Requirements of OpenXR Specification for Mechanical Maintenance Support Systems

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ABSTRACT

The paper shows what kind of factors are required for XR based mechanical maintenance support systems from existed papers. As the result of the investigation, recognition technologies in AR and connecting other devices and sharing VR space are required.

1 INTRODUCTION

Augmented Reality (AR), and Virtual Reality (VR) technologies are called as XR. These have been glowing in industrial domains such as mechanical maintenance support system. XR applications work on HMD, PC, and smart devices like smartphone and tablets. Especially a large number of Head Mounted Display (HMD) has been releasing around the world. Table.1 shows typical factors of HMD for developing XR applications. HMD has two type of display as monocular or binocular. If software engineers develop the latter type of HMD, they have to take care it has stereo vision. 3 or 6 DoF means how many axis HMD support tracking. 3 DoF supports user's head rotation (x, y, and z axis). 6 DoF supports user's head position and rotation (both x, y, and x axis). Software enginners have to take care whether development target HMD are 3 or 6 DoF. Most of HMD need one or two controllers. Users have one controller on their right or left hand. Users also have two controller on their both hands. Controller has several key or touch sensors. Software engineers have to take care appropriate key mapping for target applications.

Table. 1 Typical HMD factors for developing XR applications

Factors	Difference
display	monocular or binocular
defree of freedom(DoF)	3 or 6 DoF
controllers	1 or 2 controllers

Unity and Unreal Engine are standard application frameworks for developing XR applications. Three.js, A-Frame, and Babylon.js are also standard web based application frameworks. Software engineers have to develop XR applications with choosing from various HMD, application platform and frameworks.

To reduce burden of developing XR application, OpenXR, which is a standalization for software and hardware, has been estabilised in 2017. A lot of XR applicaitons have been developing in various domain. The paper focuses on maintenance work and shows what kind of factors are required for mechanical maintenance support system with XR from existed papers.

2 Examples AR and VR applications

An typical example of AR application is shown in [1]. The paper shows maintenance support system with AR as shown in Fig.1. The system in Fig.1 shows disassembly process with text and a 3DCG based red arrow AR. Workers can do maintenance works intuitively. Head mounted display (HMD) are also used on such maintenance support systems.

Fig. 1 An example of AR based maintenance support system [1]

An typical example of VR application is shown in [2]. The paper shows assembly and disassembly process on VR spaces as shown in Fig. 2. The system in Fig. 2 shows a power unit in VR spaces. The black rod object on bottom of rightside is a handheld VR controller. Trainees put on VR HMD and grab handheld controllers. The real controller's motion synchronize with controllers on virtual spaces. Trainees operate conrtoller for grabbing objects, confirming induction, locate on VR spaces.

3 OPENXR

OpenXR [3] has been estabilised in 2017 by Kchronos Group. Currently each application platforms provide proprietry application program interface (API) for developing XR application as shown in left side of Fig.3. OpenXR solves these fragmentation by setting application and device plugin interface. Right side of

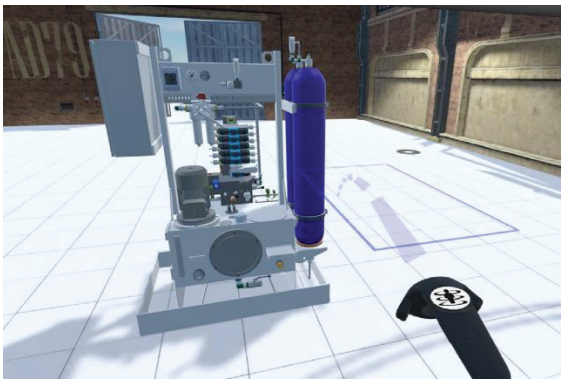

Fig.2 An example of VR based maintenance training system [2]

Fig.3 shows ideal system architecuture with OpenXR. OpenXR will be a standardization for developing XR applications. The followings are representive features.

(1) Spaces
The feature is about creating spaces OpenXR based applications. Creating, referring, and handling hand tracking VR controller's actions.
(2) Rendering
The feature is about showing image results generated from Graphics Processing Unit (GPU) for OpenXR based applications.
(3) Session
The feature is about managing state of OpenXR based applications.
(4) Compositing
The feature is rendering images as inside of a cube (cubemap), a cylinder, and a sphere for 360 image applications with OpenXR.
(5) Input and Haptics
The feature defines input and feedback with haptics on OpenXR applications.
(6) Extensions
The feature supports to access to OpenGL, OpenGL ES, Vulkan, and Direct3D 11 and 12 graphics APIs. These are main graphic engines for 3DCG based applicaitons.

OpenXR is for versatile XR applications so that it is not considered to specific applications such as mechanical maintenance.

4 METHODOLOGY

Science direct (https://www.sciencedirect.com/) is a large database for papers, proceedings, and books. Amo [4] has been used to the database to analyze past 30 years papers about what kind of maintenance system with AR and technical limitation. This paper also adapts the database to analyze what kind of factors are need to develop XR applications. "Augmented Reality mechanical maintenance" and "Virtual Reality mechanical maintenance" have been chosen as search words. Duration has been set from 2017 to 2020. 677 papers has been extracted. Theory, robotics, and mecahincal works without AR have been elminated. Finally 6 cases have been remained. The latter has been adapted the same method. 855 papers have been extracted, finally 6 cases also have been remained.

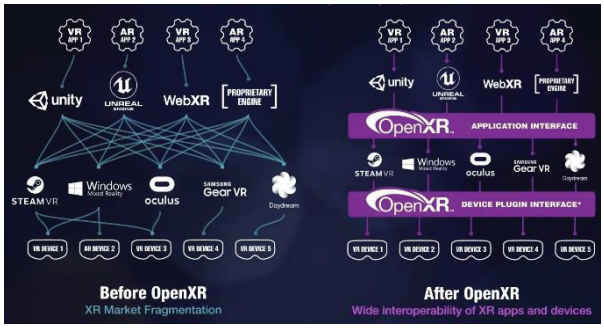

Fig. 3 A XR system architecture without (leftside) and with (rightside) OpenXR [3]

5 RESULTS

The results of papers and factors are shown in Table 2 and Table 3. Eight factors from (a) to (h) for AR application of machanical maintenance as shown in Table 2. OpenXR contains only (e), (f), and (g).

Table. 2 Mapped factors for AR

Paper	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
[1]	○	-	-	-	-	-	-	○
[5]	-	-	○	-	○	-	○	
[6]	-	-	○	-	-	○	-	
[7]	○	-	-	-	-	○	-	
[8]	-	○	-	○	-	-	-	
[9]	-	-	○	-	○	○	-	

(a) : Object recognition, (b) : Image recognition, (c) : Marker recognition, (d) : Text reading, (e) : Show 3DCG, (f) : Show texts, (g) : Haptics feedback , (h) : Network connection

Five factors from (i) to (m) for VR application of mechanical maintenance systems as shown in Table 3. OpenXR contains only (i).

Table. 3 Mapped factors for VR

Paper	(i)	(j)	(k)	(l)	(m)
[10]	○	○	-	○	
[11]	○	-	○	○	
[12]	○	-	-		
[13]	○	-	-		
[2]	○	○	-		○
[14]	○	-	-		○

(i) : Tracking controller, (j) : Sharing VR space, (k) : Recording expert's motion, (l) : Connecting with other devices, (m) : Haptics feedback

6 CONCLUSIONS

OpenXR is a standardization for developing XR applications. The standarization does not completly cover all requirements of mecahnical maintenance with AR/VR. In this paper, the result indicates that several feature are required for mechanical maintenance support systems with XR. As AR parts, marker, object, image recognition are required. AS VR parts, sharing VR space and connecting with other devices are required.

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