To Find A Mocking Bird

THESIS APPENDIX | YUAN TIAN

RA. Design brief

DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT
Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name: Tian
initials: Y. given name: Yuan
student number:
street & no.:
zipcode & city:
country:
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email: Y.Tian-16@student.tudelft.nl

Your master programme (only select the options that apply to you):
IDE master(s): ★ IPD ○ DfI ○ SPD
2nd non-IDE master:
individual programme: - - (give date of approval)
honours programme: ○ Honours Programme Master
specialisation / annotation: ○ Medisign ○ Tech. in Sustainable Design ○ Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair: Arjen Jansen dept. / section: SDE
** mentor: Yu Song dept. / section: SDE
2nd mentor: Markus Klug
organisation:
city: country:

comments (optional)

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

Personal Project Brief - IDE Master Graduation

TU Delft

Design a solution for better nature exploration with digital augmentation — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 06 - 03 - 2023 — 31 - 08 - 2023 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

With more people going on all kinds of outdoor activities for part-time leisure, more scenarios of usage are created, which means the need for nature-related optics will not stay solely on a functional level, but go up to an experience level to cope with different kind of needs. To respond to the growing needs of users, Leica and its competitors have been applying digital features and extensions into optic products. Nowadays, adventurers take their oculars and spotting scopes out into the field not only for live-observing, but also for adding photographic extension in recording the beauty of nature. With rangefinders and its collaborative technologies, hunters and sports players are able to perform better under the guidance of the collected data. By adding a thermal camera in rifle scope, hunting for excessive wild animals has never been easier..... What's next for digitalization in optic products?

As a popular topic in technology area, digital augmentation(enhancing sensory presence by using digital content) has been applied into many practical fields. With concepts like AR in smart glasses and contact lenses under development, we can see the potential in applying augmentation technology to help boost the adventurers' experience. The project will be mainly focused on applying certain augmentation technologies into nature-related optic solutions meanwhile make it clear and intuitive for users.

One opportunity for the project is, digital augmentation in nature-related optic products is still quite new in the industry, existing products with similar ideas are mostly designed for military use. Such situation also implies a limitation that augmentation technology is probably not mature enough to support consumer product concepts to become reality quickly and economically, it might take years before they could be developed at a lower cost.

Optics as well as mechanics are close to their physical limits, therefore development becomes overly expensive and resource hungry. Therefore, it's necessary for companies to distinguish from each other, and the digital world does and will play an even bigger role. At the same time, user experience of current digital application in optic products is not yet optimized, due to the lack of intuitive guidance on digital features, therefore an improvement of digital interface will of course open up new business opportunities.

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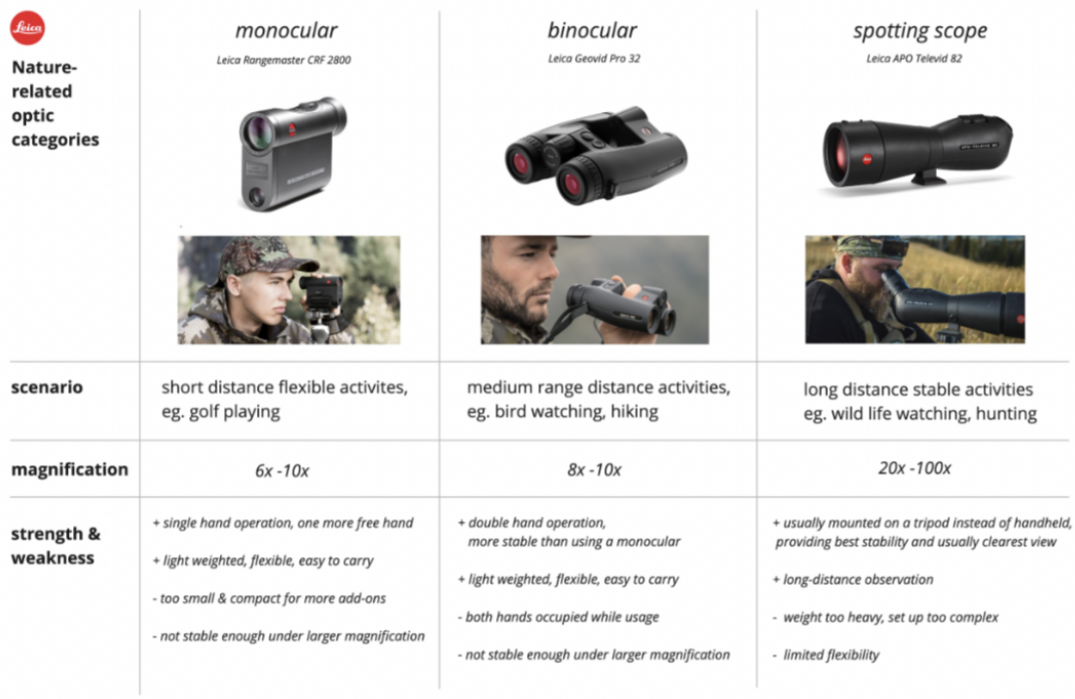


image / figure 1: 3 main categories of nature-related optic products

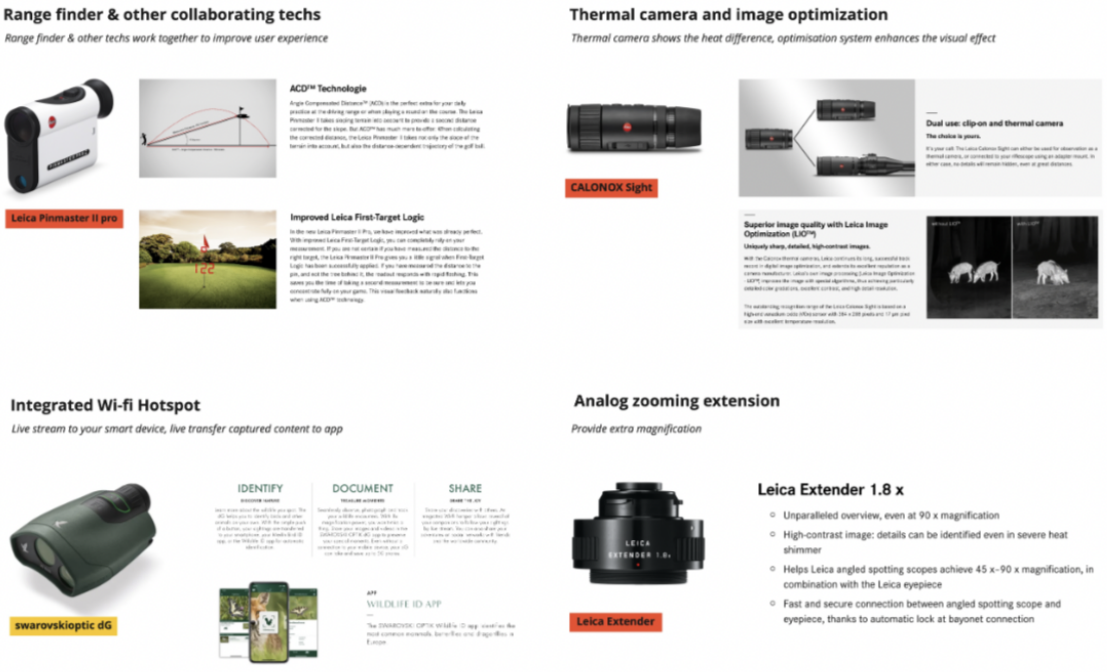


image / figure 2: Examples of current digital technology applications in optics products

Personal Project Brief - IDE Master Graduation

TU Delft

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

Firstly, there's currently no idea how to balance technology application and the current or potential need of user, it could be challenging to apply certain technologies in a way that nicely corresponds to the user needs.

Besides, it's unclear how the design result could find a balance between physical and digital features, many chances and direction are there to explore, eg. downsizing existing products by using digital attachment.

In additional, as the optics and mechanics development have almost reached a ceiling and are becoming similar among the brands of top quality, Leica needs to distinguish its products from other competitor brands with a clear brand language.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

Research users' need and insights, current functionalities of nature-related optic products, technologies that are already applied and have potential to be applied.
Design a solution that include digital augmentation technologies (eg. augmented reality) that helps improve the experience of users in their nature exploration process.

Result could be either a physical product-based solution or a digital feature to be applied on physical products.

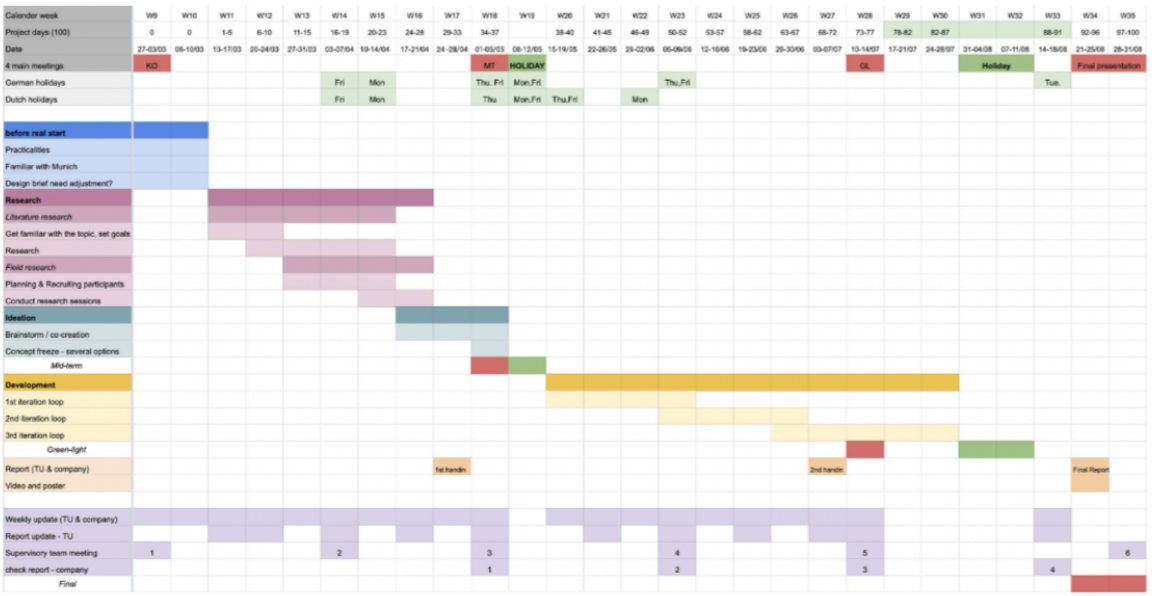
Initials & Name Y. Tian Student number 5263867

Title of Project Design a solution for better nature exploration with digital augmentation

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 6 - 3 - 2023 31 - 8 - 2023 end date



I'll be working full time based in Munich, Germany.

The thesis is planned into 2 phases:
"Research and ideation" phase which will last approx. 7 weeks till Mid-term evaluation,
followed up with "Concept development" phase that will last around 11 weeks till the end of the project.

During "Research and ideation", literature and field research will be conducted to further define user needs and design targets, then ideas will be generated under co-creation sessions, later categorized into several concept directions.

During "Concept development", multiple directions will be compared and narrowed down to one preferred direction. The project will then go into several iteration loops of "prototyping-testing-learning" before reaching a final solution.

For breaks within the project, a 1-week-holiday is planned after Mid-term and another one after Green light. Important test and supervisory meetings will be scheduled in advance to avoid national holidays. Summer vacation(4-5 weeks) is usually in between July and August, during which there won't be any tutorial.

The final presentation is now placed around end August.

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

The first reason for setting up the project is I got the opportunity to do my thesis with Leica (a German company well-known for its high quality camera and optic products). Since Leica is one of the best at its field, I believe the collaboration will help me to gain more insights into the corresponding industry.

Another reason for setting up the project is I'm looking forward to develop and apply some basic technical skills (eg. basic programming) during the time span of a thesis, and the application of "digital augmentation" will help me to gain some insights into this area.

Lastly, I want to exercise more during thesis, the "nature exploration" topic allows me to be more physical within and out of the project.

For the thesis, I want to prove my abilities in applying different design methods into different project stages, also in reasonable project management which will hopefully help me to finish the project in time before September.

I'd love to learn and improve on basic technical learning on product engineering & analysis and develop a brief understanding in coding and hardware. Besides, I need to improve my communication and presentation skills to be able to clearly and in a understandable way. If medium data analysis skills is required during the project, I'd also love to learn more about that, should I have extra time and energy.

Some personal competences that I developed over the years are design thinking, story-telling and visualization skills, and simple prototyping and iteration skills.

The personal learning ambitions that I want to address in the project are,
firstly, further develop a personal approach in learning new things (technical skills and understanding optic products).
secondly, gain insights on how designers are working at camera and optics industry.
and lastly, learn more about Germany by have an experience of living and working in one of its biggest cities.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

RB. Product principle

Binoculars

Figure 01 principle of binoculars

Spotting scopes

Figure 02 principle of spotting scopes

Functional analysis

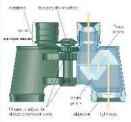
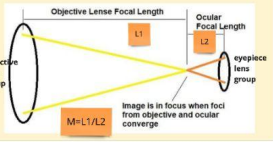
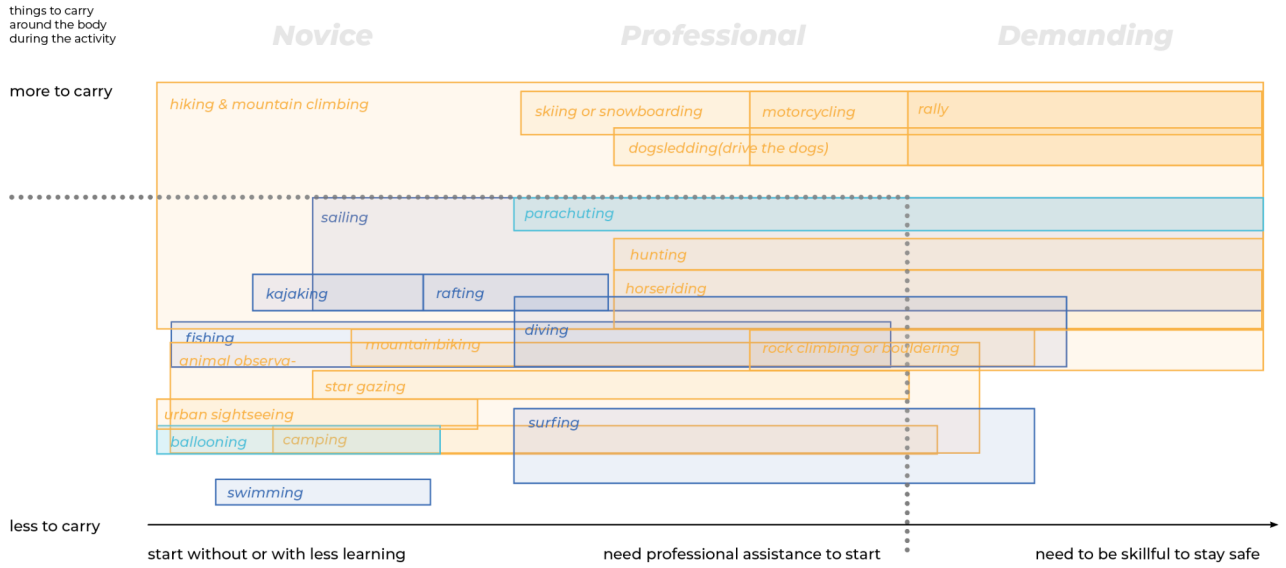
Main function	*Secondary function*		*Part*	*What does it do?*	*Where it is in the product?*	*Corresponding user need*	*Visual examples*
Get an enlarged view of objects	**Protection**		**Shell**	Protecting the inner structure	Outshell part surrounding the inner structure of the product	Protect the inner components, Withstand harsh weather, Good holding experience	
	Control	**Binoculars** 	**Focusing thumbwheel**	Adjust the distance in between objective lenses(at the front of binoculars), which changes the focus of the image	Usually between 2 barrels	Create a clear object image Adjust the focus distance	
			Eye diopter adapter(s)	Adjust the focus of the eyepiece to match user's individual eyesight, compensating for differences in visual acuity between 2 eyes	Typically located on one(or two) of the 2 eyepieces, or a separate knob or lever that can be turned or moved	Fit to personal eye condition (eyesight, eye distance, shape around eyes)	
			Hinge(s)	Adjust for the correct eye distance, some times help the product to be compact	Binoculars are usually with 1 hinge (in between barrels) or 2 hinges(on each barrel)	Observe comfortably	
			Eye rest(eye relief)	Keep a correct distance between eye and eyepiece, provide support around eyes	Usually on each barrel near the eyepiece		
		Spotting scopes 	**Focusing Dial** (sometimes composed with fast + fine focus dial)	Adjust the focus of the image by moving the internal lenses of the spotting scope	Usually on the body of the scope near the front end close to objective lens	Create a clear object image Adjust the focus distance	
			Eyepiece diopter adapter	Adjust the focus of the eyepiece to match user's individual eyesight, compensating for differences in visual acuity between 2 eyes	Usually a small knob or lever located on or near the eyepiece	Fit to personal eyesight	
			Zoom knob	Allows user to adjust the level of magnification for the target object	Near the eyepiece at the back of the spotting scope body, may be a separate ring or knob that can be turned to adjust the magnification.	Adjust the magnification range	
			Reticle and Reticle orientation control	Help measuring distance or align the scope; adjust the orientation of the reticle to match the target or compensate for uneven terrain.	In the eyepiece	Measurement reference during visual inspections	
	Magnification		**Eyepiece lenses**	2 group of lenses that receive and enlarge the view	on each barrel near the eye	receive enlarged views	
			Objective lenses		on each barrel near the observed objects		
			Prism	flip the view and make it upright	between eyepiece and objective lens groups	receive upright views	

Figure 03 functional analysis of traditional optic products(only binoculars and spotting scopes listed)

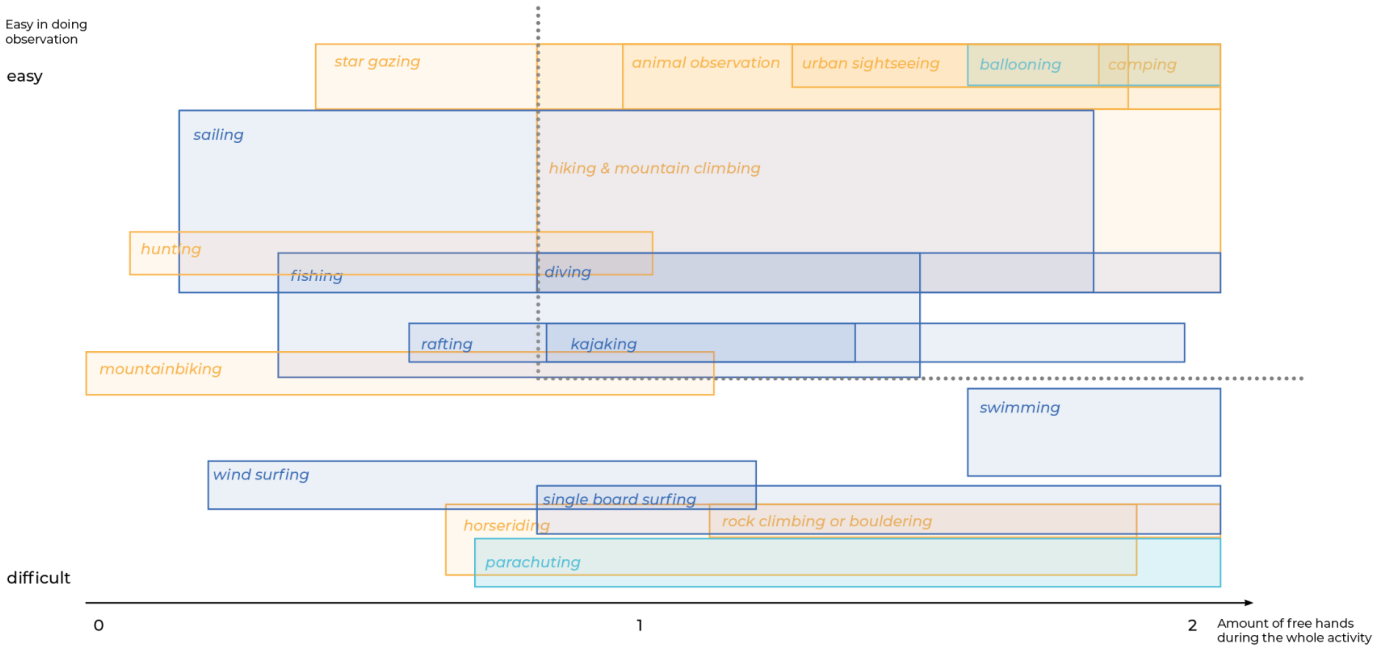
RC. Design direction selection

Activities-filtering

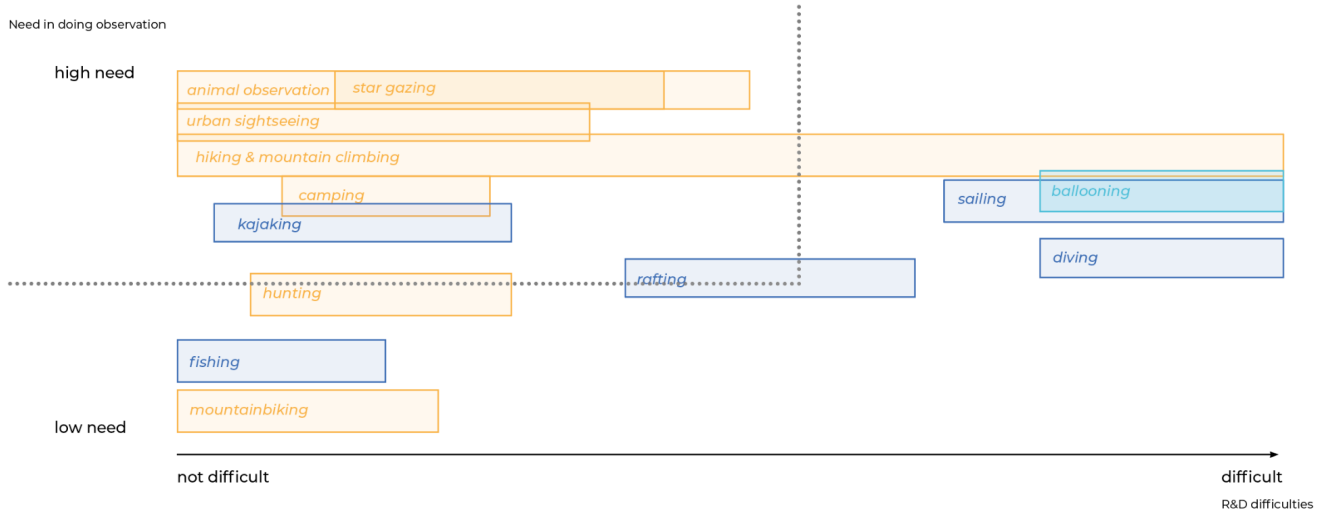
A qualitative evaluation with different nature-exploration activities was done for better deciding on what activity to design for. Different criterias were applied in the filtering process.
As this activity-filtering is not an important procedure in the design process but just a visualized thinking process, Of course, this is a general analysis without very detailed investigation, so might not be strictly correct.



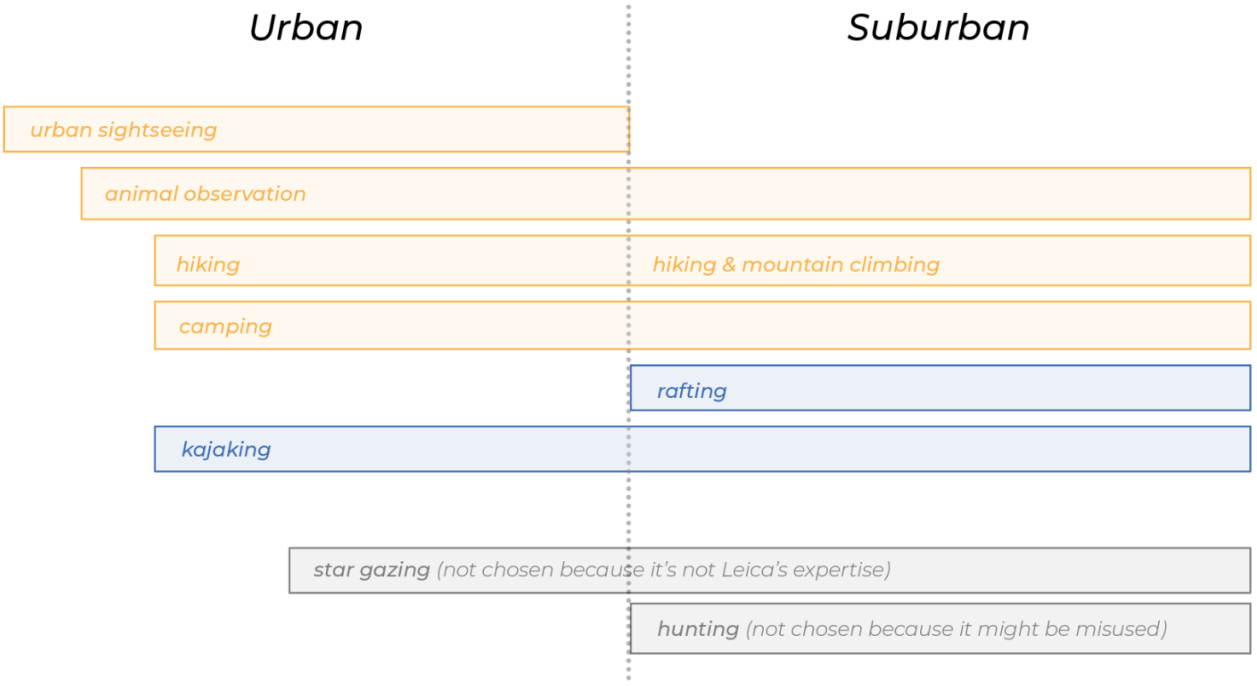
Filter 01 Skill demanding level - things to carry around the body



Filter 02 Amount of freehands during activity - difficulty in doing observation



Filter 03 Research & development difficulties and need in doing observation



Result List of possible nature exploration activities under urban and suburban environment

Conclusion from interviews

A brief user needs and insight summarization towards 3 candidate activities are concluded after 8 interviews. In the end, bird observation was selected as the target activity to design for.

Hiking(+mountain climbing)

Hiking (4)

- Stay on the correct route
- Stay safe and comfortable
- Weather prediction
- Receive information towards nature around them

1.Main purpose usually not observation
2.Don't have a clear observation target
3.Won't frequently use the device
4.Extra weight is not preferred

Bird observation (selected)

Birding (2)

- Find and locate birds
- Find birds from binoculars after spotting with bare eyes
- Take pictures easily
- Identification support
- More information on where to go

1.Clear observation target
2.Device frequently used
3. Lot of needs not satisfied, lots of potential to integrate with other features

Sightseeing

Urban sightseeing (2)

- Receive information of the attractions & local shops
- Don't want the information to be distracting
- Avoid transportation, language and currency problems

1.Observation content various among each user
2.Don't have a clear observation target
3.Hard to find the balance between 'additional information mode' and 'pure eye mode'

RD. User research - Literature and desktop

General bird observation related insights

Source of information: Reddit/Birding
Keyword: ‘tip’; ‘difficulties’
Data analysis support: Atlas.ti(generate quotes); OpenAI API playground(summarize insights)

Table 01 general bird observation related insights from Reddit

Topics	Gains	Pains	User needs
Place and time	eBird provides access to species-specific information, and allows for birders to report observations and become citizen scientists. Find areas where birds congregate can help with the observation	It’s not easy to get access to helpful resources towards birds in different habitats	To understand species-specific information Find a proper place for bird observation
Alone /with others	Going with a professional or a more experienced bird watcher can allow a starter to improve skills quickly and find birds without much effort. Enjoying yourself is the ultimate goal.	Birds can be disturbed by human noise when there are too many people on a trip. A laser pointer used in group collaboration could scare the birds away.	Enjoy and relax during bird watching trips Improve skills quickly
Attract & find	A natural environment, bird feeders and nesting materials really help in attracting birds. Sound playback is a very helpful way in attracting birds Learning alarm calls from other birds can help locate certain species of birds e.g. owls Strategies like drab clothing, unfocusing eyes, and sitting still to observe birds are helpful ways in finding birds.	Difficulty managing aggressive birds at feeders, Risk of infection from high tensile strength materials Large trees make it difficult to find birds People can mistakenly poison endangered birds while attracting them with food. Attracting birds with feeder has influenced the bird migration on a global level Only a limited number of birds could be observed in cities.	Attract birds safely(e.g. provide safe nesting material and clean food, keep unwanted birds away) Find birds without much effort Discover more species of birds
Observe	Getting closer to birds can help people to observe them in a better way.	Difficulty tracking moving targets due to the narrow field of view Difficulty in using binoculars with glasses Difficulty in finding rare birds - it requires luck and patience to find rare birds in the wild. Difference in vision between eyes lead to a complex adjustment procedure	Track moving targets with ease Simplified device set up
Identify	AI bird identification tools, e.g. Merlin app helps users identify birds. Personal and professional experience can help increase the knowledge in identification (according to sound, movement and distinguishing features) Field guide and Sibley app work well in identifying similar birds	Merlin app can return false positives and is not always accurate, and there is a lack of user-friendly bird-checking features. Difficulty mastering bird identification due to similarities between different species Difficulty in identifying birds with a camera, phone or eye sight due to distance, low light, and high ISO.	To identify birds without much effort
Take pictures	A digital camera with powerful zoom helps in taking good pictures. Good use of environment and right camera settings help in taking good photos. Getting closer to the bird is helpful in taking good photos	Digi-scoping takes some time to set up, birds might fly away during this procedure. Difficulties with camera settings: Manual focus can be challenging, Autofocus cameras have difficulty with birds It takes a lot of practice and repetition to get a best shot	Get good and clear birding pictures
After-activity	Some softwares help in quickly finding certain birding photos		Be organized and find bird pictures with ease

Insights on current optical devices

Source of information: Reddit/Birding; Reddit/Binoculars
Keywords: (R/Birding)'binocular'
(R/Binoculars) 'bird'
Data analysis support: Atlas.ti(generate quotes); OpenAI API playground(summarize insights)

The research is done under current traditional analog products without any digital functions.

Table 02 List of insights towards bird observation optics(mainly binoculars)

Insights	8x42 binoculars are mostly selected because of their nice balance of field of view, brightness, stability, size, weight and robustness.
	Binoculars are the most popular choice since they are relatively light-weighted, portable and provide a more natural double-eye view.
	Many bird observers love digiscoping through their binoculars with smartphones(though it might take longer without an adapter).
	Many bird observers take more than one device (with different magnifications) with them during birding trips for the best experience.
	A spotting scope can provide extra large magnification and enables great details.
	Specially processed optics can stop moisture from getting in the device.
	Fully coated lenses work well in reducing the light reflection and provide better observation experience.
	A robust and waterproof shell can withstand harsh weathers
	It's helpful to have a long strap for binoculars so it's easy to get them off or change the position of the strap.
Pains	Products from certain brands are of good quality but they are super expensive and not affordable.
	When the magnification reaches 10x or more, the view from optics will become shaky, also the field of view will become very small, making it hard for users to find birds in the view.
	Using a monocular for a long period of time can cause eye strain because it's not comfortable to keep one or both eyes open.
	Spotting scopes are too heavy and harder to get on target compared to binoculars, also it can be miserable to look through for an extended time with just one eyepiece.
	Digital binoculars with a camera built-in do not work well because the optics is average and the camera is hard to work with. Though it sounds like a beautiful idea to have a full-digital setup, the quality of images generated are below average.
	Some bird tour organizers just hand out binoculars to the attendees without giving them proper guidance on how to use the device or without supervision during usage, which might cause harm during the trip, e.g. looking at sun with binoculars might destroy eyes.
	Wearing binoculars crossbody might cause some bouncing and it can get complicated with a pack on too.
User needs	Affordable price range
	Good view quality(clear, bright, stable, no reflection)
	Good ergonomic experience under long observation time
	Proper and adjustable magnification
	Lighter weight and compact size
	Proper field of view for bird observation
	Close focus ability(to be able to see birds at a close distance)
	Withstand harsh weathers
	Easier way of taking pictures through optics
	Better guidance in usage

RE. Interview and personal experience

Interview questionnaire

General information: Age, Gender, Work, Current place, Nationality

Birding history

- How long have you been birding?
- Why did you start? How did you start?
- When and where did you start?
- How did you improve your skills gradually?

Current situation

- Do you go birding along or with others?
- If you go with friends, how do you collaborate with each other?
- Where do you go these days?
- How experienced would you say you are? Is there a criteria for that?
- What birding gears do you have? From which brands?
- Which app and website do you visit to improve skills or gain knowledge from?

Birding Journey(briefly introduce)

- Usually where and when do you go birding? Urban or suburban?
- What is the difference between birding in the city and birding out in the wild area?
- Any preparations before a trip?
- How do you know that there are birds nearby?
- How do you find birds(see them with your eyes)?
- How do you identify birds(tell species, maybe even tell their age and gender)?
- Do you usually take pictures of them? If so, how do you deal with the pictures?
- What do you do after a birding trip?

General takeaways

- What is the biggest difficulty you had during the process?
- Which is the happiest moment(motivation)?
- Learnings and tips for beginners/as a beginner?

Design-related questions

- Do you have a binocular or other optical devices? Which brand is it?
- What functions do you think could be included in the device?

Result documentation

Candidate A

Female, 32, Art Director, living in Belgium, birding more than 10 years
Hobbies are art, painting, kayaking(also good for birding to closely see birds in the river)

Birding history

I've been birding for 10 years already(I had times when I went every weekend, nowadays maybe once a month. Just getting into doing it more frequently again though :). I started because of self-interest and wasn't influenced by others - I found bird songs very interesting so I started to listen to bird songs and take notes of their characteristics to remember the sound and species of birds - gradually I enlarged my knowledge of birds as I met more of them in real life. The process is like a Pokemon collection.

I live in a more rural area so I started birding from little forests around my house. The forest is very quiet and not many people are there so you can do birding as long as you want without feeling awkward - when I stand still and in a peaceful mood I am always able to spot more birds. Stepping in the forest, standing still and feeling the sound of birds. I had a binocular with me at first (I remember it's a Nikon - which spec may I ask?) and later a DSLR camera(zooming https://www.tumblr.com/crotophaga
I think it's a 55 to 300 lens on the d5300 . It was my first lens and I was always worried that it would be too short range. After having that now for like... 10 years i have to say its the best zoom value vs. weight. I wouldn't want to change it for anything more long range :), both from Nikon, not the top products but okay for a birder.

Also btw some birds would be absolutely impossible to identify on site. Like Sumpfmeise(Marsh tit) and Weidenmeise. Don't know the English names :D also treecreepers. They are barely possible to identify on a good photograph so I doubt you could do that with binoculars.

Figure 01 Marsh tit (Left) and Willow tit(Right)

Looking back, I think my birding really started after I purchased the camera, Using it as binoculars when you are there. If you are on the spot searching through the lens, you quickly take a photo and can afterwards zoom in to be sure what you saw. Or look at home. Even if the photo shows only like 20%of the bird, you can make sure at home to identify it as it's a still image. If it was on site, the bird would be moving. so barely a chance to really identify if it doesn't make a sound.

Only annoying thing is the weight. Apart from the typical focus problems. I guess in newer models this is already improved. (Like if the camera doesn't focus on what I need quick enough but of course every second counts) - so you end up having sharp trees in the foreground and blurry birds in the background.... Definitely faster than manual focus on binoculars though :D haha especially tree jumping birds where you have no chance with binoculars. Like goldcrests

It's known in birding that early morning and late afternoon are two of the best timing of the day to spot birds. Sunny is the best of course :) The sunnier the better. I enjoyed the feeling of going out for birding early in the morning, it is the moment when most other species haven't woken up. There're less exercising people and cars around - I hear birds closely and feel I am one of them.

As I become more experienced I go from close-by places to hotspots for birding. Usually I go to more suburban areas(during specific seasons like migrating season. Big hotspots I would definitely approach during migration or early/late summer), where I see the migration of birds.

I improved my skills basically by self-learning:
1. Summarize what I have learnt on bird sound(Rubecula.eu : I built this website with the sound of the most common birds).
2. From websites: There are a lot of facebook groups that help identify birds - learn tips from experienced people on how to visually tell the difference between similar birds. I seldom use the Merlin app, but I will visit certain websites that help with identifying birds.
3. Nice talks with more skilled birders - but you need to let them feel you are an authentic birder instead of a tourist with a binocular - so they will be interested enough in talking with you. It's important to identify yourself as a birder.

Current situation - Birding Journey

I also do birding in cities(Nowadays barely at all. It's simply not successful as I would rather search for spots with species I have not seen. City birding seems more for beginners. You have a limited variety of birds. But once you are familiar with those few species it would be rather boring to do. So city birding is for me something I would rather do subconsciously or coincidently. When I would do something else but spot some birds.). When I go city birding, I tend to go with friends so we can discuss the birds we have seen, etc. It's a more casual experience than birding in the wild. The good thing about birding in cities is that the birds are more used to people and they are usually at a closer distance to you for you to see their details without much effort - but the sound from people and other city noises could be disturbing. I seldom take my camera with me when birding in the city, on one hand it's too heavy, on the other hand I don't want to have the fake context in the photo that I am not doing actual birding in the wild - for the birds in the city are not really 'wild birds'. It could be quite awkward to do birding in parks, especially when you are standing still and looking up searching for birds - sometimes people ask what you are doing and they start following you, which might scare the birds away. (Maybe also you don't want to be taken as a peeper with a pair of binoculars or cameras?) - Yes, but when you are dressed really like a birder and concentrate on the birds people won't think that way.

When I am visiting suburban places like in the forest or open areas, I tend to go by myself so I get the immersive experience and have better efficiency in finding the birds - also sometimes I go to a place just for certain species. The challenge of birding in a forestry environment is that sometimes you can not tell their location - e.g. Nightingales, their voices get reflected multiple times by the trees so you have no idea where they are. Also some birds change their behavior during the year - e.g. Blackbirds are less loud in spring and summer, so you suppose they are further away, but they are actually closer than expected. You really need to be an expert to be able to analyze these situations.

Also it happens a lot when you hear birds but just can not find them, because birds are good at hiding themselves from people. e.g. Golden orioles are bright yellow and middle in size that should be easy to spot, but they are so good at hiding higher in trees which makes it quite hard to catch sight of them.

Figure 02 Nightingale (Left), Black bird (Middle) and Golden Oriole (Right)

I usually take my birding books with me to identify birds, know the names of birds and learn them from another language. Sometimes when I go birding with people(who speak foreign language), though I know what kind of bird we are looking at, I fail to tell the name of the bird in another language, that makes me feel inexperienced.

It requires pure luck to see rare species. When I see rare species I not only submit it on Ebird(when you post very rare species they sometimes hide the location of witnesses to prevent too many people from going there - to protect birds) but also go to local birding websites and report a witness, which will help with their research. Ebird is a great website that I use a lot. It is very easy to understand and provides statistics and overview of birds around the world, helps you to build a collection of your own, and provides bird maps and suggests you where to go - when I have no idea where to go birding I just open Ebird to find some hotspots.

In terms of experience, here's one criteria I've heard - if you are a member of Club 300(a German website) it means you've collected more than 300 species of birds. That could be an experience level for birding.

Design-related questions

Adding sound-location functions in binoculars could be a really cool idea! But one thing you need to consider is how can you tell where to look, when you are at a place with multiple birds making sounds from different directions - the interface should be very intuitive to create good design. What could also be interesting is a detector for movement. Sometimes sit in front of a bush waiting for the bird's next movement so you can focus on that spot. Not sure though. Maybe in combination with the sound location that would be great.

Taking pictures with binoculars - there are a lot of products out there already. Sometimes I take pictures with my phone through binoculars - don't remember it being hard. I don't have a very high end scope either so it must be real easy- not for good photography but just for witness proof, the quality is okay.

Figure 03 Digiscoping work from the candidate

General takeaways

It's annoying to not be able to expect the situation before birding - e.g. sometimes one place is full of all kinds of birds but at other times there's not a single bird, that can be frustrating!

For me the motivation of birding is mainly ***collecting*** instead of taking pictures - I take pictures of birds for self-documenting, website submission to report a witness and reflection after coming back from the trips. It's a good point to check photos afterwards, because you might have captured other species during the trip without realizing it (Once I went on a rural trip for a specific kind of bird and failed to see it, but later found that it's in one of my pictures - I captured it when it was flying by my camera- so I actually have seen the bird without realizing it! But it's always better to spot birds on site.)

Now I do not do birding frequently as before, but I am constantly revising the bird songs I've known to enhance my memory, also stay familiar with the sounds of the birds that I haven't met yet - to be able to directly recognise them during coming birding trips.

Candidate B
Female, 36, Nature training manager, living in US, American, birding for 15 years

Birding history
I started birding when I started zoology in the university and we go to parks in our spare times to watch animals so I went to specific places to find birds. Practice and constantly going out. Once a week during the weekend. I love going out with others but I also go by myself a lot, small groups like 2-5 people together, 8-10 for birding tours.

Current situation
Parks. Leica products , before using Vortex, Noctivid binoculars() City park, more people, 6am morning(7am) and afternoon, water lighting(national parks and local parks).

Difference between birding in urban and wild areas: the diversity of birds is different. There are a lot of birds in city parks already and when it is migrating season there will be even more birds.species, more people, more noisy, and more peeping vibe: people also come to you from time to time and ask what you are doing, that is not the best.

Morning is always the best time to go for birding - because later it will be too hot with too much sun, also in the morning everything is quiet and there is less noise, it's a good time to observe smaller tree birds. Some also do birding in the late afternoon because the lighting is good, and water birds are always around.

Merlin ID and E-bird are the main supports, but Merlin sometimes do not identify very well. A professional birder and a field guide can correct that.

Birding Journey
We go to a park in the early morning and start listening, and your ears will tell you a lot of birds are out there. In order to find birds, we use movements in the tree, we walk around, constantly put binoculars up and down and we don't scan the binoculars. It could also be that you hear a bird whose song leads you to a tree, then you start pointing your binocular to the sound source and scan the binocular.

Finding the bird could be time consuming especially in a collaboration(teaching) scenario - when I find a bird but have a lot of people around me who have not found the bird yet. We can use laser pointers to point around the birds, but we have to circle around birds to not disturb or hurt them, also we don't use pointers when there are too many people with a laser pointer around because the risk of hurting the birds is too high. Sometimes we use the clock system a lot to help locate the bird, but it could be sometimes frustrating that the birds just fly away during this process....

I also take pictures with my camera. (how do you deal with them?) It could be frustrating to just go birding with a camera because you can not see the birds very well through the lens. The ideal situation will be to carry a binocular and a camera - or a spotting scope(already a big camera lens) and a camera body.

After each trip: add the new birds I've seen during the trip with the E-bird checklist and this process is like a Pokemon collection.

General takeaways

Difficulties: weather is not the best. Products: move the focusing wheel. Good products really help and it is part of my job in convincing people to buy Leica. I've been a guide for 7 years already and was hired by the company to do that - in order to be a guide you need to have good birding skills and be able to communicate with others with a good personality. A lot of our customers are elderly people and they don't react quickly - you have to have patience in this situation.

When I get more experienced it's not easy for me to find a new bird anymore, so I would say it makes me excited everytime I spot a new bird species and add that to the checklist.

Bigger binoculars are better at observing movements. Keep on trying and look with your eyes first. Have fun! Attracting birds with their songs(not much) is okay, but be careful not to do that all the time..

Birds are migrating in Spring and Autumn, thus they are usually more active and make more sound during this season - during summer they are lazy, staying at their nest on the trees feeding children and don't make much noise.

Design-related questions

Using sound to locate birds will be a really helpful feature for different stakeholders, especially if people are really in the need of finding birds asap.

Taking pictures with binoculars(the product will be huge then and also the image quality will be very limited). There are phone adapters that can connect your phone to your binocular, they are okay but take some time to set up. The quality of pictures depends on the quality of the binoculars.

A product service system: before and after birding: knowing more details will be surely helpful!

Watch the cost if you want to sell it to a younger group!

Leica is losing some sales due to the heavy housing and uncomfortable eye cups of their optics product.

Candidate C
22, Female, product design master student,
currently based in Delft, the Netherlands but did her birding mostly in India Bangalore,
birding during the pandemic time back in 2020 or 2021.

Birding history
I started birding back in pandemic time in 2020 or 2021. Back to the quarantine time we didn't have much other entertainment, so I started backyard bird watching. I usually know that a bird is visiting when I hear it sing, then I go out and see it - sometimes I see them cleaning themselves up in small ponds. I was the first one who started with this in my family and gradually others joined as well - in our backyard we saw 5-6 kinds of birds in total. What's interesting in birdwatching is not only 'seeing' the birds but also 'capturing' them with a camera, I use a Canon DSLR to do so(zooming range if you can remember?(0-250mm) Did you buy it for birding?No I got it because I was interested in photography but this seemed like a good place to kick it off).

I hang out with a birder friend a lot - that's when I gradually gained more skills in birding. The birder is very knowledgeable, she told me how to tell the gender of birds according to their certain features - it is very interesting.

Current situation
I do whenever I get a chance. I went once on a walk along Delft to just look for some birds, try to take pictures of them and learn some of the birds here that I hadn't seen back home. There's a bird watching activity at Delft X this Saturday that I will be going for.

Birding Journey
I started in our backyard, then I walked with the birder friend primarily within the city near small ponds and greenlands. We don't go birding together in the very urban area much, and sometimes when I go to the outskirts of the city(also within the city but with a lot of trees which provides a more forestry vibe) I do birding there as well. The difference is that in the city there are more humans and the atmosphere is more busy, while nature is more peaceful - also when I was more into nature, I saw more bird species that I would never see in my backyards.

Before going birding trips, I would make sure that I am not wearing bright-coloured clothes which will expel the birds. When doing birding we also tend to walk a lot (2 hours and maybe around 5 km) If I am going to muddy places I wear boots and shoes. I don't have a pair of binoculars by myself and usually only take my water bottle and camera with me.

I sometimes go birding with my birder friend. We can tell that there are birds nearby according to their sound(Could not do birding by ear - but I know that they are there when I hear them) or by the movement of brushes or tree leaves. Then we locate the birds(gesturing towards them or showing them on the binoculars. Pointing draws too much attention and they tend to fly away). My birder friend has a pair of binoculars and when the bird is out of my camera's zooming range, she will share her binoculars with me(Did not seem to be hard for an expert to find the location of birds, they camouflage very well and are sometimes very small). It's crazy how much they can zoom and how clear the view can be.(when I was young I used to play around with a binocular toy. It is interesting and it's surprising how much they can zoom, but I don't use them much because they hurt my eyes). Though the view is good, I am not very used to the binoculars, because it needs quite complex adjustments and the set-up takes some time - we missed some birds this way.

I tend to see birds first then raise my camera to capture them. It's not the most intuitive to start directly in the camera's field of view. If I see a new bird but fail to catch the perfect picture, I would ask my friend and describe the features of the bird so she can help identify the bird. If I catch an okay picture, I use Google Lens to identify the bird. (Is it hard to find birds within the camera viewfinder?not so much with a good picture)

Design-related questions

Picture-taking:
Auto-focus and Zooming possibilities: What if a binocular can auto-focus and zoom like my camera lens?
Auto-focus would save much time in taking pictures, and it's really helpful in capturing 'the' moment. It would be amazing to have a camera-binocular that directly captures the view I get from the oculars.

Ergonomics:
Nicer way of hanging on necks: binoculars are very heavy(I am not sure if the camera will be heavier, I think I will still prefer to take a camera instead of a binocular or take both with me) and it could be quite a burden to wear sometimes. A better eye rest is also important for long-time observation!

General takeaways

One difficulty is to find more new birds. I know there must be many kinds of birds in the city, but I constantly see the most common 4-5 species and don't know where and how to find new ones (Will something small with information help? e.g. newsletter emails) - that would be cool.

The biggest motivation is - birds are cute, stupid and funny to watch, it's just interesting to see them mess themselves up in a small pool. I do photography just to look back and identify the birds later and share them with my friend - 'look, it's your bird!' But I don't do them for other purposes, e.g. submission or collection.

As a starter, I would suggest people note down the names of birds so they won't forget about them next time they see them, if they want to start with birdwatching. Also asking professionals for advice can help you grow fast in skills.

(I think I would prefer to go birding by myself or one- two people. Many people can make noisy groups and birds get scared and fly away)

Candidate D
Age 50-60, Female, optics seller, currently based in Germany, have been birding for more than 30 years

Birding history
I grew up in the countryside and of course we saw a lot of birds in our backyard and this is what triggered my interest (also my parents were quite interested in nature observation) Then I went out every evening to go birding, to watch the animals and the birds which were easy to see.

At the age of 9 I received a pair of binoculars or had the opportunity to watch through the binoculars and this is what kept me inspired. It was a 10x Porro prism binocular - for this time it was high quality binoculars so it was from a brand that is not available yet anymore. Then when I was 14, Leica came out with the Trinovid series and I received my first 10x42 binoculars from Leica. At the age of 27 I changed to a pair of Zeiss binoculars - but only for about four months because the quality was not so good - so I switched back to Leica after that. I start to use Leica Noctivid as soon as they come out- but I have additionally a pair of 32 millimeter ultraweight binoculars as well - it is small and lighter, I think this might be a little bit more of an interest to your target group(starters). I also used to have a Swarovski 65mm spotting scope but later changed back to Leica because Leica has the best neutral optical view for bird watching(the difference is quite big).

In those old days I improved my skills by field guides and going around with older bird watchers who teached me a lot. Now I am mainly using the internet to get more bird watching related information.

Current situation
Me and my partner are planning birding holidays - sometimes we meet people in the countries we are visiting but most of the time we are playing by ourselves led by a tour guide in those countries. We usually do some pre-planning so we have a driver and a local guide as well.

Birding Journey
Design-related questions
General takeaways

(The talk with candidate D was very long and was not very well documented before the submission of this file, sorry.)

Candidate E-F

The interview towards candidate E and F was done through a 1h sharing session.

E: 26, male, product design master student, doing birding in India and Delft, started for around 1 year

F: 30, male, civil engineering master student, doing birding in India and Delft, 5-6 years

	E	F
Birding history	Around 1 year. I started in India near the botanical garden close to my place, there're birding trips organized there so I started first by joining the birding groups with 4-5 people guided by a professional birder. We walk around with binoculars from the organization(so we don't need to buy any optics by ourselves) and follow the instructions from the professional.	I have been birding with binoculars for 5-6 years mainly in the wild area far away from cities. I started birding influenced by a professional friend at work. We went out in the morning and evening together. At first I did not have a pair of binoculars so we shared the same device. Later we separated but I continued with birding even though I was in a more urban area later, and I bought several pairs of binoculars from then on.
Current situation	I do birding every weekend, that's 4-5 times a month. As I get more experienced after the first 2-3 months I tend to go with a smaller group with just 1-2 experienced people or by myself(in Delft). More people make more noise and that affects the birding experience.	Nearly every place I am going now is 20-30 km away from the city so I won't say it's an urban area anymore - in cities there are not many kinds of birds. I am also going together with other people(friends and family members who are also bird lovers) as I get more experienced, and I would prefer to go with a smaller group with people with similar experience level, one reason for less noise, and another reason is that I only want to talk bird-related stuff with people instead of all other social topics. And the more people we have, the less purpose for pure birding we have.
Birding journey	Usually I go on a 2-hour trip when I join small birding trips with professionals. We meet at a meeting point where we get the gears and learn the basic rules in birding, then we go out to have the trip and after that return to the starting point. I feel that birds are around more according to their movement in the trees. Birds move continuously, which draws attention and on the other hand makes them hard to be observed. Besides, birds I have seen during trips are usually not that loud hiding in trees. Finding birds is the hardest part. When they are on the ground they are similar with the ground color, making it quite hard to catch sight of them. During trips I used to use 7x25 and 10x50 binoculars for different magnifications, I found that shifting between these binoculars is really a pain in the ass, it's hard to find birds again or they will fly away while shifting. Merlin helps me to identify the birds. Some people can identify them with details and they love collecting multiple kinds of birds - but that's not my point. I just enjoy watching birds, nothing else. I don't take pictures during the trip. When I need help, I turn to professionals for information, no websites nor forums. After the trip, we relax and get some feedback (5-10 minutes) from the professionals that we go with.	I usually go on a birding trip with friends for a whole day. We get up very early in the morning from 6-7am and leave together to a specific hotspot(usually bird habitats so there are always birds living there), we watch birds between 3-4 times and end up at 5-6pm of the day when the daylight is not good enough to see birds. I have also once gone on a trip organized by birding enthusiasts for 3-4 days with people whose ages are between 25-35. Some professional birders really take big scopes with them When out in the wild, I detect birds according to their movements, it's hard so you need to have good patience and sit still at a place for a long time. When I am birding in cities e.g. Delft, I detect birds more by their sound because city birds are usually much louder and closer to people. Small tree birds move a lot which makes it hard to find them. Water birds, in comparison, are easier to spot because they live in a more open area and they are usually bigger. The sunlight could be disturbing when you are trying to find birds. I can identify around 20 birds with my experience but the rest I would need to ask Merlin for help. I started with Merlin because it helps with basic identification and provides a list of possible birds that help you to do the judgment, but later I got field guides for more advanced identification which really help me to tell the difference between very similar birds - the field guide is heavy, however, so sometimes I just go with binocular and Merlin. I usually don't take pictures. If I do that's only for identification and look up later. When I need help I tend to ask my birder friends and go to E-bird to look for hotspots to go to. I almost never visit birding forums. After the trip, we compare notes and check the field guide to seek the bird that we see during the trip.

General takeaways	Difficulties: Getting up in the early morning is hard. Some professionals use scopes and they point from the view from their scopes, which is different from what we can get from our binoculars, making it very hard to find the birds. Also the experience of shifting from binoculars and your real eye is not very ideal, there's nothing in between that provides zooming functions. We share the location of birds by verbal communication. Happiest moment: When you are able to tell more information about a bird according to the tips from professionals. The overall experience is relaxing which is good.	Difficulties: The accessibility of a good birding place in Europe is not easy. Sometimes we don't know how to reach a certain hotspot - if we don't have a car. Getting up early is indeed hard. We share the location of birds by writing, pointing, and explaining the landmarks that are close to the bird. The happiest moments are everything. The behavior of the birds is the most interesting part. It's interesting to see birds have something in common with humans, e.g. desperate bird moms trying to teach their babies how to find food in the water fields while babies don't want to find food by themselves.
Design -related questions	Weight is not the biggest issue for me. The adjustment of binoculars is cumbersome and the focus wheel is sometimes not easy to turn. Would prefer a zoom-in function in the binocular. Share the location of birds with other people more easily. Achieve more brightness and a light device at the same time. No tripod, stabilization functions?	Weight is an issue. The better binoculars you get the heavier they are I would say, which might be a burden for long-time watch. Also some people find it uncomfortable(e.g. nauseous) to use the binoculars for a long time. I have an Olympus 8x42 and Nikon 7x40 but I have tried Celestron and Bushnell from my friends as well, they are cheaper and more on the entry level.
Brands	Olympus and Nikon	

Personal experience

24, female, design student, Chinese, doing bird watching in Munich, Germany for 2 months.

Current situation - birding journey

I recently started bird watching on my way home from work around 5-6pm everyday. Lots of birds are in the trees and their songs come from multiple directions and distances.

I mainly watch tree birds. I feel the existence of birds mostly by hearing their sound. When there are multiple birds in the environment, I tend to follow the song that sounds not familiar(might be a new bird) and is closer(to easily find a bird without moving a lot) and look towards the rough direction of sound - usually I define 1-2 trees as the birds' possible location then check their branches. If the birds are constantly moving and jumping around branches, their movement might be useful to help me catch sight of them. Merlin bird ID is very helpful here - it is very accurate in detecting normal birds, and provides an overview of the species of birds in space.

After feeling a bird is nearby, it's actually the most difficult part to catch sight of them, especially in the seasons(between mid-spring and summer) when the tree leaves get thicker which provide conditions for birds to hide behind. Nevertheless, I can usually catch sight of birds by detecting their movement on the trees with some patience .

I collect new species in the Merlin app after spotting them in real life, also in my iphone album for photos.

Leica Ultravid 10x25 binocular is brilliant for bird watching - with a light-weighted and small-sized package, I can easily tuck it in the inner pocket of my jacket, and hold it steadily with one hand for long without getting a sore wrist - good for long-time observation and smartphone digiscoping.

Figure 04 Leica Ultravid 10x25: A compact housing

The binocular provides bright and detailed views in the late afternoon when it's sunny. But due to its small objective lenses, it's hard to get an ideal view under cloudy weather, only a black silhouette of a bird without details could be seen if it's at a longer distance.

Usually I have binoculars on one hand and smartphone(iphone SE) on the other hand with the Merlin sound ID feature on - to roughly identify what kind of birds are around me then I can find and observe them.

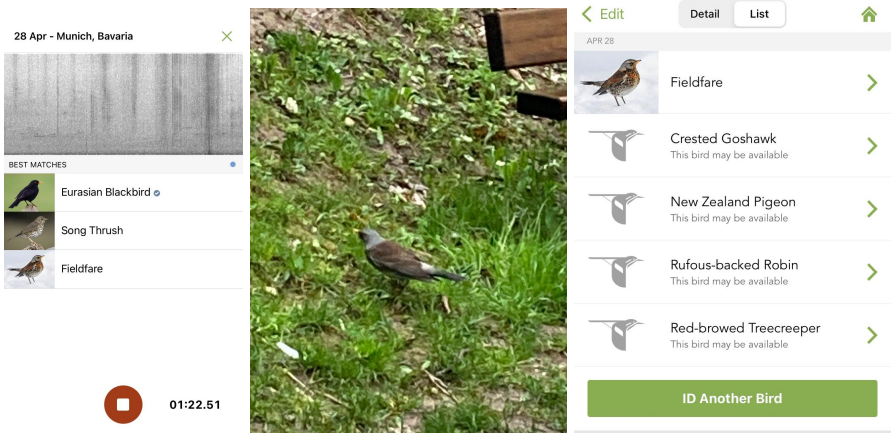


Figure 05 Identify and confirm a Fieldfare by Merlin sound ID - take a picture - Merlin photo ID

Digiscoping is fun but takes a lot of time and luck without a phone adapter. I missed a lot of birds during setting-up, but managed to capture some birds and views. I'm sharing my digiscoping pictures on social media, which is a motivation for me to spot more birds and create a collection later. Also such an activity is refreshing and interesting, I want people to know more about it.

Figure 06 Unsuccessful digiscoping could be due to failure to center the lenses, camera is too close to eyepiece, hand shake when pressing the capture button, camera or(and) binoculars not in focus, etc.

Figure 07 Better digiscoping results

General insights

To conclude, as a novice birdwatcher from a younger generation, I find the most important thing for a pair of binoculars is a compact size and lightweight so I can take it wherever I go and not feel like a peeping tom. Good ergonomics is also important for long-time holding. If the device can help me to find the bird and make digiscoping easier, that will be even better.

Collected insights from interview and personal experience

Place & time Alone/with others Attract & find Observe Identify Take pictures After-activity

Table 03 list of insights from interviews and personal experience

	Insight list	A	B	C	D	E	F	G
Gains	Certain kinds of digital help are very helpful in finding hotspots, e.g. Ebird.	1	1			1	1	
	It's less difficult to start from urban areas so observers can become familiar with most common birds first	1	1	1	1			1
	Submitting bird watching pictures and witness proof to certain websites can help with local environmental research.	1						
	Going together with a professional birder really helps starters in improving birding skills.			1	1	1	1	1
	Going alone helps bird observers to focus and have an immersive experience.(especially out in the wild).	1	1	1		1		1
	Playing bird songs can help bird observers to attract certain birds.		1					
	A laser pointer that points on the surroundings of birds can help others to find birds more easily.		1		1			
	Wearing drab colored clothes can help bird observers to approach and find bird more easily			1				1
	It provides a sense of achievement when bird observers finally find a bird after long observation.	1	1	1	1			
	It's just fun to watch birds do things and try to understand their behavior			1	1	1	1	1
	Finding a sit point is helpful for long-time observation						1	
	Merlin bird app is really helpful in terms of bird identification with sound, pictures and descriptions.		1	1	1	1	1	
	Remembering features of birds(e.g. sound, size, color, behavior....) helps bird observers to identify birds efficiently without additional help.	1	1		1			
	A field guide can be helpful in providing additional information in identifying between similar birds.	1	1		1		1	
	Cameras can improve the experience of identifying birds since they capture fast-moving birds that are hard to identify immediately.	1	1					1
	Digiscoping helps to capture enlarged views of good enough quality for later identification(usually when birds are still).			1				
	Revising bird songs or features after each trip and constantly practicing help with the skill development	1					1	1
	Enjoy the feeling of sharing bird observation results(pics, recordings, add witness to list, etc.) for multiple reasons.	1		1	1			1
Pains	Bird observers struggle in getting more detailed information, e.g. where to find new birds in the city, how to access a certain hotspot, and the bird situation at certain hotspots.	1	1				1	1
	Bird observers find birding in urban areas awkward, because 'looking up' can be weird and using binoculars brings a peeping vibe.	1	1	1				
	Current ways of collaboration(both sharing devices and sharing information towards the location of birds) do not work very well.		1		1	1	1	1
	Bird observers tend to avoid a big bird observation group since it is usually more noisy and the purpose won't stay solely on birding.	1		1		1	1	1
	(After becoming more skillful) Tend to go wild instead of staying in urban areas because the species of birds in cities are limited.	1			1			
	Hard to find (tree) birds because they move constantly, they are good at hiding, their sizes are small and sometimes they have a similar color to the environment.	1		1	1	1	1	1
	Hard to tell both the direction and distance of birds correctly according to bird songs - especially in a forest environment	1	1	1	1			1
	The shifting between optic and eye view makes it even harder to find birds because of the jumping between 2 different fields of view.				1	1		
	The digital viewing solutions has lower view quality and cause visual fatigue after long observation(max. 4-5 h), therefore is not preferred	1	1		1			
	Sometimes it's difficult to observe birds because they are constantly moving.			1		1	1	
	Birding optics are not compact and light enough, also sometimes cumbersome to adjust and not ergonomically pleasant.					1	1	1
	Sometimes it's impossible for bird observers to identify a bird on site because it could look very similar with other birds	1						
	Cameras are not always ideal to carry with because of their limited zooming range and the weight	1	1					1
	Digiscoping can be a bit hard and take time without a tripod for starters.		1	1				
Customer needs	Proper place to go for bird observation	1	1	1		1	1	1
	Good timing to do proper observation(e.g. go out on sunny weathers, early morning and late afternoon, bird migrating seasons)	1	1	1	1	1	1	1
	A focussed bird watching environment without distractions	1	1	1		1	1	1
	Better device and information sharing experience during group bird observation		1		1	1	1	1
	Able to find birds within a proper amount of effort	1	1	1	1	1	1	1
	Discover more species of birds	1	1	1	1		1	1
	Enjoyable, Immersive and unobtrusive bird observation experience	1		1		1	1	1
	Optic products that are easy to set up, ergonomically pleasant and provide good quality of view.	1	1	1	1	1	1	
	Identify the birds without much effort(identify by oneself / with the help of other professionals / digital help)	1	1	1	1	1	1	1
	Take good enough pictures with ease	1	1	1				1
	Improve or enhance bird observation skills	1	1	1	1		1	1
	Be perceived as a bird observer	1		1				1
	Help with scientific research	1						

RF. Brand & product-related information

The market research interviews are not documented as detailed as user research. Only important quotes are included.

Talk with Matthias Raff and Ronald Gruner(Sport Optics Product Managers at Leica)

At the start of the project, a material with different product solutions was prepared for getting opinions from Matthias and Ronald, check here to have a look at the preliminary research, my questions and their answers.

Talk with Mark Karn(Sport Optics Account Manager at Leica)

Mark has been selling sport optics for 25 years, 7 years for Leica and 18 years before with Zeiss UK. He's really the expert in this field.

Product-related:

- The top 3 things that customers care about before purchasing: aesthetic, weight, and compactness. They also pay attention to robustness, waterproof, good warranty, etc. Another factor that really influences people's decision is what most people are using => if everyone is using Swarovski you will most probably buy one as well.
- Swarovski dG: very smart concept and relatively light weight(because it's a monocular), but too expensive for what it can do - experience wise, would be great if it provides double eye view.

Price:

- A full size of middle-range priced product is around 400-800 pounds, if I am designing a product I should limit it to 400-1000 pounds for people to be able to afford - which is around 600-1400 euros.
- The market has been changing throughout the last few years. First, there are many cheap binoculars and premium products so people will change quite fast from cheap products to expensive ones. Recent years a lot of middle-range priced products are coming out so the process of going from cheap=> top selections is becoming slower since people are staying at the middle price range for a longer time.

User group:

- The current Leica bird watching group => mainly people aged 50+
- Professional level: mixed groups of users, the very experienced people don't earn much and are not able to afford the most expensive products
- During the last 10-15 years, the target group of the environment observation market has been shifting. First of all, more younger people are joining(17-40 years old) and a lot of people in their 20s are very knowledgeable nature professionals already(it can be very efficient to learn)! Secondly, the demand for close focus function is improving because people's observation content is not limited to birds only but also the insects etc.

Opinions on digitalisation

- Great idea to design some features to help people find birds!
- Digital assistance is more proper for starters => the professionals want to do everything by themselves.
- For something digital, at least the softwares should be upgradable so it copes with people's investment
- Sport optic products usually have 5-12 years of lifespan, with digital assistance the time might be shorter

Brand-related:

- The unique selling point of Leica products are the very good optical quality and the neutral color of view, making it very good for bird watching because you want a real view when birding - Leica is the best in this field.
- Now Swarovski is the no.1 in the birding market - with the Swarovski NL pure as the best seller(the 8x42 version came out from 2021) in the premium binocular market.
- In 1999 Swarovski Launched 8X42 EL and it came out at the right timing when a lot of users are getting rid of their old Leica/Zeiss products, so as a substitute, many just bought Swarovski => so if a product is good enough, it can change the market and the customer's loyalty to a certain brand.

RG. Personas

Professional guider

Growed up in a animal watching family, Paula was greatly influenced by her parents and was interested in birds since her childhood. Years later, Paula growed up to be a nature specialist. She travels worldwide for bird observation and also work as a professional guider in teaching starters in urban areas like city parks and forest areas.

As a skilled birder and a knowledgeable nature scientist, Paula can find birds with less effort and easily tell the difference of common birds, which makes her a perfect guider in bird watching trips for starter clients. Though Paula is already very experienced in this area, she still find it cumbersome to show people the location of birds with endless pointing and verbal communication.

Need:

Help people find bird in a much easier way in groups

Age: 45
Level: +++++
Experience: 30 years
Job: Nature specialist

Starter birdwatcher

Natalie started watching birds at her family's backyard, later she follows a professional to spot more birds around the city green lands and parks with a camera. She learned a lot from her friend, but it's sometimes tricky that they need to share the same binocular.

Recently Natalie got a pair of binoculars on her own, so she started doing bird watchig alone as well. However, without the help of her friend, she feels it can be really hard to find birds in the city forest by herself and through binoculars. Besides, she don't know where else to go to to find more birds after constantly seeing the most common 5-6 species.

Need:

Find birds without much effort

Get familiar with the common birds in the cities

Age: 23
Level: +++++
Experience: around 4 months
Job: Art student

Skillful Enthusiast

Fred finds bird irresistibly interesting. He started to remember different birdsongs by heart in his younger adulthood and can gradually tell the difference of lots of always go by himself to get the most immersed experience.

Now Fred is a quite skillful enthusiast in bird observation.
He would plan wild trips to go by himself to enjoy the most immersive experience with birds. Fred also take different devices with him: a DSLR camera for taking nice pictures and a nature recorder for collecting birdsongs - while they can be quite inconvenient to carry and take some time to set up, he still brings them everywhere.

Need: Take pictures and record birdsongs with ease

Age: 32
Level: +++++
Experience: 10 years
Job: Mechanical engineer

RH. Direction selection analysis

Viability and desirability aspects for each direction are compared below. The feasibility aspect is not discussed since the optimized technology or solution towards each direction is unknown.

1. HMW create a more efficient way of sharing the location of birds?
2. HMW help starters to find birds independently with less effort?
3. HMW create a media capturing tool that is lightweight and easy to set up?
4. HMW 'redesign' the form and experience of bird observation optical products?
5. HMW add more value to users 'before' and 'after' their journey?

Desirability: which direction could be the most attractive for users?
Viability: which direction could result in a higher business value for Leica?

	Desirability	Viablility	Comment
1	+++++	+++++	Many bird watchers get tips, share devices, and receive guidance from professionals. A better collaboration experience under this scenario will definitely help. However, a design focussing on collaborations will neglect those who want to enjoy the experience independently. Since few bird watching products enable collaboration with a lower cost, a low-cost or modular solution on this topic will for sure create a good business value.
2	+++++	+++++	'Finding bird' is agreed by all the interviewed users as the most time-consuming and difficult part in the whole journey, especially for starters. Solving the problem will not only benefit starters but all the users in need(e.g. a guide who needs to find the bird to show to clients, or a photographer who wants a photo of the bird). Features that help in 'finding bird' are neither developed by current bird watching apps, nor touched by other competitors in sport optics, and therefore is a pure innovation area. Introducing technologies into this area could really create a big business value and help Leica build strength.
3	+++++	+++++	Developing a documentation tool can for sure make this process easier, yet documentation is not a pervasive need for every bird watcher, some people just enjoy the live moment of seeing birds through their optical device. Viability wise, a concept that enables easier documentation could definitely create business value, but due to the fact that the expectation from starters for documentation quality is not very high, and that many products on the market are doing a good job with a low price, it could be challenging for Leica to create a solution that is less replaceable.
4	+++++	++++++	The 'redesign' of form and experience feels more like an add-on to the functional solution, and has less chance to bring functional innovation to the product line. However, a well-redesigned refreshing device might introduce a new look into Leica' traditional product series and attract new users.
5	++++++	+++++	The solution for this direction will be a nice-to-have feature that won't meet the biggest needs of users. As the solution will most probably be a digital feature in smart apps instead of tightly connected with the experience of optical devices, the development might not bring much business value if it is a stand-alone feature.

The 'Finding bird' direction was selected to proceed after comparison, because it opens up a new innovation area to explore, connects tightly with the usage of optical devices, and solves the biggest need of customers.

RI. Human ability in sound localization

Before starting researching sound-related technologies, It is important to understand on a biological level how humans receive and locate sound sources, what factors may influence the sound localisation ability and what can cause the inaccuracy of sound localisation.

What range of sound can humans hear? How do humans tell sound direction?

The frequency range of human hearing is often reported to be between ***20 - 20,000 Hz***. As we grow older, we all tend to lose the ability to hear higher frequencies.
Humans can hear sounds whose amplitude is bigger than ***0 dB***, the amplitude of common birdsong ranges from ***50-130 dB.***

Horizontally***, the azimuth is mainly determined by binaural factors:*** i.e. interaural time and level differentials. ***Vertically, height is determined monaurally***, involving just one ear : i.e. changes in incident spectral shape (reflection, diffraction and absorption) brought about by the pinna, head, shoulders and bust, known as the head-related transfer functions(HRTF). ***Depth distance is also mainly determined monaurally(1 ear).***

What factors influence the sound localisation?

Interaural time difference (ITD): the sound propagation time between the two ears
Interaural level difference (ILD): intensity difference between the two ears for the same sound.

Head direction
Being separated by the head(17-18 cm on average), the two ears have different spatial coordinates. The head influences the level of receiving signals. Moving the head (or, in animals, the ears) introduces extra binaural and spectral cues enhancing localization. By leaning the head (and thus the vertical interaural axis) or turning it, the amplitude and phase of the sound waves reaching either ear are altered, providing dynamic binaural cues.

Accuracy varies firstly with azimuthal position. For example, for a 100 ms 70 dB phone white noise, localization uncertainty is ***3–4◦ for frontal sources*** (azimuth 0◦), ***5–6◦ for sources behind the hearer*** (azimuth 180◦), and ***around 10◦ for lateral sources*** (azimuth 90◦ or 270◦).

Sound frequency
Sound stimulus frequency greatly affects the accuracy of localisation, which is ***best for low frequencies (< 1000 Hz), poorest between 1000 and 3000 Hz, and intermediate for high frequencies (> 3000 Hz)***
For broadband (> 1 octave) sounds, localization accuracy is independent of central frequency.
For broadband tone bursts (≥ 2 octaves: 125–500 Hz, 1500–6000 Hz and 125–6000 Hz), altering the upper and lower band-pass filter had little impact on localization accuracy in normal-hearing subjects. This suggests that locating the source of a broadband sound does not depend on the binaural ITD and ILD cues in normal-hearing subjects

Number of sounds
The maximum number of simultaneous spatially separate sources that can be distinguished is around ***4 for speech stimuli and 3 for tonal stimuli.***

Spectrum compostion
Vertical source localization depends on the spectrum composition. The trunk, shoulders, head and especially pinna act as filters interfering with incident sound waves by reflection, diffraction and absorption. These interferences modify the sound spectrum according to its origin: reinforcement (spectral peaks) or degradation (spectral notches) in certain frequency bands, locating the source in the vertical plane. This is called pinna effect

Other sensory input and familiarity
Other sensory input helps correct the perception of sound, visual especially. ***Images take precedence over sounds('proximity-image effect' theory)***, if visual clues are available, the sound source will be located accordingly. Besides, it's usually much easier for people to locate familiar sounds

What can cause the inaccuracy of sound localisation?

Cone of confusion:

When the subject holds his or her head still, sources S and S' in the azimuthal plane show the same interaural time and level differences; likewise for sources U and U' in the vertical plane. This front/back and high/low ambiguity applies to the entire surface of the cone of confusion.

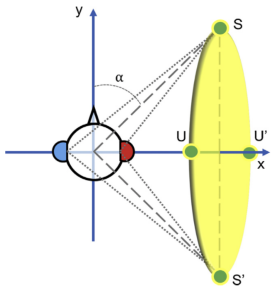
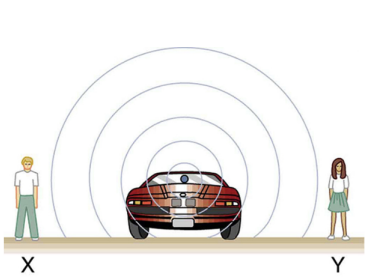


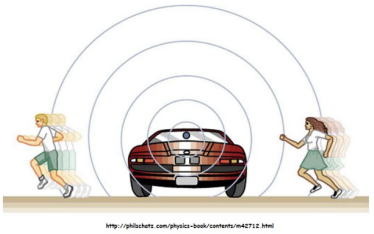
Figure 01 cone of confusion

Doppler effect

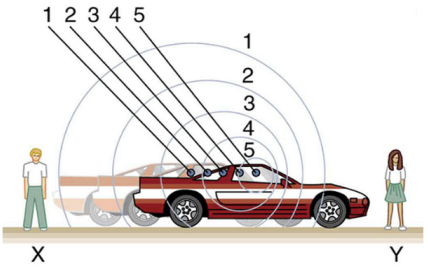
Doppler effect refers to the difference between the frequency a detector measures and the frequency a wave source actually produces. The difference is due to the relative movement of source and detector. The phenomenon was first noticed with light waves, but applies to all kinds of waves (including sound waves).



No Doppler effect: Source and detector(s) are stationary



Doppler effect: stationary source, moving detectors



Doppler effect: moving source, stationary detector(s)

Figure 02 Doppler effect

Sound frequency

When the sound frequency is between 1k-3k Hz, the human capability in telling the sound direction will be relatively inaccurate. Besides, the lower the sound frequency is, the less easy it is for people to tell the height of sound.

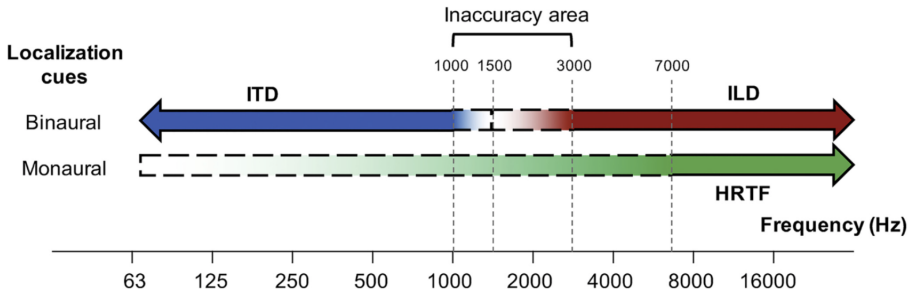


Figure 03 representation of sound source localization cues according to stimulus frequency.
ITD: interaural time difference; ILD: interaural level difference; HRTF: head-related transfer function

Distance

Generally speaking, close distances tend to be overestimated and long distances underestimated.
Binaural cues, and especially ILD, also help locate nearby (< 1.5 m) sources, due to considerable level differential between the ears (e.g., whispering in one ear).

About bird song

The author failed to get a thorough understanding towards the physical features of bird songs in the project time scope. Nevertheless, some information from the research of birdsong scientists are listed below.

Common frequency:

Many bird songs have frequency ranges between 1,000 Hz and 8,000 Hz, which places them in the sweet spot of human hearing (Allaboutbirds,2023).The current known range of bird vocalization is 50 Hz - 16 kHz for fundamental frequencies and 50 Hz - 28 kHz when including harmonics.

In the city, the pitch of the loudest part of the song is higher than that of the rural birds in the woods. In the city, birds also sang faster—instead of pausing for a certain time between their notes, they would shorten these pauses and rush their songs.

Amplitude(loudness):

The amplitude of birdsong perceived by human beings or devices is related to the hearing distance, the species of the birds, the timing within a year and their environment of residence(for example, in extratropical Eurasia and the Americas almost all song is produced by male birds; however, in the tropics and to a greater extent the desert belts of Australia and Africa it is more typical for females to sing as much as males.) Therefore it's hard to say how loud a bird can sing without a specific context. Nevertheless, literature states that bird songs in urban areas can reach as loud as 90dB and the loudest bird song known is around 125dB.

All birds actively come out and sing a lot in spring to attract other birds for breeding, therefore bird songs are the loudest and the richest in the Spring. In summer, birds become quiet and hide in their nests. Many birds immigrate during Autumn, when bird songs can be heard more again. In the winter, birds have less activity and therefore their songs are less available. Spring is regarded as the best time of a year for bird watching.

RJ. Bird observation distance

The digiscoping pictures in this appendix are taken through a pair of Leica 10X25 Ultravid binoculars with a FOV(field of view) of 90/1,000m. Knowing the common real size of the birds, their width/length proportion in relation to the binocular view, together with the FOV of the binoculars, the direct distance between the observer and the bird can be roughly calculated.

The first group of figures shows the digiscoping work taken quite far away from the birds observed, which are used to calculate the approximate furthest distance between the observer and the bird for urban birdwatching.
In the 1st picture, the observer is around 22-31 m from the observed wood pigeon,
In the 2nd pic, the distance is around 15-18 m. In the 3rd pic, the distance is calculated to be around 12-14 m.

Figure 01 furthest distance test with digiscoping pictures from the author

The second group of figures shows the digiscoping work taken at some distances that is regarded as normal by the author from the observed birds, which are used to calculate the normal distance range for urban birdwatching.
In the 1st picture, the distance is around 12-15 m.
In the 2nd pic, the distance is around 7-9 m.
In the 3rd pic, the distance is around 11-14 m.

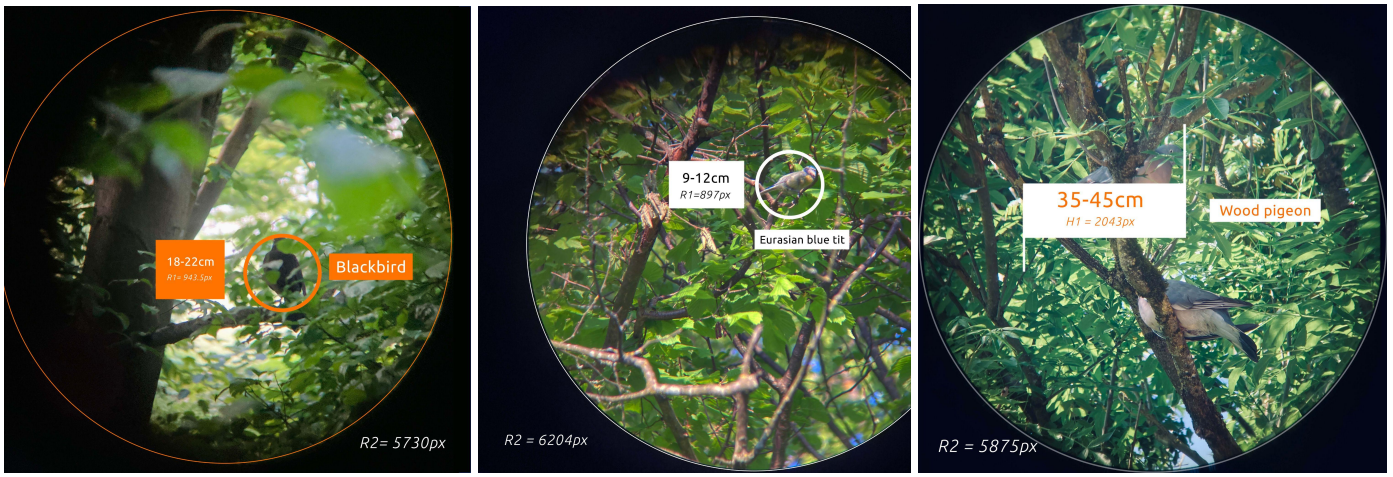
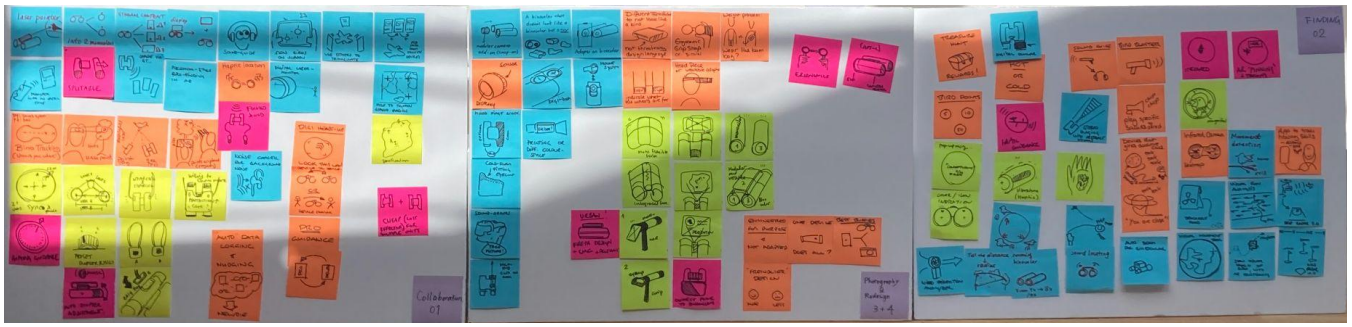


Figure 02 normal distance test with digiscoping pictures from the author

To conclude, the ***normal distance range*** for urban bird watching is around ***5-20 m***, most birds could be observed within this distance range. Nevertheless, ***the furthest distance*** between the observer and the bird could reach ***30 m or more***, that often happens when the size of the bird is big, or when there's a big color contrast between the bird and the background, making it easier to spot the bird without much effort.

DA. Brainstorming session results



1. HMW help bird watchers to collaborate - share devices & information more efficiently?

1. Collaboration	**Ideas(12)**
Device-sharing	Splittable binocular that can be turned into 2 monoculars
	Optic with a splittable display that can be used as a separate device
	Very cheap, affordable and simplified devices
	Physical snap points on optic products - snap on to enable content sharing
	Encourage people to share the device - e.g. an expensive device with good protection case that is designed for sharing
	Preset/auto adjust certain controls to reduce the cumbersome experience of the setting up procedures
Content-sharing	Share content from optics to personal smart devices, point on smart phone to show the binoculars users where to watch
	Display info directly on binocular views
	Haptic feedback for location sharing
	Use multiple devices to create a database and collect & share information - Provide location of other bird watchers - Share the bird location among the group, also show the collection result from the whole group - Auto data logging and nudging
	Laser pointer built-in
Others	Guidance from professionals

2. HMW help bird watchers to find birds in an easier and fun approach?

2. Find birds		**Ideas(17)**
System level		Turn the bird-finding process into an interesting gamified interaction
		App that trains hearing skills to improve in identifying and telling the distance
Product level	Create info	Use birdsong playback to attract birds
		Use bird blaster to disturb the birds so people can track them as they fly away (poor birds)
	Collect info	Movement detection to help find a bird(e.g. tree is still while bird is moving)
		Use microphone to collect and find the sound source
		Focus on collecting sound from single direction(under an environment with multiple birds)
		Noise cancellation for background noises to enhance bird songs
		Bird food with harmless chemical elements that are trackable
		Use infrared camera to detect birds, and show them on an additional info layer on real binocular view
	Present info	Show trail record that tracks the flying route of birds / movement of binoculars
		Stereo imaging with abstract visuals (?)
		Visual information in the optic view, e.g. a bird radar, use the distance of the bird as a scan radius
		Haptic feedback from device to indicate bird location
		Show the rough location mark of the bird, e.g. on a certain tree, then let the users find out by themselves
		Magnify the sound of certain bird and weaken the others as you approach it
		Auditive clues when approaching birds
	Function	Binoculars with auto-zooming function
		Binoculars with a digital ocular that presents visual information

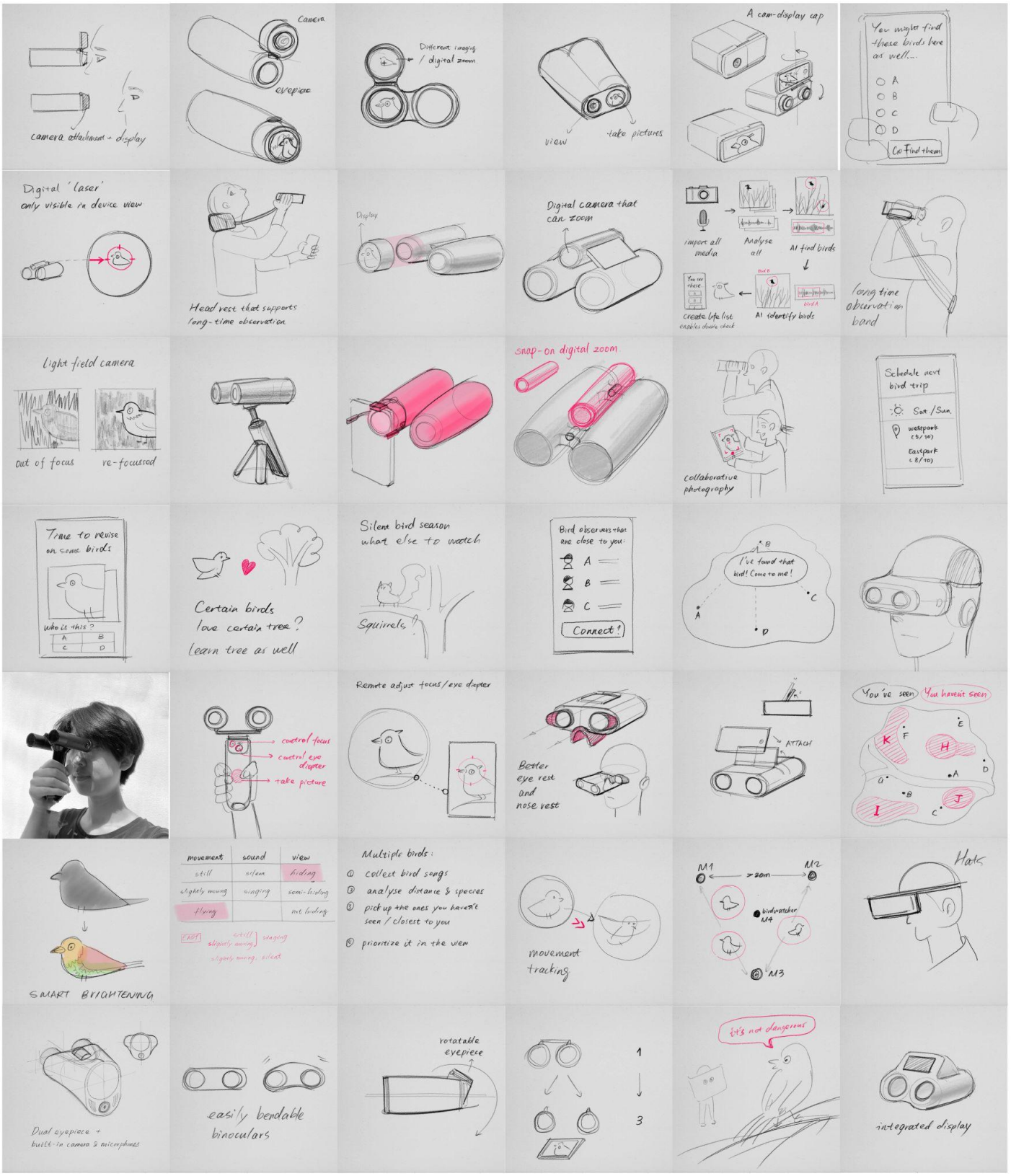
3. HMW help bird watchers to take photos with ease?

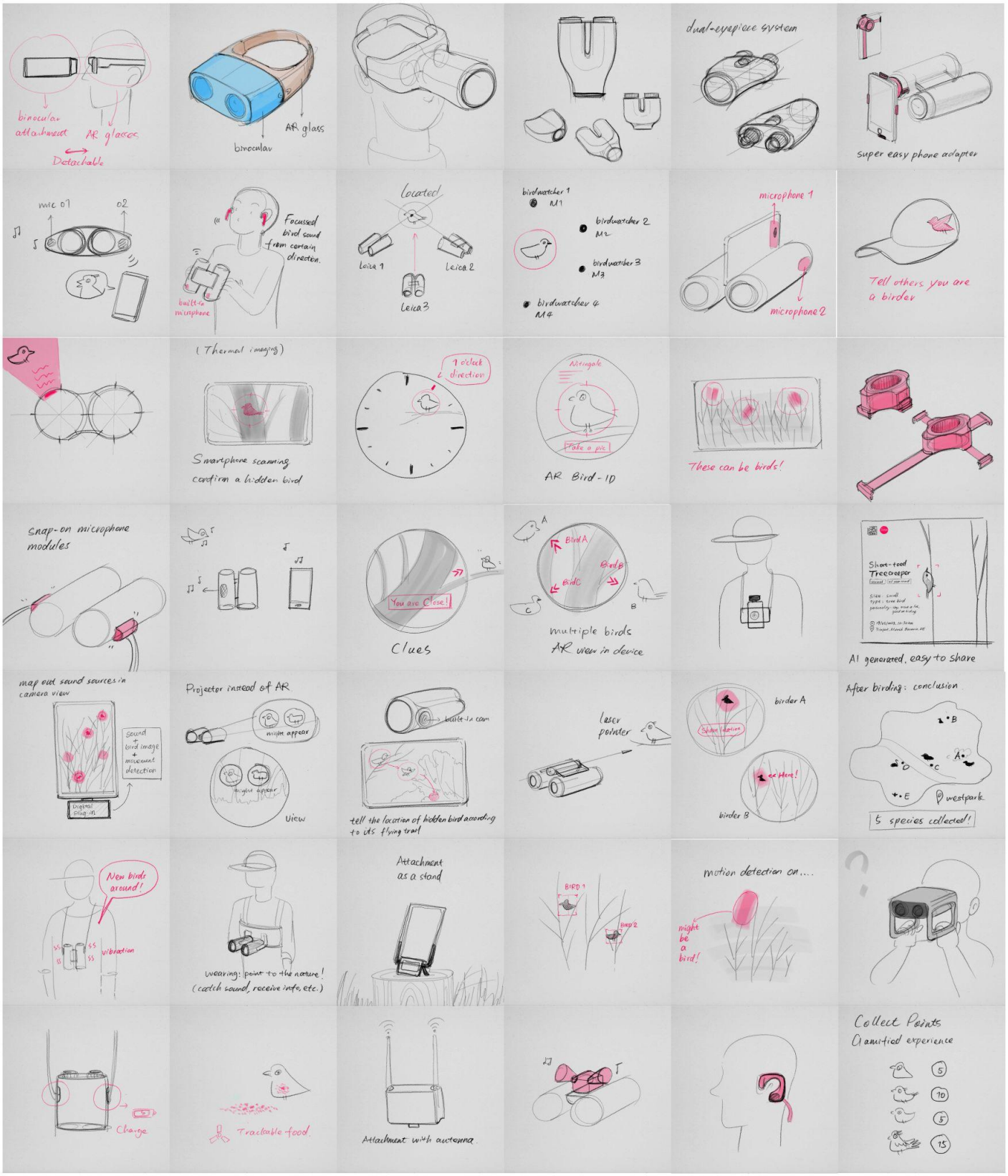
3. Take pictures	**Ideas(7)**
Digiscoping	A snap-on camera module that is adaptable to the eyepiece of multiple optics
	A moldable eyecup that can be turned into a smartphone adapter meanwhile achieve a pleasant ergonomic experience
	An optic device that can be connected and controlled by your smartphone
	Built-in smartphone adapter in optic devices.
Build-in camera	Mixed image binocular - one barrel with optics, another one is digital with camera function
	Camera sensor located near eyepiece
	A device engineered for purpose - not with compromises like ‘adapted’

4. HMW ‘redesign’ the form and experience of bird watching optics?

4. ‘Redesign’	**Ideas(12)**
General product strategy	One integrated device that achieves all the functions
	A list of devices that work together, maybe a modular solution
Product form and birder identity	A sign on the optics showing that the device is designed for bird watching
	Enhance the ‘urban’ identity by refreshing CMF and accessory design
	A more flexible and integrated form that is easy to twist and change shape
	A device that looks friendly and amiable- decrease the alertness caused by the objective lenses(which look like 2 giant eyes)
	A more advanced and fancy looking device without any threatening design language - maybe like an Apple device.
Intuitive interface and Better ergonomics	Indicate what different controls are for with hints on the product body
	Ergonomic gripping point on the device
	Way of wearing: sideway on the body / on the head
	Cold-foam fitting eyecup that can adapt to personal situation
	Use additional support, e.g. sound order to control the device

DB. Ideation sketches




binocular attachment
AR glasses
Detachable
binocular
AR glass
dual-eyepiece system
super easy phone adapter
mic 01
02
Focussed bird sound from certain direction.
built-in microphone
Located
Leica 1
Leica 2
Leica 3
birdwatcher 1 M1
birdwatcher 2 M2
birdwatcher 3 M3
birdwatcher 4 M4
microphone 1
microphone 2
Tell others you are a birder
(Thermal imaging)
Smartphone scanning confirm a hidden bird
7 o'clock direction
Take a pic
AR Bird-ID
These can be birds!
Snap-on microphone modules
You are Close!
Clues
Bird A
Bird B
Bird C
multiple birds AR view in device
Short-toed Treecreeper
AI generated, easy to share
map out sound sources in camera view
Sound + bird image + movement detection
Projector instead of AR
might appear
might appear
View
tell the location of hidden bird according to its flying trail
laser pointer
birder A
birder B
See Here!
After birding: conclusion
westpark
5 species collected!
New birds around!
vibration
wearing: point to the nature! (catch sound, receive info, etc.)
Attachment as a stand
BIRD 1
BIRD 2
motion detection on....
might be a bird!
Charge
Tractable food
Attachment with antenna
Collect Points
Gamified experience
5
10
5
15

DC. User evaluation towards concepts (with Co-creation result)

If the image is not clear enough for details, check here

Participant 01

That's the end. Thanks for helping out :)

Participant 02

Design topic : Help <u>starter bird watchers</u> to find birds(catch sight of them after detecting their existence) with an easy & fun approach <u>in an urban environment</u>

That's the end. Thanks for helping out :)

Participant 03

Design topic : Help <u>starter bird watchers</u> to find birds(catch sight of them after detecting their existence) with an easy & fun approach <u>in an urban environment</u>

Step 1-2 is harder mostly because the birds that hang around in trees are sometimes too small to be noticed. Moreover, they are also well camouflaged.

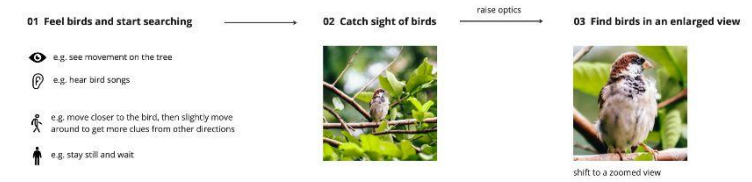
Usually, I don't skip Step 2. It is very difficult to find a bird through optics if you've not placed the bird with naked eye or hearing.

Q1:

On the right you see a detailed process of detecting the existence of birds till finding them within optical view. Pls answer questions below.

1. Which part in this process is the more difficult/time consuming for you?
Step 1-2 or step 2-3? Why?

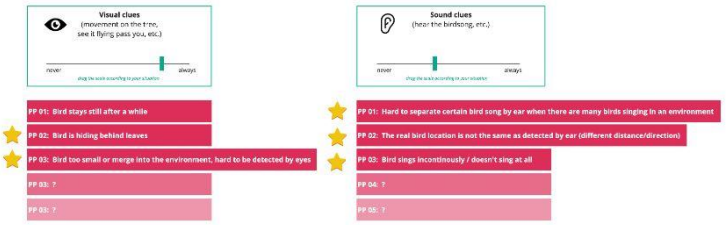
2. Do you skip step 2, directly start search for birds with your optics without seeing them with eyes? Does that helpful?



Q2:

Biggest difficulty(ies) in step 1-2?

Please do:
1. drag the scale according to your situation
2. vote under the painpoints with the stars below
3. feel free to add on!

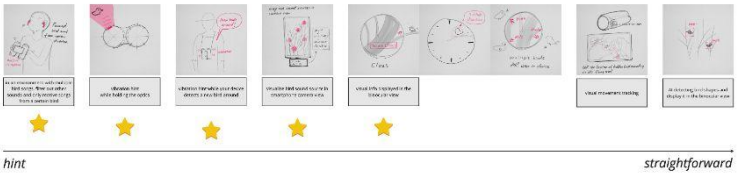


Q3:

Would you like to be helped during step 2-3?

How specific(straightforward/hint) and in what form (visually/acoustically/others) on what device(smartphone view/optical view) would you prefer the information be?

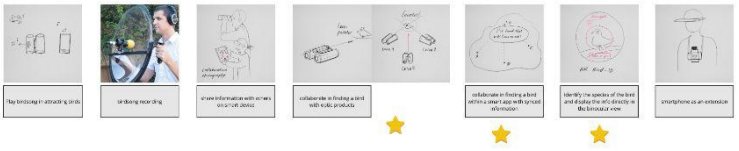
Please vote under preferred solution and explain why. Feel free to add on & write down thoughts!



Q4:

What additional features do you want to have? What other ways can help birdwatchers find bird in a fun way?

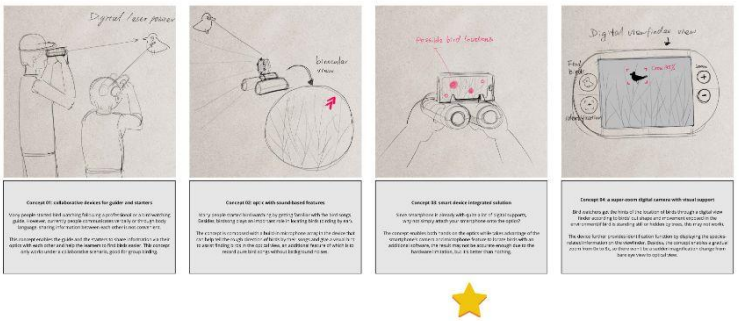
There are some inspirational ideas listed on the right for you to vote, but feel free to create your own idea!



Q5:

Any thoughts/ idea on what the concept will be?

On the right are some initial concept directions for you to choose from (just one!)
Feel free to shape it in a way that you like, or create your own concept!



Comments? Advices?

That's the end. Thanks for helping out :)

Participant 04

Design topic : Help <u>starter bird watchers</u> to find birds(catch sight of them after detecting their existence) with an easy & fun approach <u>in an urban environment</u>

That's the end. Thanks for helping out :)

DD. ODAS performance in tracking moving sounds

01 X-Y direction test https://drive.google.com/file/d/12wwpedj-4si8BbcSDlnMeC178pSP2D-8/view?usp=drive_link

02 Z direction test: https://drive.google.com/file/d/19mRLZ3DcLdsNxg2fiqlLssNy1K_X8YQz/view?usp=sharing

03: 3d spherical mapping: https://drive.google.com/file/d/1FJ0jaACEIDBYyrPG3ufBtOvkvR2_AgaH/view?usp=drive_link

DE. Setting up UMA-8 and ODAS

For starters, setting up the Minidsp UMA-8 microphone array and ODAS could be time-consuming.
As there are hardly any online tutorials available for this procedure, here is a detailed documentation from the author that might be helpful for readers in need.

01 Build a Linux environment for ODAS
ODAS requires the installation of an ALSA sound driver which only works on Linux.

The Linux system is re-installed on an existing 2012 intel-core Macbook pro. Dual-booting with an external USB flash drive(led to a cumbersome shift between 2 systems) and virtual machines(failed to provide enough computing power) are both proved to be not ideal enough. Raspberry Pi has not been tested - but according to the discussion on forums, ODAS runs just fine on an RPI.

System wise, Zorin 16 OS and Ubuntu 22.04 lTS are tested. Zorin has a similar interface to Win that is more understandable, but reports memory shortage after 1-2 times of running - a reboot is required to restart the system every time since then. Ubuntu does not have memory issues but has display driver problems while running GUI-related programs.

*P.S. If the device is using older versions of NVIDIA drivers, it's recommended to update the display driver manually and carefully. This tutorial might help.

02 Set up UMA-8 microphone
The minidsp UMA-8 microphone array could be recognised by any system(Mac/Win/Linux) once plugged in with a USB 2.0 cable. The microphone could be upgraded by its own driver in Win/Mac OS, as stated in P15 in the product user manual.

The hardware has 2 modes: a default mode of operation for plug & play operation as a far field microphone where a mono sound signal will be recorded then copied to both input channels(2xIN, 2 x OUT), and a more advanced raw mode with 8xIN (7ch coming from the MEMS microphone + 1 ch from spare PDM input) and 2 x OUT. After changing the mode from 'default' to 'raw' in the driver, the i/o of the device will be changed from (2 channels :2 channels) to (8 channels :2 channels), fulfilling the requirements of the provided configuration file "minidsp.cfg" by ODAS.

03 Install ODAS, ODAS_Web(GUI, optional) and ODAS_Ros(Robot operating system with a GUI, optional)
Install ODAS: smooth, just follow ODAS_wiki on the github page
Install ODAS_web: problems may occur during installation due to the incompatible or wrong versions of npm, grpc, python and node.js. The following combination worked for me: npm 6.14, grpc 1.24.9, python 2, node.js 12.22.12.
After that, follow the Readme file on github.
Install ODAS_ros: ODAS_ros requires a catkin workspace environment to set up. After installing catkin space, clone the audio_utils and odas_ros from Github into the src. folder of the environment. Then do "catkin build" and remember to update the bash file each time. Tutorials could be found here.
After that, follow the Readme file on github.

**Installing either ODAS_web or ODAS_ros to run GUI. To get raw data output of sound sources, installing ODAS solely would be enough.*

04 Run ODAS

After plugging in the device(and see the flashed LEDs), go to the system sound setting and select the i/o as the default built-in devices, to prevent UMA-8 from being occupied while running ODAS. Run *'arecord -l'(if your microphone is used for recording purpose)* in the terminal to confirm that UMA-8 is shown in the device list. Check the card number of the UMA-8 and make sure it is the same as written in the configuration file minidsp.cfg (or simply replace the card number by the info of the device, see the configuration file provided by ODAS_ros).

Go to the bin folder, find 'odaslive' and 'minidsp.cfg'(if the .cfg file is not there, copy it from the 'config' folder; if not using a minidsp device, there are also presetted .cfg files from ReSpeaker, Matrix, etc. in the folder), align the information in the configuration file with the UMA-8 user manual, then start the program by running: ./odaslive -c minidsp.cfg.

ODAS supports different output methods. If running the program without ODAS_web, change the output interface type of 'SSL' and 'SST' in the .cfg file to 'terminal' instead of via 'socket', then the sound source data will be directly printed out in the terminal - otherwise the system reports: sink_tracks: can not connect to server.

If putting data in a text file is preferred, simply run in the terminal: ./odaslive -c minidsp.cfg>output.txt, then an output.txt file will be generated in the bin folder with all the data output. The file will be updated at the end of each second.

05 Output explanation

Below is part of the output data from the terminal:


```
{
   "timeStamp": 2351,
   "src": [
      { "x": -0.500, "y": 0.162, "z": 0.851, "E": 0.268 },
      { "x": -0.564, "y": -0.097, "z": 0.820, "E": 0.159 },
      { "x": -0.199, "y": 0.274, "z": 0.941, "E": 0.131 },
      { "x": -0.906, "y": 0.420, "z": 0.059, "E": 0.105 }
   ]
}
{
   "timeStamp": 2351,
   "src": [
      { "id": 0, "tag": "", "x": 0.000, "y": 0.000, "z": 0.000, "activity": 0.000 },
      { "id": 34, "tag": "dynamic", "x": -0.458, "y": -0.807, "z": 0.374, "activity": 0.000 },
      { "id": 0, "tag": "", "x": 0.000, "y": 0.000, "z": 0.000, "activity": 0.000 },
      { "id": 0, "tag": "", "x": 0.000, "y": 0.000, "z": 0.000, "activity": 0.000 }
   ]
}
```


There are 2 groups of data output under the same "timeStamp". Around 141 timeStamps of data are printed out every second.

The first group of data are the results of potential sound sources(max no.4 displayed) in the environment, with x,y,z indicating the spatial vector of the sound source relative to the microphone, and E indicating the energy level(volume) of the sound source. The second group shows the information of the most likely sound source among the potential sound sources(max no.4 displayed), with 'id' labeling each sound source detected.

Changes to the printed data could be made in 'snc_pot' and 'snc_tracks' files under the 'message' section of source code. After making a change, update the program by running 'make' again under the build folder.

Now the set-up is completed :)

DF. Python code for data reception and translation

```
import time
import os
import cv2
import numpy as np
import socket
import subprocess
import json
import matplotlib.pyplot as plt
import queue
import math

def process_vector(data,vector,frame):

    # x,y negative/positive depends on the position of your microphone array.
      It should cope with the camera orientation.
    x = -float(vector[0])
    y = -float(vector[1])
    z = float(vector[2])

    if x != 0.000 and y != 0.000 and z != 0.0:

        data.append((x,y,z))

        dot_position = np.array([x, y, z])

        # Normalize the arrow direction vector to have unit length
        dot_position /= np.linalg.norm(dot_position)

        fov = 11.2  # Field of view in degrees
        projection_plane_distance = (480 / 2) / math.tan(math.radians(fov / 2))

        dot_2d_x = int(dot_position[0] * projection_plane_distance/dot_position[2] + 320)

        dot_2d_y = int((dot_position[1]) * projection_plane_distance/dot_position[2]+ 240)

        if 0 <= dot_2d_x <= 640 and 0 <= dot_2d_y <= 480:
            cv2.circle(frame, (dot_2d_x, dot_2d_y), 100, (0, 255, 0), 2)

        else:
            # Calculate the intersection point with the boundary
            center_x = 640 // 2
            center_y = 480 // 2

            # Calculate the slope of the line connecting (x, y) and the center
            if (center_x - dot_2d_x) != 0 :
                slope = (center_y - dot_2d_y) / (center_x - dot_2d_x)

                if abs(slope) > 480 / 640:
                    intersection_y = 0 if dot_2d_y < center_y else 480
                    intersection_x = dot_2d_x + (intersection_y - dot_2d_y) / slope
                else:
                    intersection_x = 0 if dot_2d_x < center_x else 640
                    intersection_y = dot_2d_y + slope * (intersection_x - dot_2d_x)
```

```
            cv2.circle(frame, (int(intersection_x), int(intersection_y)), 50, (0, 0, 255), 10)

        # Draw a circle at the intersection point


def start_odaslive():
    cmd = ['./odaslive', '-c', 'minidsp_socket.cfg']
    subprocess.Popen(cmd)


def main():
    cap = cv2.VideoCapture(2)

    if not cap.isOpened():
        print("Error: Could not open camera.")
        return

    port = 5050
    start_odaslive()

    server_socket = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
    server_socket.setsockopt(socket.SOL_SOCKET, socket.SO_REUSEADDR, 1)
    server_socket.bind(('127.0.0.1', port))
    server_socket.listen(1)



    try:
        client, address = server_socket.accept()

        print("{} connected".format(address))

        while True:

            ret, frame = cap.read()
            if not ret:
                print("Error: Could not read frame from camera.")
                break

            data = client.recv(11000)
            decoded_data = data.decode('utf-8')
            lines = decoded_data.strip().split('\n')
            data = []

            for line in lines[0:]:
                value = line.split()
                print(value)

                values = value[1:]
                vectors = [values[i:i+3] for i in range(0, len(values), 3)]

                for vector in vectors:
                    process_vector(data, vector,frame)
```

```
            cv2.imshow('Camera View', frame)

            if cv2.waitKey(1) & 0xFF == ord('q'):
                break

    except KeyboardInterrupt:
        print("Keyboard interrupt detected. Closing the server.")

    finally:
        server_socket.close()
        cap.release()
        cv2.destroyAllWindows()


if __name__ == "__main__":
    main()
```