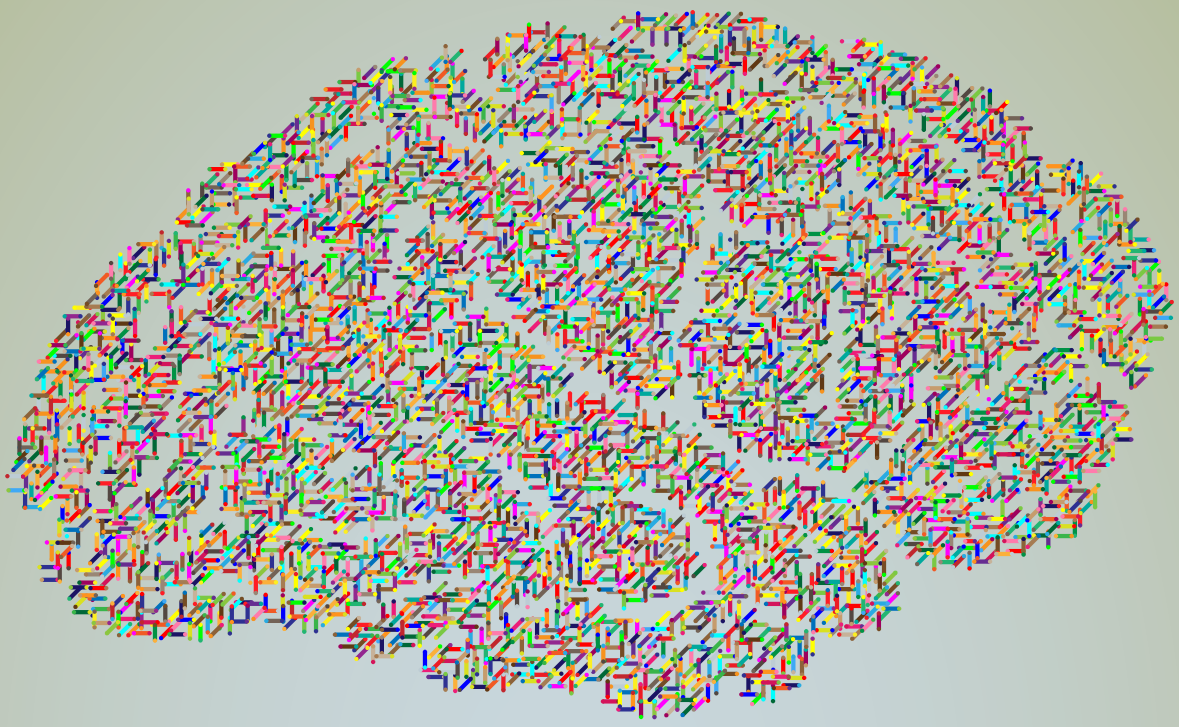

ObjectResponder

Researching & Prototyping for **Design collaboration with Artificial Intelligence**

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Master Thesis | 2019

Faculty of Industrial Design Engineering | TU Delft

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ObjectResponder

Researching & Prototyping
for **Design collaboration**
with Artificial Intelligence

This thesis dedicated to my nieces & nephew Janya, Dhimahee & Hridayansh…

Acknowledgment

This master thesis is a long persistent journey which would have been not achievable without constant support and assistance of many people around me. Therefore, I would like to take this opportunity to ***Thank all my dear ones*** who have been part of this journey.

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Lastly, the most important ***my beloved family — my dear parents, brothers & kids*** for their unconditional love, keeping faith in my ambition and encouraging me to fulfill this dream. Therefore, I would like to say this master was dedicated to my family.

Nirav Malsattar
15th April 2019

Table of Content


Please recycle the cup
cup 88%
tableware 84%
product 80%

Chapter 1

Introduction

ObjectResponder is a design toolkit that uses state-of-the-art computer vision system and allows designers to problematize context and conceptualize design ideas from a non-human (machine) perspective.

1.1 Executive Summary

In this report, I have explained my iterative design process using research through design approach. This project focuses on the context of Artificial intelligence and design collaboration. It also represents a design method of integrating human and non – human biases while designing intelligent products.

Abilities of Artificial Intelligence (AI) are expanding so rapidly, that it already surpasses the human in specific tasks that were not thought before. Recent advancements in machine learning algorithms (ML) and its techniques e.g. 'deep learning', enable the machine to develop creative content on its own (John, 2016). Meanwhile, in the design domain, people have already begun to consider artificial intelligence as new design material (Holmquist & Erik, 2017). One can consider it an intelligent design material as it can include creativity as individual machine learning models.

To understand this new paradigm of using AI in the design process, I created a speculative prototype of a design toolkit called objectResponder (v1.0). A toolkit which enables to design and prototype from the perspective of AI in the 'wild'(Rogers & Marshall, 2017). I explored this toolkit with six professional designers from various discipline. Initial results suggested that looking at the world from the perspective of the AI may enable designers to balance human and nonhuman biases, enrich a designer's understanding of the context, and open up unexpected directions for idea generation.

The results from the study initiate my graduation project with — identifying what designers need, their concerns and challenges while working with Artificial intelligence and Machine Learning projects. In my thorough investigation with professional designers and design students, I learned that there is a gap in comprehending Artificial intelligence technology in design practice. Such as,

designers struggle to incorporate these technologies into their products and services due to the complex nature of it. It was also evident in the literature study that, designers' need to understand the underpinning principle e.g. limitations of Artificial intelligence and Machine Learning (Dove, Halskov, Forlizzi, & Zimmerman, 2017). Designers' currently working with Artificial intelligence technologies mentioned that they are looking for a tool or prototyping toolkit which integrates AI with embodied ideation and rapid prototyping methods.

To understand the state-of-the-art of AI, a literature study was conducted with the exploration of various ML technologies and prototyping tools. The purpose of this literature study was to understand the state-of-the-art AI and its current state. In this literature studies, I encountered some initial prototypes of tools that showed the possibilities of Artificial intelligence intervening into the design process. Meanwhile, technology exploration with various AI and ML tools and platforms allowed me to learn some facet of current AI and ML tools and ML platforms and perceive its limitations.

From this observation, I designed three varied computer vision enabled experiments. Designers from various expertise have participated in the experiments. They were asked to follow the idea generation process with and without an AI's Computer Vision technique (Machine perspective). Based on designers' feedback about the experience of working with a designed speculative prototype, I propose a design toolkit called 'object responder v2.0' — with further advancement in it.

1.2 Methodological approach

The project facilitates a Research through Design (RtD) approach by integrating design research activities and constructing a speculative prototype of a 'design toolkit', which uses computer vision technique. To make the prototype, various machine learning tools and platforms were explored. The knowledge gained from this exploration were used to construct a speculative prototype and three iterative design experiments. These three successive design experiments were conducted with 10 professional designers and 20 design students. To capture the exceptionally unpredictable activity of designers and their experience with the prototype in three different experiments, RtD approach has been adopted.

1.2.1 Research Through Design

In the Research through Design approach, a designer 'conducts a research through designed artifacts or speculative prototype to generate new knowledge'. This approach can be also useful when the object of the design in itself a design method (Stappers & Giaccardi, 2007). Also sometimes, the artifacts uses in the research can be stimulus materials in experimental setup and play central role in creating new knowledge. Often it can be a vehicle for unfolding new research and drive it towards unexplored direction through successive iteration.

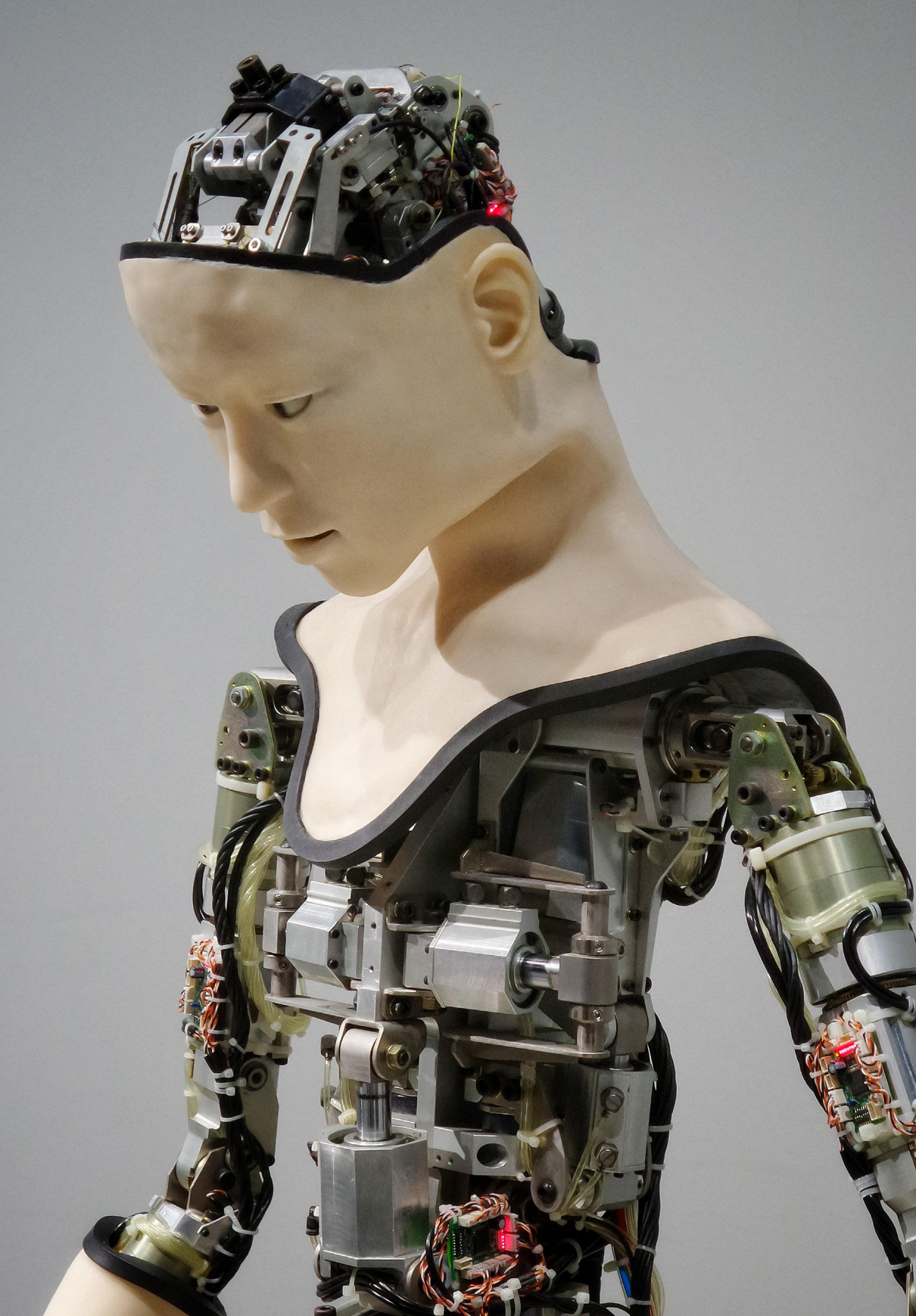
Although, the material aspects are important for user to perceive speculative design, the object that is prototyped is not necessarily conceived as material object, as in prototyping a service or a method, technique or practice (Zimmerman, Forlizzi, & Evenson, 2007). Thus, the artifacts are designed in such a way that a 'user' can explore some factors of design, perceive the experience and future interaction with it.

1.2.2 Designing from Non – human Perspective.

A non-human perspective emerges when designer perceive the world from the eyes of non-living entity and frame and solve the design problem (Giaccardi, Cila, Speed, & Caldwell, 2016).

While, in this study, designers perceived the real-world context through a computer vision technique— a non-human perspective that see real world context differently than human. Through this perspective, designers are problematize the context and conceptualize design solutions in their process. Indeed, designers provide access to the information about the patterns that holds between user – object relation in the context, that would not be attainable by human designer.

Moreover, when designer expose to the machine vision, they understand the knowledge about biases involved in the machine algorithms and balance it out during the design process. This would be the opportunity for designers to distinguish the role of individual objects situated in the context.



Chapter 2

Understanding AI

A heuristic literature study was carried out through books and articles about scientific discovery in Artificial intelligence and Machine Learning from 1955's till now. Also, some of the early intervention between design and ML algorithms were explored. The purpose behind this literature study was to understand about state-of-the-art Artificial intelligence, it's limitations and the current state.

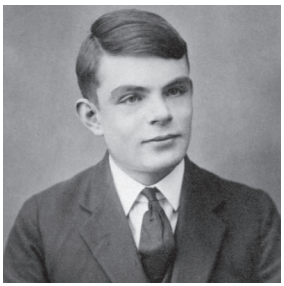
2.1 AI State of the Art

2.1.1 Definition

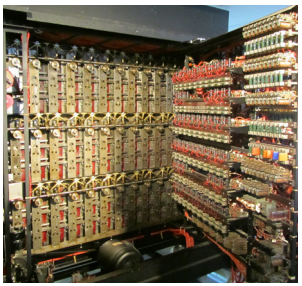
During the literature study, several definitions of Artificial Intelligence came up front. Some of them referring back to Greek Mythology characters e.g. Golem, Frankenstein (Buchanan, 2005), while others pointing towards the futuristic intelligent human agents or smart objects (Noessel, 2017). It was difficult to choose either one of the definitions because the roots of Artificial Intelligence go way back in time. These roots have evolved since then to become a tree. Moreover, since there is no specific definition of an AI defined yet, a general overview on AI research and its purpose were formulated from pieces of literature.

"Artificial Intelligence (AI) is interdisciplinary research between mathematics, computer science, linguistics, human psychology, cognitive science and many more. The purpose behind research on AI is to simulate human intelligence into the machine — so it can perform any human task in an intelligent manner. Some of the ideal characteristics of artificial intelligence machine include learning, reasoning, perception and then rationalize the given information (through various machine learning techniques) as we humans do in our daily life" (Barr, Feigenbaum, & Cohen, 1981)

To mimic a human behavior, different computer science techniques work together. So, we can see that why AI is not just a one technology, but bunch of different techniques integrated together to form a 'Artificial Intelligence' in contrast to 'Human Intelligence'.



Alan Turing



The Enigma Decrypter Machine

The Enigma Encrypter Machine

2.1.2 History

In 1950 famous computer scientist Alan Turing explored the mathematical possibility of a 'machine which can think'. After cracking the 'Enigma' code used by German military forces in World War II, Turing and his team laid the foundation of Machine Learning. He envisioned an intelligent machine which can perform tasks like a human (through learning, reasoning, perception). To make a judgment about how intelligent this machine is, Turing made a test plan in a form of a game, which later known as 'Turing Test' (Turing, 1950). In this test, he argued that if the machine could converse with a human without the human noticing that it is a machine, it would pass the test and be considered as an 'Intelligent.'

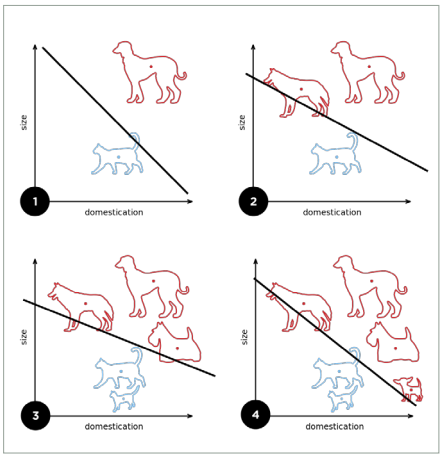
John McCarthy and other AI researcher from Dartmouth Summer Research Project.

Later in 1956, an American computer scientist John McCarthy with other notable researchers (20 researchers) hosted a "Dartmouth Summer Research Project" (McCarthy John, Minsky Marvin, Rocheste Nathaniel, & Shannon Claude, 1955). Essentially, the aim of this workshop was to do a brainstorming session about how should we perceive this intelligent machine in the future. During these two months' workshop, many topics were covered and discussed. While some of the proposals were discarded, others were considered to have been initiated and published. In this very event, John McCarthy also first coined the term called 'Artificial Intelligence (AI)' (Chris, Brian, Ting, & Gary, 2006).published. In this

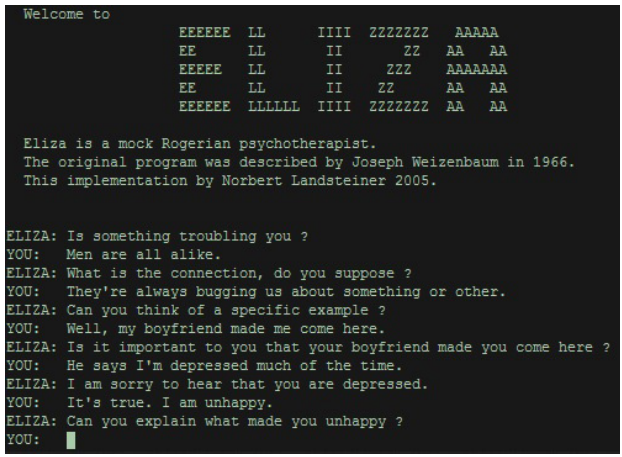
very event, John McCarthy also first coined the term called 'Artificial Intelligence (AI)' (Chris, Brian, Ting, & Gary, 2006).

2.1.3 Evolution

From 1957 -1970, advancements in computer hardware and developments of ML algorithms led to a vision for the future AI. Computer Vision algorithm 'Perceptron' (Papert, 1969), Natural Language Processing (NLP) program 'ELIZA' (Weizenbaum & Joseph, 1966) fostered an idea of building intelligent machines which have some human like abilities. During this period, many theories and concepts about AI and ML were developed. This notion ignited researchers to build an AI system which can talk, see and understand the context within the real world and human beings.



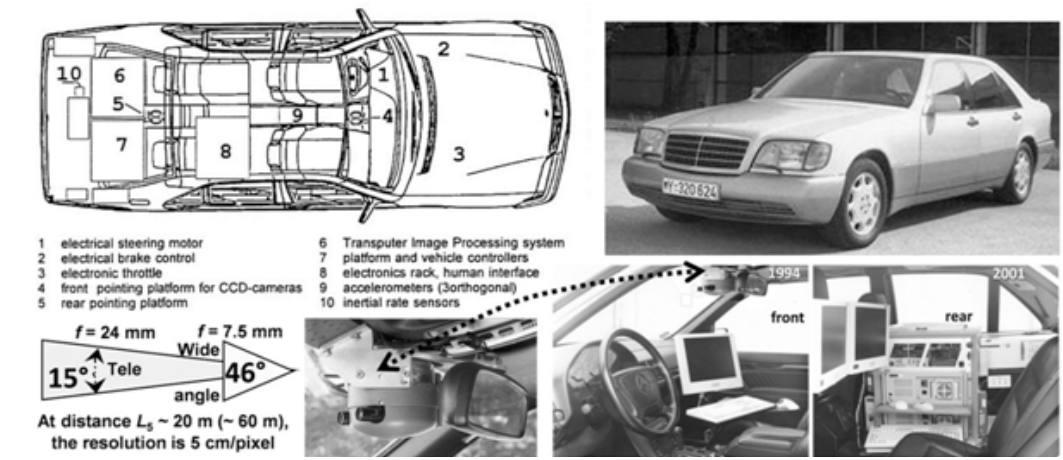
Computer Vision algorithm 'Perceptron' 1969



Natural Language Processing (NLP) program 'ELIZA' 1966

However, due to technical limitations at that time, the idea of making an intelligent machine was not discussed actively. As a result, between 1970 and mid-1990, AI computer scientists had to deal with the shortage in funding AI research, which later known as "AI Winter" in history (Chris et al., 2006).

During 1990 - 2004 major advancements occurred in the various area linked to Machine Learning, Deep Learning, Computer Vision and Natural language processing. Some of the prominent examples were, Driverless car VaMP (Maurer et al., 1995); Speech Recognition program — Dragon System (1997); IBM's 'Deep Blue' chess-playing computer (Feng-Hsiung Hsu, 1999), which defeated the grandmaster of chess 'Garry Kasparov'.



Driverless car VaMP, 1995

Grandmaster of chess 'Garry Kasparov' with IBM's 'Deep Blue' chess-playing computer

2.1.4 AI and ML Technology

From 2004 - 2015, an exponential increase in processing power and storage abilities, provided a boost to some of the advanced deep learning algorithms e.g. Convolutional Neural Networks (CNN) (O'Shea & Nash, 2015). Big technology giants and research labs used vast amount of data for training machine learning algorithms and making them more efficient and accurate in perform specific task. These advanced algorithms and hardware capabilities started a notion of creating narrow artificial intelligence (NAI) applications. The purpose of these NAI applications was to accomplish a specific task extremely well. They were not capable of performing tasks outside of its realm. e.g. An algorithm specifically trained to detect diseases from human blood sample could not be used to identify a particular fruit from thousands of pictures.

In last 15 years, companies like Google, Amazon, Baidu, Microsoft, and IBM leveraged the use of these algorithms for various narrow application domains. An individual can either use pre trained ML model provided by companies like the ones listed above as a service or create their own model for specific AI / ML enabled products. Many of the ML models and development platforms have become open source for further research purpose.

This level of accessibility of AI / ML technology allowed various domain & individuals (e.g. Healthcare, Social Media, Retail, Financial Services, and Manufacturing) to take advantage of it.

For example, converting a speech into text and translate it into multiple languages; Identifying harmful diseases in humans blood samples using smartphone camera; Making your entire home environment connected through conversation agents with meaningful interaction; Enabling future of transportation with minimal intervention of human drivers using self-driving vehicles.

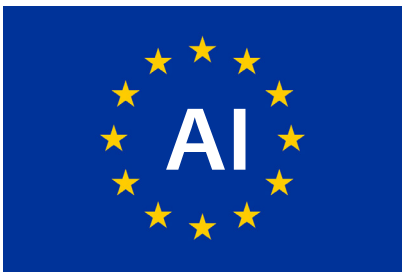
Though these cases are just some of the highlighted applications, there are many more small-scale interventions using AI / ML technology that revolutionize various industry domains.

2.1.5 Current state of affairs

The advancements in AI / ML and its applications show remarkable future benefits for the human race. However, the possibility of creating products/services with some intelligence always raises questions related to integrity and privacy of human values shared with these products.

One of the major arguments was the rationale behind decision made by AI algorithms. These algorithms were not transparent about the process and conclusion of results. This behavior of algorithms devises suspicious feelings about its usage and also makes it look like a vicious problem of the future (Holtel, 2016).

This leads to some government agencies to take control in the advancements of these technologies (Ethics guidelines for trustworthy AI, 2019). In respect to that, some companies have also created a set of guidelines to streamline the development and make sure it sustains ethics and moral values while developing these intelligent products (Amershi et al., 2019). AI researchers and data scientists also try to make sure that the algorithms are transparent and do not carry any bias or injure the moral values of a human being (Srivastava & Rossi, 2019).



Ethical guidelines for trustworthy AI by the experts of the European Union Commission

2.2 AI and Design

The current state-of-the-art AI and its prominent techniques e.g. deep learning is a buzz word in many industries, academia and also design domain. Design researchers are exploring various possibility to develop future dynamic interactions scenarios and interfaces (Yang, Zimmerman, Steinfeld, & Tomasic, 2016). The aim to consider this advanced technology as a new design material and explore feature possibility of designing intelligent products and interfaces. Design researchers from academia have been exploring the understanding and operationalization of this technology in design practice. They provide initial list of challenges and concerns behind having less innovation on AI and ML products in design (Dove et al., 2017).

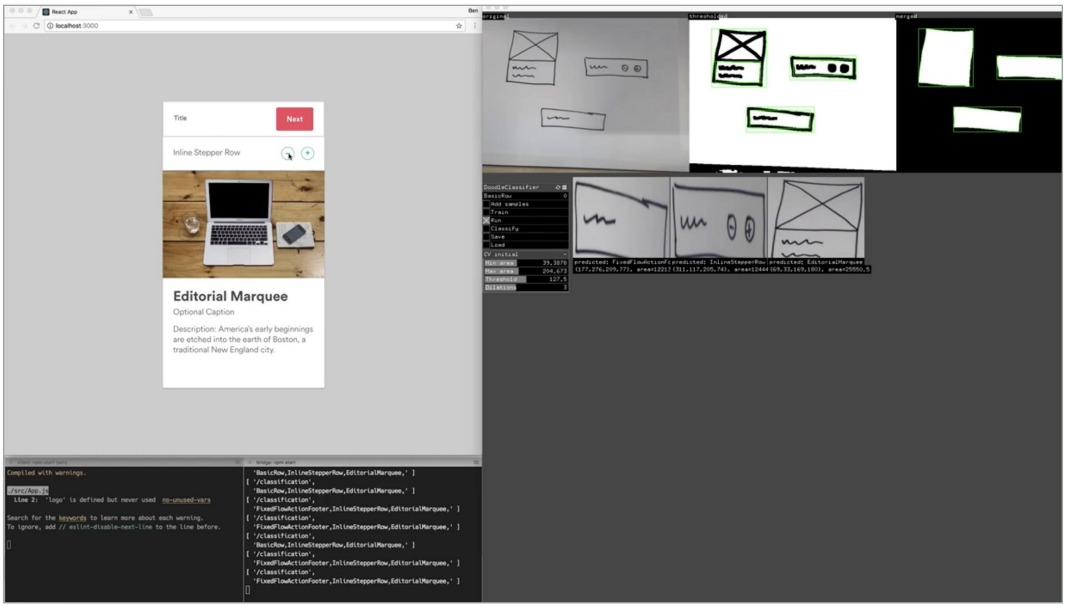
However, technologist and design enthusiasts from creative industries have already begun to use machine learning as design partner to make designers mundane work faster and creative.

We will discuss some of the prominent areas where AI is playing a significant role to speculate future design space further.

2.2.1 AI & User Interface Design

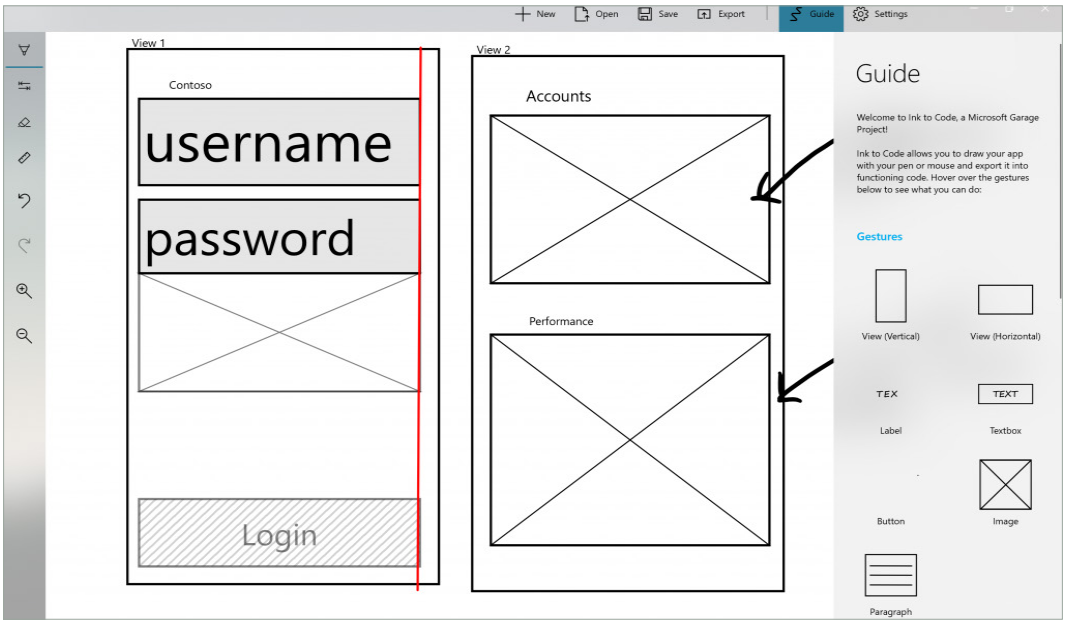
Increased performance in machine learning algorithms and nurturing vast amount of data have made possible to design and develop user interface on its own for the machine. The interface can be used for a website / presentation / poster or an illustration for product branding. For example, using a sophisticated machine learning algorithm fed with different example of layouts gives you a number of variations to choose from.

In last couple of years, creative industries have developed several prototypes and platform to achieve this kind of machine intervention into the design field. A prototype version of the tool from Airbnb (Sketching Interfaces, Airbnb Design) which can convert any sketched interface on paper into a coded website to test.



A prototyping tool from Airbnb which simultaneously converts wireframe sketches into coded Graphic User Interface

(Still from Airbnb design—sketching User Interface, 00:23) `



Ink to Code captures sketches of basic visual elements and translates them into the beginnings of an app in Visual Studio

(Image Reference: https://www.microsoft.com/en-us/garage/blog/2018/01/napkin-disrupted-meet-ink-code-microsoft-garage-project/)

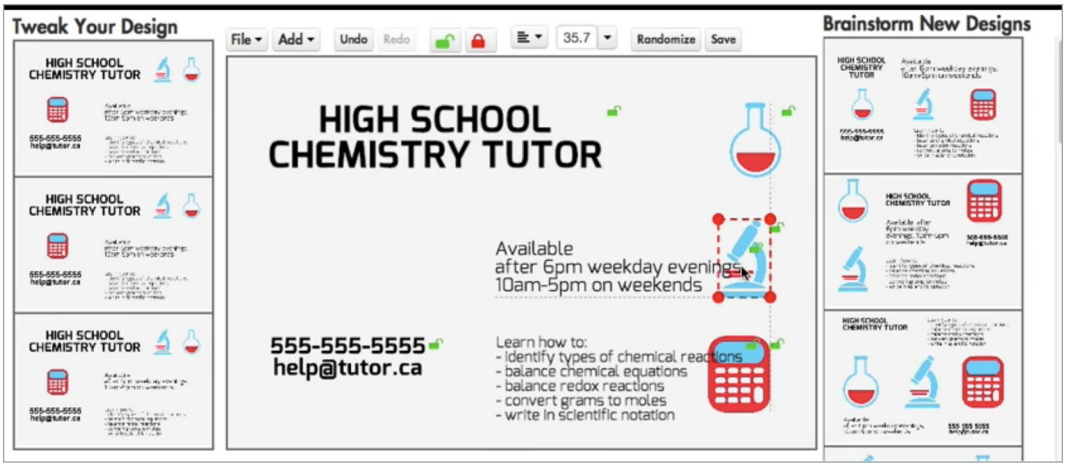
Similarly, Microsoft Xamarin team developed a platform called 'Ink to Code', which allow designers to create user interface in traditional way and convert it into functional prototypes on the go. The performance of these kind of tools is improving so rapidly that in the near future UX / UI designer can rapidly make prototypes and test within the help of AI / ML algorithm.

2.2.2 AI & Graphic Design

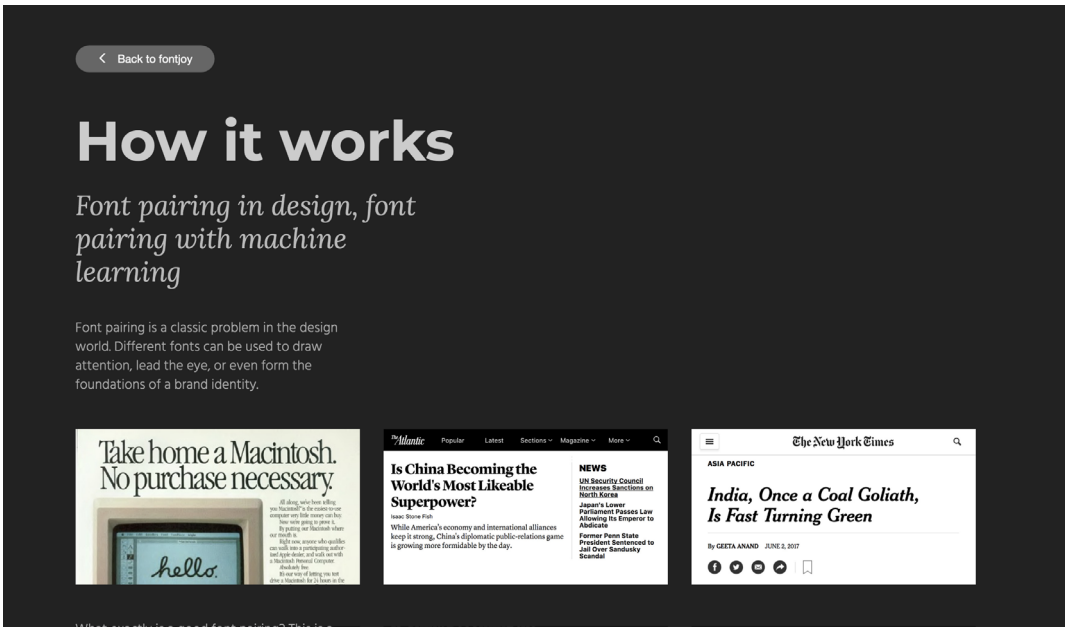
A graphic designer, typographer or a visual designer can take advantage of machine learning algorithms in generative design practice Many approaches and initial prototypes have been developed to show that the future of AI generated graphic design exists.

An experiential tool called 'DesignScape' (O'donovan, Agarwala, & Hertzmann, 2015) developed by Adobe and the University of Toronto allows novice designers to create beautiful graphic designs template. A font search tool called Fontjoy used machine learning identifies similar fonts according to its font weights and curves. A tool called Logojoy can produce variation of logos based on given parameter like color, styles and content. It shows how brand identity in future would be created using AI and Designer working together. A Google's AI experiment 'AutoDraw', which can convert rough sketches of a symbol into beautiful icons enables any novice graphics designer to create beautiful infographics in less time.

All these interventions show the potential future of AI in the graphics design. They also show how it will revolutionize the design industry, where the limit is designer's imagination.



DesignScape, a system which aids the design process by making interactive layout suggestions (O'donovan, Agarwala, & Hertzmann, 2015)
(Still from DesignScape: Design with Interactive Layout Suggestions, 00:52)



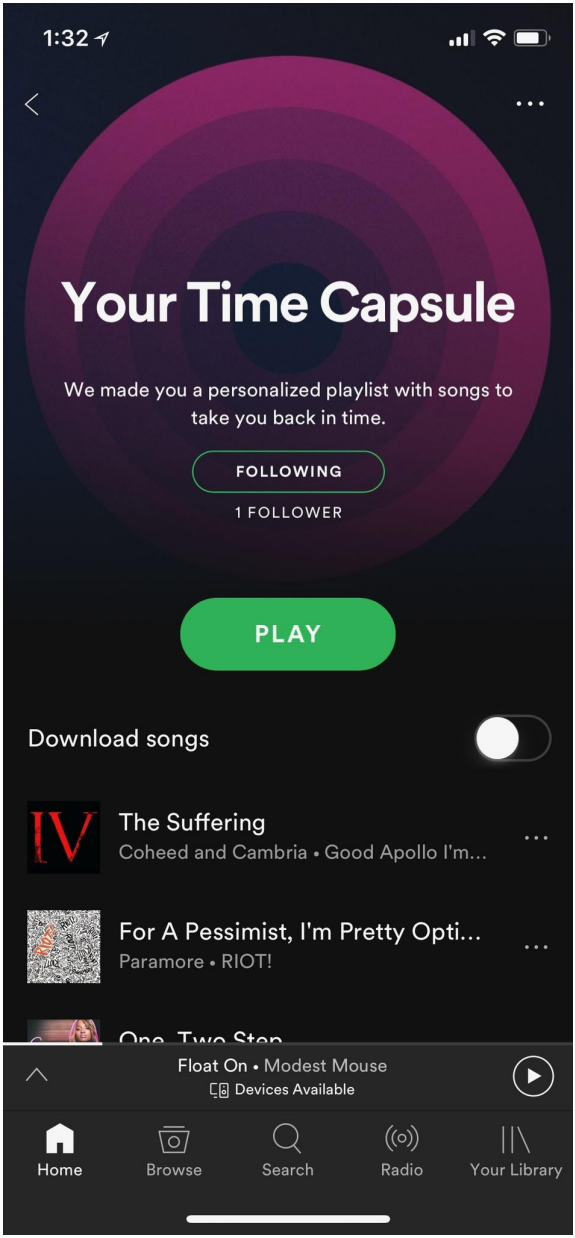
Font pairing with machine learning
(Screen-shot from https://fontjoy.com/pairing/)

2.2.3 AI & User Experience

Understanding the user needs and their desire is the foremost step to enhance user experience within designed products and services. Getting to know the user's habits / preferences / likings provide valuable insights which can be incorporated by a designer in their idea generation process. Similarly, using machine learning together with sensors and digital objects, a designer can see and analyze different patterns of the individual user and personalize the product according to user's needs (Kuijer & Giaccardi, 2018). This kind of personalized approach makes user-product relationship personal and creates a unique bond between human-product-context interaction.

One can experience the personalization with ML enabled products and services. For example, map application suggesting some of the usual routes one frequently travels [Google Maps, iOS Maps]; A music application proposing a playlist based on your previous listening activity [Spotify]; Or a home temperature regulator [Thermostat] knows an individual family member's preference, analyze the context details and keep regulating temperature based on all this information.

Nest Thermostat



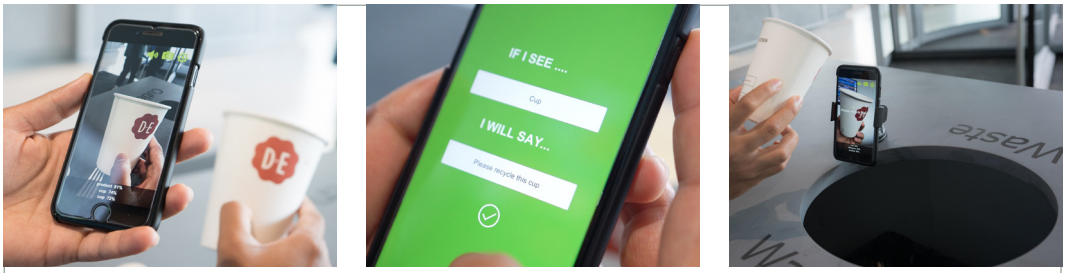
Spotify Music App : a personalised music playlist suggested by an algorithm based on your previous music interest (Image Reference: https://www.spotify.com)

2.3 Object Responder (v1.0)

Interest in using ML and AI as a design material is growing within and beyond the HCI community (Holmquist & Erik, 2017). Researchers are investigating the integration of UX and ML in both design practice e and HCI research (Koch, 2017; Yang et al., 2016). The team led by Dove surveyed fifty-one UX professionals who work with ML and most of them expressed frustration about the difficulty of prototyping with ML (Dove et al., 2017). The challenge of working with innovative and unexplored materials is a theme that recurs often in UX research. Buxton argues that the "experience" is the most difficult part to prototype since there is a lack of tools that allow designers to do it (Buxton, 2007). To encounter this problem, educators are using tools such as Wekinator to help students understand and design with AI in a more intuitive fashion (Allen & Hooker, 2017). However, these software works on a system, thus making it difficult to prototype experiences in the actual context of use (R. Fiebrink, Trueman, & Cook, 2009). On the contrary, projects like Objectifier (Karmann, 2016) propose an alternative approach towards integrating computer vision and machine learning into the design process in the actual environment. Yet, it also faces the limitation of low accessibility as this research-driven experimental hardware are rarely distributed for the wide audience to use. To ensure accessibility for a wide audience, an app-based tool was developed, that allows designers to use their own smartphones as a design material to sketch innovative interactions with AI.

2.3.1 How to use ObjectResponder

The tool ObjectResponder helps designers rapidly prototype and test early concepts of context-aware intelligent systems in the wild. The tool can be used in the following three steps (Image).



Step 1: See from artificial perspective

First, the designers see how their surroundings are interpreted from the perspective of an AI. The tool runs real-time object recognition by using Google Cloud Vision's object recognition framework. For each object that appears in front of the camera, three labels of the possible interpretations are shown. These labels will be used as a starting point for idea generation (i.e. Bottles).

Step 2: Create a response

For each detected object label, the user can set a chat-bot like utterance in the form of a sentence. This sentence will be spoken out by text-to-speech function upon detection of the object. The sentence-based response is used to fake the function of the bot in a manner of Wizard of Oz prototyping (Maulsby, Greenberg, & Mander, 1993). This creates space for users to ideate on the interaction outcomes without technical restrains. (i.e. "I detected wine-bottles; I will dim the lights for party mode")

Step 3: Test it out in the wild

After setting the sentence as a response to the detection of the object, the designer can then place the smartphone in the environment and test out the use case in the actual scenario. We provided users with a smartphone holder which could attach the smartphone to any existing objects. This allows designers to envision a computer vision embedded version of objects that they encounter

with in their daily life such as a trash bin. In the case of Figure 2, the designer is attaching the smartphone to a recycling bin and set the phone to say, “Please recycle the cup”, when a cup is detected near the bin.

2.3.2 Experimenting with Designers

We wanted to observe how designers with different expertise and — who never engaged in any kind of project that uses artificial intelligence — responded to this way of designing and prototyping with AI in the wild.

Participant Number	Gender	Age	Occupation	Professional Experience in Design (Years)
P1	Female	28	Product Designer	3
P2	Female	35	Product Designer	8
P3	Male	26	Product Designer	2
P4	Male	32	Digital Designer	7
P5	Male	40	Sr. Designer	>10
P7	Male	23	UX Designer	1

Participants background information

For this reason, we approached a design consultancy based in Netherlands and recruited 6 professional designers (age 23-40, males and females) from different design discipline, including User experience Design, Digital Strategist, Product Design. The test was conducted inside the cafeteria of the design consultancy.

We first conducted baseline interviews with our participants to learn more about their knowledge of AI. Then, we introduced them the tool along with the purpose of our study. We used a small demonstration to explain how the tool works and what they can do with it. Once they familiarized with the tool and its way of working, we asked them to generate ideas and quickly prototype concepts

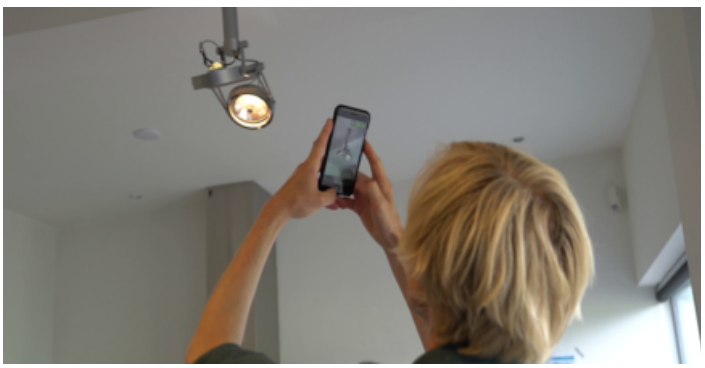
for a future scenario where AI is used to create a context-awareness system that detects and reacts to human interaction. The design brief was as following:

"How will you design your future workplace where AI is monitoring the context and reacting your interaction with that particular context? Use the tool to explore your workspace and come up with one design idea that can make the workplace more efficient, fun or engaging."

Participants used this design brief to begin experimenting with the tool and ideate on the possible solution-based insights they gathered through machine perspective. We video recorded their activities and asked each participant to document their ideas also on paper. At the end, we prompted them to reflect on their experience with a follow-up semi-structured interview. We asked them questions, including: "What was your inspiration for this design?", "What challenges have you encountered when designing with this tool?", "How did the tool help you come up with ideas", "How would you improve this tool?"

2.3.3 Findings

Findings are the result of our analysis of the video recordings of each participant using the tool (for a total of approximately 10 hours), triangulated with direct observation of their responses and the follow-up interviews. We used Affinity Diagram and Clustering as qualitative analysis methods.



P5 setting a response to the light bulb to explain how to change it

Seeing from the perspective of AI

Being able to look at the context from the perspective of an AI became a starting point for designers to directly experience how differently the AI was able to 'see' the world. This was evident when participant 5 was trying to set a response to a chair and the object recognition returned several labels of the carpet and floors near it. This diversion allowed P5 to come up with a different idea and envision a device that informs the cleaning ladies how each thing in the office should be cleaned. P5 reacted: "Although sometimes random object categories were false and frustrating, it inspired me to think more broadly about my idea and try it out with the tool".

Embodied prototyping with AI in the wild

During the user test, participants were quick to generate ideas, prototype and test them out in the actual context of use. One participant had the idea to build a system that detects opened doors and nudges people to close them. Within three minutes, she was able to build the system by attaching the smartphone next to the door and setting the message "Close the door".

P2 a system that alerts people to close the door by using 'door' as label for detection

This embodied way of explorative ideation in the wild helped designers to come up with new ideas and immediately prototype them and test them out. In the follow-up interview, participant 4 said" "This tool was giving me more freedom to iterate over my ideas without any technical AI knowledge".

Difficulties faced with the tool

Of course, there were also failures and frustration when object detection did not work as they wanted. Participant 4 said: "I had an idea which I wanted to try out, but their random categories kept appearing on the screen and it was taking too much time to adjust the camera for the right label to be detected. I couldn't make it to test it out". Participant 1 also mentioned: "Sometimes the object detection terminology was too general or different each time, and I could not prototype my idea". While differences in perspective between the AI and the designer (e.g., multiple possible labels) helped generate new ideas, the API limitations (e.g., inconsistency of the classification) were experienced as frustrating.

2.3.4 Discussion

Learning to design and prototype with AI is a challenge for designers. Exploring possibilities and tools for how to work with it for creating products and services is a growing effort within the HCI community (Yang, 2018). Not only data scientists and HCI researchers, designers in particular are seeking ways to play and tinker with AI as a design material for innovation. Our study suggests that tools like ObjectResponder may offer designers a way to approach AI as a design material that can be used just like wood, a screwdriver or color palette. Below we would like to discuss some general observations derived from the findings of our research.

AI as design material

Designers are trained to use various tools in such a way that they can tinker with them and adjust them according to their own preferences. This also enables them to be creative and innovative in the way in which they can use a tool for communicating and testing their ideas. We observed a similar behavior with designers using our tool, when they were trying to find a way to use ObjectResponder to respond to their own style and knowledge. Participant 4 shared: "As a product designer, I can use this tool not just to come up with an idea, but quickly prototype my idea about future social interaction."

The biggest struggle for designers working with AI is having to focus on understanding how it works and what it can do. Our decision was to provide designers not with a framework or method (Koch, 2017) but with a tool that is easy to use and to some extent adapt to one's creative style. When participants used the tool to iterate over ideas, they started tinkering with how the AI would see the objects in their surrounding environment. This perception of a 'sense' and 'agency' of the AI yielded to a very different creative process, which participants seemed quite at ease tuning. The freedom of allowing designers to generate ideas over the perspective of the AI, leveraged their creative design process for designing with the AI in context. P1 shared that while using the tool, she felt empowered to do whatever she wanted and not what the machine wanted.

Realizing the ambivalence of context

Designers often believe that context is one snapshot, but there are a lot of layers and perspectives to it (Kuijer & Giaccardi, 2018). All needed to access this richness and nuances, is to look at things from a different angle. Similarly, enabling designers to access and experience unique perspective of an AI helps them realize the ambivalence of a context.

We believe that to design with ML and AI, you not only need pen and paper — or a team of software developers — but also a non-human perspective (Kuijer & Giaccardi, 2018). The integration of human and nonhuman perspectives in the design of context-aware intelligent systems can provide an understanding of the context richer and more nuanced than the one designer could develop alone. Moreover, collaborating but also bumping against an intelligent system that is objectifying context into different layers, may enable designers to experience in situ, both human and non-human biases, and perhaps prompt them to consider their ethical implications.

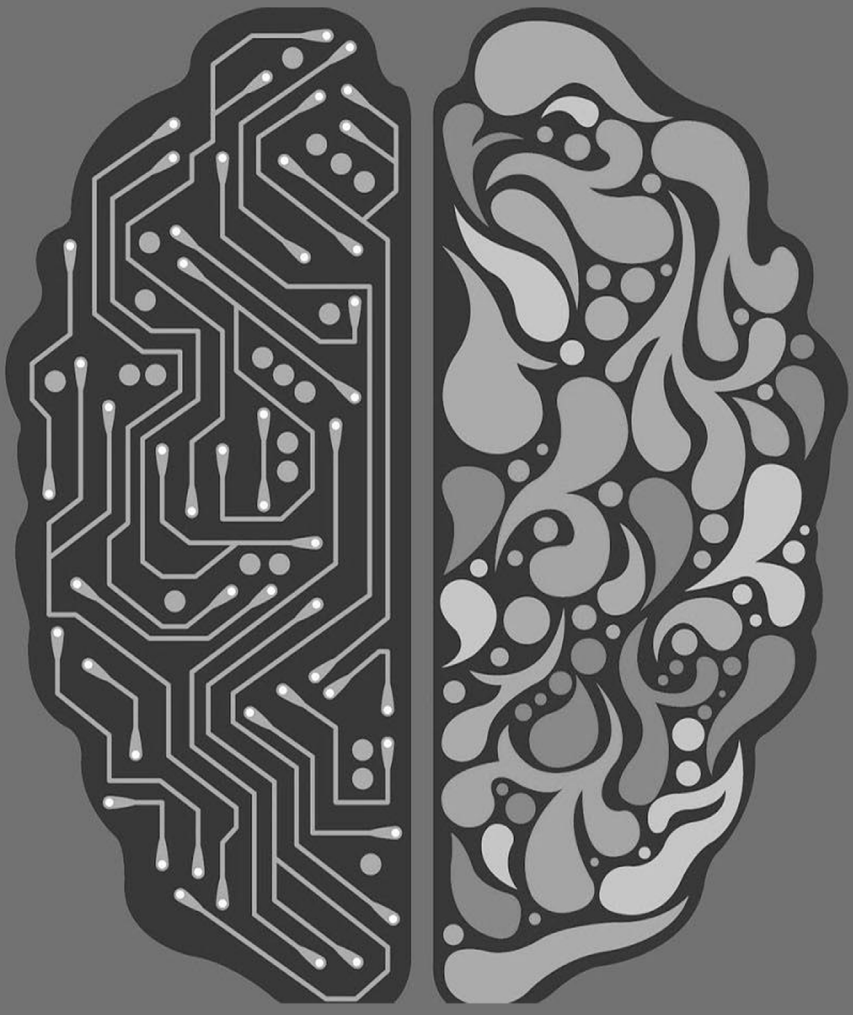
AI as design partner

Our findings suggest that when you let designers explore the context from a non-human perspective, they can augment their own creative thinking. These results are consistent with design work in HCI concerned with possible collaborations between humans and non-humans. Designers were able to envision ideas and concepts on the fly that would have been impossible just through traditional means of design such as studying user's behavioral pattern or brainstorming. P2 mentioned that looking into the contextual information provided from the perspective of the AI allowed her to brainstorm on ideas that were popping in her mind but were not yet formulated properly. As designers will develop "designerly ways" of incorporating AI perspectives and open up unexpected directions for ideas and opportunities they can work with, AI should be considered as a design partner rather than a simple design material.

2.3.5 Conclusion

In this chapter, we have presented and discussed initial findings from the use of ObjectResponder — a tool that allows designers to use Artificial Intelligence (AI) to design and rapidly prototype concepts for intelligent context-aware interaction in the wild. The

tool expands previous work by introducing a simple and highly accessible way of designing and prototyping with AI in the wild by means of an average smartphone camera. In the discussion, we have argued that our understanding of context changes when a designer is introduced to 'seeing' the world from the perspective of an AI. We also argue that — as designers will develop "designerly ways" of incorporating artificial perspectives in their creative process and open up unexpected directions for idea generation — AI should be considered more than just another design material. One limitation of this work is the limited number of professional designers with whom we tested our tool. In the future, we plan to test the tool with more designers and in multiple settings.



Chapter 3

Unpacking The Future Of AI & Design Collaboration

Based on the literature research and preliminary study with ObjectResponder (v1.0), a problem definition was articulated. Two different contextual inquiry were setup with design students and professional designers. The findings from this contextual inquiry become base for creating three research questions and design goal.

3.1 Problem Definition

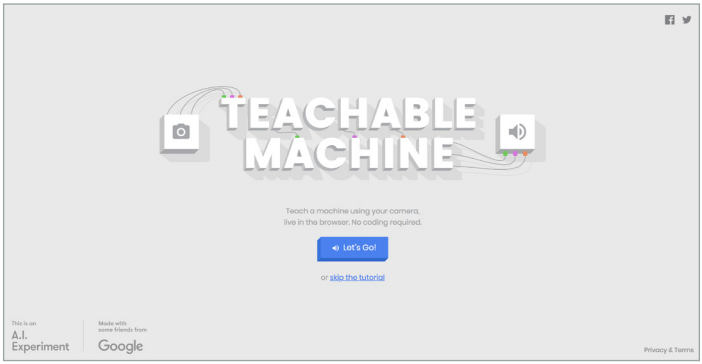
A paradigm shift is starting to take place in the meaning and use of a machine learning enabled products. Combined with deep learning-based computer vision, they are becoming a context-aware agent that can judge things based on what it sees. Novel services like Amazon Go use computer vision to provide a cashier-less shopping experience where the customers can just pick up what they want and leave. The demand for interaction designers to understand these technologies and prototype new services has been building up.

However, finding proper use cases with Machine Learning (ML) and Artificial Intelligence (AI) is a challenge for designers (Dove et al., 2017). In contrast, we argue that the issue is not that designers lack technical background, but rather the fact that the number of available design tools for quickly sketching and conceptualizing design ideas with AI is still limited. Some tools exist such as Wekinator (Rebecca Fiebrink & Cook, 2010) and Google's AI experiments ("Teachable Machine," 2017) that allow designers to use ML for designing and prototyping. However, they either require understanding of fundamentals of AI/ML concepts. Therefore, time to develop the set of skills needed to take full advantage of the tool (such as with Wekinator) or have minimal features and limited application (such as Google Teachable Machine).

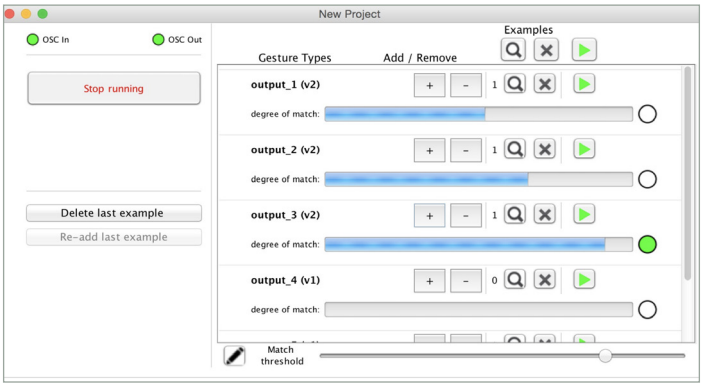
For designers to take the lead in designing future intelligent product or systems requires a tool which designer can quickly adapt and tinker with it for exploring, communicating and testing their ideas.

Moreover, a tool that integrates computer vision and machine learning technology in the back-end and lets designers sketch and prototype an in-situ experience in the wild with an easy interface is necessary. This tool will require to address the possible biases

and inherent tension between the machine's perception of a context and a human perspective, and to find ways to integrate these perspectives productively in the sketching and prototyping of solutions (Kuijer & Giaccardi, 2018).



Doing machine learning live on the browser without writing any code — Google AI Experiment
(Screen-shot from https://teachablemachine.withgoogle.com)



Wekinator: an open source tool for using machine learning to build new musical instruments, gestural game controllers, computer vision or computer listening systems, and more.
(Screen-shot from http://www.wekinator.org)

3.2 Contextual Inquiry with Design Students

The purpose of this study was to understand how design students perceive Artificial Intelligence and Machine Learning during their studies. Also, we explored some challenges and barriers design students face while working with this technology in academic context.

3.2.1 Participants

Participant Number	Gender	Age	Occupation	Experience in AI and ML (Scale 0 - 10)
P1	Female	19	Bachelor's Industrial Design	0-1
P2	Female	27	Master's in strategic Product Design	1
P3	Female	24	Master's in strategic Product Design	<2
P4	Male	28	Master's in strategic Product Design	<2
P5	Male	22	Bachelor's Industrial Design pursuing masters in software engineering	3

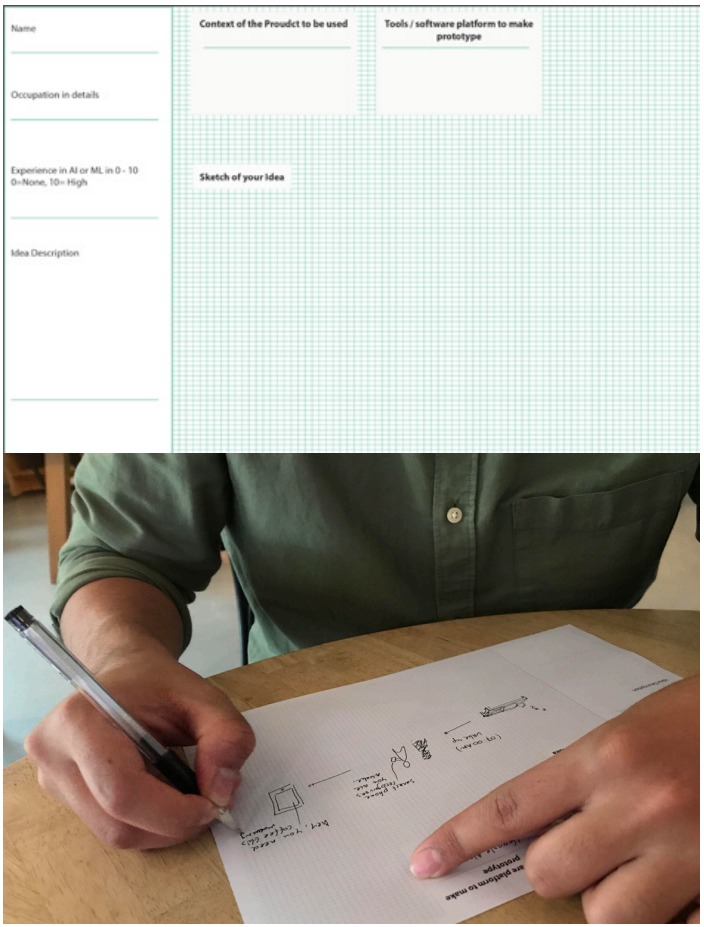
Background of the students recruited for the study

Five industrial design students were recruited in this study. These students were pursuing their master and bachelor in various design disciplines from Faculty of Industrial Design Engineering at TUDelft. All the master students have some exposure to AI / ML technology while working for a small design project. Bachelor students have keen interest to work this technology in future with. Besides one of them has started pursuing master's in software engineering after his bachelor's in design.

3.2.2 Method

Design students were asked to describe their design experience and what makes them interesting about this technology. They were asked to explain some conceptual understanding about how this technology works and what would be their approach as a designer if they had to design any one physical product or service.

Later, the students were also asked to design one product or system which consist AI / ML technology and sketch it out in the sketchbook. The purpose was to see the process they are approaching while they were given a task to design any AI / ML oriented product or service. And also, understanding novelty in their sketches.

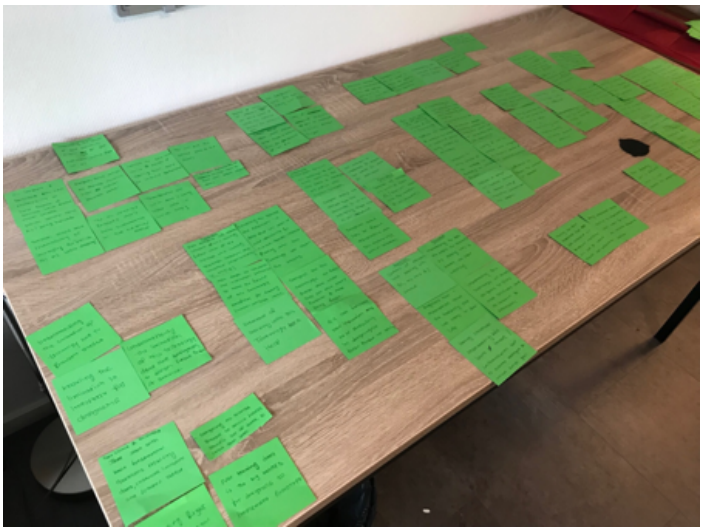


Sketchbook for students to conceptualize possible machine learning application and current available tools and platforms.

3.2.3 Data collection & Analysis

A qualitative analysis of the interview transcripts was done to observe students understanding and their opinion about machine learning. We developed a textural description from feedback given during the interviews.

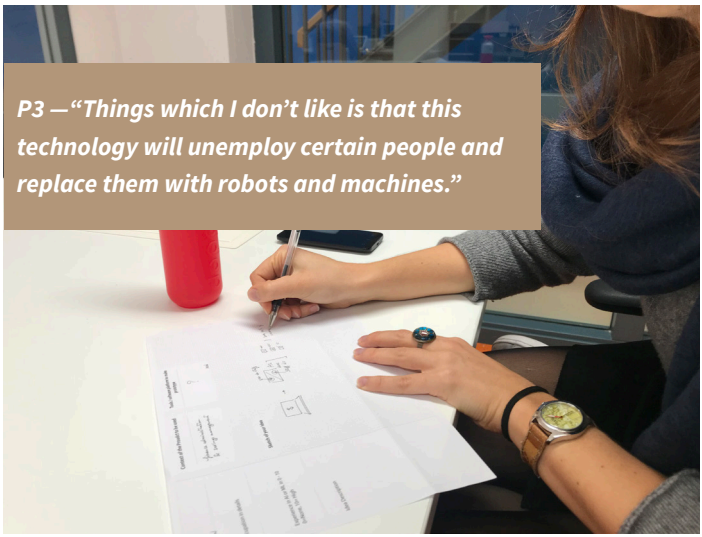
The sketches drawn by students were analyzed to understand what kind of approach the students took, and how interested and practical they are to conceptualize AI / ML products in academics context.



Textual Description generated from students feedback during the interview

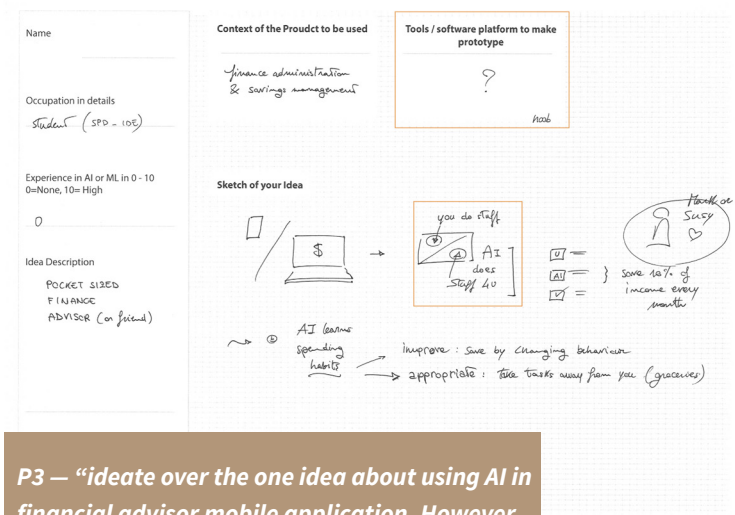
3.2.4 Findings

A strategic master student's (P3) opinion about this technology was abstract and vague. She perceives AI / ML technology as threat, and which will create an unemployment in some domain by replacing labors with robots and machines, as she concerned.



P3 —"Things which I don't like is that this technology will unemploy certain people and replace them with robots and machines."

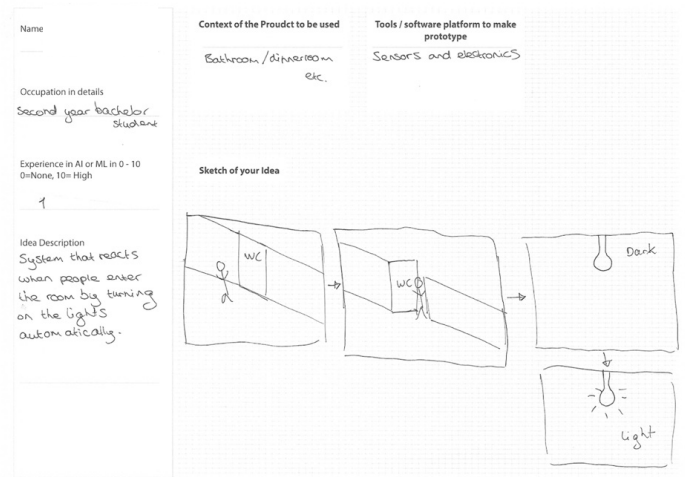
When she asked to conceptualize one idea of AI and ML oriented products, the results show that she wants to use this technology as a benefit for its users. However, she doesn't know how it could be possible or what kind of AI system or tools would be useful.



P3 — "ideate over the one idea about using AI in financial advisor mobile application. However, she could not exactly able to describe how this could be possible with AI and what tools will be required to explore."

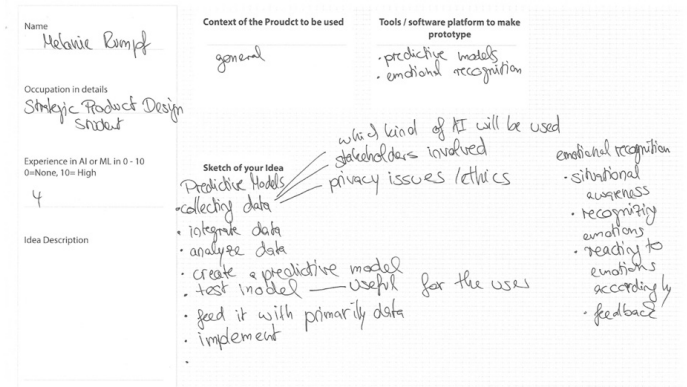
When a bachelor design student (P1) was asked about describing AI or ML oriented products, she compared a sensor based small devices or gadgets products to an intelligent product. Although it is true if we talk about intelligent products before a decade, but the current definition of intelligent products is far beyond than just small automation happening through it (Noessel, 2017).

P1 — "A smart light which will detect human presence in the room and automatically turn ON / OFF. A toilet seat which automatically flush when one stands-up."

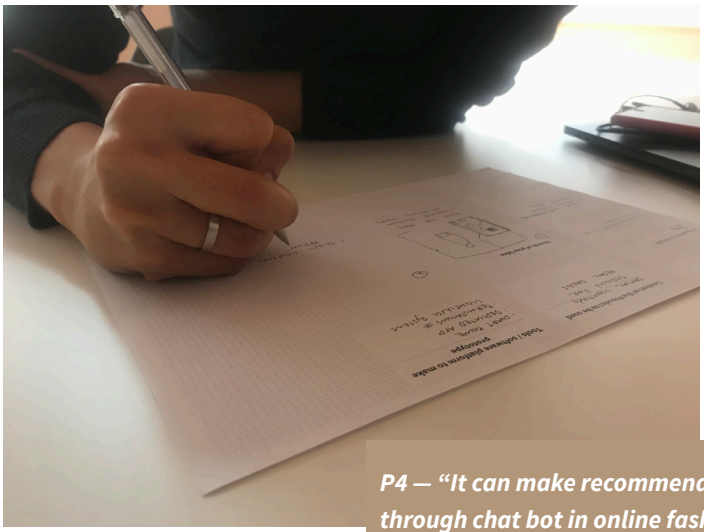


P2 thinks that AI / ML products consist analytical skills and considered as pattern recognition systems. She perceives the system as large data analysis tool with strong analytical skill-sets. Her understanding about how ML use data were also based on online literature or academic design lectures. However, there was no practical experience or exposure with the technology in here academic career till now.

When P4 asked to explain some application of AI and ML he knows, he gives an example like pattern recognition, recommendation engine, or chat-bots. However, he could not think any novel use of AI / ML in particular domain or product/service.



P2 — "It's a system that continuously collects data and find patterns from this data. And then gives a proposal what the next step should be or even it can decide for you."



P4 — "It can make recommendation service through chat bot in online fashion shopping."

P4 —"It can Personalize all kind of stuff and then see what customers like and don't like."

3.2.5 Conclusion

From the analysis, it can be concluded that design students struggle to articulate feasible AI and ML applications. Their knowledge about AI and ML technologies is very naive. Students' conceptual knowledge about AI and ML were based on their own presumptions or some literature read during their academic course.

It can also be concluded that exposure to AI / ML technology in design education is very basic and not fundamental. Requirement of practical knowledge is a must to design AI/ML oriented products. It would be a good approach if designers learn about the technology through some practical experience or understanding about this technology during their education or design practice.

3.2.6 Limitation

One limitation of this study is that very limited number of students were interviewed. Also, not all of them have enough exposure in designing AI and ML products or system. Hence these results may differ if we do the study with design students who are involved with AI and ML oriented projects.

3.3 Contextual Inquiry with Professional Designers

The purpose of the study was to assess where design community (currently working with AI and ML technology) are breakthrough in design innovation. In addition, we wanted to understand the challenges designers' phase and how it is affecting their design process. Therefore, a survey was conducted with five designers and one data engineer. Our intention of doing the survey was to gather insight about current designers' situation whose working in AI and ML and a broad overview about design practice evolving in this area.

3.3.1 Participants

One limitation of this study is that very limited number of students were interviewed. Also, not all of them have enough exposure in designing AI and ML products or system. Hence these results may differ if we do the study with design students who are involved with AI and ML oriented projects. The study was conducted with

Background of the Professional Designers participated in the study

Participant Number	Gender	Age	Education	Company	Occupation	Experience with AI and ML (Years)
P1	Male	29	Master Integrated Product Design	TomTom	UX Designer	2-3
P2	Female	31	Master Design for Interaction	TomTom	UX Researcher	2-3
P3	Male	38	Graphic Design	TomTom	Visual Designer	1-2
P4	Male	26	Master Strategic Product Design	Microsoft	Design Researcher / UX Designer	1
P5	Male	26	Master Integrated Product Design	WT - Interactive	Interaction Designer	1
P6	Male	27	Master Integrated Product Design	Envision (Startup)	CEO	2-3
P7	Male	27	Master in Control & Simulation	Dutch Analytics (Startup)	Co-Founder	5-7
P8	Male	33	Master of Arts	TUDelft	PhD candidate	4-5
P9	Male	27	Master Strategic Product Design	TUDelft	Student cum Design Researcher	2

3 professional designers from TomTom, and virtually with w 2 designers from Microsoft – Beijing and WT Interactive (Amsterdam). Two founders of AI enabled startup (Envision and Dutch Analytics) were also interviewed. In addition, one design researcher (PhD) from Faculty of Industrial Design, TUDelft also participated in the study.

3.3.2 Method

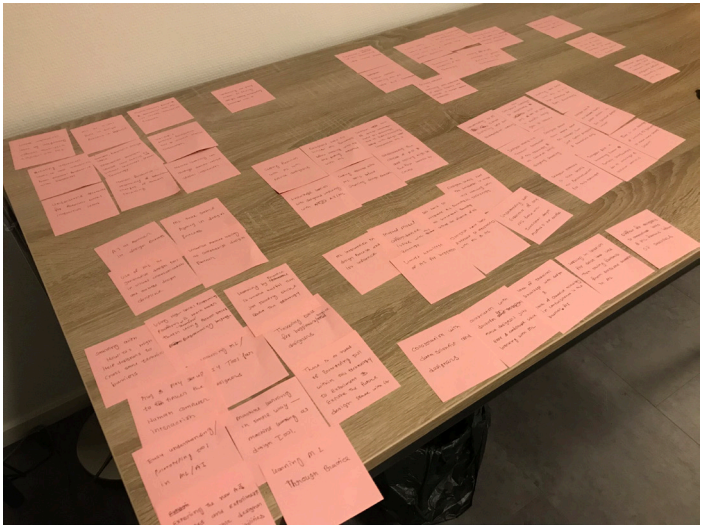
An iterative process was used to develop the survey where the questions were first being tested between design researchers and changes were made to address the issue of ambiguity. This resulted in a 11 questions survey. Participants were worked before AI and ML projects and describe few important things about particular that project. They were asked to describe the challenges and approaches they took during their design process. They were also asked about knowledge development with this technology and what are their concerns which they would like to implicate in future. At the end, they were given an opportunity to share some initial tips for future designer going to start working with this technology.

We conduct this survey with designers in their respective companies. While some designers from outside Netherlands were interviewed through video call. The video was recorded for later analysis.

Interview setup at TomTom in one of their office in Amsterdam

3.3.3 Data collection and Analysis

Interviews with designers were audio taped. All the interviews were transcribed and organized in terms of accuracy and textual errors. Once the data were organized, we thoroughly read all the transcriptions and coded into its respective individual description points. This description points were further used along with literature review to come up with the research questions.



Respective individual description points from professional designers feedback on their experience working with AI and ML

3.3.4 Insights

Designers do realize that they have to collaboratively work with developers to be effective in designing AI / ML oriented products.

> ***P6 — "I had help from an engineer because as a designer, I don't have much engineering expertise on how to implement this AI research that I was doing."***

A designer should get familiar with some of the AI / ML terminologies/theories and its limitations to pro-actively evaluate and discuss their ideas in a team.

> ***P4 — "AI cannot do everything right now; designer needs to know what the possible application within current limitation of AI in near future are. ..... That is where you need a knowledge of current advancement in AI / ML."***

> ***P6 — "Having an understanding about how AI works will help them to see where AI can actually help."***

> ***P4 — "When I had to discuss my design ideas with developer or project manager, I had to explain how this thing going to work.... that was difficult for me."***

Designers are seeking for a prototyping tool which they can incorporate into their design process and optimize the process for designing intelligent products.

> ***P8 — "...making ML part of the process so process can be more kind of a realistic or richer than otherwise."***

Designer (together working with developer) has to take responsibility to make sure that this technology does not injure human moral values and privacy.

P1 —"...it's not only to identify the possibilities with this technology but after that what we do in ethical terms of people's privacy and it's used for right purpose is also a responsibility of designers."

P1 —"It's designers' responsibility to achieve a design goal in such way that respect everyone's privacy."

P2 —"Be true to yourself about how you wanted your data to be used before you start designing or creating for other people, in order to make people aware about the ethical issues of it."

3.3.5 Conclusion

A Designer seeks for collaborative work environment while working with AI / ML technologies and while designing products or services. They realize that before start designing product or services, they should learn some theoretical concepts behind this technology. Designer needs some prototyping tool kit to have in-hand practical experience with this technology. They do understand that knowing more about this technology and working collaboratively with developers, they can design a better AI system. And also keep ethical concern in mind and avoid it while designing product or service with this technology. Some of these insights were also evident in our literature study as well (Dove et al., 2017).

3.4 Formulating Research Question

Artificial Intelligence consist long history as described in the literature review. It shows how intelligence has been developed or designed in form of an intelligent machine. Current AI technologies are rapidly improving in terms of its performance and accuracy. They are also intervening into various design fields as well. Designers are exploring various methods and tools. Meanwhile they are also facing challenges to use AI/ML technology into design process. As future designers are going to play a foremost role in designing intelligent products from AI/ML, it will be their responsibility (together with data scientists) to make sure that these products do not injure human moral value.

Future designers have to keep artificial intelligence and design together to take advantage from this technology for creating meaningful products and services for various domains and individual solutions.

This research explores the needs and concerns for future AI-Design collaborations and how effective it would be.

3.4.1 Research Questions

- What are the biases and pitfalls deriving from the predictive nature of ML algorithms that needs to be considered, while designing contextual-aware interactions?
- How can working with AI as a partner help problematize and enrich future design space for context - aware interaction.
- What are expectation and challenges for an effective collabora-

Remark: *The term 'contextual-aware interactions' in above research question is explaining the interaction between intelligent products, humans and how it affects the context to become reactive due to this interaction.*

tion between human designers and artificial design partners?

3.5 Design Goal

The aim of designing the experiment was to understand the role of AI in design. To achieve this, the entire process was focused on the following four directions.

1. The experiment must include actual computer vision technology to understand machine perspective.

2. Throughout the experiment the designer should be able to perceive the difference between human and machine.

3. At the end of an experiment a designer should clearly articulate the biases present in the algorithm and learn out how to balance it out during the design process itself.

4. The experiment should aid designers in their conceptualizing and idea generation process for future context - aware interaction system or product.

Construct a semi working Construct a semi working interactive design toolkit, which allows designers to do ideation & rapid prototyping for AI / ML oriented products.

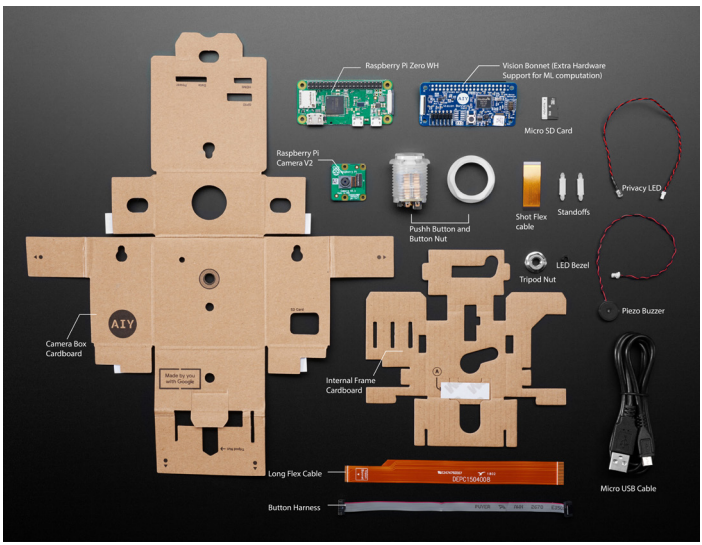
Chapter 4

Technology Exploration And Prototyping

To achieve the design goal, various Machine Learning platforms, and tools were explored. The goal of this exploration was to get familiarized with these tools/ platforms and figure out which one would be best suitable to construct the interactive design toolkit.
— Which enable designers for doing ideation & rapid prototyping for machine learning oriented products.

4.1. AIY Vision & Voice Kit

Initially the DIY prototyping kits from Google's AIY project were chosen for making a prototype of the design toolkit. This AIY kit use Raspberry Pi and extra hardware support to perform machine learning operation. Also, by using opens source machine learning libraries e.g. TensorFlow, Keras together with python programming language, one can construct her/his own prototype of smart chatbot or an object detection camera. Which they can further prototype according to individual design goal.



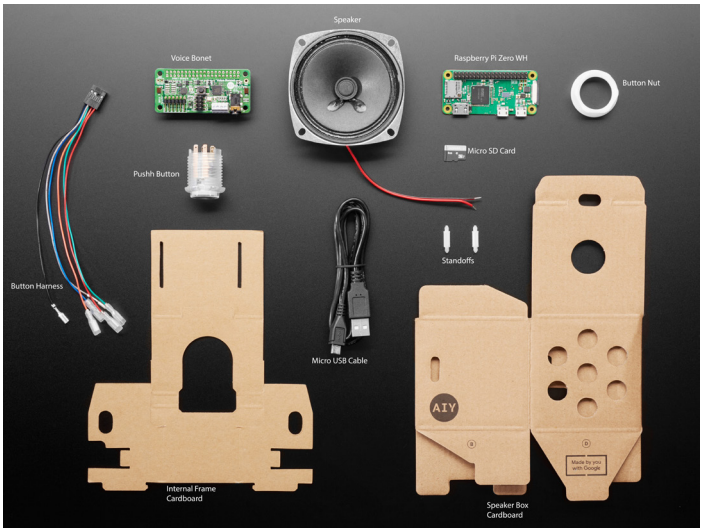
Different hardware to build computer vision enabled prototype kit

AIY Vision Kit to prototype computer vision enabled products and services

Compactness of these kits encouraged to try and see if it fits with the idea of making interactive toolkit. Some of the basic machine learning functionality were tried out using the kit. e.g. making a google chatbot or creating smart object detection camera. However, to make a more feasible prototype, it requires advanced python programming experience and machine learning knowledge.

However, designers are not used to with advanced programming skills, and it will require an easy interface to play with this kit during the prototyping session. Providing easy and robust programming interface was the key element, which was required to enable designers to make AI / ML oriented prototypes — together with the google AIY vision kit.

This led to next step towards exploring platforms which allow making AI / ML enabled using more easy way which designer can adapt.



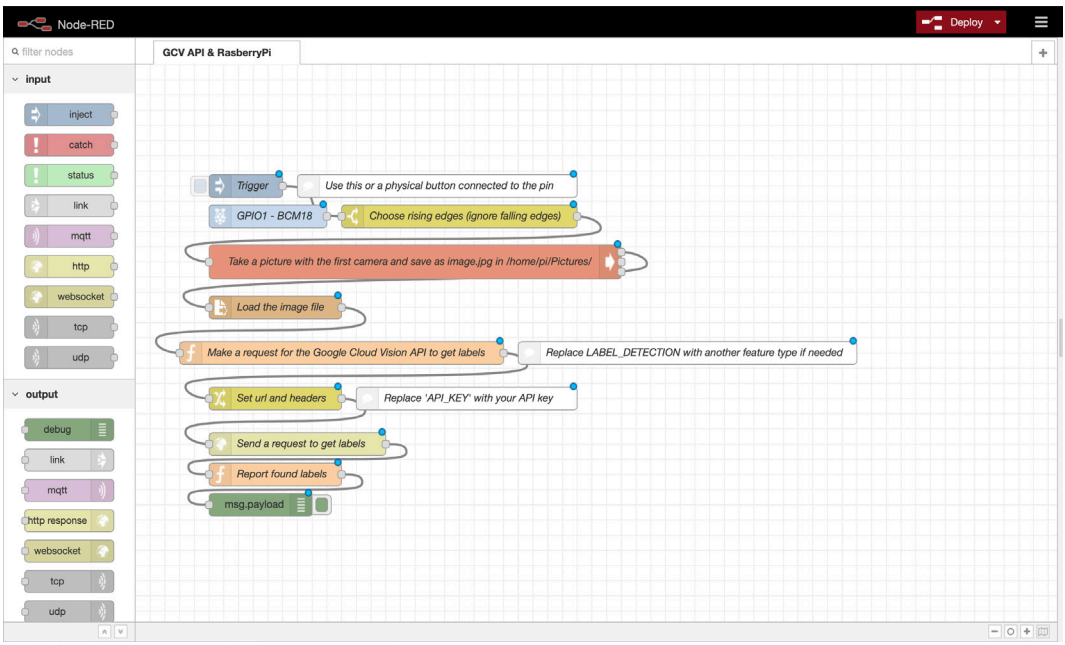
Different hardware to build the Natural Language Processor

AIY voice kit to prototype voice assistant interface using Natural Language Processor

4.2 Visual Programming—IBM NodeRed

While researching for the appropriate method, which designer can adapt to build program without actually writing a programming code, a visual programming platform called Node-Red came up front. The easy drag-and-drop interface provided by this platform can allows no-voice programmers connecting hardware devices, APIs and online services together. One can conceptualize and prototype complex interactive system by connecting various hardware and software technologies together as like physical components. For example, connect Raspberry-Pi, Camera and Machine Learning API like IBM Watson together to make an intelligent bot.

A system diagram was made using this tool. It connects Google Cloud vision API and AIY vision kit. This integration would provide the use of state-of-the-art AI technologies in making intelligent prototypes of machine vision without advanced programming



A visual programing flow for connecting Raspberry PI camera with Google cloud vision API through single HTTP request. The HTTP request consist a 64byte data of picture taken through camera. This request sent to Google Cloud Vision API and return a response with detected object categories as text labels

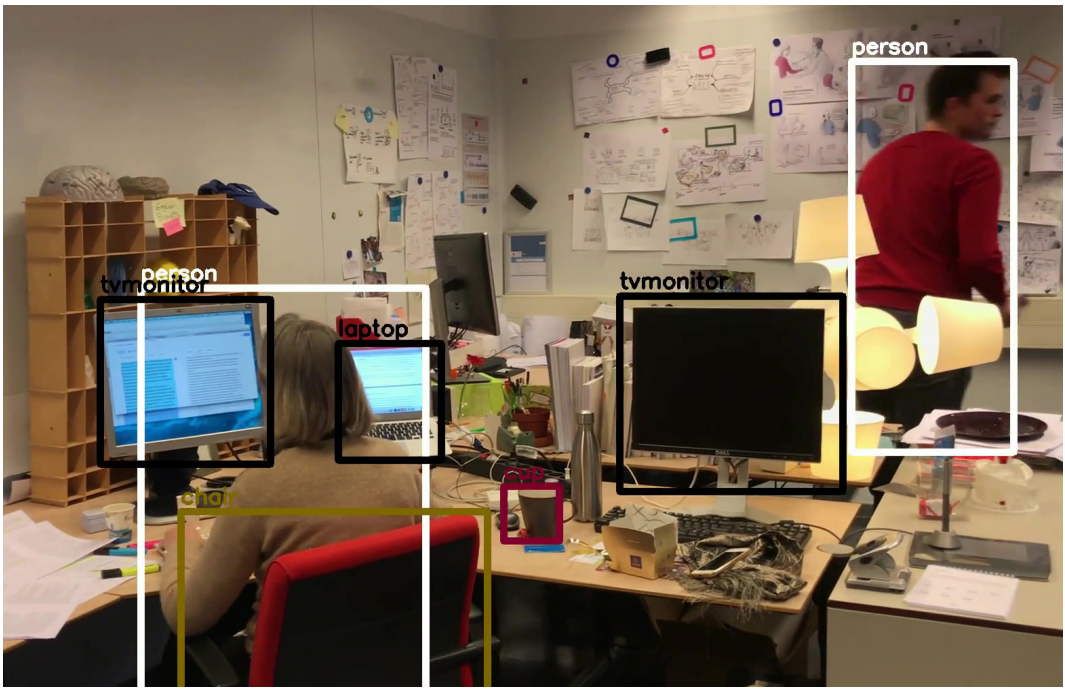
knowledge.

In the initial process of making an interactive toolkit using this platform, it observed that this platform requires some basic understanding of hardware technology and ‘node-based programming’ concept. In addition, this would take extra time to develop visual flow of the code using NodeRed, which designer can understand and use to prototype. Because of time constraints, other directions were explored

4.3 YoLo Object Detection System

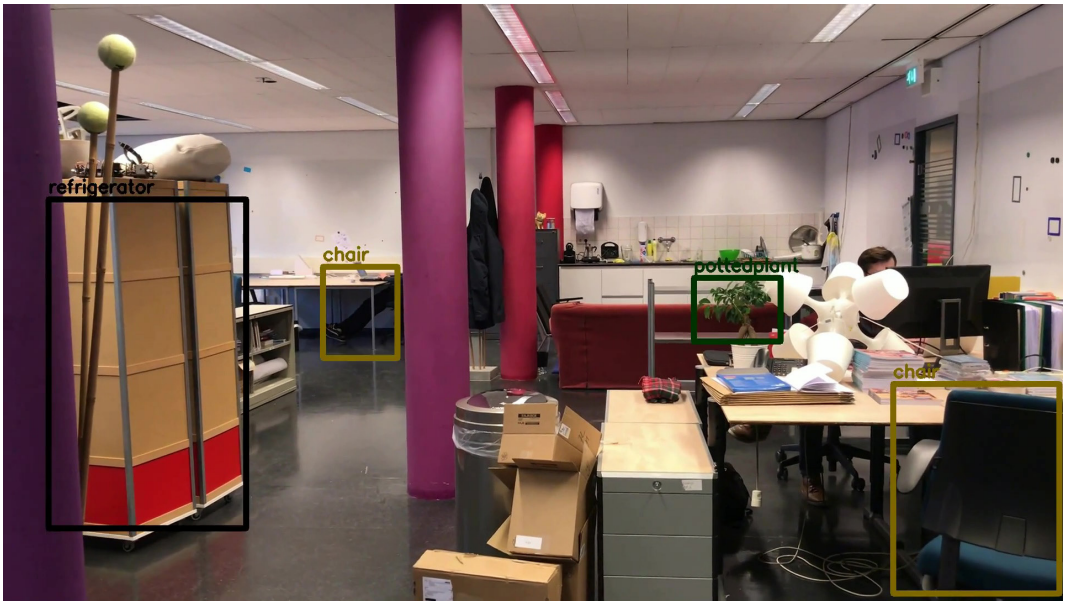
Yolo V3 (You only look once) is an advanced computer vision algorithm which is 5x faster and accurate in object detection. It uses a state-of-the-art deep learning technique to identify hundreds of object categories in its initial trained model (Redmon & Farhadi, 2018).

One can set up the environment on their personal computer machine and perform the object detection on picture or webcam feed. Although you can use any CPU powered machine to perform the object detection, within GPU hardware support the speed of detecting object can be 15 times faster.



A YoLo (You-Look-Only-Once) system detecting an objects situated in the context. This system trained using COCO datasets to detect 80 categories of objects.

This technology exploration led to the idea of designing a speculative prototype with an AI enabled experiments. However, due to privacy and practicality issues it seems unethical to use this kind prototype in an actual setting. To overcome this, a speculative prototype has been designed in an experimental setup.



An example of biases in computer vision algorithm. e.g. Refrigerator

4.4 ObjectResponder 2.0 – a Speculative Prototype

The goal was to construct a design toolkit by which designer can perceive a real-world context from the non – human perspective. At the same time, let designers experience the future AI and design collaboration and doing design research with a non – human entity (Giaccardi et al., 2016). An Ai's computer vision technique is considered to achieve this goal.

Results from the technology exploration study provided valuable insights to make this kind of toolkit. State-of-the-art technology like YoLo object detection system and prototyping tools like AIY vision & voice kit can be use to provide non – human perspective while doing design research. Using this knowledge as a starting point, a speculative design toolkit was brainstormed.

The idea was to let designer observe a real-world context from human and non-human perspective through computer vision technique in different a phases of an design experiment. Indeed at the same time, understand designers' experience of following these two different design processes.

However the challenge to pursue the study in this way is that due to privacy and practicality issues it would be unethical and difficult to perform the experiment in an actual setting using camera. Moreover, it wouldn't be possible to construct a fully functional prototype of the toolkit in given time. That is why, the study was considered to perform in an experimental setup in a virtual setting.

It was considered that, the two different perspectives (human and non-human) will be perceived by designer in a form of a videos. In this case, a normal 360 video of an office space considered as a human perspective and the same video with applied object detection algorithm will be considered as non – human perspective.

The designer seating in the virtual setting will analyze the contexts of an office space from different videos (human and non-human perspectives) during separate phases of the experiment. Later based on the insights gathered in each phase, he/she will ideate a solution on paper. Once the experiment finished, they were asked to reflect on these two different design processes and give feedback on that.

4.4.1 Preparation of the videos

To make the video, initially a 360-panorama video of an actual office space was shot. We took the employees consent present in that space before shooting the video. This video was fed into the YoLo object detection system++ to identify specific objects present in the office through computer vision algorithm — a machine perspective. An output was generated with specific objects labeled as expected.

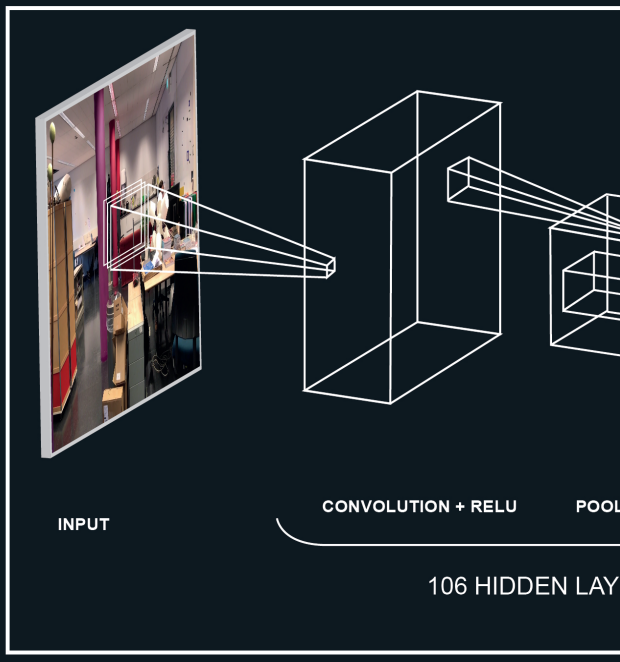
To provide better user interface of the generated video, it was recreated with better visualization of identified object and its name using Adobe After Effects. The recreated output video was later used for further ideation of three different experimental setups mentioned in the next chapter.

Reaction of the machine vision using After Effects

ObjectResponder 2.0

A speculative prototype of the design toolkit for Human - AI collobration in Design.

Real World Design Context
(Human Perspective)



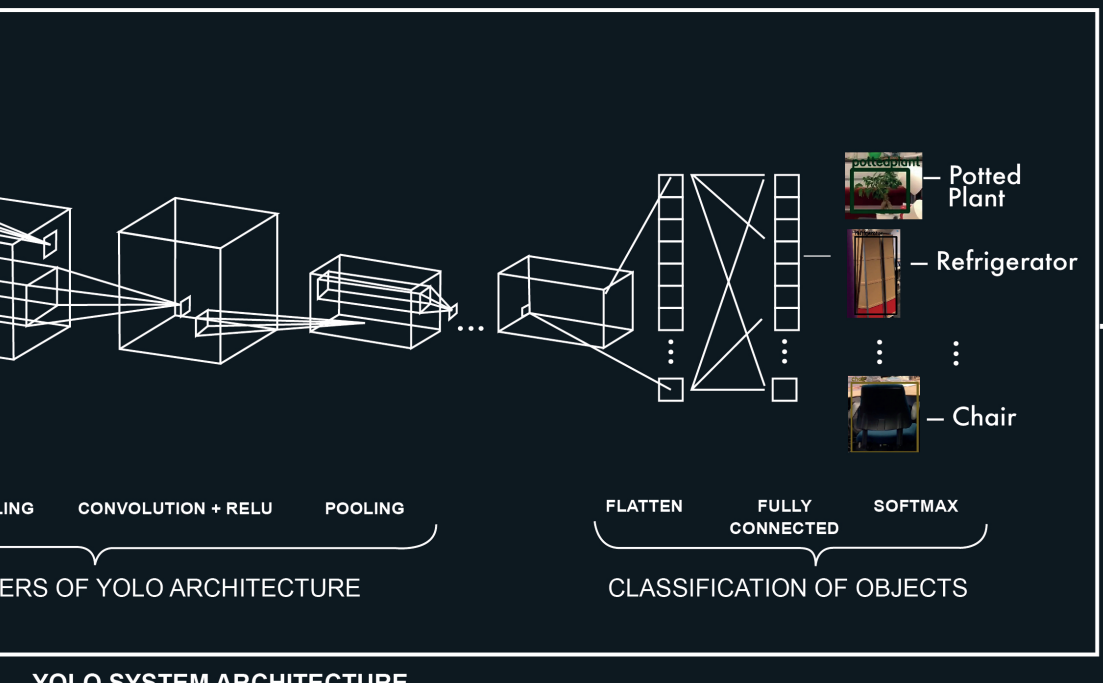
Designer perceiving
the context from
Machine perspective

Recreation
using Adobe

COCO
Common Objects in Context

Algorithm Training Data

123,287 Hand Labelled Images, describing 80 different object categories

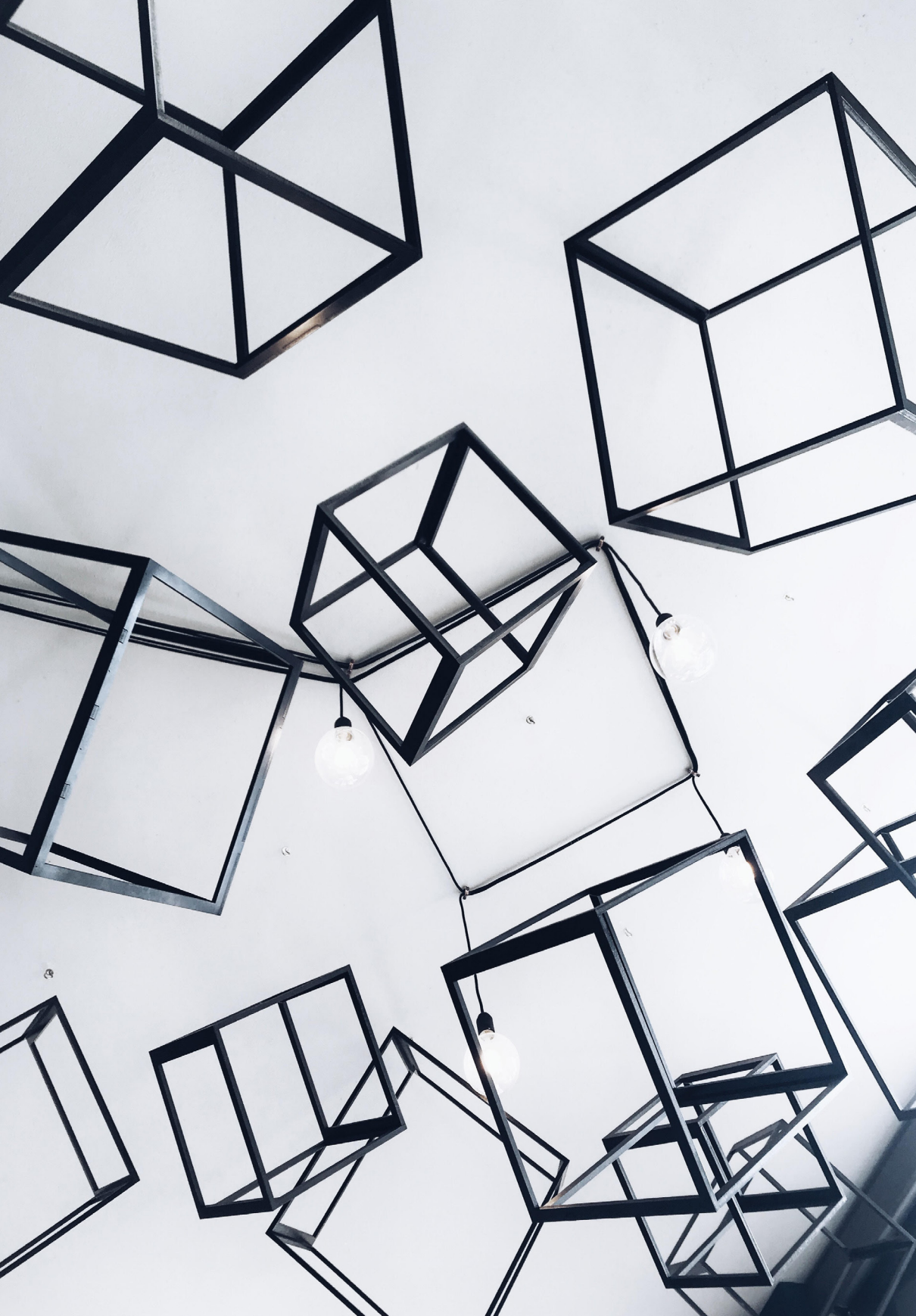


YOLO SYSTEM ARCHITECTURE

Ae

of the video
e After Effects

Machine Perspective on a real - world context with biases



Chapter 5

Iterative Design Experimentation

Three different design experiments were created using a speculative prototype called ObjectResponder 2.0. In each experiment, designer perceived the real-world context from machine perspective and follow the design process. After the experiment finishes, they've asked to explain the difference between designing through human and non-human perspective.

5.1 Design Experiment 1: Learning about AI aided Idea Generation

In this experiment we tested our initial speculative prototype of design toolkit with three different phases. Designers were asked to use the prototype and describe the experience of designing with and without non – human perspective. Findings from the interviews analysis and sketchbook showed that seeing the context as labeled object narrow down designers focus and let them use those objects to ideate solution. Moreover, designers able to balance out biases appearing from computer vision algorithm with creative design solution.

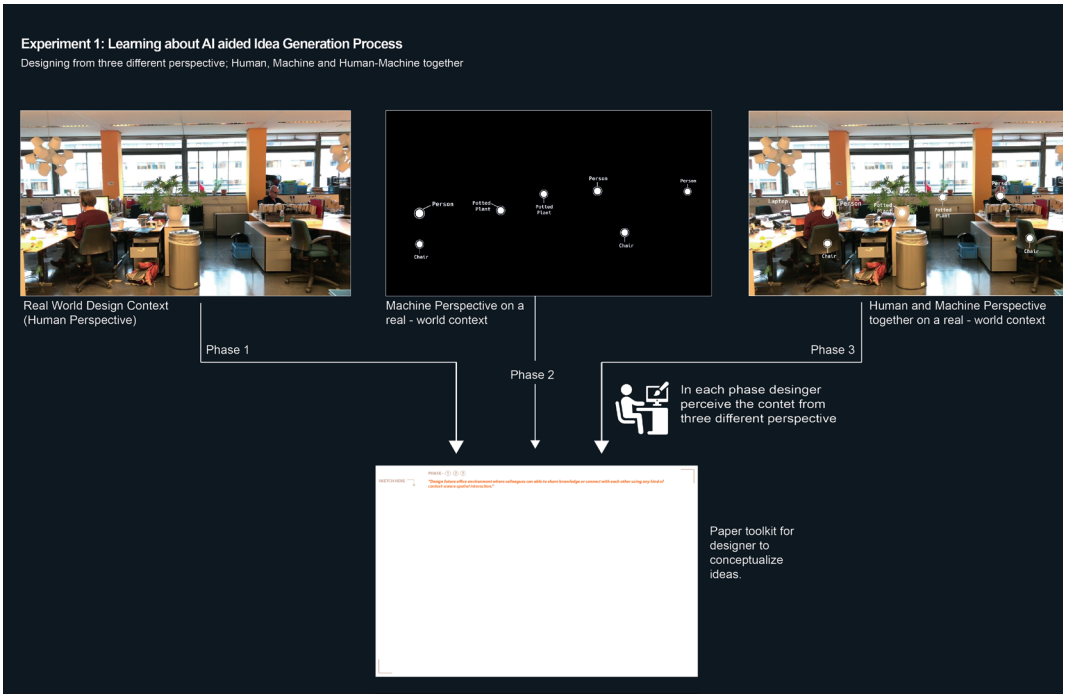
5.1.1 Participants

Participant Number	Gender	Age	Education	Ocuupation	Professional Experience in Design (Years)	Experience with AI and ML (Years)
P1	Male	26	Master's in Design for Interaction	Student	2	<1
P2	Male	27	Master's in Design for Interaction	HCI Researcher	2	<1
P3	Male	25	Master's in Integrated Product Design	Student	1	<1
P4	Male	27	Master's in Strategic Product Design	Student	1	<1

Background information of the students who participated in the study.

Four design students were recruited for the pilot round of the experiment. They were either pursuing their masters in various discipline or working as a researcher at the Faculty of Industrial Design, TU Delft. The participant had some exposure to AI and ML technologies in terms of conceptual understanding or some background knowledge. They acquired this knowledge through personal interest or working in a small design assignment during their education.

5.1.2. Experiment Setup



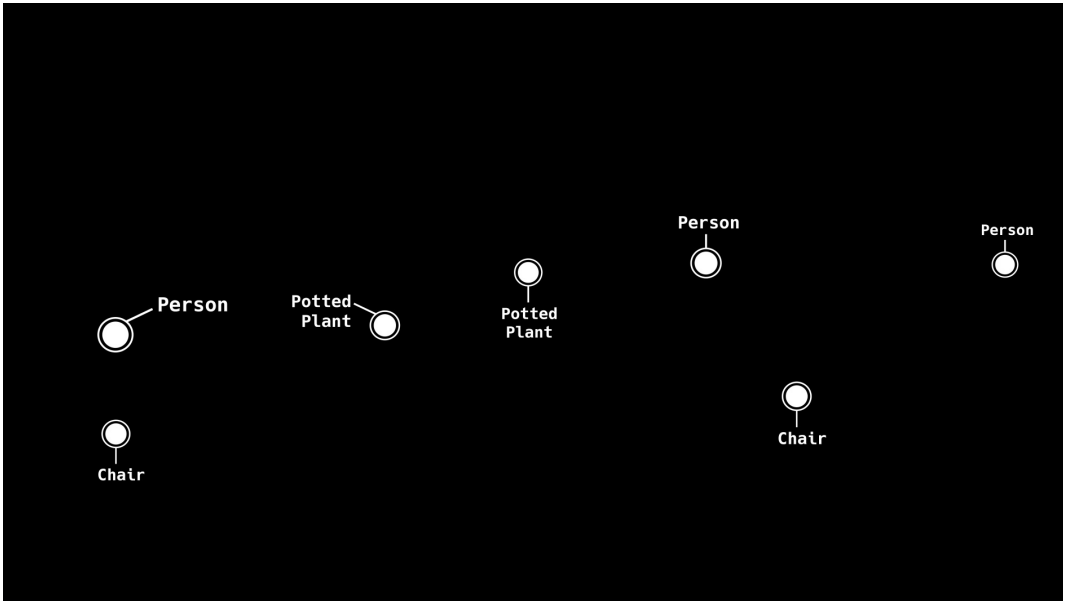
Experiment setup and the process followed by designers during the Experiment -1

The experiment had three phases, where in each phase designer performed a contextual inquiry of an office space through three different perspective — human perspective in phase 1; machine perspective in phase 2; human-machine perspective together in phase 3.

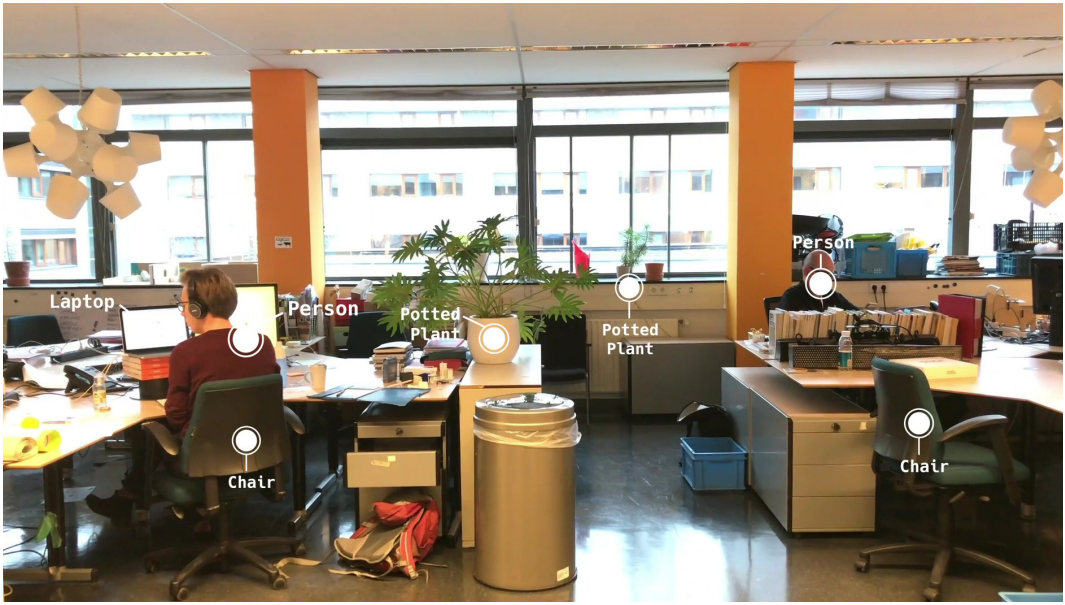
Phase 1 (Human Perspective)

After thoroughly understanding of an office context in each phase from human or machine perspective, they were given one design goal to ideate upon. This design goal was articulated according to the contextual information shown in the video.

"Design future office environment where colleagues can able to share knowledge or connect with each other using any kind of context – aware spatial interaction"

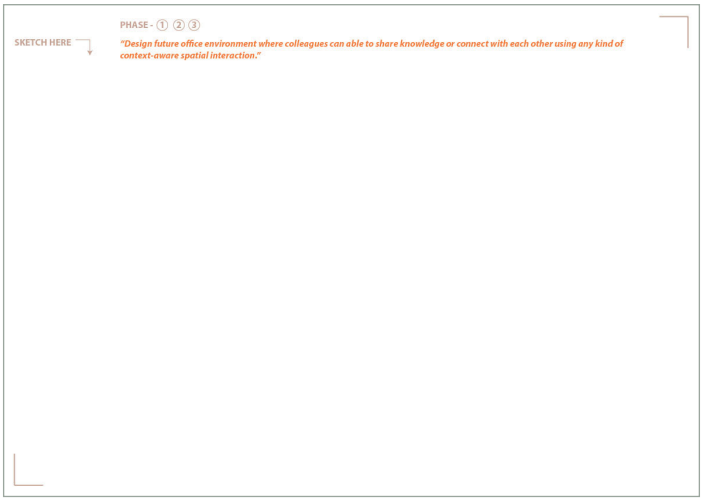


Phase 2 (Machine Perspective)



Phase 3 (Human – machine perspective together)

Designers had to focus on this design goal in each phase and brainstorm different ideas based on insights gathered in the contextual inquiry. To take a note and brainstorm the ideas, a paper toolkit was also provided with design goal written on it.



Sketchbook for conceptualize design ideas during all the phases of the experiment 1

After phase 3 finished, the designers were asked to explain the difference between designing with and without machine perspective. They have asked to explain the differences in problematize context and brainstorming ideas while designing through human perspective and machine perspective; Also, to describe their struggles during the process and how does this multi-perspective (Human and Machine together) aid in their idea generation process.

5.1.3. Data collection & Analysis

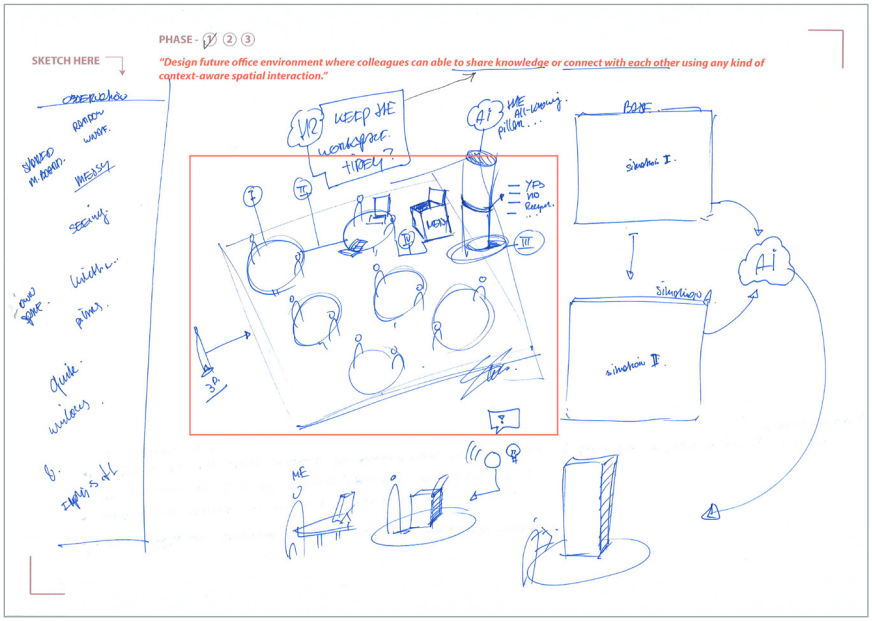
The experiment with each designer was recorded using camera. The A3 sketchbooks was also collected to understand their design approach during each phase of the experiment. All the interviews were transcribed and organized in terms of accuracy and textual errors. Once the data were organized, all the transcriptions were read thoroughly and coded into its respective individual description points. Based on these descriptive terms and observation on

Equipment setup for collecting data

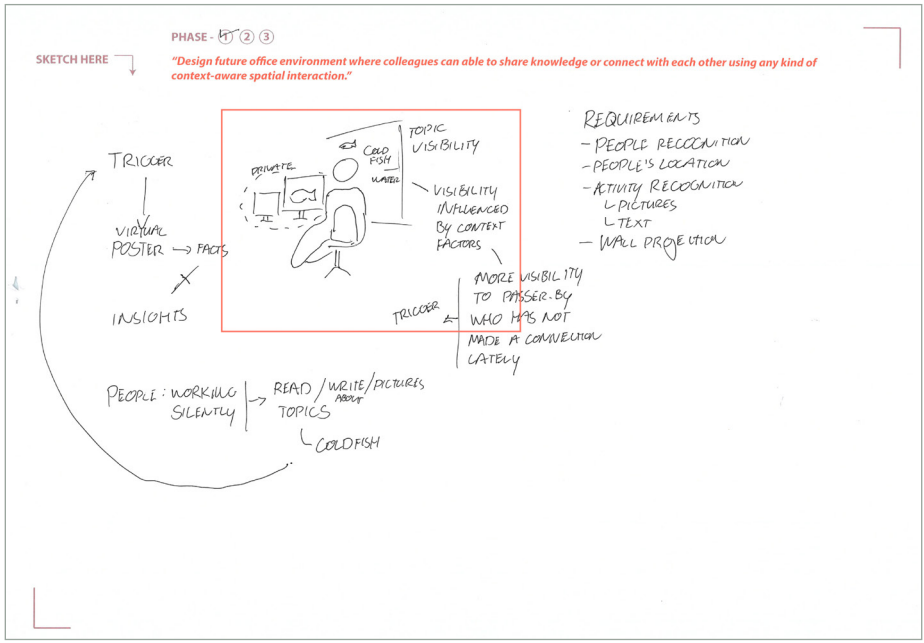
sketched idea during each phase, preliminary findings from the experiment was articulated.

5.1.4. Findings

While analyzing the sketched ideas of designers, it had shown that in phase one of the experiment (Designing from human perspective), P1 was problematizing the context from the organizational point of view. They observed things like how people seat; what are the distance between two people; and how things are arranged in the office space in terms of cleanliness. In result their design ideas were more focused on re-decorate the office environments and make the place socially accessible and clean.

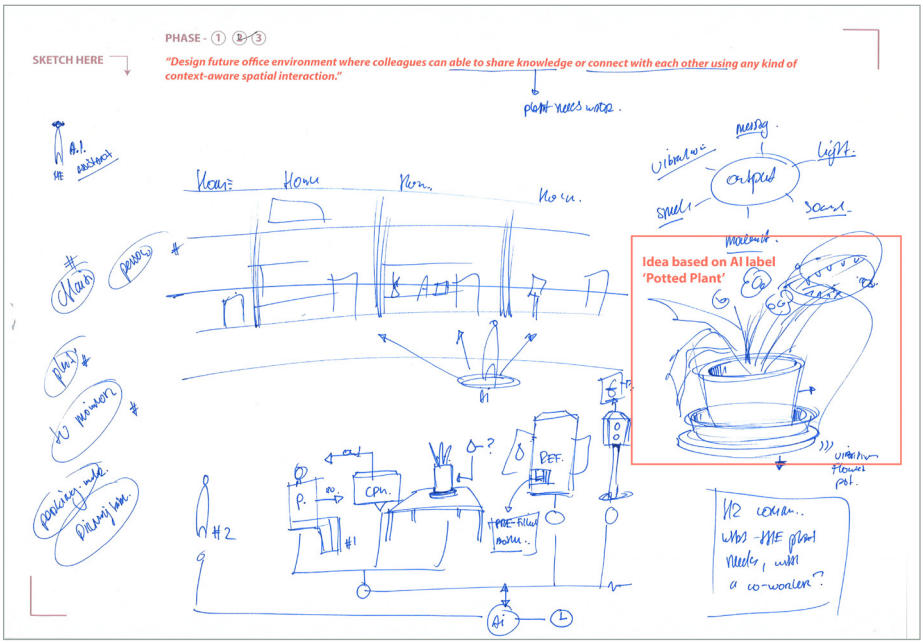


P1 — Brainstorming ideas during his phase 1 of the experiment 1

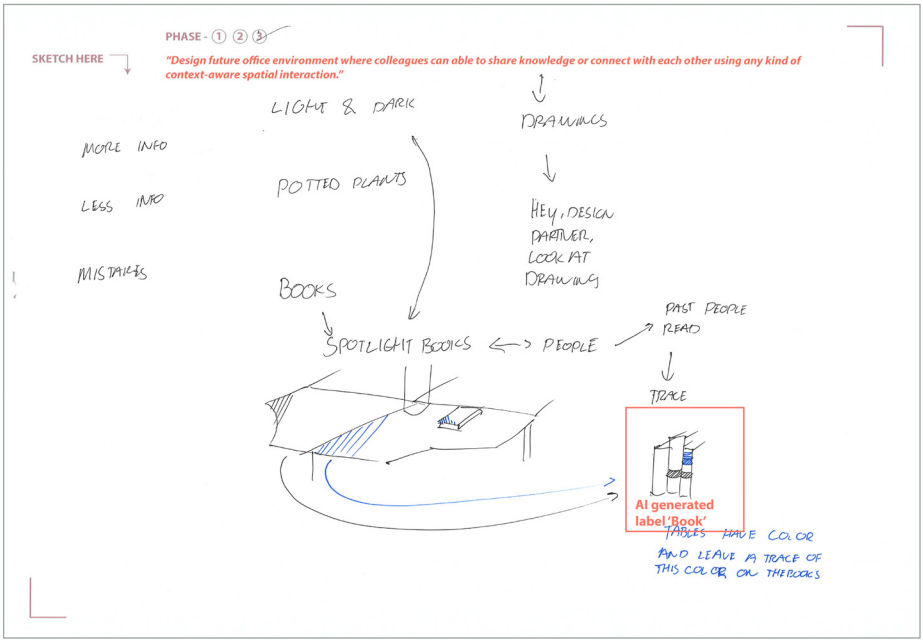


P2 — Brainstorming ideas during his phase 1 of the experiment 1

However, when designer did expose to the context from an AI perspective (showing labelled objects), their focus of problematize and find a solution for give design goal was diverged. They used the recognized object labels together with other contextual information to create novel solutions. As a result, their ideas were more focused on objects and human interaction, which are situated in the context.

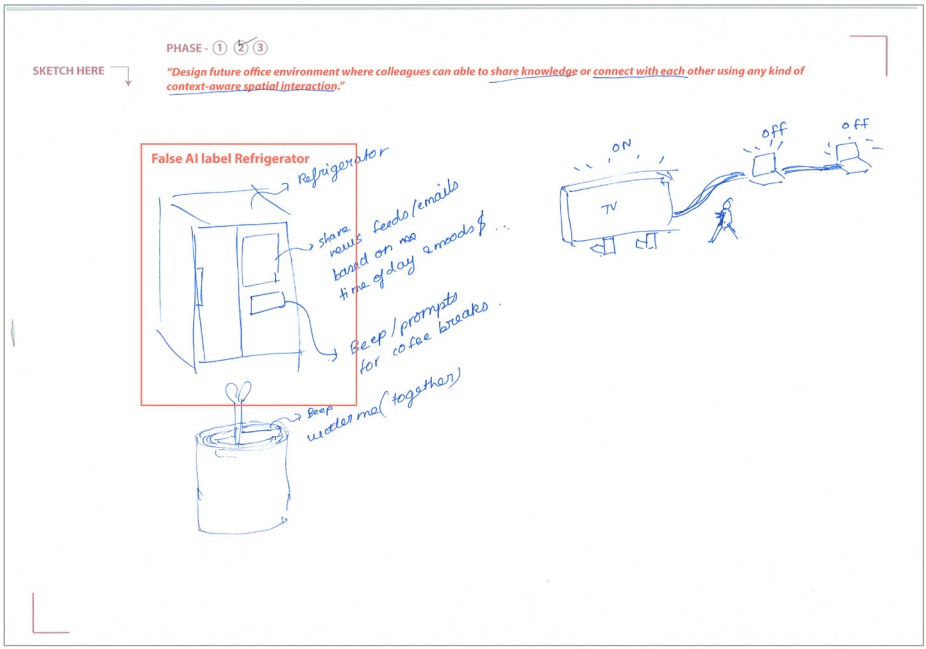


P1 — Brainstorming ideas during his phase 1 of the experiment 1

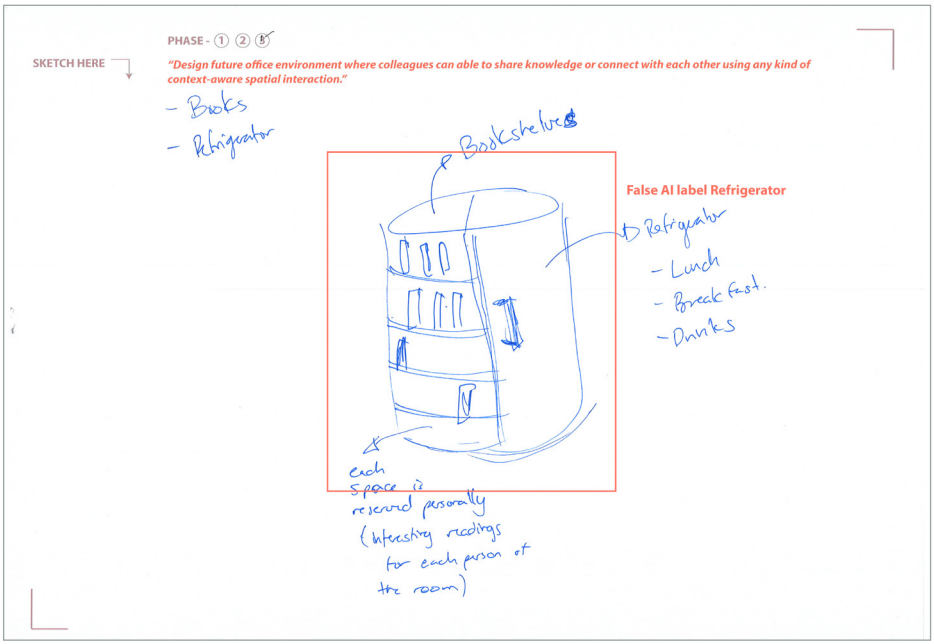


P2 — Brainstorming ideas during his phase 3 of the experiment 1

In the sketched ideas, it has also been shown that designer appreciated false labels (e.g. 'Refrigerator') appearing due to bias training data in the algorithm. Designer (P3 and P4) use these false labels as an inspiration to combine it together with more novel ideas to address problem definition. Although the false labels did not inspire all the designers to think about vivid ideas, but P3 and P4 could able to use this false label creatively and manage to balance the biases.

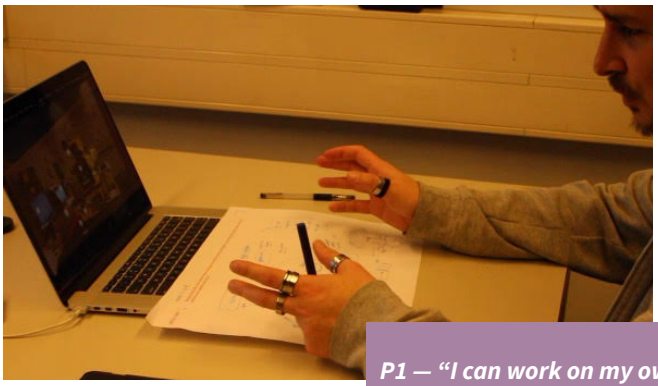


P3 — Brainstorming ideas during his phase 2 of the experiment 1



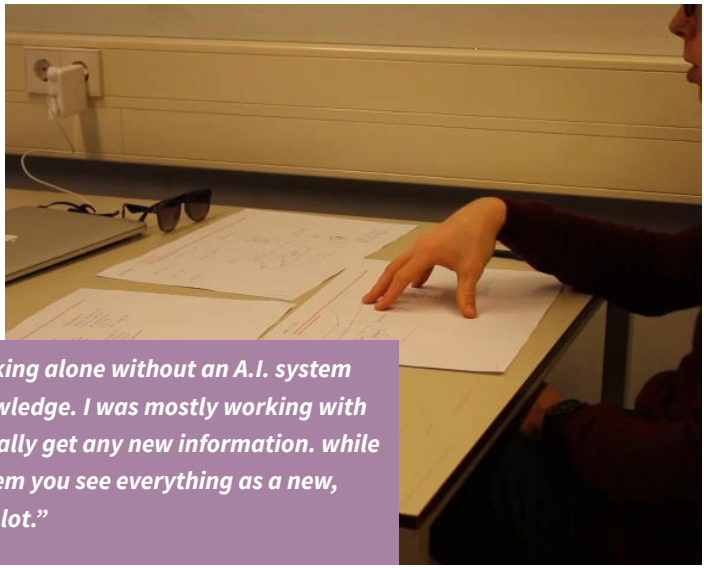
P4 — Brainstorming ideas during his phase 3 of the experiment 1

During the feedback session, P1 explained that while analyzing the context from machine perspective, bring them to whole new level of novel ideas, which cannot be achievable alone.

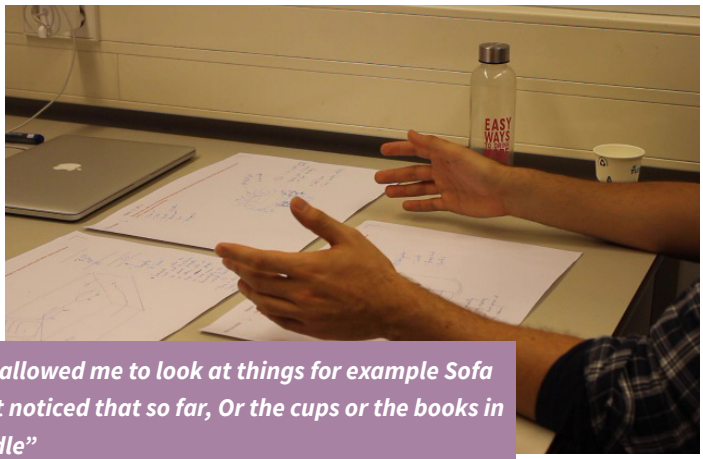


P1 — "I can work on my own, but I cannot achieve this kind of ideation level where I can really work with a dynamic context."

P2 and P4 explained that AI perspective help him to look at the same office space with lots of new contextual information which is new and were missed before. It helps him to co-relate relation between human and object situated in the context.

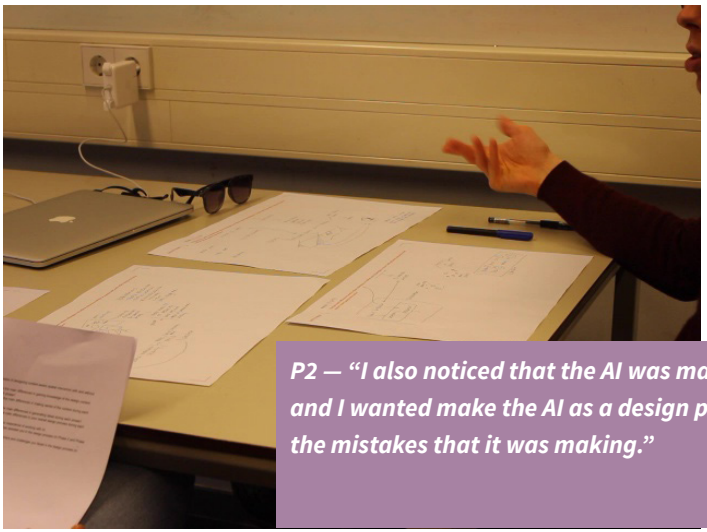


P2 — "I felt like when I was working alone without an A.I. system .... I didn't really learn new knowledge. I was mostly working with existing knowledge... I didn't really get any new information. while as an artificial intelligence system you see everything as a new, which means that you'd learn a lot."



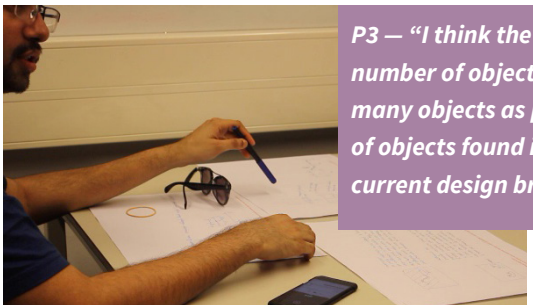
P4 —"AI allowed me to look at things for example Sofa I haven't noticed that so far, Or the cups or the books in the middle"

Looking at the machine perspective, P2 learned how machine perspective is different. This different perspective gave him the understanding about the way current algorithm work and what would be needed to make it ideal combination for design partner during the design process.



P2 — "I also noticed that the AI was making mistakes .. and I wanted make the AI as a design partner aware of the mistakes that it was making."

Discussing about challenges while working with machine perspective, the smaller number of labels were not providing much help according to P3's feedback. As he said, he need more labels or insights from this AI to ignite new ideas. During the experiment, it also came to notice that designer struggle to understand the design brief and relate it to the context shown in the video.**5.1.4.**



P3 — "I think the phase 3 was more about boundaries and the number of objects its being detected. So basically, you need as many objects as possible to form association. but the number of objects found in phase 3 were very less for me to assist with current design brief".

5.1.5 Conclusion

The experiment took long to finish, as a result designer lose their enthusiasm to pursue the experiment actively till the end. Though the idea of problematizing the context and ideate from machine perspective show positive results, but due to experimental setup and a smaller number of labels appearing, it was hard for them to follow the experiment. Also, the design brief given to solve was complex and designers struggle to ideate over it.

These insights taken into consideration for the second iteration of the experiments with some changes

5.2 Design Experiment 2: Learning about Design toolkit Features

The intention in this experiment was to see how machine biases may influence designers' process of problematizing the context and brainstorming ideas for solution. For this reason, some additional self - made false object categories were manually added in the design of the object responder prototype. e.g. Identifying 'Lamp' as 'Space Shuttle', 'Basket' as 'Trolley', even identifying toy as Humanoid Robot etc.

5.2.1 Participants

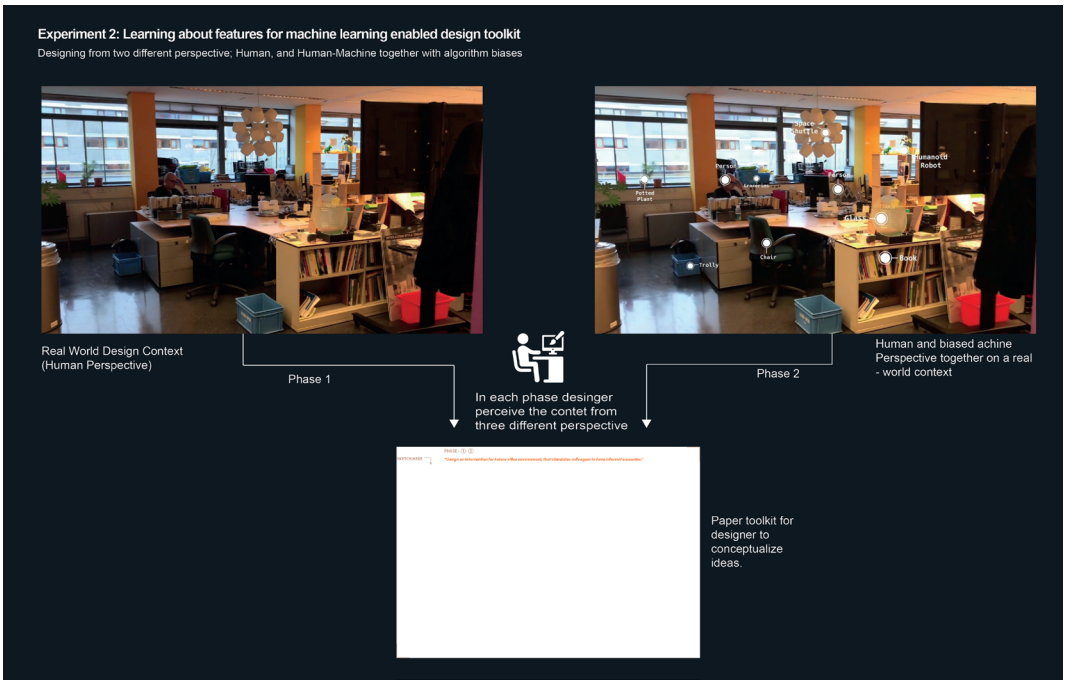
Participant Number	Gender	Age	Education	Occupation	Professional Experience in Design (Years)	Experience with AI and ML (Years)
P1	Female	27	Humanities (Degree)	UX Architect	5	0
P2	Female	28	Graphics Designer (BA Degree)	UX / UI Designer	4	0
P3	Male	26	Industrial Design	R&D/Technologist	3	1.5
P4	Male	42	Design (Degree)	Chief Compliance Officer at the Design Firm	>10	2-3
P5	Male	25	Creative Technology (Degree)	Product Designer	2	0
P6	Female	21	Communication and Multimedia Design	UX / Product Designer	< 1	0
P7	Male	32	Msc Design for Interation	UX Designer	6.5	<1
P8	Male	27	Bachelor's Industrial Design	Product Designer	4	<1
P9	Male	46	Msc Industrial Design	UX / Product Designer	14	0
P10	Male	>45	Design	Innovation Directors at the Design Firm	>20	<1

Background information of the designers from MOBGEN and Info.nl, who participated in the experiment 2

10 professional designers Male and Female aged from 21 - 46 were recruited for the experiments. These designers have expertise in various design domains. (e.g. User experience Design, Graphics Design, Product Design, Service Design and Design Technologist). All of them have minimum 2 years of experience working in a professional design firm. Though it was not the requirement, few of them had some experience in designing ML oriented products or service.

5.2.2 Experiment Setup

According designers' feedback and the observation from the experiment 1, few changes were made in the experiment setup. To reduce a total time and provide an easier design goal, phases of the experiment setup were redefined.



Experiment setup and the process followed by designers during the Experiment -2

As the focus of this experiment was not to judge the quality of designer's idea but understand the process of designing from human and non – human perspective. To make this achievable, first a new design goal was articulated with simple design task. — which designers can relate to the information shown in the video.

"Design an Intervention for Future office environment, that stimulates colleagues to have informal encounter."

Similarly, P1 also explained that whatever the information she was receiving from the machine perspective are not fitting with her ideology of human centered design practice. She mentioned about having more contextual information in terms of fulfilling the current design goal.

Phase 1 (Human Perspective)

Phase 2 (Human Machine Perspective with biases)

Designer had to focus on the given design goal in each phase and brainstorm different ideas. To achieve brainstorm idea, they would use the insights gathered during the contextual inquiry of an office space through the videos. They were free to use the information they think is relevant for their idea generation otherwise neglect it. To take a note and brainstorm the ideas, a same paper toolkit with new design goal was provided.

Sketchbook for conceptualize design ideas during all the phases of the experiment 1

After phase 2 finished, the designers were asked few questions about their experience to conceptualize and ideate through two individual perspective. They've asked to explain the differences in problematize context and brainstorming ideas in each phase; Also, they were asked to describe the challenges during the process and how does this multi-perspective (Human and Machine) with machine biases aid in their idea generation process.

5.2.3 Data collection & Analysis

The activities performed with all designers were audio recorded and videotaped. In addition, the design concepts sketched for each phase in A3 sheet were kept for further analysis. All the video recordings and sketches were analyzed carefully. Meanwhile important statement given by user were noted down in a post-its and placed in front of their ideas. This textual information written on post-it was used to understand what designer actually brainstormed upon and how did it come up with particular idea. Later based on this insight, preliminary findings were articulated and concluded.

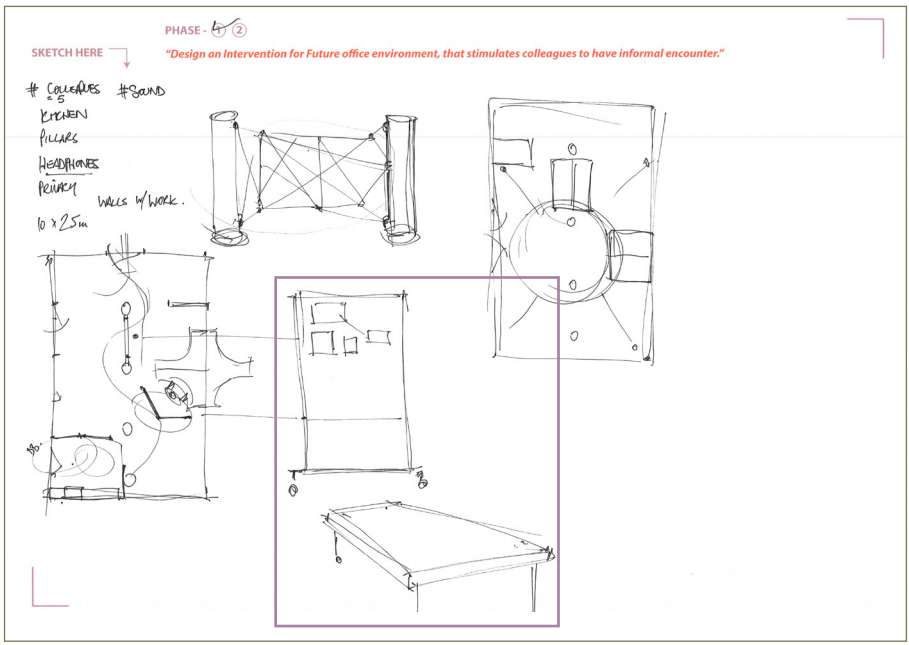
Textual information collected on post-it from the interview with designers about explaining the process

5.2.4 Findings

While analyzing the sketches of brainstorming session by professional designer, there were few findings which was similar to experiment 1 (with design students). But at the same time, it provided richer insights in terms of understanding their approach and way of using this kind of design toolkit.

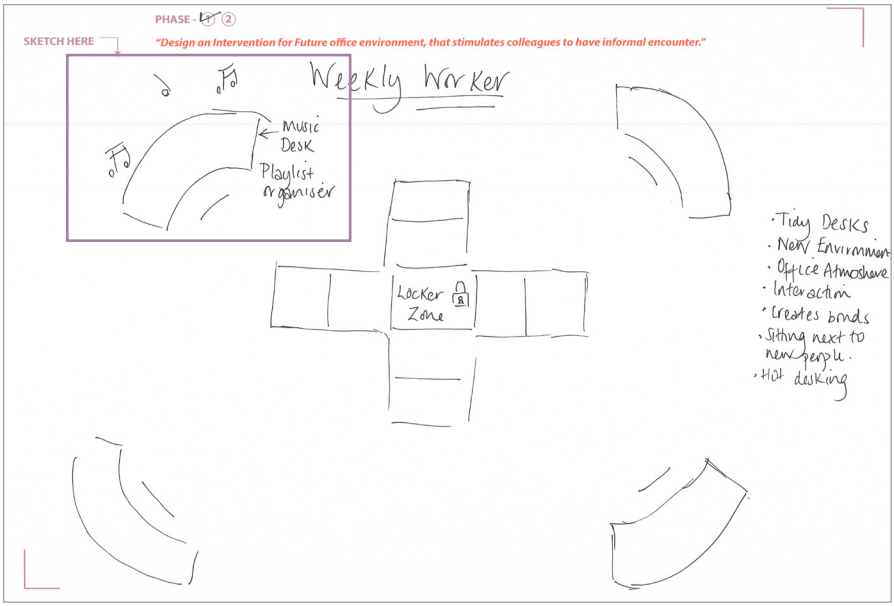
Designing from Human Perspective

For example, in the phase one of the experiment (human perspective) designers were problematized the context in terms of interior of the room. Such as in the phase 1 of the experiment, P4 was brainstorming an idea about having a moving desk, so as designer does not have to stick in the particular one area of an office. Also he drawn a sketch of having a space for hanging new project ideas in the center of the office space.



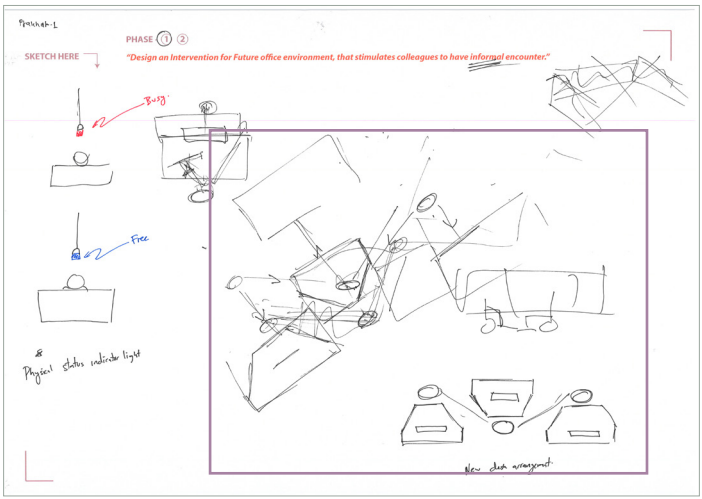
P4 - Phase 1 — Focusing on the idea for having moving desk in the office, which everyone can use to change the place regularly in the office.

Similarly, P2 brainstormed an idea of having a music desk in the office to play music on the speaker and having relax time with colleague during a stress full day. She described her idea such as, “whoever is interested to have some social interaction and a small break, they can go to the music desk and play songs which everybody likes.”

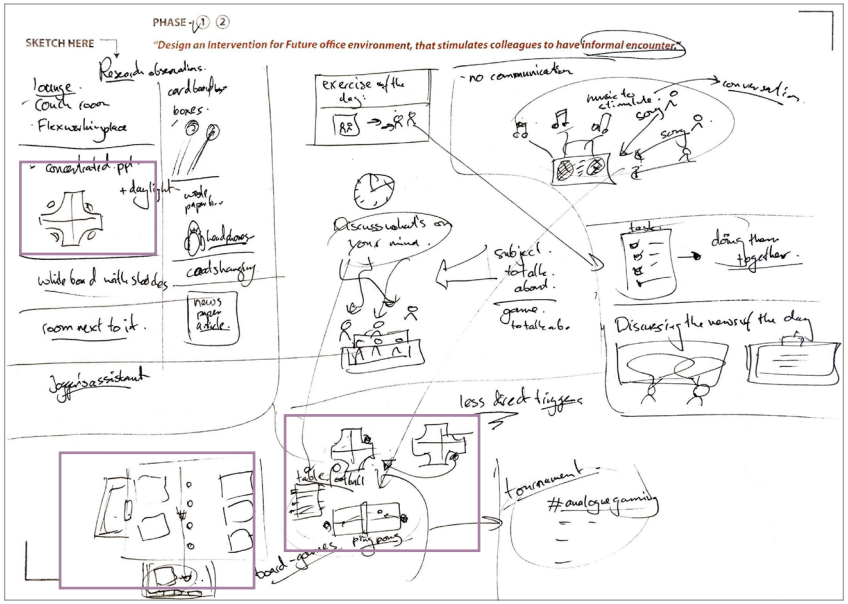


P2 - Phase 1: focused on the idea of music desk with play-list controller to play interesting music, which everyone likes to hear.

Furthermore, during the phase one of the experiment, designers (P3 and P7) focused on how people are seating and which direction they are facing the most. Thus, as a result their ideas were more focused on re-arrange the work desks to have proper eye contact between colleagues. e.g. having more open space between each desk or having a space for social and relaxing activities like coffee break, Friday evening etc.



P3 - Phase 1: Focused on the idea about replacing the table in zig-zag position to have better eye contact.

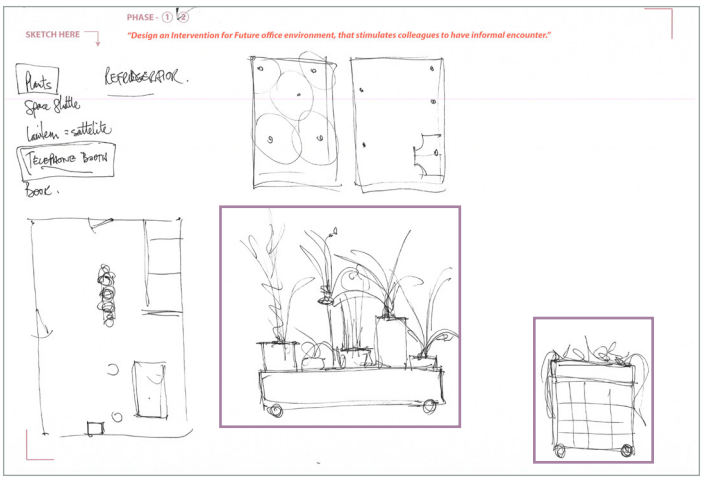


P7 - Phase 1: Focused on the idea of how to arrange desks ti have more communication opportunity between colleague

Designing from Machine Perspective

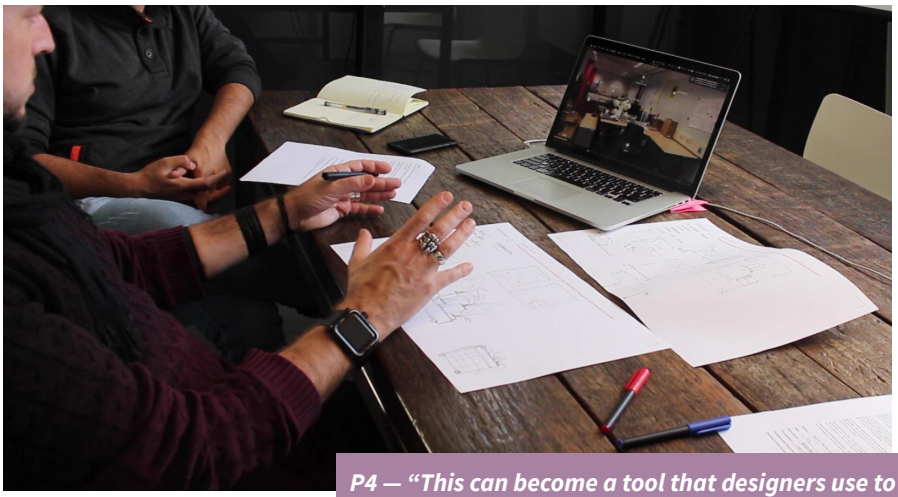
However, while looking at the sketches from phase two, it came to realization that observing the context from an AI perspective enable designers to narrow down their focus into individual objects. This AI perspective intrigue designers to correlate an interaction between human and objects situated in the context of an office space.

For example, P4 used one of the reappearing labels (e.g. potted plant) as an inspiration and integrate labelled object called potted plant in his idea. He explained this idea as green moving desk which has potted plants on it. The pot also contains a humidity sensor to collect the pH data of the water and notify other colleague to pour more during specific time period.



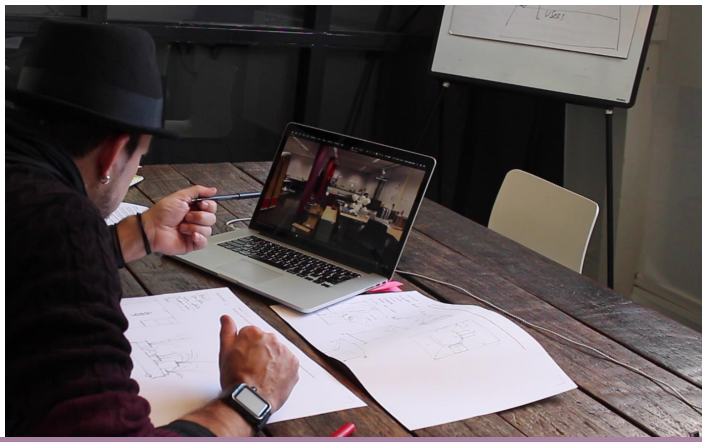
P4 - Phase 2: Used plant AI label plant as an inspiration to come - up with green office desk idea

In the feedback session P4 also mentioned the importance of this kind of toolkit and how it can be useful for designers to evaluate context based on the design goal or problem definition.



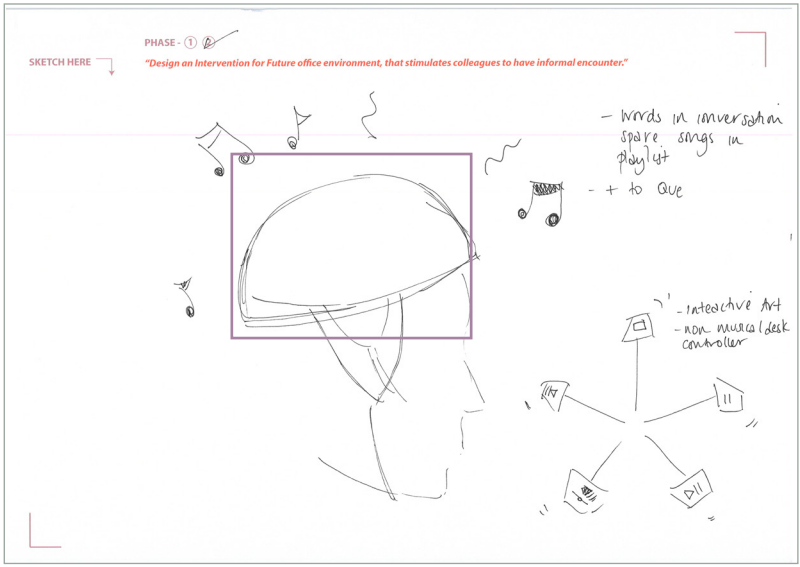
P4 — "This can become a tool that designers use to evaluate on what is most important thing for the end user".

He also mentioned that the tool was helping him to perceive the context without any pre-assumption about office space. Which, according to him is always the case when designer analyzes the context from human perspective and her/his own bias influence the design process.



P4 — "In phase 1 (human perspective), I worked a lot on my presumption that this office space is bit messy; there is kitchen; or guy with headphone doesn't want to get disturb. While the phase two (machine perspective) break that assumption and showing me things which I didn't noticed before. For example, I've seen there were almost 6-7 plants in the office which means people in the office prefer to have more plants"

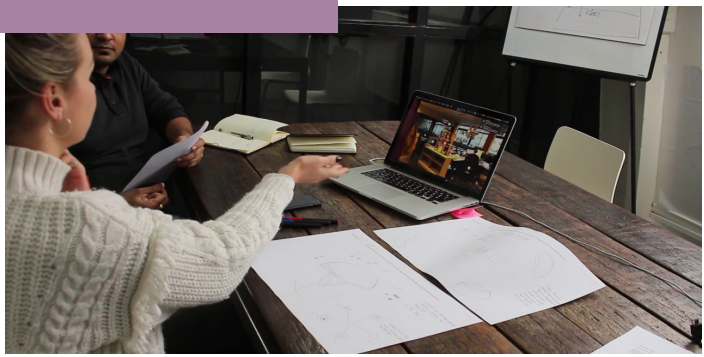
Likewise, P2 has also used some of the false labels like 'Helmet' and 'Interactive Art' to brainstorm her concept during the phase 2 of the experiment. She conceptualizes the idea of controlling a music play-list through smart gadgets, which uses brain-computer interfaces technique to interact with physical objects.



P2 - Phase 2 — Use of false AI label 'Helmet' to diverge towards different idea

While having a discussion about the difference in designing from human and machine perspective, P2 mentioned that these labeling were forcing her to be more imaginative by showing different objects and its relationship with other objects, which also can be part of the idea generation process.

P2 — "It sparking me more imaginative ideas because it forcing me to see the objects with different perspective rather than how I used see it in everyday life."



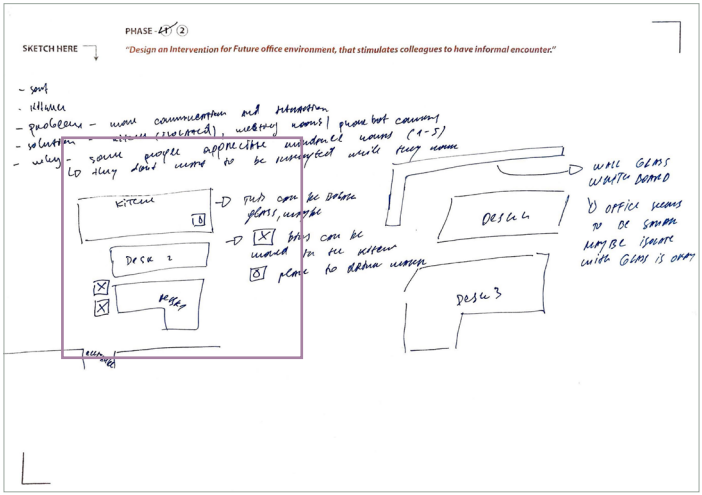
Challenges while following the design process from machine perspective

In contrast to these findings, there was also some tension between following this new kind of design process. P1 and P8 mentioned their struggled to get useful information from machine perspective to pursue towards meaningful ideation generation.

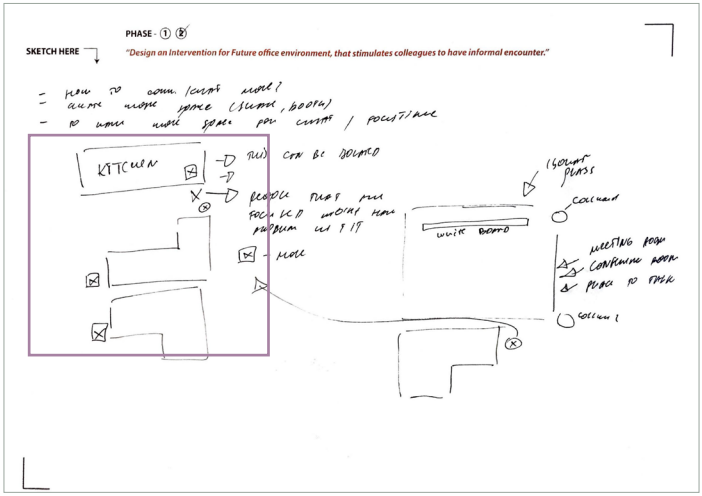
For example, P8 decided to stick with the same idea in both phase of the experiment with some minor alteration. According to his opinion, the false labels (e.g. space shuttle or ATM) were not providing the information which is required to understand the

P8 — "In phase 2, I was focusing on the false labels like ATM which is just a tissue paper machine. At one point it made me think about it, but I was not sure how can I use that label with this given context of an office space"

context. As the result, P8 focused on idea of re-arrange desks and furniture and make the space more social and open, which he did followed in the phase one as well.

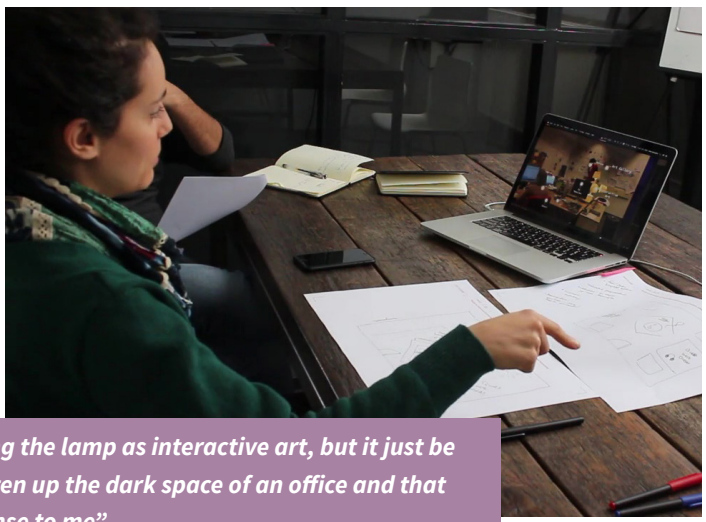


P8 - Phase 1: Focused on the idea of incorporating social room inside the office space

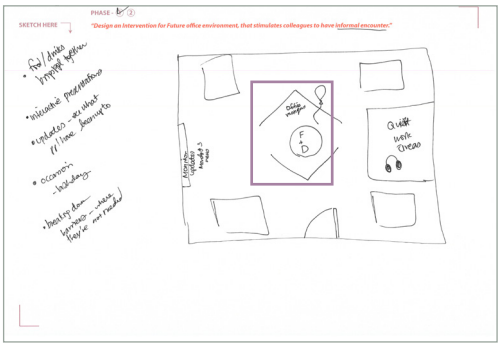


P8 - Phase 2: Iterated on the same idea of incorporating social room inside the office space with some minor modification on it

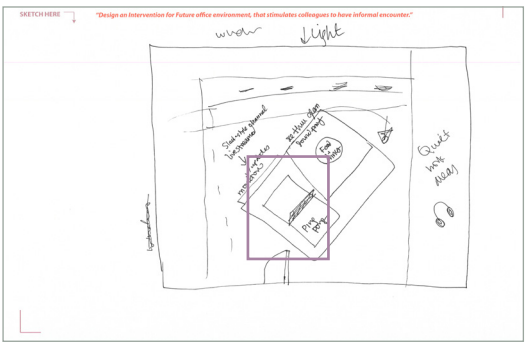
Similarly, P1 also explained that whatever the information she was receiving from the machine perspective are not fitting with her ideology of human centered design practice. She mentioned about having more contextual information in terms of fulfilling the current design goal.



P1 "AI recognizing the lamp as interactive art, but it just be a lamp that lighten up the dark space of an office and that doesn't make sense to me"



P1 - Phase1: Sketch of an idea about refurbishing the office space in terms of placements of desk and chair



P1 - Phase2: Sketch of an similar idea about refurbishing the office space with some minor modification. e.g. Ping-Pong Table or place for social gathering

5.2.5 Conclusion

While following the design process from machine perspective, designers intrigue by the way the machine vision showing contextual information. For P2 and P4 this information was quite helpful to diverge towards novel idea generation and noticing things about user and objects situated in the context that they missed before. However, this wasn't the case with P1 and P8. Both the participants have concluded that the false labels were quite broad and not helpful to provide meaningful contextual information.

5.2.6 Limitation

The findings explained in this chapter were the preliminary result of the observation on the recorded videos and analysis of the professional designers sketches together with their design approach. With more time and resources, the data could be more analyzed from different design research perspective and concluded more thoroughly. For the time being, it shows some of the highlighted insights discovered during the analysis.

5.3 Design Experiment 3: Consolidating Insights for the Design toolkit

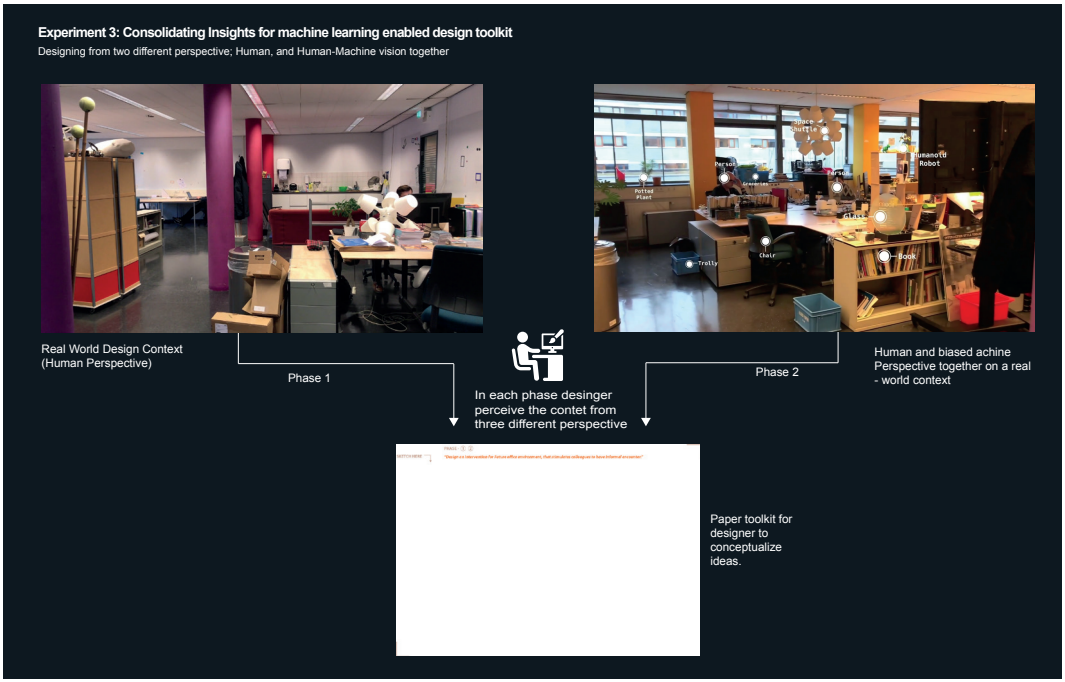
The purpose of this experiment was to give design student an opportunity to perceive the context from an actual machine vision and let them understand the difference between machine and human perspective. They were asked to use this both perspectives separately to collect data and ideate upon a solution for given design problem. Once the experiment finished, the feedback was collected through Q&A template book. Initial findings suggested that design students positively adopted the approach of designing from machine perspective and able to diverge towards vivid ideas during the process.

5.3.1 Participants

Participant Number	Gender	Age	Education	Occupation	Professional Experience in Design (Years)	Experience with AI and ML (Years)
P1	Female	23	Integrated Product Design	Master Student	0	0
P2	Female	24	Integrated Product Design	Master Student	1	0
P3	Female	24	Design for Interaction	Master Student	4.5	1
P4	Female	22	Integrated Product Design	Master Student	0	0
P5	Female	27	Design for Interaction	Master Student	3	0
P6	Female	24	Integrated Product Design	Master Student	0	0
P7	Female	23	Integrated Product Design	Master Student	0	0
P8	Female	22	Integrated Product Design	Master Student	4.5	0
P9	Female	25	Design for Interaction	Master Student	6	1
P10	Female	27	Integrated Product Design	Master Student	1	<1
P11	Male	22	Design for Interaction	Master Student	<1	0
P12	Male	22	Design for Interaction	Master Student	5	0
P13	Male	22	Design for Interaction	Master Student	0	0
P14	Male	24	Design for Interaction	Master Student	1.5	0
P15	Male	24	Design for Interaction	Master Student	0	0
P16	Male	24	Design for Interaction	Master Student	4	0

17 Design students from the faculty of industrial design were participated in the experiment. These students were pursuing their master in three different design discipline. e.g. Design for Interaction, Integrated Product Design and Strategic Product Design. These students were also pursuing an elective course “Thing Centered Design” during the experiment. As a result, they were all familiar with the concept of designing from non – human perspective or machine perspective in terms of this project.

5.3.2 Experiment Setup

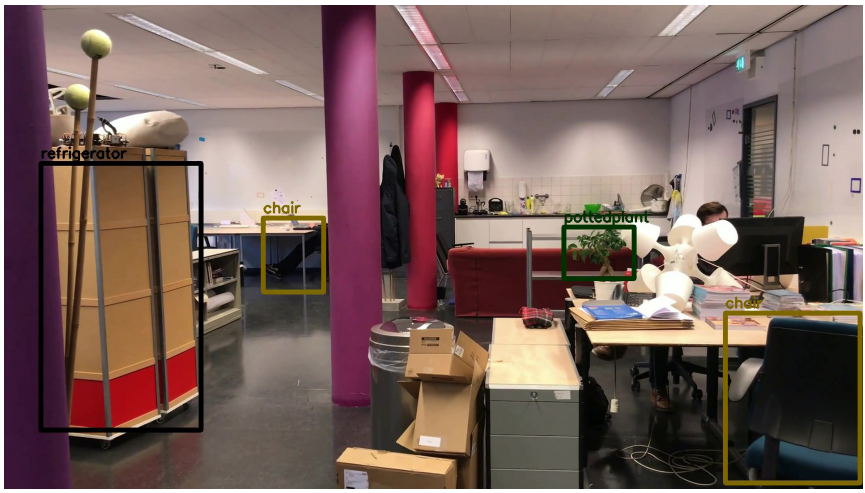


5.3.3 Experiment Setup

The experiment was conducted in two phases. In phase design students each in group of 3, conducted a contextual inquiry of an office space from a human perspective. In phase two they conducted the contextual inquiry of a same office space from machine per-

spective. However, this time the machine perspective was shown in the form of actual machine vision video. Unlike the experiment one and two, this video was actual output from Yolo computer vision algorithm. So as there were no visual effects or self-made bias, but only actual algorithm bias was there. For example, the algorithm identified shelve as a refrigerator.

Phase 1 (Human Perspective)

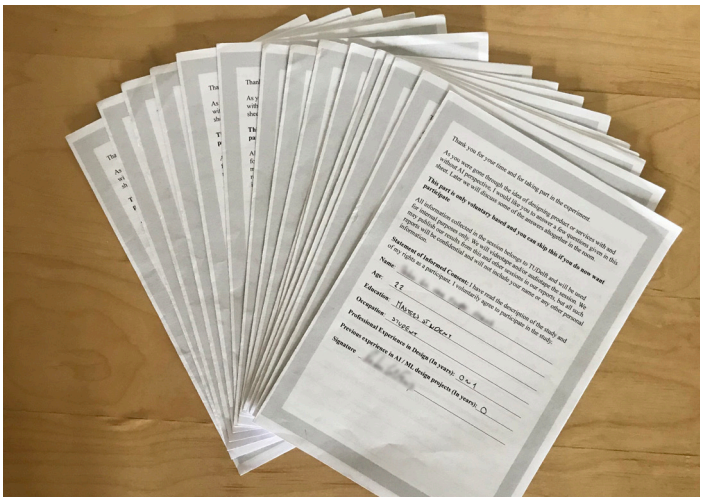


Actual Machine Perspective with algorithm biases.

They collected the contextual data from both the perspective in each phase. Based on this information, they brainstormed the ideas to achieve given design goal. An A3 sketchbook was given to them for brainstorming and sketching ideas.

5.3.4 Data Collection and Analysis

After the experiment finished the designers were given a Q&A booklet to provide their feedback about their experience based on semi-structured questionnaires. This booklet had same questionnaires as compare to experiment one and two. Students were asked to give feedback about the difference between designing from human perspective and machine perspective. They were asked to explain differences in terms of gaining knowledge during each perspective; gaining generating ideas while observing the space from human and machine perspective. And how did this perspective have been assisted or been a challenge during design process. Moreover, their designed ideas / sketches were used for further analysis.



A Question & Answer booklet for filled by 17 design students after phase two of the experiment finished

5.3.5 Findings

During the analysis of the students' feedback from their individual booklet, it showed that students got adapted to this kind of ideation process quickly. Some of them had aid from AI in terms of gaining new knowledge about the context.

P6 — "The AI phase showed me emphasis on certain elements, that gave me new inspiration"

P14 — With AI vision machine could make relations between things that could have been ignored by a human observer.

P5 — "It is needed to gain knowledge of the context in the first phase of the experiment so you can really solve the problem adequately."

While for some designers the machine perspective was an aid to focus on the small information and patterns that they can relate. But at the same time, it was a struggle to ideate due to smaller number of object categories showed by machine learning output. Also, according to some students, the categories were not helping that much to achieve the design goal.

P8 — "The AI perspective emphasize designer's focus on certain element to gain data from machine perspective and inspire new ideas".

P12 "AI provided me with focus point, as it showed patterns. However, as the different recognized objects were limited, it did not really be new insight as such."

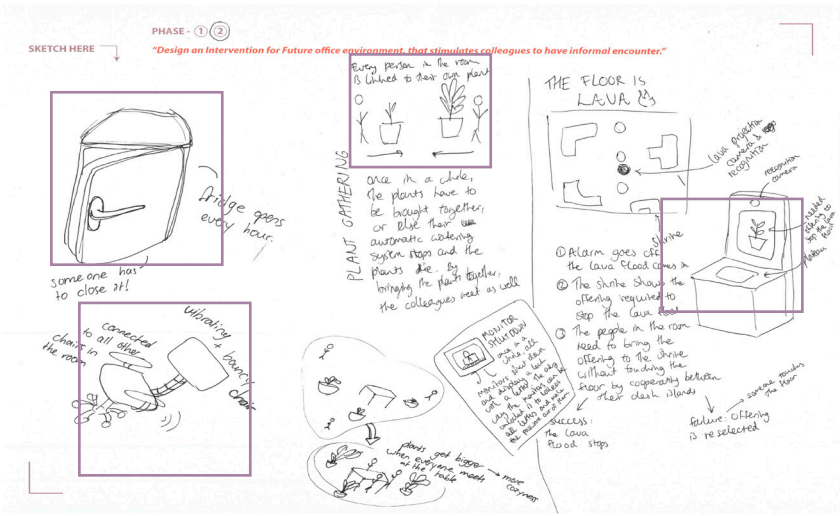
P5 —It gave me some contextual information. However, if AI only gave me the word, it detected then it would have taught the context is a house and not an office.

5.3.6 Conclusion

Some preliminary findings showed that design students were quite intrigue by the idea of embed machine perspective into their data collection process. The responses explained that, the labels showed by machine vision were diverging their idea generation process. However, due to limitation with the current prototype and small number of labels appearing on the video, it was struggle for some of them to follow the design process.

5.3.7 Limitations

The findings explained in this chapter were the preliminary result from the designers feedback given in the booklet. Due to time constraint and resources, designers sketches were not thoroughly analyzed. However on overview, it seems that, a machine perspective or object labels took designers attention and pursue them to think of vivid ideas.



One of the sketch from the study where 3 design students use some of the most appearing AI labels and also bias labels during their idea generation process

Chapter 6

Discussion

Detach from presumption

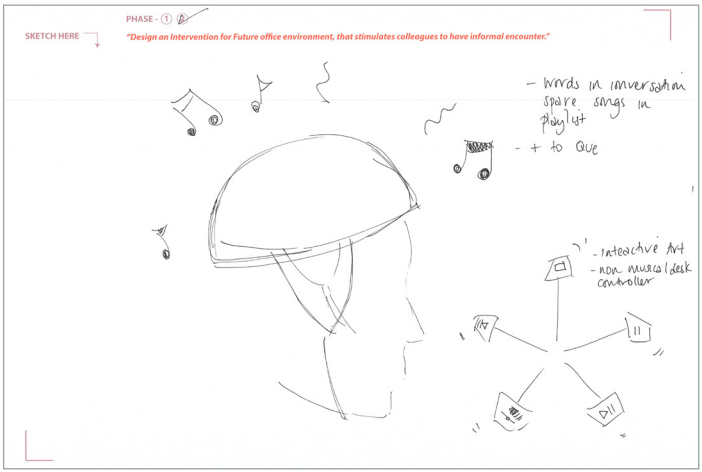
Designers mentioned that, during the experiments, AI perspective disengages their thoughts from their own presumption about human nature. It drives their focus towards small contextual information which they can use in their idea generation.

> ***P4 -Experiment 2 : "..the fact that everything is equal (in AI perspective), it allows you to observe things in a different way. You are not attaching any notion or pre-assumption while ideating."***

Diverging towards different ideas

Mis-detection of an object intrigue designers' thoughts to use it for their ideas. For example, in one of the shot AI algorithms mislabeled shelf as a refrigerator. However, this mislabeled trigger an idea to use refrigerator as medium to have informal encounter.

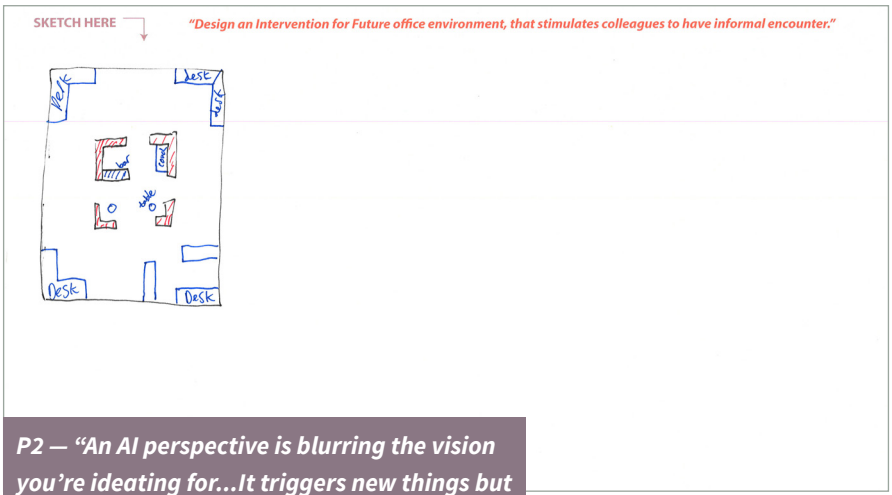
"Though few labels were not right, it triggers the ideas" for example one of the mislabel is helmet, however designer used the label to come up with an idea.



Even while some of the labels were quite wrong, it took attention of the designers towards that object. Through this kind of mis detection of an object, designer diverges towards unique design concepts to create human-product interaction.

Too random labels were not useful for the idea generation

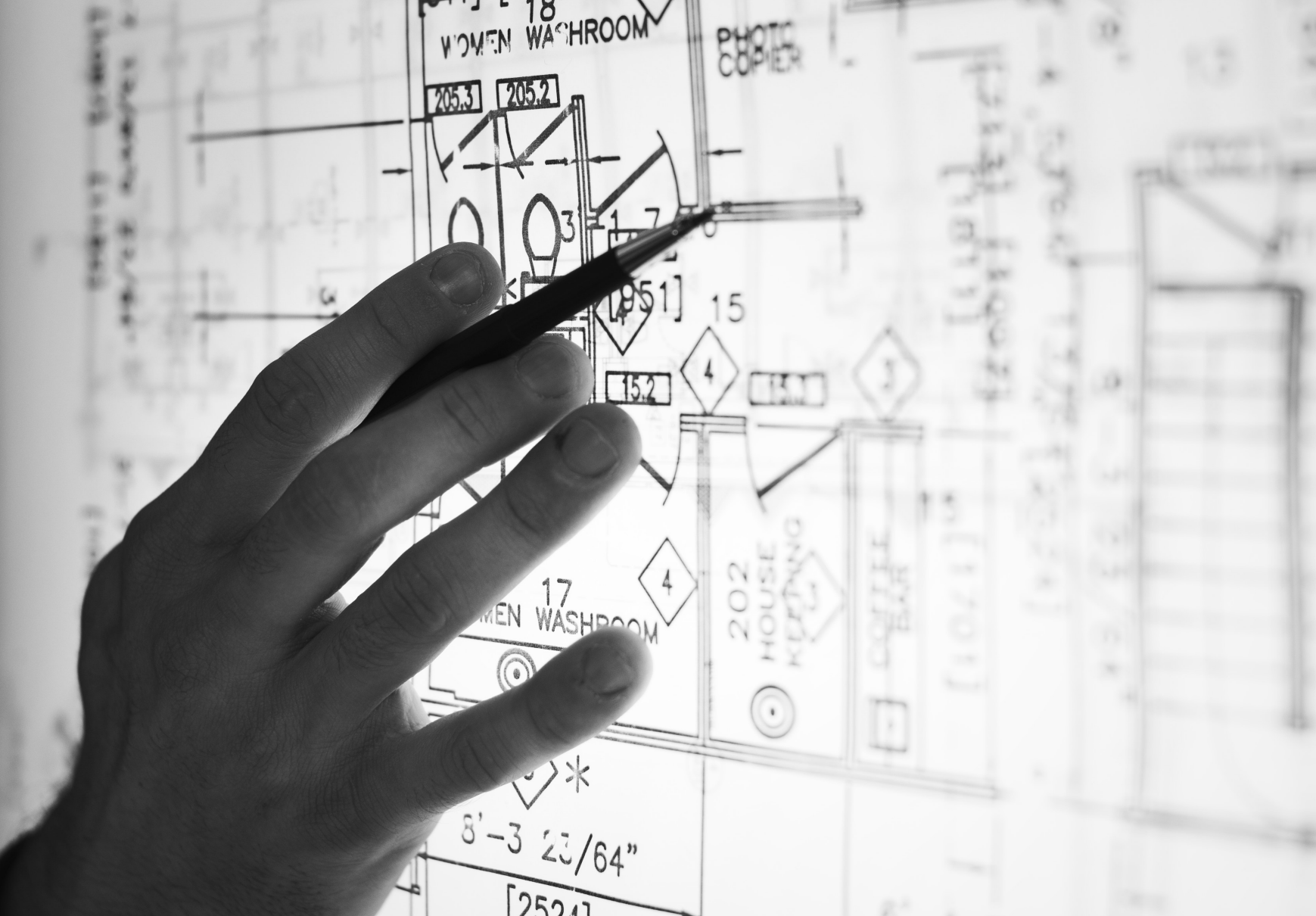
For a few designers' false labels (e.g. satellite instead of Lamp) were not so useful. They lost in their goal of ideation. According to their response, the labels do not have any meaning or usefulness to use it in my idea generation process. This particular case mostly happened in phase 2.



P2 — "An AI perspective is blurring the vision you're ideating for...It triggers new things but also blocking my thoughts in some way."

6.6.1 Conclusion

From the perspective of an AI designer a correlation of new interaction between human and objects that were situated in the same context. The perspective of AI disengages their thought processes from previous assumptions and make them think about new interaction ideas. False labels (biases) allow designers to diverge their thoughts towards creative idea generation. It seems that the if the false labels are too vague and/or are too many at once, it breaks the barrier of igniting the thoughts and designer loose that intrigue moment during idea generation.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Chapter 7

Recommendations: Development Of ObjectResponder 2.0 As A Design Toolkit

From the findings and designers feedback on the process of designing from non - human perspective, a set of recommendations were made for the next version of the ObjectResponder. This recommendation meant to be further develop and research in future.

Recommendations: Development Of ObjectResponder 2.0 As A Design Toolkit

7.1 Context based Machine Perspective.

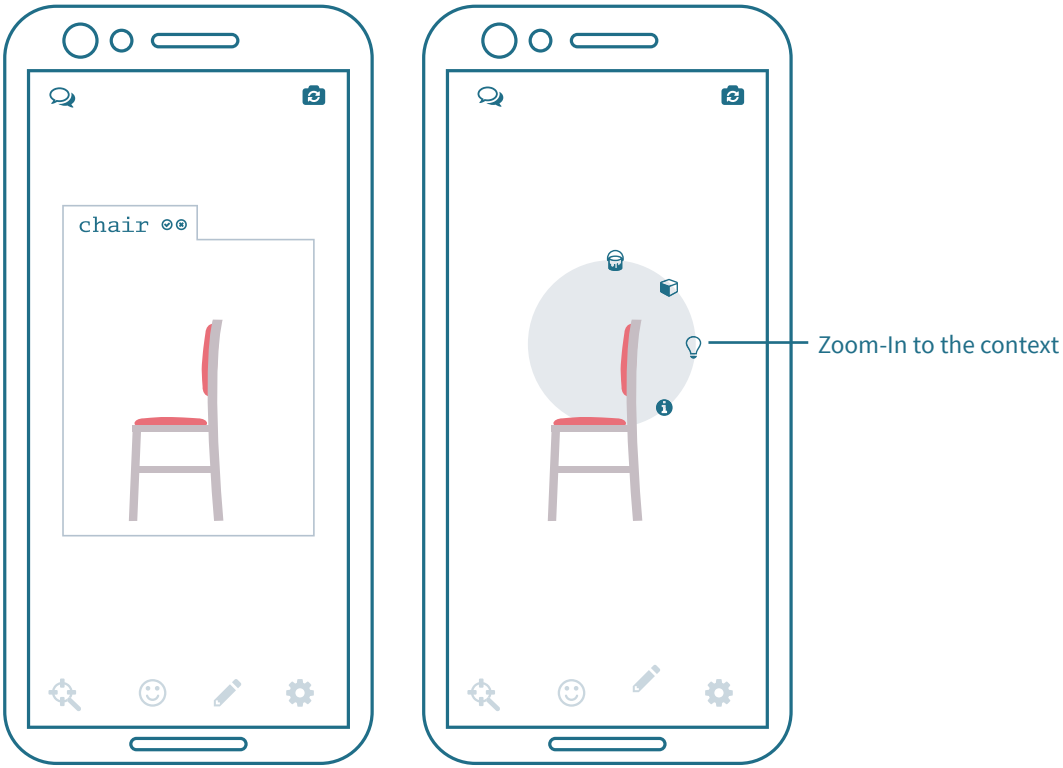
According and insights, we've seen that whenever a certain object category appear, it ignited an idea. For example, a detected object - Potted Plant enable a designer to make office workspace greener. This could be possible if particular machine learning model is trained according to context or problem. For example —

- Environment based Model: In this mode, AI will focus on objects or insights which are related to environmental issues or benefit. e.g. Plastic, Potted plants

- Social Interaction based Model: In this mode AI will focus on the objects which are uses in social settings. e.g. a relaxing couch, Party Lights, Food and Beverages.

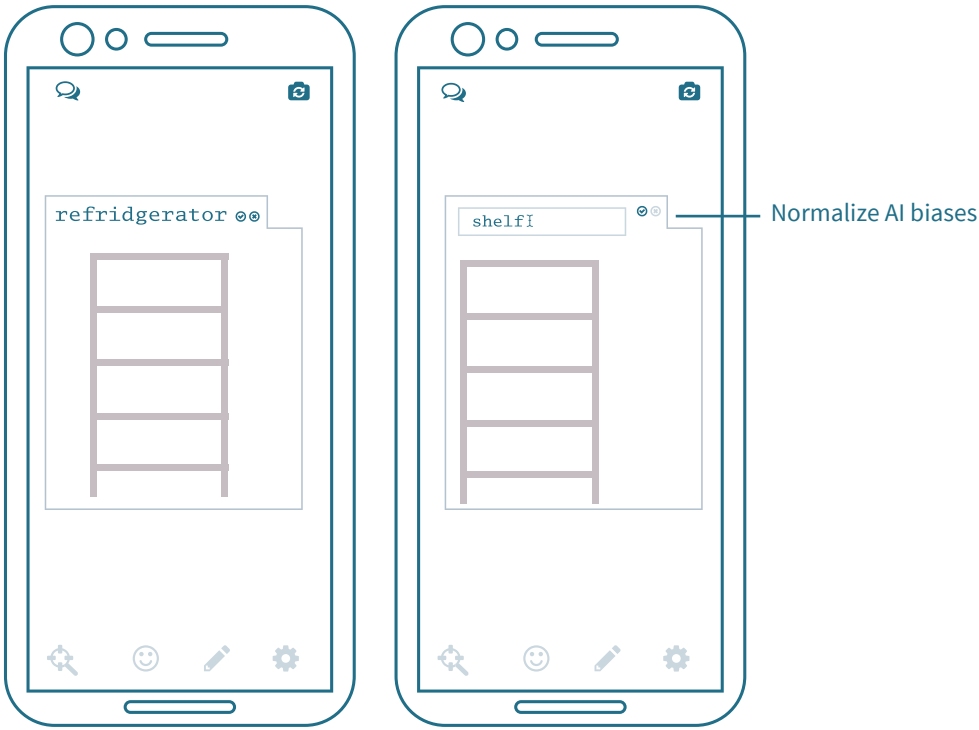
7.2. Zoom-In to the context

Clicking on each object labels shows more information about the object's material and alternative according to it shapes, color. This could enable designer to diverge into more creative object-based ideas and context. For example, when machine identify chair situated in the context, designer can see more details about shape and color more information about object and recommendation. Then the designer can recommend different ideas of chair



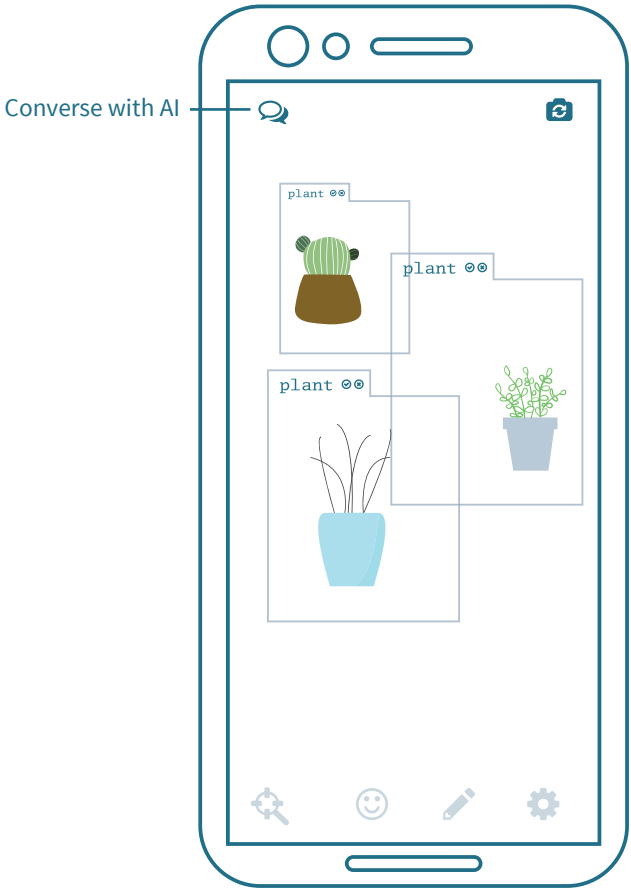
7.3. Normalize AI's biases

The biased labels appearing on the screen sometimes encourage designer to correct the machine learning model. This can also let designers create and train their own machine learning model based on their own creative perspective. For example, if a computer vision algorithm identifies shelf as a 'Refrigerator' then designer can correct it on the spot or give some creative label for future idea generation.



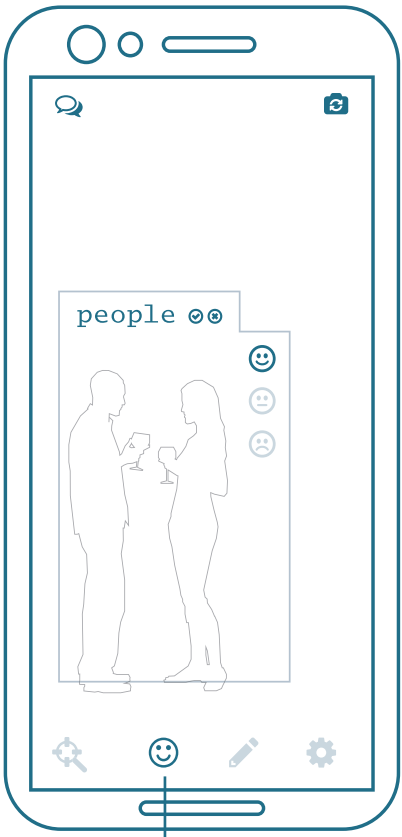
7.4. Converse with AI

To create a feedback loop between human designer and AI design partner, a sophisticated voice interface is required. This voice interface should able to accept command like ‘how many plants are in the room’. The tool will keep counting the plant object identified in the room and give an output. This could be useful when designers are using head mounted display together with machine perspective.



7.5. Incorporate Basic Human emotions

Although current AI is not advanced enough to justify human emotion, but in future it can be possible that we can add some emotion recognition abilities (Tired, Bored, Excited, Happy, Sad). It can detect certain emotions of a human and suggest ideas. For example, while contextual inquiry of an office space, a machine vision identifies that people seems stressed then it can propose designer to design object / service that can influence that particular emotion.



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