# Quality of Experience of Virtual Reality in Industry 4.0.

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## Introduction

VR (Virtiual Reality) is still a largely novel form of multimedia which has largely been confined to the area of entertainment. As a technology that allows one to freely explore and interact with virtual environments much akin to the real world, it has much more potential for use in areas beyond this. The purpose of the research I am currently conducting is to investigate the Quality of Exerience a user may have when using this technology in an industrial domain. Quality of Experience (QoE) refers to a mixed qualitative/quantitatinve measure of a users enjoyment derived from using some service or application, in this case VR. In this way we can investigate the viability of a tecchnologies use cases in an area while aslo considering user centric factors such as engagement, ease of use and comfort. In this body of research we are currently aiming to evaluate the impact that network latency would have on a users QoE when attempting to opperate a virtual representation of some indutrial apparatus.

## Methodology

We use a HTC Vive as our apparatus for displayign and interacting with a virtual environment. The Vive allows for a high fidelity virtual environment while also providing a concise method of control for the purposes of interacting and manipulating virtual elements in a natural way.

To represent an industrial apparatus we use a Fanuc Injecttion Moulding machine. This machine is designed to create highly precicse and reproducable plastic moulds in a quick manner using a method by which a molten plastic poymer is injected into a custom mould. This is ideal for virtual representation as it's primary operation cycle is very visable and it's outputs are a physical object that can be also represented in a virtual environment naturally.

In our experiment, a virtual environment is constructed using the Unity engine. Here a user is place in a room with a virtual Fanuc and is instructed to perform various operations using the Fanuc. Latency for a users actions, such as having a delay between the action opening a door and the door actually opening can be introduced to varying degrees. The user then evaluates their enjoyment of the simulation and how easy they found it to operate the machine within a virtual environment.

**Fig 1. HTC Vive**

## Quality of Experience

Quality of Experience (QoE) is the measure of delight or annoyance of a user of an application resulting from the fufillment of their expectations from use of said application or service. [1]

An accurate measure of QoE is essential for critical evaluation of all forms of VR and AR (augmented reality) evaluations, as a users enjoyment and comfort in a virtual simulation is integral to it's measure of success. While traditionally QoE and general user experience has been measured through subjective means, such as questionaires, more ojective methods such as heart rate and electro dermal activity have been investigated as viable methods of measuring QoE. [2]

This furthering of QoE measurement has allowed us to take more objective approaches to QoE evaluations while still maintaining subjectability measures.

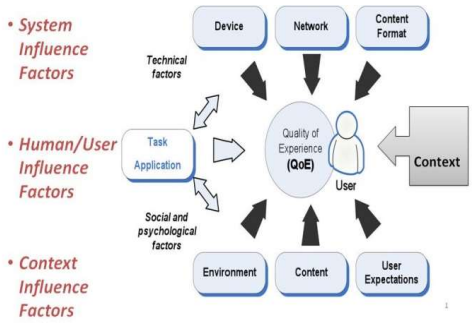


**Fig 2. An overview of QoE influence factors [2]**

## Discussion

Virtual Reality is still a largely misunderstood area of research. While the practical tehcnology of Virtual reality streches back to the 1970's. This is largely a result of of the lack of commecial hardware avlaible for this technology and the traditional dificulty of both creating and running a virtual environment. Even today comercial VR head mounted displays can be expensive for the average consumer and high end devices require high processing capabilities and graphical fidelity.

However, the technology has become more widespread and research into the applications and effects of this technology is now practical and accessible. This has opened the doors for immesive multimedia technologies to broaden their domains into other areas such as construction, communication, mediicne, education and industry. We believe that proper evaluation of this technology could lead to innovations in use cases across multiple domains.

VR has already proved its uses in medical eduction areas, [3] and we believe that this could extend to industrial use as well, with several possbile use cases, such as virtual training, teleoperation and process simulation

**Fig 3. Representation of virtual vs real Fanuc**

## Future Work

In the future we aim to explore multiple use cases for this technology. While the current focus in the refinement of user interaction with an industiral machine, we for see this to be a sprinboard to investigate a variety of applications.

Of particular interest is the area of teleoperation, which is the ability to remotely operate a machine or robot over a distance using some other independant system. We believe that VR provides an excellent base for this technology as a user may interact with a realistic representation of a virtual machine and have thier actions influence a real world instance of the same machine. This could provide many advantages in the realm of safety and training costs as well as allow operators to influence real world systems over large distances.

We can also demonstrate the interoperable nature of Cyber Physcial Systems through a “Lego Building” style application where a user is able to create factory floors using prebuilt elements then simulate the predicted processes and create connections between machines dynamically and easily. This creates a cost saving benefit as manufacturers could design and test virtual representations of a factory system before committing to a physical one.

## Refrences

1)Egan, D., Brennan, S., Barrett, J., Qiao, Y., Timmerer, C. and Murray, N., 2016, June. An evaluation of Heart Rate and ElectroDermal Activity as an objective QoE evaluation method for immersive virtual reality environments. In Quality of Multimedia Experience (QoMEX), 2016 Eighth International Conference on (pp. 1-6). IEEE.

2)Brunnström, K., Beker, S.A., De Moor, K., Dooms, A., Egger, S., Garcia, M.N., Hossfeld, T., Jumisko-Pyykkö, S., Keimel, C., Larabi, M.C. and Lawlor, B., 2013. Qualinet white paper on definitions of quality of experience.

3) Seymour, Neal E., et al. "Virtual reality training improves operating room performance: results of a randomized, double-blinded study." *Annals of surgery* 236.4 (2002): 458.