A SURVEY ON VISUALIZING THE DIGITAL TWIN USING WEB SERVICES AND AUGMENTED REALITY

Sejal Lunawat[1], Pranjali Dethe[2], Samiksha Jain[3], Prof. Mohit Popat[4]

[1]*Student, Computer Science And Engineering, J.D.I.E.T, Maharashtra, India,* ***sejallunawat70@gmail.com***
[2]*Student, Computer Science And Engineering, J.D.I.E.T, Maharashtra, India,* ***pranjalidethe03@gmail.com***
[3]*Student, Computer Science And Engineering, J.D.I.E.T, Maharashtra, India,* ***samikshajain321@gmail.com***
[4]*Professor, Computer Science And Engineering, J.D.I.E.T, Maharashtra, India,* ***mohit.popat@rediffmail.com***

Abstract

The main objective of this paper is comprehensive study on Visualising the Digital Twin using Web Services and Augmented Reality.With the development of industrial systems, number of network connected devices in an industrial system increases. The management and handling of the information generated by these devices is important. In this paper we explore concepts of cyber-physical system (CPS) which is integration of computation, networking, physical processes whose behaviour is defined by both cyber and physical parts of the system.CPS is a system of collaborating computational elements controlling physical entities. Cyber-Physical System model is the virtual part of industrial devices like sensor, machines, CLPs. In this paper we also proposed the architecture of digital twin based on web services for accessing their data. This architecture is consisting of five layers i.e. Device Layer, User Interface Layer, Web Services Layer, Query Layer and Data repository Layer. We present key enabling technologies i.e. Augmented Reality and web service, where an Augmented Reality is the technology that expands our physical world, by superimposing digital content onto the real world and web services are modular unit of application logic. The Twin Model data is accessed by Augmented Reality system via web services and display real-time information to the user. Moreover, we present applications, advantages, and disadvantages of digital twin.

Keywords: Cyber-Physical Systems, Augmented Reality, Digital Twin

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1. INTRODUCTION

Many new national advanced manufacturing strategies, such as Industry 4.0, Industrial Internet, and Made in China 2025, are issued to achieve smart manufacturing, resulting in the increasing number of newly designs in growing to large lines in both developed and developing countries. Under the individualized designing demands, more realistic virtual models mirroring the real worlds of production lines are useful to bridge the gap between design and operation. We are facing the fourth industrial revolution or the so called Industry 4.0.

The Digital twin is a virtual representation of the physical product, a digital shadow that contains all the information and knowledge of it. It is connected with the physical part somehow, allowing data transfer from the physical to the cyber part. It is defined as a distributed and decentralized approach to manage product information at product item level along its lifecycle. The digital twin is directly linked to the concept of Product Lifecycle Management (PLM) systems. PLM consolidates diverse business activities that create, modify and use data to support all phases of a products lifecycle from begin-of-life, middle-of-life, and end-of-life.
Digital twins, a name given by General Electric to identify the digital copy of an engine manufactured in their factories, are now a reality in a number of industries. They are almost “identical” to the real thing, like in the case of General Electric engines and some modern keys where you have to take their digital twin to get a copy, or an accurate replicas like in case of Tesla cars or more coarse representation.

These digital twins can be used for a variety of purposes, simulation and monitoring are clearly common applications of it. They can also be useful as platform to test adds on. The growth of digital twins is steamed by the growing digitalization in the design phase that ends up in producing a digital copy of the final product, digital copy that is also used in manufacturing of the product by using robots and other sorts of digital controlled manufacturing tools in factories.

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2. THEORETICAL FOUNDATION

Theoretical foundation consist of cyber physical system and digital twin.

2.1 CYBER-PHYSICAL SYSTEM

A cyber-physical system (CPS) is an integration of computation, networking, physical processes whose behaviour is defined by both cyber and physical parts of the system. Embedded computers and networks monitor and control the physical processes, where computations affect physical processes and vice versa. In cyber-physical systems, physical and software components are deeply intertwind, these components operate on different structural and temporal scales, exhibiting multiple and distinct behavioral modalities, and interacting with each other in a lot of ways that change with context.Ongoing advances in science and engineering improve the link between computational and physical elements by means of intelligent mechanisms, increasing the adaptability, autonomy, efficiency, functionality, reliability, safety, and usability of cyber-physical systems. This will broaden the potential of cyber-physical systems in several directions, including: intervention, precision , operation in dangerous or inaccessible environments, coordination , efficiency and augmentation of human capabilities .

Figure Gives the architecture of Cyber-physical systems which consists of sensors and actuator which collects information and act into the physical world. In addition,The information collected by sensors which is in analog format are converted into the digital format. The data management system keeps database of information and send it to the data analytics system. After receiving inputs, the decision making system executes the computations to analyze the collected data and then by a sequence of control processes decision making system relays its decision to the actuators in the physical world.

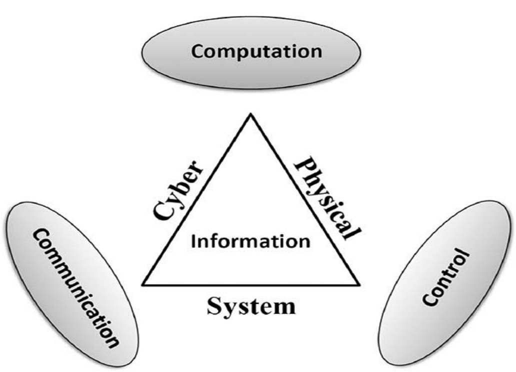

Fig.1. Cyber-Physical System.

CPS is a system of collaborating process components dominant physical entities. Today, a precursor generation of Cyber-physical systems (CPS) will bring advances in personalized health care, emergency response, traffic flow management, and electric power generation and delivery, aerospace, automotive, chemical processes, civil infrastructure, manufacturing, transportation, entertainment, and consumer appliances as well as in many other areas now just being envisioned.

2.2 DIGITAL TWIN

The Digital twin is a virtual representation of the physical product, a digital shadow that contains all the information and knowledge of it. Digital twin is connected with the physical part in some way, allowing data transfer from the physical to the cyber part. It is defined as a distributed and decentralized approach to manage product information at product item level along its lifecycle. The digital twin is directly linked to the concept of Product Lifecycle Management (PLM) systems. PLM consolidates diverse business activities that create, modify and use data to support all phases of a products lifecycle from “begin-of-life” (design, production), “middle-of-life” (use, maintenance), and “end-of-life” (recycling, disposal). A digital twin includes both static and dynamic information. The static information can be: geometrical dimensions, bill of materials, processes, etc. The dynamic information is the one that changes with time along the product lifecycle. A digital twin can have intelligence. For example, an intelligent product can retrieve information about itself and is capable of participating or making decisions about its own future. As pointed out In an intelligent product presents following characteristics: Requires a global unique identification; Is capable of communicating with its environment Can retrieve and store data about itself Is capable of participating in or making decisions relevant to its own destiny.

3. KEY ENABLING TECHNOLOGIES

In this section, we present the key enabling technologies for implementing an augmented reality system in which different users can access the information stored in the digital twin. The idea is to have different databases, located in different places. With the use of web services, the AR systems can query the information stored in these repositories. Here, we have explain what are AR Systems, how they work, as well as what are web services.

3.1 AUGMENTED REALITY

Augmented reality is the technology that expands our physical world, by superimposing digital content onto the real world, thus enhancing one’s current

perception of reality. The meaning of the augment is to add or enhance something. Augmented Reality enhances user experience in direct view of an existing environment and adds sounds, videos, graphics and touch feedback into our natural world.
There are four types of augmented reality

Marker-based AR: It requires a special visual object and a camera to scan it and some type of visual marker, such as a QE/2D code; hence it also called as image recognition. It may be anything, from a printed QR code to special signs when the marker is sensed by a reader. This QR code is distinct, but patterns are simple, so that they can be easily recognized and less power can be require for reading it. In some Cases, to position the content AR device calculates the position and orientation of a marker in which some type of content or information is overlaid the marker.

Markerless AR: It is also called as location-based or position-based augmented reality. It is most widely implemented applications of augmented reality. It utilizes a GPS, digital compass, gyroscope, velocity meter or accelerometer which is embedded in device to provide data based on user's location. What AR content you find or get in a certain area is then determined by this data. With the availability of smartphones and location detection features they provide, this type of AR typically produces maps and directions, nearby businesses info and hence it is a strong force behind markerless augmented reality technology. Applications include events and information, business ads pop-ups, navigation support, mapping direction.

Projection-based AR: It project synthetic light or artificial light to physical surfaces. In some cases it allow human to interact with it and then sense the human interaction of the projected light. These are the holograms that detect user interaction with a projection by its alterations.

Superimposition-based AR: It partially or fully replaces the original view of an object with an augmented view. In Superimposition based AR objects recognition plays a key role, because without it the whole concept is simply impossible. If the object is not determined, application cannot replace the original view with an augmented view. We've all seen the superimposed augmented reality in IKEA augmented reality furniture Catalogue app, that allows users to place virtual items of their furniture catalogue in their rooms.

3.2 WEB SERVICES

Web services are defined as modular units of application logic that provide functionality for other applications over the network. It acts as an abstraction layer, separating the programming details (such as programming language and platform) of how the application code is invoked. Thus, programs in different languages and platforms can communicate through the use of this technology. This kind of technology have been used in some works in industrial applications, as described in, motivated by the fact that a Web service can be seen as a software system designed to support practical machine-to-machine interaction over a network. Many industries companies use multiple software systems for management and they need to exchange data with each other. A Web service is a method of communication that allows 2 code systems to exchange this knowledge over the net. The two main protocols on Web services are Simple Object Access Protocol (SOAP) and Representational State Transfer (REST).

3.2.1 SOAP

SOAP-based architecture has its communication of Extensible Markup Language (XML)-encoded messages over Hypertext Transfer Protocol (HTTP). SOAP service sets are defined in Web Service Definition Language (WSDL) files which are XML files standardized according a W3C-specified grammar.

3.2.2 RESTful

The REST was introduced as an architectural style for distributed scalable systems and large-scale systems. Given that the great majority of RESTful Web services are not described using the WSDL description, it's not possible to reuse existing clients that require this description. REST is based on four architectural principles: i. Resource identification through URI: exposes resources which identify the targets for interaction with its clients. ii. Uniform interface: resources can be manipulated using four operations: PUT (create), GET (read), POST (update), DELETE (delete). iii. Self-descriptive messages: the resources can be accessed in a variety of formats (e.g., HTML, XML, plain text, etc.) iv. Stateful interactions with hyperlinks. The interaction with a resource is stateless.

4. ARCHITECTURE

CPS consists of a data collection system; a data management system; a decision making system and an interactive visualization system which interact with the human. In this paper, the visualization of the physical data in the context of a cyber physical system using Augmented Reality (AR) systems is the main goal of this architecture. The architecture of the proposed system is shown in Fig. This architecture is divided into five layers: devices, user interfaces, web services, queries and data repositories.

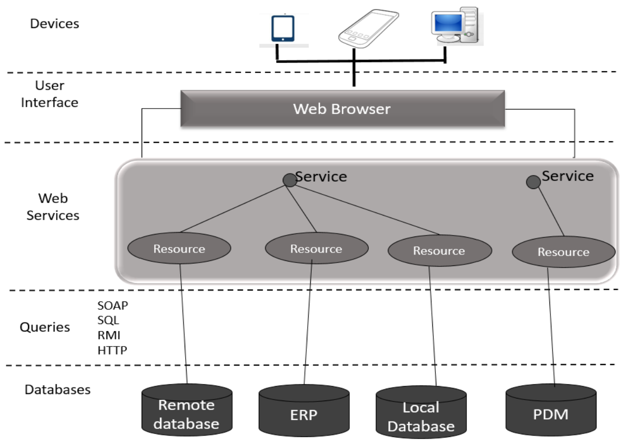

Fig. 2. Concept of the architecture for digital twin data management based on web services

4.1 Device Layer

The first layer is contains the physical twin which includes various devices. They can be computers, tablets, mobile devices, sensors, accumulator etc, which can provide signal exchange. The visualization systems are run by these devices; in this case the visualization system is AR system. In this architecture these devices are operated as client by the user.

4.2 User Interface Layer

For operation of devices user interface is required, in this case the user inter face can be augmented reality interface. By using a browser the user interface can accesses the web service.

4.3 Web Services Layer

The RESTful web service was used in digital twin. It has various services. Each service can have several resources and also it was considered as an individual task. These services can be addressed by a HTTP call. The HTTP calls the service to retrieve all information related to the request made by the client and the requested information was collected from the involved resources. The representation of the resources which was the response from server can be generated from one resource or more number of resources.

4.4 Query Layer

To retrieve data from the database, the resources build queries. The data management system uses software that gives protocol of each query. These protocol types can be SOAP, SQL, RMI, HTTP and others.

4.5 Data repository Layer

Data is retrieved from the database systems. This data is retrieved by resources. By using a RESTful web service the data is accessible in the same way, independent of the type and structure of data management system. Data stored in different data management systems is accessed by using a web browser. It is the benefit of using web services. This allows the use of mobile devices and the retrieval of manufacturing data.

5. APPLICATIONS

Customer experience: customers play a key role in influencing the methods and choices in any business. The ultimate aim of any organization is to achieve and retain a large client base; and this {can be} suggests that enhancing your customer's expertise A digital twin can facilitate boost the services directly offered to customers. For example, a digital twin could be used for modeling fashions on a visual twin of the customer.
Performance tuning: A digital twin facilitates confirm the best set of actions that may help maximize a number of the key performance metrics, and conjointly give forecasts for long coming up with. For example, the performance of a scientific device, that is deployed on a orbiter, can be tuned from Earth using digital twin as a 3D real-time visualization.
Digital machine building: A digital twin is used as a digital copy of the important machine, created and developed at the same time. Let's take the example of a German machine manufacturer that determined to digitally map the packaging and special machinery that it created for several industries. The data of the important machine was loaded into the digital model before the particular producing began. So a digital twin allows simulation and testing of ideas, even before the particular producing begins.
Healthcare: A digital twin will facilitate virtualize a hospital system so as to form a safe atmosphere and take a look at the impact of potential changes on system performance. Not simply operations, digital twins may also facilitate improve the quality of health services delivered to patients. For example, a surgeon can use a digital twin for a digital visualization of the heart, before operating it.
Smart cities: A digital twin is used for capturing the spatial and temporal implications to optimize urban property. For instance, 'Virtual Singapore', a part of the Singapore government's Smart Nation Singapore initiative, is the world's first digital twin of an existing city -state, providing Singaporeans and effective way to engage in the digital economy.
Maintenance: A digital twin is capable of analyzing performance data collected over time and under totally different conditions. For example, with a digital twin, a racecar engine can be visualized to identify the required maintenance, such as a component that is about to burn out.

6. ADVANTAGES AND DISADVANTAGES

6.1 ADVANTAGES

- It Increases the life of assets and equipment
- Detect operational inefficiencies
- It reduce maintenance costs by predicting maintenance issues before breakdowns occur
- It improves situational awareness
- It is efficient for production control
- Optimization of operability and reduction of operating cost
- During lifecycle of system, assessment of a system's current and future capabilities is possible
- Before physical processes and development of product, discovery of system performance deficiencies is possible by simulating way of results which reduce risk in various areas including product availability, marketplace reputation
- Optimization of sustainability and manufacturability
- Through data capturing and easily crossed referencing to design details, continuous refinement of designs and models is possible.

6.2 DISADVANTAGES

- Data security and privacy is the main problem that arises with digital clones. Numerous resources of business and private information are access by smart software and it is subject to data theft and cyberattacks.
- Another disadvantage is high cost of technology implementation. But, it is a one-time investment that will pay off in the future.

7. CONCLUSION

In this paper, the focus is on how to retrieve data from digital twin and propose the use of augmented reality and web services to visualize the data. The concept of Digital Twin, in the context of Cyber Physical System and Industry 4.0 is shown. The Digital twin is a virtual representation of the physical product, It is defined as a distributed and decentralized approach to manage product information at product item level along its lifecycle. The architecture using web services can enable users to easily access product, simulation and manufacturing data of a Digital Twin, via a web browser. It is independent of any device and enables the data to be visualized on portable computer and devices. A digital twin has many applications across the life cycle of a product and should answer queries in real time that couldn't be answered before, providing kinds of worth considered nearly inconceivable just a few years ago.

ACKNOWLEDGEMENT

We would like to sincerely thank all the authors and reviewers for their efforts toward the success of this special issue.

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