Internet of Tangible Things: Workshop on Tangible Interaction with the Internet of Things

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CHI'18 Extended Abstracts, April 21–26, 2018, Montreal, QC, Canada

ACM ISBN 978-1-4503-5621-3/18/04.
https://doi.org/10.1145/3170427.3170634

Abstract
The rise of the Internet of Things (IoT) brings abundant new opportunities to create more effective and pleasing tangible user interfaces that capitalize on intuitive interaction in the physical world, whilst utilizing capabilities of sensed data and Internet connectivity. However, with these new opportunities come new challenges; little is still known how to best design tangible IoT interfaces that simultaneously provide engaging user experiences and foster a sense of understanding about the often-complex functionality of IoT systems. How should we map previous taxonomies and design principles for tangible interaction into the new landscape of IoT systems? This workshop will bring together a community of researchers from the fields of IoT and tangible interaction, in order to explore and discuss how parallels between tangible interaction and the properties of IoT systems can best be capitalised on as HCI research moves increasingly toward the Internet of Tangible Things (IoTT). Through ideation and discussion, the workshop will function as a springboard for the community to begin creating new taxonomies and design considerations for the emerging IoTT.

Author Keywords
Internet of Things; tangible interaction; IoTT.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

Background

The Internet of Things (IoT) is permeating our everyday lives. While early IoT devices were limited to industrial applications, many commercial devices are now increasingly utilizing IoT infrastructure. In these terms, the IoT is transforming daily interactions with computers, edging ever closer to Mark Weiser's original vision of ubiquitous computing [23], where computers diffuse through our everyday environments and routines and disappear into the fabrics of everyday life.

Technological advances have brought computation, data-collection, actuation and communication capabilities to coin-cell battery powered objects. The advent of 5G communication technologies will further enable large-scale low-power Internet connectivity, exponentially increasing the number of connected objects [17]. However, in a world where every physical object is able to collect and share digital data, there are numerous challenges to designing appropriate user experiences with IoT devices, in particular through traditional graphical user interfaces. For instance, screens cannot always be embedded in IoT objects, and smartphone apps separate the interaction from the source of information. This is problematic where the goal is to provide the user with immediate understanding and control about what information is acquired by an IoT object and how it is shared, which is key for affording data privacy [5].

Moreover, Rowland et al. have highlighted that IoT working principles transcend traditional users' mental models [19]. From an HCI perspective, facilitating the understanding of and the habituation to IoT objects can be particularly challenging [1]. Despite this, until recently, IoT research has largely focused on technological aspects, rarely putting the user at the center of the investigations [11].

Most commercial IoT object interfaces are developed as smartphone and web apps [12]. The physical opportunities of IoT objects are seldom taken into account. Conversely, physical tangible controls are often substituted with touch controls, or completely removed in favor of digital app-based controls, for the sake of cost-reduction, maintainability and ease of upgrade [19]. Such devices allow the user to access and control digital information at a swipe of one finger, capitalizing on convenient and economic interaction paradigms that even children and older adults are acquainted with. But the intuitiveness of smartphone interaction is counterbalanced by a number of opportunities that are often neglected: smartphone apps rarely exploit the richness of human sensorimotor abilities [22] and are increasingly isolating people by drawing their focus from social interaction in the physical world to manipulating their phone to interact within their own digital bubble [18]. Tangible interaction can work to mediate these challenges; simultaneously, bridging the IoT and tangible interactions can enable completely new applications, such as interactive artworks in public spaces or interconnected toys for fostering social connection over a distance. Furthermore, augmenting IoT objects with tangible controls has been suggested to increase user understanding and accessibility, enabling even digital novices (e.g., older adults [2]) and visually impaired

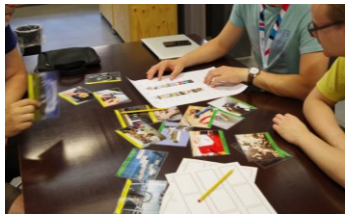

Figure 1. ETIS'17 workshop participants discussing about tangible interaction properties fo IoT, using as a support for discussion a card deck specifically developed for the Internet of Tangible Things [4].

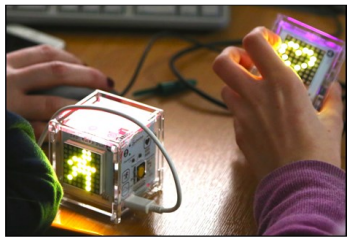

Figure 2. Magic Cubes used for rapid prototyping of tangible systems during a workshop.[13]

people [14] to more intuitively use and trust IoT systems.

Tangible interaction has a long history in HCI for trying to bring the interaction with digital information back to the physical world. By exploiting a shared space where users can directly interact with physical artifacts, tangible interaction is a natural facilitator for learning and collaboration [10]. The IoT, which distributes digital information in our everyday physical environments, can be considered an obvious platform for the adoption of tangible interaction. Nevertheless, applying tangible interaction to the IoT requires new research directions to explicate how tangible properties can be used to improve the user experience with the IoT. For example, can a tangible control for video collection (such as a physical cover on a camera) build more trust in an IoT system than a switch in an app? Can zoomorphic design and life-like behavior support the development of emotional attachment to an IoT object [20]? Can tangible IoT interfaces help sustain user interaction over time, reducing electronic waste due to early abandonment of technology [7]? At the same time, new challenges arise: for example, how can we design tangible interaction with connected lights, considering that light is inherently intangible [6]?

These questions, and others are still nascent. However, research on bridging tangibility and the IoT is rapidly gaining interest. While Koreshoff et al. highlighted the importance of a user-centered HCI perspective on IoT in 2013 [11], the first theoretical definitions of tangible interaction with IoT are much more recent. In 2016, during the Second European Tangible Interaction Studio [15], Gallacher proposed the term Internet of Tangible Things (IoTT) [8], to highlight a paradigm shift towards tangible interfaces for IoT. A systematic literature review of tangible interaction with the Internet of Things by Angelini et al. has begun to identify how tangible properties have been explored in IoTT papers to different extents [3]. Recently, Ambe et al. [1] explored how tangible interaction can support the adoption, appropriation and habituation of connected objects. Soro et al. offered a human-centered critique of the IoT by building IoT things that foster user engagement and reciprocity [21].

These works have begun to highlight that designing tangible interaction for IoT objects involves not only facilitating the understanding of the IoT working principles through intuitive metaphors and rich interactions, but also encouraging appropriation of the device [1], through seamless integration of those interactions into daily routines and through the development of emotional attachment with the IoT product [20]. Designing and building a shared language for such interactions now requires joint effort from different disciplines—bridging human factors and engineering—to design effective and appropriate tangible IoT interfaces that seamlessly blend into everyday life.

Workshop Goals and Methods

The goal of this workshop is to foster discussion about how best to bridge theoretical, technical, design and human considerations when designing for the IoTT. Specifically, participants will be guided through brainstorming properties of tangible interfaces that might be particularly applicable to IoT infrastructure. To support this phase, design and ideation cards for tangible interaction (e.g., Hornecker [9]) and IoT

interaction design (Angelini et al. [4], Mora et al. [16]) will be provided to the workshop participants.

Subsequently, through ideation, prototyping and discussion, the participants will explore how these properties might change with the application domain of the IoTT interface. In particular, participants will have at their disposal a large palette of low-fi prototyping materials (such as cardboard, textiles with different haptic feedback, scented paper, etc.) and ready-to use and hack hardware prototypes, based on Arduino and the Magic Cubes [13]. These materials will aim to foster the participants' creativity, helping them in designing new tangible user interfaces for the selected IoT application domains. Moreover, the planned activities will support the discussion about the challenges for the design of the Internet of Tangible Things from both a human and a technical perspective. By discussing specific IoTT scenarios around the table, we hope to bridge the variety of competencies that participants from different research fields will bring.

The final workshop objective is to foster a new community of researchers in the IoTT, and push forward emerging research through a journal special issue after the workshop, in which theory and design considerations for the IoTT will be explored.

Workshop Scheduling

9:00 – 10:30 Getting Together

- 9:00 - 9:10 Welcome and overviews by the organizers
- 9:10 - 9:50 3-minutes pitches from the participants, presenting their ongoing work in the field
- 9:50 - 10:10 Space for questions, introduction to the workshop structure and schedule, introduction to the application domains to be explored during the workshop (selected by the organizers from the participants' submissions).
- 10:10 - 10:30 Brainstorming in groups: identification of relevant tangible properties for the selected IoT application domain, without defining a specific object (there will be 2-3 application domains, 4-6 groups, and 2 groups per application domain)

10:30 – 11:00, Coffee Break

11:00 - 12:00 Brainstorming

- 11:00 - 11:30 Identification of 1 or a set of IoT object(s) for the specific application domain. Storyboard creation for the selected object(s).
- 11:30 - 12:00 Introduction to the prototyping materials and activities: a variety of low-fi prototyping materials will be provided by workshop organizers, along with ready-to-use/hack Arduino and Magic Cubes toolkits, pre-programmed with examples for each tangible property.

12:00 - 13:30 Lunch Break

13:30 – 15:00 Prototyping

- 13:30 - 14:30 Hands-on activity in groups: Ideation and creation of a tangible IoT object, exploring different tangible interaction properties through the provided prototyping materials.
- 14:30 - 15:00 Presentation of the prototypes

15:00 – 15:30, Coffee Break

15:30 – 17:00 Discussing

- 15:30 - 16:30 Analysis and comparison of the results, discussion of insights, and how they relate to the future IoTT
- 16:30 - 17:00 Wrap-up and future activities

Organizers

Leonardo Angelini is a post-doctoral researcher at the HumanTech Institute and Lecturer at HES-SO. He has run several workshops in interaction design, including workshops on tangible interaction with IoT at Ubicomp'16, ETIS'16 and ETIS'17, workshops on full-body and multisensory interaction at TEI'16 and Ubicomp'15 and '16, and a workshop on tangible gestures at TEI'15. Such workshops included both paper prototyping and hardware prototyping with Arduino.

Zuzanna Lechelt is completing her doctorate at the University College London Interaction Centre (UCLIC). Her current research focuses on exploring the benefits of introducing tangible IoT devices to classrooms to support learning.

Eva Hornecker is a Professor in Human-Computer Interaction at the Bauhaus-Universitat Weimar, Germany. Her research investigates user experience and social interactions with tangible and embodied interaction. Her work is interdisciplinary and connects technology, social sciences, arts and design.

Paul Marshall is a Senior Lecturer in the UCL Interaction Centre, and will be joining the Computer Science Department at the University of Bristol in January 2018. His research seeks to understand how people might use near future ubiquitous computing and IoT technologies, particularly in real world contexts.

Can Liu is a postdoctoral researcher at the University College London Interaction Centre (UCLIC). Her current research is focused on using IoT interfaces for sharing situated knowledge about urban places, in the context of a human-centered vision of smart cities. She has a track record of CHI publications on various topics including embodied interaction with large interactive surfaces.

Margot Brereton is Professor of Engineering and Interaction Design at at Queensland University of Technology (Australia). She develops innovative designs, methods, and theoretical understandings by designing to support real user communities in selected challenging contexts. She has a passion for social and tangible interaction and the IoT.

Alessandro Soro is a research fellow at Queensland University of Technology (Australia). His research is focused on designing Internet of Things applications to support social interaction and natural interfaces for specific contexts, from smart cars to interactive learning spaces. He is co-author of 50+ research papers and co-editor of 6 collective works gathering workshops/conference proceedings.

Nadine Couture is currently Professor at ESTIA, the Institute of Advanced Industrial Technologies, South-West of France, and she is in charge deputy of ESTIA-RECHERCHE. She is member of the research center LaBRI (UMR CNRS 5800). She has organized several workshops in the field of Human-Computer Interaction

and is part of the steering committee of the European Tangible Interaction Studio.

Omar Abou Khaled is member of the HumanTech Institute and Professor in Computer Science at HES-SO. His expertise lays in human-computer interaction, gesture and tangible interaction as well as intelligent data analysis and visualization. He has organized several workshops in the field of Human-Computer Interaction and Wearable and Ubiquitous computing.

Elena Mugellini is head of the HumanTech Institute and Professor in Computer Science at HES-SO. Her research interests are in the areas of human-computer interaction, multi-sensory and tangible interaction, user-centered design and development of interactive systems as well as machine learning and artificial intelligence. She has organized several workshops in the field of Human-Computer Interaction and Wearable and Ubiquitous computing and is part of the steering committee of the European Tangible Interaction Studio.

Pre-Workshop Plans

Prior to the workshop, the workshop website (https://sites.google.com/view/tangible-iot) will be populated with information about the workshop, the call for participation and the submission instructions for participants. Participants will be recruited online from the CHI and UbiComp communities, from previous workshops on IoT and tangible interaction, and from the research networks of the organizers. The organizing committee will work to ensure an interdisciplinary range of participants, with backgrounds in a variety of application domains (e.g., IoT for the home, healthcare, connected cities, environment and sustainability, education).

Post-Workshop Plans

The aim of this workshop is to bring together the emerging community of researchers working to realize the vision of the IoTT, and to foster lasting, interdisciplinary collaborations between researchers. To this end, after the workshop, attendees will be invited to collaborate on a special journal issue on the IoTT. Moreover, plans for future collaborations will be discussed in depth during the workshop.

Call for Participation

The *Internet of Tangible Things: Workshop on Tangible Interaction with the Internet of Things* at CHI 2018 will explore future directions for coupling Internet of Things systems with tangible interfaces. Specifically, through ideation, prototyping and discussion, it will aim to answer the questions of a) what opportunities exist for tying together IoT infrastructure and tangible interaction b) how existing taxonomies and design principles for tangible interaction can be best applied to novel IoT systems and c) how these might change in relevance between application domains (e.g., interfaces in the home, environment, connected cities, healthcare, or education).

We invite position papers from researchers in the CHI and UbiComp communities interested in the theoretical basis, design, implementation, and evaluation of novel Internet of Tangible Things (IoTT) systems. Authors are asked to submit 4 page papers related to their work on IoTT systems in the SIGCHI Extended Abstract format. The workshop will aim to be interdisciplinary, bridging and synthesizing design, theoretical, and methodological contributions; given this, submissions in alternative formats, for example design portfolios or videos of demos, are also welcome. Please send your

submission via e-mail to the workshop chairs. The specific submission details can be found on the workshop website at: https://sites.google.com/view/tangible-iot

Participants will be selected based on the relevance of their submission to the IoTT. At least one author of each accepted paper must attend the workshop at CHI 2018. The workshop will aim to foster lasting collaborations between researchers interested in the IoTT. Following the workshop, the participants will be invited to submit their work to a journal special issue about emerging research and future directions for the IoTT.

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