DYNAMIC HUMAN-CENTERED DESIGN: REINVENTING DESIGN PHILOSOPHIES FOR ADVANCED TECHNOLOGIES

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ABSTRACT

As technology becomes more advanced and saturated in various industries, the role of design becomes equally significant. Traditionally, human-centered design (HCD) has been the main creative approach for the design decisions in numerous applications. However, the role of HCD within the technology raises concerns. This paper examines the design philosophy of the HCD in parallel with rising technologies, specifically artificial intelligence and machine learning systems, and explores the implications of utilizing a more dynamic approach. With HCD, much of the considerations are determined through user research; the dynamic HCD approach is introduced to accommodate the different units of analysis presented by advanced technologies to create more streamlined designs that support and accelerate technological innovation.

KEYWORDS

Human-computer interaction, human-centered design, artificial intelligence

1. INTRODUCTION

Technology is at a critical point where improvements result in significant effects on real-world applications. With advancements such as artificial intelligence (AI) and machine learning paired with big data and analysis, most of the current technologies will drastically change in the future. Such examples include assistance software such as Amazon's Alexa, Apple's Siri, or Google Home; introduction and competition to perfect autonomous vehicles; and reformation of healthcare operations, procedures, and equipment. The role of design is similarly becoming equally significant; however, these technologies are not fully utilized unless they are provided to the users in a practical manner [1].

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In exploring design directions, the human-centered design (HCD) is one of the most widely adopted creative approaches used by various industries. As the role of the HCD is evaluated against today's technology, the related concerns become more apparent. This study explores these shortcomings and offers solutions that address the ever-changing nature of technology. The present research aims to expand on the current design philosophies to go further than designing for a single part (i.e. the user) and considering all the factors and units of analysis. Such action is reasonable, because given our understanding of cognition and the theories of how human cognition works, we rely heavily on all parts of a culturally-complex system. Considering just the user is insufficient; instead, we must explore the interactions among all agents of the system [2]. Not only will this research examine the user to improve the lifestyles and economies from accelerated innovation, it will also provide more accurate and streamlined use of the products through removal of bias and explain ability, as described later.

2. HUMAN-CENTERED DESIGN

2.1. Role

Don Norman introduced the HCD approach as a solution to the repetitive problems faced by new technologies and applications. Norman stated that, "HCD puts human needs, capabilities, and behavior first, then designs to accommodate those needs, capabilities, and ways of behaving." [3] HCD is therefore a design philosophy that was created to focus on user needs. HCD has also apparently aided the industries of today: products have been refined or redesigned with improved user flow. The design and use of technology matter just as much as the functions themselves.

Although a fairly commonplace approach for much of the designs, the HCD can be subliminally observed in numerous applications today. In technology and product applications, any design direction that emphasizes and utilizes user research and analysis is essentially applying the HCD. For example, the smart phone gestures and functions are programmed according to the abilities of the user and the affordances of the device. The Figure 1 shows examples of common finger gestures for smart phone applications. These examples are designs that use the HCD approach by accommodating affordances of the device and abilities of the user.

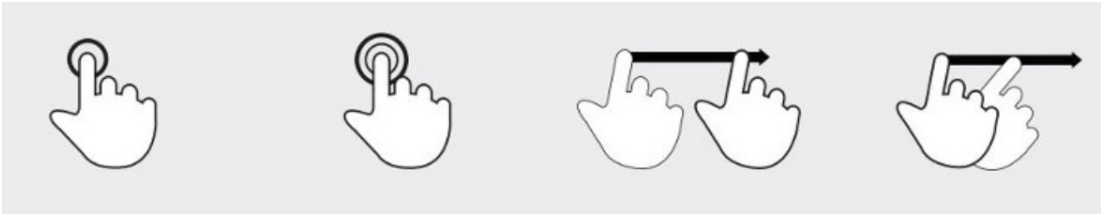

Figure 1. Example of common finger gestures for smart phone applications.

In terms of the interface design, the weight is shifted more for the operators and decision-makers to reduce the human errors. Examples include the cockpit displays. Other examples include the areas of decision-making or operating procedures, as observed in command center areas for military personnel or dispatch centers. The basic planning for situations is considered with the users in mind (who will take part in the decision-making?) and determining their needs (what do they need to know?). The Figure 2 shows the navigation team aboard a navy. The bearing recorder is in the foreground. The plotter is to the left. The interaction among the people on the team is a result of the HCD approach from the planning and operating procedures [4].

Figure 2. Navigation team aboard a navy.

2.2. Shortcomings of the HCD

When the HCD is applied to technologies such as AI, various existing implications can result in negative outcomes. Although the HCD is practical in the sense that it is a design philosophy that can be applied to various industries, it is also constrained by that very idea; Norman referred to this condition as hitting the local maxima, that is, not knowing how to adapt beyond the user [5]. When reflecting on the HCD on applicable technologies today, the concerns may include the following:

(1) The HCD may provide the users with what they want, but this step may not necessarily be the most optimal improvement. In the past, technology was simple enough with a limited understanding sufficient for use. In those cases, the challenge for users lay more on the user journey and interaction. With technologies such as AI, the users face difficulty in comprehending their potential. Therefore, the intelligent agent needs to be technically designed without the extreme consideration for the users. In this manner, HCD and its reliance on the user research and analysis inherently constrains the technology itself.

(2) An imbalance exists between the users. Considering all the users for features or products—essentially the units of analysis in terms of distributed cognition—the values and differences among the users are inexplicable. For example, for a product, the users may include the general consumers, businesses, clients, and shareholders. With cases regarding AI, long-term goals and business decision-making might be more beneficial than centering around the general consumers. Therefore, the units of analysis expand to strategy, economic benefit, and company influence. In the industry, a perpetual struggle exists between the designers and players, such as the engineers or corporate stakeholders. This situation is a concern that influences design direction.

(3) The HCD focuses not on augmenting technology nor inhibiting innovation. That is, we do not say that a human-centered approach is fallible, but rather that it may be inadequate. With HCD, the focus on its users deviates the attention from the technology itself. As the designers focus more on iterating the interactions between humans and computers, equal efforts must also be spent on improving the technology. For advanced technologies, such as AI, HCD may be a limitation to the maximum potential of the intelligent agent.

(4) The HCD is very much based on past experience and interpreting the future based on these past ideas. When paired with big data and analysis, the focus on these things indicates that the designers are constantly correcting past problems; they rely on past records to determine the future. Although correcting the problems necessarily improves the products, the designers should also consider the future implications of their designs. Much of this concern

originates from the understanding of technology and making decisions according to the technology and not the users.

(5) The HCD considers empathy and designs for the emotions of the users but fails to inspire unique qualities for the technology itself. This consideration is not much of a concern than it is an inconsideration of the true values of advanced technology and what it offers for the users. The bounds of technology should not only be explored but also examined in a manner that makes the technology unique.

An example of the limitations of the HCD can be observed in Apple Health, a health monitor and fitness tracking application. Here user data is gathered but not explained; generic and short videos which relate to a patient's overall health are shown instead. However, the patients are not individually assessed. For example, one video focuses on the activity and how exercise benefits the body but fails to address the particular individual's needs. What if the specific user suffers from medical or physical conditions that render him or her incapable of exercising? The videos would fail to supply practical information. The Figure 3 shows examples of a health monitor application that fails to provide explanations according to the patient data.

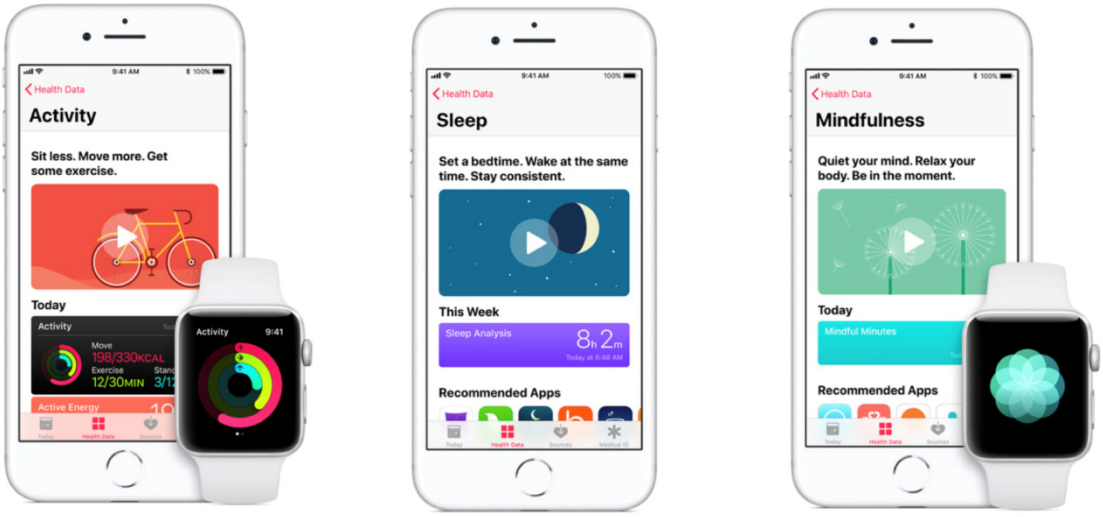

Figure 3. Example of a health monitor application.

The advanced technologies, such as AI and machine learning, can use gathered data to determine the best approach for such specific individual. However, failing to consider technology as a unit of analysis, the design of the product may not provide the user with the most optimal solutions.

If the AI played a greater role in the development and design of Apple Health, the application itself would be able to recognize user limitations, per his or her medical history and current state (through vital signs), and use the analysis to provide the individuals with a more tailored solution to improve user health.

3. DYNAMIC HUMAN-CENTERED DESIGN (DHCD)

3.1. Authors

The DHCD provides an improved approach for the concerns of the HCD. By focusing not only on the users themselves but also considering the potential of technology, the designers can remove the limitations otherwise presented. DHCD is less about shifting from a user-centered approach

than simply but deeply examining all the elements of the advanced technology. The question transforms from, “What do users want?” into “How do we augment the lifestyles of all users while best considering the abilities of the product?”

The implications of refining this approach would mean accelerating innovation and deeply considering otherwise big-picture concepts, such as long-term economic stimulation and empowering human civilization. The specific changes may include removing bias from the data from artificially intelligent agents or improving the explain ability by interpreting the analysis in a more functional and correct way, as described in Section 4.

3.1. Theories of cognition

The development of the DHCD approach originates mainly from the theories of cognition such as the en activist view and distributed cognition.

3.1.1.Enactivist view

The en activist view argues that cognition arises from the dynamic interaction between an acting organism and an environment [6]. If the users are the acting organisms, the environment may consist of tools and cognitive artifacts, which are designed for the users themselves, in place today. These artifacts deeply impact user cognition and therefore shape interaction and future development [7]. Several artifacts may be internal or external representations and may be considered as currently existing technology, including something as simple as a hammer or prescription glasses. AI would also be considered another representation. With this logic, when designing and reshaping the technology for what it is, one must absolutely consider more than the users as acting organisms and also infer on the environment and the products and technology available because these factors directly affect the human cognition [7].

The interaction between the acting organisms and their tools and artifacts rest on the concept of affordances—what the objects provide, offer, or furnish—for the organism, for good, or for ill [8]. These affordances influence design decisions. In terms of the technology, understanding these affordances comes from a deeper knowledge of the potential of these advanced technologies.

3.1.2.Distributed cognition

The DHCD approach may very well be an expansion on the ideas of Edwin Hutchins regarding distributed cognition. The fundamental premise of distributed cognition involves the idea that cognition emerges from the interactions among the elements of complex systems [4]. Although the HCD relies on the acting organism side of enactivism, the DHCD’s role lies in its considerations for these elements. The Figure 4 shows an example and model of distributed cognition as represented by the cognitive scientist Taylor Scott.

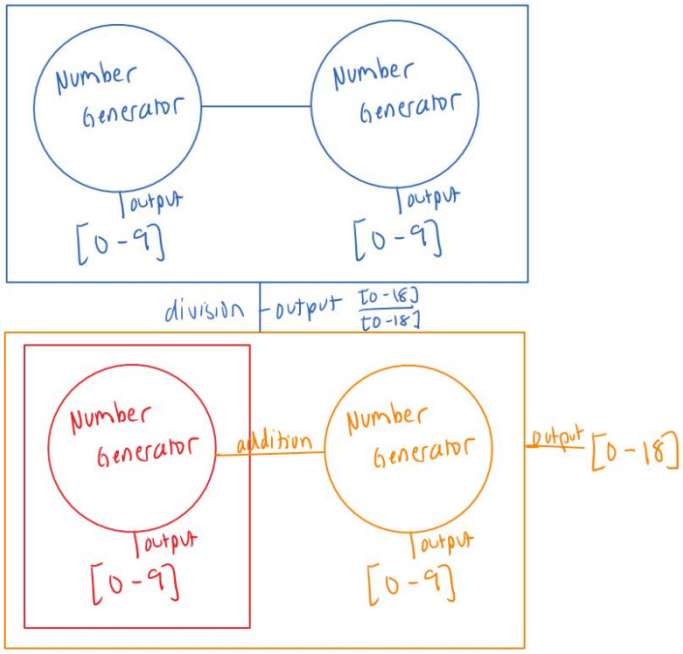

Figure 4. An example and model of distributed cognition.

The above representation presented by the cognitive scientist Taylor Scott from the University of California, San Diego, illustrates the benefits of utilizing the distributed cognition framework for applications other than the individual unit of analysis.

David Kirsh, a pioneer of distributed cognition, stated that, “If we can understand how individual people engage their environments, how they appropriate artifacts, how they rely on material aspects of their activity space to help them stay in control, to manage thought, perception, and choice, then perhaps we can begin to put these individuals together into larger socio-technical systems” [9].

The cognitive artifacts that make up our socio-technical systems all contribute and influence culture and thought [10]. By considering these factors, we can find useful qualities in various agents and alter them to influence the design and planning of future technologies. Hutchins [11] and Marvin Minsky [12] also support this notion by proposing a direct consideration from the extended mind to cognition in cultural–cognitive ecosystems [13].

3.2.Value-based approach

The DHCD should contain variable weights that determine the true value of each element considered during the design process. Thus, the areas emphasized by the DHCD would differ for each project. For example, in terms of user interface design, more weight may be put on understanding user psychology and preferences. For AI, more weight might better serve the analysis, interpretation, and explain ability of data.

To expand on this approach, storytelling becomes heavily important for artificial intelligent agents. These agents rely on specific datasets to accomplish accurate outputs. However, the outputs are rendered useless if the information cannot be conveyed in a meaningful way. In this way, the DHCD allows the designers to not only focus on the users but also on interpreting the data that are most similar to the conclusions.

4. DHCD APPLICATION TO AI

4.1. REMOVAL OF BIAS

When applied to advanced technologies, such as AI or machine learning, the DHCD expands the units of analysis from distributed cognition and provides significance to elements such as bias in data.

As the accuracy of AI output is hugely based on data, the data selection becomes fundamental in determining the overall direction. Each selection of data infers certain biases depending on the product goals. For HCD, the approach would be to determine the data points that yield higher accuracy according to the user needs. However, this condition increases bias and although it may sufficiently provide for what the users want, it may not be helpful for the goals of the company or the lifestyles of the users.

For example, when applying AI in the healthcare industry, a product may be available to predict future medical risks for obese individuals. This application will be based on a variety of selected data, such as the individual's weight, health and fitness levels, vital signs, family history, and medical history. However, the data selection includes bias for these individuals when determining the medical risk.

If a certain level of medical risk is determined, then the risks are based solely on these factors alone when truthfully, risks for obese individuals may also depend on demographics, environmental conditions, and workplace stress levels, to name a few. These factors may be the outside bounds of the user but may heavily impact the goals of the product. The DHCD aims to empower AI by considering the ideas outside of the unit of analysis of the user in industries such as healthcare [14].

4.2. Increased explain ability

The concept of explainability is another potential solution when applied to AI. As the designers need to create representations that convey the information the artificial intelligent agent produces, the information should not be lost in translation and should be insightful.

Simply sharing an output is insufficient because such action may not result in a direct effect on the users. Instead, the analysis and interpretation of the information provide users insights into their understanding of the product.For example, an application regarding obesity and medical risk, insights would interpret all data points, provide an assessment, and also advise the user on how to improve the individual's lifestyles in a way that addresses the specific category of the data at fault. A specific instance of this example might be that an individual's increased medical risk is due to environmental factors, such as air quality and stress level. An HCD approach might simply advise the user that these factors may distress the physical condition of the individual. A DHCD approach would not only evaluate this condition but also explore methods that would truly aid the individual, reinforcing the storytelling aspect and essentially designing for what the users need and not what they want. Emphasizing the variables that are more or less outside the domain of the user may improve the user's situation. The design of representations must be considered when utilizing AI [15].

4.3.Example of a the DHCD approach in complex systems with data-driven technologies

When considering the design approach for the National Taiwan University's Medical Bioinformatics Lab, DHCD is valuable when determining the direction for the Precision Medicine project. With the ultimate focus on utilizing data for analysis and implementing AI and machine learning to predict medical risk and assessment, the significance of the project lies not only on the user journey and how the technology is used but more on how the analysis obtained from the AI evaluations are used to determine the results. For example, this approach was considered when prototyping the user interface of a dashboard for caregivers (Figure 5).

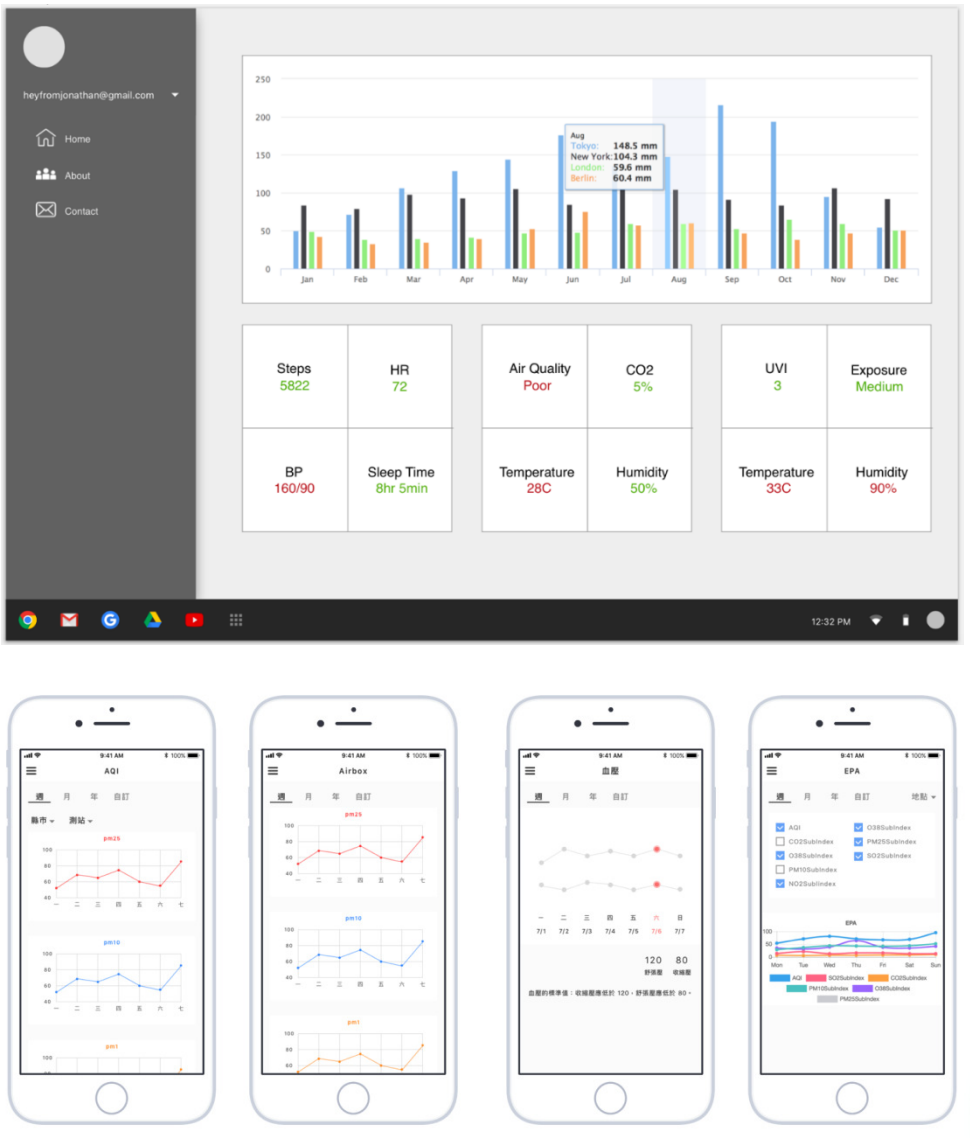

Figure 5. Example dashboard design that utilizes DHCD.

In the user interface prototype shown in Figure 2, the analysis is represented in a way that supports the correlations drawn from the data gathered. By using interactive buttons, charts, and graphs, the user data are retained and the user journey remains efficient and human-centered. As

for the medical risk and prediction, the user can easily determine where the risk might originate according to the color schemes.

The achievements of modeling user experience and interface from the considerations of the DHCD include the streamlined use of web applications. Sorting through datasets becomes easier with more interaction, where correlations and trends are more easily recognized. The economic implicationsshould also be recognized. The caregivers and healthcare workers are more available to attend to patients instead of managing their collected information, including vital signs and medical history. This type of work is replaced by intelligent agents that can collect and analyze data. Future implications regarding artificial intelligent work concern accuracy and how, by considering all the factors of data, the artificial intelligent agents can increase their accuracy in predicting medical risk.

5. CONCLUSION

The DHCD approach aims to shift the design philosophies for players in the technology industry to accommodate advanced technologies. By exploring the role and concerns of the HCD and evaluating them against the theories of cognition, we determine the importance and methods of how to feature the technology in way that augments user lifestyles. This importance creates a more dynamic approach - one that considers all elements within a system and assigns weights accordingly - to shape the product into something that supports and augments human life. Although the HCD approach is sufficient to perfectly apply technology, new considerations must be explored when advanced technologies are involved.

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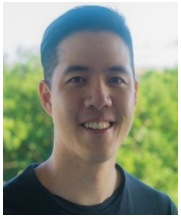

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