# Unity and VTK for VR Medical Image Analysis - an Initial Clinical Evaluation

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## 1 Purpose

Three-dimensional (3D) medical images such as Computed Tomography (CT), Magnetic Resonance (MR), and 3D Ultrasound (US) are normally visualised on 2D displays, resulting in sub-optimal perception and manipulation of these images. To solve this problem, the use of Virtual Reality (VR) and Augmented Reality (AR) with 3D medical images has been proposed and is currently an active field of research in areas such as surgical training [1] and planning [2], and extending existing tools into VR, such as 3D Slicer [3].

We are focusing on developing an intuitive application for imaging specialists to better communicate with non-imaging clinicians, for example surgeons, as well as patients and families. To this end, we recently proposed a framework for incorporating 3D medical images into VR by integrating the Visualization Toolkit (VTK – www.vtk.org) into Unity (unity3d.com) [4].

Here we present an initial clinical evaluation of a simple VR application to interrogate 3D medical images, and compare it to standard clinical software. Specifically, our evaluation addresses the following questions: (1) Does our framework enable visualisation of medical images in VR with a quality acceptable to clinicians? (2) Is our VR system sufficiently comfortable for clinician use? (3) Would participants prefer to use our VR system or standard clinical software?

## 2 Methods

Thirteen clinicians (5 imaging cardiologists, 5 cardiac physiologists, 2 cardiac surgeons and 1 cardiac interventionist) from the Evelina London Children's Hospital volunteered to participate in the evaluation (all passed a stereoscopic vision test). Experience level varied (1 trainee, 4 with $\leq 5$ years experience, and 8 with $> 5$ years experience). The majority of participants were familiar with 3D echocardiographic software, mainly Philips QLAB: 9 used it at least weekly and

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4 used it less than 3 times or never used it. Familiarity with VR was low: 6 had previously used VR less than twice, and 7 had never used a VR system.

The evaluation involved two distinct visualisation platforms. The first was our proposed VR system, which ran on a Dell Alienware laptop with a Core i9-8950HK 2.90GHz processor, 16 GB RAM, and an Nvidia GTX1080 graphics card with 8GB RAM, connected to an HTC Vive headset and two controllers. A second reference clinical imaging platform running Philips QLAB 10.8, was used on a Dell Precision 5510 laptop with a 15" 1920 × 1080 resolution screen.

The clinical image data was a time sequence of 3D cardiac US volumes acquired using a transesophageal probe on a patient with a normal heart using a Philips iE33 scanner and an X7-3t matrix array transducer. Institutional ethical approval and patient consent were acquired prior to the study.

The systems described above were configured at the Evelina London Children's Hospital, in a room with clear space to allow free movement, Fig. 1. The participants started each VR task seated on a wheeled chair, in a consistent location with the scene directly in front of them and within arms' reach. The users were then free to move on the chair, or alternatively to stand up and walk.

Each participant carried out three activities: (1) training to gain familiarity with the system, (2) image quality evaluation, and (3) interaction evaluation.

During the training activity we explained the study and the use of the proposed system to the participants. All aspects of using the Vive display and controllers to manipulate the scene were included in the explanation, using a real controller as an aid. The participants then practiced using the controls in a VR scene with a non-medical CT image of a terracotta rabbit [5]. Practice was supervised to ensure that the participant was capable of performing all of the required actions comfortably: picking-up, moving and placing scene objects (e.g. the volume, a landmark, the cropping plane), adjusting gain and contrast, and controlling animation playback.

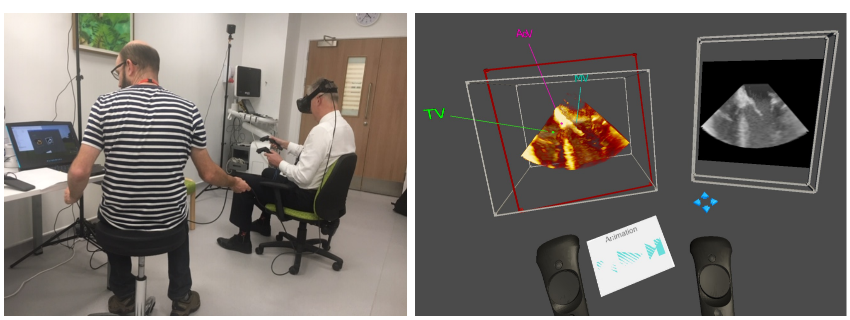


**Fig. 1.** (Left) The evaluation taking place (Right) The VR evaluation scene

In the image quality evaluation activity, the user first looked at the clinical image using QLAB with the default gain/contrast and transfer function (which used colour depth cueing: closer objects were brown and more distant objects were blue). The same data were then presented on the VR system, with a similar transfer function (but without colour depth cueing). In both cases the playback was at the default speed. The participants were not allowed to interact with the volume in either case, but they could move around the volume in the VR case.

For the interaction evaluation activity, the participants were asked to use the interactions learnt in the first activity on the clinical data, and were then let free to explore the VR scene before they completed a dedicated questionnaire. Following an initial test run with a single participant, twelve further clinicians evaluated our system, with each trial taking approximately 30 minutes.

## 3 Results

The results on image quality assessment are shown in Fig. 2. When asked how comfortable using the VR system was, 1 participant found the proposed VR system 'Somewhat Uncomfortable', the remaining 12 participants found the VR system comfortable. However, three users identified uncomfortable aspects of the VR system: one experienced minor vision abnormalities, one found it difficult to fit their spectacles into the headset and one exhibited mild dizziness afterwards.

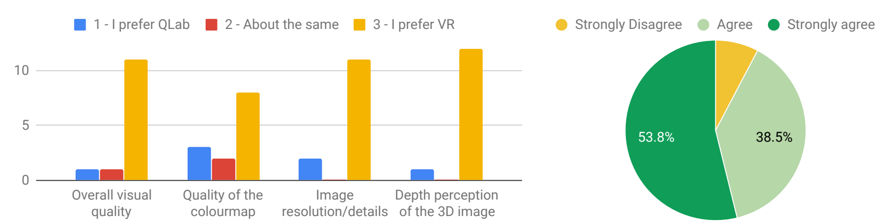


**Fig. 2.** (Left) Comparison of image quality between the proposed VR system and QLAB (Right) Response to the question of whether 'image quality of the VR system is adequate for clinical use'

Asked whether they would prefer to use the proposed VR system or QLAB if both had similar functionality, eleven participants preferred the VR system and two participants had equal preference. No participant preferred QLAB over the VR system. The participants identified specifically the advantages of the VR system, as the intuitiveness of manipulating the volume in VR and cropping plane, and the improved sense of depth it gave them.

## 4 Conclusions

The results show a generally positive attitude of clinicians towards our proposed VR framework. All but one participant agreed that in our approach 'the image quality is adequate for clinical use' and that 'the VR system is comfortable'.

Comfort includes many aspects, such as the fit, weight and temperature of the headset, as well as ease of adjustment and use of glasses, all of which are continuously improved by manufacturers. Most notably, we have aimed to minimise discomfort by maintaining a high frame rate (90fps). Further investigation is required into other means of improving user experience. Importantly, the majority of users preferred the VR system to QLAB, with more intuitive control and improved depth and anatomical perception in VR being consistently cited in support of this view.

VR was a new technology for our participants and had an associated learning curve. We believe that a good initial experience is important to facilitate technology acceptance, and since the response from our participants was consistently positive, we will use this configuration to continue with regular testing as we improve our VR system.

During the evaluation we observed that the workspace required for VR use can be quite large – and this may be a problem in the confines of many hospital environments. We also observed differences in mobility between imaging specialists and surgeons due to the nature of their professions: while imaging specialists tended to stay quite still and move the image, surgeons tended to be much more mobile, moving around the 3D image themselves, similar to the manner in which they interact with patients.

In the future we will improve visualisation and control, as well as adding the ability to make measurements. As a tool for interrogation of images and communication we will perform more tests with clinicians, as well as with patients and families. We also plan to translate this technology into intervention planning environments, to assist in intra-cardiac device placement for example.

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