Trends on Engineering Interactive Systems: an overview of works presented in workshops at EICS 2019

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ABSTRACT
Workshops are a great opportunity for identifying innovative topics of research that might require discussion and maturation. This paper summarizes the outcomes of the workshops track of the 11th Engineering Interactive Computing Systems conference (EICS 2019), held in Valencia (Spain) on 18-21 June 2019. The track featured three workshops, one half-day, one full-day and one two-days workshop, each focused on specific topics of the ongoing research in engineering usable and effective interactive computing systems. In particular, the list of discussed topics include novel forms of interaction and emerging themes in HCI related to new application domains, more efficient and enjoyable interaction possibilities associated to smart objects and smart environments, challenges faced in designing, developing and using interactive systems involving multiple stakeholders.

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INTRODUCTION
By definition, workshops are dedicated forums focused on specialized topics that require reflection, discussion and maturation before become trendy and mainstream. Workshops are very important as they allow to identify people with similar interests, which is the first step towards creating new research communities. Moreover, due to the specialized nature, workshops help to focus the attention of participants on a few topics that can, therefore, be covered in depth. Many workshops produce outcomes that become recognized and well cited references on specialized fields such as distributed user interfaces [3], and formal methods in HCI [5]. It is interesting to notice that many symposiums and conferences are in fact outcomes of repeated and successful workshops. The ACM Symposium on Engineering Interactive Computing Systems (EICS) itself emerged as a combination of workshops, the oldest one being the the Design, Specification and Verification

of Interactive Systems(DSV-IS) which started as an workshop at the conference Eurographics in 1994 [4].

The workshops track always played an important role at EICS. Except for its first edition in 2009, the series of EICS symposium welcomed workshops. For the edition of EICS in 2019, held in Valencia, Spain, we have solicited workshops featuring paper presentations, workshops with innovative formats such as experience design and evaluation workshops (where participants design and/or evaluate artifacts), and interactive sessions based on collaborative work. Hereafter we summarize the scope and aims of each of the three workshops at EICS 2019. We also present a summary of the contributions they received and the activities that were included in their program. In the last section, we present concluding remarks.

WORKSHOPS AT EICS'2019

The three workshops organized at EICS 2019 as well as the names of the corresponding organizers are:

- HCI Engineering 2019: 2nd Workshop on Charting the Way towards Methods and Tools for Advanced Interactive Systems, organized by José Creissac Campos, and Judy Bowen;

- EISMS 2019: Workshop on Research and Practice Challenges for engineering Interactive Systems while Integrating Multiple Stakeholders Viewpoints, organized by Jan Van den Bergh, Regina Bernhaupt, Philippe Palanque, and Benjamin Weyers;

- SmartObjects'19 7th International Workshop on Interacting with Smart Objects organized by Florian Müller, Dirk Schnelle-Walka, Karola Marky, Sebastian Günther, Tobias Grosse-Puppedahl, Kris Luyten, Oliver Brdiczka, Alexandra Voit, Max Mühlhäuser, and Markus Funk.

Hereafter we present a summary of the outcomes of each workshop.

HCI Engineering 2019: 2nd Workshop on Charting the Way towards Methods and Tools for Advanced Interactive Systems

Engineering interactive systems is a multidisciplinary endeavour positioned at the intersection of HCI, software engineering, interaction design, and other disciplines. In recent years, the range of interactive techniques available and their applications has broadened considerably and can be expected to grow even further in the future. While new interaction techniques offer the prospect of improving the usability and user experience of interactive systems, they also pose new challenges for methods and tools that can support their design, development and evaluation in a systematic engineering oriented manner. This is aggravated by the fact that they are increasingly being applied in novel and less understood application domains (e.g., wearable medical devices and AI-based systems).

New interaction techniques involve aspects that are currently not sufficiently covered by existing Human-Computer Interaction Engineering (HCI-E) methods/tools, such as design spaces, task models, model-based generation of user interfaces, toolkits, evaluation methods. This may require the definition of new methods/tools or the adaptations/extensions of existing

ones. The HCI Engineering 2019 workshop, organized by the IFIP WG 2.7/13.4 on User Interface Engineering and held in Valencia (Spain) on June 17-18, 2019, in conjunction with EICS 2019, aimed at identifying, examining and structuring the engineering challenges related to novel forms of interaction or to emerging themes in HCI due to new application domains.

Overall, the 12 papers accepted at the workshop reflect the challenges above and served as the starting point for the discussion during the workshop sessions. Accepted papers discuss the challenges faced when designing and developing interactive computing systems for a range of application domains, from Smart Environments (such as smart homes) to Human-Robot Interaction or interaction in hyper-connected cars. The use of interaction approaches, such as augmented reality or gestures is also discussed. Finally, two clear concerns arise from the different contributions: *i.* ensuring the quality of the developed systems (in particular, but not restricted to, when considering safety critical contexts), and *ii.* the impact of artificial intelligence on interactive computing systems.

Judy Bowen and Annika Hinze presented a paper titled "Smarter Software Engineering Methods for Smart Environments" which addresses challenges that arise from smart environments (smart-homes, smart-cities etc). It proposes that engineering principles used to design and develop IoT systems and smart environments, as well as the evaluation and testing technique used, must be able to include detailed considerations of the effect on a user's quality of life (QoL) as well as data sovereignty management (DSM) principles.

The paper titled "Challenges in Multi-User Interaction with a Social Humanoid Robot Pepper", by Peter Forbrig, discusses the challenges of engineering applications for humanoid robots like Pepper. The discussion is based on the project E-BRAiN (Evidence-Based Robot-Assistance in Neurorehabilitation), where patients are supported in their training after a stroke. The humanoid plays the role of a trainer. Managing the appropriate interaction technology (voice, gesture, lights, tablet, other devices) is a challenge. Domain-specific languages seem to be one way to specify necessary models.

In his paper titled "Usable-by-Construction", Steve Reeves presents the view that when we claim to be designing a usable system we have to also give assurances about its usability properties. The idea of usable-by-construction is introduced, which adopts and applies the ideas of correct-by-construction to (very abstractly) think about usable systems. A set of construction rules or tactics to develop designs of usable systems is outlined.

Hyper-connected cars can store, process, and share a large amount and variety of digital content; in their paper titled "Towards Interactions with Augmented Reality Systems in Hyper-Connected Cars", Ovidiu-Andrei Schipor and Radu-Daniel Vatavu propose to model the smart car as a smart environment, and introduce a five-layer software architecture based on Euphoria, a recent, high-performing event-driven architecture design for supporting effective communications between heterogeneous input/output devices in smart environments.

Lucio Davide Spano discussed the impact of Deep Learning techniques in the present and future of the interactive system engineering. In his paper titled "Understanding Each-Other: Engineering Challenges and Opportunities for Users and Systems in the Deep Learning Era", the author identifies different opportunities in the support for more complex vocabularies in the communication between the user and the system. On the other end, he also presents a set of challenges and opportunities in the engineering of interactive systems opened by the integration of Deep Learning techniques into different components of the classic interaction framework by Abowd and Beale [2].

End-User Programming enables inhabitants to create a smart home according to their lifestyle. In order to help an end-user to program her/his home, several researches propose adapted programming languages or adapted interfaces. These interfaces defined a smart home program as composed of a set of rules mainly expressed following the Event-Condition-Action paradigm. Considering the home behavior as a concrete system translation of the programmed rules, in their paper titled "End User Development: Verifying Home Behavior" Alexandre Demeure, Sybille Caffiau, Sophie Dupuy-Chessa, Huong Ta, and Lydie DuBousquet propose to support the specification and the maintainability activities through the study of the home behavior.

With the increasing ubiquity of touch-enabled devices, gestures are quickly becoming a mainstream interaction modality. The implementation of gesture-based user interfaces however requires specialized engineering methods. Testing gestures is particularly crucial to ensure smooth and intuitive interaction, but is often accomplished manually. In their paper titled "Test Automation for Gesture-Based Interfaces", Marc Hesenius, Matthias Book, and Volker Gruhn argue that test automation techniques for gesture-based interfaces are urgently needed and require further investigation into suitable methods and tools and propose a research agenda that focuses on evaluating gestures' quality and automatically testing gestures' functionality.

In the position paper titled "A Roadmap Towards the Engineering of Interactive Systems Deployable in Safety Critical Contexts", David Navarre and Philippe Palanque present how the engineering of interactive system may be impacted when these systems are designed to be deployed in safety critical contexts. These domains are specific as they are usually driven by constraining standards defining precisely best practices and mandatory processes to be applied. The authors discuss how it is possible to take into account these constraints in real-life domains where critical and non-critical components may coexist.

Cyber-Physical Systems (CPS), as distributed systems of computational elements interacting with the physical world, are highly complex systems. They can, in many instances, be considered safety critical interactive systems, as errors in interaction can have disastrous consequences. High assurance is, then, an underlying requirement, also at their user interface. In their position paper titled "High assurance on Cyber-Physical Interactive Systems", Rui Couto and José Creissac Campos

identify five challenges to be solved both in the short and in the long term, regarding the modelling of (1) distributed and (2) heterogeneous interactive systems, (3) the analysis and relation between the different abstraction layers of CPS, (4) the modelling of real time/hybrid systems, and (5) the modelling of the dynamic nature of such systems.

Intelligent algorithms have reached a new level of performance in recent years and are increasingly employed in application areas such as speech and image recognition, data analytics, or recommender systems. The proliferation of these techniques poses a range of new challenges for the design and engineering of interactive systems since they tend to act as black boxes and do not have the transparency and control to the user which is considered a prerequisite for user-centered design in the HCI field. In his position paper titled "Challenges in User-Centered Engineering of AI-based Interactive Systems", Jürgen Ziegler provides an overview of the broad areas related to intelligent algorithms and HCI that will need further research in the future to make systems useful, usable and trustable.

A number of engineering challenges raised by interactive software in the last decades have been addressed, so when planning the development of large systems, user interfaces are considered a solved problem and resources go elsewhere. However, it can be argued that some of the new challenges (role of humans in large systems, explainability of AI) are reformulations of problems that are well known to the community of interactive systems engineering. The paper "Toward Usable Theories for Human-Automation Systems", by Stéphane Chatty, attempts to distinguish which problems have been addressed by empirical methods and which remain to be solved by scientific methods.

The last position paper presented at the HCI Engineering 2019 workshop was "Formal Verification of Interactive Computing Systems: Opportunities and Challenges", by José C. Campos and Michael D. Harrison. In this paper, the authors discuss the opportunities created and the challenges posed by the use of formal verification in the analysis of safety and mission critical interactive computing systems. In particular, they discuss the extensions to existing tools for formal modelling and analysis that have the potential to enable their use by current development teams who are not expert in formal methods.

EISMS 2019: Workshop on Research and Practice Challenges for Engineering Interactive Systems while Integrating Multiple Stakeholders Viewpoints

The Workshop on Research and Practice Challenges for Engineering Interactive Systems (EISMS 2019) was organized by Jan Van den Bergh, Regina Bernhaupt, Philippe Palanque, and Benjamin Weyers, and was held on June 18, 2019 in Valencia (Spain), in conjunction with EICS 2019. The main goal of the workshop was to offer a platform for scientists who are interested in the design, development and use of interactive systems involving multiple stakeholders with different viewpoints integrated before, during or after the development of the interactive system. More precisely, the *first objective* was to identify and gather information about knowledge and practice in the workshop's domain:

- Get an overview of current practices in multi-stakeholder R&D practices (methods/notations/tools) to engineer usable interactive systems as well as lessons learned and recommendations;

- Identify a systematic approach for describing multiple stakeholders' viewpoints and assessing their impact on properties such as users' UX and systems' usability;

- Understand how multiple stakeholder identify properties to describe them and to assess their relative importance (going beyond the classical UX and usability, but also address aspects such as, performance, dependability, and safety);

- Understand how multiple stakeholders reach agreements and trace design decisions and their rationale.

The *second objective* was to elicit the main gaps in information gathering and exchange among multiple stakeholders and to outline a research agenda for bringing together diverse and sometimes competing views from multiple stakeholder. One critical aspect of handling information and activities from stakeholders with multiple and diverse perspectives is how to represent, store, use and maintain this information. Heterogeneous models [5] may be a suitable option to do this.

The workshop was a follow up activity of the interactive working session organized at HCSE 2018 [1] and of the first edition of the same workshop organized at EICS 2018.

The 7 contributions accepted for presentation by the workshop program committee provide a mix of perspectives. Some focus on experiences with methods and/or notations, while others focus on research challenges to support effective engineering. There are contributions from a variety of domains including manual assembly in manufacturing, automated transport in warehousing, and testing in avionics or games, while others describe concerns, challenges or potential solutions that engineering teams might experience across domains. This variety of viewpoints may contribute to achieving the goals of the stated objectives of the workshop based on experiences, knowledge about the state of practice and research, as well as current and potential future research lines.

During the first part of the workshop, the presentations of the accepted contributions provided a starting point for a sequence of focused discussions with all participants in the second part of the workshop. This led to the creation of a list of gaps in information capture and exchange in multi-user engineering as well as to an outline for a research agenda at the end of the workshop.

The list of accepted papers with a summary of their contribution follows.

The paper "Crafting Privacy: Two Case Studies Integrating Cross-Disciplinary Perspectives on Privacy in Design" by Maaike Harbers, Mortaza Bargh, Florian Cramer, Sunil Choenni, Jeannette Nijkamp and Anne Nigten, investigates the potentials and shortcomings of a workshop format used in the early stages of a (re)design process of an information system to integrate the viewpoints of multiple stakeholders from different disciplines. The results of two case studies show that different stakeholders, representing different perspectives,

identified different problems thus providing a more complete view on the issues at stake, forming a better starting point to account for privacy in the design process.

Software development is a multidisciplinary process which typically involves many stakeholders. The paper titled "Stories, Use-Case Slices and Behavioral Models: Unifying Stakeholder's Views", by Peter Forbrig and Anke Dittmar, looks at stories as a means to consider their different viewpoints. Although stories are generally valuated to increase empathy and promote discussion, the understanding of what forms a story varies substantially depending on the discipline. The paper discusses the applications of different types of stories and their combination with domain-specific behavioral models as part of the requirement specification and user experience design process.

The interaction and collaboration between humans and robots in the same working environment will become soon a reality in future industries. In these contexts, the control of transport systems will be decentralized and the autonomous behavior of robots will pose safety issues for humans and possible issues in process optimization. In the paper titled "Integrating Humans in Decentralized Control Systems with Autonomous Transport Vehicles under the Premise and Use of Proxemic Distances", Thomas Kirks, Jana Jost and Tim Uhlott describe an experimental working environment in which such issues are dealt by using augmented reality to provide humans an increased awareness and by integrating them in multi-agent systems of autonomous transport robots.

Effectively testing an interactive system requires different skills, including that of usability experts, software engineers and human-factor specialists. So far, each of these stakeholders has conducted testing activities using approaches from their respective areas of expertise thus not taking advantage of others stakeholdersâĂŹ expertise. In the paper "On the Importance of Supporting Multiple Stakeholders Points of View for Interactive Systems Testing", by Alexandre Canny, Elodie Bouzekri, Célia Martinie and Philippe Palanque, the authors highlight that a common view of the interactive system under test can serve as a mediating tool for each stakeholder to share information and identify/execute more relevant test suites.

When multiple stakeholders with different perspectives are available for a system to design, it is often difficult to find a suitable solution that satisfies everybody. In the paper titles "When You Don't Know With Whom to Collaborate: Towards an Interactive System Connecting Contributors in a Research Project, by Jil Klülnder, Wasja Brunotte and Kurt Schneider, the authors propose an approach that facilitates the collaboration between the different contributors of an interdisciplinary research project by enabling data exchange between research groups.

In "Understanding and Exploring Operator Needs in Mixed Model Assembly", Jamil Joundi, Peter Conradie, Jan Van Den Bergh and Jelle Saldien, describe two studies conducted to investigate the human needs for a digital process that streamlines the input of operators in the creation or adaptation of work instructions in a Mixed-Model Assembly Systems. The authors

found that any system should take into consideration, among other things, current operator mobility, presence of multiple operators at a workstation, and different technological skill levels as important factors to consider when developing new systems to capture operator knowledge.

The paper "An Attempt to Fathom the Role of Annotations in User-Centered Design Process", by Jean-Luc Hak, Olivier Nicolas, Marco Winckler and Philippe Palanque, investigates the role played by annotation along the development process of interactive systems. In particular, the authors propose a process to explain this co-evolution of annotations and artifacts along the development process of interactive systems. The authors' ultimate goal is promoting annotations as a first class artifact that could be used for tracking design decisions along the development process of interactive systems. The authors discuss how stakeholders can use annotation for communication, leaving a written trace of their opinions and decisions along the development process of interactive system.

SmartObjects'19: 7th International Workshop on Interacting with Smart Objects

In the era of the Internet of Things (IoT), more and more traditional everyday objects become smart by embedding additional computing and communication capabilities. The 7th Workshop on Interacting with Smart Objects (SmartObjects'19), held on June 18th, 2019 in Valencia (Spain), in conjunction with EICS 2019 and organized by Florian Müler, Dirk Schnelle-Walka, Karola Marky, Sebastian Günther, Tobias Grosse-Puppedahl, Kris Luyten, Oliver Brdiczka, Alexandra Voit, Max Mühlhäuser, and Markus Funk, focused on how the intelligence situated in these smart objects can be harvested to provide more efficient and enjoyable interaction possibilities for the users and investigates unique challenges and opportunities for designing the interaction with smart objects.

The workshop received a variety of submissions and accepted 4 of them for presentation during the workshop sessions and for inclusion in the workshop proceedings published through CEUR-WS.org. The two main topics investigated by the accepted papers are *i.* technical solutions for smart spaces, and *ii.* ways through which existing objects can be enriched towards smart objects by displaying additional information.

After the presentations of the accepted papers, a discussion about unique challenges for improving the interaction with and the use of smart objects from an interdisciplinary perspective took place among participants. The topics covered the engineering of smart objects from various perspectives, including the processing of data from sensors embedded in everyday objects, the self-representation of their behavior, interaction techniques to control and query intelligent objects, privacy and security implications, along with novel methods, processes, and tools to engineer and fabricate smart objects.

The workshop program also featured a keynote speech titles "From Smart Objects towards Autonomous Objects" by Prof. Katrin Wolf from the Department of Media Technology and Games of the Hamburg University of Applied Sciences.

Signage is moving from static analogue signs towards Digital Signage (DS), which provides a variety of benefits including remote-maintenance, support for dynamic content (e.g., videos and animations), and facilitation of the content update. However, DS solutions, despite being ubiquitous, are often tailored to specific use-cases, which limits their reuse and updateability in case of severe changes to their environment. To overcome these limits, Rolf Egert, Tim Grube, and Max Mühlhäuser, in their paper titled "MODS: Modularly Operated Digital Signage", propose a framework for Modularly Operated Digital Signage (MODS). The framework enables dynamic adaption of DS to multiple use-cases by organizing different functionalities in a plugin-based fashion. The properties of the currently implemented modules and the pre-study conducted to receive a first indicator for the usability of the framework are also discussed.

In the paper titled "Improving Presence Detection For Smart Spaces" Julian von Wilmsdorff, Biying Fu, and Florian Kirchbuchner present a novel sensor based on electric field sensing which is able to improve the presence detection in smartspaces. In particular, the sensor is able to detect if a person is present inside or outside the room by identifying if a person enters or lefts a room. The test conducted by the authors with 12 participants showed an accuracy of the detection of the given classes of 90.3%.

Digital interaction with everyday objects has become popular since the proliferation of camera-based systems that detect and increase objects in real-time. However, in different contexts, object detection faces challenges as it highly depends on environmental parameters and the conditions of the object itself. In the paper titled "Enabling Tangible Interaction through Detection and Augmentation of Everyday Objects", Thomas Kosch and Albrecht Schmidt examine different strategies that enable object detection and augmentation and show how everyday objects can be turned into user-created smart objects by augmenting them with in-situ projections.

Mastering a music instrument requires a considerable amount of time in practicing it, even with the guide of an expert. In most of the time, students practice instruments by themselves, using traditional teaching materials, (e.g., textbooks and videos) which offer poor interaction and guidance. An appropriate feedback, however, is very important to prevent learning wrong motions and potential health problems. In the paper titled "Mastering Music Instruments through Technology in Solo Learning Sessions", Karola Marky, Andreas Weiß, Julien Gedeon, and Sebastian Günther investigate how smart music instruments can enhance solo learning sessions at home and derive recommendations for designing smart and augmented music instruments.

CONCLUDING REMARKS

The program of EICS 2019 encompasses three workshops that run on June 17-18, 2019, preceding the symposium. Following the tradition of previous events, EICS 2019 renewed with successful workshops organized in the past such as the HCI Engineering workshop (2nd edition at EICS) but it also openned the door for new workshops such as EISMS and SmartObjects (in its 7th edition but first time at EICS).

All workshops presented at EICS 2019 followed a traditional program made of a series of paper presentations and invited keynote. In total, these three workshops welcomed 23 papers and one keynote speech that enrich the overall program of EICS 2019. Moreover, all workshops include in their program sections dedicated to group discussions and definition of a research agenda. We consider these interactive sections are highly important for promoting the interaction among the participants.

As illustrated here, EICS workshops are an interesting venue for discussing trendy topics. Indeed, EICS is fond of workshops proposals that push forward the boundaries of the engineering of interactive systems. For that, we encourage our colleague to participate and contribute to the workshops track in future editions of EICS.

Last but not least, we would like to thank all the authors and participants that contribute to the success of the workshops organized at EICS 2019.

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