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► **To cite this version:**

Mahyar Tourchi Moghaddam, Mina Alipour, Mikkel Baun Kjærgaard, Henry Muccini. Introduction to IoB: Internet of Behaviors Minitrack. Proceedings of the 56th Hawaii International Conference on System Sciences, Jan 2023, Hawaii-Honolulu, United States. hal-04040529

HAL Id: hal-04040529

<https://hal.science/hal-04040529>

Submitted on 22 Mar 2023

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Introduction to IoB: Internet of Behaviors Minitrack

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Abstract

Internet of Behaviors (IoB) links human behavior to the digital world to provide services that meet humans' dynamic needs. IoB can observe and record human behaviors (physical and mental alike), analyze them, adapt itself accordingly, and continuously affect humans' decisions in implicit and explicit ways. A crucial point is understanding human individual and social behaviors, which are reactions to various internal or external events. For instance, intentions and emotions that cause specific behaviors could be analyzed and further impacted by stimuli toward different behaviors. At the social level, people's social attachment to each other or their belongings could influence their behaviors. At the cultural level, behaviors could be impacted by expressiveness, mobility habits, social interactions, and privacy concerns of a country or region's population. Therefore, while IoB opts to engineer intelligent connected systems adaptive to behaviors, it will only be effective with a deep behavioral analysis from social and psychological perspectives. A novelty IoB provides is that it considers not only the direct users but also citizens, occupants, visitors, or customers who may not directly interact with the system and may mostly be unaware that they are part of the system but could benefit from the way the system works. The IoB minitrack at HICSS 2023 aims to shape a community around the novel concept of IoB. Since IoB is yet to be discovered, its various dimensions should be discussed by academics, industry, and political decision-makers. The success of IoB depends on applicable dimensions regarding ethics, privacy, artificial intelligence (AI), and more.

1. Scientific Approach

Behavior data on the net and mobile is increasing at an explosive rate. It is a major social and human imperative to learn to deal with this development in a human and socially acceptable way and develop

productive and useful technological systems, tools, and services using behavior data. The intelligent connected socio-technical systems could be designed to perceive and act on human behavior data [1], but this necessitates an approach beyond what is currently proposed by academia and industry. IoB has the potential to link people and actions. Individual activities will be tracked digitally by IoB to influence, benefit, and service 40% of people worldwide by 2023 according to Gartner.

With the IoB [2], we introduce methods to link the digital world to humans, their characteristics, goals, and interactions and provide a desirable adjustment or trade-off between humans' *quality of experience* (QoE) and the system's *quality of service* (QoS). QoE involves assuring that people have positive feelings when using a system directly or indirectly [3]. IoB makes it possible by approaching people at the right time when a known mental or physical behavior occurs and doing it with relevant information, interventions, and services. Technically, QoE could be achieved by developing techniques to quantify or qualify people's preferences and choices in different contextual situations. If only the internal quality of service (such as performance [4], fault tolerance [5], etc.) is considered and QoE is ignored, the systems will not be responsive to the users.

IoB provides us with a more inclusive vision of humans that is different from related disciplines. Humans are experiencing and intentional citizens, occupants, or building visitors who *do not directly interact with the system* and who are mostly *unaware that they are part of the system* but could *benefit* from the way the system works. After analyzing human behaviors, IoB could directly optimize the system's behavior, satisfy humans' acute psychological needs and situations, and silently impact their decision-making process, pushing them towards specific behaviors, moderating undesired behaviors, and improving their quality of experience. IoB provided us with an awareness of human-related contextual knowledge, i.e., the situation and behavior of humans at a specific time and place. In order to act on such data, intelligent

connected systems must be able to interpret possible human behavioral patterns and react to them, which requires comprehensive knowledge in the design phase [6].

The idea of IoB is formed around the principles:

- Observing and analyzing human behavior in various situations by designing intelligent connected systems, such as Internet of Things (IoT) infrastructures, and applying social science methodologies,
- Providing users with tools that allow them to express otherwise hidden (mental, e.g., intentions, emotions [7, 8], experiences, plans, and motivations) phenomena so that they can be approached with relevant and timely information and services,
- Predicting human behaviors by data-driven or agent-based modeling approaches,
- Adapting the system [9, 10] to real behaviors and impacting the humans' decisions and actions within the application in real use cases.

2. Contributions

In Hicss 2023, the IoB minitrack accepted two excellent papers summarized as follows.

2.1. Webcam Eye Tracking for Desktop and Mobile Devices: A Systematic Review

The authors (*Melanie Heck, Christian Becker, Viola Deutscher*) focus on capturing human behaviors within IoB. They present a systematic review across the IEEE and ACM databases – complemented by snowballing and input from eye-tracking experts at CHI 2021 – to list and characterize publicly available software for webcam eye tracking that estimate the point-of-regard with no additional hardware. Sixteen eye trackers were found that can be used by the community. The restrictions regarding license terms and technical performance are presented, enabling developers to choose appropriate software for their IoB application.

2.2. Input Output HMM for Indoor Temperature Prediction in Occupancy Management Under User Preferences

The authors (*Kamrul Islam Shahin, Anooshmita Das, and Mikkel Kjærgaard*) propose a probabilistic machine learning method to predict the indoor temperature of an office environment. They developed an IOHMM-based model that represents the office environment under different circumstances of heating sources. One year of time series data is observed and

studied to learn the dynamics of the indoor thermal states. The uncertainty associated with the changing aspects of the indoor temperature and its dependence on the outdoor temperature is considered in the model development. A numerical application demonstrates the model development steps and the training and testing results. The model's performance is validated using leave-one-out cross-validation, which shows that the model has a prediction accuracy of about 78%.

References

- [1] Julie Dugdale, Mahyar T Moghaddam, and Muccini. Human behaviour centered design: developing a software system for cultural heritage. In *Proceedings of the ACM/IEEE 42nd International Conference on Software Engineering: Software Engineering in Society*, pages 85–94, 2020.
- [2] Mahyar T Moghaddam, Henry Muccini, Julie Dugdale, and Mikkel Baun Kjærgaard. Designing internet of behaviors systems. In *2022 IEEE 19th International Conference on Software Architecture (ICSA)*, pages 124–134. IEEE, 2022.
- [3] Ramesh Jain. Quality of experience. *IEEE multimedia*, 11(1):96–95, 2004.
- [4] Claudio Arbib, Davide Arcelli, Julie Dugdale, Mahyar Moghaddam, and Henry Muccini. Real-time emergency response through performant iot architectures. In *International Conference on Information Systems for Crisis Response and Management (ISCRAM)*, 2019.
- [5] Mahyar Tourchi Moghaddam and Henry Muccini. Fault-tolerant iot. In *International Workshop on Software Engineering for Resilient Systems*, pages 67–84. Springer, 2019.
- [6] Henry Muccini and Mahyar Tourchi Moghaddam. Iot architectural styles. In *European Conference on Software Architecture*, pages 68–85. Springer, 2018.
- [7] Mina Alipour, Sophie Dupuy-Chessa, and Eric Céret. An emotion-oriented problem space for ui adaptation: From a literature review to a conceptual framework. In *2021 9th International Conference on Affective Computing and Intelligent Interaction (ACII)*, pages 1–8. IEEE, 2021.
- [8] Mina Alipour, Sophie Dupuy-Chessa, and Eline Jongmans. Disaster mitigation using interface adaptation to emotions: a targeted literature review. In *10th International Conference on the Internet of Things Companion*, pages 1–15, 2020.
- [9] Henry Muccini, Romina Spalazzese, Mahyar T Moghaddam, and Mohammad Sharaf. Self-adaptive iot architectures: An emergency handling case study. In *Proceedings of the 12th European Conference on Software Architecture: Companion Proceedings*, pages 1–6, 2018.
- [10] Mahyar T Moghaddam, Eric Rutten, Philippe Lalanda, and Guillaume Giraud. Ias: an iot architectural self-adaptation framework. In *European Conference on Software Architecture*, pages 333–351. Springer, 2020.