ANALYSIS OF INTENT-DESIGN RELATIONSHIP FOR ARTIFICIAL INTELLIGENCE DESIGN AGENT MODEL BASED ON PRODUCT PURCHASING PROCESS

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Abstract

This study aims at proposing an AI-agent model that helps designers to understand and interpret clients' intent and create customized design outcomes. We recorded and analysed the purchasing process of collecting product information, selecting alternative products and making decision to understand the influence of artefacts on the client's intent during the purchasing process and collect the basic data for proposing an AI-agent model. We analysed the process by Linkography and found the relationship between the decision-making patterns and the artefacts that presented by the AI-agent.

Keywords: decision making, client's needs, linkography, artificial intelligence (AI), design tools

1. Introduction

Nowadays, it is not rare that a machine can compose music, draw pictures, and write scenarios by gathering the data and learning from musicians, artists, and writers' works. Gatys et al. (2016) conceived the concept of Neural Transfer Style to transfer an art painting style to a chosen image. Dai et al. (2018) proposed a music style transfer model that can transfer jazz to classic musing without losing the aspects of original music. The novel '1 the Road' composed by Artificial Intelligence (AI) was published in 2018 (BOMB Magazine, 2018). Such experimental AI-created artworks are generated almost entirely algorithmically by feeding the artworks into a generative AI algorithm that tries to imitate the styles of these inputs. The AI algorithm learns the algorithmized data of the inputs and then generates a range of output images based on the data. In the field of graphic design, clients can use AI-based design services to generate designs. Clients select the desired font, colour, template, and the like, and the AI tools present the best combinations of these elements by referring to the existing designs and allowing the clients to select the design they prefer. AI layout design tool "Automatic Generation of Visual-textual presentation layout" proposed by Yang et al. (2016) can generate magazine covers of different themes, and AI logo maker "LOGOJOY (www.logojoy.com)" can generate logos based on clients' choice of colour and style. Such an AI design service can be summarized as an algorithm that recommends popular styles based on the data of existing designs. Therefore, the experiments of AI creation in the field of art and design can be seen as taking an essentially similar approach. In other words, it can be described as a process of algorithmizing the patterns of existing works, learning the patterns and generating new results based on the frequency of use of the existing data.

Although a report from Adobe (Abramovich, 2018) indicated that most creative professionals believe that AI tools cannot replace a human's creativity, some artists are worried about being replaced by AI

someday. In the Age of AI, creativity may come in a different way, such as an elegantly programmed machine or a tasteful selection from several algorithmically produced prototypes (Stolzoff, 2018). Those artists and designers who imitate the styles of existing works will be meaningless then.

However, as shown in Figure 1, art and design have different features and processes in nature. Artists create artworks based on their inner interpretation and style while designers create design outcomes as texts that are 'written' by designers and 'read' by consumers (Crilly and Clarkson, 2006). Thus, the understanding of the clients, including buyers and users, is very important in the design process.

Figure 1. Different processes of art and design
(Left)Process of fine art; (Right)Process of design

Therefore, designers must understand clients' intent and preferences that change across situations and contexts, interpret them with their design styles and then create a new design concept, that is, create new design data that are different from the existing works. Only designers who can function this way will survive as creators even in the age of AI.

The existing AI design service that suggests design outcomes based on the usage frequency of the existing data is limited because the clients' intent and preferences change according to the situation. Therefore, this study proposed an AI agent model that helps designers understand and interpret clients' intent and create design works considering the feature of the design process. A client selects products and decides to purchase one or some of them based on his or her needs and preferences. That is, we can find out the client's needs and preferences and the change of intention across situations by analysing the purchasing process. To this end, we present a model that explains the role of AI design agent and analyse the purchasing process through an in-depth interview. In addition, by analysing the relationship between the client's intentions and the artefacts presented by the agent, we try to find out how the artefacts presented by the agent match the client's intentions and ultimately help the client achieve the desired design outcomes. The understanding of this process can be a basis for developing an AI design agent.

2. AI agent model

What is an agent and what role does he or she play? Dictionary definition (Wiktionary, 2019) is that agent is "*one who acts for, or in the place of, another (the principal), by authority from him/her; someone entrusted to do the business of another.*" A designer is also an agent. Gero and Fujii (2000) describe a designer as a design agent who interacts with the environment (including design requirements and constraints, clients and other shareholders and things) to change the design and the resulting environment. Designers can bridge the gap between design and clients' intent by trying to grasp the clients' intent through the interaction with the clients by presenting the design concept to clients and getting the feedbacks from the clients. The process of product design, in which customer involvement is crucial, can be described as a process of closing the gap by trying to understand the client and presenting design results continuously.

Hence, what is the role of the AI design agent in the design process? Smith and Gero (2005) described a model of a situated artificial agent based on the interaction with an external representation of a developing design to bridge the gap between the user's interpretations and the designer's intention. That is, the AI agent's role is to link clients, designers, and design artefacts, record the process and bridge the gaps. As shown in Figure 2, the client select the product and the AI agent records the product selection process, analyses the client's needs and preferences, delivers them to the designer, and recommends elements that meet the needs and preferences. The designer interprets the client's needs and expresses them in his or her design style. The AI agent learns the designer's style, which means the way he or she solves a problem with design in a particular situation, and recommends elements that fit the designer's style in the next similar situation. In other words, in our study, the AI agent will serve as a surrogate that bridges the gap between the client's needs and preferences and the designer's style.
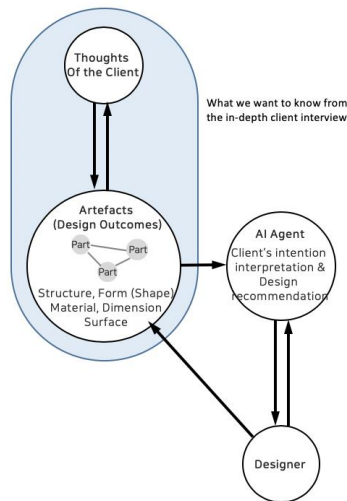
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Figure 2. AI agent model

From the perspective of Double Diamond Design Process (Design Council, 2005), the AI design agent understanding the intent and preferences can be the first diamond step towards defining problems while the second diamond step would involve using its existing knowledge of the designer's style to develop element propositions that can be used to create the design outcome. In doing so, the agent can also adapt, learn and improve itself for future tasks. In the age of AI, designers will have to go to a higher creativity level than imitation or rearrangement of existing elements through collaboration with such AI agents to inspire their creativity. An AI design agent model is different from the AI tools that suggest design outcomes based on the choice of the client and the use of probabilities of existing data. In this study, as shown in the blue area of Figure 2, we focus on the process of how the client select the artefact according to his or her thought and how the artefacts influence the client's thought.

3. Purchasing process as understanding client

The clients' needs and preferences can be identified in various ways. Observing the product in use, interviews, focus groups, surveys, and other methods can be used in the design process to identify clients' needs (Ulrich and Eppinger, 2015). In the participatory design process, designers and users interact closely through interviews, focus groups, workshops, organizational games and prototyping sessions (Spinuzzi, 2005). Alternatively, an interview with a field sales force can be used to understand the clients' needs or preferences (Ulrich and Eppinger, 2015). Gero and Kannengiesser (2004) suggested an FBS ontology framework and modelled designing in terms of three basic classes of variables: function, behaviour derived or expected to be derived from the structure, and structure. In this view, the goal of designing is to transform a set of functions into a set of design descriptions. Tjalve (1979) described design as a process of determining the structure, form, material, dimension and surface of a product. To determine the design descriptions, including the five properties, the designer should interpret the clients' needs and preferences, including functional and appearance, and reflect them in design. Let us imagine the various ways of understanding the client's needs and preferences from perspective of the agent of our study. If you can easily draw a sketch or make a prototype, you can use concept sketching or mock-ups to identify the five properties that your client wants to design. Alternatively, if you have various related products, you can show them to your client like a store clerk and find the one that best matches the five properties your client wants. Therefore, the most important thing to an agent is to identify the five properties of a product that fit the client's situation and context and suggest the most appropriate product. Online companies often use services that recommend products highly relevant to the products that the clients scrutinize and the purchase history of clients. For example, Amazon offers individualized recommendations to users based on the historical data stored in Amazon S3 and the streaming data that are sent in from users' applications (Amazon Web Services, Inc., 2019). However, finding or recommending related items like those the clients have searched is different from determining appropriate product properties based on the clients'

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needs and preferences. In other words, this study focuses on providing a personalized product that meets the needs and preferences of each client. If there is something that is perfect for the client, the AI agent can find it. If there is not, designers will design it based on the clients' needs and preferences provided by the AI agent.

Many studies on customer experiences have focused on the influence of prior customer experiences, social environment, information processing, involvement, attitudes, affective processing, atmospherics, and consumer attributions (Puccinelli et al., 2009; Verhoef et al., 2009; Lemon and Verhoef, 2016). Such an external focus on customers has been the domain of marketers while the internal focus on product has been the domain of designers and manufacturers (Herrmann et al., 2000). To bridge the gap between customer needs, customer satisfaction, and products, it is necessary to have a deep understanding of the clients' process of selecting a product to design a product that would fit his or her needs rather than an ordinary product. Therefore, this study analysed purchase process data obtained from a in-depth interview to find out the role of an AI agent in grasping client's needs and preferences.

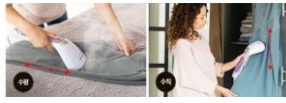## 4. The pattern of selecting product

A good agent can recommend a product that fits the situation well. In other words, it is important to present the stimuli that can express the client's intent or preference. A good designer or salesperson is an agent who presents these stimuli well through sketches, prototypes, or products. Zhang (2018) and his team at DigitalFUTURES Shanghai 2018 workshop suggested an AI design concept, "God of Design", which helps clients define their design goal more clearly by showing them infinite design schemes generated by AI based on the colour, style, and reference images the clients have selected. In the decision-making process of purchasing a product, the client selects the required functions and the preferred forms by his or her thoughts and the references which the thoughts are referenced to . Therefore, a pilot study is conducted to understand the role of the media (i.e., product photos, product reviews, and the environment of one's home) that stimulate and influence the client's intent during the product purchase process and collect the basic data for creating an AI agent model.

We interviewed a 26-year-old female who bought a steam iron online in Oct. 2019 and was not involved in the research at her home where she would use the product and we reviewed her decision-making process of purchasing. Through an in-depth interview, we recorded and analysed the process of collecting product information, selecting alternative products, and making a final decision.

The interviewee was taking the winter clothes out from the clothes storage box because it was getting colder. She realized that the coats were wrinkled and smell musty because of the moisture. Then she searched the Internet and found that the steam iron was able to solve her problem by eliminating wrinkles and sterilizing at the same time. Therefore, she decided to buy a steam iron.

After searching for the related products in an online shopping mall, she found that basic irons come in a standing form and hand-held form. Because of the limited space in her home, she needed a steam iron that does not take up much storage space and can iron without ironing boards, so she chose the hand-held steam iron as the basic form. Then she selected three handy steam irons with reasonable prices and many reviews as the alternative products, compared them, and finally bought one of them. To select the method of analysis, we referred to Crilly and his team's research (Crilly et al., 2008). Designers and clients may interpret the product differently because of diverse experiences, beliefs, motivations, expectations, capabilities, and cultures. Therefore, Crilly et al. suggested a communication-based model of design which elaborates how the artefact mediates between the intentions of the designer and the interpretations of the consumer. The designer expresses his or her intentions by presenting photos, sketches, prototypes, and the like, to the client, and the client gives feedbacks and may change his or her intentions because of the influence of these artefacts. In our study, the AI agent played the role of the designer and presents artefacts to the client to identify the client's intentions. The process of selecting, comparing, and purchasing the steam iron and the thoughts of the interviewee are summarized in Table 1. In the table, we also present the artefacts that influenced the thoughts of the interviewee during the purchasing process. Although the artefacts that influence decision making are presented by the online store or the agents that have the information of the products such as product reviews at present, they will be presented by the AI agent in our further study.

Table 1. Analysis of selecting, comparing and purchasing a steam iron by the interviewee

No.	Steps	Thoughts of the Interviewee (as a Client)	Artefacts that influence decision making (provided by agent)	Type of steps
1	Find a problem	*I wanted to wear the winter clothes and took them out from the clothes storage box, but they were wrinkled and smelled musty because of the moisture.*		🟠 Client's action
2	Search on the internet to find the solution	*I Searched on the Internet and the steam iron seems to be able to solve the problem by eliminating wrinkles and sterilizing.*		🟠 Client's action
3	Define the basic function	*It can eliminate wrinkles, sterilize. And I can iron my clothes quickly and easily with it before I go out on a busy morning.*		⚪ Client's need
4	Search products in online stores	*There are steam irons of regular form, standing form, and hand-held form.*		🟠 Client's action
5	Basic components	*My room is small. I want an iron with only basic components without ironing broad, stand frame, etc.*		🟢 Product structure
6	Decide the basic form	*I chose the handy steam iron because it does not take up much storage space and can iron without ironing boards.*		🟢 Product structure
7	Select and view Product 1 (Philips GC299/48)	*It looks pretty and has many product reviews. It can satisfy my basic functional needs*		⚪ Alternative product
8	Appearance	*The design is stylish and the colour is pretty.*		🔵 Advantage
9	Portability	*It's small and light so I can put it in the luggage. But personally, I do not travel a lot, so I do not need the portability very much.*		🔵 Advantage
10	Capacity	*I saw a review said that the water tank is so small that it needs to be filled twice to iron one shirt.*	& reviews	🔴 Disadvantage
11	Safety	*The iron does not seem to can be stood. The heated steam head may be a danger factor if placed somewhere while ironing.*		🔴 Disadvantage
12	Think about Structure 1	*Similar products with Structure 1 seem to have these problems, so I'm going to look at other types of products.*		🟢 Product structure
13	Select and view Product 2 (HAAN HI-850RD)	*The product has many reviews. And it can satisfy my basic needs.*		⚪ Alternative product
14	Capacity	*250ml, much larger than product 1. It is said that you can iron five shirts once.*		🔵 Advantage
15	Weight	*A review said that it is will be too heavy if you full the water tank.*	Reviews	🔴 Disadvantage

16	Changeable water tank	*The water tank can be changed to a common PET bottle. But I'm not sure why I need to change it. There seems to be no such need for me.*		● Advantage
17	Safety	*If you change to PET bottle, it does not seem to be able to stand well, and it will have a similar safety problem as Product 1.*		● Disadvan-tage
18	Think about Structure 2	*Although it seems to fit my needs better than Structure 1, I'd like to explore other Structures of products.*		● Product structure
19	Select and view Product 3 (Bomann DB8230)	*A product with many reviews. And it can also satisfy my basic needs.*		○ Alternative product
20	Capacity	*200ml, smaller than Product 2, but I think it is enough.*		● Advantage
21	Safety	*It seems to stand well and be safe to use.*		● Advantage
22	Form	*It looks cute.*		● Advantage
23	Colour	*I hope there is more choice of colour as Product 1. The colour scheme now seems a bit cheap.*		● Disadvan-tage
24	Think about Structure 3	*Products with Structure 3 seem satisfied most of my needs, so I found some more similar products.*		● Product structure
25	Decide to purchase	*I decide to buy Product 3 that meets the main needs and has a reasonable price.*		● Client's action

5. Linkography analysis

Linkography is a protocol analysis method developed by Goldschmidt (1990) that codes and visualises the links between the 'design moves' expressed during an ideation session. Goldschmidt (2014) described a 'design move' as '*a step, an act or an operation in the process that changes the situation*' and 'Nodes' denote '*a link between two design moves assessed through a process of judging whether each move is linked to any other move that precedes it*'. Linkography is used to analyse designers' cognitive activities by graphically representing moves and the links between them. We can easily find the relationship between each step of decision-making though the Linkography. And it can intuitively express and quantify the designer's intentions in the design process and can be converted into code that AI can understand. That is, it will be useful in our future study of developing the AI design agent.

Just as a designer starts with a problem and solves it through design, a client as a consumer encounters a problem and then tries to solve the problem through the purchase of a product. A client starts with the basic process of problem-solving, looks up product information, compares products, gets a clearer idea about what he or she wants, and finally chooses a product that meets his or her needs. In other words, the client's purchasing decision-making process is similar to the designer's design process. Therefore, we generated the linkography of purchasing decision-making process as shown in Figure 3. The linkography was produced by the first author and arbitrated by the second author who was not previously involved in the interview. Our approach to generating the linkography was founded upon the guidelines outlined in Goldschmidt (2014). In addition, to identify the pattern of the purchasing decision-making process, as shown in Figure 3, we coded each step of the process into linkography moves classified into 6 types (client's action, client's need, product structure, alternative product, advantage and disadvantage) based on the data in Table 1.
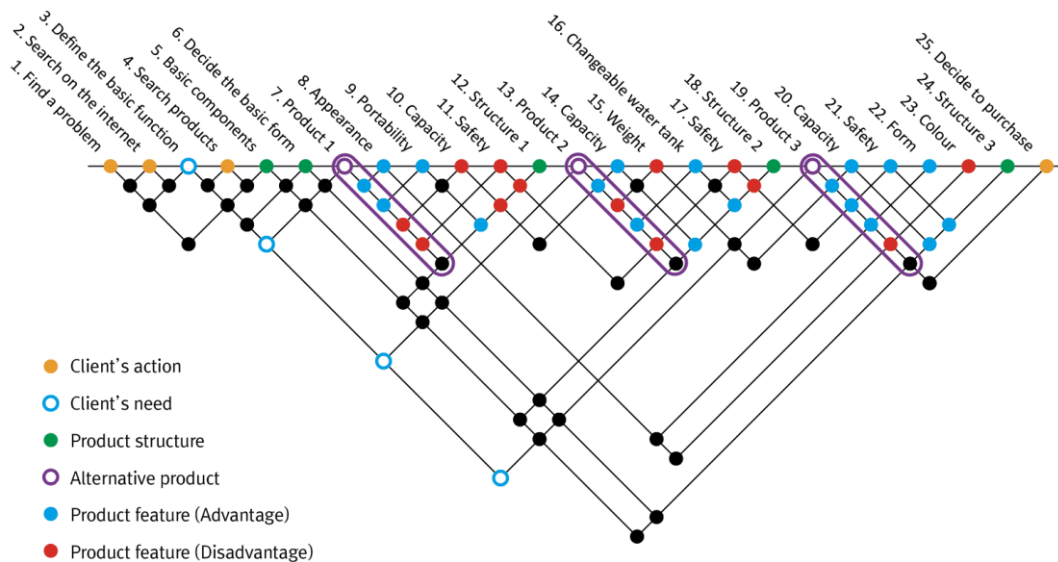
Figure 3. Linkography of purchasing decision-making process

The blue dots represent the products' advantages, and the red dots represent the disadvantages. Product 1 has the advantage of good portability (move 9), which results in the disadvantage of having to add water frequently during ironing (move 10) because of the small water tank capacity. The advantage of product 2's large water tank capacity (move 14) results in its heavyweight (move 15), and the advantage of the changeable water tank (move 16) may cause a safety problem (move 17). In other words, the factors of portability, large water tank capacity, changeable buckets, and safe use have some benefits and drawbacks. The patterns depicting the relationships between these pros and cons of each feature, as shown in Figure 4, can be found in the linkography in Figure 3.

Figure 4. The patterns of the contradictory needs

During the selection process, an AI agent records the client's product selection process and find the patterns, as shown in Figure 4, and then presents the relevant artefacts to find the balance of the contradiction. For example, it shows the relationship between the capacity of the water tank, the number of clothes that can be ironed once, and the weight of the product after filling water.

Among the contradictory needs, the interviewee chose to increase the capacity of the water tank rather than the portability and selected the product 2 as an alternative product. However, due to the large capacity, the product became too heavy to use, so the capacity was reduced again and Product 3 was selected. Figure 5 shows the process of finding a balance between these contradictory needs.

In the process, the AI agent continues to find the product that meets the consumer's changing needs and delivers the final result (final blue dot) to the designer.
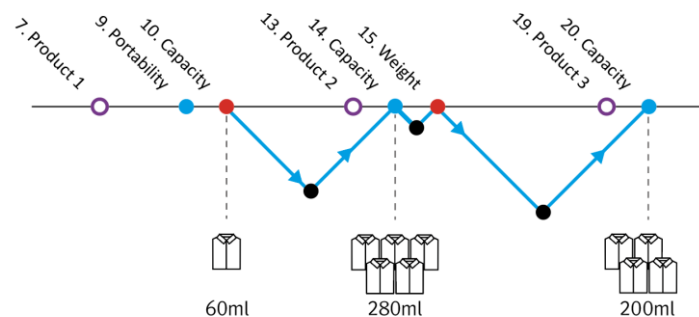

Figure 5. The process of finding a balance between capacity and weight

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Another disadvantage of Product 1 is that it cannot stand upright and the heated steam head could be a danger factor. The interviewee found a new problem, safety, which she did not think about when looking at the product image but started to pay more attention to it when she viewed Product 2 and Product 3. Product 2 looks unstable when the water tank is replaced with a PET bottle, and Product 3 can stand well. Figure 6 shows the process of finding a safer product based on the product images presented in the online shopping mall. As shown in Figures 5 and 6, the process starting at the red dot (disadvantage) and arriving at the final blue dot (advantage) means that the product that satisfies the client's need is finally found.
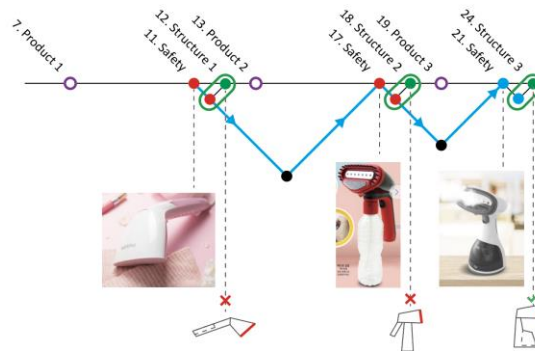

Figure 6. The process of finding a safer product based on the product images

The AI agent recognizes the red dot (disadvantage) in this process and highlights the relevant information in the next recommended product. When a consumer marks the relevant information with a blue dot, the information is recorded. For example, as shown in Figure 6, the AI agent recommends a product with a different structure from Product 1 in response to the safety issue. The safety property of product 3 is marked with a blue dot so that the AI agent records the relevant image and the structure of Product 3 and then recommends other products with a similar structure.

Finally, although the interviewee had some dissatisfaction with the colour, she decided to buy Product3 that satisfies the main needs, has good reviews and is reasonably priced.

After using the product, the interviewee found a new problem, realizing that it is difficult to fill the water tank. Hence, she had a new need, which was to improve the connection structure of the water tank and the body. The final needs, including the new one after trying out the product and other needs recorded in the purchasing process, were extracted and reorganized, as shown in Figure 7. The yellow part of Figure 7 shows the interviewee's final needs for the product that she wants.
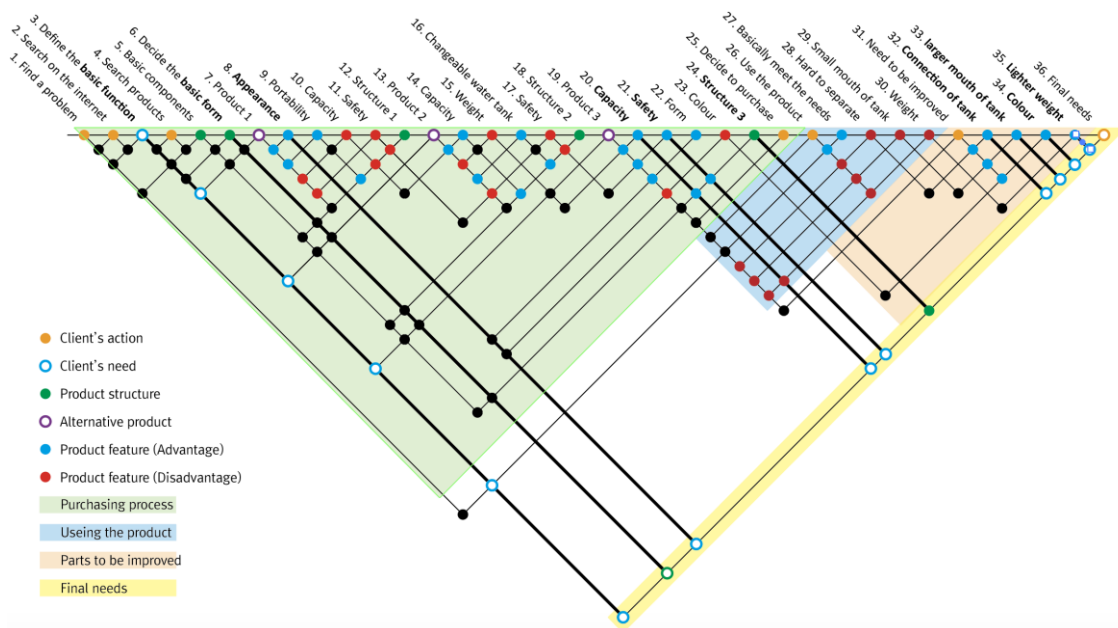

Figure 7. Reorganizing client's needs after using the product

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Through reorganizing the needs derived from the pilot study, we could identify the parts of the current product that needed to be improved. It should be easy to separate the water tank from the body. Maybe the designer can add some mechanical structures to the connection part or change the surface of the water tank to increase the friction between the hand and the water tank. The water tank should be easy to fill with water and easy to clean; therefore, the mouse of the water tank should be larger. The product did not satisfy the client's need for colour, so the new product should be more colourful, like Product 1.

6. Conclusion

In this study, we conducted an in-depth client interview and analysed the purchasing process through the method of linkography to find the relationship between the client's intentions and the artefacts presented by the agent.

This study yielded two important findings for developing an AI design agent. The first is that, as shown in Figures 4, 5, and 6, we found the relationship between the decision patterns and the artefacts that influence the client's intent and preferences that the agent presents in each step. Second, we found that the design descriptions (structure, form, material, dimension, and surface) of a product that the client needs can be defined after he or she selects and uses it through the analytical method that we used in this study. We can suppose that the AI agent can help define the design descriptions based on the same analytical method.

The AI agent that we want to develop in our future study is shown in Figure 8. The AI design agent interprets the client's intention though analysing the artefact selection process and presents the artefacts that may influence the client's thought in the next step. The properties of the product that the client desired can be revealed according to the client's feedback to the artefacts presented by the agent during this process. The process is repeated until the five properties of the product can be defined. Though this process the data of the client can be accumulated and the designer can clearly know what the client wants though the AI agent.
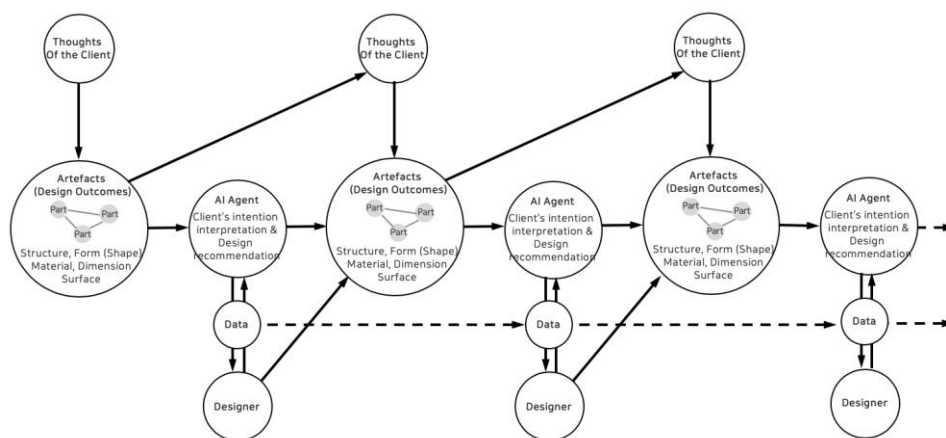

Figure 8. AI agent model in our future study

Considering that customized manufacturing with 3D printers and virtual products used in VR space may become trends in the future, the AI design agent will be a very useful tool for designers. Therefore, this study is meaningful in that it can guide the development of the AI design agent that help designers to identify the clients' needs and design customized products. However, at present, we analysed only one product in depth. We will replicate the relationship between the decision-making process and the artefacts suggestion method to help decision making by analysing the purchasing process of various other products in the future, and we will conduct follow-up studies to more systematically organize the pattern and the process of determining the five properties of the product.

Acknowledgement

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