



Editorial

Human-centric software engineering – Approaches, technologies, and applications

1. Introduction

We live in a world where digital technologies are deeply ingrained into our everyday lives. Our personal and physical environments are becoming increasingly intertwined, and the quality of our everyday life is reliant upon a variety of smart services and cyber-physical infrastructures that are used for delivering critical citizen-centric services such as healthcare, education, banking, and transportation. Software is the key ingredient that facilitates this cyber-physical-social convergence, and humans are at the centre of this convergence—not only as the creators, designers, coders, testers, and users of the software systems but also occasionally as abusers. However, most current software engineering research and practices still tend to be function, data, or process-oriented without paying much attention to the human-centric issues such as accessibility, usability, emotions, personality, age, gender, and culture, leading to the problem of misaligned software systems. In recent years, human-centric software engineering is becoming more prominent and has attracted a lot of attention from both academia and industry. The topic of “Human aspects of Software Engineering” has now been included in the topics of interests by all flagship software engineering conferences including ICSE, ESEC/FSE, and ASE.

2. Overview of the special issue

The theme of this special issue is “Human-Centric Software Engineering – Approaches, Technologies, and Applications”. The objective of this special issue was to provide a summary of recent research that advances human-centric software engineering and to also serve as a collection of current state-of-the-art approaches and technologies. It seeks to report on high-quality original and unpublished work on research and innovative practices to systematically capture and use human-centric software requirements during software development and verify that systems meet these requirements. We solicited papers on enhanced theory, models, tools, and capabilities for next-generation human-centric software engineering that are aimed at improving software quality, user experience, developer productivity, and cost savings. While we encouraged authors of top-quality papers accepted by the 2021 Workshop on Human Centric Software Engineering and Cyber Security (HCSE-CS 2021, co-located with ASE2021) and 2021 International Workshop on Affective Computing in Requirements Engineering (AffectRE 2021, co-located with RE2021) to submit their extended articles, this special issue also had an open call to the wider research community.

The call for papers attracted 25 submissions covering a range of relevant topics, and after a rigorous peer review process, this special issue has selected 10 outstanding research papers for publication. These accepted papers focus on various areas, including emotions and behaviours, industry applications and tools such as robotic systems, mobile applications, online gambling, as well as trust and privacy issues.

Specifically, there are three papers focusing on theoretical aspects of human-centric software engineering:

- In the paper titled “*Theory of constructed emotion meets RE: An industrial case study*” by Iqbal et al. the authors emphasise that emotional requirements should be treated as first-class citizens rather than subsumed under “non-functional” requirements. The authors aim to find out the advantages of grounding requirements engineering in the theory of constructed emotion, and explore the possible methods or techniques that support the construction of emotions in the requirements engineering process for building emotion aware systems. The key contribution of this paper is an original repeatable methodology for eliciting and representing requirements for interdisciplinary design projects aimed at designing software-intensive emotive artefacts.
- The paper titled “*On the subjectivity of emotions in software projects: How reliable are pre-labelled data sets for sentiment analysis?*” by Hermann et al. investigates the alignment between the labels of the statements in the pre-labelled data sets from different sources (including GitHub and Stack Overflow) and the perceptions of potential members of a software project team. Through an international survey with 94 participants, the study reveals that there are significant differences between individual participant's ratings and the predefined labels. Interestingly, no participant completely agrees with the predefined labels, and the data set with labels based on guidelines outperforms the ad hoc labelled data set.
- In the paper titled “*Investigating acceptance behaviour in software engineering—Theoretical perspectives*” by Börstler et al. the authors delve into the exploration of acceptance models and theories and their applicability in studying acceptance behaviour within software development. Through a comprehensive literature review conducted by an interdisciplinary team, the authors identified 30 potentially relevant models and theories. However, only a few of these models and theories have been utilised in researching acceptance behaviour in software development contexts, and very few

have undergone validation in such settings. The authors conclude that greater use of acceptance behaviour models and theories in software engineering research can aid in understanding and predicting the adoption of practices in the industry. They also emphasise the need for careful consideration of factors such as validation, overlap, construct operationalisation, and data collection mechanisms when employing these models and theories.

There are five papers focusing on approaches for human-centric software engineering with various industry applications:

- The paper titled “*Assessing industrial end-user programming of robotic production cells: A controlled experiment*” by Mayr-Dorn et al. focuses on investigating the problems faced by non-programmers when utilising visual languages to control the behaviour of robots and their interaction with other machines on the shop floor. The authors conduct a controlled experiment in the injection modelling industry to assess the performance of participants. The results indicate that participants were relatively quick in comprehending the program behaviour using both a familiar sequential function chart-based language and a Blockly-based language. However, they experienced difficulties in multiple aspects unrelated to the language itself due to the interweaving of physical and software-centric interaction between robot and machine. As a result, the authors conclude that assistance should go beyond optimising available language elements and encompass the provision of relevant programming elements and their sequencing to address these challenges effectively.
- In the paper titled “*The Prevent-Model: Human and Organizational Factors Fostering Engineering of Safe and Secure Robotic Systems*” by Glasauer, the author presents an overarching model that addresses both human and organisational factors essential for the development of safe and secure robotic systems. Through a qualitative interview study with three focus groups consisting of experts from robotics, software engineering, and related domains, Glasauer proposes the integrative Prevent-Model. This model encompasses 17 individual factors and 13 organisational factors that collectively contribute to the establishment of a safe and secure environment. The Prevent-Model serves as a roadmap for developing tailored measures, and provides guidance to practitioners in enhancing personnel development programs, organisational structures, working environments, and other crucial aspects crucial related to the development of safe and secure robotic systems.
- The paper titled “*Investigating end-users’ values in agriculture mobile applications development: An empirical study on Bangladeshi female farmers*” by Shams et al. the authors investigate the violations of end-users’ values (e.g., fairness, honesty, social recognition, etc.) in mobile applications, which may bring more severe and lasting problems for marginalised and vulnerable end-users. Specifically, the study focusses on marginalised and vulnerable end-users, specifically Bangladeshi female farmers, whose values play a crucial role in their app preferences. Through an empirical study involving a survey of 193 Bangladeshi female farmers, the authors identify three underlying factors and also observe the strong influence of demographics on certain values. The findings provide valuable insights for developers of Bangladeshi agriculture apps, highlighting the importance of tailoring app design strategies to different groups of Bangladeshi female farmers based on their values.
- In the paper titled “*Explainable persuasion for interactive design: The case of online gambling*” by Cemiloglu et al. the authors study the concept of explainable persuasion, its potential forms, benefits, and the user demand for explainable persuasion. The study specifically focusses on online gambling as a case study, employing an online survey based on persuasion and explainability principles. The results indicate that players possess an understanding of the use, persuasive intent, and potential harm of various persuasive design techniques employed in online gambling platforms, including their persuasive intent and potential harm. However, participants also expressed agreement that explainable persuasion can assist users in maintaining control over their online experience, fostering a positive attitude towards the system, and raising awareness of the potential consequences of persuasive interfaces. Consequently, future research is necessary to advance the design and implementation of explainable persuasion in persuasive interfaces, enabling users to make informed decisions and ensuring a responsible online gambling environment.
- The paper titled “*A mobile intelligent guide system for visually impaired pedestrian*” by Chen et al. presents an innovative approach to assist visually impaired individuals through an intelligent guide system implemented on a smartphone. The system utilises the phone’s camera to capture videos of tactile paving, which are processed and analysed by the system to generate guide messages in the form of sound or vibration. To achieve this, the authors employ various techniques, including the MobileNet model, which is fine-tuned by transfer learning, Single Shot MultiBox Detector (SSD) for tactile walking surface indicators (TWSI) detection, and the Score Voting algorithm for determining the user’s position. Additionally, to enhance real-time performance of the system, the authors apply model quantisation to compress it while maintaining accuracy. Experimental results using real tactile paving demonstrate that the proposed system achieves high accuracy and real-time performance, showcasing its effectiveness in aiding visually impaired pedestrians.

There are two papers focusing on addressing privacy issues from an end-user perspective:

- In the paper titled “*Privacy explanations – A means to end-user trust*” by Brunotte et al. addresses the critical issue of end-users’ lack of awareness regarding data collection, its purpose, access rights and storage practices. The authors investigate the potential of explainability as a solution to this concern. They develop privacy explanations designed to help clarify to end users about the specific data requirements and the collection purposes. To gauge the effectiveness of privacy explanations, the authors conducted a survey among end users. The results indicate that the majority of respondents (91.6%) are generally interested in receiving privacy explanations. These findings indicate that privacy explanations can be an important step towards increasing trust in software systems and can increase the privacy awareness of end users.
- Finally, in the paper titled “*People want reassurance when making privacy-related decisions – Not technicalities*” by Kulyk et al. the authors aim to explore how an information-based decision can be supported, and also to understand the cues used in a heuristics-based approach. In their first study, the authors employ metaphors to enhance participants’ understanding of underlying encryption mechanisms. Interestingly, participants expressed a preference for reassurance

rather than being burdened with becoming “technical experts”. Subsequently, the participants’ free-text responses were subjected to a Q-sort analysis to determine the cues relied upon for heuristic-based decision making. The findings reaffirmed the participants’ desire for reassurance. Finally, in their third study, the authors elicited “cyber stories”—unprompted narratives about cyber-related experiences—to detect emotional undertones in this domain. The results revealed predominantly negative responses from participants, indicating a potential influence on cybersecurity-related decision-making.

We hope that this compilation of research will inspire further research in the field of human-centric software engineering.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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