Empathy building by feeling present with riders at a distance

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Digital Twins are becoming commonplace in some industries but are not well integrated yet in the cycling industries, despite promising potential. Existing user research methods hamper the realization of Digital Twins, therefore in this paper a new method is conceptualized. The conceptual method consists of capturing experiences and feeding this experiential data into a Digital Twin, which designers can use to empathize with bicycle riders at a distance. Building on novel measurement methods and a virtual representation of a physical experience, the aim of the method is to investigate whether such Digital Twin helps designers to build empathy with end-users. For the capturing of experiences part, ideation and prototyping was conducted using a wearable wristband which can measure physiological variables. For the Digital Twin part, a concept was developed. Next steps are to feed the captured data into a Digital Twin, and to develop a sensory actuation system. The latter will be needed to stimulate senses of designers, so that they can get closer to the experiences of the users they work for and thereby increase the chance that their designs meet user needs.

CCS CONCEPTS • Human-centered computing ~ Human computer interaction (HCI) ~ Interaction paradigms ~ Mixed / augmented reality

Additional Keywords and Phrases: Digital Twin, smart connected bicycles, evaluation method, mixed reality

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1 INTRODUCTION

The research project Smart Connected Bikes aims on developing the cycling ecosystem, by leveraging innovations in areas such as data driven design, digital twins, and artificial intelligence. Specifically, the project aims on developing digital twins which can help designers to facilitate better cycling experiences. Existing literature on digital twins and user experience design offers limited knowledge on whether digital twins can be used for building empathy, while empathizing with end users has been articulated as key to success in design [14]. Furthermore, it can be argued that traditional user research methods such as interviews and surveys are only partially suitable as data gathering methods for digital twins. This may be related to the actuality and richness of such data, which is relatively small compared to live biosensing and video streaming [15]. To mitigate these challenges in empathy building via digital twins, in this paper a conceptual method will be presented which can be explained as follows.

In essence, our conceptual method is aimed at understanding whether designers can make better product-service systems if they feel part of what cyclists are feeling. Feeling the same as what riders are feeling can be made possible by capturing data of experiences, by transmitting this data into a Digital Twin, and then by stimulating the designer's senses via an actuator system. There should be a mapping between the experiential data that is captured and the sensory stimulation that the designer receives. As a simple example, imagine a cyclist cycling over a rather rocky road. Accelerometer measurements could be taken, from which the a degree of rockiness of the road could be derived. Strapping a vibrating system to a designer's body can then be used for vibrating the designer's body. In this way, the rider and the designer can simultaneously experience varying levels of road conditions. A more complex scenario could entail that a rider's skin conductance values are transmitted to a designer who is wearing clothing with heating pads, so that the designer feels a slight increase in heat if the rider is cycling intensely.

As an analogy, the cyclist experience of for example rocky roads or strong headwinds could be described in words, and a designer could read such textual description. But such carry-over of experience can be considered quite limited: it is not live, there is no rich data, it is based on cognition and little on embodied experiences. Therefore, we find it worth investigating if feeling almost-the-same can increase empathy and thereby build better product-service systems. The next sections conceptualize respectively the Digital Twin, the capturing of experiences, and the experience of the Digital Twin. We conclude by recommendations on future work, which include inspiration for other knowledge domains in which would be needed to bring the concept of empathy over a distance into reality.

2 DIGITAL TWINS

With the goal of supporting designers during design processes, we first dive into the concept of Digital Twins. The concept of Digital Twin is widely understood in manufacturing and maintenance [1,2] and it is being implemented in the development and mechanical design processes [3,4]. However, Digital Twins for industrial designers have not yet surfaced [5]. In the context of this paper, we take the view that a Digital Twin of a customer facing product should become a Digital Twin of the experience of the user. This means that a “Designerly” Digital Twin – which is a Digital Twin meant for use by designers focused on the user experience – can become a tool for user research. Designerly Digital Twins, as tools for user research, become then like Ethnography, Data Driven Design, and other design research methods.

	Small scale	Large scale
High fidelity	Entangled Ethnography	Designerly Digital Twin
Low fidelity	Traditional Design Research	Data Driven Design

Table 1 - Comparison of fidelity and scale of user research methods

To differentiate and explain the potential benefits of “Designerly Digital Twins”, we can take aforementioned design research methods and plot them in a matrix. See Table 1. The two axes that can help differentiate the methods are built on the promise that Digital Twins are exact copies of the entity that they duplicate [6]. Ideally, user research methods describe the subject under research on a high fidelity (exact copy) and on a high scale (each subject is copied). With “traditional design research” such as user interviews and focus groups, the fidelity is relatively low. Because in traditional methods, only elements the researchers note down or happen to record are captured. Additionally, the scale is low, as each capture of each experience needs to be done by one or more researchers. One proposed improvement on this is Entangled Ethnography, which means using probes that are Digitally Twinned to enable design researchers to capture, interpret, and inquire into their users’ experience [7]. This offers many of the same benefits of Digital Twins, however the scale is limited by Digitally Twinned probes. An approach that does operate at scale is Data Driven Design. By capturing and using large amounts of user data, designers can tailor designs to aggregate personas based on hard data. However, the data captured is often impersonal and static [8]. To these known limitations, we add the stance that especially the lack of embodiment reduces fidelity of the Digital Twin, because by embodying Digital Twins the designer can get a multi-sensory feeling of the data which in turn can help to get a rich understanding of the physical situation that is Digitally Twinned. In the section “UX of the Digital Twin” we elaborate on how we intend to realize that multi-sensory embodiment of a Digital Twin.

Now that the benefit of a "Designerly" Digital Twin has been established, implementation remains. Using the phases as defined in [4], the implementation of a Digital Twin for research is primarily focused on the Physical to Digital pathway. If implementation would be from digital to physical, then changes in the Digital Twin would initiate changes in a real product-service system.

First, the physical entity needs to exist, which in our context is embodied by a real cyclist using a real bicycle. While a user experience of a service is not strictly a "physical" entity, it is "embodied" in the world. Then this experience is captured through "metrology", described in next section. These captured experiences are then "realized" into the "virtual entity". See Figure 1 for a schematic model of this realization. Finally, designers need to be able to use the virtual entity in their design process efficiently – this will be described in the section "UX of the Designerly Digital Twin.

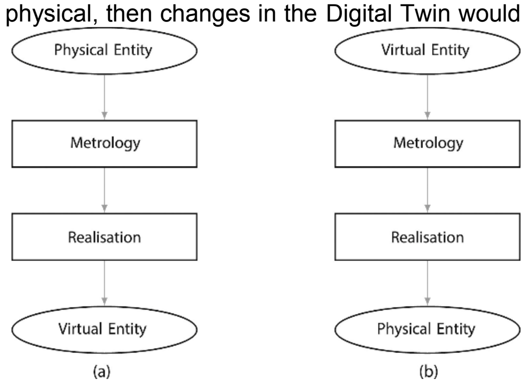

Figure 1 - The Physical to Virtual (a) and Virtual to Physical (b)

3 CAPTURING EXPERIENCE

With the Digital Twin model in mind, now it needs to be established how input for the Digital Twin will be gathered. This is where capturing cycling experiences comes in. Traditionally, user experiences were captured with methods such as interviews and observations [12]. We take the stance that for the realization of Digital Twins, two important disadvantages are visible in these user research methods That is, significant time delays occur between 1) the moment an experience of a research subject is captured and 2) the moment that the data of the captured experience can be accessed by other researchers. In addition, most research methods do not seem to include physiological data, despite the promising potential of such data which will be described in next paragraph.

Regarding data capture methods suitable to Digital Twins, wearable devices offer interesting potential for experimental purposes [9,10]. The availability of wearable wristbands and their potential of measuring relevant physiological processes motivated the research team to choose for experimenting with an Empatica E4 wristband. This wristband is developed by a company co-founded by Rosalind Picard, who proposed a theory of affective computing. Affective computing concerns the idea that digital systems may be able to sense, interpret and/or even "have" emotions [11]. This idea is relevant to Digital Twins and to empathy in design: cyclists have emotions, and when designers can feel the same emotions or at least part thereof they may be able to understand cyclists better than without these emotions.

The first experimentation with the Empatica E4 wristband proved to be useful. Tinkering with the wristband revealed that at least the following themes are important:

- System scalability: for 1 or 2 wristbands it would be feasible to process data manually, but for experiment setups with e.g. 300 test participants a technology stack offering automatic wireless data retrieval and processing would be needed. Expertise from other domains, for example embedded electronics and artificial intelligence, is needed. The conclusion section of this document will elaborate on this topic.
- Meaning of data and need of rich data: highs and lows in graph (Fig. 2) resulting from the wristband immediately raises questions: why did that happen? What triggered the research subject to change heartbeat and skin conductance levels? To answer such questions, data capturing would need to be enriched e.g. by user diaries, post-ride interviews and video footage as has been done in e.g. [13].
- Human factors: the wristband needs human involvement to function, e.g. for taking the band on and off and for charging. In large scale trials, it becomes important to investigate this matter systematically. Target audiences with particular needs, such as elderly people, need to be involved in the design process.

Figure 2 - Slice from an Empatica E4 heartbeat measurement. What caused the double peaks?

4 UX OF THE DESIGNERLY DIGITAL TWIN

Once the experience of the user has been captured, the next step is for designers to interact with that virtual representation. What the designer learns during that interaction, can improve the product-service system under investigation. While many insights can be gathered from virtual representations, they can be broken down into two types: understanding and empathy. Here we refer to understanding as the designer(s) grasping the context and objective factors surrounding the experience. We take Kouprie & Sleeswijk-Visser’s view [14]’s on empathy as designer(s) grasping the emotional and cognitive elements of the user during the experience. By focusing on these two insights, the designer gain insights into their user, context, and existing product-service systems, thereby creating the best possible input for the continued (re)design of the PSS.

However, creating understanding and empathy in the designer is not a trivial task. While an experience can be captured, how it is understood by the designer will make a world of difference. To increase the understanding of the designers, enriched and synchronized contextual data is crucial. Data from the Empatica E4 wristband is measured on a time scale (Figure 2), however, without some form of context, the reason and meaning behind these values is lost. Similarly, only having video data throws the designer into an ethnographic process where all video must be reviewed and the designer must rely on their own interpretation of the user's behavior. By synchronizing the data, designers may be able to find “interesting” moments (based on psychological responses), know what the reaction is in that moment, and have access to the context the user was in during that moment.

To increase the empathy generation of a virtual experience, it’s important to follow the four stages of empathy as discussed in [14]: Discovery, Immersion, Connection, and finally Detachment. While each stage has a plethora of potential methods that could support the process, we want to focus on the “Immersion” stage. Immersion is the process of “Wandering around in the user’s world, taking the user's point of reference” [14]. While this “Immersion” is not the same concept used in Virtual Reality applications (‘giving an enhanced sense of “being there.”’), we propose leveraging several of the ideas from that field in order to increase the feeling of immersion. The clearest method of increasing immersion is adjusting the levels of interactivity and fidelity.

A more abstract approach is the use of haptics to either replicate what the user feels, or even using sensory substitution to have the designer “experience” information about the user via a different sense. Indeed, this shift from a realistic replication of the user’s experience to a looser representation aimed at increasing the designer’s empathetic relation with the experience opens up the possibility of leveraging “presence” (The designer’s subjective response) in addition to immersion.

5 CONCLUSION & NEXT STEPS

We readily acknowledge that this project is far from complete. However, valuable inspiration can be drawn from the proposal. The main potential lies in investigating whether designers are supported in their design processes when they can experience a part of what research subjects are experiencing. This question is relevant due to the recent importance that is given to empathy in design and engineering [16,17].

Concerning future steps, we recommend the following:

- To make possible that designers can “wander around in a user’s world”, it would need to be explored how to enrich experiential data and how to build an immersive experience for the designer which enables for maneuvering through the user’s experiences.
- In the light of recent developments in opportunistic sensing [19] and biosensors [18], it may be valuable to evaluate whether the Empatica wristband and video footage are the most suitable combination to capture experiences.
- A cloud-based technology stack including data management and information architecture is likely to be needed. Also integrating Responsible and Explainable Artificial Intelligence may be beneficial.
- The sensory stimulation system for designers at the receiving end of the digital twin would need to be developed. Such system should be based on a mapping between “input experience” (the cyclist) and the output experience (the designer), so that the designer experiences sensations which are intuitively linked to the rider’s experiences.

We look forward to sharing this idea in the workshop and to learning from the field about related progress.

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