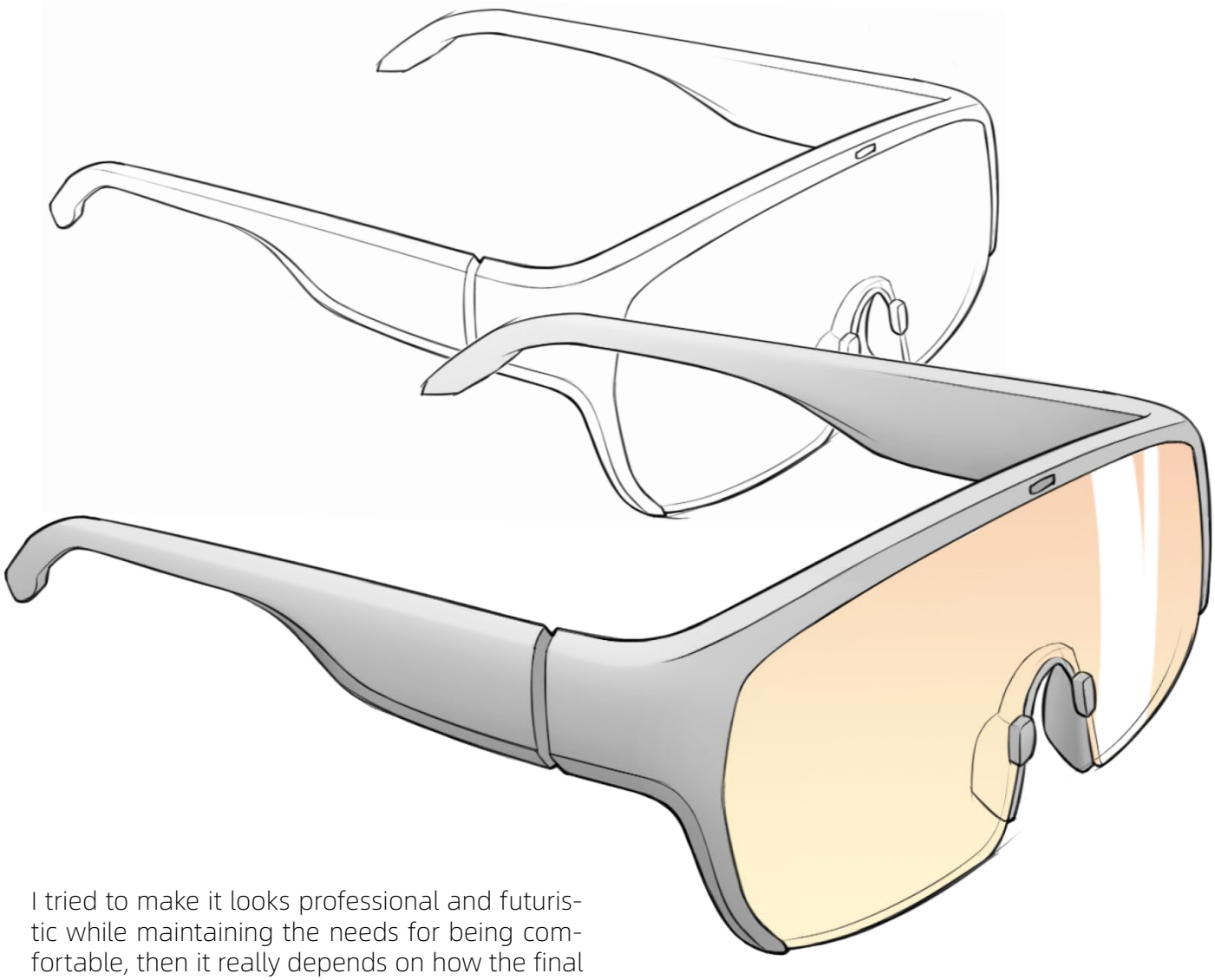
Bottom edge Mounted Nose Pad↓



I replaced the rangefinder feature with the ToF sensor in the center of the frame. I just put it on the model's face and check how it looks. Firstly, I tried to put the nose pad in an upper place to keep the bottom edge of the lens as clean as possible, but I realized that this design will cause trouble to user with optical glasses when wearing.

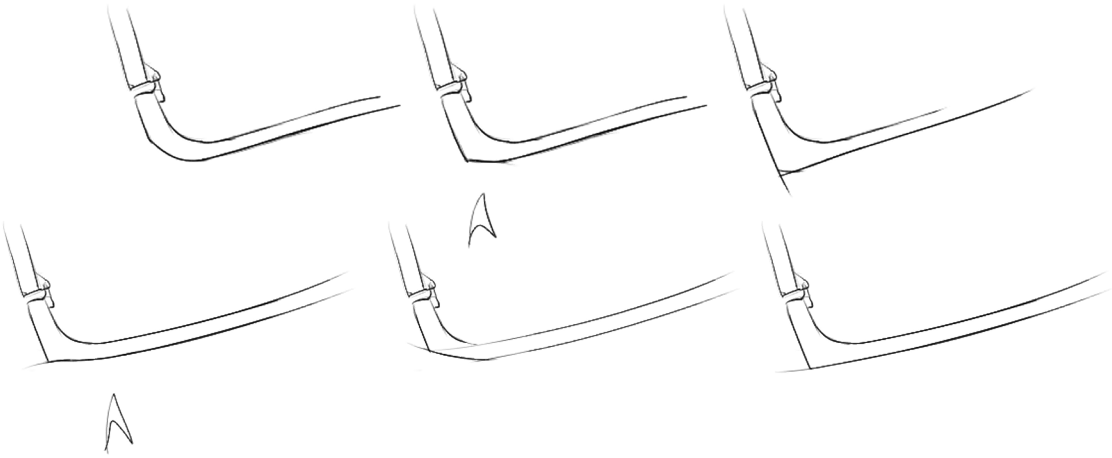
Hence, I gave up on the top frame nose pad design, and tried to position the nose pad in the bottom place. Here I drew 3 different styles and finally chose the right one since it is the cleanest solution, and I also figured out how to assemble this nose pad later.

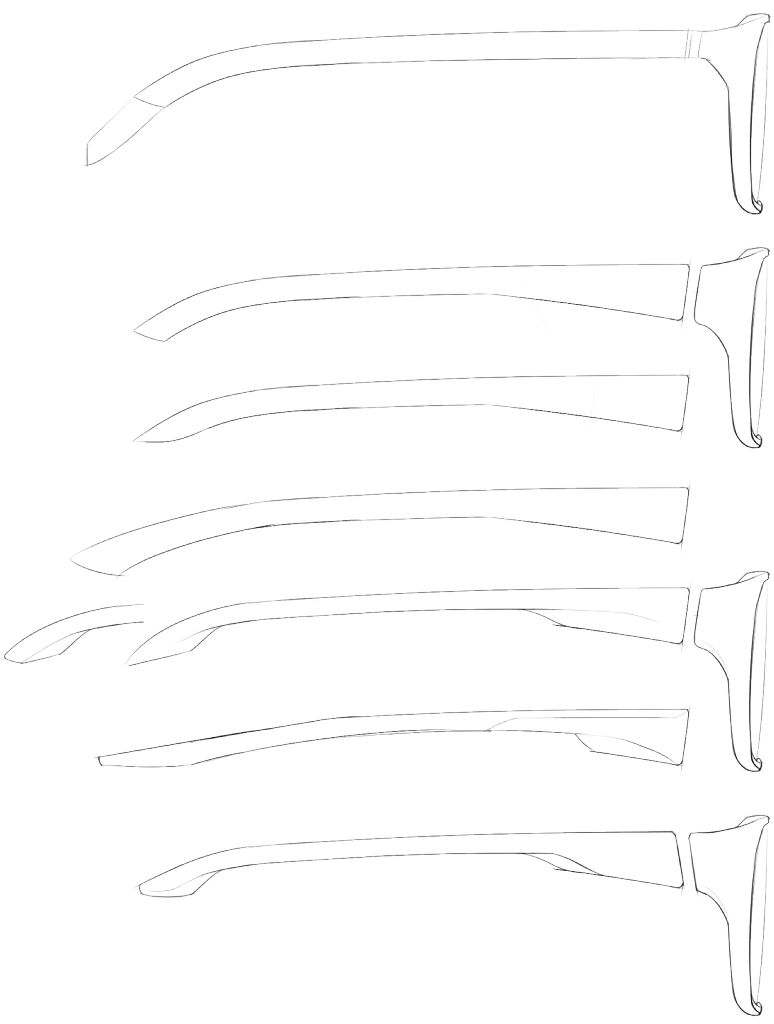
Mature Concept

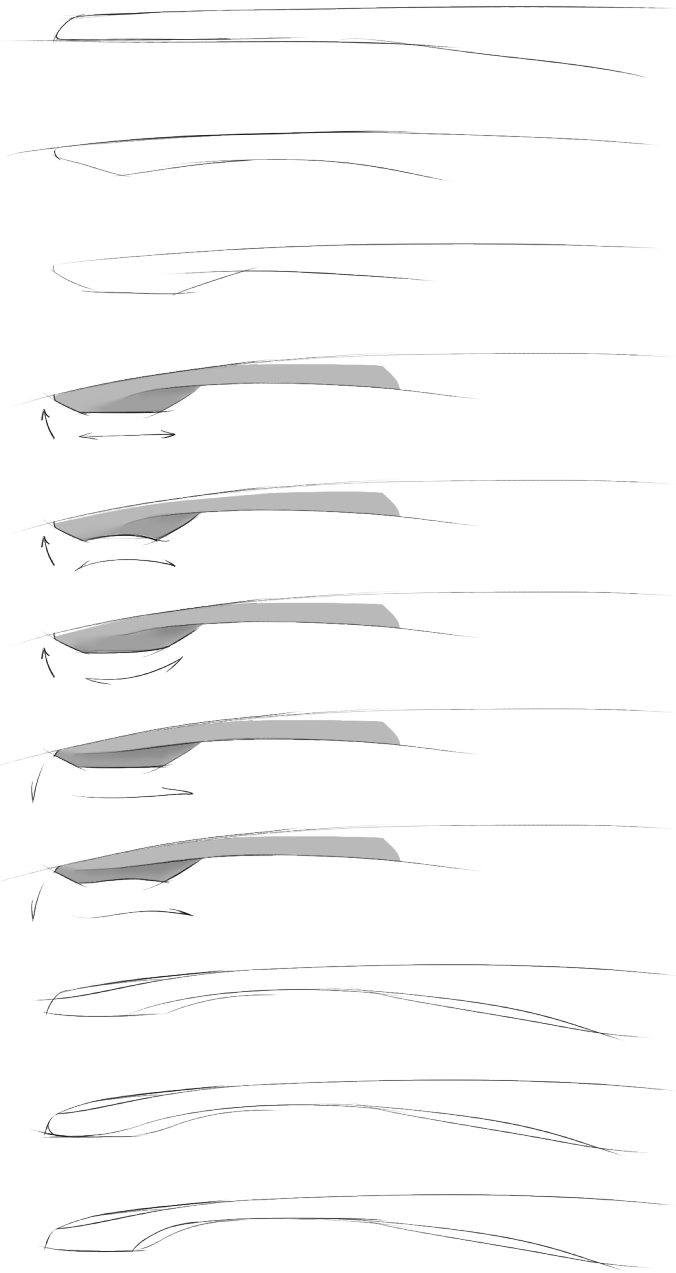


I tried to make it looks professional and futuristic while maintaining the needs for being comfortable, then it really depends on how the final model comes to be. Overall, I think it matched my intention that the form should achieve a good balance between simplicity and technology.

Other feature like the thickened temples were to leave space to place components such as batteries, PCBs, wireless charging coils, and vibration motors as well.







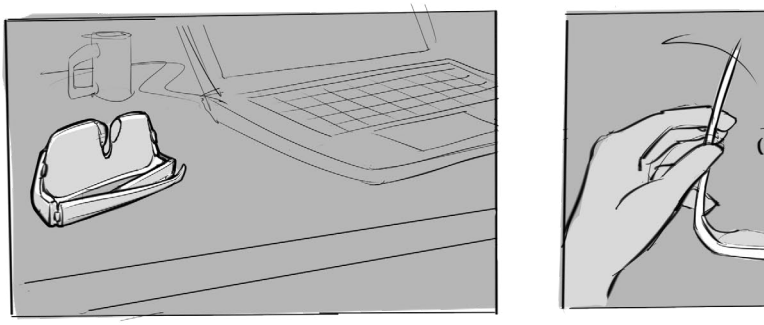
Countless form possibilities

Then I tried some form styling for the temples, I started with a relatively more classic optical glasses temples, but later I realized that it has countless possibilities when it come to form and taste, and also it would heavily depends on the size of the actual components inside, so it would be less value to drew a solid conclusion, whereas I would just pick one as a concept that fits the feeling that I want to convey.

Storyboards

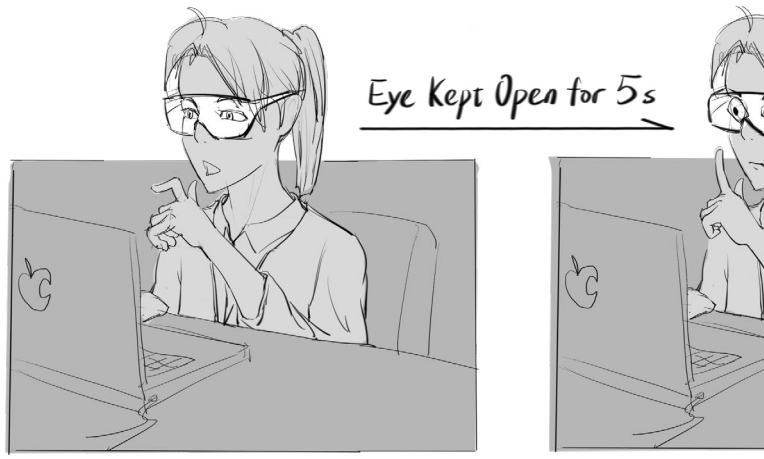
1. Wear to switch on

There is a switch hidden inside the hinge, when you open the temple, it powers on and stands by, the indicator LED will be on, too. The light sensor on the back side of the frame detects whether you put it on your face or not, it only starts working when wore. Similarly, when you take it off, it goes into standby mode, and it shuts down when temples are folded back.



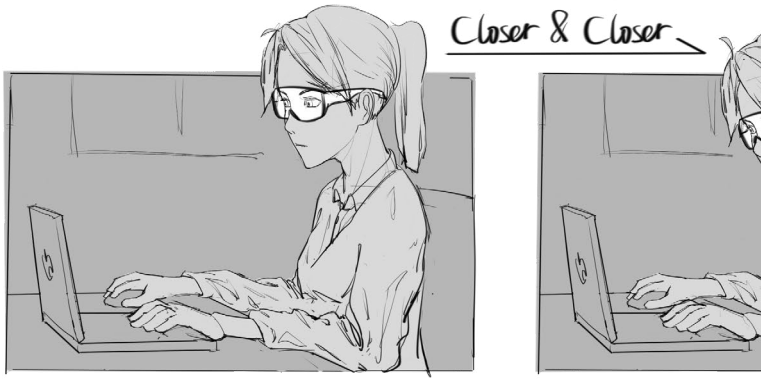
2. Gap time > 5 seconds

The gap time means the gap duration between two blinks, and the default reminder will trigger once over 5 seconds. When it triggers, the frame will vibrate in a pattern like mm-mm per 1s until blink detected. This ensures you have a minimum average blink rate of 12 times per minutes, and also solve the case that someone blinks a lot in the beginning and forgets to blink later.



3. Too close (30-40cm)

The distance between computer screen and your eyes varies a lot. The default reminder would start from 40 cm, so when your screen distance gets shorter and goes under 40 cm, the temples will starts vibrating from the front to its back with a gradient vibration pattern like mmm-mm-m, and the closer you reach the screen, the stronger the vibration will be. This will ensure that you keep a minimum screen distance to prevent eye strain.



4. Too long duration (30mins)

Frequent short breaks are better than few long breaks if you work for prolonged hours in front of screen. Thus, the default screen time is set to be 30 minutes, which means when you are detected sitting in front of the screen for over 30 minutes, the whole goggle will vibrate, and you are supposed to watch something far for 1 minute as an example. Then it will continue to calculate the duration once the short screen distance is detected.


OPEN TO
POWER ON
(STAND BY)
START MONITORING
WHEN WEARING
FRAME
VIBRATION
BLINK
TEMPLE
VIBRATION

Prototyping

Dimension control

Choose Head Width

Since the Vision Goggle was a wearable device, it is critical to fit human body. In this case, the width of the head is very important. I looked at the data of adult human characteristics of the head from Wikipedia Human head page, since I knew the 3D model I was making will be a concept trial, not a final product, which can be later scaled or adjusted.

I chose 95% percentile of men's bitragion breadth so it would be theoretically large enough for 95% of men and women as well. From the table below we should differentiate the bitragion breadth from head breadth, as the space of ear were not valid, and we could find the number was 15.5 centimeters.

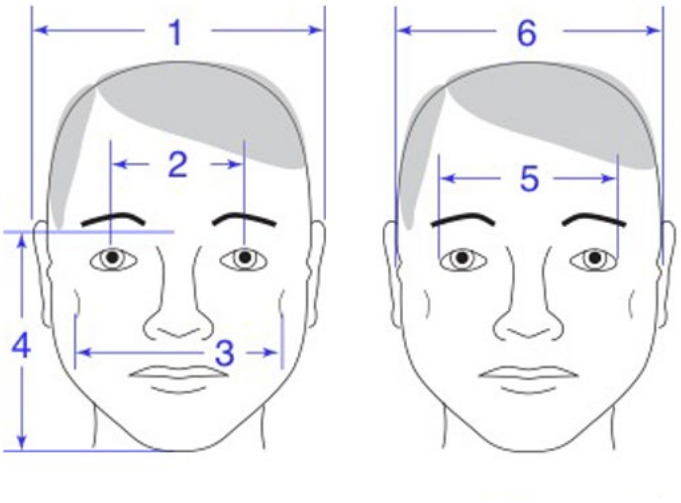


Table 4. Static adult human physical characteristics of the head, from Wikipedia

Measurement	Image	Description	Gender	Percentile (Centimetres)				
				1st	5th	50th	95th	99th
Head breadth	1	The maximum breadth of the head, usually above and behind the ears.	Men	13.9	14.3	15.2	16.1	16.5
			Women	13.3	13.7	14.4	15.0	15.8
Bitragion breadth	6	The breadth of the head from the right tragion to the left. Tragion is the cartilaginous notch at the front of the ear.	Men	13.1	13.5	14.5	**15.5**	15.9
			Women	12.5	12.8	13.3	**14.3**	15.0

Choose Base Curve

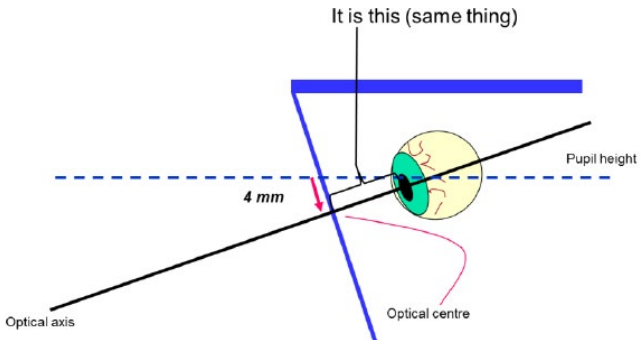
Base curve radius, or simply base curve, is the flatter curvature of the front surface on a spectacle lens. It is also the measurement of how much the lens curves to the shape of the face. The high or low base curve indicates how curved or flat the frame and lenses will be.

There are base curves range from 2 to 10. Most of the prescription eyeglasses have a 2 or 4-base curve, which means vision goggle need to be under 2-base curve to be able to fit most of the prescription eyeglasses while maintaining less volume dimension and weight. Besides, 6 to 9-base curve are commonly used in sports glasses and sunglasses. 10-base curve is typically found in shield style glasses.

Vertex distance and Pantoscopic angle?

Vertex distance, sometimes referred to as back vertex distance or BVD, is an critical part of ophthalmic optics. It is the distance between back vertex and corneal apex along the optical axis.

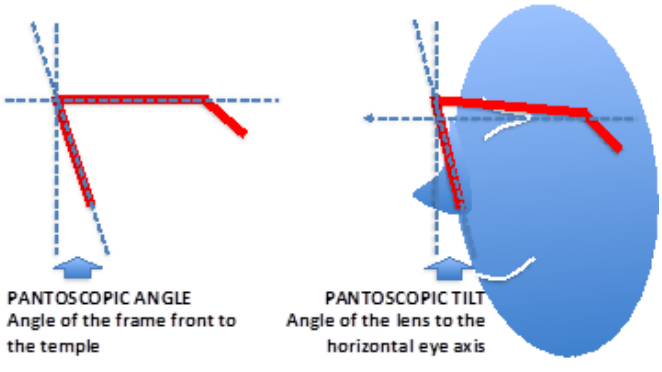
Averaged values calculated from a large amount of real-world fitting data. Examining this data, they found that on average, most lenses would be positioned approximately 13mm in front of the eyes for vertex distance, 10 degrees for Pantoscopic lens tilt and 5 degrees for frame wrap angle, otherwise called position of wear, or POW.



Vision goggle?

The lens should be further away from eye than prescription eyeglasses is, which means it should have a "vertex distance" at least over 13mm.

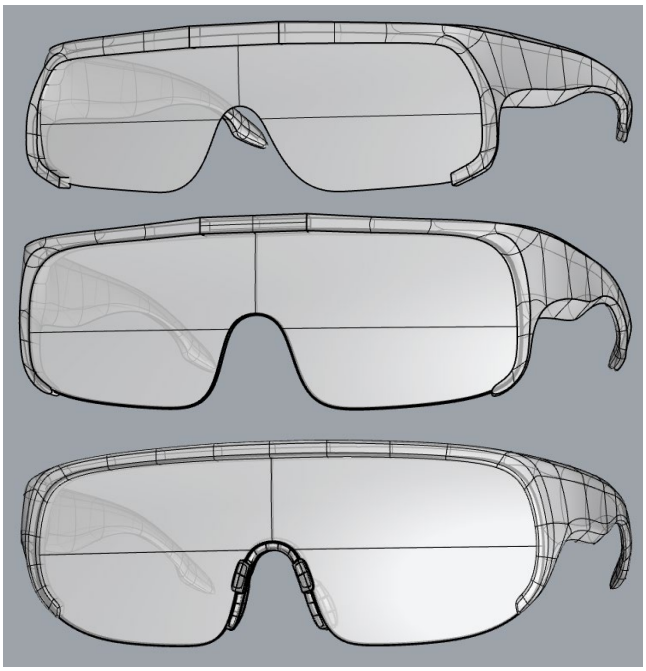
Also, it should not tilt too much, other wise it will interfere with the existing optical lens, thus I can go for a 6 degree tilt just for aesthetic purpose.

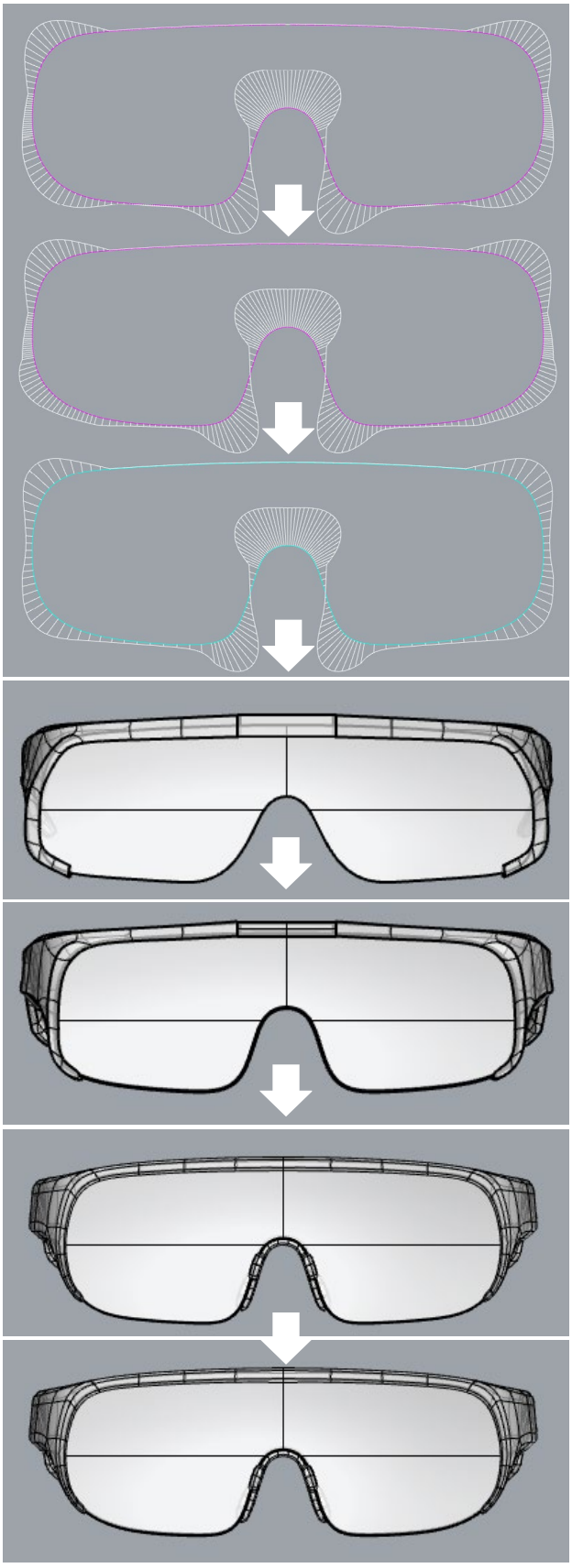


3D Modeling

Adjustments on Lens contour

I took the modern shape of safety goggle and ski goggle as a reference, and drew lens contour with several iterations of fine tuning the curvature as well as the overall looking. I intended to not make it looked like either safety goggle or ski goggle and etc., and I wanted it to convey a sense of future, too.

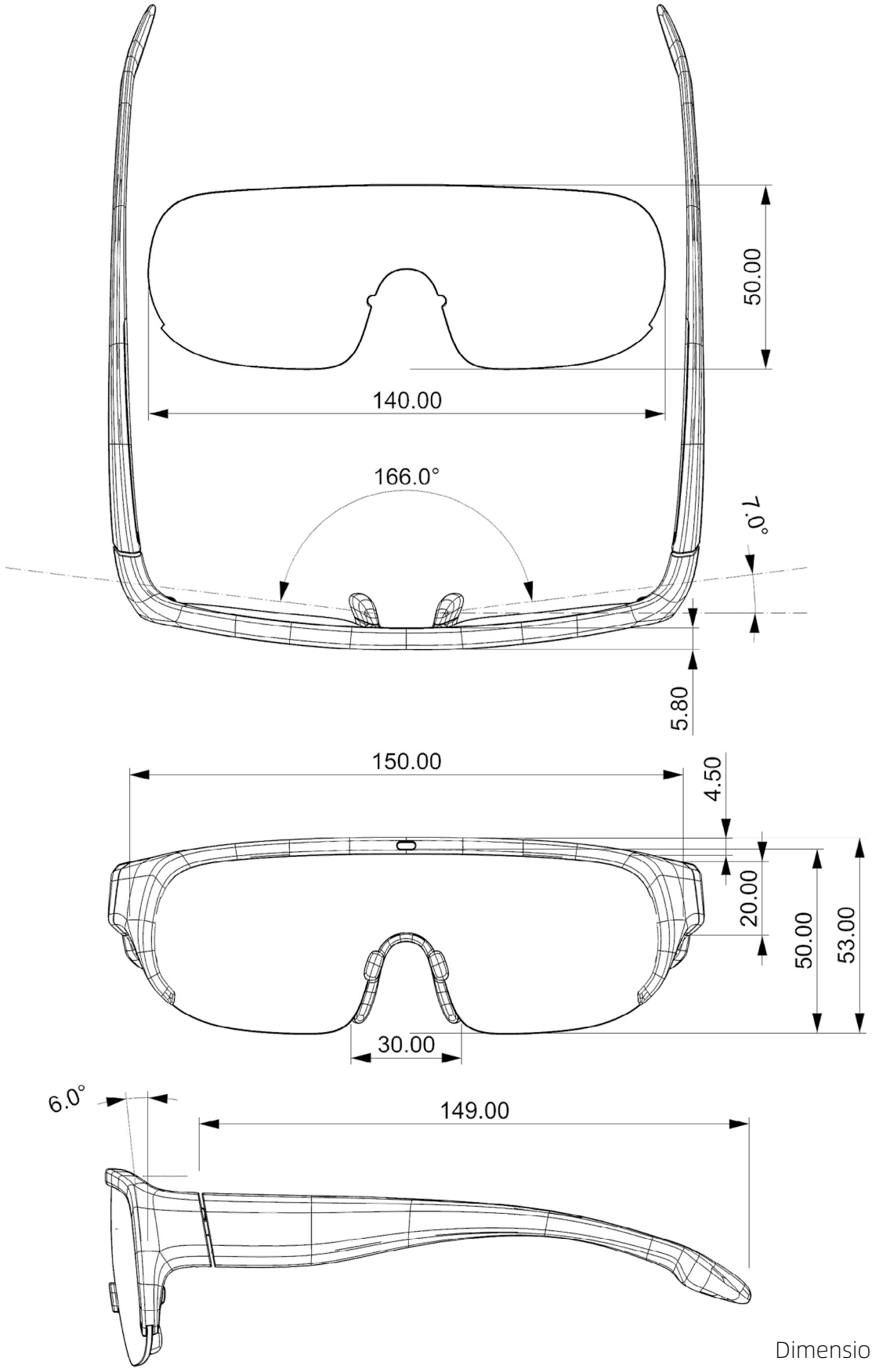




Adjustments on form

The frame form followed the contour of the lens, and the half frame design made it more immersive when wearing. The extended part on both left and right sides of the frame left enough space for IR eye sensorsvv. The overall form was adjusted several times to achieve the sense I mentioned in the mood boards. You can see it become less aggressive and more neutral look as I tuned.

Dimensions

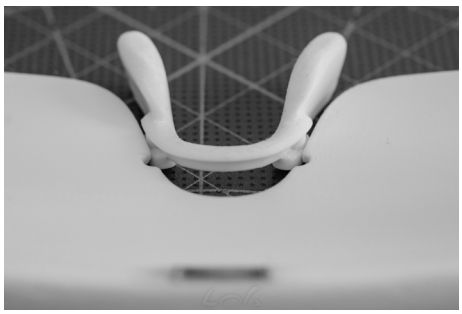
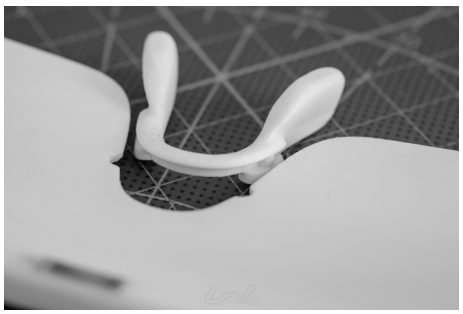
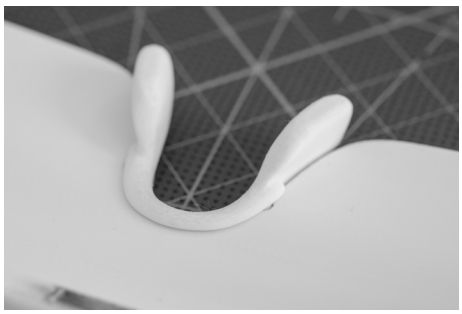


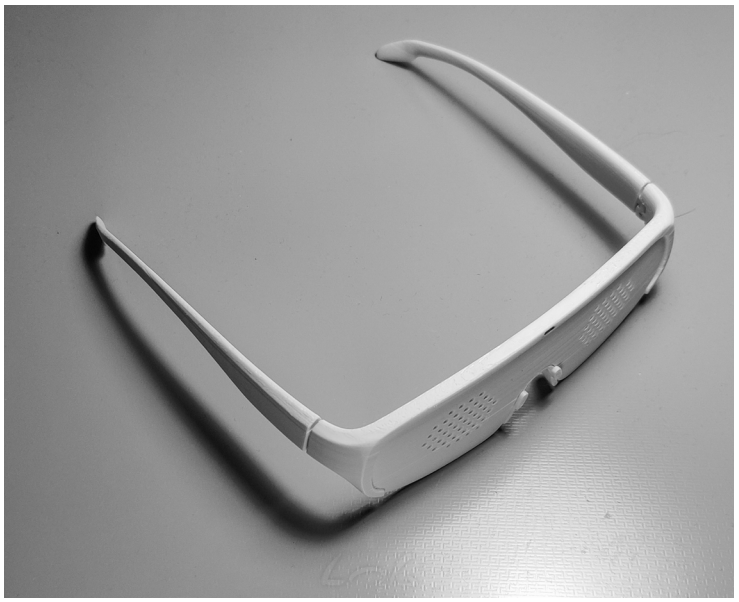
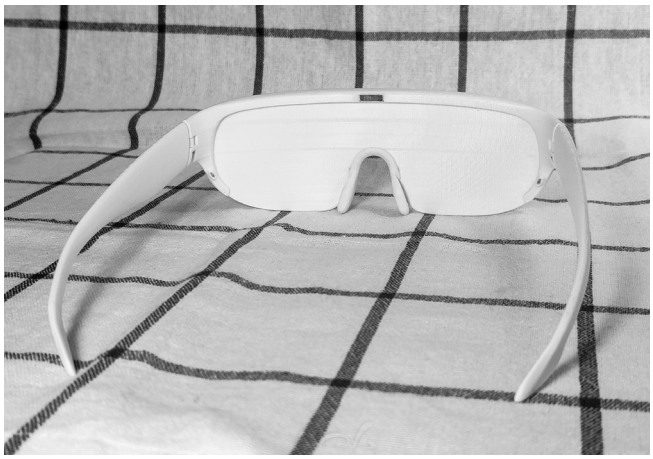
Dimension Drawing
Units: mm

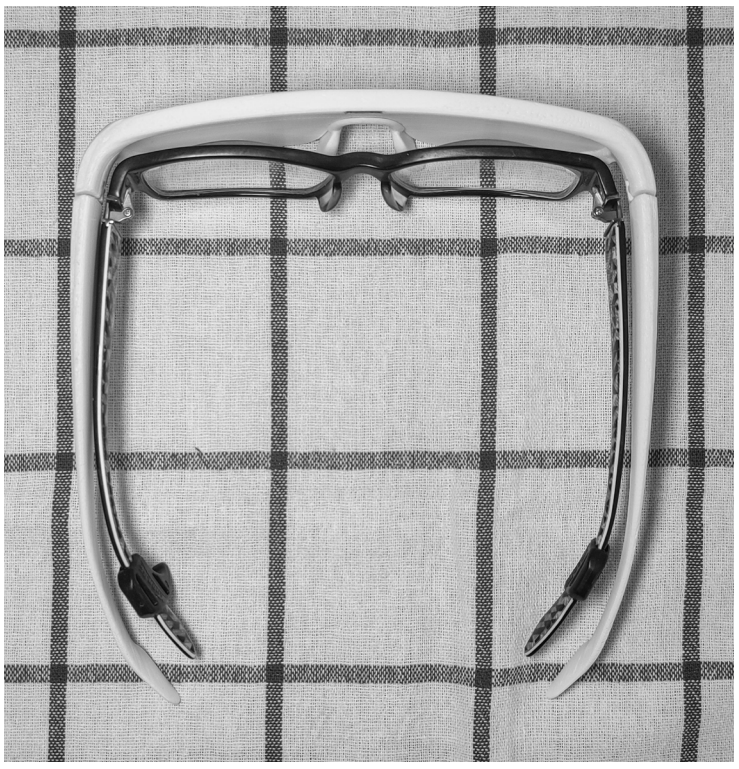
3D Printed Mock-up

To test the basic dimension of the 3D model, I printed it out with FDM printer. The lens was not made transparent since I did not have access to the workshop due to the COVID-19 pandemic, so I printed it together with the frame. The temples were assembled together with 2 screws.

This set of photos shows the details of the quick attachable nose pad and how it is put together.

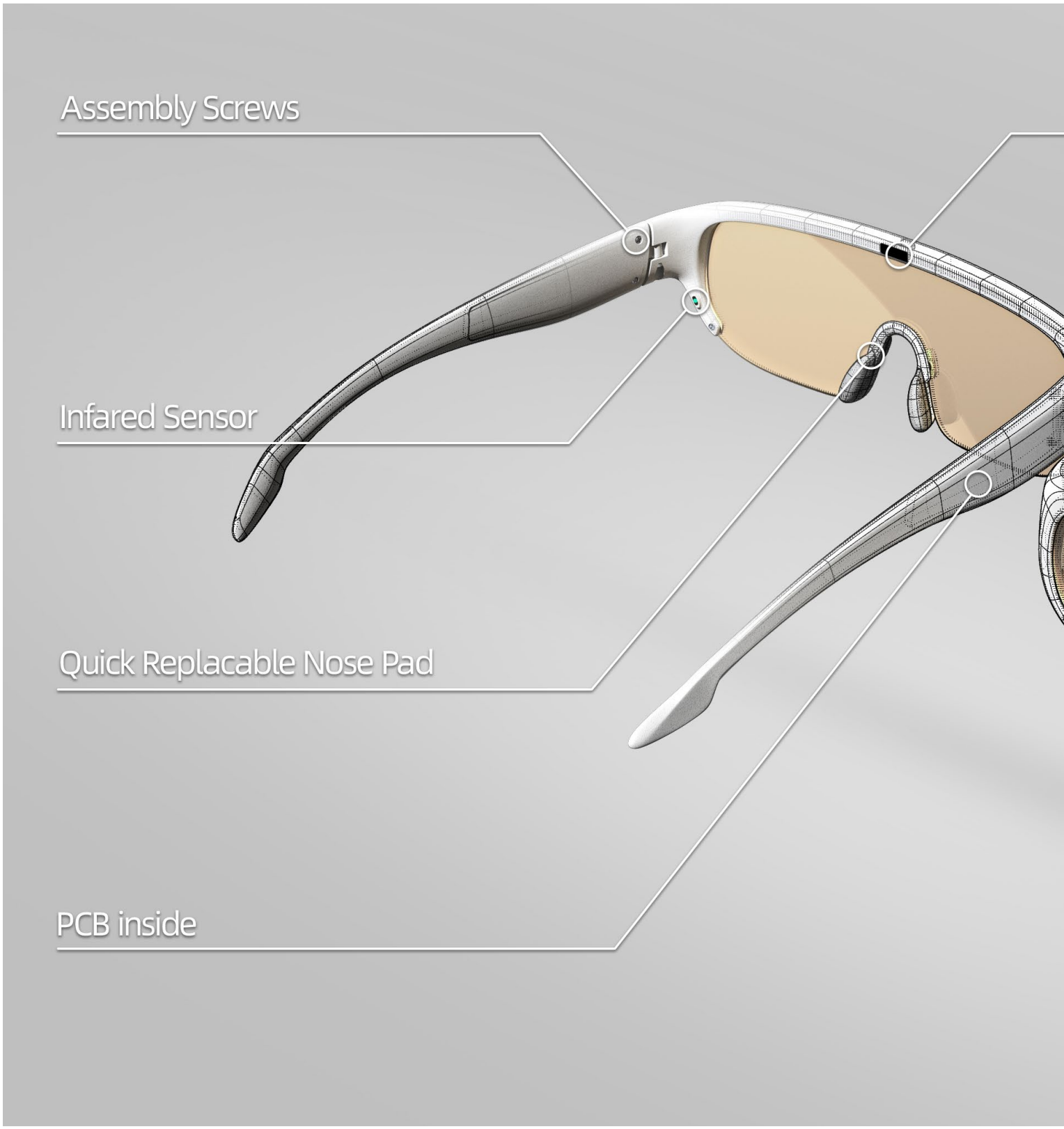



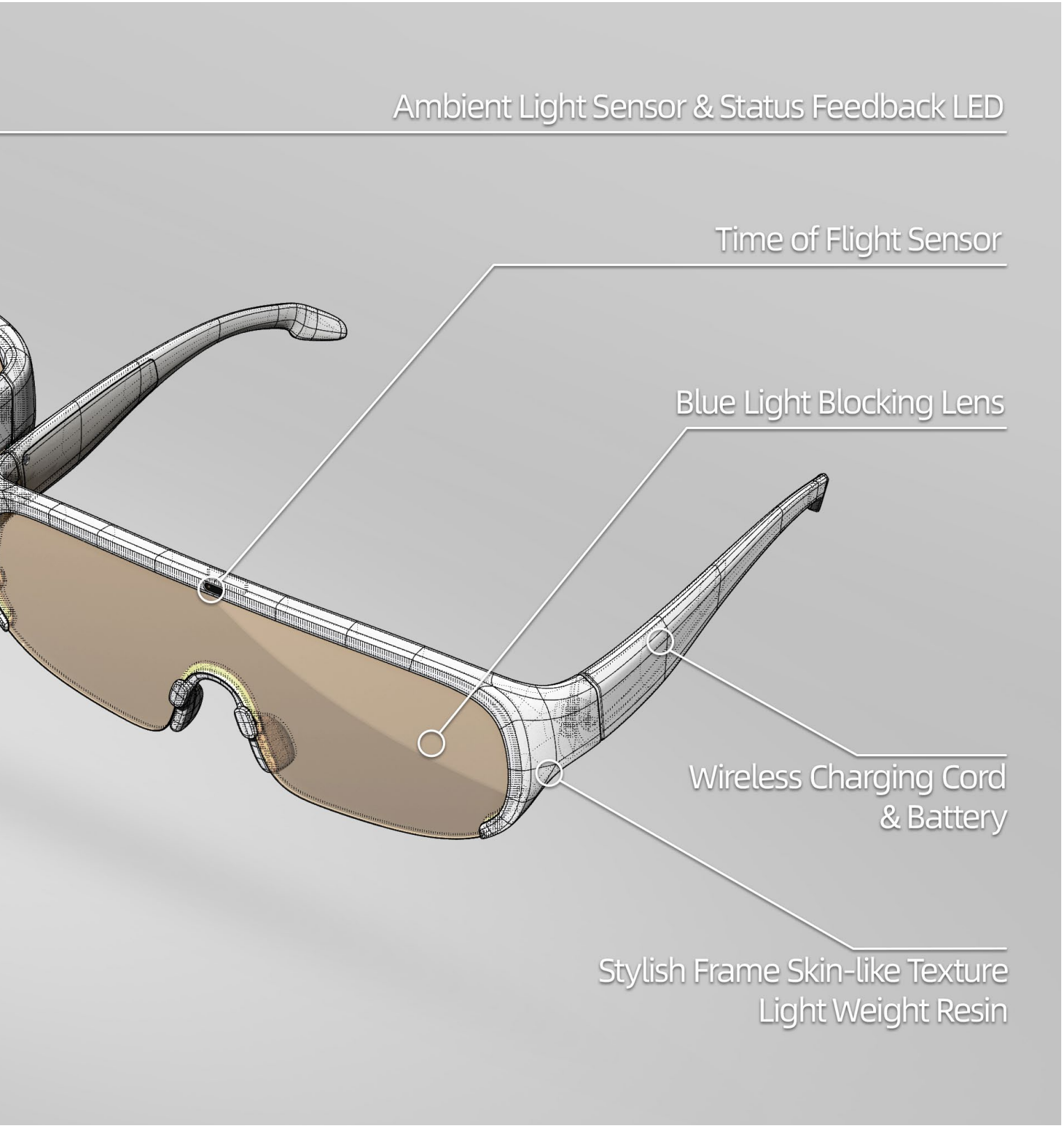
You can see how the size of it differs from a typical optical glasses in these pictures.

I tried wearing it with and without my own optical glasses. It fitted very well without my own glasses as the left photo shows.

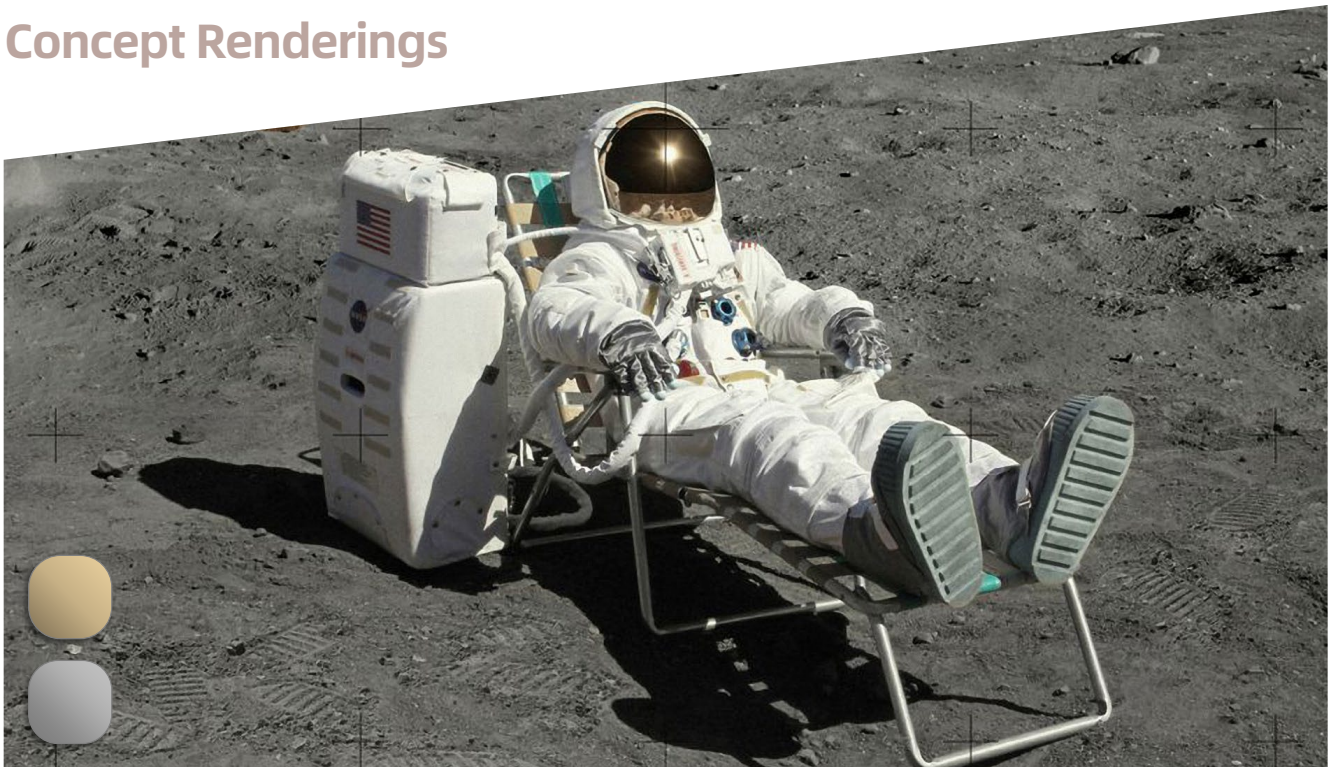
This photo was taken to show how both glasses can fit together. In fact, the temples form still need to be modified to be more compatible with existing eye glasses. I had experience wearing OTG (Over The Glasses) safety goggle which fitted very well, but I did't get one to refer to at that moment.

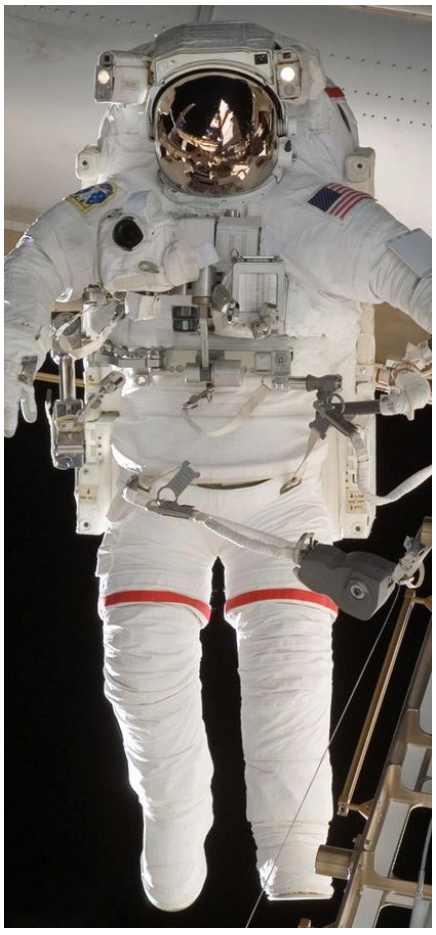
Construction




Ambient Light Sensor & Status Feedback LED
Time of Flight Sensor
Blue Light Blocking Lens
Wireless Charging Cord
& Battery
Stylish Frame Skin-like Texture
Light Weight Resin

Concept Renderings

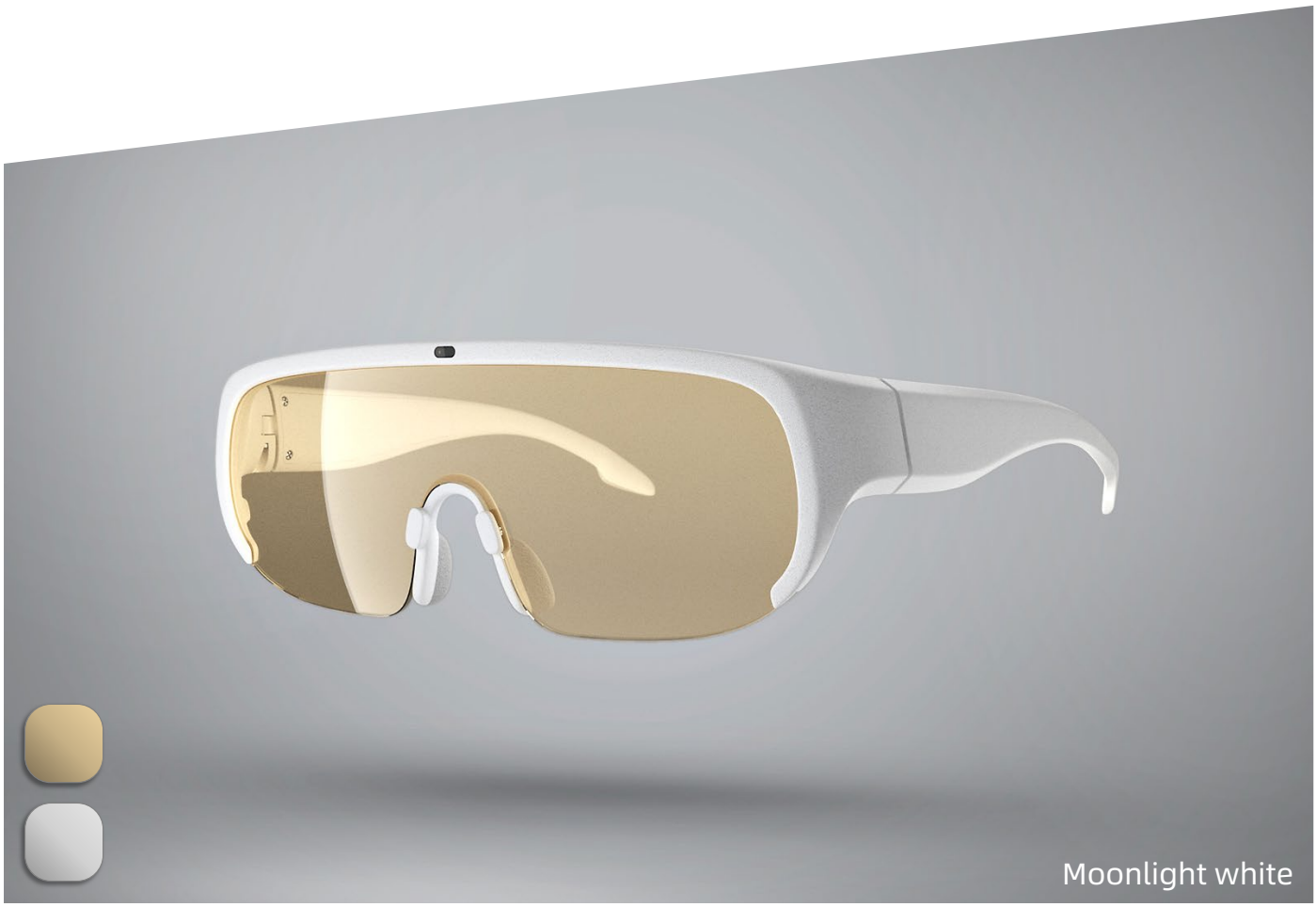




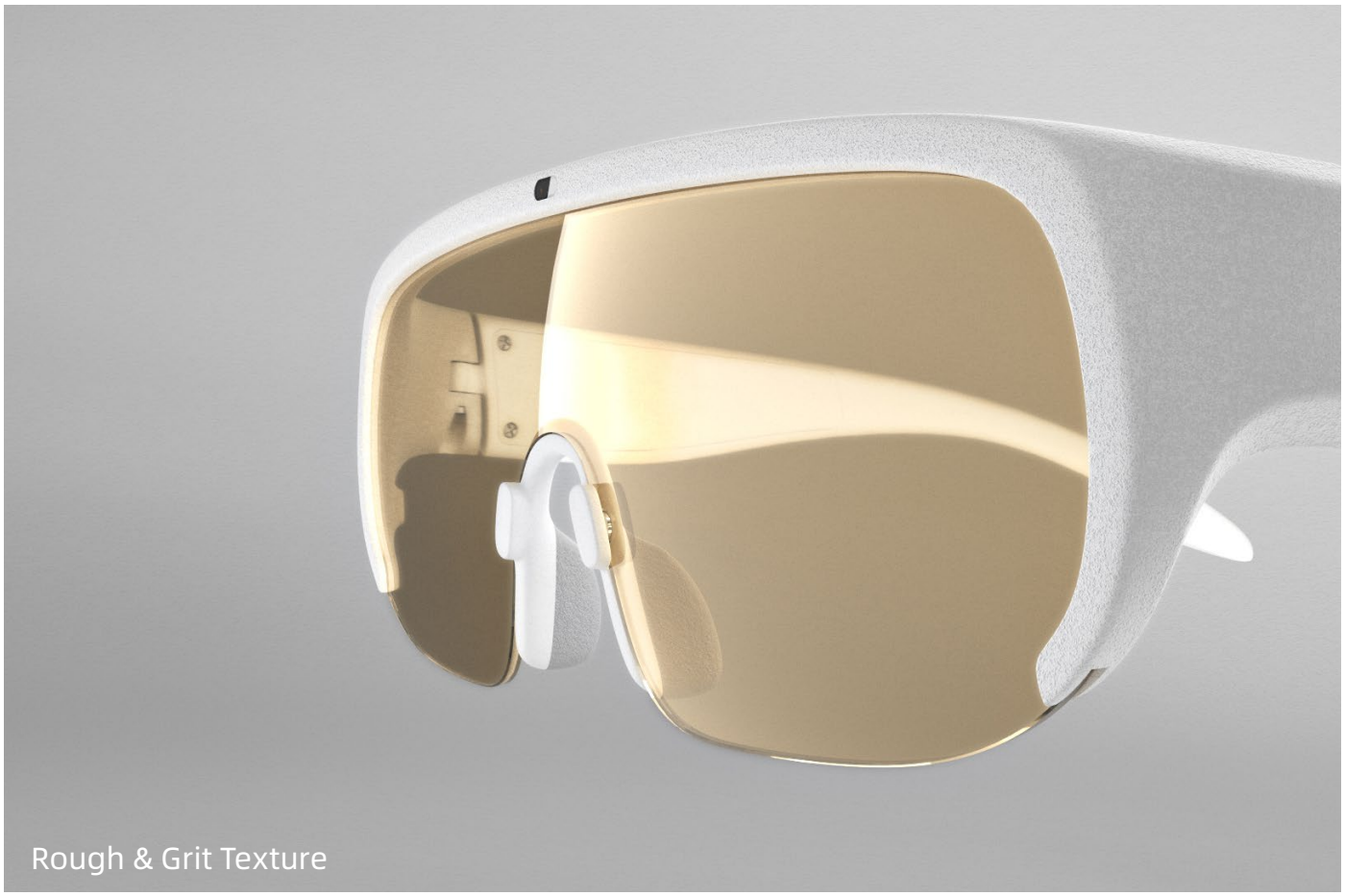
Cool & Focused

I was inspired by space suit, since it is the symbol of science and technology, and it feels futuristic and cool. When astronauts perform space mission as the image shows on the left, they are calm and focused, which is what I wanted to convey that when wearing this goggle, you can be calm and focused.

So I picked a very light grey that is almost white and named it moonlight white, as well as a darker grey called moondust grey, but in the end I favored the white version very much. The lens color is a coincidence as current computer glasses lens can block blue light and looks yellowish.

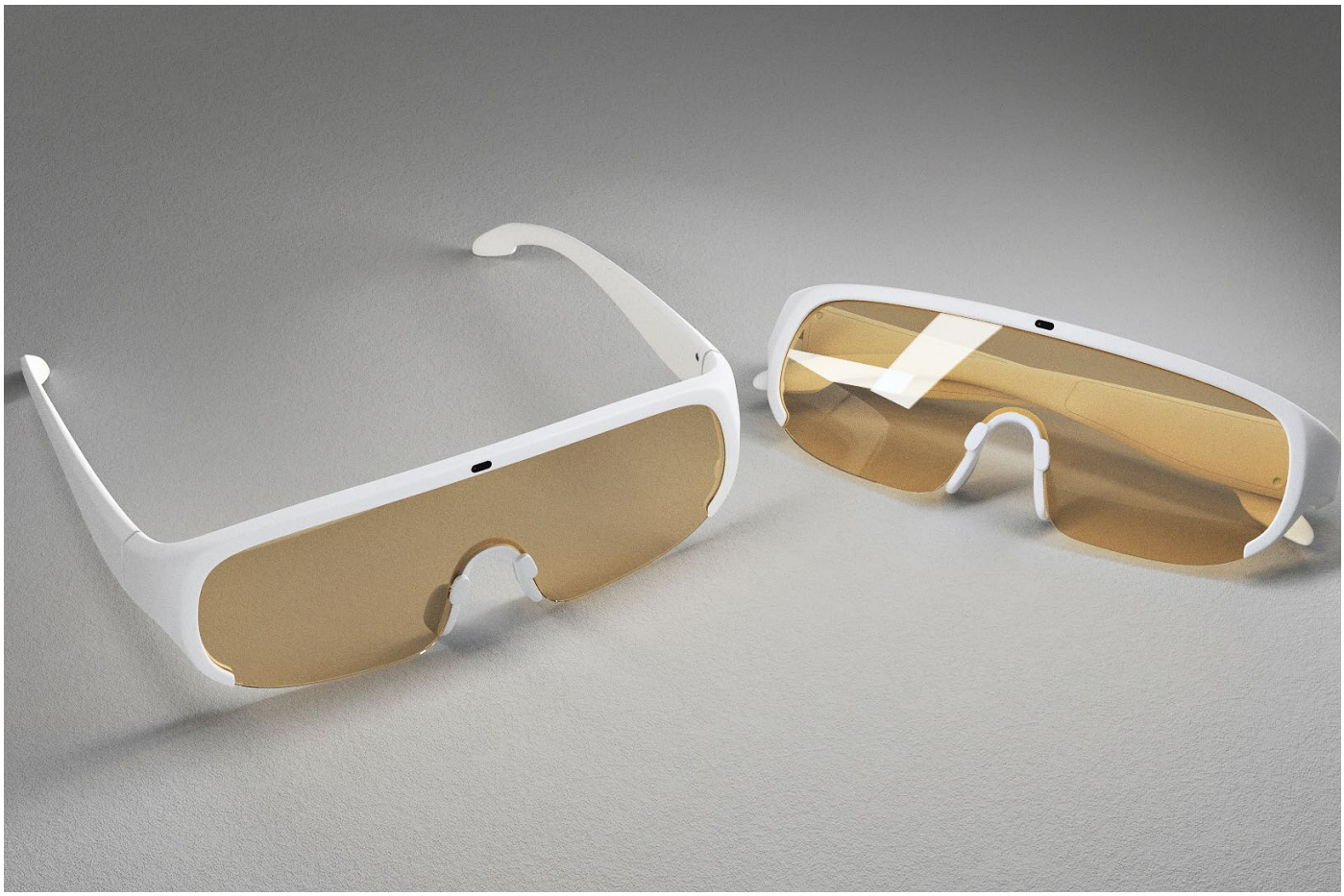

Moonlight white


Moondust grey



Rough & Grit Texture

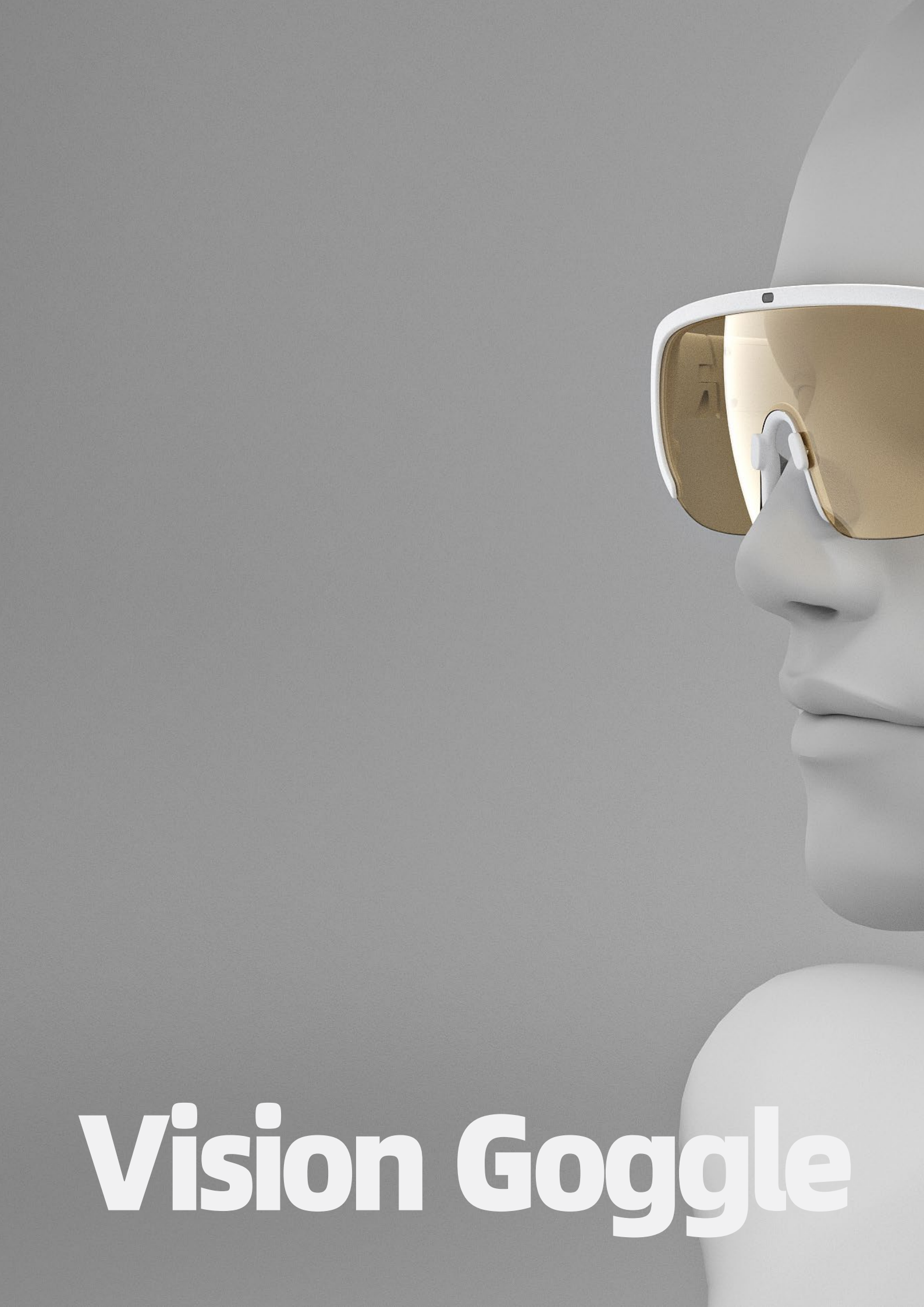
Smooth & Speckle



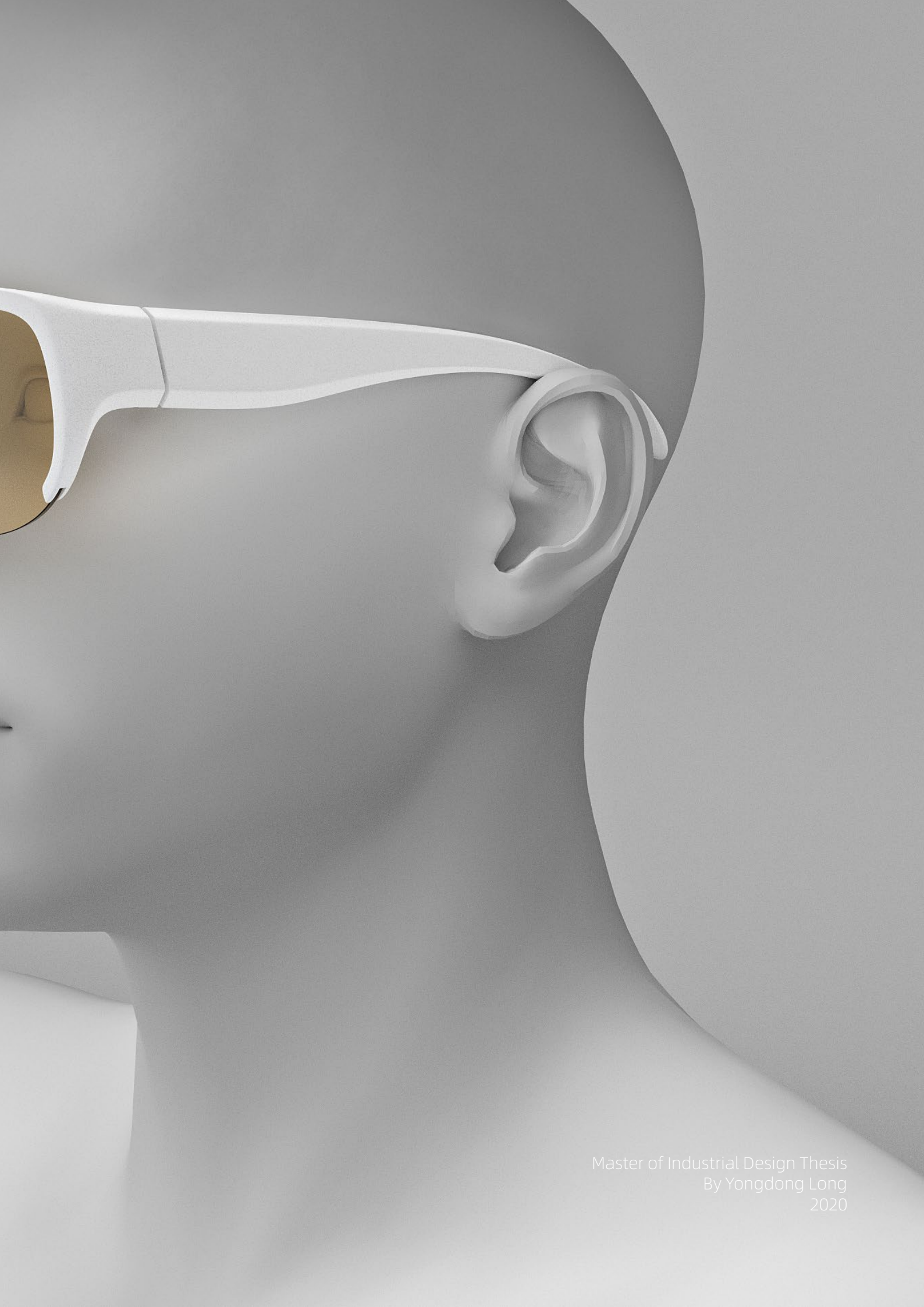

Vision
20

Goggle
020

Vision Goggle

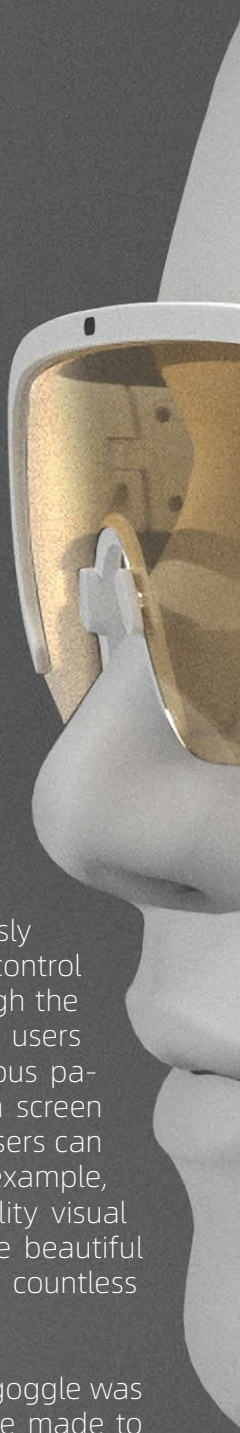


Vision Goggle



Master of Industrial Design Thesis
By Yongdong Long
2020

Reflections



Concept Reflection

The concept itself was quite interesting as it focused on helping people to achieve better habits and preventing CVS symptoms, and there was no such product on the market yet. It was quite challenging for me to sort out what function it should cover, how it should be defined and the overall concept itself, but I think, to me it was a good learning opportunity to do a concept design rather than another existing product.

In terms of the form design, I think through quite a few different combinations, errors and trials, the final result came out fine, which matched imagination of what this type of new product should be and not following the image of other type of goggle. I do thank my examiner Claus who pointed out this important principle for me. Final model looked futuristic and professional, but not too complicated as what I drew in the beginning, which was a success to me.

In terms of the detail, a LED indicator needed to be added to the back side of the frame as a feedback of standby mode. The lens can be designed separated, thus the lens can be easily regulated and customized for the distance of user's computer screen by optometrists. Wireless charging feature can be shown by putting an icon or pattern on the inner side of the temple. The hinge was not decided in fact, the final model was just modeled in order to be printed well and assembled with what I have currently, since under the COVID-19 situation, I could not either go out and buy stuff, or make stuff in the workshop at school.

In fact, it would be better to wirelessly connect with smartphone. Users can control it with more intuitive interaction through the mobile phone interface. For example, users can easily modify the settings of various parameters of the goggle through touch screen to better match their own scenarios. Users can also get feedback in other form, for example, mobile phones can provide high-quality visual and auditory feedback, there could be beautiful informative animation, and there were countless interaction possibilities.

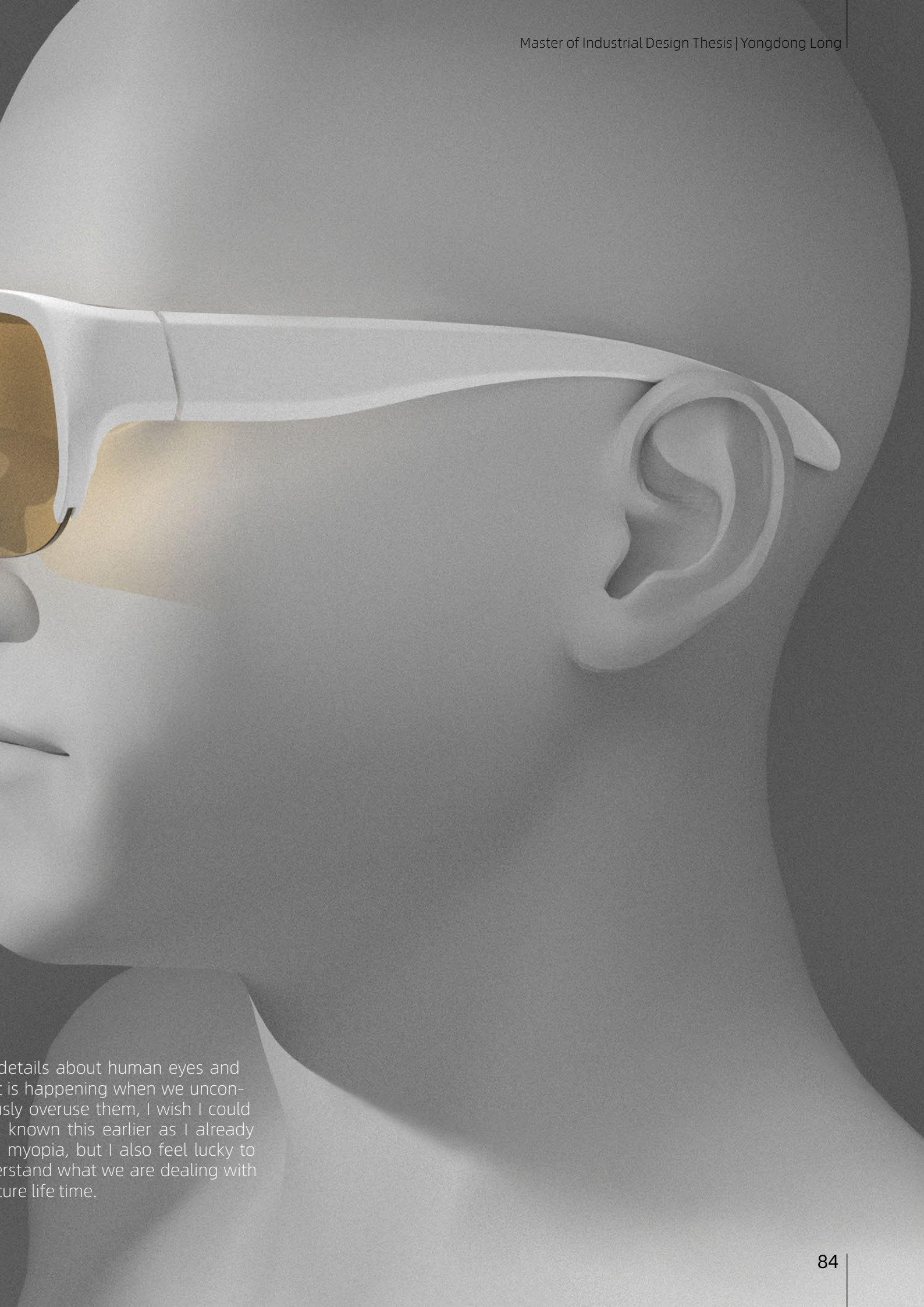
Overall, the achievability of the Vision goggle was high. Functional prototype needs to be made to conduct real user test. I think it opened up a possibility for people to look at as well.

Looking Forward

In addition to connecting to our cellphones, it can be connected to other smart IoT devices, such as computers, smart speakers, light bulbs, and other smart homes, and there are abundant possibilities.

Maybe there could be other better solutions into preventing CVS symptoms, which would be achieved through more sustainable ways instead of making physical products, thus I do hope my project and ideas can inspire other people, as well as bring the awareness of this underlying issue along with all of us.

Through this degree project, I get to know quite a few
what
sciou
have
have
unde
in fut



details about human eyes and
t is happening when we uncon-
usly overuse them, I wish I could
known this earlier as I already
myopia, but I also feel lucky to
erstand what we are dealing with
ture life time.

Reference

Literature Reference

Adrian Bartoszek, Kamil Szalast, & Grzegorz Kardas. (2019). Computer Vision Syndrome among undergraduate dentistry students. Journal of Education, Health and Sport, 6, 407. https://doi-org.ludwig.lub.lu.se/10.5281/zenodo.3253457

Al Tawil, L., Aldokhayel, S., Zeitouni, L., Qadoumi, T., Hussein, S., & Ahamed, S. S. (2020). Prevalence of self-reported computer vision syndrome symptoms and its associated factors among university students. European Journal of Ophthalmology, 30(1), 189–195. https://doi-org.ludwig.lub.lu.se/10.1177/1120672118815110

American Optometric Association. Computer Vision Syndrome (CVS). Available from: http://www.aoa.org/x5374.xml.

Anthony, K. (2018). What Causes Dark Circles Under Your Eyes? Retrieved from https://www.healthline.com/health/dark-circle-under-eyes

Akinbinu, T. R., & Mashalla, Y. J.* (2014). Impact of computer technology on health: Computer Vision Syndrome (CVS). Medical Practice and Reviews, 5(3), 20-30. Retrieved from https://academicjournals.org/journal/MPR/article-abstract/0905F9948599

Blehm, C., Vishnu, S., Khattak, A., Mitra, S., & Yee, R. W. (2005). Computer Vision Syndrome: A Review. Survey of Ophthalmology, 50(3), 253–262. Retrieved from https://doi-org.ludwig.lub.lu.se/10.1016/j.survophthal.2005.02.008

Computer Vision Syndrome. (n.d.). Retrieved from https://www.aoa.org/patients-and-public/caring-for-your-vision/protecting-your-vision/computer-vision-syndrome

Electronic screen alert: Avoid this vision risk (2017). Retrieved from https://www.health.harvard.edu/diseases-and-conditions/electronic-screen-alert-avoid-this-vision-risk

Fernández-Montero, A., Olmo-Jimenez, J. M., Olmo, N., Bes-Rastrollo, M., Moreno-Galarraga, L., Moreno-Montañés, J., & Martínez-González, M. A. (2015). The impact of computer use in myopia progression: A cohort study in Spain. Preventive Medicine, 71, 67–71. Retrieved from https://doiorg.ludwig.lub.lu.se/10.1016/j.ypmed.2014.12.005

Hassan, A., Kashifq, M., Masud, Z., & Raza, M. A. (2017). Prevalence of Computer Vision Syndrome (CVS) amongst the Students of Khyber Medical University, Peshawar. Ophthalmology Update, 15(2), 59–64.

Heiting, G. (2019). Red eyes (bloodshot eyes): How to treat red eyes. Retrieved from https://www.allaboutvision.com/conditions/red-eyes.htm

Jatinder Bali, Naveen Neeraj, & Renu Thakur Bali. (2014). Computer vision syndrome: A review. Journal of Clinical Ophthalmology and Research, (1), 61. Retrieved from https://doi-org.ludwig.lub.lu.se/10.4103/2320-3897.122661

Mutti, D & Zadnik, Karla. (1996). Is computer use a risk factor for myopia?. Journal of the American Optometric Association. 67. 521-30. Retrieved from https://www.researchgate.net/publication/14317819_Is_computer_use_a_risk_factor_for_myopia

Ranasinghe, P., Wathurapatha, W. S., Perera, Y. S., Lamabadusuriya, D. A., Kulatunga, S., Jayawardana, N., & Katulanda, P. (2016). Computer vision syndrome among computer office workers in a developing country: an evaluation of prevalence and risk factors. BMC Research Notes, 9, 1–9. Retrieved from https://doiorg.ludwig.lub.lu.se/10.1186/s13104-016-1962-1

Torrey, J. (2003). Understanding Computer Vision Syndrome. Employment Relations Today (Wiley), 30(1), 45–51. Retrieved from https://doi.org/10.1002/ert.10073

Vieira, F., Oliveira, E., & Rodrigues, N. (2019). iSVC – Digital Platform for Detection and Prevention of Computer Vision

Syndrome. 2019 IEEE 7th International Conference on Serious Games and Applications for Health (SeGAH), Serious Games and Applications for Health (SeGAH), 2019 IEEE 7th International Conference On, 1-7. Retrieved from https://doiorg.ludwig.lub.lu.se/10.1109/SeGAH.2019.8882438

Wisniewski, S.W. (2019). How Staring at Screens Affects Your Eyes. Retrieved from https://elemental.medium.com/how-staring-at-screens-affects-your-eyes-ebb4d686ec0e

M. Logaraj, V. Madhupriya, and S. Hegde, "Computer vision syndrome and associated factors among medical and engineering students in chennai.," Ann. Med. Health Sci. Res., vol. 4, no. 2, pp. 179-85, Mar. 2014.

Saito, S., Sotoyama, M., Saito, S., & Taptagaporn, S. (1994). Physiological indices of visual fatigue due to VDT operation: pupillary reflexes and accommodative responses. Industrial Health, 32(2), 57-66.

Luberto F, Gobba F, Broglia A. [Temporary myopia and subjective symptoms in video display terminal operators] La Medicina del Lavoro. 1989 Mar-Apr;80(2):155-163.

Ra, C. (1998). Good vision at work. Occup. Health Saf. 67(9):20-24.

Logaraj, M., Madhupriya, V., & Hegde, S. (2014). Computer vision syndrome and associated factors among medical and engineering students in chennai. Annals of Medical and Health Sciences Research, 4(2), 179-185. https://doi.org/10.4103/2141-9248.129028

Izquierdo JC, García M, Buxó C, Izquierdo NJ. Factors leading to the computer vision syndrome: an issue at the contemporary workplace. Boletín de la AsociaciónMédica de Puerto Rico Journal. 2007 Jan-Mar; 99(1): 21-28.

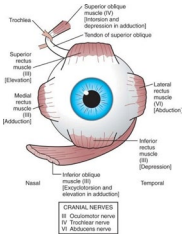
D. Wilson. Vertex distance and pantoscopic angle - a review. www.odob.health.nz, online publication 2015

Websites Referred

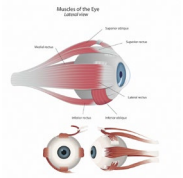
https://en.wikipedia.org/wiki/Eye_strain
https://www.nvisioncenters.com/conditions/tired-eyes/
https://www.pexels.com/
https://pixabay.com/
https://www.thoughtco.com/reduce-and-eliminate-glare-1206483
https://www.ifixit.com/Guide/iPhone+6s+Plus+Taptic+Engine+Replacement/51220

https://pupil-labs.com/products/core/
https://pupil-labs.com/products/invisible/
https://en.wikipedia.org/wiki/Time-of-flight_camera
https://www.st.com/en/imaging-and-photonics-solutions/vl53l0x.html
https://www.sohu.com/a/291297900_120083455
https://en.wikipedia.org/wiki/Human_head
https://en.wikipedia.org/wiki/Base_curve_radius
https://www.sportrx.com/blog/what-is-the-base-curve-of-sunglasses/#base-curve-basics
https://www.2020mag.com/article/base-curve-selection
https://www.2020mag.com/ce/improving-free-form-lenses-with-99E33
https://www.2020mag.com/ce/the-real-details-of-vertex-5E16F
https://www.slideshare.net/askararipra/vertex-distance
https://spaceplace.nasa.gov/all-about-the-moon/en/
https://earthobservatory.nasa.gov/images/82693/earthrise-revisited

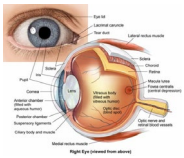
Image Sources



[Muscles And Eye Movements (Extraocular Eye)]. (n.d.). https://www.pinterest.com/pin/92464598580002106/

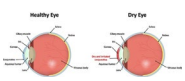


George R. Beauchamp, M.D. (n.d.). [Muscles of the Eye]. http://pediatricophthalmologypa.com/strabismus-surgery-table-contents/anatomy-actions-extra-ocular-muscles/

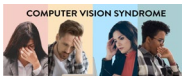


[Anatomy of the Eye]. (n.d.). https://columbiaeyeclinic.com/anatomy-eye/

[Eye-pain-computer-man]. (n.d.). https://iristech.co/matte-vs-glossy-screens/



[Diagram of Dry Eye]. (n.d.). https://www.themedicaleyecenter.com/eye-conditions-manchester/dry-eye/



New England Eyecare. (n.d.). [Computer Vision Syndrome]. https://gunnar.com/blog/what-is-digital-eye-strain/

[Steam eye mask sold on AliExpress]. (n.d.). https://www.aliexpress.com/item/4000357844791.html?spm=a2g0o.productlist.0.0.1bec4120drjuvc&algo_pvid=94b0d42a-a57f-4fa0-98e3-3275af060da0&algo_expid=94b0d42a-a57f-4fa0-98e3-3275af060da0-32&btsid=0ab6f82c15929261296898537ebfc0&ws_ab_test=searchweb0_0,searchweb201602_,searchweb201603_

[Steam eye mask sold on Amazon]. (n.d.). https://www.amazon.cn/dp/B002RUL0BO

[USB powered hot compression eye mask sold on Amazon]. (n.d.). https://www.amazon.de/ARRIS-Electric-temperaturgesteuerte-Schlafst%C3%B6rungen-Meibom-Krankheit/dp/B07HQ66GTT/ref=sr_1_18?dchild=1&keywords=usb+augenmaske&qid=1592927188&sr=8-18

[USB powered hot compression eye mask sold on AliExpress]. (n.d.). https://www.aliexpress.com/item/4000251113600.html?spm=a2g0o.detail.1000015.1.1af329d9UGVWUt&scm=1007.14452.151110.0&scm_id=1007.14452.151110.0&scm-url=1007.14452.151110.0&pvid=679a8598-7c76-4c98-8d5e-d22b27d36beb&ad_pvid=202006230852002418605229445654891343_1&fromDetail

[USJ USB powered hot steam eye mask]. (n.d.). https://m.tb.cn/h.VLb-8gop?sm=6ae866

[Hand-held multi-purpose Steam Console]. (n.d.). https://m.tb.cn/h.VLs-d5H7?sm=32cbaf

[Multi-purpose Steam Console]. (n.d.). https://m.tb.cn/h.VLsdXLG?sm=5cf52e

Aurai. (n.d.). [Aurai-The World's 1st Cool/Warm Water-propelled Eye Massager]. https://www.kickstarter.com/projects/aurai-rio2019/aurai-the-worlds-1st-cool-warm-water-propelled-eye

[Breo iSee M air pressure hot compression eye massager]. (n.d.). http://my.breocare.com/product/isee/35.html

[Breo iSee4 air pressure hot compression eye massager sold on Amazon]. (n.d.). https://www.amazon.de/Massager-Electric-Portable-Pressure-Eyestrain/dp/B07M5RZD1Q/ref=pd_sbs_364_4/262-7586069-4232815?_encoding=UTF8&pd_rd_i=B07M5RZD1Q&pd_rd_r=6613bf47-c3db-4a5e-a5d6-4814099baa19&pd_rd_w=yH6Hf&pd_rd_wg=Tsapi&pf_rd_p=42bf0ad8-ce6f-4127-a2f0-106727020a41&pf_rd_r=E35S4CBKP5FQT2NFFHTG&psc=1&refRID=E35S4CBKP5FQT2NFFHTG

[RENPHO air pressure hot compression eye massager sold on Amazon]. (n.d.). https://www.amazon.de/RENPHO-Augenmassageger%C3%A4t-W%C3%A4rmekompression-Wiederaufladbar-Augenschmerzen/dp/B07SM61FCT/ref=sr_1_1_sspa?__mk_de_DE=%C3%85M%C3%85%C5%BD%C3%95%C3%91&dchild=1&keywords=eye+massager&qid=1587849277&sr=8-1-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExT09LUkZSVVJFWTMxJmVuY3J5cHRlZElkPUEwNzgzMjgzVzBQRVJMMTMzT0oxJmVuY3J5cHRlZEFkSWQ9QTAyNjI2OTNRUU41OUUxVDc1T0gmd2lkZ2V0TmFtZT1zcF9hdGYmYWN0aW9uPWNsaWNrUmVkaXJlY3QmZG9Ob3RMb2dDbGljaz10cnVl

[SKANDAS® air pressure hot compression eye massager sold on Amazon]. (n.d.). https://www.amazon.de/SKANDAS-Augen-Massageger%C3%A4t-Modell-2018/dp/B076ZTVHTT/ref=sr_1_2_sspa?__mk_de_DE=%C3%85M%C3%85%C5%BD%C3%95%C3%91&dchild=1&keywords=eye+massager&qid=1587849277&sr=8-2-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExT09LUkZSVVJFWTMxJmVuY3J5cHRlZElkPUEwNzgzMjgzVzBQRVJMMTMzT0oxJmVuY3J5cHRlZEFkSWQ9QTA3NDYzNTM4UjY1UzFNUUs1OUsmd2lkZ2V0TmFtZT1zcF9hdGYmYWN0aW9uPWNsaWNrUmVkaXJlY3QmZG9Ob3RMb2dDbGljaz10cnVl

[Magnetic vibration eye massager sold on Amazon]. (n.d.). https://www.amazon.de/Komfortable-elektrische-augenmassageger%C3%A4t-gesundheitsversorgung-massageger%C3%A4t/dp/B07KG8MYMC/ref=sr_1_11?__mk_de_DE=%C3%85M%C3%85%C5%BD%C3%95%C3%91&dchild=1&keywords=SKG+eye+massager&qid=1588266199&sr=8-11

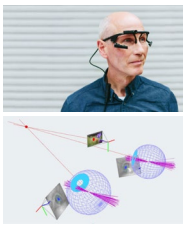
Krazycos. (2014). [Computer "Eyegonomics "]. http://www.newenglandeyecare.com/AboutUs/services/cvs/index.aspx

[SKG 4301 Detachable hot compression eye massager sold on AliExpress]. (n.d.). https://www.aliexpress.com/item/4000639314771.html

[LEFAN Cool/Warm handheld vibration eye massager]. (n.d.). https://www.banggood.com/LEFAN-Multi-Temperature-Vibration-Handheld-Eye-Massager-Wand-for-Wrinkle-Relieves-Dark-Circles-Puffiness-p-1430919.html?ID=513346&cur_warehouse=CN https://gagadget.com/en/33322-xiaomi-launches-portable-lefan-eye-massager-for--46/

[Brain illustration]. (n.d.). https://images.app.goo.gl/7P2jZTRyGqzcbNex9 https://www.healthline.com/human-body-maps/brain#conditions

[Anti-blue light computer glasses]. (n.d.). https://images.app.goo.gl/7P2jZTRyGqzcbNex9 https://www.amazon.cn/dp/B07PRD8869/ref=lp_111067071_1_21?s=hpc&ie=UTF8&qid=1592983006&sr=1-21



[Pupil Core eye tracking kit from Pupil Labs]. (n.d.). https://pupil-labs.com/products/core/

[Pupil Core eye tracking kit from Pupil Labs]. (n.d.). https://www.tobiipro.com/product-listing/tobii-pro-glasses-2/

[Duka LS-P rechargeable rangefinder]. (n.d.). https://www.banggood.com/XIAOMI-DUKA-LS-P-Intelligent-Digital-Laser-Rangefinder-Rechargeable-Hunting-Golf-Distance-Meter-Range-Finder-p-1515410.html?cur_warehouse=CN

[Infared Laser Ranging Module sold on AliExpress]. (n.d.). https://www.aliexpress.com/item/4000258125803.html?spm=a2g0o.productlist.0.0.422b4457Vwss3H&algo_pvid=39419e87-7702-4775-85d1-b9674608a93e&algo_expid=39419e87-7702-4775-85d1-b9674608a93e-33&btsid=0be3769015929855281374909e2d08&ws_ab_test=searchweb0_0,searchweb201602_,searchweb201603_

Evan Noronha. (n.d.). [iPhone 6s Plus Taptic Engine Replacement]. CC BY-NC-SA. https://www.ifixit.com/Guide/Image/meta/PkcuG3snQBAjOhHS

[mEngine in MEIZU smartphone]. (n.d.). https://www.sohu.com/a/331605549_120247572

[Fujifilm X-T3 mirrorless camera]. (n.d.). https://fujifilm-x.com/global/products/cameras/x-t3/

[TEMT6000 Ambient Light Sensor sold on AliExpress]. (n.d.). https://www.aliexpress.com/item/32807018099.html?spm=a2g0o.productlist.0.0.2f7d660aQAWKc0&s=p&ad_pvid=2020062401113046244738371923000 4833534_5&algo_pvid=4cf88700-0a5a-466b-8be6-0e3bfa1a8b92&algo_expid=4cf88700-0a5a-466b-8be6-0e3bfa1a8b92-4&btsid=0ab6f8221592986290010723 8e6860&ws_ab_test=searchweb0_0,searchweb201602_,searchweb201603_

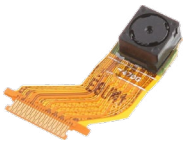
[POC Crave Sunglasses]. (n.d.). https://www.pocsports.com/eu/crave/CR3010.html?dwvar_CR3010_color=Hydrogen%20White&cgid=sunglasses-all#start=1

[OAKLEY Flight Deck™ XM Snow Goggle]. (n.d.). https://www.oakley.com/en-se/product/W0OO7064S?variant=888392103994

[OAKLEY Fall Line XL Snow Goggles]. (n.d.). https://www.oakley.com/en-se/product/W0OO7099S?variant=888392407481

[POC TECTAL Mountain Biking Helmet]. (n.d.). https://www.pocsports.com/eu/tectal/10505.html?dwvar_10505_color=Kalkopyrit%20Blue%20Matt&cgid=mountain-biking-helmets

[DJI MAVIC Mini Drone]. (n.d.). https://store.dji.com/product/mavic-mini?vid=84621



[Camera Module sold on AliExpress]. (n.d.). https://www.aliexpress.com/item/32902132134.html?spm=a2g0o.productlist.0.0.644b6d07elshf8&algo_pvid=46533c5c-6e7b-4e27-8258-f86893f66cf2&algo_expid=46533c5c-6e7b-4e27-8258-f86893f66cf2-59&btsid=0be3746c15929877260387983e6baa&ws_ab_test=searchweb0_0,searchweb201602_,searchweb201603_

[3M VisitorC Safety Goggle sold on Amazon]. (n.d.). https://www.amazon.de/3M-Arbeitsschutzbrille-Brillen-tr%C3%A4ger-VisitorC-Elektrowerkzeugarbeiten/dp/B00EJINCYK/ref=sr_1_15?dchild=1&keywords=3m+schutzbrille&qid=1592995792&sr=8-15

[Transparent Safety Goggle]. (n.d.). https://m.tb.cn/h.VpQ27tM?sm=56d69c

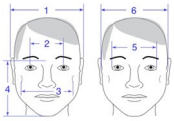
Syda_Productions. (2014). [Smiling female doctor with goggle]. https://depositphotos.com/39708651/stock-photo-smiling-female-doctor-pointing-to.html

[Pupil Invisible Eye-tracking glasses from Pupil Labs]. (n.d.). https://pupil-labs.com/products/invisible/

[Screenshot - Pupil Invisible Eye-tracking glasse]. (n.d.). https://www.youtube.com/watch?v=ZaUoyuBEOJo

[ToF Depth sensor on Vivo NEX smartphone]. (n.d.). https://www.sohu.com/a/291297900_120083455

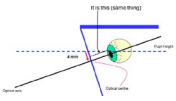
[VL53L0X Time-of-Flight (ToF) laser-ranging module]. (n.d.). https://www.st.com/en/imaging-and-photonics-solutions/vl53l0x.html



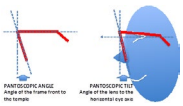
MarkStevenCohen. (2017). [Static adult human physical characteristics of the head]. CC BY-SA 4.0. https://en.wikipedia.org/wiki/Human_head#/media/File:AvgHeadSizes.png

[The different type of Base curve in sunglasses by @proofeyewear]. (n.d.). https://www.pinterest.ru/pin/159877855500880492/

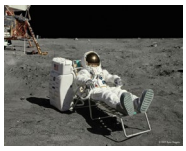
[Different Base Curves]. (n.d.). https://swindle.co.za/banner-tort.html



David Wilson. (2015). [Vertex distance (shown with normal pantoscopic angle)]. https://swindle.co.za/banner-tort.html



[Difference between Pantoscopic Tilt and Pantoscopic Angle]. (n.d.). https://www.2020mag.com/ce/the-real-details-of-vertex-5E16F



Ryan Nagata. (2017). [Astronaut lying on a chair on the Moon]. https://twitter.com/ryannagata/status/877195484086927361?lang=fi

[Astronaut Floating druing EVA]. (n.d.). https://www.taringa.net/+imagenes/traje-espacial-eeuu_137iu3

NASA. (2013). [Astronaut Working during EVA]. (n.d.). https://commons.wikimedia.org/wiki/File:ISS-38_EVA-2_(e)_Mike_Hopkins.jpg

Thanks

Master of Industrial Design Thesis
By Yongdong Long
Lund University
2020