HICSS-56 Minitrack
Digital Twins: Platforms, Methods, Applications, and Impact

Tim Schattkowsky
University of Applied Sciences
Hamm-Lippstadt
tim.schattkowsky@hshl.de

Gregor Engels
Paderborn University
engels@upb.de

Achim Rettberg
Carl-von-Ossietzky Universität
Oldenburg
achim.rettberg@informatik.uni-oldenburg.de

Abstract

This minitrack provides a brief overview of the current state in the application, construction and management of digital twins. The presented approaches range from practical government application scenarios to theoretical foundations for the construction of digital twins for safety critical systems.

Keywords: digital twin, digital transformation, society, robot programming, augmented reality, distributed systems, safety critical systems

1. Background

The idea of creating digital twins as connected virtual counterparts for physical objects becomes increasingly popular and may soon be a key factor in enterprise success across the industries. Nowadays, the concept is already applied in various application fields such as engineering, manufacturing, e-commerce, social media platforms or health care. As a consequence, digital twins often already directly or indirectly affect the work and daily life of humans. Therefore, it is also important to consider the effects of digital twins from the perspective of other fields like psychology, sociology, or organizational management.

2. Intended Audience

The intended audience for this minitrack is anyone interested in any aspect of digital twins from theory to application. This in particular also includes researchers and practitioners from adjacent fields that may be interesting for the application of digital twins

3. Paper Presentations

This Minitrack includes four paper presentations, for which abstracts are provided here:

Towards a Digital Twin of Society (Chircu, Czarnecki, Friedmann, Pomaskow & Sultanow, 2023): This paper describes the potential for developing a digital twin of society - a dynamic model that can be used to observe, analyze, and predict the evolution of various societal aspects. Such a digital twin can help governmental agencies and policy makers in interpreting trends, understanding challenges, and making decisions regarding investments or policies necessary to support societal development and ensure future prosperity. The paper reviews related work regarding the digital twin paradigm and its applications. The paper presents a motivating case study - an analysis of opportunities and challenges faced by the German federal employment agency, Bundesagentur für Arbeit (BA), proposes solutions using digital twins, and describes initial proofs of concept for such solutions.

Simple Design Approach for Shared Digital Twins (Hasse & van der Valk, 2023): The collaborative utilization of data becomes increasingly important in industry and requires increased consideration of interoperability and data sovereignty aspects. Distributed systems play a decisive role in this context, which allow for a closer communication between the stakeholders involved and are characterized by the shared use of data and devices. At the same time new concepts emerge that enable a structured mapping of data. These include Digital Twins, which primarily allow a holistic digital representation of an entire asset lifecycle. Digital Twins offer significant potential for distributed systems and form a suitable basis for the collaborative utilization of an asset's lifecycle data. Although studies assume an increased use of Digital Twins in cross-company networks, they are still predominantly used as a purely company-internal concept. In the context of this publication, we demonstrate how to get started easily with the design of Digital Twins intended for use in collaborative distributed systems.

URI: https://hdl.handle.net/10125/103449
978-0-9981331-6-4
(CC BY-NC-ND 4.0)

Enhancing Robot Programming through Digital Twin and Augmented Reality (Yigitbas & Engels, 2023): Nowadays, robots are widespread across diverse application contexts. However, robot programming is a cumbersome and error-prone task that requires a high domain and programming expertise. To simplify the process of robot programming, we combine Augmented Reality (AR) with the concept of Digital Twin (DT). By combining them, the robot system can be simulated through a digital equivalent representation while the real environment is extended with useful virtual artifacts. To enable users to work in the robot space, reducing the amount of mentally taxing coordinate space conversions, we have developed the DT- and AR-based robot programming framework, called DART. DART supports users to program a robot through interactive gestures, offers AR in-place program simulation, and direct building of finished programs to the real robot. We evaluated our AR-based programming approach regarding usability compared to a web-based robot programming approach. The evaluation showed that our approach is more usable than the conventional method and has the potential to enrich and ease current robot programming processes.

Contract-based Digital Twin Synthesis for Autonomous Safety Critical Systems (Henkler & Hirsch, 2023): The development of Digital Twins is a complex process. The complexity increases with the autonomy and networking of the system under consideration. However, progressive scenarios in the area of smart farming or platooning in road traffic in particular require reliable Digital Twins that can consider safety-critical aspects. Previous approaches do not consider this and are also not suitable due to the often manual construction. We present an approach based on a well-defined contract-based engineering that automatically synthesizes the complex interaction with the system under consideration by preserving safety and liveness properties.

References

Chircu, A., Czarnecki, C., Friedmann, D., Pomaskow, J., & Sultanow, E., (2023). Towards a Digital Twin of Society. In *Proceedings of the 56th Hawaii International Conference on System Sciences (HICSS)*.

Hasse, H., & van der Valk, H., (2023). Simple Design Approach for Shared Digital Twins. In *Proceedings of the 56th Hawaii International Conference on System Sciences (HICSS)*.

Henkler, S., & Hirsch, M., (2023). Contract-based Digital Twin Synthesis for Autonomous Safety Critical Systems. In *Proceedings of the 56th Hawaii International Conference on System Sciences (HICSS)*.

Yigitbas, E., & Engels, G., (2023). Enhancing Robot Programming through Digital Twin and Augmented Reality. In *Proceedings of the 56th Hawaii International Conference on System Sciences (HICSS)*.