BrainstorML

Exploring the applications of Artificial Intelligence in Interaction Design

by Stefania La Vattiata

This research study was approved by the Institutional Review Board at Carnegie Mellon University.
IRB ID: STUDY2020_00000362

Received the kynamatrix Research Network “Innovation through Collaboration” 2021 Grant Awards for projects in design, engineering, and computer science.

BrainstorML

Exploring the applications of Artificial Intelligence in Interaction Design

A thesis submitted to the School of Design, Carnegie Mellon University, for the degree of Master of Design in Design for Interactions

Stefania La Vattiata, Author — May 18, 2021
Graduate Student

Kyuha Shim, Advisor — May 18, 2021
Assistant Professor

Acknowledgements

I want to thank my advisor, Kyuha Shim, for his support and always insightful feedback. His ideas and guidance were essential for the successful development of this process. Thank you for being so encouraging and challenge my ideas to help me grow and understand better the purpose and scope of my thesis.

I want to thank my husband, Kin, who provided valuable knowledge and skills for the brainstorming ideas and prototype making. Thank you for cheering me to pursue this masters. This wouldn't have happened without your immense support.

Many thanks to Anuprita for your reassuring messages, lending me an ear, and providing me with energy and confidence through this process.

Finally, I want to thank my classmates and faculty members for their valuable feedback, assistance, and direction. You are all an indispensable part of this process, and I am truly grateful.

Table of Contents

Abstract

Artificial Intelligence (AI) has impacted various aspects of our lives and provided ubiquitous and efficient information using algorithm-based products and services (through calculation, recognition, classification of data). Although it has been widely applied in everyday interactions, unlike engineers, designers can rarely integrate it into their design processes, primarily due to technical barriers, the lack of knowledge in computer science and statistics. Therefore, this research examines different AI-powered platforms and Machine Learning algorithms to identify the current use of AI in Design or by designers.

This research uses case studies and interviews to explore the opportunities in the Interaction Design process that avail from Machine Learning integration. It proposes a new application obtained from the research to enhance the affinity mapping process to allow for first pattern discovery in the ideas collection and enable the labeling of those groups.

I hypothesize that the applications of AI and ML can assist designers throughout their processes and provide the first step towards the generation of creative concepts. They could automate repetitive and tedious tasks that are time-consuming, like ethnographic research transcription, that do not require creative aptitudes. And potentially have computational assistance to augment their vision with diverse interactions, allowing for inventiveness to ignite new thinking, frameworks, tools, systems, and experiences.

Important Terms

Artificial Intelligence
The theory and development of computer systems able to perform tasks that normally require human intelligence. (Nucera & Onuoha, 2020)

Machine Learning
A branch of artificial intelligence in which a computer generates rules and predictions based on raw data that has been fed into it. (Nucera & Onuoha, 2020)

Natural Language Processing (NLP)
A branch of artificial intelligence that gives the machines the ability to read, understand and derive meaning from human languages. (Yse, 2019)

Generative Adversarial Networks (GAN)
GANs are a Machine Learning model that use two neural networks, one to generate instances of data like images, and the other that evaluates if that data can pass as real data. (Goodfellow et al., 2014)

Word Embeddings
A word embedding is a learned representation for text where words that have the same meaning have a similar representation. (Brownlee, 2019)

Semantic Analysis
The process of drawing meaning from text. It allows computers to understand and interpret sentences by analyzing their grammatical structure, and identifying relationships between individual words in a particular context. (Wolff, 2020)

Global Vectors for Word Representation (GloVe)
GloVe is an unsupervised learning algorithm for obtaining vector representations for words, a.k.a word embeddings. (Pennington, Socher, & Manning, 2014)

t-distributed Stochastic Neighbor Embedding (t-SNE)
The t-SNE is a method for dimensionality reduction, used mainly for visualization of data in 2D and 3D maps. (Van der Maaten & Hinton, 2008)

Google Home Mini - Speech Recognition.
Photo taken by Nathana Rebouças, 2020

Introduction

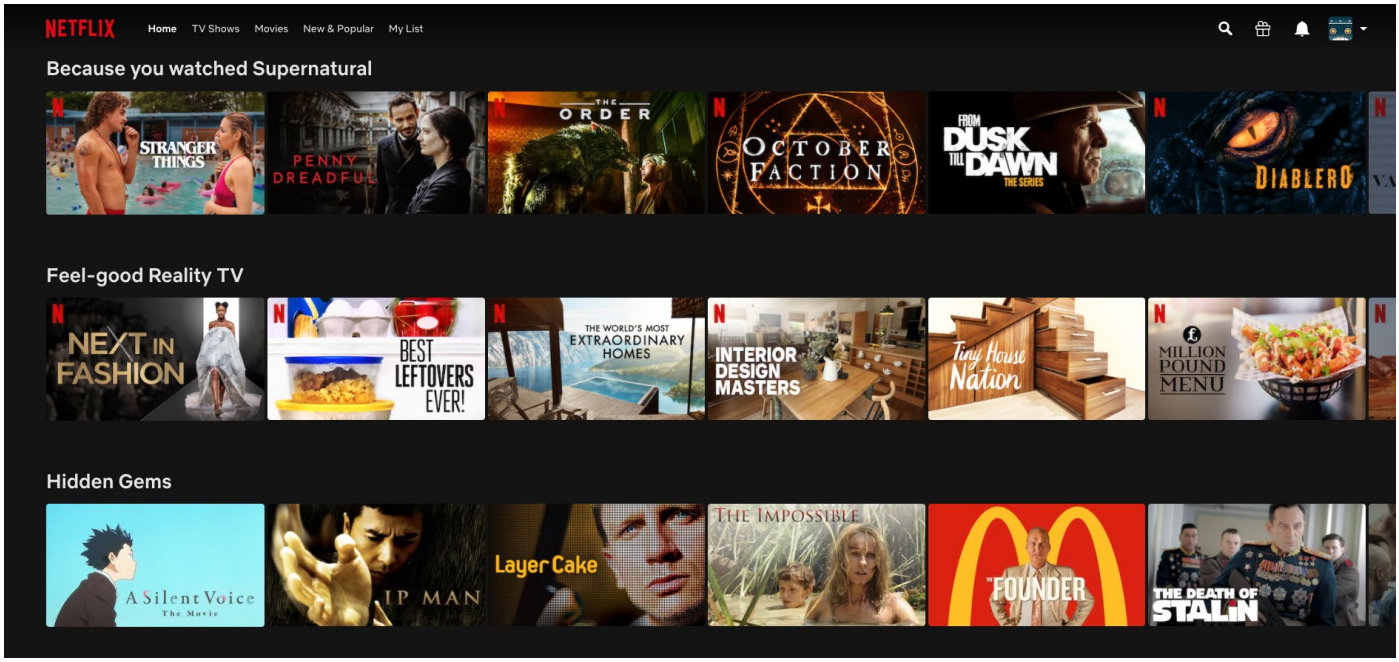
AI is the new electricity - Andrew Ng

Just as electricity changed the world a century ago, AI is now taking the role of revolutionizing every single aspect of our lives. AI is allowing people to review their emails without spam, having personalized playlists in Spotify, and movies on Netflix based on the user's preferences. Alternatively, ask for anything just by saying: "Hey, Google/Siri." Moreover, like electricity at its time, AI is changing every industry. According to a Gartner survey last year, 39% of the companies across all sectors surveyed have implemented AI in some form, creating a 270% percent increase since 2015 (Costello, 2019).

Artificial Intelligence is a buzzword that everyone is associating with the future, and that it will solve every single problem. However, the truth is, AI is not a new concept. The field was first explored in 1956 by the Dartmouth Summer Research Project, and it has been around since then, making it over 60 years since it first started. Furthermore, although it is the new electricity and has been around for a while, it is not nearly as omnipotent as most people think (Donfro, 2019).

Right now, most of what is called AI is Machine Learning (Jewell, 2019). Machine Learning is a sub-set of Artificial Intelligence that studies algorithms that provide computers the ability to learn and make decisions without being directly programmed to do so. Like when a user watches a video on Youtube, the ML algorithm of recommendation runs patterns of that watched video and provides

Netflix Browse Page
The ML algorithm suggests contents to the user based on previous watched series and movies.



a new recommended video. Machine Learning (ML) is creating a revolution into automation and solving complex problems in fractions of time and creating new opportunities and challenges for everyone, including designers.

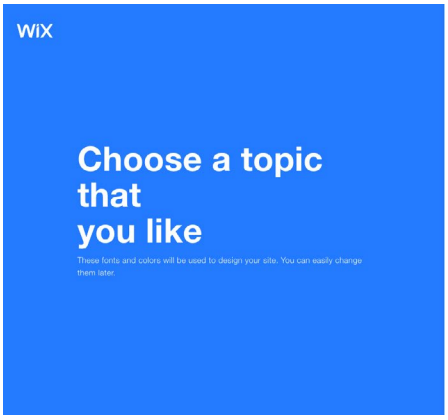
Today, there are numerous examples of AI-generated art (Cascone, 2017) and user-customized de-signs in minutes, as the Wix ADI websites. So, even the creative fields are a˙ected by this new technology. With all of this automation, it is reasonable to have worries about being substituted by a machine, like the Wall Street stock and bond traders replaced by AI algorithms (Kelly, 2019). And designers are not the exception.

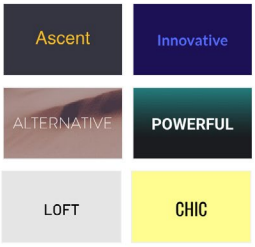
Nevertheless, might AI replace designers? There are current debates that position people on one side where it will not happen, and the other side that AI will replace the designers from the present, and the Design field will have to evolve to adapt to the new technologies. I agree with the latter; instead of looking at Artificial Intelligence and Machine Learning as a threat, designers can take advantage of these new technologies to improve their practices.

As IBM CEO Ginni Rometty mentioned, “if I considered the initials AI, I would have preferred augmented intelligence.” (Fritschle, 2019) AI can support designers to take care of the tedious and mechanic tasks like product search, and allow them to focus on the creative part instead. Alternatively, AI could compute all the variables in a very complicated situation like a wicked problem and create opportunities for designers to improve their imaginative capabilities and make well-informed decisions when discussing Design.

However, Design is a field that breaks up in many domains. So, I will be focusing on Interaction Design (IxD) and its practice. While there is no commonly agreed definition of interaction design, its core is to develop digital artifact, products, services, and spaces with particular attention given to the qualities of the user experience (Fallman, 2008).

Wix ADI (Artificial Design Intelligence)
An AI-based tool from Wix that creates a tailored website page for the user based on a few questions.



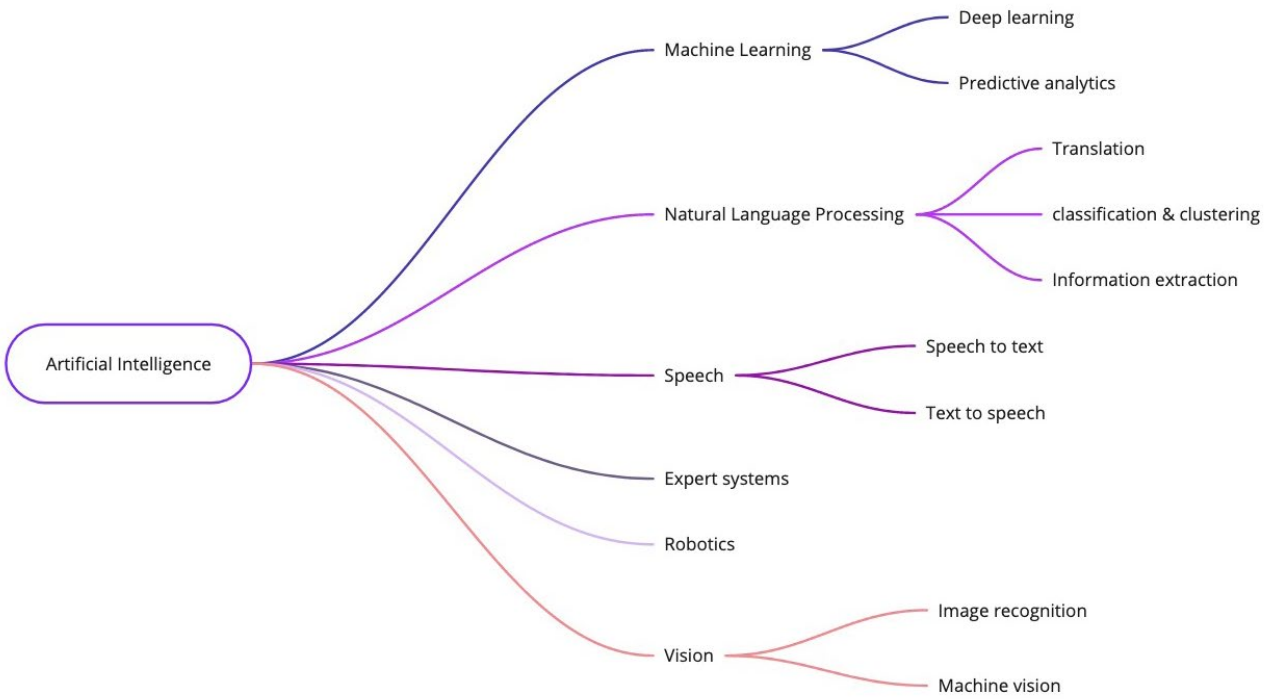


Interaction design intends to create products that enable the user to achieve their objective(s) in the best way possible. As an Interaction Designer myself, I see this purpose as something that can be achieved better with supporting technology. That is why the significance of the research is personal and suitable to my work.

Furthermore, AI is a concept that will not leave the scene for a while, so the field of Interaction Design should adapt to these new opportunities and challenges. Designers are currently following this trend, yet they are unprepared to e˙ectively leverage ML capabilities, even though many understand how ML works generally (Yang, Scuito, Zimmerman, Forlizzi, & Steinfeld, 2018). AI and ML should be part of the new Design materials repertoire to provide designers ways to apply this technology.

Finally, the comprehension of AI applications is crucial to the proper application of these technolo-gies in the context of the Interaction Design practice stages. Therefore, creating an opportunity to bridge the knowledge gap between designers and the complexity of Artificial Intelligence is essential. Like understanding which sub-fields of AI apply to certain cases. Moreover, identifying and unpacking opportunities that AI yields for the interaction design practice, where opportunities for adaptability and collaboration with AI experts can provide designers with tools and skills to work in this new digital revolution.

Artificial Intelligence sub fields
This diagram breaks down some of the most important sub fields of AI and their applications. This diagram was inspired by "The role of Artificial Intelligence in future technology" research from Amr Kayid, 2020.



Research Question

With the idea of AI integration with Interaction Design, I pose the following research question:

How can interactions with Artificial Intelligence and Machine Learning be leveraged to improve the Interaction Design processes and augment the designer's abilities?

I'll break down this question into two parts. The first one, which is interactions with AI and ML, refers to the interventions, applications that already exist that are integrating these fields with Design, and designers could leverage to assist their practice.

The second part, which talks about Interaction Design processes, refers to the activities in the Design stages that designers engage with, that could be opportunities for AI/ML integration and provide assistance or enhance certain aspects of the methods.

RunwayML library
This image presents some example of the Machine Learning models available for artists and creators in the RunwayML website.

Remove background from objects

Image/Video

Upscale Images by 2x, 3x & 4x

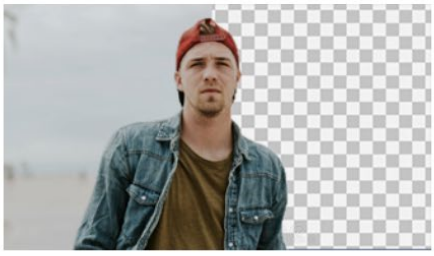
Image/Video

Estimate Depth

Image/Video

Colorize Images and Videos

Image/Video



Remove background from people

Image/Video

Transform Day to Night

Image/Video

Scope

The main focus of this research is two-fold. First, explore di˙erent AI-driven applications that exemplify the use of Machine Learning models in simple tasks like voice-to-text transcription or image categoriza-tion. And allow for designers to reduce time-consuming tasks and take advantage of di˙erent interactions to discover and prototype real-time feedback with users. The latter refers to a case study where the setting was a live Zoom meeting in a reflective origami-folding session.

Second, explore the integration of ML models into a web-based tool that could enhance one Design method (Aÿnity Mapping) for generative research, to understand the creative potential of AI and Interaction Design integration. This last exploration stems from the user study insights and personal motivation to discover patterns in the automated clustering in the Affinity Mapping method, where qualitative data is analyzed to get insights and categories from it. I kept the context of this integration closely to Machine Learning (AI subset) due to its importance for UX practitioners (Yang et al., 2018).

Finally, ethics and value-sensitive design principles are critical in the context of Artificial Intelligence, and researchers have established principles (Pichai, 2018). I acknowledge the importance of the topics; however, the way I incorporate machine learning in the design process does not use big data of human subjects to raise such issues. For example, the participants in one of my case studies either use the images/photos of their own as data to train custom models to be implemented in their work or incorporate a computational linguistic dictionary.

For these reasons, I will not focus on the topic in my research. However, I understand its significance and will regard it as a continuation of my study.

Design Process

Based on my research question, how can interactions with AI and ML be leveraged to improve the IxD processes and augment the designer's abilities? I decided to connect two approaches through the double diamond framework (Design Council, 2019), the research for Design and research by Design.

Research for Design

During the Discover and Define of the double diamond framework for innovation, I used Research for Design. This approach is specific to answering the second part of the research question, referring to the Interaction Design processes that professionals encounter and can employ ML integration.

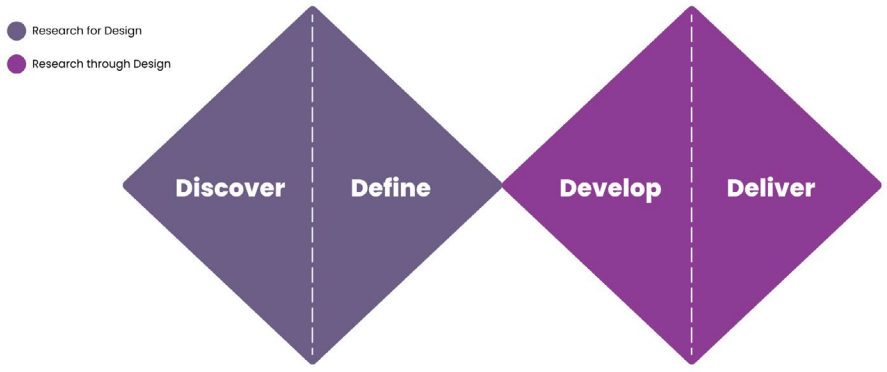
I did user interviews for the Discover phase focusing on understanding the pain points of designers through their process and looking for ML integration opportunities. For the Define phase, I synthesized the information from the interviews, preparing the groundwork for the next stage. I used content anal-ysis with AI-driven platforms to identify themes and patterns from the user research that resulted in meaningful insights.

Research through Design

For the Develop and Deliver phase, the ideation and prototyping activities were part of the Research through Design approach. This approach covers the first part of the research question, referring to the interventions and tools that use ML-driven applications that Design can leverage.

I explored two different projects to examine the feasibility of ML and IxD integration. In both, I reflected on the value of the used ML-driven technology as a new Design material. Thinking on the ease of learning it and how much it can assist designers with a particular task, or if it opens new possibilities of interaction. Through these projects, I focused on the development component of the design concepts created.

Double Diamond Diagram
This is the process I followed for my research.



This person doesn't exist - GAN, Model by Karras et al., 2019

Exploratory Research

For the exploratory research, I did a literature and artifact review focusing on Artificial Intelligence and Design, exploring first AI as a general foundation to dive deep into Machine Learning applications for Interaction Design after. Additionally, I did ethnographic research with professional interaction designers to understand their pain points during the design process and look for potential optimization opportunities in their activity.

Literature Review

For the literature review, I read numerous articles, books, and case studies that integrated Artificial Intelligence with Design to some extent. These helped me understand the problem space, learn the various AI tools, find possible opportunities, analyze valuable frameworks, and focus on the feasibility of applying Machine Learning to Interaction Design processes.

The following literature review is structured as follows; the first section focuses on AI Driven-Design, and the building blocks to comprehend its significance and implementation principles. The second section centers on Machine Learning as a Design material and its applications to Design, probing for di erent opportunities and questions about its efficiency.

Artificial Intelligence-Driven Design foundation and guidelines for implementation

AI Driven-Design by Joël van Bodegraven

In this e-book, the author, with guest contributors, analyzes how AI is already affecting UX design by giving examples and exploring opportunities for enhancing the creative fields. Additionally, it presents a non-technical overview of Machine Learning and how Design affords qualitative data for the model to be trained accurately, providing relevance to the biases, privacy, and other consequential ethical issues that AI can bring when applied in an experience. This reading was valuable to my research because it summarizes four main aspects of how Design could benefit from AI by being creative support, curator, pattern creator, and enabler of creativity.

This person doesn't exist

The images shown in the cover for this section are from a page called "This person doesn't exist", they show pictures of people that indeed do not exist, but instead are generated by a Machine Learning model called GAN, which means Generative Adversarial Network. The model used for this webpage is the StyleGAN2, and it was trained with a dataset of millions of images to generate the most accurate portraits of people, as you can see in the image. The most interesting part of GANs is the generative component, that can create images from a dataset or adapt images to a particular artistic style.

From these opportunities, the one that interested me the most was the assistance role that AI can play to designers; the author mentions: “creativity still remains very much a human endeavor. However, AI can do some legwork to enable us to get up to speed. Looking at the framework of human and machine, AI can function as an assistant. It can help with research, collecting data, or more creative tasks.” (Van Bodegraven, 2019).

The last of the options, the enabling creativity potential, is also fascinating, but from the examples that he shares and some of the ones I have tried myself*, this is still a long-shot.

Guidelines for Human-AI Interaction by Saleema Amershi et al.

This article from the Microsoft team presents eighteen general guidelines for human-AI interaction, breaking them down along the technology implementation process (Initially, During the interaction, When wrong, Over time). These guidelines are used and tested in different AI-infused interfaces, scenarios, and products. They prove their relevance through this test, giving the interaction designers a resource to harness AI’s advantages in the best way possible.

In the AI-Driven Design book, Jöel summarizes five basic principles for AI-infused Design; nonetheless, this study gives an in-depth breakdown of the purpose of each of the guidelines and their importance to the user through each interaction stage. Apart from the most apparent guidelines about intuitive interfaces, transparency, and wrongdoing correction, the principles that I want to focus on are the “Over time” ones. These describe the design system learning from the user (G13), its cautious adaptability (G14), and user encouraged feedback (G15), among others.

Since my research centers on Machine Learning for Interaction Design, these guidelines exemplify the best way to ensure the trained model I create, adjusts to the user’s needs based on the feedback provided and presents the user with a reliable, understandable, and engaging AI-infused experience.

Please refer to the artifact review

People's Guide to AI by Mimi Onuoha and Diana Nucera

In this booklet, the authors explain the basics of AI and its most prominent applications in a participative and straightforward way. They focus too on Machine Learning and its function and examples in a general way. The booklet's overarching idea is the impact of these technologies on society, equity, diversity, and the agency we have on them.

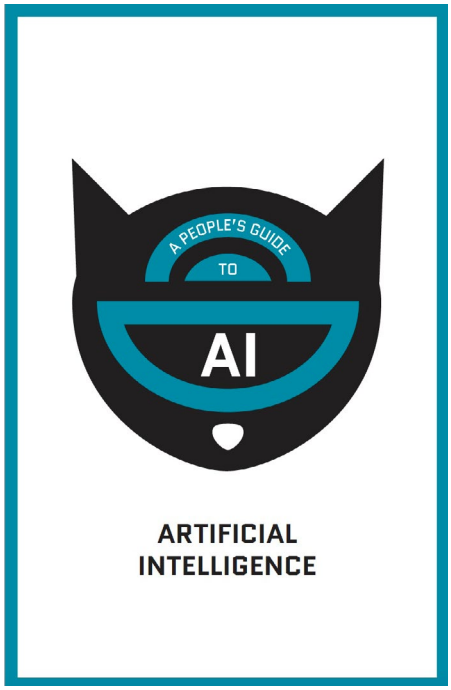
This is an accessible resource for people not knowledgeable in the subject, filling the gaps in AI and ML information and providing simple exercises to demystify these technologies.

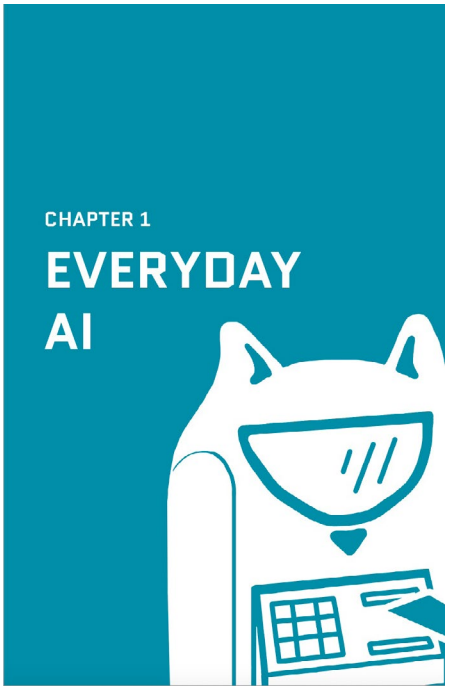
The authors reference Pamela McCorduck's book and James Boggs's work to analyze the paradigm shift that technology has brought upon humanity.

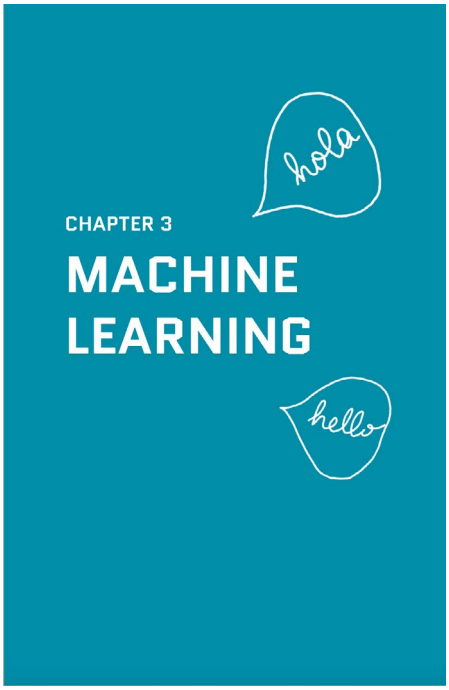
"James Boggs' writing from the 1960s is proof that conversations about work, automation, and jobs being taken over by machines have been happening for decades." (Nucera & Onuoha, 2020, p.70).

This insight brings the question from this research introduction, of whether AI and ML will replace designers? And it's remarkable to think that even though there is the possibility, we need to enhance our understanding of these technologies and adapt our skills accordingly to avoid feeling worthless.

Booklet Cover and chapters
These illustrations from the People's Guide to AI cover and chapters make a basic example of the content, like the ATM and the translation applications.





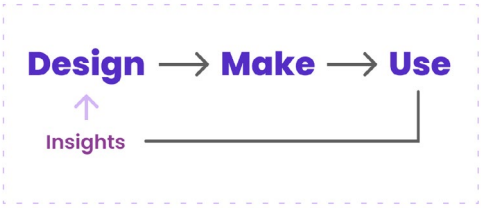


Interactive Design Process Based on Augmented Intelligence by Chin-Yi Cheng

Following the thread of AI replacing human creativity, Chin-Yi Cheng explores a framework and creates a toolkit for designers to interact and collaborate with AI algorithms through her thesis. She highlights how AI generates solutions, and designers only select from the given output without having too much agency over the system.

Although her approach is remarkable and provides several examples of her toolkit applied to various models, it is essential to consider that her thesis stems from Architecture and all her applications are about physical structures. Yet, the seven-step framework is what I found more valuable from her proposal. It focuses on providing the designer the appropriate interface parameters to interact and collaborate with the system, including interruption and feedback interactions. Her framework is the applied case of the human-AI guidelines in Architecture, providing me with the concept of integrating both in the Interaction Design field.

Traditional HCD approach
Design Practice in the Context of Traditional Human-Intensive Operating Models - by Roberto Verganti et al.

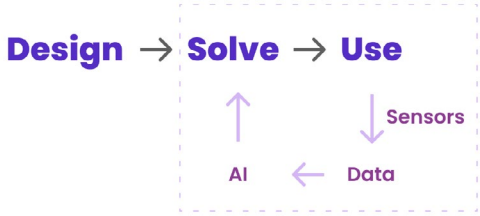


Innovation and Design in the Age of Artificial Intelligence by Roberto Verganti et al.

The authors explain that AI is inherently a decision-making technology. It offers opportunities to automate many tasks relating to learning and devising solutions (Verganti et al., 2020, p. 213), bringing particular interest in how AI affects Design practice, the principles of Design, and the theory of Design innovation.

Through many examples about AI applied to Design processes and vice versa, the authors bring two crucial points that need focus. One of them is that traditional methods, based on HCD (Human-Centered Design) are not enough when playing with AI as Design material. The learning of this technology works differently, and designers are not educated in thinking how elementary tasks, once replicated time and time again, can autonomously provide extremely complex solutions to users (Verganti et al., 2020, p. 221).

AI-driven Design approach
Design Practice in the Context of AI Factories by Roberto Verganti et al.



The second point, and something I was focusing on during my research, was that problem finding is the focus now and that humans are the best to provide those loops for AI to solve. That is now the creative value we provide for the technology. We can't solve problems as quickly as the computers, but we can offer the potential intricacies that need solutions from those data iterations.

Machine Learning as a Design Material

Machine Learning for Designers by Patrick Hebron

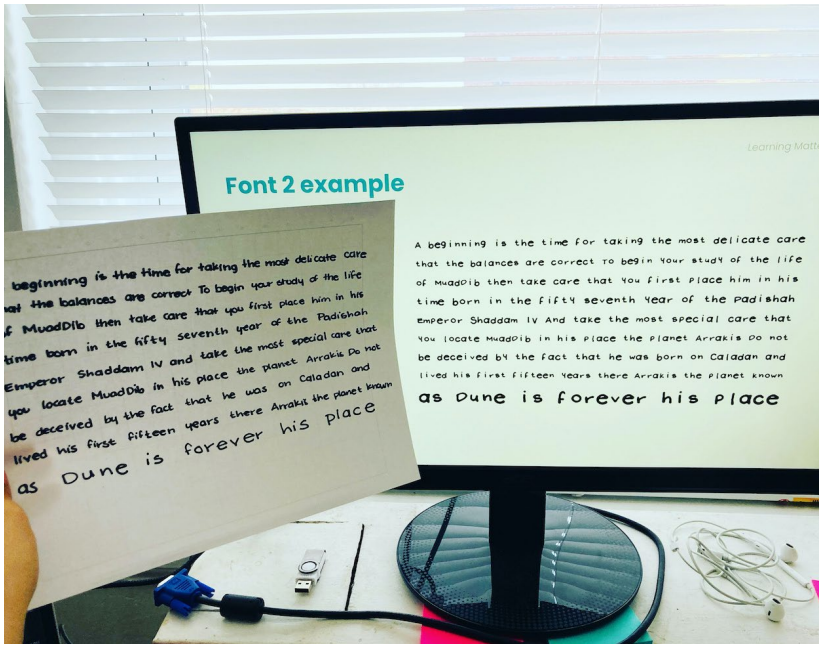
In this book, the author summarizes Machine Learning for non-technical users, giving analogies to how Machine Learning works and how it is applied in real-world scenarios. It explains how ML should be used when there is no viable conventional approach due to the algorithms' simplicity and how it can solve everything, as some would think.

"while machine learning systems can be taught to perform simple tasks such as arithmetic operations, as a general rule of thumb, you should only take a machine learning approach to a given problem if no viable conventional approach exists." (Hebron, P., 2016, p.6)

The most important part of this book regarding my research, is the chapter on Enhancing Design with ML. The author explains three main topics that could benefit Design, like Multimodal input (visual, aural, corporeal, and environmental), creating dialogue, and building blocks. This chapter examines some of these opportunities in Design, which can be achieved with ML tools. It does point out that designers need to have a basic understanding of coding skills to work properly with ML models freely.

"As machine learning continues to make a wider variety of media understandable to the computer, designers should begin to employ multimodal forms of human-computer interaction, allowing users to convey ideas through the optimal means of communication for a given task" (Hebron, P., 2016, p.25).

ML created typeface
This image shows the typeface created with a Machine Learning model called Conditional Variational Auto-encoder, using my personal handwriting as a dataset.



UX Design Innovation by Graham Dove et al.

In this paper, the authors explore UX Design's challenges when incorporating Machine Learning (ML) as a material. The research is through a survey in which the participants are asked to explain their experiences while dealing with ML projects, which challenges were presented, and any previous ML introduction during their UX Design Education.

From the survey, the main insights about ML as a Design Material were that designers lack a specific understanding of what ML can and can't do.

- There is a high-level comprehension of how ML works but is unclear how they might use it and apply it in UX Design. Additionally, the ML education in Design practices is wanting and not very specific to allow for UX Design and ML integration.
- The second finding was prototyping complications with ML since there are no tools available for designers (then) that can portray the data dynamism that the algorithms work with.
- Finally, there are some ethical questions and concerns about how ML works since most UX designers treat it as a black box and can't tell the real purpose and intention of the ML application.

These insights are valuable, and they back up the idea of designers being precluded from AI or ML enough to avoid applying it in their own process.

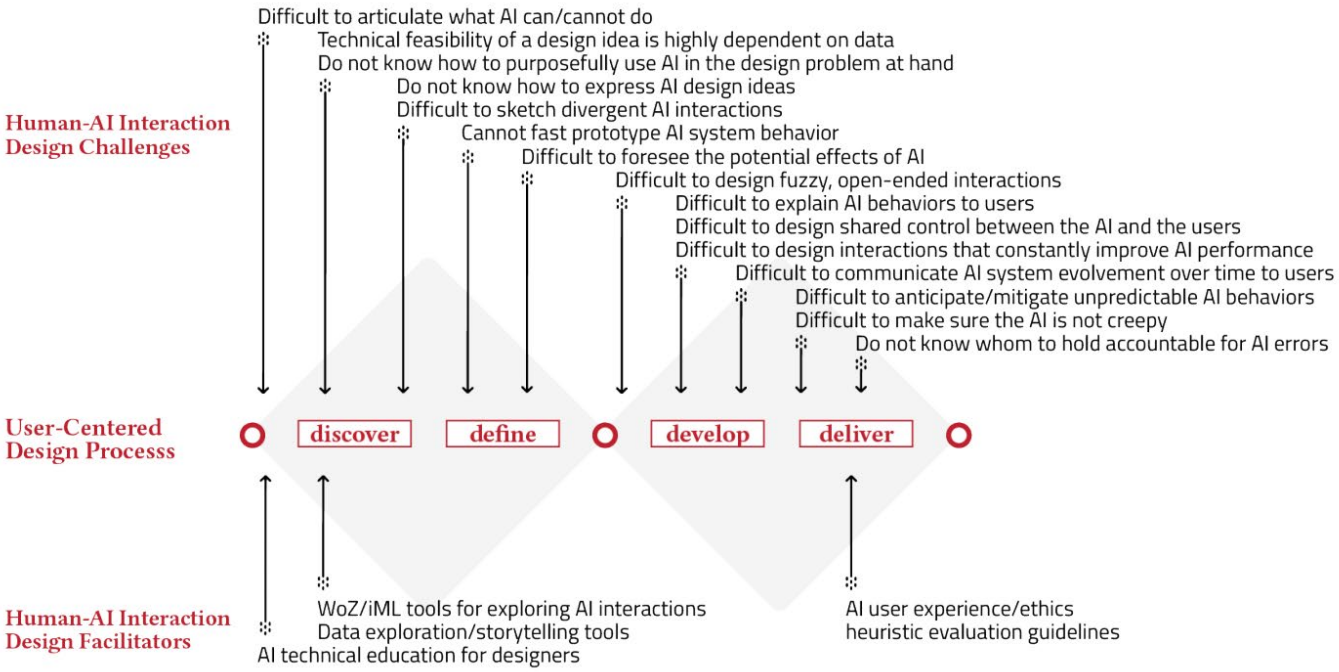
Re-examining Whether, Why, and How Human-AI Interaction Is Uniquely Difficult to Design by Qian Yang et al.

This paper explains the UX Design challenges of AI found in the innovation process. These challenges refer to the difficulties of understanding AI capabilities and the problems in envisioning implementable AI technology for a given UX problem, which derives from the lack of knowledge of the AI capacities. Additionally, there are challenges in iterative prototyping and testing human-AI interaction due to the lack of tools and resources (e.g., time to learn and train the models).

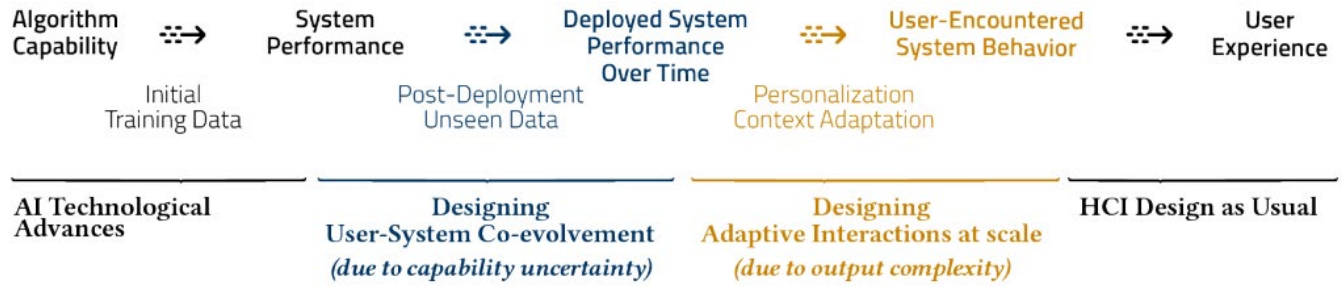
Another critical challenge refers to the crafting of thoughtful interactions that match the previous problems mentioned—referring to the unpredictable outputs of AI and its societal and ethical impact.

The authors pinpoint these challenges to propose facilitation of Human-AI Interaction Design. With these proposals, there is a framework that is the one I'll be using for my UX-ML project implementations. It focuses on understanding the AI's capability at a basic level (challenge one), then designing a user-system co-evolvement that provides solutions to the second and third challenges by understanding the UX problem and prototyping in collaboration with the user. Finally, creating adaptive interactions that craft thoughtful interactions based on the user's feedback resolves the last challenge.

Human-AI design challenges
Mapping the human-AI interaction design challenges onto a user-centered design process - by Yang, et al.



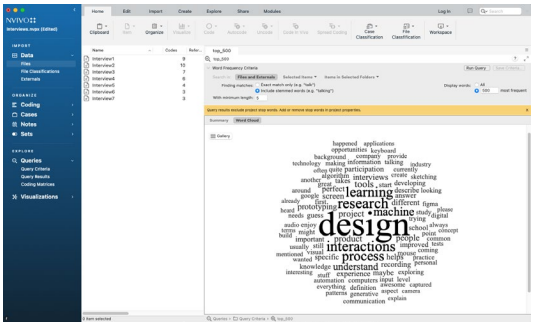
Framework proposed for AI-driven designs
The conceptual pathway translating between AI's capabilities and thoughtful designs of human-AI interaction - by Yang, et al.



Artifact Review

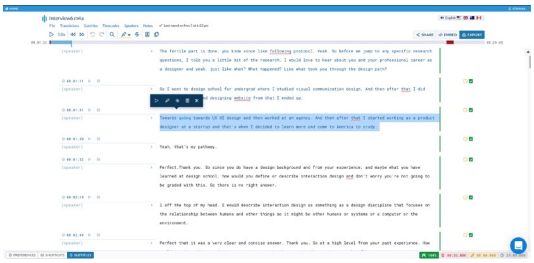
AI for Design Research

Nvivo



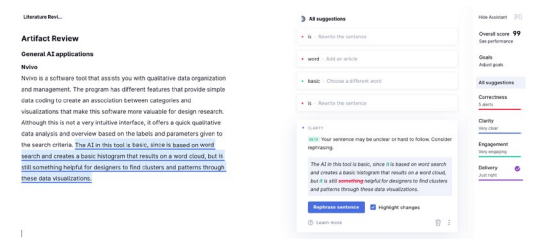
Nvivo is a software tool that assists you with qualitative data organization and management, better known as a Computer Assisted Qualitative Data Analysis Software (CAQDAS). The program has different features that provide manageable data coding to create an association between categories and visualizations that make this software more valuable for design research. Although this is not a very intuitive interface, it offers a quick qualitative data analysis and overview based on the labels and parameters given to the search criteria. The AI in this tool is simple since it is based on the word search and creates a histogram that results in a word cloud, but it is still helpful for designers to find clusters and patterns through these data visualizations. NVivo can work well with most research designs and analytical approaches (Zamawe, 2015).

Sonix.ai



Sonix is a web-based transcription tool that automates an audio transcription to text. The interface is user-friendly and is for the general public, although it requires a paid subscription for transcriptions longer than 30 minutes. This tool is an excellent example of AI automating tasks that are a hassle for any researcher. As part of the Exploratory phase, I used Sonix to transcribe my interviews; it has the convenient feature of highlighting the transcribed text while the audio is playing. It is accurate enough, but it still requires human verification. The AI model does not detect many words if the audio is not clear or affected by external factors (accent, volume, background noise).

Grammarly

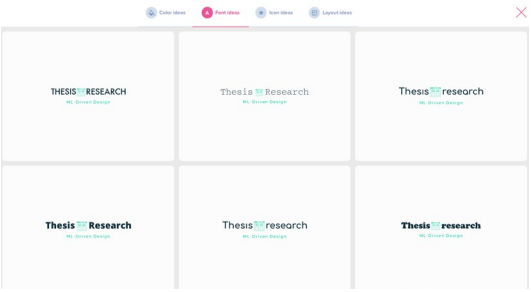


Grammarly is one of the most known AI web-based applications lately. The tool corrects your grammar, redaction, and tone of the revised text according to four different parameters (Correctness, Clarity, Engagement, and Delivery). It presents suggestions according to the goals and audience set for the reader. Grammarly has mentioned that it uses labeled data to train its Machine Learning models and utilizes user's feedback to improve and adapt the output. As a non-native

English speaker, I repeatedly used this tool while redacting my thesis research to ensure accuracy and coherence. It is accurate and user-friendly, but it limits the suggestions if the free version is used.

Applied AI for Generative and Assisted Design

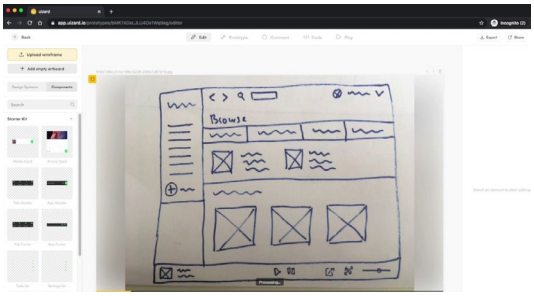
BrandMark



BrandMark is a web-based tool that creates a logo and brand identity for your project in a matter of seconds with the user's input about the brand name, slogan, relevant keywords about the brand, and color selection. This AI-infused service provides users with a sequence of potential logos with their brand identity based on various deep learning ML models.

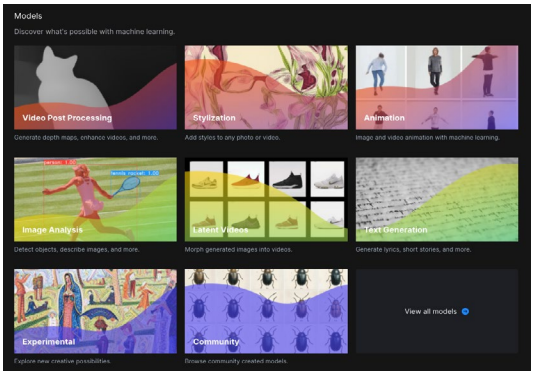
As a designer, I believe this is not a replacement of our inventive traits but more of an assistant to provoke and encourage imagination, allowing us to stem from these examples to create something more nuanced and unique for a brand.

Uizard



Uizard is an AI-powered design assistant for prototype creation. This tool has an audience for non-designers, which explains the tool's user-friendly interface and guided usability. The most notable feature that Uizard has for designers is uploading a sketch wireframe and processing that image with deep learning models into a usable and interactive interface in the tool. Although I couldn't make it work as advertised, it would be a fantastic time-cutting effort for UI Design and development prototyping if it is a working project.

RunwayML



RunwayML is a tool library for creatives that allows for quick actions like removing backgrounds from pictures and videos, colorizing images, rescaling them, and more. But it also has different pre-trained Machine Learning models to interact with and stylize and analyze images in different ways.

There is a model training feature available for paid subscriptions, but it is interesting to find a non-technical library for designers to assist on quick tasks that require time, like removing a picture's background. Although the background removal is not perfect when the photo is

not highly contrasted, the ML models for stylizing images are quite interesting and potentially helpful for generative designs.

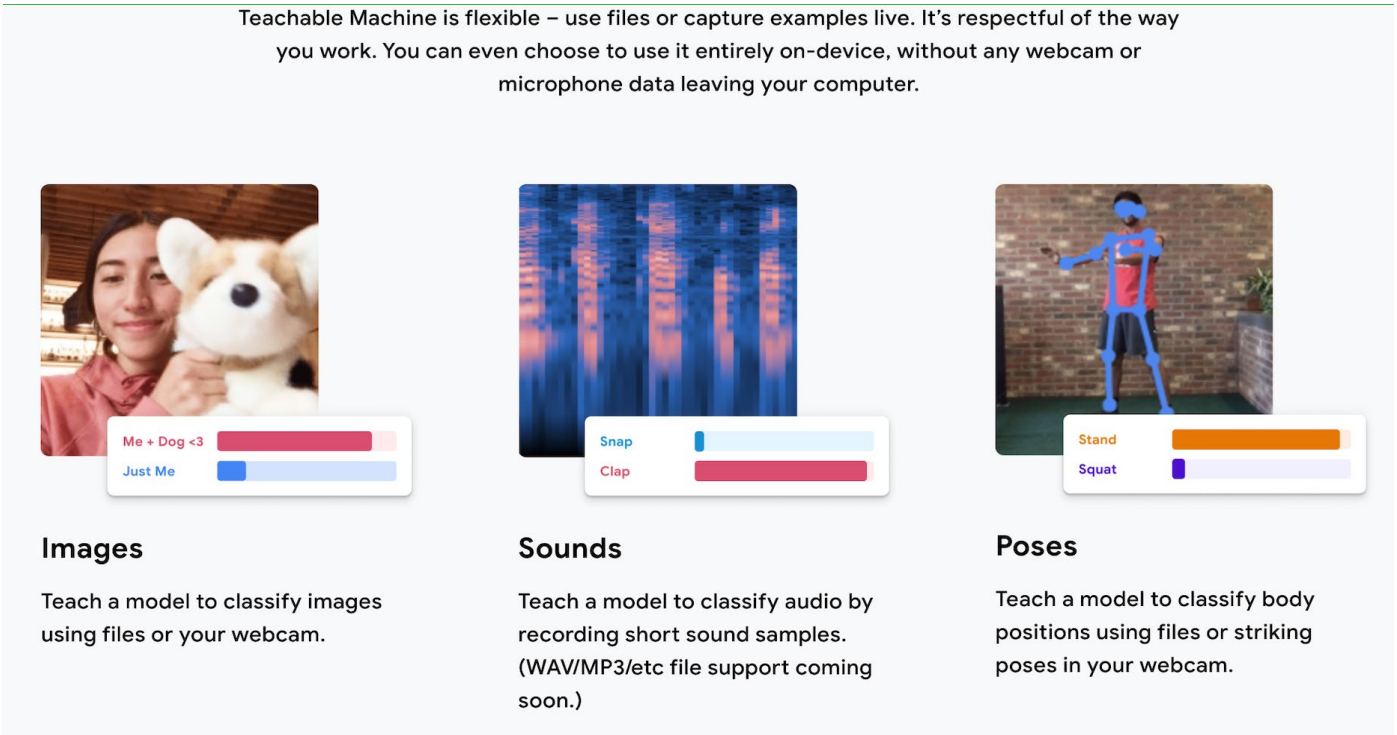
Teachable Machine

Google's Teachable Machine is a web-based tool that helps the general public create their ML models easily. It takes the user's categorized images, video, and audio data as input for the model then trains and exports the model as a javascript or TensorFlow code. The user uses it for whatever project they want as an interactive supervised ML model. I used this tool for one class, and I found it fascinating. The idea of just training a model to categorize video or audio could help designers explore responsive interactions in real-time. It does require javascript coding skills to apply it properly, though.

Conclusion

The insights I got from the literature and artifact review helped me understand the current research in the ML and IxD fields. Additionally, to learn the basics of ML without the technical jargon found in the ML papers submitted to ML conferences. This friendly adapted introduction to AI and ML is a perfect entry point for interested designers who require mathematical and statistical skills.

Teachable Machine Training
This screenshot is showing the training process of the Teachable Machine application, using origami photos as the main dataset.



Stakeholder Interviews

For the ethnographic research, I had the opportunity to interview seven professional Interaction Designers. The purpose of the interviews was to understand designers' current needs to improve the used methods and address the potential to integrate AI in their process based on the current knowledge of these tools.
The interview was divided into two main topics, Design and AI/ML.

The first part was to have a clear framework of what is the creative process for designers and how this differentiates from one professional to the other, create a baseline of the most common methods utilized, and find the pain points inside that process. The second part was to assess the designer's current knowledge about AI and ML, and evaluate the current use of any tools seizing this technology.

Some of the key questions included the following:

From your design process, which is the step you consider take the most time to develop?

What are some interactions you think could be improved/ reduced/augmented?

From the known AI tools that you use, do you think these resources are helping you with your creative process?

What do you think is the most important aspect of the integration between Machine Learning and Interaction Design methods?

Some of the most important remarks were the following:

"And that part I feel like designers are lacking the language and tools to actually understand and get access to those valuable resources."

"Existing endeavors to build data sets and collect data from human being is actually kind of helpful for designers to build insights into the phenomenons in the world."

"...if you're using post-its of like interview quotes or insights or whatever and then you have to draw connections. And so I think that research process just takes a long time."

IRB Study
These interviews were approved by the following IRB study, STUDY2020_00000362. Due to participant protection, no information is provided about the interviewees througout this document.

Interview Insights

During my synthesis process, I used two AI-based tools to process the interview transcripts rapidly and gather the files' main ideas. The first one was sonix.ai, a web-based tool that provides audio to text transcription in minutes with 95% accuracy. I had to go through the transcript and revise it, but the feature of increasing the speed in the audio file reduced the time during the revision.

The second was Nvivo, a software tool that assists you with qualitative data organization and management. Refer to my artifact review for more detail on this application.

I ran a query of the dataset (interview transcripts) to find the most common definitions and create a word cloud. Once the most repeated words emerged, I found the most important nouns and verbs to explore using the word tree query (see understand word tree).

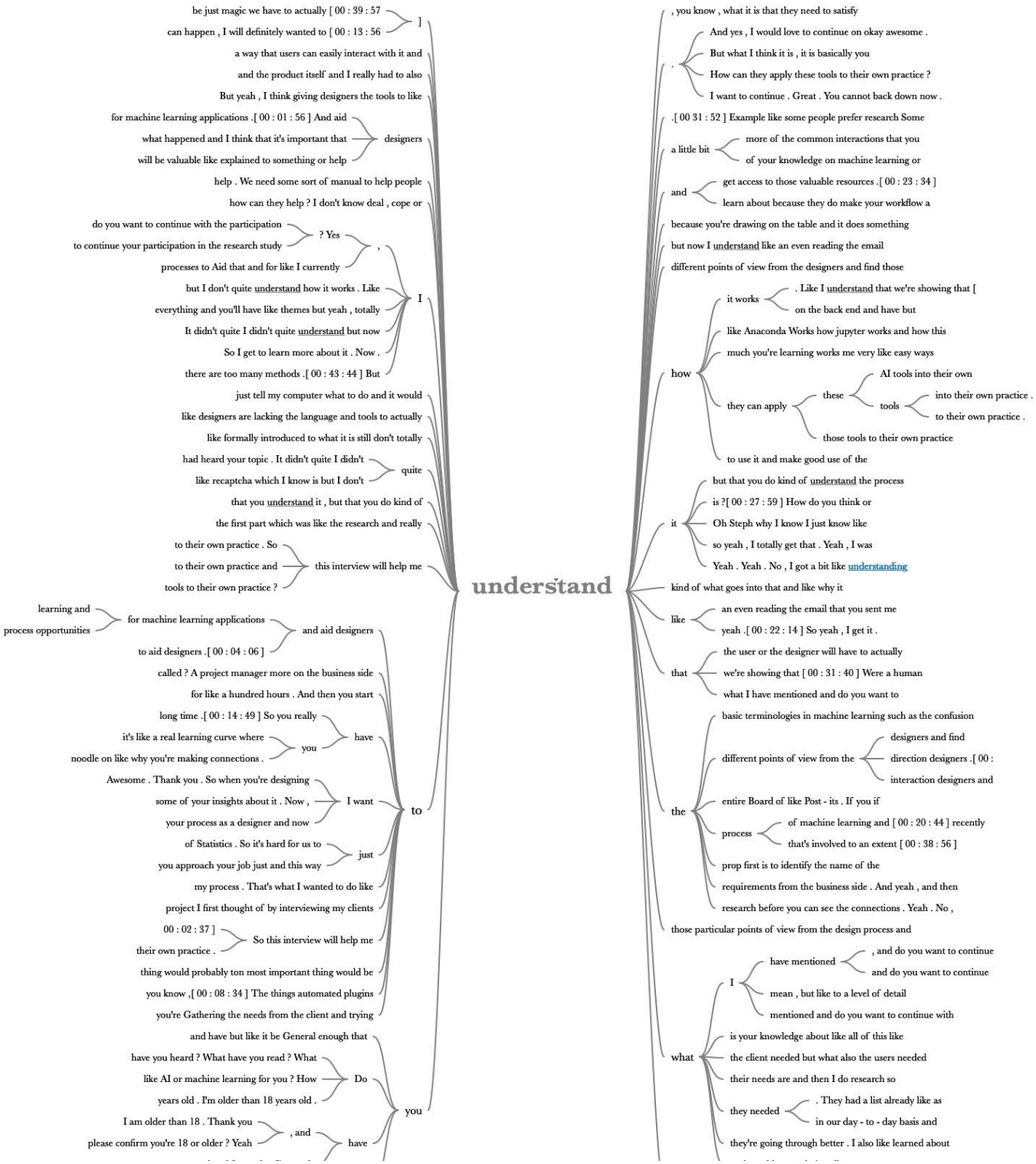
This narrow down of the keywords and relations made it easier for me to find the interviews' key insights, apart from just reviewing each of the questions' answers. It was easy to find patterns in those responses and have clear statements.

Additionally, it revealed some threads in the interviews that, at first, I wasn't aware of, but that were important for the insights, like the collaboration component. I didn't account for this during the interviews, but many interviewees highlighted it as crucial through their design process.

Synthesis word cloud
This word cloud shows the top 100 words on the interviews I conducted. I set up a default of 5 letters as a minimum length to avoid filler words.

Understand word tree

This word tree brings all the sentences from the interviews that had the word understand on them.



Particularly during the prototyping process, where the technology and time constraints impact the project, the feedback from developers was essential to create valuable models. The analysis made me realize the gaps in my research, and it helped me to fill them.
The most notable insights were the following:

Synthesis is an opportunity area

Designers find the most time-consuming tasks during the synthesis part of the Exploratory and Generative Research. Reviewing, understanding, and translating every piece of information into valuable observations takes time.

"Gathering the needs from the client and trying to understand, what it is that they need to satisfy, ... and so that might take time because you're doing research and also looking for inspiration. There's a lot of sense-making and a lot of shared understanding that needs to be gained at that point."

Designers are highly adaptive to new tools

As I was interviewing them, most of them showed high adaptation to new tools, and some stating that they are eager to learn new platforms to ease and facilitate their process.

"I'm confident in my own skills to be able to learn a new tool easily. I've also switched around a lot (between tools) at one point."

ML applications should provide agency to the user

Any new Machine Learning tool needs to have the user's control over it to allow for the agency to avoid specific outputs. Designers agreed to this idea. This is also an important insight from the literature review. Whenever designing an AI application, the model's interpretability is essential to explain to the user what is going on.

"just the idea that you're in control over what happens or you make some of the choices, for example the prototyping tools like XD and Figma, they still give the designer all the agency to control what you want to automate. "

Designers have a high-level understanding of how Machine Learning works

Still, they were more worried about the impact of AI and ML applications in society. Although it is outside of the thesis's scope, it was fascinating to understand how people have a value-driven approach to any application that handles user data.

"...recently I am exposed to the idea of human centered machine learning that is centered around fairness transparency and accountability. And how the scientist's community are actually trying to build responsible machine learning models and processes."

Current ML tools require programming skills

The existing tools that integrate ML and Design are good enough to explore and learn how pre-trained models work, but they require Python programming knowledge to interact with them. This is something designers are not as comfortable using due to the complexity of learning how to code.

"...it seems you can do a lot with machine learning but the barrier to entry as a designer is quite high. I don't know how to code or even how to begin an experiment like that as a designer and it seems like it would take a lot of work. "

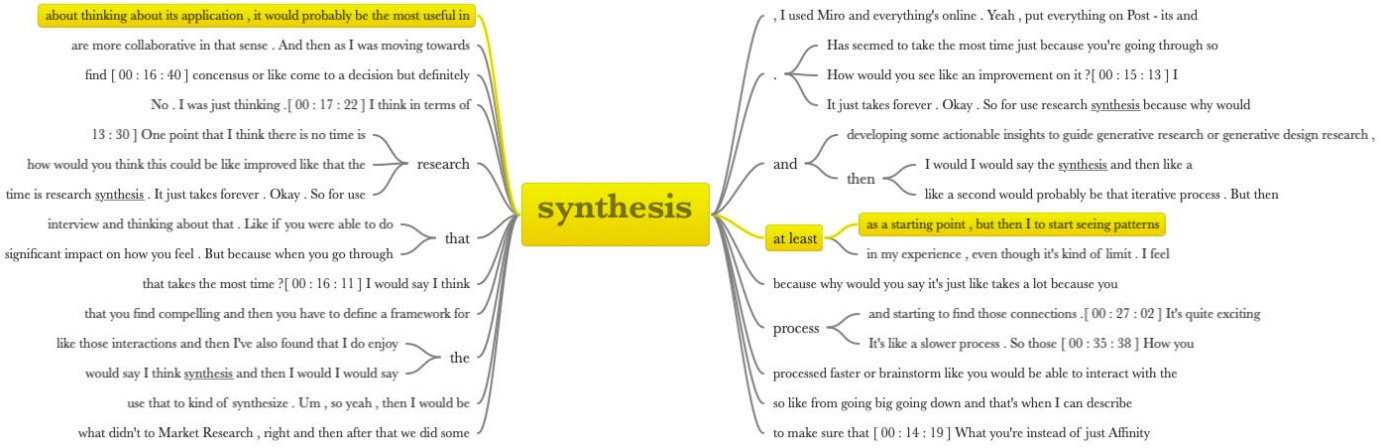
Collaboration with ML experts is highly recommended

Close collaboration with the development team is crucial to make the process work swiftly and efficiently. This insight is not original, but cooperation with experts in the ML field should be essential to understand the limitations and constraints of the technology for AI-driven applications.

"I think there is a lot around the shared understanding that you have with the developer and maybe there is a potential for machine learning to play in that space of creating shared understanding between the team. "

Synthesis word tree

This was the word tree that brought the first insight to light, the image shows how many interviews mentioned the synthesis process to be slow and could be improved.



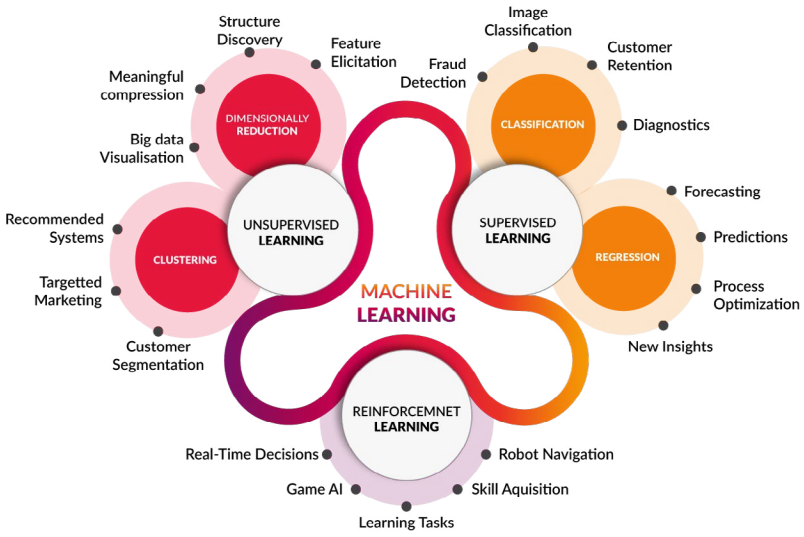
Conclusion

These insights informed opportunities in Design for me to explore further and leverage AI/ML integrations. Still, there are apparent knowledge barriers and limitations as designers that hinder interaction with ML applications. One of them is programming skills, which are currently highly required if anyone wants to interact with open-source ML libraries (Hebron, 2016, p. 55).

Another limitation is the broad spectrum of ML models that could solve a particular problem (see Machine Learning categories). As a designer, I am not aware of all the ML models available out there, and neither if any of them has better performance on a specific task or is easier to implement. There is technical information that designers are not obligated to know, but that is important to understand on a high level to follow and collaborate with specialists in the field (Dove et al., 2017, p. 279).

Some of the insights cover ML features that I can't develop with my current skill set, so I take these as guidelines to develop ideas from what I comprehend. Additionally, I look to collaborate with ML experts for direction in the concept implementation, allowing to explore things I am not currently informed of.

Machine Learning categories
This diagram represents the three categories in the Machine Learning subfield and the applications and models available in those categories - by Cognub, 2019.



Machine Hallucinations installation - GAN,
Created by Refik Anadol, 2020

IxD + ML Exploration

For the exploration between these two fields, I broke down my research into two parts. The first part focuses on integrating physical and digital interactions with one of the tools I explored during my artifact review. The second part is creating a Design tool powered by Machine Learning algorithms to analyze what it is to be a designer implementing their tools.

Unfolding

This exploration was based on a class project, so in the following section, I'll explain how the team of four people, I included, went through to achieve a live demo of a prototype in 5 weeks.

For this assignment, the team and I were asked to create a system where digital signage could respond to dynamic contexts based on specified conditionals and events. This was limited to the tools that we had to work with: Zoom and Teachable Machine.

Everyone is already familiar with Zoom by this point. We engaged with it more than any other tool during the pandemic due to its use for remote classes. The team and I knew the fundamental interactions it had, video, chat, sound, screen share, emojis, raise the hand, yes/no buttons, remote control of the shared screen, among others.

But the most essential feature to consider here was the video and sound. So once we knew that those were the core interactions to play with, we wanted to focus on that.
Google's Teachable Machine, as mentioned in my artifact review, is a web-based tool that allows users to create their own ML models. This interface is straightforward to use. The user trains a computer to recognize images, sounds, and poses without writing any machine learning code. Then, use the model in projects, sites, apps, and other things.

But as mentioned before, it can classify images, sounds, and poses. We cared more about the image classification due to the video feature in zoom being fundamental for the project.Once we understood the tools and fundamental features we had to work with, we started with the concept development.

We started to think about opportunities that could leverage both tools in the best way possible for this stage. We wanted to give our project a good purpose, not do it just because of its fun. So first, we needed to

evaluate specific criteria and, based on those, move forward with the brainstorming.

The criteria were the following:

Connection
People know each other (familiar), or people don't know each other

People
A small group of participants (2-10), intermediate (10-50), or a large one (50+)

Age
Children or adults

Device
Laptop or Mobile

Zoom Dynamic
Discussion or Lecture

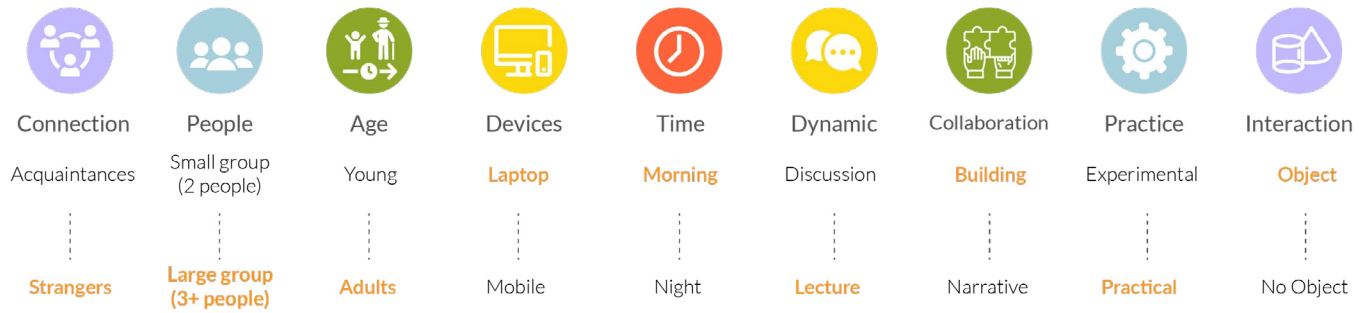
Mood
Experimental or serious and more practical

Interaction
Having an object to interact with or no object

Once we voted on the spectrum sides of the criteria above, we focused on what opportunities were available that followed all those guidelines.

When we were voting for the criteria we wanted for our project, one of the teammates found that loneliness was one of the most relevant themes during the pandemic (Kerwin McCrimmon, 2021).

Unfolding criteria
This image shows the spectrum of criteria based on the interactions and experience we wanted to explore, and the selected features.



So we focused on how to alleviate this condition in people. At first, we thought about group yoga and allowed Teachable Machine to categorize certain poses to trigger audio or another prompt for the users.

Still, we realized that these relaxing activities weren't genuinely engaging with the video in the Zoom meeting, they are just following the instructor, and we wanted something more dynamic.
One of the teammates suggested origami and how it can help reduce stress and allow for meditation. We determined to go for the origami activity.

One of the most significant decisions we had to consider was the object we wanted to play with and classify with the Teachable Machine (TM) tool. When we confirmed that we wanted to go with the Origami activity, it allowed for multiple color papers to be classified and so allow for different interactions according to the color of the paper. Also, the precise folding could be seized with the TM classification algorithm.

For the visual system, we decided on a color palette that could represent each emotion's power and energy. It was vital for us to allow the users to feel safe in an intimate but open space with others, so we also decided on the paper-cut figures inspired by Ann and Paul Rand's art.

Another major decision that we had to focus on was the colors used for the TM model training. We had to work with very distinctive colors for the model to differentiate between them. We used the feelings wheel by Gloria Willcox for psychology treatments (Willcox, 1982) and went for the 6 primary colors and emotions that are found in the center.

Once we had the main design decisions for our images and the things we were going to train for the model, we now needed the demo structure to code every interaction according to the script. We mapped out every task to be programmed based on the script's steps and the participants because we went for two primary users, the origami folders and the facilitator. These users had different interactions and responses through the experience, so I had to program those in the p5.js sketch.

Emotions wheel
This image shows the colors, emotions and assets used for the zoom display whenever a specific colored paper is shown to the camera.

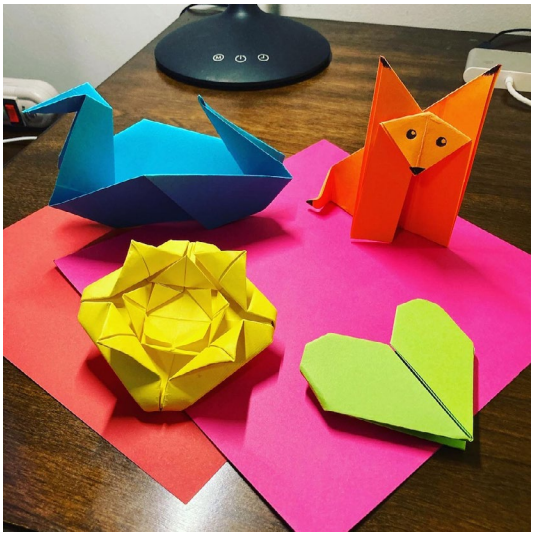
Prototype

I was in charge of the prototyping part, so before I asked my teammates to train their models, I had to teach mine first to verify how the Teachable Machine model worked and how it would be used by them. Also, I took responsibility for coding the p5.js sketch for the demo, which required many tries with lots of code lines.

I did many origami figures to understand the precision of the model to classify per color or per shape. Then I realized that since it classifies the pixels of the image given in the data, there had to be particular positions to make each folding of the same color distinct. I also realized through my mistakes that once the model was uploaded and the tab closed, you couldn't update or improve the sample data. So I had to retrain a couple of models from scratch due to this error.

For most of the images, I had to put placeholders in the code until I got the final assets because there were several changes to the final designs to display during the session. The good thing was that it was minor changes in the code since the training model worked with general labels connected to any asset.

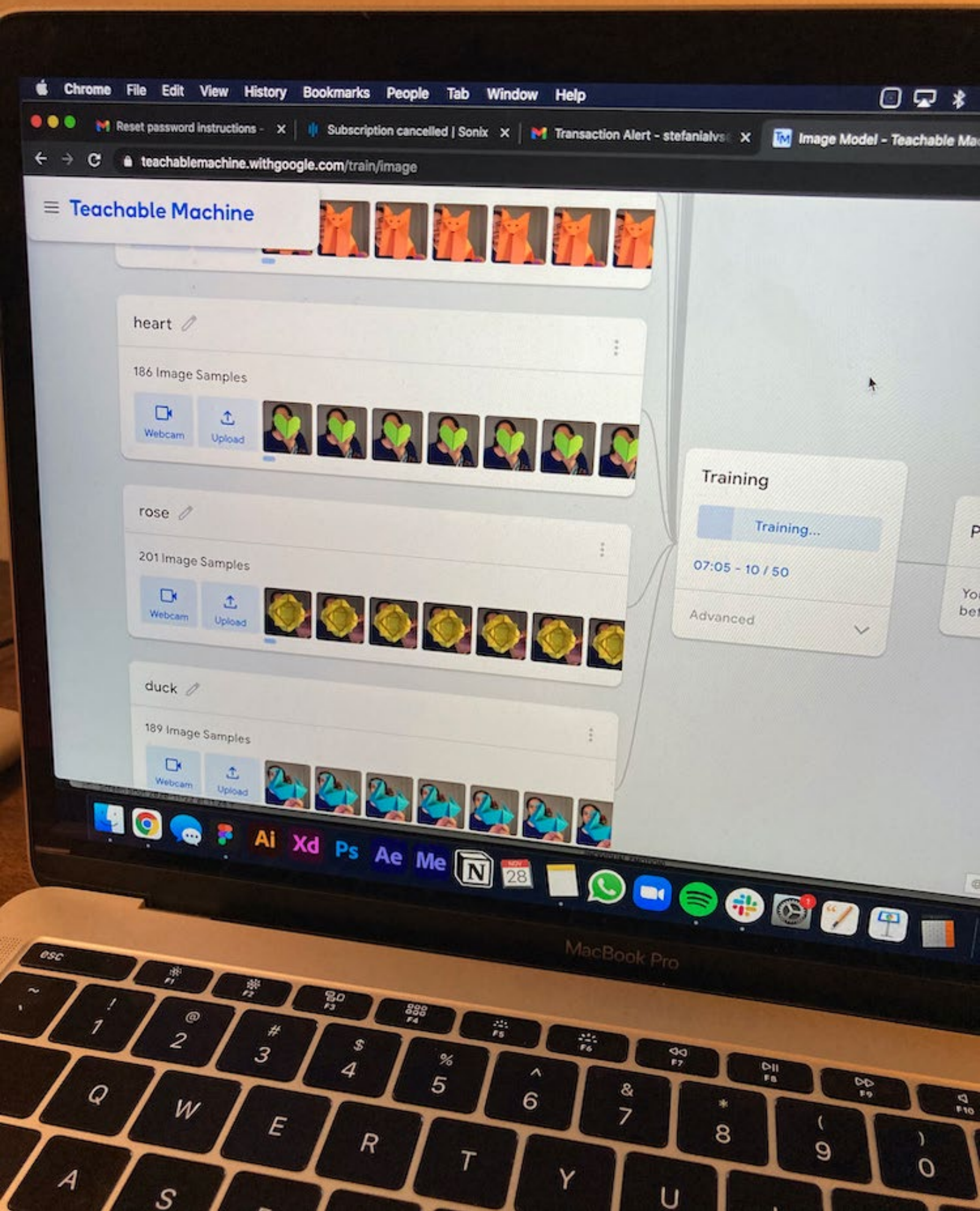
Origami examples
This were some of the figures used to train the Teachable Machine model to understand its interaction with the users live input.



Reflection

This project started with particular guidelines based on the most critical features from the technology we worked with. Since the team and I worked with Zoom and Teachable Machine, we had to think about the possibilities of interaction that these technologies could afford, like camera and audio interactions, but not text in the case of TM for example. We had to refer to those as our starting point before we did anything else because we couldn't think of something that was out of the scope of Zoom or TM. The exploratory research consisted of thinking specific situations that would determine types of communication and interaction among people, while using these platforms (Zoom and Teachable Machine).

Once we had a topic and a concept, the prototyping part required tons of iterations. As with any implementation work, everything has to be broken into phases and small steps to achieve the primary goal.


Chrome File Edit View History Bookmarks People Tab Window Help
Reset password instructions -
Subscription cancelled | Sonix
Transaction Alert - stefanialvs
Image Model - Teachable Ma
teachablemachine.withgoogle.com/train/image
Teachable Machine
heart
186 Image Samples
Webcam
Upload
rose
201 Image Samples
Webcam
Upload
duck
189 Image Samples
Webcam
Upload
Training
Training...
07:05 - 10 / 50
Advanced
MacBook Pro

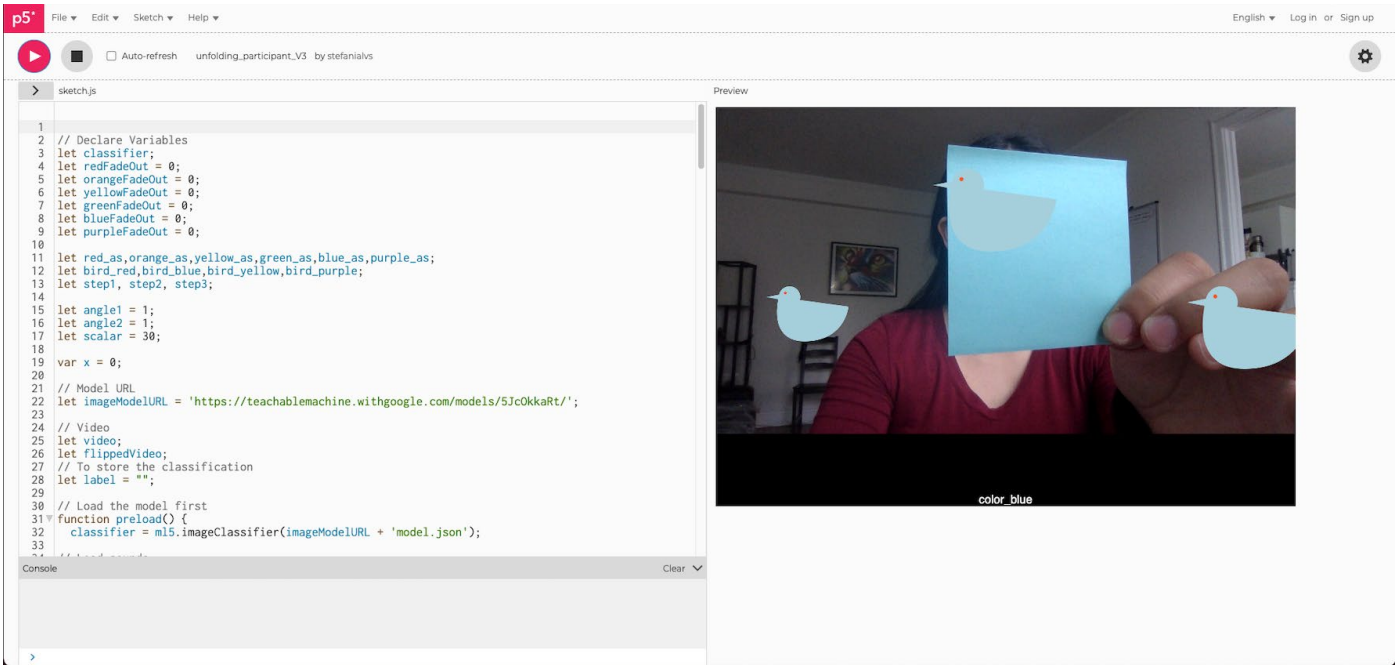
The script helped because I made progress for each user's interactions as we developed the concept and made design decisions. Still, every interaction had to be improved and tweaked according to the evolution of the project.

I realized the input dataset to the TM model only worked on the images given, and it was still lacking. Because the accuracy between one category and the other was dependent on the differences between the pixels shown. This insight made me realize how fragile ML is and how we're still scratching the surface of potential capabilities with these prototypes.

For the first time, I was a developer for a project, and I had a fantastic time doing it. Still, I realized how important it is for designers and developers to be together and discuss the technology's capabilities and limitations. There were times where my teammates asked for specific things I couldn't figure out with p5.js, making it hard on me, and we had to adapt to something more manageable.

Although I had to code the interaction with the Teachable Machine categories, I didn't need to know how it actually worked. I mean that I didn't have to focus on the back-end of the Machine Learning model. I know now that it uses transfer learning, and the base model mobilenet was trained with 1000 classes (Carney et al., 2020), but this is not explicit on the website and needs to be looked for on the web through journal papers.

p5.js sketch
This screenshot is an example of the live interaction using the Teachable Machine model to label the blue paper as color_blue and the p5.js code is displaying the blue birds according to the label.

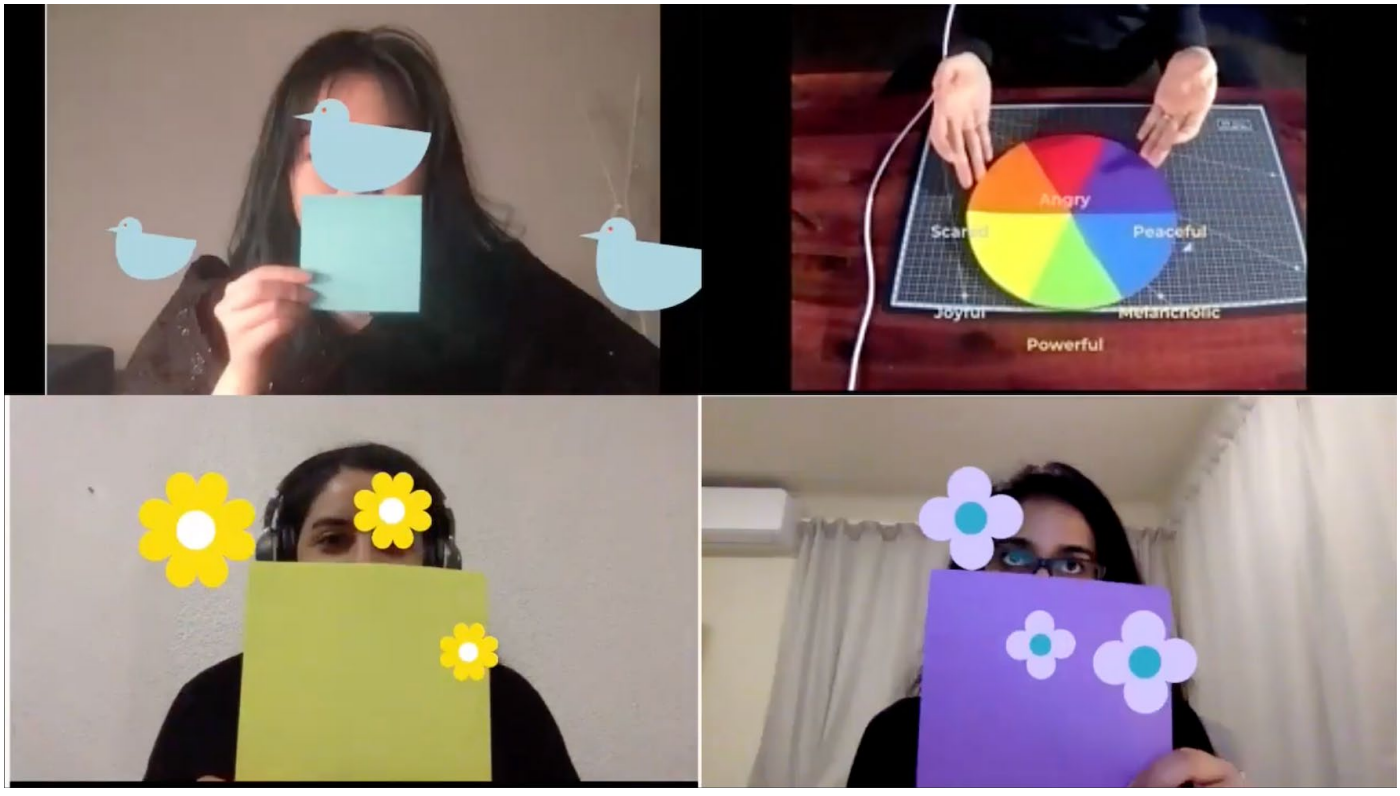


Additionally, made me understand how important it is to learn how the model works for us to seize better, like knowing that the pixels are the ones that are being classified. For one category to be different from the other, there needs to be a change in color or some other evident way for the categorization to be precise.

Furthermore, this physical and digital interaction helped me think about the possibilities for designers to play with props and not only focus on digital experiences but to integrate these two have an interesting reaction and encounter from the users.

I realized there exists plenty of potential for prototyping live interactions with ML in a collaborative setting. In this case, it was a virtual origami session, but it made me think, what other platforms could have live interactions with collaboration.

Zoom & TM interaction
This image is showing the Zoom session of the team using the p5.js code with the trained Teachable Machine model, while it displays the assets according to the colored paper showed to the users camera.



Insights

From this engaging experience, I learned some impactful insights that applied directly to this pre-trained model interaction.

+ (clean) data = + accuracy

This pre-trained model worked with data from the user, so the more it could work with, the more accurate the classification would be. Meaning the more data input you upload to the model, the better the accuracy.

The input data must be cleaned and precise

This is to avoid errors and false positives in the results. During this prototype, the data that I worked with depended only in the user's input, so it was our duty to make sure we were uploading the correct images and videos for the interaction. Still, this insight opens the question, on how are we making sure that the data used to train this model is clean for everyone? This is definitely something that should be addressed on any ML interactive application.

Multi-modal interactions are allowed

The models can work with different data inputs, like videos, images, and sounds, this feature allows for opportunities in other devices and media.

ML applications require basic programming skills

This insight is almost a repetition from the insights in the stakeholder interview synthesis, but is still an important one, that most of these ML applications require knowledge in programming languages like python, but in this case javascript was also an option, which is I believe an easier entry point for designers instead of python. Because of its useful application in web development.

Early and constant participation of designers is crucial

The designer role should be integrated from the beginning of the project along with the engineering and development aspect of it. The designer's contribution through the touchpoints and interactions of the experience makes the development more convenient and helps with fast iteration.

Design process is similar to ML implementation

Just as the design process diverges and converges, the ML interactions work like that too. We devise a general idea, and then we focus on the small parts of the whole. For this experiment, we had to break the whole experience into the small details that needed to be coded and adjusted with the ML model.

These were some of the findings I had from working directly with this tool, making me wonder how the experience would be if I used Machine Learning models without a user-friendly interface to work with as the one Teachable Machine has.

BrainstorML

By this point, I had already explored Machine Learning tools for my Exploratory research and for a Prototyping phase in one of my class projects. For my next exploration, I wanted to focus on the missing stage mentioned in the interview findings -- the Generative phase synthesis.

During this analysis, I asked myself
how do designers generate ideas?

What kind of methods/processes do they go through? Might there be an opportunity to use machine intelligence to make the process undemanding and focused on the creative instead of the time-consuming small tasks?

During the generative research phase, many participatory activities allow for collaboration between the designer and the user. During this collaboration, some of the methods may include the following: creative toolkits, design workshops, card sorting, collages, cognitive mapping, affinity diagrams, and flexible modeling, to name a few (Hanington & Martin, 2019).

Based on my experience as an interaction designer and the interviews with other professional designers, I noticed that affinity diagrams were a standard method used by all of us. Although the collaborative methods mentioned before are valuable, I wanted to concentrate on a frequent generative approach for designers to engage with (Lucero, 2015).

Card sorting method
This is a UX research technique in which users organize topics into groups to synthesize ideas - photo taken by UX Indonesia, 2020.

Thinking, of course, the AI integration with this method could enhance their sense-making and reduce time-consuming tasks, like the clustering component, and potentially generate more ideas.

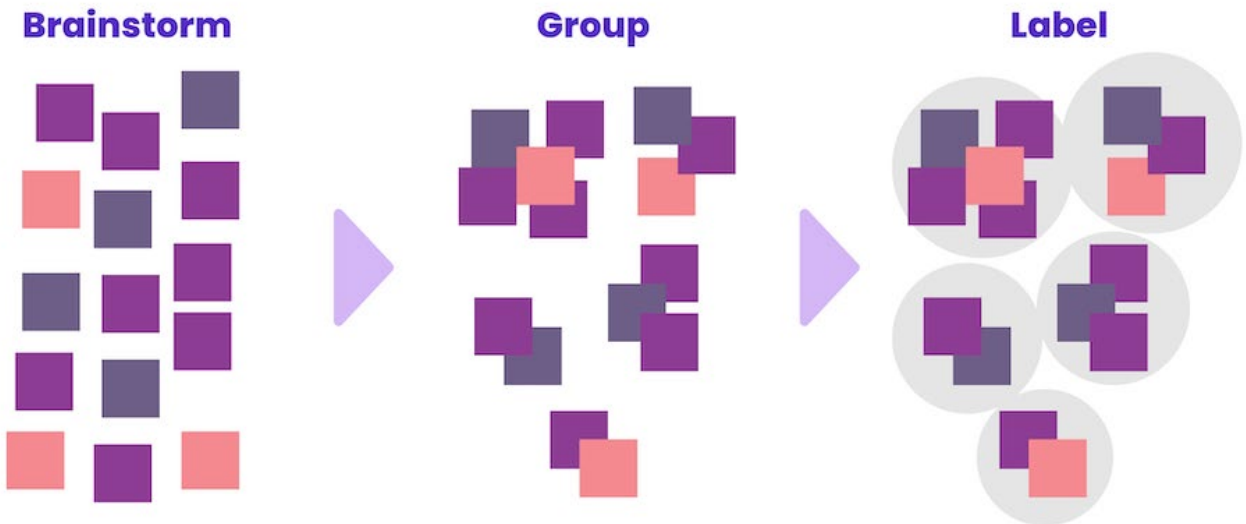
"In design practice, affinity diagrams are used to analyze a design problem or create first design solutions. With a given design problem in mind, designers write down words, short sentences or make small sketches on sticky notes to stimulate diversity in ideation phases. Ideas are then clustered to identify common issues and potential solutions" (Lucero, 2015).

Prototype

With this in mind, I started to look at how to automatically create value for this method with AI integration. I named this project BrainstorML as a play on words of Brainstorm and Machine Learning.

As I experienced during the Unfolding project implementation, the interactions' steps need to be clear before I started anything else. So I broke down the affinity diagramming process's main steps, starting with brainstorming, allowing for many ideas to be displayed simultaneously. Then, the organization and grouping of the concepts. Finally, labeling of the groups and generation of more ideas in those clusters.

Following this structure.



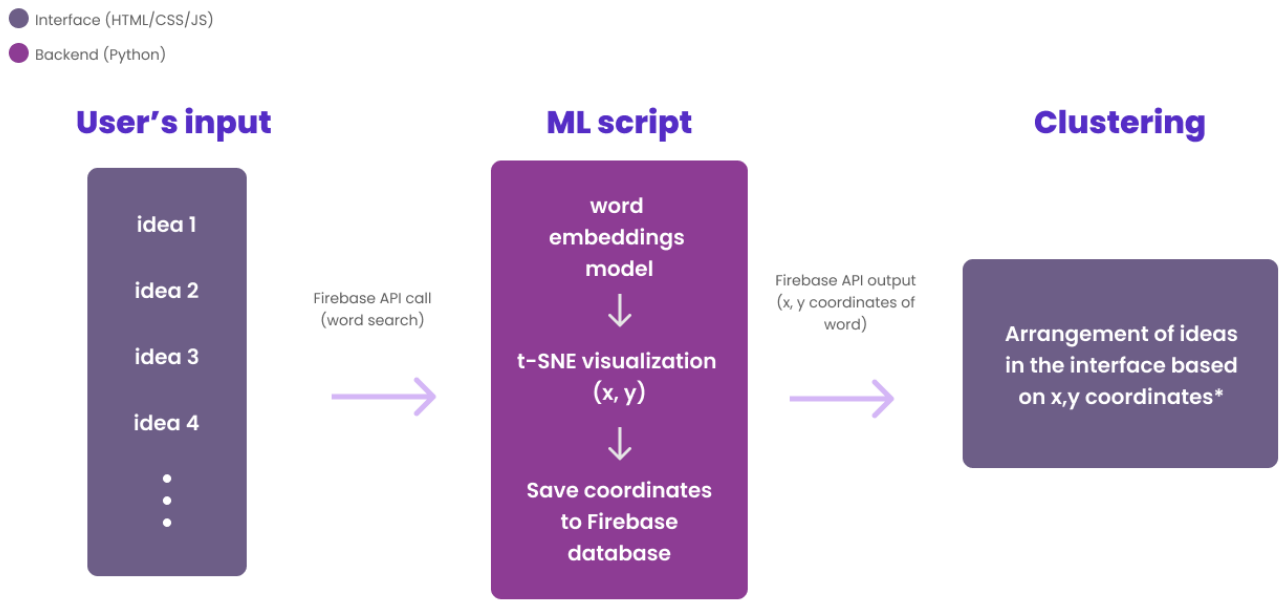
Once I understood the activity's composition, I understood that the last three steps in the process could be integrated with Artificial Intelligence. Now I needed to find which models could fit this activity and provide acceptable results for a prototype.

For this, I collaborated with Kin Gutierrez, a 3rd-year Machine Learning Ph.D. student from the School of Computer Science at CMU. His input and participation were essential for the prototype to come to life. He mentioned that the AI field called Natural Language Processing (NLP) would be perfect for this task, mainly using semantic analysis for the words (Deerwester, Dumais, Furnas, Landauer, &Harshman, 1990).
This field also uses Machine Learning models to process text or language information like the speech-to-text conversion from the tool I used called Sonix.ai during my exploratory research.

Prototype Pipeline

Once I knew that I had to work with Natural Language Processing, I divided the main components into two. The front-end covered all the interactions for the interface and user's input and backend, referring to the NLP and ML elements and integration with the interface. This made it easy for me to break down the details of the whole interaction.

Based on the Affinity Diagram structure showed before, I modeled the prototype's pipeline and how the experience would be.



*x and y coordinates represent the semantical proximity of the words in a space

p5.js prototype

This code is showing some functions coded for the sticky notes interactions with the user, when the sticky note is clicked, it shows the clicked border and can be dragged around, if the sticky note is double clicked the value inside can be changed.

First, the user would have a landing page where some introduction to the application is presented. The main interface would be the workspace where the users would be displaying their ideas and organizing them. This is the user's input that will be queried through a database where word embeddings have been processed and assigned x,y values. This allows for the ideas to be arranged in the workspace according to their x,y position. This will automatically cluster and group the stickies based on the x,y relations. Finally, the user can generate more ideas based on selected words.

Since I wanted to execute the prototype myself, I needed to get my coding skills up to par with the standard I wanted to deliver. I started as most designers, creating wireframes for the interface. My baseline was Miro's experience, the collaboration application that allows multiple users to collaborate at the same time and has brainstorming features.

Interactions

I created the land page and workspace basic structure with HTML and CSS. The interactive element in the workspace was all coded in p5.js, which is a JavaScript library for creative coding. To achieve an intuitive interaction, I had to list all the user behaviors that needed to be coded in p5.js functions, like the following:

- clicking on a sticky note
- selecting a sticky note
- dragging the selected sticky note
- click to add text to the sticky note
- double click for sticky note editing
- delete key to remove the sticky note

All these interactions were coded based on Miro's available interactions since that is a standard tool for collaborative brainstorming. And I wanted for the BrainstorML workspace to feel as familiar as Miro.

Data Processing

Once I had the primary interface for the user's input to be retrieved, I now needed to engage with the NLP and ML parts. From my collaboration with Kin, we worked on something called word vectors. Word vectors are the magic component making the clustering work.

To summarize, word vectors are the numeric representation of the meaning of a word. They represent words as multidimensional numbers that group together to semantically similar words (Ahire, 2018).

With this figured out, I just needed a word vector dataset to work with. Fortunately, Stanford scientists developed an open-source ML model that could quickly get semantically similar words of any text in the vector space (Pennington, Socher, & Manning, 2014). The datasets come in different sizes. The one I worked on had 400,000 English words.

To be specific, the meaning that these words are given in a mathematical interpretation is obtained from a corpus of text, which was given to train the Machine Learning model.

I must admit that I am not aware of what are the texts that build this corpus. They could be any type of literature and writings, like websites, articles, books, blogs, news, or maybe all of them combined. This may cause several defaulted assumptions from the texts that don't follow current ethical standards, like gender bias roles (see gender bias dataset).

This is all based on the data given to the model. The BrainstorML prototype doesn't work with complete sentences as of now, so the clustering is only done using semantical similarity, not based on contextual information like gender. But I did want to address one of the limitations of using off-the-shelf Machine Learning models and datasets for future project implementation.

Gender bias dataset
These are some example of a particular word like doctor or engineer with a gender added and one substracted to refer to particular gender roles for that word.

```
In [23]: print(find_closest_embeddings(
             embeddings_dict["doctor"] - embeddings_dict["woman"] + embeddings_dict["man"])[1:6])

['man', 'dr.', 'brother', 'physician', 'taken']

In [24]: print(find_closest_embeddings(
             embeddings_dict["doctor"] - embeddings_dict["man"] + embeddings_dict["woman"])[1:6])

['nurse', 'physician', 'woman', 'dentist', 'pregnant']
```

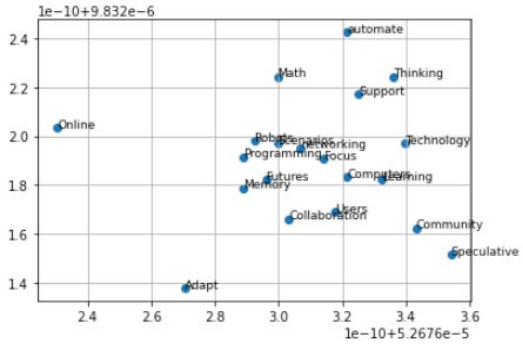
```
In [21]: print(find_closest_embeddings(
             embeddings_dict["engineer"] - embeddings_dict["woman"] + embeddings_dict["man"])[1:6])

['mechanic', 'engineers', 'master', 'technician', 'architect']

In [22]: print(find_closest_embeddings(
             embeddings_dict["engineer"] - embeddings_dict["man"] + embeddings_dict["woman"])[1:6])

['technician', 'educator', 'contractor', 'surgeon', 'pioneer']
```

t-SNE model visualization
This is an example of the first iteraction of the t-SNE model clustering with a set of words.



Data Visualization

Once I had the dataset, I now needed to translate these words with multidimensional relations to an interpretable bidimensional (x,y) set. This required another model that did precisely that. Kin pointed me to the t-SNE model that visualizes high-dimensional data (like the word vectors) by giving each datapoint a location in a two or three-dimensional map (x,y or x,y,z) (Van der Maaten & Hinton, 2008).

The t-SNE model was run in python by Kin, who helped out with the assignment of x,y points for all 400,000 words in the dataset. Now that I had the position of the words related to a vector space, I now needed to integrate the GloVe dataset with the x,y points to the interface. For this integration, Kin and I realized that doing a javascript query (web interface) to a python notebook (GloVe dataset) would be more challenging than we initially thought. That is why we moved the dataset from a python notebook to a JSON file with all the 400K words with their respective x and y values and uploaded it to a database using Google's Firebase platform. This shift made the javascript query to the Firebase data immediate and accurate, providing an easy and straightforward result for the user.

Once we had the Javascript code ready to make the Firebase queries of the user's given words, we tested it out with a few examples and realized that it worked.

Reflection

The prototype of BrainstorML addresses the question of how can the interactions of AI and ML improve the Interaction Design processes and augment the designer's abilities by improving a, in this case, Design method with time-saving and categorization. Regarding enhancing the designer's skills, the application is only sorting the ideas by semantical similarity, so there is an opportunity for growth and possible generation of ideas based on the cluster category.

One thing that is part of the next step for the prototype is working with sentences because that uncovers a different spectrum of Design and technical decisions regarding the context and attention to the intent of the sentence. Additionally, there should be enough space between the sticky notes to move them around when the grouping happens. If the words are very similar, the sticky notes overlap, and it is hard to separate them if two or more sticky notes occupy the same space.

While working with the BrainstorML prototype, I realized how hard it was to work or integrate ML models into an application without the proper developer skills. So I was relieved that I had Kin to help me out during those stages with his coding skills, along with his knowledge on the subject. It was a discovery process, but one that was highly rewarding because making it work only proved how the integration of two fields through exploration was successful. BrainstorML is certainly a tool I will be using more during my ideation process.

Insights

From this fascinating and arduous experience, I learned some obvious yet valuable insights that I would like to share with my fellow designers.

Working with code from scratch and implementing a tool is more complicated than it appears to be.
If possible, I highly recommend the no-code platforms that allow for drag and drop components to create design applications. I decided to code the application myself because the templates in these platforms did not cover the interactions I wanted the user to experience.

Collaboration is critical when working with AI/ML algorithms.
Because I am not an expert in AI or ML, having an expert by my side guiding my efforts and teaching me how to improve and develop my application was vital for this prototype to come to life.

Usability design is required when developing a tool.
As mentioned before, how people will use the application is a challenge that is necessary to discuss with the developers to provide the best experience to the user—taking into account all the small details of the users' interaction through all the tool features.

These were some of the insights from the BrainstorML prototype experience. Still, now I needed to evaluate the application and make sure it was a viable product and understand the users' perspectives, the designers.

Uber Self Driving Cars - Computer Vision.
Photo taken by Jared Wickerham, 2019

Evaluative Research

To evaluate the prototype, I made sure to have a working prototype that covered the satisficing principle from Herbert Simon (Simon, 2013), a composition of the words satisfy and suffice. He mentions that through decision making, the Design should quickly meet the user's needs instead of being the "optimal" solution that covers all the features intended.

Based on this term, I prototyped only the primary clustering of the words by their semantical proximity instead of having all the ideal characteristics in the application. For example, grouping sentences, categorizing automatically, generating more ideas for a group, and modify the sticky notes accordingly to the user's interaction. So I just covered the clustering, which was the primary need of the designer through this process.

Prototype Evaluation

Once I had that, I discussed the tool's functionality and opportunities with three professional designers. The discussion took around 30 minutes, where I asked fundamental questions about the UI of the landing page and content, like:

What is your (first) impression of this product/feature?

They mentioned that as they were reading the first sentences of the landing page. They expected the synthesis to be fast.

"My initial impression is an Ai will assist me with machine learning, and it will be super fast."

And that the application would help them with the synthesis easier.

"That it becomes easier, I mean the impression of it becoming easier."

Once we entered the main workspace, and after writing a brainstorming prompt to guide the discussion, in this case, was the question what makes you happy? They started sharing information for me to work on within the sticky notes.

After we had enough sticky notes with different words, I clicked the group button, and the algorithm grouped the ideas in specific clusters. As mentioned before, some words were so similar that some sticky notes overlapped, so I had to move them around a little bit to see the

groups better.
After the groups were clear, I asked the following:

Did the clustering make the groups as you expected?

When I asked this question, they analyzed the groups and started realizing some patterns between some of the words, but others did not fit so well with the rest. So they were mentioning how they could see relations between some but that some could be integrated with other terms better.

"I would imagine cats and dogs to be more clustered with family and friends. I like to think that they are part of the family or like companions."

Do you think you can see relationships between the clustered groups?

When I asked this, they said they were looking at some of the words that could fit better together and that considering the context and other words existent in the board is essential when clustering information.

"I do agree and feel that games it's more entertainment just given the fact that movies and music are also on the board at this moment." - during this quote, the games word was part of a group that had walks and weekends.

What do you think would be best to make the relationships clearer between the groups?

For this question, they said that having overarching categories in the groups would make it easier to understand the context or the thread in the groups. This feature would provide the designer with a clearer idea of the patterns existent throughout the board.

"If there is an overarching theme that explains why they are connected and maybe that could be surfaced because I feel like the themes is the thing that in synthesis you are trying to find."

Would this be useful for you?

They mentioned that it would be for the initial stages of ideation. Even sorting it with a margin of error was enough to start finding patterns in the information, which would reduce the cognitive load of doing this by hand. Additionally that it saves them time to do this by hand from the beginning.

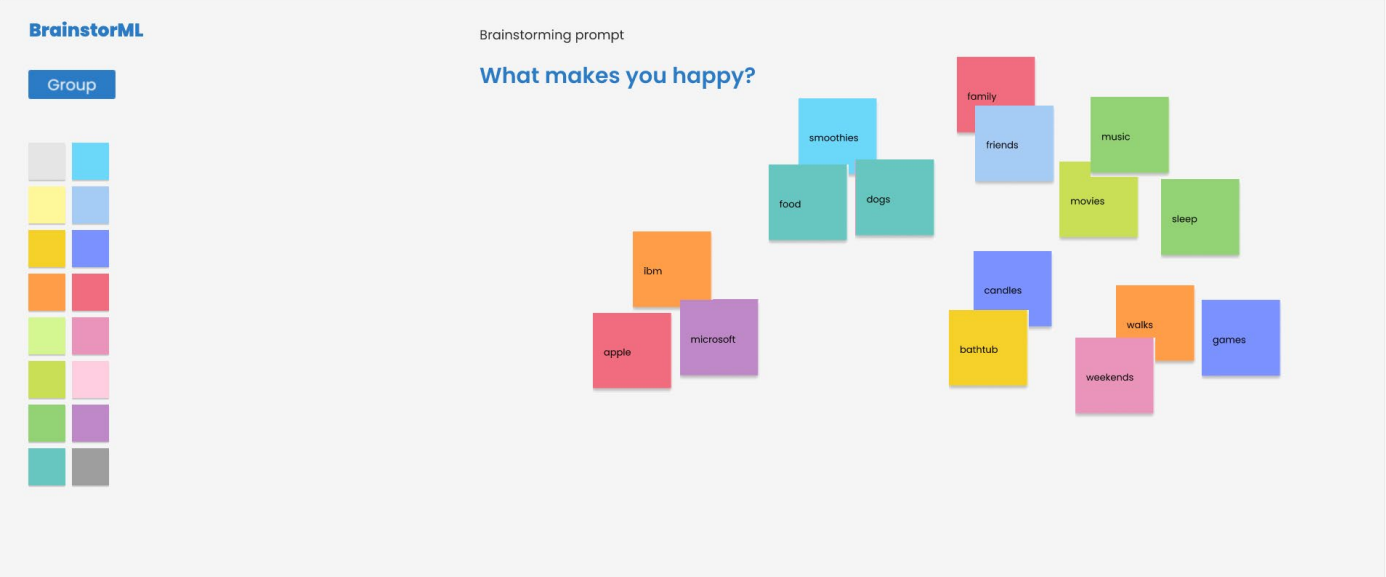
"That initial process of ideation I could see something like this being useful when and also when you have just so much data that's just very cognitively overwhelming."

"If we had to do this manually, I think we would spend at least 15 minutes and reaching this stage by ourselves."

Another interesting comment was that this tool could also use filters to look for specific and relevant words for a topic.

"Like a nearest vector, it could just be the words that relate to the prompt that is being generated. I think that's going to be more relevant to add into to answer the question."

Evaluative session result
This screenshot shows the words brainstormed during the evaluative session and the groups that the ML model created.



Insights

This session helped me understand how potential users thought about this intervention and how useful it could be. It uncovered certain aspects that I did not consider, like reducing the cognitive burden of having so much information cluttered by just organizing it by semantic approximation and other features like filtering by relevance. The most relevant insights from the session are the following:

It is helpful for the initial round of synthesis and seeing what patterns are existent.

"if I had a massive amount of post-its on this board, even if the initial grouping that ml thing does is like kind of off, it would still be helpful, because of how it creates that initial round of seeing what patterns are there, it's just like understanding the board."

It reduces time significantly and allows for clarity in identifying the cluster outliers.

"If we had to do this manually, I think we would spend at least 15 minutes to reach this stage by ourselves, but because the clustering just happened, the only thing that we had to do was identify the outliers or things that did not make sense"

It would be beneficial to spark creativity by throwing random ideas.

"I think this might be helpful in very early stages of ideation, if you have to come up with 50 ideas, this might be a tool that assists you by throwing random words that you think of and it might help us spark some creativity with the pattern recognition."

From these insights, I looked into potential interventions to my prototype and came up with the final solution and features to create a better experience with BrainstorML.

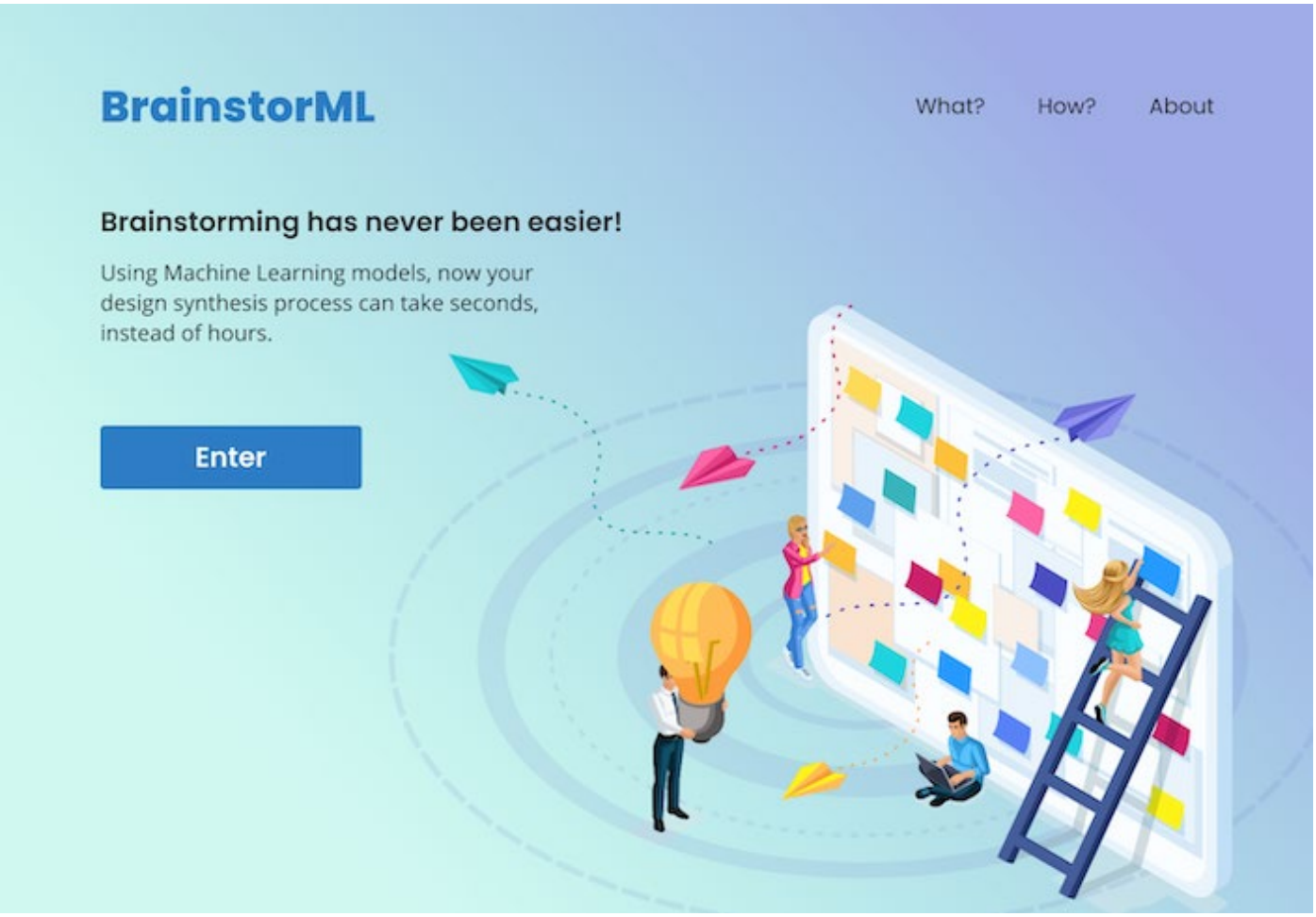
BrainstorML

Final Design

For the final version of BrainstorML, I left many of the current features used in the evaluative session since they were working as expected for the users. And here, I'll showcase some of them and look into the potential future characteristics to make this the best experience.

Land page

The land page is the entry point for the application. It has an appealing gradient background and an isometric image representing a brainstorming session. The subpages What? and How? provide a brief explanation of what BrainstorML is and how it works with Machine Learning models (GloVe and t-SNE). The button Enter is referring to entering the workspace where the magic happens.



Workspace

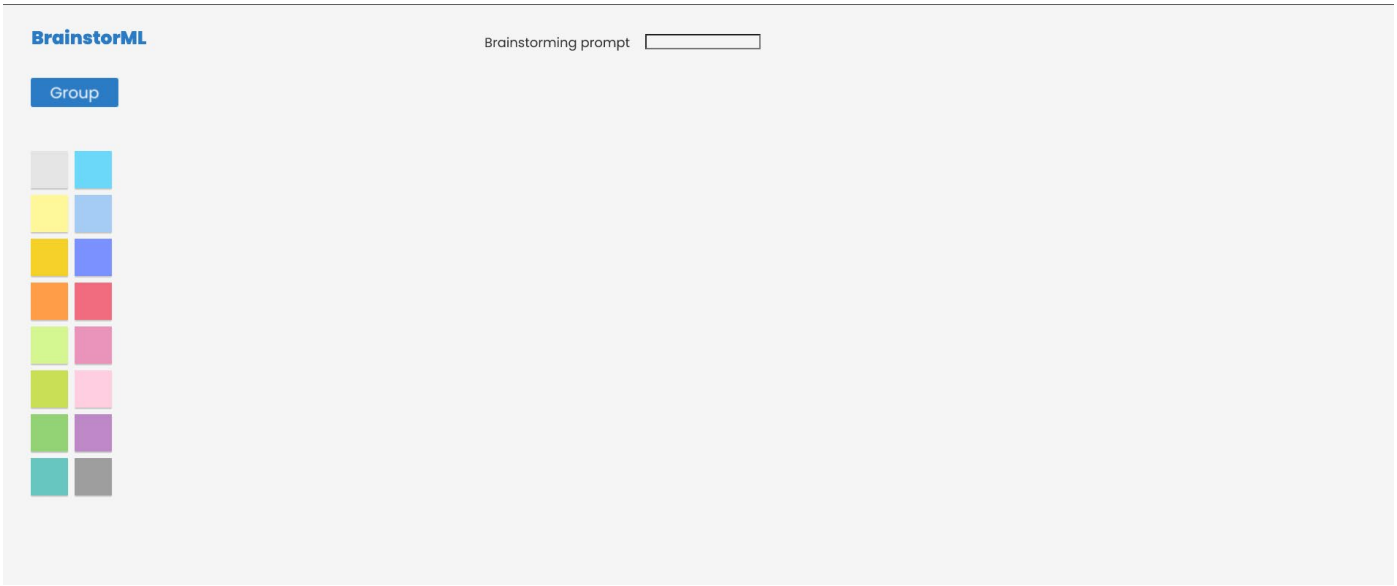
When the user enters the space, the interface shows three main components, the brainstorming prompt waiting for input, the sticky notes on the left, and the Group button above the sticky notes. I will explain the features individually, in the order of their expected interaction flow.

Brainstorming prompt

The prompt is a question or statement that the user inputs for guidance about the session's goal. In this case, we will use the same brainstorming prompt as the evaluative discussion, "what makes you happy?". Once the user press Enter to confirm the input, the question stays there to conduct the rest of the party about the brainstorming purpose.

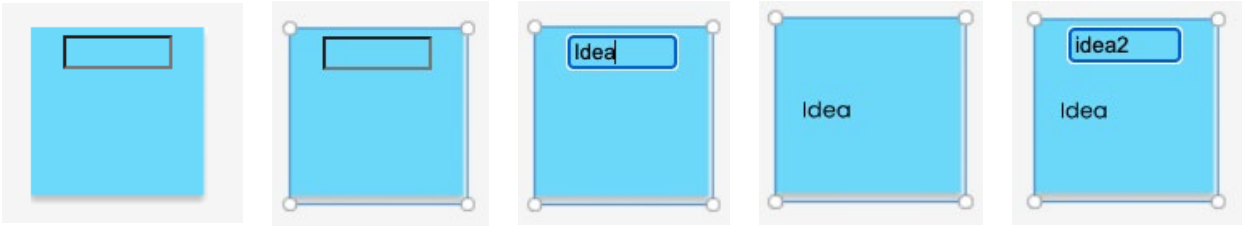
Sticky notes

The sticky notes will appear in a random spot within the canvas if clicked, corresponding to the pressed color. When they appear, they will have an input box waiting at the top of the sticky note for the user to type an idea following the brainstorming session.



There are some interactions coded for the sticky note that are worth mentioning. If the user clicks the sticky note, a selected border box will appear and allow the user to drag the sticky note anywhere within the canvas.

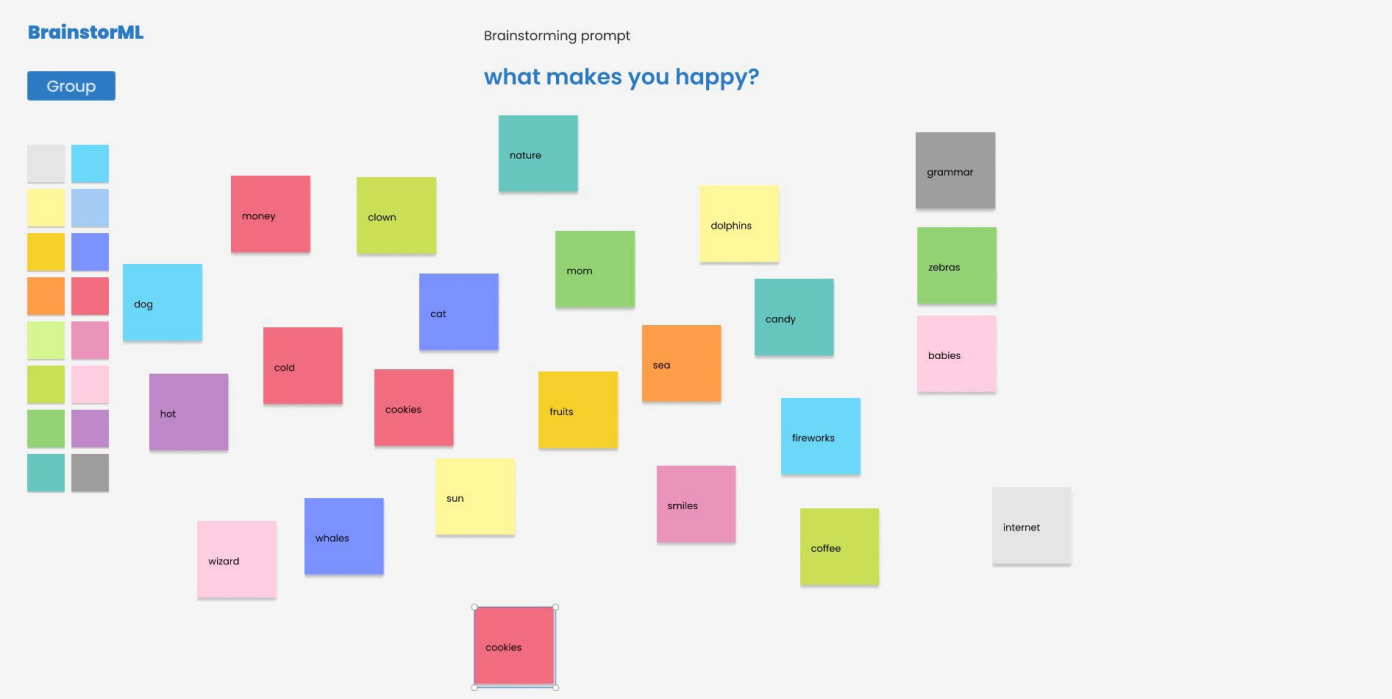
Additionally, if the user double clicks the sticky note, the input field will appear to change the current value. To confirm the new word, the user must press the key Enter, so the new idea replaces the old one.



Initial sticky note | Selected sticky note | Input first idea | Confirmed first idea | Idea change

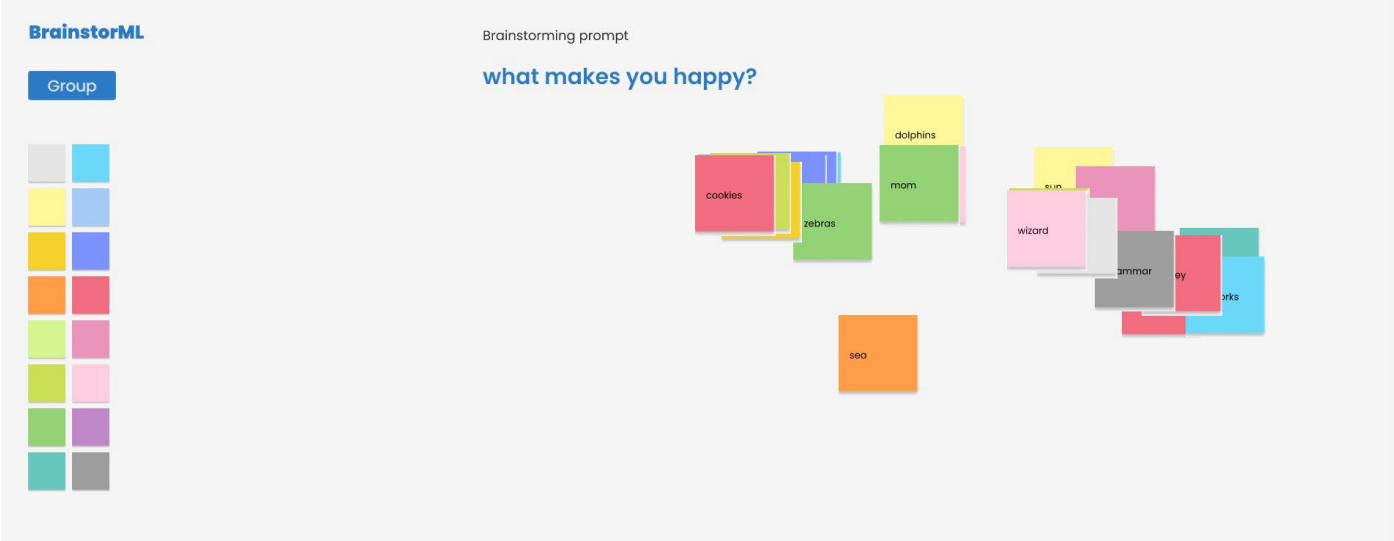
To showcase the next feature, which is the grouping, I will mimic a brainstorming session, in where different words are added in the canvas as part of the prompt “What makes you happy?”.

As shown below, the sticky notes can fit perfectly within the canvas, and the legibility of the ideas is adequate even for someone seeing them with a small size monitor.

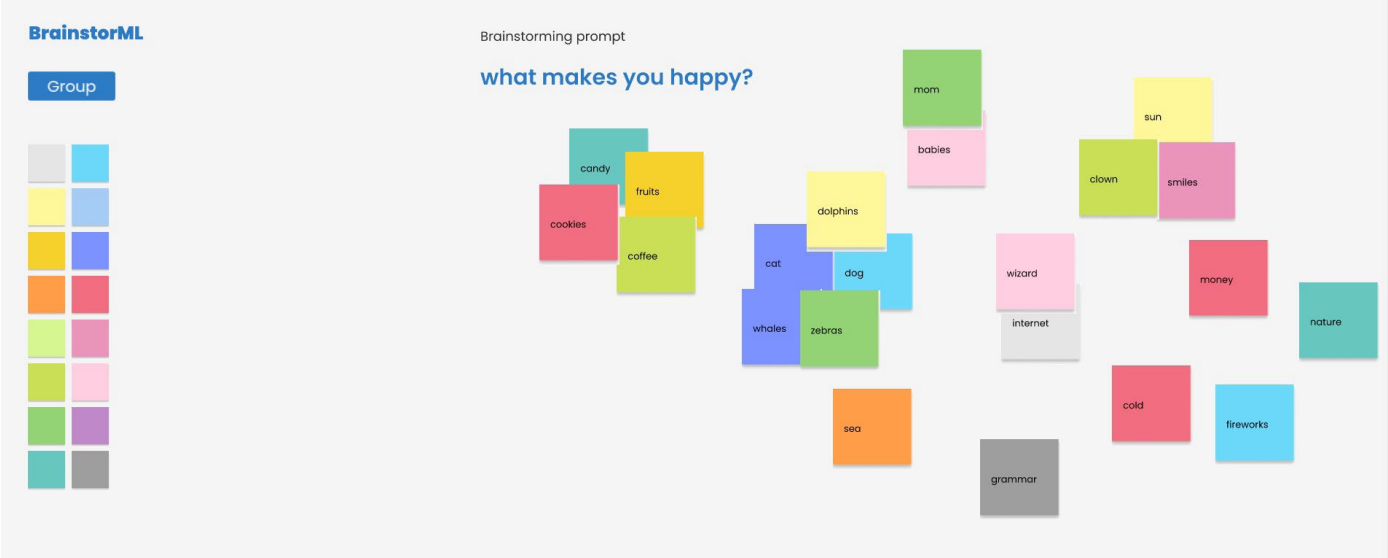


Grouping

Once all the ideas are in place, the group button will place the words according to the x,y coordinates retrieved from the Firebase API calls. This location is based on the semantical proximity of each term.
At first, the model orders the sticky notes to a specific area, but as seen in the image below, some space has been left between each sticky note to avoid overlapping and difficulty to separate them.



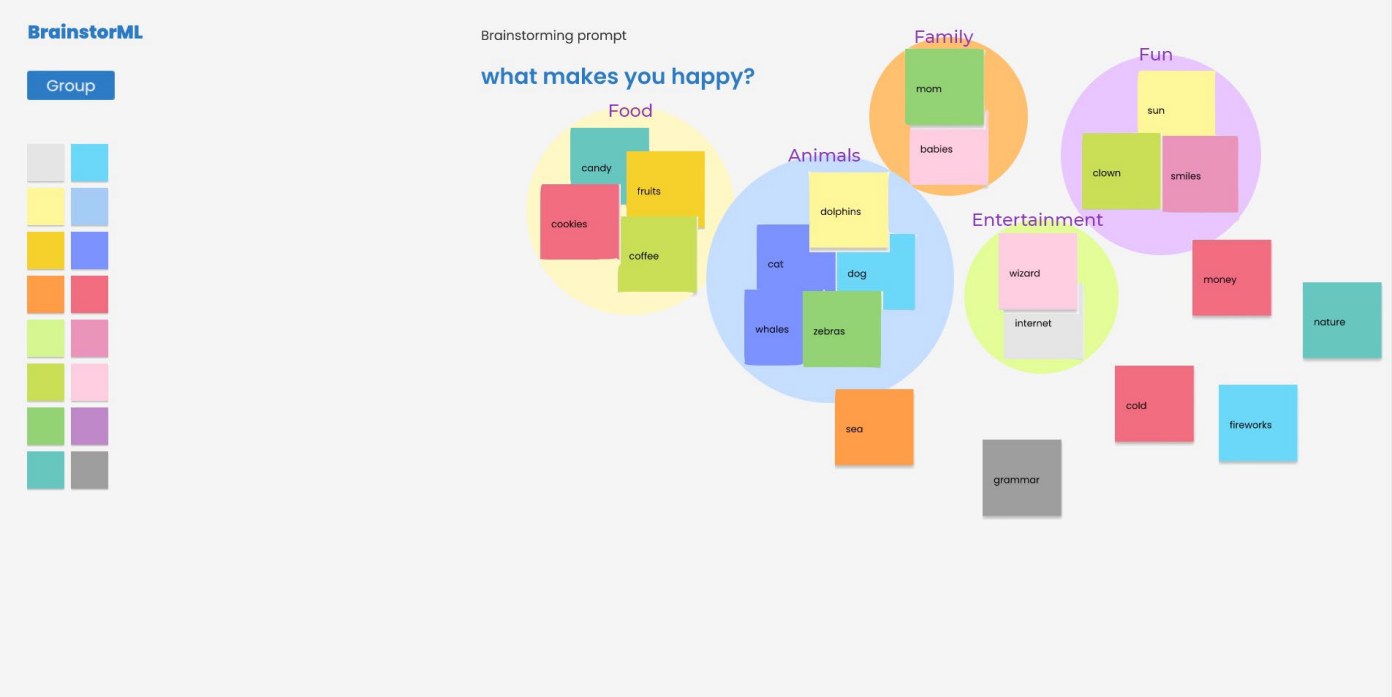
But it still requires the user's ability to move the stickies to see all the words in a group. So after sorting that out, the screenshot below is the result.



Labeling

The labeling feature allows the user to create a circle around a group of sticky notes and label it according to the category they think fits best.
In this example, we have different categories placed, like Food, Animals, Family, Entertainment, and Fun. The user can create the class by dragging the clicked mouse through a group of sticky notes. The color will is assigned randomly. Once a circle is completed, an input box appears at the top requiring the group's name.

This feature results in the following screenshot, where the user can now discuss patterns and add even more ideas to the current groups. For the sticky notes that are isolated, the user can drag them to one of the groups, and start synthesizing and creating more clusters with more ideas, and allowing ML to assist them through the process.




BrainstorML
Brainstorming has never been easier!
Using Machine Learning models, now your design synthesis process can take seconds, instead of hours.
Enter

Conclusion

Throughout this exploration, I realized how Artificial Intelligence and Machine Learning algorithms could assist designers' tasks and processes. It is worth mentioning that I don't consider automation as a replacement. These technologies are not removing the creative endeavor of the process but just assisting through some time-consuming, not imaginative activities. For example, BrainstorML, the tool I created, is not a replacement for the brainstorming exercise but an assistant to make the first patterns visible in an extensive collection of ideas.

This first pattern identification lets the designer create better and more aligned groups according to the required context once there is a starting point. It also provides the ability to categorize according to their understanding of the groups, not just letting the machine do it. This was thinking about the agency that users asked for whenever working with a Machine Learning application.

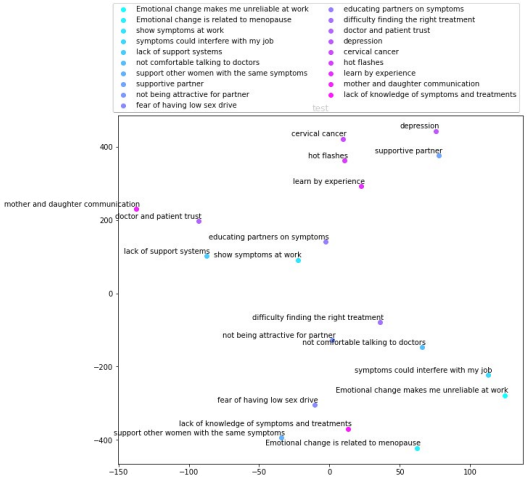
Additionally, the Machine Learning model is not absolute. There is potential to improve it to accommodate specific settings, like providing contextualized embeddings to avoid misinterpretations of the word, like "Apple" as a fruit and not as a company.

Moreover, this research made me realize how important the designer role is in any idea creation and implementation. It is equally valid to say that designers interested in these fields need to better understand the technologies used to collaborate efficiently with developers and ML experts.

In summary, no, I don't believe AI/ML will replace designers. Still, it can help spark creativity. For this particular application, it is created by the clustering and visualization of patterns in the data and allows for initial assistance in their workflow, apart from being just fast. But this is still just a tiny focus of ML for IxD. There is so much potential for this technology to support the Design field and stimulate designers' capabilities.

Future Work

BERT embeddings
This screenshot shows the grouped sentences ideated for a class project about menopausal transitions, using the BERT model.



Sentences Clustering

One of the features I look forward to work for the BrainstorML application is sentence clustering. Right now, it is working with words, but sentences require an extra layer of complexity due to the contextual meaning of the sentence. It is not the same to say “Live to work” and “Work to live”, although the words are the same in those sentences, understanding and providing the machine the ability to put attention on a term to give meaning is harder.

Fortunately, some models are open-source and starting to look at precisely this feature. I started the first iteration with a model called BERT (Bidirectional Encoder Representations from Transformers). BERT is a deep learning algorithm that helps a machine understand what words in a sentence mean, but with all the nuances of context.

I used the synthesis ideas of a previous class project about the menopausal transition. It was remarkable to see the groupings work to specific patterns, like symptoms and work-related sentences.
But it still needs a lot of work to figure out how to give more attention to a context and implement it in the current interface.

Generation of Ideas

Another step further for the application and that aligns better with the concept of augmenting designers’ abilities with Machine Learning is generating ideas based on a particular word or sentence. There is currently an ML model called GTP-3 (Generative Pre-trained Transformer 3), an auto-regressive language model that produces human-like text, and IDEO used it for brainstorming (Syverson, 2020).

This exploration would be exciting to try and evaluate since this was a highlight of the evaluative discussion with the users. They asked for idea generations to assist and provide more interpretability about how the machine understands the sentences.

Ethical Considerations

There are evident issues about dealing with these Generative models that ML engineers train with chunks of the internet, as mentioned by the Senior Design Lead from IDEO Chicago.

"The result is that the model can reproduce the language of a scientific paper just as easily as it can mimic an internet troll. You get the good with the bad" (Syverson, 2020).

There needs to be an additional effort to manually work and clean the negative input fed in the model training. And bias is another issue by itself because, as I mentioned before, biases only represent the literature of our epoch.

"These models literally encode a snapshot in time, and are inherently biased to reproduce the status quo. Companies and designers will need to question and problematize the output of these models with the same rigor that we are learning to bring to our human interactions." (Syverson, 2020).

Collaboration

Finally, I see the future of this application to be collaborative and allow for multiple users to engage simultaneously. There are currently various applications with better placement within the users and more features to contend with, like Miro, Mural, and Figma.

There is a possibility of pitching this idea to one of these already established applications and providing a better and holistic experience for designers throughout their process and activities. But for now, I'll keep working on my small but functional and enjoyable application.

Referenced Literature

Ahire, J. B. (2018). *Introduction to word vectors*. Retrieved from: https://dzone.com/articles/introduction-to-word-vectors#:~:text=Wordvectors aresimplyvectors,fromtraditionalrepresentationsofwords.

Amershi, S., Weld, D., Vorvoreanu, M., Fourney, A., Nushi, B., Collisson, P., Horvitz, E. (2019). *Guidelines for human-ai interaction*. In Proceedings of the 2019 CHI conference on human factors in computing systems (p. 1–13). New York, NY, USA: Association for Computing Machinery. Retrieved from: https://doi.org/10.1145/3290605.3300233doi: 10.1145/3290605.3300233

Brownlee, J. (2019, Aug). *What are word embeddings for text?*. Retrieved from: https://machinelearningmastery.com/what-are-word-embeddings/

Carney, M., Webster, B., Alvarado, I., Phillips, K., Howell, N., Griffith, J., Chen, A. (2020). *Teachable machine: Approachable web-based tool for exploring machine learning classification*. In Extended abstracts of the 2020 CHI conference on human factors in computing systems (p. 1–8). New York, NY, USA: Association for Computing Machinery. Retrieved from: https://doi.org/10.1145/3334480.3382839doi: 10.1145/3334480.3382839

Cascone, S. (2017, Jul). *AI -generated art now looks more human than work at art basel*. Art net News. Retrieved from: https://news.artnet.com/art-world/rutgers-artificial-intelligence-art-1019066

Cheng, C.Y. (2017). *Interactive design process based on augmented intelligence: a framework andtoolkit for designers to interact and collaborate with ai algorithms* (Unpublished doctoral dissertation). Massachusetts Institute of Technology.

Costello, K. (2019). *Gartner survey shows 37 percent of organizations have implemented AI in some form*. Retrieved from: https://www.gartner.com/en/newsroom/press-releases/2019-01-21-gartner-survey-shows-37-percent-of-organizations-have

Deerwester, S., Dumais, S. T., Furnas, G. W., Landauer, T. K., & Harshman, R. (1990). *Indexing by latent semantic analysis*. Journal of the American Society for Information Science, 41(6), 391-407. doi: https://doi.org/10.1002/

Design Council. (2019, Sep). *What is the framework for innovation? Design councils evolved double diamond*. Retrieved from: https://www.designcouncil.org.uk/news-opinion/what-framework-innovation-design-councils-evolved-double-diamond

Donfro, J. (2019, Sep). *Al 50 founders say this is what people get wrong about artificial intelligence*. Forbes Magazine. Retrieved from: https://www.forbes.com/sites/jilliandonfro/2019/09/17/ai-50-founders-say-this-is-what-people-get-wrong-about-artificial-intelligence/?sh=22a29bcc7077

Dove, G., Halskov, K., Forlizzi, J., & Zimmerman, J. (2017). *UX design innovation: Challenges forworking with machine learning as a design material*. In Proceedings of the 2017 chi conference on human factors in computing systems (p. 278–288). New York, NY, USA: Association for Computing Machinery. Retrieved from: https://doi.org/10.1145/3025453.3025739

Fallman, D. (2008). *The interaction design research triangle of design practice, design studies, and design exploration*. Design Issues, 24 (3), 4–18. doi:10.1162/desi.2008.24.3.4

Fritschle, M.(2019, May). *How ai is changing the role of the designer*. Retrieved from: http://www.campaignmonitor.com/blog/email-marketing/2019/03/how-ai-is-changing-the-role-of-the-designer/.

Goodfellow, I. J., Pouget-Abadie, J., Mirza, M., Xu, B., Warde-Farley, D., Ozair, S., Bengio, Y. (2014). *Generative adversarial networks.*

Hanington, B., & Martin, B. (2019). *Universal methods of design expanded and revised: 125 ways to research complex problems, develop innovative ideas, and design effective solutions.* Rockport Publishers. Retrieved from: https://books.google.com/books?id=SFnBDwAAQBAJ

Hebron, P. (2016). *Machine learning for designers*. O'Reilly Media, Inc.

Jewell, C. (2019, Jun). *Artificial Intelligence: the new electricity.* WIPO Magazine. Retrieved from: https://www.wipo.int/wipo_magazine/en/2019/03/article_0001.html

Kelly, J. (2019, Sep). *Unbridled adoption of artificial intelligence may result in millions of job losses and require massive retraining for those impacted*. Forbes Magazine. Retrieved from: https://www.forbes.com/sites/jackkelly/2019/09/30/unbridled-adoption-of-artificial-intelligence-may-result-in-millions-of-job-losses-and-require-massive-retraining-for-those-impacted/#70335b9d1de7

Kerwin McCrimmon, K. (2021, Jan). *Loneliness during the covid-19 pandemic: Fight it with kindness*. UCHealth. Retrieved from: https://www.uchealth.org/today/loneliness-during-the-covid-19-pandemic-fight-it-with-kindness/

Lucero, A. (2015, 09). *Using affinity diagrams to evaluate interactive prototypes*. In (Vol. 9297, p. 231-248). doi: 10.1007/978-3-319-22668-2_19

Nucera, D., & Onuoha, M. (2020). *The peoples guide to AI*. Pioneer Works.

Pennington, J., Socher, R., & Manning, C. (2014, October). *GloVe: Global vectors for word representation. In Proceedings of the 2014 conference on empirical methods in natural language processing* (EMNLP) (pp. 1532–1543). Doha, Qatar: Association for Computational Linguistics. Retrieved from: https://www.aclweb.org/anthology/D14-1162doi: 10.3115/v1/D14-1162

Pichai, S. (2018, Jun). *AI at Google: our principles*. Google. Retrieved from: https://www.blog.google/technology/ai/ai-principles/

Simon, H. (2013). *Administrative behavior, 4th edition*. Free Press. Retrieved from: https://books.google.com/books?id=_obn42iD3mYC

Syverson, B. (2020, Oct). *The rules of brainstorming change when artificial intelligence gets involved*. IDEO. Retrieved from: https://www.ideo.com/blog/the-rules-of-brainstorming-change-when-ai-gets-involved-heres-how

Van Bodegraven, J. (2019). *Artificial Intelligence Driven Design.* awwwards.

Van der Maaten, L., & Hinton, G. (2008). *Visualizing data using t-sne*. Journal of Machine Learning Research, 9, 2579-2605.

Verganti, R., Vendraminelli, L., & Iansiti, M. (2020). Innovation and design in the age of artificial intelligence. Journal of Product Innovation Management, 37 (3), 212-227. Retrieved from: https://onlinelibrary.wiley.com/doi/abs/10.1111/jpim.12523

Willcox, G. (1982). *The feeling wheel.* Transactional Analysis Journal, 12 (4) , 274-276. Retrieved from: https://doi.org/10.1177/036215378201200411

Wolff, R. (2020, Aug). *Semantic analysis in linguistics: An introduction.* Retrieved from: https://monkeylearn.com/blog/semantic-analysis/

Yang, Q., Scuito, A., Zimmerman, J., Forlizzi, J., & Steinfeld, A. (2018). *Investigating how experienced UX designers effectively work with machine learning.* In Proceedings of the 2018 designing interactive systems conference (p. 585–596). New York, NY, USA: Association for Computing Machinery. Retrieved from: https://doi.org/10.1145/3196709.3196730

Yang, Q., Steinfeld, A., Rosé, C., & Zimmerman, J. (2020). *Re-examining whether, why, and how human-AI interaction is uniquely difficult to design.* In Proceedings of the 2020 CHI conference on human factors in computing systems (p. 1–13). New York, NY, USA: Association for Computing Machinery. Retrieved from: https://doi.org/10.1145/3313831.3376301

Yse, D. L. (2019). *Your guide to natural language processing*. Towards Data Science. Retrieved from: https://towardsdatascience.com/your-guide-to-natural-language-processing-nlp

Zamawe, F. (2015). *The implication of using nvivo software in qualitative data analysis: Evidence-based reflections.* Malawi Medical Journal, 27 (1), 13. Retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4478399/

Referenced Images

[Google Home Mini] Rebouças, N. (2020). *Google Nest + Kindle* [photo]. Unsplash. Retrieved from: https://unsplash.com/photos/b0-Kp69nXOo

[Machine Learning Categories] Krzyk, K. (2018). *Machine Learning Categories* [image]. Medium. Towards Data Science. Retrieved from: https://towardsdatascience.com/coding-deep-learning-for-beginners-types-of-machine-learning-b9e651e1ed9d

[Machine Hallucinations installation] Simonite, T. (2020). *Artist Refik Anadol Turns Data Into Art, With Help From AI* [video]. WIRED. Retrieved from: https://www.wired.com/story/artist-refik-anadol-turns-data-art-help-ai/

[Card Sorting Method] Indonesia, UX. (2020). *Card Sorting* [photo]. Unsplash. Retrieved from: https://unsplash.com/photos/WCID2JWoxwE

[Uber self driving cars] Wickerham, J. (2019). *Uber autonomous vehicles in Pittsburgh* [photo]. Pittsburgh City Paper. Retrieved from: https://www.pghcitypaper.com/pittsburgh/ubers-self-driving-cars-cant-detect-pedestrians-who-walk-outside-of-crosswalks-says-report/Content?oid=16160888