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LINKING CAD MODELER AND XR ENGINE FOR DIGITAL TWIN-BASED COLLABORATIVE ROBOTIC ASSEMBLY

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Abstract: *Production paradigm of mass customization and development of highly complex products impose the need for development and using xR technologies in manufacturing. Immersive technologies (xR) are currently the best solution for human-machine interfaces and as such are great candidate for further development and usage in industry. In this paper, a way of integration between CAD modeler and xR development engine will be shown. For CAD modeler, SolidWorks software is chosen, which is well known as one of the most widely used engineering design tools, and for the xR development system is used Unity. Even thou SolidWorks offers great capabilities it still lacks proper xR technologies interfaces which can connect HMD xR interfaces(e. g. Facebook Oculus Rift). Using Unity API library and SolidWorks SDK digital-twin system is created which allows remotely xR interaction between CAD and XR models.*

Keywords: *Smart Manufactoring, Virtual Reality, Digital Twin, CAD-xR Dynamic Linker, xR.*

1. INTRODUCTION

Although virtual and augmented reality technology [1] (collectively xR) is objectively far from mass and thus, routine application in the manufacturing industry, it is undoubtedly one of the technologies that has a huge transformative potential to significantly change the production technologies as we know them today. This potential lies in the fact that xR technologies represent the technological basis for building a new generation of human-machine interfaces [2] (HMI). It is impossible to realize the concept of intelligent manufacturing systems (regardless of what we really mean by intelligent and which we often use uncritically), or more broadly, cyber-physical production systems, without realizing such a communication channel that will enable natural, unconstrained human communication with the world of digitalized information. Human's system of visual perception is undoubtedly a key component of such a communication channel. But what is meant here is not simply the transmission of visual information, but technology that will allow man's natural ability to penetrate three-dimensional space and use it effectively, through the amazing and almost incredible cognitive abilities of his brain (we see with Our brain, not with our eyes!). This topic far exceeds the available space for this paper, and its elaboration will end with the view that it is undoubtedly one of the most challenging research directions in the field of production technologies at the moment. It has a number of subdomains. One of the most important is the concept of so-called digital

twins [3], through which the integration of man into the concept of cyber-physical production systems on a holistic basis and in a structured way, which allows for further systematic research. In this context, the issue of integration of existing CAD tools for engineering design, ie their graphic kernels, and xR kernels of modern platforms for application development in the gaming industry is of special importance. The convergence of these two worlds, fundamentally differently shaped and focused on fundamentally different applications, may be a good response to the rapid and wider application of xR technologies in the near future. Especially on the tasks of programming robots using demonstrations, and quasi-physical interactions in virtual space. This paper presents the basic ideas how this problem could be practically solved through the realization of an appropriate system architecture for dynamic interaction of CAD graphics kernel and xR engine in real time, with performance that is relevant for practical application. This concept has been practically verified on the mockup example of the integration of SolidWorks 3D CAD modeler and UNITY xR engine.

2. SYSTEM ARCHITECTURE OF XR – CAD LINKER

One of the first problems in creating a system for XR interaction with a CAD modeler is the importing of CAD model by an XR development system. The CAD model is imported into the XR development system to allow the system to function as naturally as possible, in real-time operation. In this way, the interaction between the VR Headset and the CAD model takes place in the XR development system, and then that interaction is simultaneously mapped to the 3D CAD modeler in real time, if possible.

One way to transfer 3D models from one application to another (e.g. from a 3D CAD modeler to an XR development system) is using the glTF [4] format. glTF (GL Transmission Format) is an open source standard for efficient transfer of 3D models and scenes from one application to another. It was designed by the COLLADA working group in 2012 and published in October 2015. The glTF format enables the minimization of the required memory space for the transfer of 3D models. It also reduces the time required to unpack the model, which can take some time with sophisticated 3D models.

After transferring the 3D model from the 3D CAD modeler to the XR development system, it is necessary to write program codes that allow interaction between HMD and XR development system, then map this interaction to the CAD modeler in real time. As we have transferred the 3D model from the 3D CAD modeler using the glTF format, the functionality of the system can be divided into three unity.

The first unit deals with servicing supported XR interactions (features) over a 3D model in an XR development environment. Supported XR interactions in the XR development system are defined by program code that allows the HMD joystick to rotate objects (robotic segments in our example) with appropriate manipulation.

The second unit deals with the detection and processing of manipulations on the model in the 3D CAD modeler, which involves calculating the angles of the object. Manipulating a robot in a 3D CAD modeler is possible using the supported API for that 3D CAD modeler or simply by manipulating the computer cursor.

The third unit enables communication between the previous two units, ie synchronization of the model in the 3D CAD modeler and the model in the XR development system in real time, including data collision protection mechanisms, and thus system oscillation. System oscillation protection means maintaining the stability of the entire system while simultaneously manipulating both models at the same time. The UDP communication protocol is used.

By building a system that includes these three functional units, we have created a platform that allows bidirectional connection between CAD and XR models in real time.

Graphical representation of the XR-CAD linker architecture is shown in Figure 1.

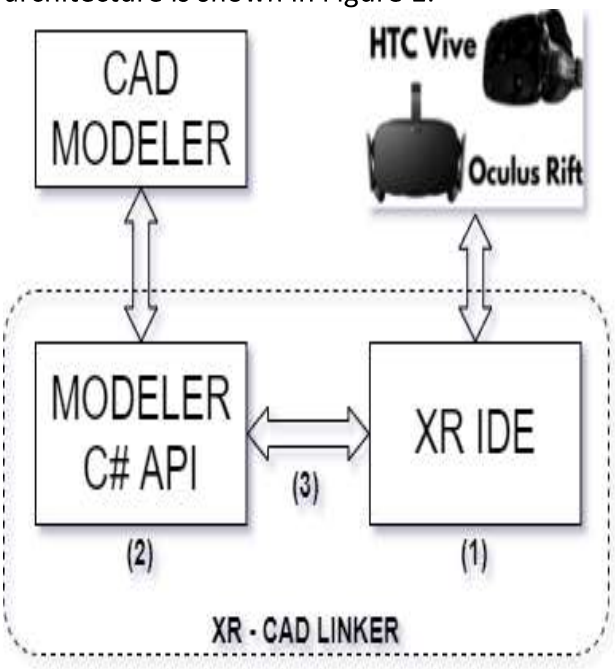

Figure 1. XR-CAD linker architecture

3. DEMONSTRATION OF THE XR-CAD REAL TIME LINKER

The practical implementation of the system described in the previous section will be presented on the SCARA mockup robot [5]. The SCARA mockup robot consists of three robotic segments, two mobile (R01_LINK_01 and R01_LINK_02) and one stationary (R01_LINK_00). It is a robot that has only two degrees of freedom, which made it easier to demonstrate the concept of system functioning in this paper, without losing generality.

The SolidWorks software package was used as a CAD modeler. The representation of the structure of the robot tree R01_ROBOT.sldasm and the representation of the 3D model in SolidWorks are shown in the Figure 2.

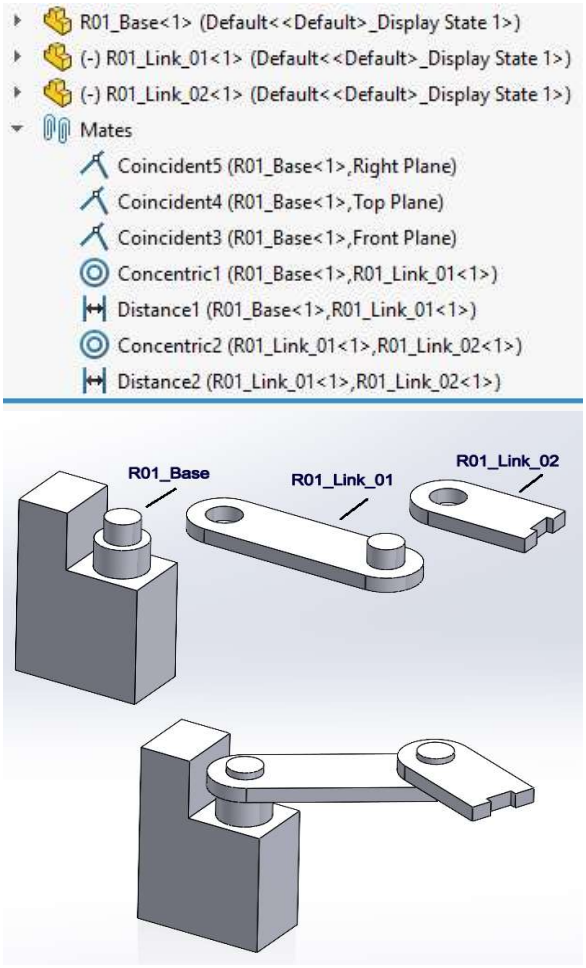

Figure 2. Design tree and 3D model of SCARA robot in SolidWorks

In order to export an assembly from SolidWorks to an XR development system, it is necessary to save the assembly R01_ROBOT.sldasm as an R01_ROBOT.gltf file. This is done by simply selecting an option from the SolidWorks drop-down menu.

The XR development system uses the Unity software package intended primarily for video game development. As XR technology is increasingly used in video games, this choice of XR development system seems right, due to the compatibility of different HMI Headsets. In Unity, by installing the appropriate package that allows the import of gltf files, we import the assembly from SolidWorks into Unity. The display of the tree structure as well as the 3D assembly, in Unity look exactly the same as in SolidWorks.

Figure 3. Design tree and 3D model of SCARA robot in Unity

The structure of the program code on the side of the 3D CAD model is the same as on the XR development system side. It consists of checking the requirements of mutual communication on the other side of the connection. If such a request exists, the data is accepted, parsed, and responded to by setting the angles of the 3D assembly to the values applied. In case there is no request to receive data, the program checks whether there is a change of angles on the 3D assembly. If it is, in that case an appropriate message is formed and sent to the other side of the connection.

```
while (true)
{
    if (udp_client.canRecieve() > 0)
    {
        angles = parserUDP.angles(udp_client.udpRead());
        set_angle.set_angles(angles[0], angles[1]);
        Array.Copy(uglovi, 0, old_angles, 0, angles.Length);
    }
    else
    {
        angles= get_angles.calc_angles();
        if (!Array_Sequence_Offset(angles, old_angles, 0.1))
        {
            Array.Copy(uglovi, 0, old_angles, 0, angles.Length);
            udp_client.udpSend("angle1:" + angles[0] + ";" +
                               "angle2:" + angles[1] + ";\n");
        }
    }
    XR_CAD();
}
```

Figure 4. Main code loop

4. CONCLUSION

In this paper, we have shown concept for development of interface between xR technologies and CAD platforms, such as SolidWorks, to be used as a tool for development of the Manufacturing Digital Twin concept, applicable in real industrial environment. The integration is done indirectly, by creating digital-twin in xR game development engine UNITY. Then a bidirectional synchronization of 3D models, between UNITY and SolidWorks is achieved. This type of, xR technologies and CAD systems integration, allows for development of many systems for practical application in advanced manufacturing, such as industrial robotics and many others.

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