What We Talk About When We Talk About Human-Computer Integration

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In 2017, a CHI panel titled "Integration vs Powerful tools" debated whether our relationship with digital technology had begun to shift from interaction to integration. Today, Human-Computer integration developed into an emerging paradigm, rapidly gaining traction and developing a theoretical basis over a number of recent symposiums and publications. However, as more contributions are made to the establishment of Human-Computer Integration, the more its concepts and principles seem to diverge, such that we now find that each theorist talks about something different when they say "integration". Building on the 2017 panel, in this panel, we ask "What is the essence of Human-Computer Integration? And what are its implications for the future of HCI?" This panel seeks to facilitate discourse between leading thinkers from diverse backgrounds with the audience to come to a shared vision and mutual understanding of human-computer integration.

CCS Concepts: • **Human-centered Computing**; • **Human-computer interaction (HCI)**; • **Interaction paradigms**;

Additional Key Words and Phrases: Human-Computer Integration, Cybernetics, Wearables, Human augmentation, Intelligent Agents, Ubiquitous Computing

1 BACKGROUND

In 2017, a panel was hosted at the ACM Conference on Human Factors in Computing Systems (CHI) titled "Human-Computer Integration versus Powerful Tools" [4]. In this panel, Farooq and Gruden articulated what they deemed to be a new paradigm within HCI, "Human-Computer Integration", which proposed a move in technology away from the "stimulus-response" paradigm we commonly think of when we talk about *interaction*, and toward a "symbiotic partnership" between humans and computers, in which both parties are *integrated* and must be considered holistically. From the basis of this notion, the moderators posed to the HCI community the questions: "Have we moved from interaction to symbiosis or integration, should we focus on this or on other aspects of human augmentation via powerful

tools, and how will such decisions affect us as designers, researchers, and members of society?" Leading this debate were three experts, each representing a unique answer to this question. This included: Xiangshi Ren, who suggested synergism between "engaged" humans and computers may permit high level wisdom enhancing the survivability and potential of humanity; Pattie Maes, who reasoned that integration with machines is the future of computing because it is inevitable, necessary and desirable; and Ben Shneiderman, who argued for increasing automation with more human control.

Fig. 1. Ena, an e-bike which integrates with the riders visual cortex through EEG, allowing the bike to detect sudden changes in the riders peripheral vision. [1]

Following this panel was a 2018 Dagstuhl symposium, in which 29 leading experts from industry and academia came together over a five-day workshop to develop and discuss the future of HInt [7]. The discussions had during this workshop ultimately spawned an overarching work titled "Next steps in Human-Computer Integration" which was drafted in 2019 and presented at CHI 2020 [8]. The work, articulating a synthesis of contributions made toward Human-Computer Integration, summarised the contemporary state of the emerging paradigm. The paper defined HInt as "a new paradigm with the key property that computers become closely integrated with the user", which included examples in which "humans and digital technology work together, either towards a shared goal or towards complementary goals (symbiosis)"; and "integration in which devices extend the experienced human body or in which the human body extends devices (fusion)".
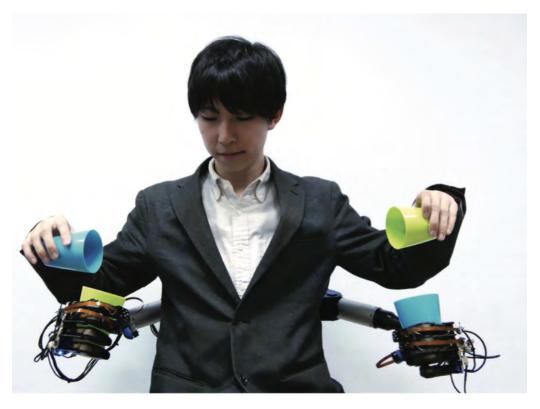
Fig. 2. MetaLimbs, a HInt system which extends the users body through two additional robotic arms. [10]

Since the writing of "Next steps in Human-Computer Integration", many new researchers have joined the discourse of the paradigm and many new contributions have been made to toward building it's theoretical cannon. However, with the growth this body of knowledge is experiencing, we also find a growing divergence in the way each of its key thinkers describes integration. For example, it appears the original symbiosis element dimension of HInt, in which computers are integrated with humans on a societal level as proposed by Gruden and Farooq, has disappeared from contemporary definitions of HInt all together. This has been done in favour of focusing on the "fusion" element, discussing integration on a bodily level. Similarly, since the publication of the last summative article on HInt [8], the type of integration previously described as "fusion" has also been articulated as "embodied integration; and "bodily integration", showing some growing redundancy in the lexicon of HInts theoretical cannon. Meanwhile, there is a growing body of works both within and without HCI, that are beginning to speak about and deal with the same fundamental themes and questions HInt deals with. This includes the recently proposed and quickly growing "next wave of HCI" titled "Entanglement HCI" [5], which discusses the growing intimate entanglement between humans and technology, and the resulting ontological questions we must consider. Furthermore, theories such as Steve Mann's "Humanistic Intelligence" [6], and the entire discipline of Cybernetics [14] have both provided thorough frameworks for thinking about the human-computer assemblage long before the articulation of HInt. Similarly, neurocognitive sciences are beginning to consider the way in which the human body assimilates externalities and even integrates with tools and the environment, as described by theories such as "Integrated Information Theory" [13] and the "Extended Mind Theory" [2, 3].

Fig. 3. This wearable robot augments the wearers neck by expanding their range of visual motion in space, thereby influencing their visuomotor processes. [12]

Taken together, we suggest that in considering the growing deviancy in how HInt researchers talk about HInt, and the growing prevalence of theories outside of HInt that deal with the same themes, it is time to bring its leading experts back together. We argue the necessity to facilitate discourse between leading thinkers from diverse backgrounds with the audience to come to a shared vision and mutual understanding of what we talk about when we talk about human-computer integration.

2   AIMS AND GOALS

This panel will raise notions on the composition and theoretical space of HInt, calling into question what are the core elements and principles of the paradigm, posing questions such as: Is integration just a matter of how close technology is with the human body?; Can integration be generalised beyond human-computer assemblages?; Can integration occur beyond the level of the individual?; Is integration human-centered?; How do we know when a system is "integrated"?; Can we measure integration? What is the ontological basis of HInt?; Is it a theory of being or becoming?

Similarly, we aim to initiate discussion on other theories which deal with similar concepts to HInt, such that we can articulate what defines HInt through identifying its differences with related theories. This includes: (how) does HInt relate to cybernetics?; does HInt fit in with Frauenbergers increasingly popular "Entanglement HCI"?; Is integration different to augmentation?; how is HInt different to Andy Clacks notion of "natural born cyborgs" and the "extended mind hypothesis?"; should HInt be grounded in the sciences?; and, if HInt poses itself as a new paradigm, what are the implications of it's relationship to HCI moving forward?

Through addressing points such as these, we hope that a more comprehensive conceptualization of HInt emerges from the associated debate and discussion, such that new theorists and designers working with and contributing to HInt have a more complete understanding to what defines the paradigm.

Fig. 4. Neo-Noumena, a brain-computer interface which allows wearers to interpersonally integrate emotion through generating affective fractals in a shared AR experience. [11]

3   PANEL FORMAT

The panel includes five panelists and two moderators, and builds on a previous CHI panel on HInt [4] while also extending the discussions of a workshop and SIG which have been submitted alongside this panel. The panel will aim to have a minimal allotted time devoted to pre-prepared presentations, rather emphasising the interaction between panelists and the audience for a communal and democratised development of the ideas of HInt. Careful moderation will be taken to ensure that all views are equally represented, further taking advantage of the online format by having the option to freely for the audience post points or questions in the chat, which will have a moderator specifically dedicated to managing this chat.

The panel in its entirety will last for 75 minutes. It will begin with a three-minute introduction given by our moderator, Nathan Semertzidis, summarising the background of HInt leading up to this panel, and introducing our panelists.

Each panelist will then have five minutes to give a prepared presentation of their position in response to the following questions:

- "What is the essence of Human-Computer Integration?"
- "What are its implications for the future of HCI?"

We anticipate each panelist will have a unique position, interpretation and understanding of the topic and this is appreciated, as we believe this will provide the basis for a constructive debate that will help build toward a more unified and generalized conception of HInt that all its theorists and the designers being informed by it can agree upon. During the position statements, audience members will be able to post comments and questions in the chat. During discussion time, questions and comments will be solicited from the audience, through the chat, by the chat moderator. These questions can be addressed to a specific panelist, the entire panel, or others in the chat. The panelists will also have the ability to pose questions for the audience to answer.

4 PANEL MODERATORS

NATHAN SEMERTZIDIS is a final year PhD candidate at the Exertion Games Lab, Monash University, Australia. His current research investigates how neural interfaces can be designed to facilitate integration between humans and computers, and from brain to brain. His PhD thesis explores how human-computer integration, taken with insights from neurocognitive sciences, can inform the design of systems that become one with the user's ontological subjective experiences of consciousness and its underlying cognitive processes. He has previously co-organised the CHI 2020 MotorHCI workshop [9], and will be providing the introduction for the panel.

ZOE XIAO FANG is a graduate student at Harvard Graduate School of Education. Zoe's role as panel moderator is to manage points and questions and online discussion.

5 PANEL MEMBERS

KAI KUNZE works as a Professor at the Graduate School of Media Design, Keio University, Yokohama, Japan. Beforehand, he held an Assistant Professorship at Osaka Prefecture University, Osaka. He is a researcher in the emerging Eyewear Computing, Augmented Humans and Cognitive Activity Recognition fields includes digitalizing affective responses and amplifying human senses. His most significant research contributions are in placement robust activity recognition. He is co-chairing the International Wearable Computing Community together with Prof. Thad Starner. He is an Executive Board and Founding Member of the Superhuman Sports Society. Website: https://geist.pro

PEDRO LOPES is an Assistant Professor in Computer Science at the University of Chicago. Pedro focuses on integrating computer interfaces with the human body—exploring the interface paradigm that supersedes wearable computing. Some of these new integrated-devices include: a device based on muscle stimulation that allows users to manipulate tools they never seen before or that accelerate their reaction time, or a device that leverages the nose to create an illusion of temperature. Pedro's work also captured the interest of media, such as New York Times or NewScientist, and was exhibited at Ars Electronica and the World Economic Forum. Website: https://lab.plopes.org

FLORIAN 'FLOYD' MUELLER is a Professor in the Human-Centred Computing department at Monash University, Melbourne, Australia, where he directs the Exertion Games Lab. His research sits on the intersection between the human body, technology and play, aiming to help people live a fulfilling life. He aims to integrate the human body with the computational machine to help people figure out who they are, who they want to become, and how to get there. He has co-organized nine workshops at CHI previously and was general co-chair CHI'20. Website: https://exertiongameslab.org

PATTIE MAES is a professor in MIT's Program in Media Arts and Sciences and until recently served as academic head. She runs the Media Lab's Fluid Interfaces research group, which aims to radically reinvent the human-machine experience. Coming from a background in artificial intelligence and human-computer interaction, she is particularly interested in the topic of cognitive enhancement, or how immersive and wearable systems can actively assist people with memory, attention, learning,decision making, communication, and wellbeing.

PAUL PANGARO is a professor in the Human Computer Interaction Institute, at Carnegie Mellon University. He promotes an intersection of design, humanities, and theory to generate richer human interactions, with technology and without. Paul has sought, studied, and contributed explanatory models of interaction that aid understanding of human-to-human and human-with-machine conversation. These models have proved valuable for teaching design, writing code, evolving organizations, and proposing new methods for the design process itself. Framing situations as systems that are animated by social actors leads unavoidably to ethics. Paul is committed to defining minimal axioms for design that bound ethical and humane interactions. Website: https://www.pangaro.com/

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