DESIGN FMP BRIEF

DESIGNING A USER INTERFACE FOR A PERSONAL COOLING SYSTEM

NOVEMBER 2019

STUDENT: YIWEN SHEN
MENTOR: PROF. LOE FEIJS
ASSESSOR: PROF. STEPHAN WENSVEEN
CHOSEN TRACK: RDD
EXPERTS: JACOB VERHAART & LENNEKE KUIJER
COMPANY: KROPMAN INSTALLATIETECHNIEK

INTRODUCTION

This document presents my proposition for my Final Master Project. First of all, I would like to address my identity and vision as an industrial designer, as well as my personal developments during the entire master study as they are relevant for the project. The direction of this project is related my vision and education background. Secondly, the background of this project will be described, client information, design requirement and stakeholders that will be also presented. Then I will describe theoretical background and design method for this project. Thirdly I will present my design space, design process, and evaluation method that determines to the success and boundaries of this project. Finally, I will discuss the planning and envisioned design deliverables.

Fig 1. Yiwen Shen

IDENTITY

I envision myself to become a UX/UI designer in the field of architecture & building services design. My educational background and practical experience creates the opportunity to become a cross-border designer. Here I would like to give a brief introduction:

- In 2013, I achieved my first diploma in Landscape Architecture at Suzhou University from China. During my internship at EIH Architecture & Planning, I aroused my interests in emerging technology and architectural visualisation, additionally, I also raised interest to study abroad.

- In 2017, I obtained my bachelor diploma in Art & Technology at Saxion Hogeschool, where I gained a lot of practical skills to produce digital products for the market. For example, 3D visualisation, product design and UI design.

- In 2018, I started my master study in Industrial Design at Eindhoven University of Technology. During my master's studies, I broadened my horizons and gained valuable knowledge about design methods and theoretical skills. I am passionate about exploring the boundaries of different design areas. Therefore, I envisioned myself to be an inter-disciplinary designer. In my entire master program, I would like to explore and discover the connections and strive to bridge the gap between architectural & building services design and industrial design. Currently I am working as a junior draftsman at PAI Electric as a part-time job.

I specialise in two areas: parametric design and interaction design.

- Parametric design is a design process that utilises parametric modelling techniques in grasshopper 3D. It was originally used by architects to set up complex models such as facade with irregular curve forms. During the first year of master study, I explored intensively in parametric design method within the context of industrial design, in terms of creating generative patterns and geometry. I created a Tangible User Interface, where I applied design framework of rich interaction design to create a medium to connect parametric designers and other specialists.

- I believe that aesthetic interactions and good user experience not only exist in the field of industrial design, but also exist in architectural and building services design. Especially in the realm of intelligent building control systems. With the increased emphasis being given on user experience and occupants' health and productivity, the thermal comfort and other environmental aspects of buildings, such as lighting quality, should be maintained in a way that satisfies the all the users, In my graduation project, with applying my skills in industrial design, knowledge in UX/UI and great interests in architecture and building control system, I plan to explore interactions between humans and intelligent building systems, especially in the UX/UI design.

DESIGN VISION

The most important technology trends over the past few years relate to the increasing use of data analytics, popularity of the IoT paradigm and growing emphasis on user experience and comfort (Wen, J. T., & Mishra, S. 2018). Taking a look at our life, it is surrounded by new technologies and data. A cross-border designer should be open minded and creative, adopt and explore new technologies and turn them into pleasant experiences and innovative ideas. I strive to do this by:

DESIGN VISION

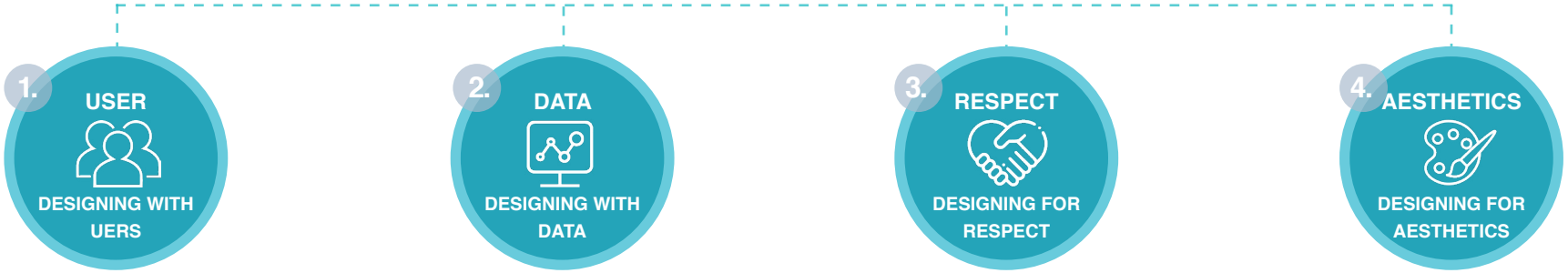

Fig 2. Design Vision

The design of everyday artefacts is not always user friendly and intuitive, and sometimes it can frustrate users. The essence of design is to facilitate people's lives and create meaning for their daily lives. Good interaction and user experience are shaped by one's feelings, motivations and behaviours (Hassenzahl, 2001). In order to design a product that provides functions and a superior user experience, designers are required to have a deep understanding of the user and their contexts.

Data analytics have made significant progress over the last years in the domain of industrial design as well as building applications. The capability to collect and analyse data from multiple data platforms allows the implementation of powerful applications that may provide useful insights. For technology companies, users, products and data are always intertwined. Companies can collect data from users and then optimise their solutions to meet their design goals, while also ensuring that their decisions meet the desires of stakeholders.

The users of the product are human, when designing systems or products, the design process always involves the whole human being, designer should always respect human skills: cognitive, perceptual-motor, emotional and social skills (Hummels, Djajadiningrat, and Overbeeke, 2001). In my design, I try to take user as the centre and their skills as the radius, it is used to establish a harmonious relationship between people and artefacts, to maximise the potential of human beings and thereby to improve user experience.

Aesthetics are important qualities to industrial design. It increases the level of user commitment to the product, also creates an engaging and intriguing experience. Aesthetics exists not only in the form of products, but also in their interactions and functionalities.

PERSONAL LEARNING GOALS

The following learning objectives are related to the areas of expertise that I would like to focus on in this project, as well as the knowledge and skills that I think are required for my envisioned future profession.

User & Society

User involvement in the control of personal cooling system is essential (Verhaart et al, 2018). In this project, I will be in charge of designing the user interface for a smart personalised cooling system. I will not only collaborate with different users and stakeholders, but also study user interaction patterns and their cooling behaviours to develop the user interface. This project also has societal values, creating a comfortable indoor environment is one of the essential functions of buildings as it affects user's satisfaction, well-being and productivity. Personalized cooling system is a promising solution to reduce energy consumption in a commercial building, at the same time it could deliver thermal comfort that satisfies people's individual thermal preference.

Math, Data & Computing

The entire project involves a lot of data collection, analysis and visualization. Data will be used as creative materials for designing the user interface. Each iteration involves data collection and analysis, which will provide design insights for the development of the user interface. Both quantitative and qualitative data will be collected during the design iterations. Proper statistical methods will be applied to evaluate the final prototype.

The relevant electives I completed for project:

Constructive Design Research (core course)

The chosen research subject was related to smart thermostat and intelligent home systems. In this elective, I learned several constructive design methods and performed the research through prototype in design process. The research was supervised by Lenneke Kuijer, a researcher from the Future Everyday group, with specialization on thermal comfort and prototype deployment. We learned co-performance and explored relations between user interactions and contextual parameters through designing a digital thermostat interface.

Researching Future Everyday

Another elective offer by Lenneke Kuijer. In order to study the scalability of co-performance, Atlas, the most educational building in terms of sustainability and intelligent control system & management, was used as the context and research artefact. Several research prototypes (tangible interface) were designed to acquire a deeper understanding of co-performance between occupants and Atlas building. Furthermore, we intensively explored the user behaviour and their interaction with the thermostat, which allows users to control (+/- 2 celsius) degree of certain space temperature and the position of the blinds.

Intelligent Buildings (Minor elective)

An elective from the Built Environment offered by the Building Services research group. This elective brought me useful insights on thinking about how machine learning can be applied and integrated in building services design, especially on HVAC system design. I have learned a lot from this elective, not only the theoretical frameworks of performing data analysis and visualization in both Jupyter Notebook and MATLAB, but also gain practical experience to quickly apply these methods to a new machine learning project.

Applied Statistics (Following...)

To understand the concepts of the statistical analysis methods and statistical assumptions. Also, able to apply them to real data sets and know which method to choose. Using ASA to perform data analysis and visualization.

CLIENTS & PARTNERSHIP

Kropman & Technische Universiteit Eindhoven

This graduation project is a cross-faculty project offered by the Building Services Research Group (TU/e - Technische Universiteit Eindhoven, 2019) at the Faculty of Built Environment, Eindhoven University of Technology. Their mission is to design future proof buildings with minimal renewable energy usage by seamlessly integrating building services with building design. To be more specifically, their research focuses on thermal comfort and optimal personalised control, big data analysis and building energy management system.

In their previous experiment that was conducted by Verhaart (Verhaart, Li, & Zeiler, 2017), a personal cooling system was developed and tested by 11 participants in a climate chamber with controlled environmental conditions and limited timeframes. The purpose of the experiment was to investigate the possibility of predicting thermal satisfaction especially the expected personal cooling. The user interaction was also studied by asking participants to operate the interface [sliders] to control the airspeed. The operational data in setting were recorded continuously in the PCS system. In the future work, the research team would like to redevelop the user interface. Therefore, the design requirement is proposed as the following:

- From the perspective of the users: the interface should be visually pleasing, approachable and easy to use while also providing ready access to, and intuitive navigation within the system, that is capable of receive a variety of different types of user settings, data and control parameters. The computer should also communicate information to the user to aid interaction and foster understanding about the current state of the system.
- From the perspective of researcher: the collected data from user will be stored and visualized that serves the research purpose to create a Personal Comfort Model (PCM).

The final experiment will be conducted at the Kropman office in Breda. Kropman is an installation company that specialises in building automation services including design, implementation, management and operation. Their mission is to make buildings greener, healthier and more efficient. This project involves two experts in thermal comfort from two different departments. Which gives different design perspectives for the development of this user interface.

STAKEHOLDERS

The Build Environment:

• Prof. Wim Zeiler: The chairman of Building Services Research Group and the University Representative of Kropman Installatietechniek company.
• Jacob Verhaart: PhD student, expert in thermal comfort and personal cooling system.

Industrial Design:

• Prof. Loe Feijs: Graduation mentor from Future Everyday Research Group
• Lenneke Kuijer: Expert in thermal comfort in Future Everyday Research Group.
• Yiwen Shen: Industrial Design Student

THEORETICAL BACKGROUND

Creating a comfortable indoor environment is one of the essential functions of buildings as it affects occupant satisfaction (Verhaart, Li, & Zeiler, 2017), well-being (Hawkins, L. H. 1981) and productivity (McCartney & Humphreys, 2002.). According to Kim (Kim, 2018), commercial buildings consume over 30% of the total energy consumption in the world, especially in heating and cooling, which accounts for nearly 60% of energy use within a building. However, only 44% of building succeed to accomplish this goal that delivers a standard thermal condition that satisfies 80% of occupant's preference, still a large portion of occupants are dissatisfied with the thermal environment of the building. At the same time, the most commonly used methods (e.g. PID control and on/off control) to manage cooling, heating and ventilation systems of the entire building are becoming inefficient and unsustainable (Katić, Li, Verhaart, & Zeiler, 2018).

A personal cooling system seems to be a promising solution to address this problem as it is able to provide personalised experience in the building, which also results in energy saving, therefore, brings sustainability within building services and management to improve building performance (Kim, 2018) , (Katić, Li, Verhaart, & Zeiler, 2018). Designing personalised experience requires both studies and explorations to be performed among users, interactions and personal thermal preference. However, personal thermal preference can be a difficult subject to measure due to the different individual responses to mainly two categories of factors: personal factors (age, gender, metabolism rate etc.) and environmental factors: air speed, relative humidity, building insulation and temperature. Moreover, personal thermal preference is hard to predict becuase it is unknown to what extent the personal perference is based in physical factors. The thermal condition within one person is relatively stable, however, in some situations for instance if the user is being ill, his or her thermal perference will be different.

Thanks to the technological development in big data in the design of HVAC systems, engineers and designers are able to collect personal data to learn individual thermal preference. The real-time processing enable the personal thermal comfort prediction to be developed by utilizing machine learning algorithms. However, advanced automation system and technologies often require appropriately trained technicians and engineers to operate them, most building don't have staff available (Wen, J. T., & Mishra, S. 2018). This requires companies to invest a lot of time and specialism to perform intensive data analysis if building managers/owners want to improve the building performance.

Designing a user-friendly interface can overcome the problem. By integrating building automation system and user interaction patterns, designers are able create interfaces for users to better control and adjust heating and cooling systems (Fadell et al, 2012). The system is also able to learn from occupant's heating and cooling behaviours to improve its personal comfort system for the development of personal comfort model to predict individual's preference. The design of such user interfaces must meet the following design requirements: 1. Providing the possibility to balance user comfort and energy saving. 2) Provide easy-to-use user interaction design. If users find interactions intimidating or confusing, they are likely to restore default settings or simply stop interacting, reducing user satisfaction, in my opinion, feedback to the user would be one of the main objectives of the interface.

RESEARCH QUESTIONS

The user interface will main serve two purpose: offering user friendly interaction to operate the cooling system and collecting personal data for the development of the personal comfort model. Therefore, the research questions is proposed:

1. How can a user interface be designed for personal cooling systems for users to interact with?

2. How the data will be collected and visualized that can be interpreted easily by both users and companies?

METHOD:

Since the focused areas of expertise are Math,Data & Computation and User & Society, therefore this interface will be designed by integrating the following design methods: Data Enabled Design, Co-performance and Rich Interaction framework.

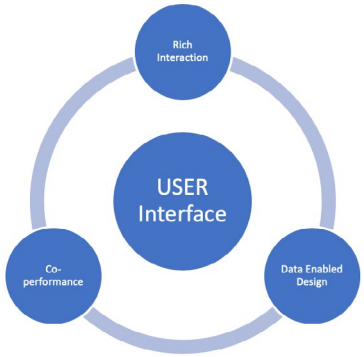

Fig 3. Method

Data Enable design (MDC)

Data Enable design utilizes data as creative material when designing for intelligent ecosystems. The design process is inspired by the gathered data. Each iteration of data collection will provide different insights for improvements. In this project, datasets have been generated from the previous studies conducted by Verhaart (Verhaart, Li, & Zeiler, 2017), besides that, a sensor set is developed by the Kropman, namely climatebuddy, will be used in the pilot test to collect environmental data. All the datasets will be analysed and visualized in Python to generate design insights to design this interface.

Co-performance (UC)

Kuijer and Giaccardi offer a perspective on designing artificial agents they named co-performance that automated artefacts is capable of performing actions in the absence of people, due to they are being equipped with sensors, actuators and computing power that can make decisions about how to proceed in specific, situated circumstance (Kuijer, 2018).

Co-performance will be applied in this project to study the patterns of user interaction and behaviour, these aspects are crucial for the development of personal comfort model. The envisioned interface is the embodiment of the building automation system that offers access for user to operate HVAC system. The interface aims to learn from the user and perform appropriate actions according to different and complex user scenarios' and yet predict preferred thermal comfort.

Rich Interaction

Rich Interaction is a design framework that covers two aspects, respecting people's skills and aiming for aesthetic interaction through the unity of form, interaction and function (Frens, 2006). The envisioned interface aims to deliver good user experience; however, user experience cannot be designed directly but may be approached through the interplay of interaction and people's skills: perceptual-motor, emotional and cognitive skills, in other works, how people can feel, think and behave.

DESIGN SPACE

In this project, I will be responsible for development of the User Interface, which will be used by users to operate the cooling system. Jacob Verhaart will be responsible for the development of the machine learning model and the effect of automated control on user satisfaction, comfort and productivity. The experiment setup will be provided by the Kropman at Breda. The envisioned interface will be performed as a medium to collect personal data, the environmental data will be collected by using the ClimateBuddy that is developed at Kropman. Both data source will be used to developing the PCM by utilising machine learning algorithms.

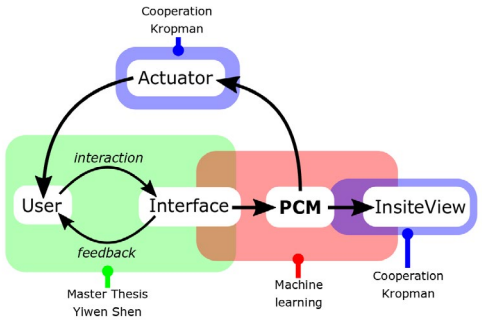

Fig 4. Measurement Plan (Verhaart. 2019)

The user interface will be created by programming an Arduino UNO board, multiple temperature sensors will be embedded on an artefact (for instance a chair in the previous experiment), which allows to measure direct perception of temperature from the users. The data will be stored in a CSV file for data analysis and development of the machine learning algorithms. The interface will be programmed by using the Python or Java programming environment or platforms.

The final experiment will be running for one and half month to collect both qualitative and quantitive data. After the data collection is completed, the datasets will be imported into Jupyter NoteBook (Python based programming platform) to perform data visualization, this serves to generate insights for the improvement of the user interface.

The datasets will be also imported in MATLAB to develop a predictive model that delivers the highest accuracy, this requires interactively training and evaluating classification model. The training procedure will be executed as the listed below:

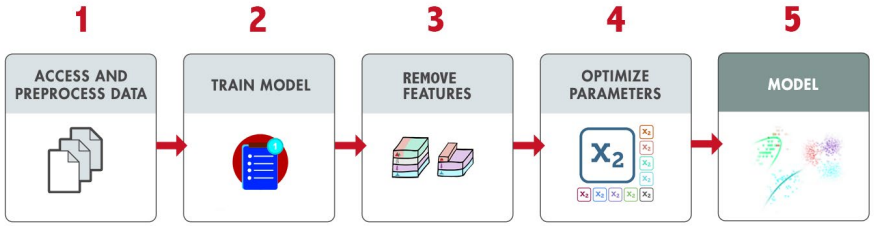

Fig 5. Machine Learning Flow In MATLAB

DESIGN PROCESS

First of all, theoretical studies will be conducted, especially on personal thermal comfort. For instance, what are the affecting factors and how to evaluate the personal thermal comfort. The designing process and planning is presented as the following:

Phase 1: Literature review

When: November – 15th of December 2019

Deliverable: FMP Proposal

The first phase, the FMP will be finished and presented. The related literature including user interface design, thermal comfort and building automation system will be studied. I will also apply my experience and knowledge I learned the Intelligent buildings elective given by the Building Services Research Group.

Phase 2.1: 1st iteration UI

When: Nov – 15th of Dec 2019

Deliverable: 1st iteration of UI

The datasets from previous experiements will be analysed and visualized as design inspiration for the first UI iteration, besides that, the climatebuddy sensor will be used to collect in-situ environmental data including air temperature, light and humidity.

The pilot interface (1st iteration) will be designed after analysing the collected dataset. The user behaviour will be learned by observing how they interact with the interface and design implications will be drawn up and then applied to the next iteration. therefore, the interface will be improved. The pilot test will be executed in the Climate Chamber at TU/e.

Phase 2.2: Development of the ML system

When: 16th of Dec – 15th of Jan

Deliverable: 1st iteration of UI

In this phase, a user survey will be created, and user tests will be conducted. This phase involves qualitative data collection from users. What will be the expectation from the users and engineers when using this interface and how to operate it to control the cooling system. The development of ML model will be performed by Jacob Verhaart.

Phase 2.3: User data analysis

When: 16th of Dec – 15th of Jan

Deliverable: Data analysis

In this phase, data will be analysed to acquire user insights and draw design implications for the improvements of the 2nd iteration of UI prototype. A Diary booklet will be created for this to collect qualitative data concerning their experience and perception.

Phase 3.1: 2nd Iteration

When: 14th of Jan – 31th of Feb

Deliverable: 2nd iteration of UI

In this phase, the 2nd prototype will be completed for the final experiment that will be executed at Kropman Office. Three prototypes are required for final experiment.

Phase 3.2: Preparation of the room at Kropman

When: 20th Mar – 31th of Mar

Deliverable: The prototype will be placed at Kropman ready for the final experiment.

Phase 4: Data collection at Kropman.

When: 1st Apr – 15th of May

Deliverable: The prototype will be collected at Kropman Office and user data will be collected for one and half month to evaluate the design of prototype, as well as the PCM model. A Diary booklet will be also prepared for this to collect qualitative data concerning their experience and perception of the environment. The study will run for one and half month to collect both qualitative and quantitive data.

Phase 4: Data analysis

When: 15 of May – 31th of May

Deliverable: The collected data will be analyzed for the evaluation see check to performance of the personal cooling system and its user interface.

Expected success criteria

The user interface that is able to enable the user to indicate their desire in an intuitive way, which is easy and quick and at the same time, give feedback to the user on the prediction of the PCM. The PCM will be evaluated by using following criteria.

- CBE (Center for the built enenvironment)
- PMV (predicted mean vote)
- PDD (predicted percentage dissatisfied)

The PCM is able to predict the personal thermal comfort model before the human inputs. Ideally, the user interaction will be reduced with time goes by, while the PCM model will become more active in predicting the thermal preferences.

The rich interaction framework will be used to evaluated the usability and aesthetic qualities of interaction. The design of the user interface, functions and interactions should be integrated in a harmonious way that delivers pleasant user experience. The thermal preference would be easily reached by interacting with this interface.

PROJECT TIME PLAN

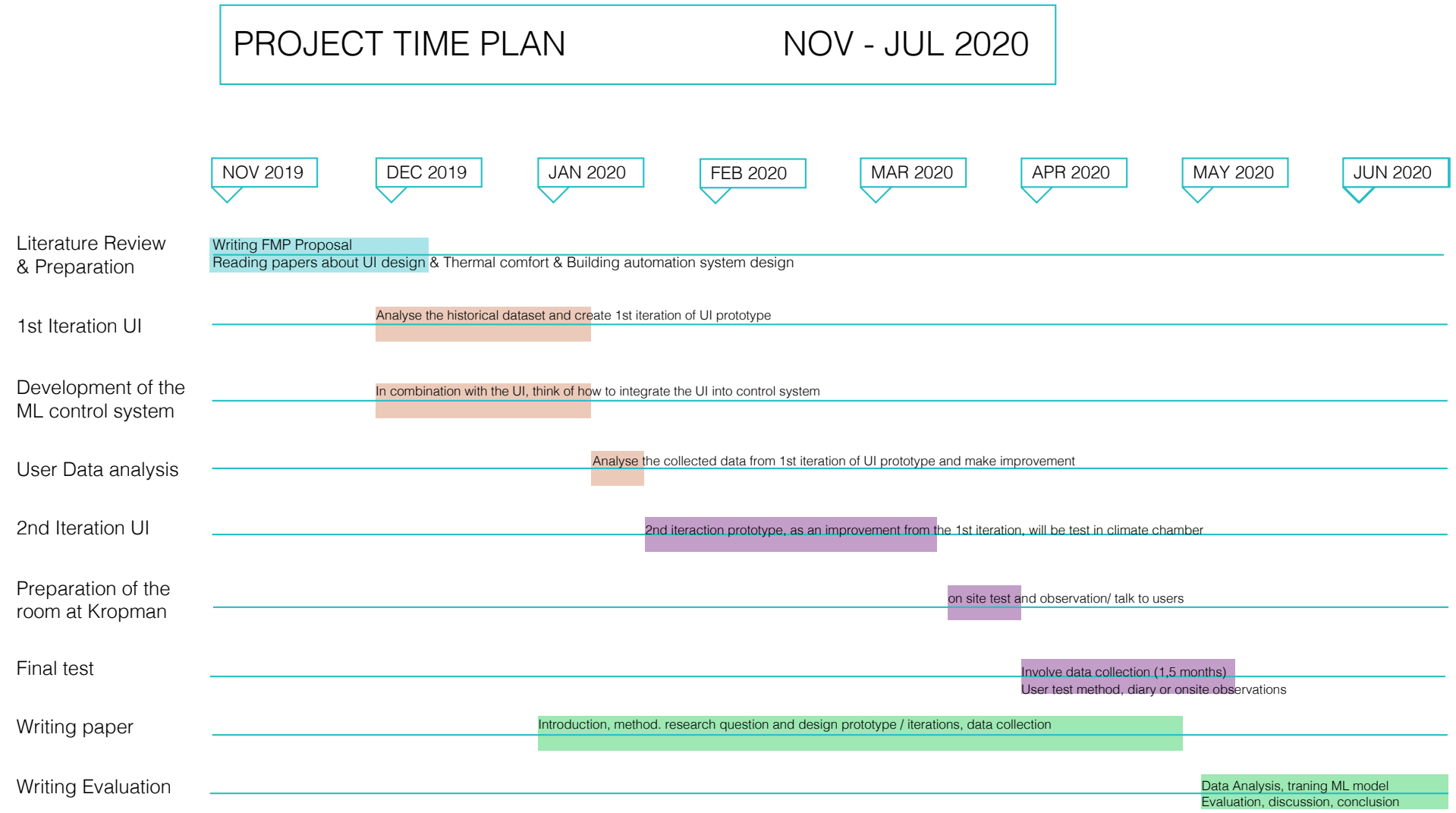

Fig 6. Planning

REFERENCE

1. TU/e - Technische Universiteit Eindhoven. (2019). Building Services. Retrieved November 27, 2019, from Www.tue.nl website: https://www.tue.nl/en/research/research-groups/building-services/

2. Verhaart, J., Li, R., & Zeiler, W. (2017). User interaction patterns of a personal cooling system: A measurement study. Science and Technology for the Built Environment, 24(1), 57–72. https://doi.org/10.1080/23744731.2017.1333365

3. Kim, J. (2018). Advancing comfort technology and analytics to personalize thermal experience in the built environment. Retrieved November 27, 2019, from Escholarship.org website: https://escholarship.org/uc/item/58m331f

4. Mccartney, K., & Humphreys, M. (2002). THERMAL COMFORT AND PRODUCTIVITY. Retrieved from://pdfs.semanticscholar.org/1aaa/d824cfb9f5105fdaebf97f8ec7ddf9e4f83f.pdf

5. Hawkins, L. H. (1981). The influence of air ions, temperature and humidity on subjective wellbeing and comfort. Journal of Environmental Psychology, 1(4), 279-292.

6. Kuijer, L., & Giaccardi, E. (2018, April). Co-performance: Conceptualizing the role of artificial agency in the design of everyday Life. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (p. 125). ACM.

7. Wen, J. T., & Mishra, S. (2018). Intelligent Building Control Systems: a Survey of Modern Building Control and Sensing Strategies. Cham: Springer International Publishing.

8. Verhaart, J., Li, R., & Zeiler, W. (2018). User interaction patterns of a personal cooling system: A measurement study. Science and Technology for the Built Environment, 24(1), 57-72.

9. Kim, J., Zhou, Y., Schiavon, S., Raftery, P., & Brager, G. (2018). Personal comfort models: Predicting individuals' thermal preference using occupant heating and cooling behavior and machine learning. Building and Environment, 129, 96–106. https://doi.org/10.1016/j.buildenv.2017.12.011

10. Van Den Hoven, E., Frens, J., Aliakseyeu, D., Martens, J. B., Overbeeke, K., & Peters, P. (2007, February). Design research & tangible interaction. In Proceedings of the 1st international conference on Tangible and embedded interaction (pp. 109-115). ACM.

11. Katić, K., Li, R., Verhaart, J., & Zeiler, W. (2018). Neural network based predictive control of personalized heating systems. Energy and Buildings, 174, 199–213. https://doi.org/10.1016/j.enbuild.2018.06.033

12. US8195313B1 - Thermostat user interface - Google Patents. (2012, January 17). Retrieved November 27, 2019, from Google.com website: https://patents.google.com/patent/US8195313B1/en

13. Verhaart,J. (2019). Kropman Plan.

Week 1, 11-11-2019

FMP Proposal Reflection

Yiwen Shen

Overview reflection:

This project is a cross faculty project stands in between the Department of Industrial Design and the Built Environment. I think this project would fit my design identity and vision perfectly. I have educational experience in both fields of studies. Therefore, this project would be an integration of the knowledge and skills I learned in the past.

The envisioned design challenges is described as the following:

- **Different specialism**

As I mentioned earlier, this project will be performed across two different departments. The expected deliverable will be a User Interface for a personal cooling system. I have knowledge and experience in UX / UI design, however, I consider it would not be sufficient because designing a UI for building automation systems also requires knowledge and experience in building control systems. Before starting this project, I took one elective that is given by the Building Services Research Group, This elective brought me useful insights on thinking about how machine learning can be applied and integrated in building services design, especially on HVAC system design. I have learned a lot from this elective, not only the theoretical frameworks of performing data analysis and visualization in both Jupyter Notebook and MATLAB, but also gain practical experience to quickly apply these methods to a new machine learning project.

- **Stakeholder management**

This project will involve researchers from different departments, as well as the client company. This requires me, as the UX designer, not only to connect different stakeholders, keep them updated with design process, but also be self-discipline, executing every step of the design process on time.

- **Time management**

The prototype needs to be finished before April, 2020. There will be three interface prototypes required for the final experiment. The data collected will be running for one and a half months, the data analysis and evaluation will be also performed after the data collection within a short time period. Therefore, all the design process needs to be on time.

Chosen Track: RDD

Identity

I envision myself to become a UX/UI designer in the field of architecture & building services design. My educational background and practical experience creates the opportunity to become a cross-border designer.

1. In 2013, I achieved my first diploma in Landscape Architecture at Suzhou University from China..
2. In 2017, I obtained my bachelor diploma in Art & Technology at Saxion Hogeschool, where I gained a lot of practical skills to produce digital products for the market.
3. In 2018, I started my master study in Industrial Design at Eindhoven University of Technology. During my master's studies.

I am passionate about exploring the boundaries of different design areas. In my entire master program, I would like to explore and discover the connections and strive to bridge the gap between architectural & building services design and industrial design.

Unique expertise profile

I specialise in two areas: **parametric design** and **interaction design**.

- Parametric design is a design process that utilises parametric modelling techniques in grasshopper 3D. In first year of master study, I explored intensively in parametric design method within the context of industrial design, in terms of creating generative patterns and geometry. I created a Tangible User Interface, where I applied design framework of rich interaction design to create a medium to connect parametric designers and other specialists.

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Vision

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Designing with users:

The design of everyday artefacts is not always user friendly and intuitive, and sometimes it can frustrate users. The essence of design is to facilitate people's lives and create meaning for their daily lives. Good interaction and user experience are shaped by one's feelings, motivations and behaviours (Hassenzahl, 2001). In order to design a product that provides functions and a superior user experience, designers are required to have a deep understanding of the user and their contexts.

Designing with data:

Data analytics have made significant progress over the last years in the domain of industrial design as well as building applications. The capability to collect and analyse data from multiple data platforms allows the implementation of powerful applications that may provide useful insights. For technology companies, users, products and data are always intertwined. Companies can collect data from users and then optimise their solutions to meet their design goals, while also ensuring that their decisions meet the desires of stakeholders.

Designing with respect:

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Designing for Aesthetics:

Aesthetics are important qualities to industrial design. It increases the level of user commitment to the product, also creates an engaging and intriguing experience. Aesthetics exists not only in the form of products, but also in their interactions and functionalities.

Ethical Review Form

(Version 27.06.2019)

This Ethical Review Form should be completed for every research study that involves human participants or personally identifiable data and should be submitted before potential participants are approached to take part in the research study.

Part 1: General Study Information

1	Project title	Final Master Project
2	Researcher	Yiwen Shen
3	Email researcher	y.shen1@student.tue.nl
4	Supervisor(s)	Prof.Dr.Ir.Loe Feijs
5	Faculty/department	Industrial Design
6	Research location	Kropman Installtietechniek & the Built Environment
7	Research period (start/end date)	Jan 2019 / Jul 2020
8	Funding agency	
9	[If Applicable] Study is part of an educational course with code:	Final Master Project, DFR210
10	[If Applicable] Proposal already approved by external Ethical Review Board: Add name, date of approval, and contact details of the ERB	
11	Short description of the research question	How can a user interface be designed for personal cooling systems for users to interaction with?
12	Description of the research method	The research method will be an integration of three frameworks that I learned during the master study: Data-enable design, rich interaction and co-performance. The research will be part of a design process. In which the user will be asked to participant in and interact with the prototype, filling diary study booklet and interview. It is an iterative process.
13	Description of the research population, exclusion criteria	Participants will be three office workers at the Kropman Company. They are aged 45+. Two thermal comfort experts from the Department of the Built Environment and Industrial Design will be also involved. They offer their expertise of thermal comfort on this project.
14	Description of the measurements and/or stimuli/treatments	The project will include a pilot test be executed at Climate Chamber at the Department of the Built Environment. The Final experiment will be executed at Kropman Office in Breda. Three participants will be asked to fill in a diary booklet and interact with the prototype, their personal data regarding to their personal thermal preference will be collected. The environmental data including air speed, humidity, temperature and co2 level will be also recorded by

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		using the ClimateBuddy, a sensor box developed by Kropman.
15	Number of participants	Three workers from Kropman Installatietechniek. They are volunteers for this project.
16	Explain why the research is socially important. What benefits and harm to society may result from the study?	This project will focus on developing a user interface for users to control a personal cooling system. Creating a comfortable indoor environment is one of the essential functions of buildings as it affects user's satisfaction, wellbeing and productivity. Researches have also shown that by better adjusting and controlling HVAC system can improve building performances, for instance: save energy consumption. The project might generate a large amount of data for the development of predictive model, however, in some situation that a considerable proportion of data will be wasted, so it is not that the personalized service (cooling in this case) is difficult to land, but that the data is not fully and effectively used at all. At the same time, it might be also difficult to convert data into services due to the current technical level.
17	Provide a brief statement of the risks you expect for the participants or others involved in the research or educational activity and explain. Take into consideration any personal data you may gather and privacy issues.	The expected risks are the photo and video material that will be taken for this project. As it could be used for the report. But this will be anonymized and de-identified. Sensitive personal data will not be collected, such as name, address, religion etc. The prototype will only environmental data in the office and operational data when users are interacting with the prototype. Their thermal preference will be stored for the development of machine learning model.

Part 2: Checklist for Minimal Risk

		Yes	No
1	Does the study involve participants who are particularly vulnerable or unable to give informed consent? (e.g. children, people with learning difficulties, patients, people receiving counselling, people living in care or nursing homes, people recruited through self-help groups)		X
2	Are the participants, outside the context of the research, in a dependent or subordinate position to the investigator (such as own children or own students)?		X
3	Will it be necessary for participants to take part in the study without their knowledge and consent at the time? (e.g. covert observation of people in non-public places)		X
4	Will the study involve actively deceiving the participants? (e.g. will participants be deliberately falsely informed, will information be withheld from them or will they be misled in such a way that they are likely to object or show unease when debriefed about the study)		X
5	Will the study involve discussion or collection of personal data? (e.g. name, address, phone number, email address, IP address, BSN number, location data) or will the study collect and	X	

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	store videos, pictures, or other identifiable data of human subjects?[1]. Please check the FAQ's on the intranet. If yes: please follow the procedure. Make sure you perform a Data Protection Impact Assessment (DPIA) and make a Data Management Plan if necessary and let the data steward check it.		
6	Will participants be asked to discuss or report sexual experiences, religion, alcohol or drug use, or suicidal thoughts, or other topics that are highly personal or intimate?		X
7	Will participating in the research be burdensome? (e.g. requiring participants to wear a device 24/7 for several weeks, to fill in questionnaires for hours, to travel long distances to a research location, to be interviewed multiple times)?		X
8	May the research procedure cause harm or discomfort to the participant in any way? (e.g. causing pain or more than mild discomfort, stress, anxiety or by administering drinks, foods, drugs)		X
9	Will blood or other (bio)samples be obtained from participants (e.g. also external imaging of the body)?		X
10	Will financial inducement (other than reasonable expenses and compensation for time) be offered to participants?		X
11	Will the experiment involve the use of physical devices that are not 'CE' certified?		X

Important:
If you answered all questions with ''no'', you can skip parts 3 - 4 and go directly to part 5. Check which documents you need to enclose and continue with signature and submission.

If you answered one or more questions with "yes", please continue with parts 3 – 5.

Part 3: Study Procedures and Sample Size Justification

1	Elaborate on all boxes answered with "yes" in part 2. Describe how you safeguard any potential risk for the research participant.	
2	Describe and justify the number of participants you need for this research or educational activity. Also justify the number of observations you need, taking into account the risks and benefits	There will be three participants involved in the final experiments. They are the office worker at the client company. They are volunteered to participant to this research.

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Part 4: Data and Privacy Statement		
1	Explain whether your data are completely anonymous, or if they will be de-identified (pseudonymized or anonymized) and explain how	The will be de-identified by blurring photo material and anonymizing possibly created transcripts of the interview/ focus groups.
2	Who will have access to the data?	Myself, the designer. Dr. Jacob Verhaart, the PhD student from the Built Environment Prof. Wim Zeiler, the University Representative of Kropman Installatietechniek company.
3	Will you store personal information that will allow participants to be identified from their data? See VSNU draft.	☒ No ☐ Yes, and I declare I will follow the general data protection regulation (GDPR).
4	Will you share de-identified data (e.g., upon publication in a public repository)?	☐ No ☒ Yes, and I will inform participants about how their data will be shared, and ask consent to share their data. I will, to the best of my knowledge and ability, make sure the data do not contain information that can identify participants.

Part 5: Closures and Signatures		
1	Enclosures (tick if applicable): ☒ Informed consent form; ☒ Informed consent form for other agencies when the research is conducted at a location (such as a school); ☐ Text used for ads (to find participants); ☒ Text used for debriefings; ☐ Approval other research ethics committee; ☐ Any other information which might be relevant for decision making by ERB; ☐ Data Protection Impact Assessment checked by the privacy officer ☐ Data Management Plan checked by a data steward	
2	Signature(s) Yiwen Shen Signature(s) of researcher(s) Date: 02-11-2019 Signature research supervisor (if applicable) Date:	

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2	Signature(s) Yiwen Shen Signature(s) of researcher(s) Date: 02-11-2019 Signature research supervisor (if applicable) Date:	