Ubicomp Tutorial - UbiCHAI - Experimental Methodologies for Cognitive Human Augmentation

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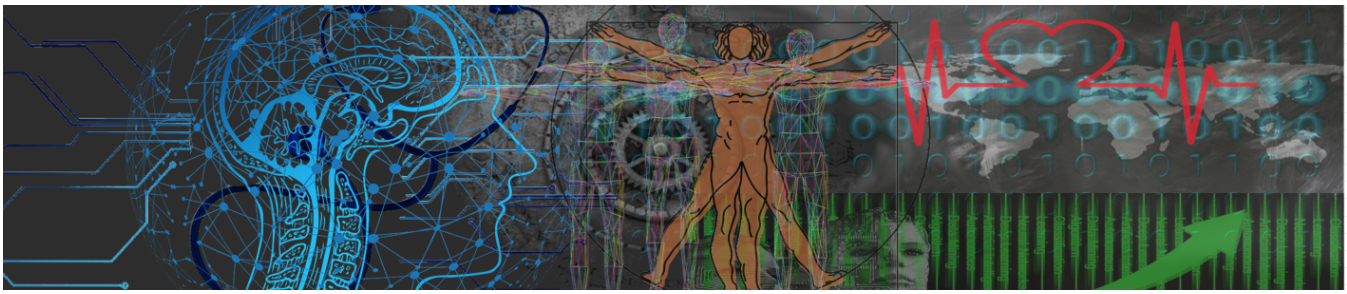

Figure 1: Humane-Centric Cognitive Artificial Intelligence (free graphics taken form pixabay.com)

ABSTRACT

A central research goal of Ubicomp has always been the development of systems and methods that seamlessly support humans in accomplishing complex tasks in everyday life. In the wake of rapid advances in artificial intelligence (AI), topics such as "Human-Centered AI" and "Hybrid Human AI" are showing a growing interest in this very research that puts us humans and our needs at the center of artificial intelligence. While methods for augmenting the human body and the impact of these augmentations on human physical life are being extensively researched, there has been very limited progress in evaluating the impact on human cognitive perception and its impact on the overall outcome of augmentations to the human body. In this tutorial, we will address the question of how to evaluate the cognitive impact of human augmentation. We will address the different levels of cognitive effects, how to measure which methods of augmentation have the best effect, and which cognitive measures have the greatest impact on augmentation, and we will give the audience the opportunity to test and evaluate cognitive human augmentation systems themselves.

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CCS CONCEPTS

• **Human-centered computing** → *Ubiquitous and mobile computing design and evaluation methods*; *Collaborative and social computing theory, concepts and paradigms*; *Interactive systems and tools.*

KEYWORDS

HCAI, HHAI, cognitive science, augmenting human capabilities, ubiquitous technologies, shaping cognitive and social behavior

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1 BACKGROUND AND MOTIVATION

A central research goal of Ubicomp has always been to develop systems and methods that seamlessly support humans in complex tasks in their daily lives. AI should not only mimic human behavior, as has been the case in the past, but should be able to complement and support us in managing a wide range of cognitive processes and decision-making within complex activities, personalized and adapted to the situation at hand. In the Ubicomp community, the notion of cognitive augmentation goes back to the early days of wearable computing, where head-mounted displays were often seen as a way to provide users with "anytime, anywhere" access to digital information. The research focus here has been primarily on how and when to provide what information, and how to capture the user's activity or context for this purpose.

However, while extensive research is being conducted on methods for enhancing human capabilities and the impact of these enhancements on the physical lives of humans, there has been very limited progress in assessing the impact on human cognitive perception and its impact on the overall outcome of human enhancements. This requires linking AI with a variety of other disciplines, such as psychology, to link augmentation with human cognitive processes. This means a transition from today's established AI approach, which focuses on mimicking human capabilities, to systems that complement and augment human capabilities. Such a transition is a key challenge for the human-friendly and socially acceptable digitization of education, the economy and society itself. In the wake of rapid advances in AI, a very similar issue has also gained prominence in the AI community: Hybrid Human Artificial Intelligence (HHAI), often subsumed under collaborative AI or human-centric AI. Several ongoing large-scale projects, such as the European Union's Human AI Network project, the Moonshot Goal 3 projects in Japan [1], and many others, have given rise to a new community of researchers from different fields.

In our tutorial, we want to make the transition to these new research communities and give the Ubicomp audience an opportunity to get in touch with human-centered cognitive augmentation by addressing the question: What are good ways to assess the cognitive impact of human augmentation? We will go into detail about how to assess the impact of a variety of augmentation methods and which cognitive measures have the greatest impact on augmentation outcomes.

2 TUTORIAL ACTIVITIES

2.1 Overview and Expected Attendance

We propose a half-day (4 1/2-hour) tutorial with a maximum number of participants of 20-25. A higher number of participants is not appropriate for tutorials because it would limit the direct and practical interaction and the possibility to deepen the own knowledge. However, we can imagine to record the tutorial and make it available to interested participants of Ubicomp/ISWC afterwards. A basic understanding of computer science is a prerequisite for participation; experience with sensors and augmentation is beneficial but not required. We welcome a diversity of participants with varying degrees of experience, as new and young researchers can learn a lot when working with more experienced researchers.

The tutorial will begin with a brief introduction to the process, followed by a keynote introducing the topic of cognitive augmentation. In the following three sessions, we will explain the three stages of cognitive augmentation in human augmentation. During these hands-on sessions, participants will have the opportunity to work together in small groups to test different methods of augmentation and their effects on cognitive awareness. The tutorial will end with a summary of the activities and each group will have the opportunity to present their impressions.

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[1] www.humane-ai.eu/ and www.jst.go.jp/moonshot/en/index.html

2.2 Major changes in regards to the originally planned workshop

The original proposed workshop was intended to cover a broader range of topics (and thus be accessible to a wider audience), and because it was a workshop, the audience was expected to contribute primarily by submitting research and research ideas, and only secondarily to participate in the break-out sessions. The style of a tutorial differs from that of a workshop in that participants are expected to gain new insights (possibly cutting-edge knowledge) during the tutorial that will help them improve their research skills in the future. In order to take the originally planned workshop into the form of a tutorial, we decided to reduce the topic to one main question of cognitive augmentation, namely how to measure the cognitive effects of augmentation. The original workshop was designed to have participants present their research and ideas on various aspects of human-centered AI (of which cognitive augmentation is one), and then break into different groups to explore these topics in more depth. The tutorial, on the other hand, will focus on one aspect (cognitive effects of human augmentation) and tackle different levels of it in three stepwise practical teaching sessions. These levels of human cogntitve augmentation are the following:

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2.3 Tutorial TOPICS

- **Reduction of effort:** The first and lowest effect human augmentation should provide is reducing the effort to fulfill a task. This again consists of three different aspects:
  - **cognitive load:** What is the cognitive load to perform a task and how does human augmentation influence it? In this part, we will address methods to measure cognitive load.
  - **physiological response**: how to measure emotional stress and the effect human augmentation has on it.
  - **subjective perception:** We also want to evaluate the subjective perception of the user. The NASA-TLX assessment tool lends itself as a measure of choice to evaluate the subjective effects, but other options will be introduced as well.
- **Performance enhancement:** After understanding how human augmentation can reduce the effort to reach a goal, the second part of this tutorial will deal with the question of how to enhance the performance to reach the goal. Meaning, not only reaching a goal with less effort but also doing it better.
- **Learning:** Can human augmentation actually help to learn or acquire skills? What are the cognitive processes to learn, how can augmentation help to learn faster and learn better, and how can we measure the quality of learning?

During engaging in all three of these levels of cognitive augmentation, we will show different methods for measuring cognitive perception, alertness, and physical parameters, and we will go into detail about questions about ethical aspects.

2.4 Pre-Workshop activities

Contrary to the initially planned workshop the tutorial requires more in-depth preparations of the different sensing and measuring

technologies to make sure the attendees find an optimal situation to learn and extend their knowledge. This will include preparing sensing tools for measuring subjective perception, cognitive load, and stress, but also preparing sufficient numbers of augmentation devices, to program and test during the Tutorial.

2.5 Tutorial schedule

*__Welcome__ (8:45-9:00) The workshop will start with an introduction given by the workshop organizers in which they will introduce the workshop and its schedule and will highlight the workshop's motivation and goals.

*__Keynote__ (9:00-9:30) The introductory Keynote will provide an overview of the state of the art of cognitive augmentation, its potential, and its limitations, and will highlight the challenges and

Session 1: Reducing of Effort (9:30-10:30): In the first session, the lowest level of complexity in augmentation will be tackled: how can cognitive augmentation help to reduce the effort to reach a goal?

Session 2: Enhancing the Performance (10:35-11:35): The second session goes a step further. Here we will dive into methods of how cognitive augmentation not only can reduce the effort to achieve a goal but also improve performance. Meaning, how can augmentation not only make it easier to fulfill a task but also perform the task in a better or more efficient and more effective way.

Session 3: How to learn (11:40-12:40: In the third session, we even go a level higher. What are ways for augmentation to help people actually learn and acquire skills? For example, in [2] we showed that a smartwatch can help bystander to perform CPR correctly on the fly. In [1] on the other site we demonstrated, that training with the smartwatch-CPR-assistant would help people acquire the skill of performing CPR correctly particularly faster.

*__Closing__ (12:45-13:15 The workshop day will conclude by summarizing the different lessons. All participants (in small groups) will be invited to present their impressions and what they have learned when testing augmentation systems.

2.6 Post-Tutorial Activities

In the course of the Tutorial, we intend to summarize the idea, experience, and outcome in a tutorial paper and submit it to a Journal. Which Journal is yet to be determined

3 ORGANIZERS

Agnes Grünerbl is a postdoctoral researcher at the German Research Center for Artificial Intelligence and the Rhineland-Palatinate University of Technology (RPTU). She holds a Ph.D. in natural sciences from the Technical University of Kaiserslautern. Her research interests are in artificial intelligence, mobile and mental health, cognitive science, and education.

Kai Kunze is a Professor at Keio University Graduate School of Media Design. His areas of expertise are Wearable Computing, Applied Machine Learning, Human-Computer Interaction, and Perception-Aware Computing.

Thomas Lachmann is a Professor of Psychology, Head of the Center for Cognitive Science, Director of the Graduate School of Cognitive Science, Speaker of Research Initiative (Universitärer Potentialbereich Cognitive Science), PI Research Initiative AI Enhanced Learning and Cognition at the Rheinland Pfälzische Technische Universität (RPTU).

Jamie A Ward Jamie A Ward: is a senior lecturer (Associate Professor) at Goldsmiths, University of London. He works on wearable computing, with contributions to topics like social neuroscience, activity recognition, performance evaluation, and applications to real-world problems in health, industry, and the arts.

Paul Lukowicz is a Professor of Computer Science at Rheinland Pfalz Technical University (RPTU), Embedded Intelligence Lab, and Scientific Director at the German Research Center for Artificial Intelligence (DFKI GmbH). His research focuses on **human-centered** and context-aware ubiquitous and wearable systems including sensing, pattern recognition, system architectures, models of large-scale self-organized systems, and applications in areas ranging from healthcare through industry 4.0 to smart cities.

4 ACKNOWLEDGMENTS

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A CALL FOR PARTICIPATION

A central research goal of Ubicomp has always been the development of systems and methods that seamlessly support humans in doing complex tasks in their daily lives. In the wake of rapid progress in artificial intelligence (AI), topics like "Human-Centered AI" and "Hybrid Human AI" reveal a growing interest in research that puts us humans and our needs at the center of artificial intelligence. While extensive research is done on methods to augment humans, and the effects these augmentations have on the life of the human physically, there is very limited progress in evaluating the effects on the human cognitive perception and its effects on the overall outcome of human augmentations. In this tutorial, we will explore the question of how to evaluate the cognitive impact of human augmentation. We will go into detail about different levels of cognitive effects (reducing effort, improving performance, and how to acquire actual skill with augmentation), how to evaluate methods of cognitive augmentation and measure their effect, what cognitive measures have a significant influence on augmentation and how to understand and use them, and we will provide the audience with the opportunity to test and evaluate cognitive human augmentation systems themselves.