

論文内容の要旨

This dissertation aims to provide a more systematic interpretation of the overall thought of Human-Engaged Computing (HEC) and its five key concepts: Antibiosis, Engagement, Engaged Humans, Synergized Interactions, and Engaging Computers. Our research is guided by perspectives from the field of Human-Computer Interaction (HCI), to explore the essence behind various technological phenomena and historical developments. By combining the problems faced by individuals and society in today's highly technologically advanced world, and the future ideal relationship between humans and computers, we ask: Where are humans heading? What kind of technology do we need to achieve this vision? Thus, HEC is aimed at to bridge humanistic thought and technological development for establishing a macroscopic theory. Our approach involves organizing a wide range of cross-disciplinary perspectives and reflecting on how Western dominant thoughts have led to the overdevelopment of human Biophysics and Intellect capacities, while introducing Eastern concepts of "Xin/心" as a way to the transcendence of humanity - a neglected essence and experience that may guide us out of current difficulties. This dissertation leads to two critical contributions: The Belief System, which demonstrates the theoretical justification of HEC in analyzing ideal human-computer relationships; and The Computing System, offering potential design ideas for future computer forms, with the goal of providing directional inspiration for the development of human-computer interaction and related information technologies.

The contents in each chapter are shown as follows:

Chapter 1: We attempt to analyze the challenges faced by current HCI, though HCI has enabled everyone to use computers while continually introducing numerous big technological concepts - whether they be artificial intelligence, generative large models, embodied cognition, quantum computing, or metaverse, Web3, digital currency, brain-computer interfaces, and Society 5.0. We observe individuals and society experiencing more and more difficulties on both the micro and macro levels. At a microscopic level, this includes individual daily experiences of smartphone or gaming addiction, privacy breaches; at a macroscopic level, it involves facing various uncertainties threatening human survival, such as the crisis of meaning in the wake

of AI and other new technologies, economic stagnation, and sustainability issues. These problems are related to the current high-tech context but have been difficult for HCI's tool-oriented perspective to address.

We need to propose a more systematic theory for future HCI development directions, which is even a fundamental premise for the entire technology development process - this is the motivation behind HEC. The core theme of HEC revolves around designing engaging computers that enhance our human survival probability and full potential as humans. It suggests that HCI's position in future research should not be limited to input/output methods but become a path or environment for human capacity (especially inner capability) development. The main work of this dissertation is to offer a more systematic interpretation of HEC for its significance.

Chapter 2: Regardless of whether it is to identify the current issues in HCI or to position the theory of HEC, both need to be placed within a broader macroscopic history of HCI, and to make a rationalization of the evolution of human-computer interaction. The history of HCI development can be said to be also the history of the entire information era. This dissertation first reviews the four paradigm shifts in the general sense during the development process of HCI history to gradually identify the changes in academia's understanding of human factors - behavior, cognition, society, emotions, and neural ways. This is also the mainstream recognition of HCI today.

Secondly, we have reviewed how the powerful idea of Augmenting Human Intellect proposed by Douglas Engelbart, Alan Kay, and others as a milestone in the development history of HCI, which serves as a guide and critical significance for us today. Additionally, we have also reviewed various human-computer interaction concepts proposed by the HCI community, from Ubiquitous Computing, Social Computing and Embodied Interaction to Human-Centered Computing, Natural Interaction, and User Experience. We attempt to explore the research motivations and thought axes of these concepts. We have also reviewed HEC theory and made a preliminary positioning.

Chapter 3: Based on the HEC ideas, this chapter mainly constructs a more complete "The Belief System" of HEC through "interpretation". The basic methodology of interpretation combines three aspects: 1) "Self as Method" - related authors'

experiences in HCI and their own problems awareness; 2) organizing multiple interdisciplinary perspectives on technology and humanities, such as philosophy and thoughts in the East and West, anthropology, psychology, sociology, psychoanalysis, communication studies, computer science, design, etc. to form relevant insights; and 3) discovering the unity within these interdisciplinary perspectives, i.e., how human history of ideas can be a main thread helping to converge research phenomena and inner spirits of various fields. On this basis, we have further interpreted four important concepts in the HEC framework:

- **Antibiosis:** Inheriting our basic methodology's "big picture", we list the major problems threatening Human Survival from three levels - Microscopic, Mesoscopic, and Macroscopic - and regard them as Antibiosis. We believe that the reasons for Antibiosis are related to traditional human understanding limitations. Through reviewing the history of Western thought development on two aspects of human - natural humans (animal nature) and constructive humans (rational humans), we have proposed two classes of human meta-capacities in HCI - Biophysics (including Behavior, Cognition, and Emotion) and Intellect (human subjective construction) as an understanding of human capacity classification. We also list their respective manifestations in HCI. We generalize the original problem between humans and computers, Antibiosis, to negative actions of humans towards the outside world, and its deeper reasons lie in the Polarization of Biophysics (animal desires without limits) and Alienation of Intellect (the revealed rational defects in modern society over the past 500 years), as well as the Downward Spiral of Hybridization formed by the two. Humans cannot rely on their limited "Biophysics" body and infinite knowledge of "Intellect" to support real life. However, Antibiosis cannot be effectively addressed by various philosophical, sociological, and technological solutions based on Biophysics and Intellect. Furthermore, we analyze the fundamental reason for Antibiosis is the conflict between the external world's duality and human non-duality.

- **Engagement:** To respond to this current situation, we need to consider the complete human experience and ultimately return to the origins of civilization. Through discussions on the axes of Eastern and Western thought - the differences between inward transcendence and outward transcendence, and their formation in real historical context, we aim to reevaluate the neglected experiences of Eastern thought since the advent of modernity. As the common concept in Eastern thought

(Confucianism, Buddhism, and Taoism), we introduce "Xin/心" to discuss human responses to ultimate questions about existence when facing oneself, and thus complete our understanding of the "transcendent humans" beyond the "natural humans" and "constructive humans". In the current era where Biophysics and Intellect in Western thought continuously strive for outward transcendence under the dominance of Western thought, humans urgently need to recognize their Xin capacity - from Awareness, Initiative, to ultimately achieving an inwardly transcendent Enlightenment state as a response to Human Nature, Life, and Survival. We start our discussion from the theoretical position of Xin and further explore the ideal human Engagement and its differences with previous proposals such as Flow theory and self-realization in wellbeing.

- Engaged Humans: We propose a Human Capacity Framework based on "Biophysics-Intellect-Xin" to understand a whole person, and put forward the concept of Engaged Humans as an ideal model within the HEC thought. We believe that the soft skills, e.g., Mindfulness, Aesthetics, Empathy, Trust, Loving, etc., can serve as paths for recognizing Human Xin Capacity because these soft skills' core lies in human development as purpose rather than mere means. We emphasize that understanding these soft skills should ultimately be based on the level of Xin, not from a knowledge-based Intellect or a physical experience-driven Biophysics.

- Synergized Interaction: Facing the wide range of duality between the external world and non-duality within humans, Synergized Interaction aims to enhance the whole human capacity as its ultimate value. We proposed five conditions for finding a balance between various human capacities and technology, striving for an ideal relationship between humans and computers. Lastly, using "Biophysics-Intellect-Xin" structure as the core of analysis, we pointed out the essential differences in understanding human-computer relationships between HEC and past HCI ideas.

Chapter 4: This dissertation takes previous attempts on GUI computational aesthetic and information interaction within HCI as cases. Starting from a HEC perspective with enhancing overall human capacity at its core, we attempt to discuss the ways of transforming understanding of human abilities from Biophysics to Intellect within HCI, while also reflecting on the lack of purposeful rationality and true meaning in current research regarding concepts such as "humans", Xin, and "aesthetics".

In the computational aesthetics case, we discuss the current state in which computation-based aesthetics metrics are overly inclined towards predicting visual sensations but ignore how designers understand and improve aesthetics. This point is particularly evident in the difficulty of understanding aesthetics evaluative scores. Our work proposes an interpretable aesthetics metric for GUI design that integrates visual aesthetics (visual similarity and spatial proximity) and GUI structure (semantic similarity and white space) to model visual grouping distribution. Two experiments were conducted to validate the metric's ability to predict aesthetics and interpret outputs. Experiment 1 showed that our metric had a stronger correlation with users' impressions of GUI visual aesthetics than past metrics. Experiment 2 suggested that our metric was easier to interpret and appeared more useful to Visual/Graphic/GUI designers than a conventional score-based alternative, by visualizing the metric outputs as an experimental tool. Furthermore, this work provided five potential insights to further advance computational aesthetics research.

In the information interaction case, we look at the limitations of existing designs and guidelines in the current usability paradigm, considering fake news, continuous rumors, and prejudiced opinions from digital platforms and social media. Under the framework of HEC, we propose 12 research agendas from the theoretical, principled, and practical aspects, in order to develop future synergized interactions between humans and information. The present crisis presents us with a good opportunity to reflect on the need to empower humans in relation to the tools they use and to consider the next paradigm shift for designing information interaction.

Chapter 5: Based on the above overall interpretation and reflection, we discuss the vision and characteristics of "The Computing System" of HEC - Engaging Computers that possess both outward transcendence and inward transcendence. We also discussed the balance relationship between "reality" and "virtual". Based on the analysis framework given in Chapter 3, we listed interaction design ideas based on Xin and showed a preliminary demo called MIRROR (which will be continuously supplemented) as an inner projection of "Biophysics-Intellect-Xin".

Chapter 6: We extended our discussion of "The Belief System" and "The Computing System". On one hand, we discussed HEC's position in predicting the development

of eras from a natural society dominated by Biophysics to a modern society dominated by Intellect, and then to an era led by Xin, the next stage of human civilization. We also considered whether HEC can provide suggestions for the transition of Xin in more extensive fields such as humanities. On the other hand, we analyzed potential factors that affect the feasibility of Engaging Computing – 1) Social needs for the artifacts integrating both “Rites” and “Laws”; 2) Economic model transformation required to fundamentally address Antibiosis. HEC can offer some thoughts on these two points.

Chapter 7: We concluded our contribution in terms of "The Belief System" and "The Computing System" across three levels:

Microscopic (daily experience, tools, self, small communities): HEC and the "Biophysics-Intellect-Xin" concept could become the basis for human understanding of their own capabilities, discovering one's complete humanity through an Engagement-oriented Enlightenment to enjoy life and create; users can gradually enhance their abilities and perceptions through daily interactions with computers and artificial objects, thus improving themselves and surrounding issues.

Mesoscopic (technology, society, nation): HEC hopes to integrate precious insights from both Eastern and Western perspectives, providing a theoretical understanding that enhances human and societal capabilities for HCI, multiple disciplines, technological thinking, and even policy levels; offering an option for paradigmatic migration in technology innovation and serving society.

Macroscopic (world, humanity, ecology): HEC aims to predict the changes of human eras using a systemic theory, specifically exploring how from Intellect-driven modernity into a new possibility; and how overall computing and artificial objects can serve as mediators for humans entering a new stage.