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Visualisation, Representation and Interoperation of Digital Twins with Open-Source Software Frameworks

Abstract: Digital twins (DTs) refer to digital information constructs of physical assets and feature automatic two-way exchange of information between the digital and physical counterparts. Typically, DTs allow communication from the physical systems they represent, and are often used as interfaces to obtain information such as sensor data. Sending information back to the physical system digitally is possible; however, changing system behaviour, besides settings or optimization, requires more than merely updating parameter related information. To facilitate propagating changes made in digital systems back to physical systems, we approach the problem in this paper with an example framework and implementation – using a miniature toy factory and open-source software (OSS) frameworks. In the long term, our ongoing research is aimed to empower workers with remote interaction while performing expert maintenance tasks in industrial settings. Furthermore, adopting OSS frameworks enables new solution providers to enter contested markets more easily in the future.

Keywords: Digital twin, interoperability, virtual reality

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1 Background

Digital Twins (DTs) [1] refer to digital constructs of physical assets, such as products or processes, connected with an automatic two-way flow of information between the digital and the physical [2]. DTs are one of the driving forces behind Smart Manufacturing and Industry 4.0 paradigms [3], providing enhanced prediction and analysis capabilities for cyber-physical systems. However, it is not clear how DTs can be utilised to support experts in field maintenance tasks [4].

The OXILATE project (1) focuses on the complementary integration of expert knowledge in professional settings to empower workers. Remote work is quickly becoming more common, and industrial maintenance workers require relevant system information from customers to resolve technical support tasks. This almost always requires information regarding customer systems and related maintenance activities, such as maintenance reports, manuals, and implementation specifications. Information must be presented for maintenance workers in a meaningful way (such as system simulations), requiring solutions to be implemented with regard to customer systems. Often the latter is causing the most issues as maintenance workers might not have access to the real system for implementing changes, and therefore must instruct local workers to carry out the necessary changes.

This issue presents a research opportunity for describing real systems in simulations, and on how changes in simulated environments can be propagated to physical systems directly. Moreover, the emerging DT ecosystems [5] enable new solution providers to enter the market more easily in the future. This suggests an increasing need for open-source software (OSS) frameworks to integrate dynamically interoperable DTs from different vendors, and their visualisations for the needs at hand. To this end, we describe a solution based on OSS frameworks.

2 Aims

This paper reports on an ongoing research process for enabling changes in real systems with interoperable parts. Our research focuses on propagating changes automatically between two systems: the digital and physical counterparts of a miniature toy factory. Our objective is to provide a simulation capable of mimicking the behaviour and actions of a real system with accuracy,

1 https://itea4.org/project/oxilate.html

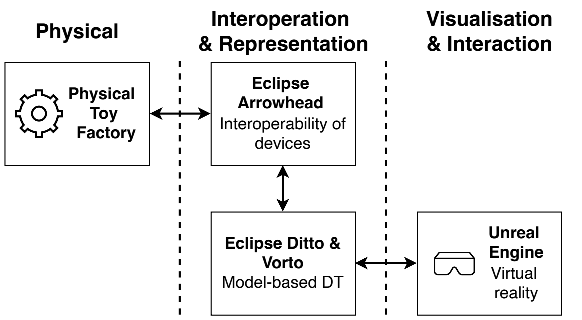

Fig. 1. An example implementation of a Toy Factory digital twin using OSS frameworks.

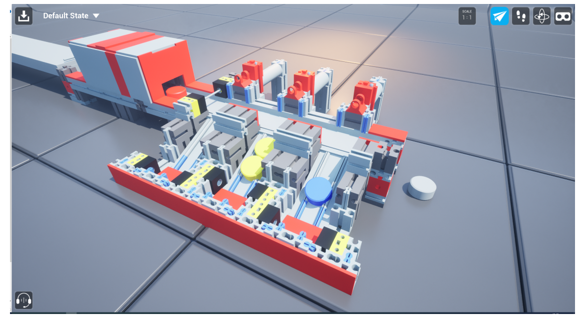

Fig. 2. A modelled sorting line conveyor belt from a toy factory made interactable with virtual reality.

while also allowing changes to be made in the simulation – which are then propagated back to the real system.

3 Materials, Methods, and Results

As a piece of constructive research, the main result of this paper is a design of an architectural framework (Fig. 1) where physical systems are digitally represented as DTs and can be used in visualisation and simulation software to view and modify the toy factory. The framework describes how communication between simulated and real systems, consisting of more than one device with their respective DTs, can be established. A key research goal with the framework is to study what kind of methodology is needed to enable change propagation between the simulation and the real system.

The results include a demonstration of using the framework (Fig. 1) in connection to a miniature factory (modeled with NX CAD (2) and implemented by Luleå University of Technology) which includes separate devices and subsystems: Eclipse Arrowhead Framework (3) to enable device-to-device interconnect ability, Eclipse Ditto (4) and Vorto (5) to represent the DT layer – connected with the MQTT-protocol (6), and Unreal Engine (7) to simulate the system (Fig. 2) with Valve Index VR glasses (8).

2 https://www.plm.automation.siemens.com/global/en/products/nx/
3 https://arrowhead.eu/eclipse-arrowhead-2/
4 https://www.eclipse.org/ditto/
5 https://www.eclipse.org/vorto/
6 https://mqtt.org/
7 https://www.unrealengine.com/
8 https://www.valvesoftware.com/en/index

4 Conclusions

The purpose of the current study is to determine how changes can be propagated between the digital and physical counterparts of DTs using OSS frameworks. The implementation and demonstration described in this paper elaborate the state-of-the-art by using some of platforms from the vendor neutral open-source Eclipse Foundation – including the Arrowhead framework, and the Vorto and Ditto platforms – and the open-source Unreal Engine. As a natural progression of this work we plan to design and implement the communication protocol back from virtual reality interaction to the physical toy factory, including the necessary instructions for the toy factory. These results may be of use for enabling new solution providers to enter various markets more easily in the future with OSS solutions.

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