Head-worn Mixed Reality Projection Display Application

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ABSTRACT

The main goal of this research is to develop a mixed reality (MR) application to support motion capture actors. This application allows seeing and exploring a digital environment without occluding the actor's visual field. A prototype is built by combining a retro-reflective screen covering surrounding walls and a headband consisting of a laser scanning projector with a smartphone. Built-in sensors of a smartphone provide navigation capabilities in the digital world. The integrated system has some unique advantages, which are collectively demonstrated for the first time: (i) providing fixed field-of-view (50^o in diagonal), fixed retinal images at full-resolution, and distortion-free images that are independent of the screen distance and shape; (ii) presenting different perspectives to the users as they move around or tilt their heads, (iii) allowing a focus-free and calibration-free display even on non-flat surfaces using laser scanning technology, (iv) enabling multiple users to share the same screen without crosstalk due to the use of retro-reflectors, and (v) producing high brightness pictures with a projector of only $15\ lm$; due to a high-gain retro-reflective screen. We demonstrated a lightweight, comfortable to wear and low cost head-mounted projection display (HMPD) which acts as a stand-a-lone mobile system. Initial informal functionality tests have been successfully performed. The prototype can also be used as a 3D stereo system using the same hardware by additionally mounting polarized glasses and an active polarization rotator, while maintaining all of the advantages listed above.

Author Keywords

head-mounted projection display; mixed reality; motion capture; laser projector; immersive environments

ACM Classification Keywords

I.4.9 Computer Graphics: Image Processing and Computer Vision - Applications; H.5.1 Information Interfaces and Presentation: Multimedia Information Systems - Artificial, Augmented, and Virtual Realities

INTRODUCTION

Entertainment industry products such as video games and films are deeply depending on Computer Generated Imagery (CGI). There are many cases where CGI characters' movements need to meet real world physics. One of the widely used ways is to capture motions of human actors in a dedicated vision based motion capture [22] studio as shown in Figure 1. Alternative motion capture techniques beside vision based techniques have also been investigated for daily-activities and professional motion capture [24, 33]. A typical set up of a motion capture studio is as shown in Figure 1; a large space shoot area, motion capture cameras aiming at the shoot area, conventional cameras and sometimes projection displays, film cameras and pre-visualization (previs) cameras.

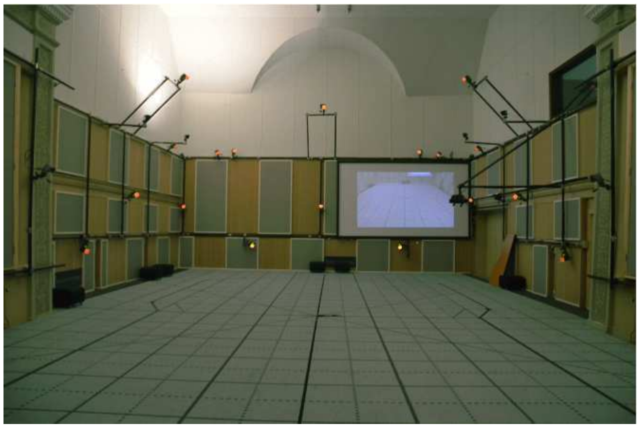

Figure 1. Motion capture studio of Imagination Studios located in Uppsala, Sweden. The studio is equipped with near infrared light source equipped motion capture cameras, and a projection display.

Motion capture actors are generally using a quite minimal scenery as acting environment. Usually simple metal or wooden props are used to create the acting environment. Previous research has shown that actors can experience challenges to perform in such an environment and that these quite

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diversely skilled 'actors' would benefit from improvements in a motion capture shoot procedure [15, 16]. This is why this research addresses this issue and aims at providing a new interface for motion capture actors that is closer to an actual movie set and especially allows to give visual aid that can be used to act off.

Providing a mixed reality application to motion capture actors would bring the benefit to see and explore a digital environment without having to build real-world props. Scenery and animation could be shown through CGI. The mixed reality is meant to support actors to perform. Such a system could help to guide and immerse the actors through their performance and to understand the scenario of the play faster. Furthermore, it could allow actors to find their positions and paths to walk, act and interact.

To provide an application for a motion capture environment, the application needs to comply with the specific needs of the environment. It is important for some motion capture shoots that the face and vision of an actor is not occluded by virtual reality glasses or other equipment. This is especially the case for facial motion capture shoots, stunts and when interactions with real world objects or other persons would interfere with the worn hardware.

For some motion capture shoots, as depicted in Figure 1, a projection display showing the virtual environment from a single perspective is mounted and usable for motion capture shoots. During a motion capture performance it is in most cases not possible for actors to see the computer generated virtual world around them without performing unnatural movements like turning the head to look at the screen. This is especially an issue if this is an unwanted movement. Therefore, it would be better for an actor to see the virtual environment in a more natural and usable way while acting.

In this paper, we describe our prototype combining a retroreflective screen that covers the walls and a headband consisting of a laser scanning projector with a smartphone and an additional battery pack for the projector. The smartphone's built-in sensors allow real actors to explore the digital world freely. Our prototype is a stand-a-lone, lightweight, mobile system that fits the requirements of a motion capture environment. Additionally, we have presented data on our initial informal functionality tests, which we performed to get feedback on the potential and the usability of the developed prototype.

We see a potential to use the developed prototype in other applications as well, especially in the field of gaming, training and entertainment. Therefore, we developed the system to be independent from other systems such as e.g. tracking systems. We use the scenario of motion capture acting as depiction on how we applied the technology to create a mixed reality application and believe that our findings and the application in itself can be used for other entertainment applications as well.

STATE-OF-THE-ART

The interest in head-worn display systems [3, 27, 26] is rising with the increasing number of products on the market, where they are being used excessively in entertainment industry. Most of the see-through products offer a near-eye solution with a limited field of view, a constant focus, single eye usage (no stereoscopy), and limited depth of field. Many near-eye solutions come with a great deal of optical complexity in design, e.g., Google Glass [23], or [9], in which an additional specially made contact lens has to be used to see the content. Thus, the users are having the problem of interacting naturally with the physical world due to these optical limitations. By simply disconnecting the user from the real world, the mentioned problem is avoided via opaque wearable stereoscopic head-worn displays on the market, e.g., Oculus Rift [5] as virtual reality glasses. Nonetheless, the challenge remained the same for real-life use cases. Our focus is to address these challenges by enhancing the optical quantities such as bigger field of view, or focusing at any depth that are vital in a real life scenario.

Although there are great advancements within the past years, head-worn display prototypes from different institutions are not yet in an affordable price range and real life applications do not meet the promised usability on a everyday basis, even though there is research that proposed a projection display for daily use [19]. Usability is especially of importance as we intend to provide real-time video content shown from a game engine to motion capture actors while acting.

A laser scanning pico-projection display was an exciting development, because it does not require any optical components to focus on any surface, and the amount of the pixel displayed stays constant with the increasing distance between the projector and the screen. Additionally, it comes with a coin size light engine [6], where it is very obvious that it reserves room for miniaturization in head-worn display systems.

HMPD's and their image qualities as well as the use and evaluation of reflective materials, used as a screen, have been discussed and introduced by others already [12]. This technology was also already used in other research where digital content is projected to reflective surfaces [2] as well as non-reflective surfaces [20, 21] to allow interactions between users and the system. Even though this research uses a head-mounted projector setup that projects 2D video content onto a reflective surface and allows for interaction with the system, it differs to the approach we describe in this paper.

According to our point of view, a laser scanning pico-projection display has some interesting aspects to explore in research as it does not require any optical components to focus on any surface and the pixel size stays nearly constant with the increasing distance between the projector and the screen. Additionally, it comes with a coin size light engine [6], which allows to build even smaller head-worn display systems. One of the valuable contributions of this paper was embedding such a pico-projector into a head-worn display, so that it can provide infinite depth of focus, enhanced color gamut through laser technology and serves as a light-weight mobile system without requiring fixed cabling to a stationary system. The system we provide is independent from any additional system, e.g. a tracking system or an image processing server, and carries all equipment on a headband.

Laser projectors, as we use it in our research have been used in other research as well [11]. There, a shoulder mounted projector was combined with a depth camera to project images to non-reflective surfaces and to allow gestural interactions. It is obvious that the use of their mentioned system is completely different, even though the laser projector is the same. For our purpose it was necessary to have a head-mouted system that allows to have the projector close to the eyes without blocking the users' vision. Furthermore, our system needs to record head movements and should not limit an actor in his movement capabilities. This also means that a rigid setup that cannot move easily was needed in our setup, as for motion capture acting, stunts and athletic movements have to be considered in the requirements towards a HMPD. Furthermore, a more optimized projector setup was needed for our purposes. So we reduced the size of the projector and connected it to an external battery pack which allowed to extend the uptime of the projector and allowed to have a more minimal setup.

Unlike other systems like e.g. from CastAR [13] or other research [31] our system does not require multiple projectors. Thus, problems originated from using multiple projectors such as the keystone or image registration effect are not an issue in our system. Even though the CastAR glasses or even similar AR glasses are about the size of normal sport sunglasses, parts of the face such as the eyelids and eyebrows are still covered when acting for facial motion capture. In our system, only a minor part of the forehead is covered.

Another more practical issue and difference to our system lays within the fact that the CastAR system uses tracking markers with infrared LED's on their reflective display material. A reason to try to avoid this within motion capture is that the cameras would pick up the light and could get affected by it. Masking the regions of those markers within the motion capture software so that these regions are simply ignored while acquiring motion capture data could be a solution for stationary reflective surfaces or objects but for dynamic setups it is rather unlikely to mask and recalibrate a motion capture system after every setup change; it is simply ineffective.

With our head-worn display, connected to a game engine which is running on a mobile phone, we approach to create a wearable mixed reality projection in a slightly different way than as literature has shown. Others have created an augmented reality application that provides additional information about certain real-world locations and provide navigational help using RFID technology. This information is then shown on wearable data glasses [17]. Such applications differ to our application scenario, especially in the sense that the purpose for our use case is to immerse users into the digital environment and allow them to explore it instead of providing information or navigational guidance. This includes that the digital environment should be superimposed onto the normal vision in a higher resolution showing digital content from a game engine.

Conventional off-the-shelf laser scanning pico-projectors can provide an illumination of $10 - 20\ lm$. On the other hand, conventional off-the-shelf projectors can provide up to $1000\ lm$. Thus, it is required to use the light in the most efficient way in a system equipped with such a pico-projector. Availability of different retro-reflective materials is another excitement for our purpose, since they provide high light gain when used as screen. In the past, retro-reflective surfaces were used as a part of head-worn displays as in the case of [2, 14, 29] as well. Combining a recently licensed stereoscopy method [7, 1] based on polarized glasses is as well an easily realizable method for providing 3D imagery.

HEAD-WORN PROJECTION DISPLAY

Head-worn display systems are investigated extensively among the optics design community, and are believed to be the expected hardware upgrade for future virtual reality applications. In this section, we introduce a theoretical background on our simplistic head-worn projection display architecture. The section also provides information on our mixed reality application implementation.

Hardware Description

Our head-worn projection display system, as shown in Figure 3 consists of several off-the-shelf hardware: 1) a stripped-down laser pico projector, SHOWWX+ from Microvision, Inc., 2) a Sony Xperia S smartphone, 3) retro-reflective material from Reflexite (not in the figure), and 4) in-house 3D printed housing for the equipment.

Pico Projector

The white laser light from the pico projector is a combination of three different laser light sources (RGB: 643 nm, 530 nm, and 446 nm respectively). The laser spot scanned from the projector is a Gaussian beam [8]. The Gaussian laser spot beam waist and the best resolution appear at about 80 cm distance from the projector. However, using 1st order optical approximations, we can assert that the image is always in focus beyond that distance since the image size and the spot size both increase linearly with distance, i.e., a number of resolvable spots do not change with distance. The laser light source does not require beam shaping optics as in conventional projectors. The content shown with the pico projector, remains in focus and brigthness even in case of distance variations. In Figure 3, the pico projector acts as the light engine in our head-mounted display prototype, thus, a user wearing the prototype does not suffer from any key distortion effect, even when the surface used as a screen is totally distorted, as can be observed within Figure 4.

Smartphone

A conventional smartphone is equipped with different types of sensors (gyroscope, accelerometer, magnetometer, GPS sensor, ...) and can be hooked to the pico projector through an HDMI port or an MHL adapter. The maximum native resolution of the projector is $848px \times 480px$ @$60\ Hz\ vsync$ in size. Thus, a smartphone provides content at the same resolution and refresh rate. For our application, we address the sensors of the smartphone as means of controlling the digital environment.

Figure 2. The top picture shows two different photographs of a user with our wearable augmented reality display, the system is composed of a smartphone, an external battery and a pico projector with 3D printed housings. The two photographs(middle and bottom) are showing a scenario where multiple users independently taking benefit of a passive retro-reflective screen without crosstalk.

Figure 3. A photograph of the hardware device, equipped with a smartphone, a battery and a pico projector. The housing for both items is in-house 3D printed.

Figure 4. Left: A photograph of the visible key-distortion problem when the separation between the camera and the projector is high. Right: This photograph shows that there is no visible key-distortion effect when the camera is placed close to the pico projector, although the surface is curved.

Battery

An off-the-shelf pico projector comes with a Lithium Ion battery with $3.7\ V$, and $1800\ mAh$, which corresponds to $6.7\ Wh$ of energy. The mentioned battery allows a pico projector to operate constantly around approximately $1,5$ hours. In our prototype, we replaced the parts of the projector's housing and the battery with two Lithium Polymer batteries $(2 \times 3,7\ V \times 2000\ mAh = 14,8\ Wh)$. This modification reduced the size of the overall system, and increased the usage time of the pico projector. Furthermore, the modification also allows us to upgrade the battery by adding more battery cells to the prototype. It should be mentioned that the smartphone runs on its built-in battery. As an overall system, the expected uptime is $3-4$ hours.

Retro-reflective Screen

The final part of our head-worn projection display is a high-gain screen, which has the property to retro-reflect the light to the source. Thus, a user standing close to the light source, in our case the projector, has high light gain; he or she basically sees the screen very bright. Through trials, it is observed that the screen brightness is good enough for outdoor applications, e.g., sunny weather situations. Nonetheless, for our application we only aimed at indoor use.

Retro-reflective material, used as a screen can be in different forms: cloth/paint type [4], corner-cube (prismatic) type [28], and cat's eye type [30]. The one used for our prototype was a corner-cube type retro-reflective material. The corner-cube retro-reflective material can have the highest efficiency among the others, when they are placed in a hexagonal arrangement to have a high-fill-factor. Typical corner-cube type retro-reflective materials, found on the market, have a pitch size in between $0.1\ mm - 0.3\ mm$. The distance in between the pico projector and the screen is in the range of $1 - 10\ m$.

Use of Reflective Materials in Optical Motion Capture

During our research we encountered an obvious issue: when using a projector-based solution that includes a retro-reflective material, an optical motion capture system will be affected by the light reflections of such a material. We tested different retro-reflective materials within a motion capture studio and found that all reflective foils were recognised by the motion capture system. In some situations the cameras were not functional for a short time anymore as the retro-reflective foil returned too much light to handle for the camera.

As a test environment, we used a motion capture studio with 32 Eagle 4 cameras and the Cortex software from Motion Analysis. The foils that we tested were the Reflexite VC310 and the 3M 4090.

A4-sized samples of each foil were picked up by the motion capture cameras in an equal manner. Moving an A4-sized piece of the foils towards one camera led to a shutdown in about 2 m distance to the camera. A larger piece that was available from the Reflexite VC310 foil was then placed as intended on a wall of the shoot floor, behind the cameras. The sample sheet was 9 m x 0.775 m in size. Cameras on the other side of the shoot floor in about 8 m distance from the foil started to shut down immediately when running the motion capture software. Other cameras that faced the foil at an angle but were located at the very end of the shoot floor were still affected by the returned light and sporadically shut down as well.

We found two solutions to the above explained problem:
1) Masking the foil in the motion capture software, so that it will not be considered.
2) Applying a notch filter to the retro-reflective foil.

The first solution is only possible when the reflective materials are not covering a large enough area to affect the cameras and when the reflective materials will not be moved. Otherwise re-masking would be necessary.

The second solution worked in our quick tests surprisingly well. To avoid the problem of reflecting infra-red light that the motion capture cameras could pick up, a screen has to have a band-pass filter (a notch filter), which absorbs infra-red wavelength light, but allows visible light to pass. Initially, we tested a see-through plastic coating on top of the retro-reflective material. We observed that the see-through plastic coating seems to act as a notch filter for infra-red light. Nonetheless, this finding needs extended empirical testing and development.

Stereoscopy

The hardware described so far can provide stereoscopic vision [32] through conventional stereoscopic methods using additional passive 3D glasses, such as the long known Anaglyph method [34], or a common method in movie theaters: the polarized glasses method [25]. The active methods such as shutter glasses [10] causes noticeable flicker with our prototype, due to the low vertical refresh rate of the pico projector. Previously, a new method [1] which solves the flicker problem and combines the benefits of a shutter glasses system with a polarized passive glasses type system has been invented. Although the method has an active component (a liquid crystal polarization rotator) mounted on the projector, it works without any noticeable flicker in pico projectors that have low refresh rates. The method requires the screen to be polarization maintaining. There are polarization maintaining retro-reflective foils on the market as well. To make our prototype stereoscopic using the mentioned technique, a polarization rotator has to be mounted on the photonics module of the pico projector. Additionally, the user has to wear polarized passive glasses or contact lenses. Currently, our system does not provide 3D imagery, but with the modifications mentioned it is possible to provide 3D imagery.

Software Description

As software development environment, the Unity 4 engine, which is widely used in industry and research, was chosen for our prototype. One requirement for the software was to be able to create and change digital environments that will be shown to actors in a quick way and by allowing to use file formats that are common in computer games creation and entertainment applications. Another requirement to be considered was that the built-in sensors of our prototype such as gyroscope and accelerometer were meant to be used to control the digital environment. These decisions limited our choice to a few game engines that support mobile phone game development. As the Unity 4 game engine is a cross-platform and state-of-the-art game engine, our decision was to use it to develop our software. To develop the software and create the digital environment we used Unity 4.3.1f1 by compiling the software to an Android phone (tested phones: Samsung Galaxy S4, Samsung Galaxy S4 mini, Sony Xperia S, Samsung Galaxy S3).

Furthermore, we implemented controls to make the environment explore able through using the gyroscope reacting to the movements of the phone which can be mounted in different positions on the head of a user (back-head, top-head and side-head). The accelerometer was used to determine the steps and the direction of movement of a user. In places where there is limited space to walk, a solution based on walk-in-place [18] was also implemented as an option. Note that multiple users using multiple prototypes can run the same software independently but our software does not provide any synchronization between the users at this moment. Head rotations, independent from the phone's mounting position, and walk-in-place movements look accurate, so that exploring a digital environment is possible.

Moreover, we figured that a few features needed to be implemented so that testing the system, the software and the user experience was possible. One of those features was to be able to scale the character controller from the debug menu we added. This was especially useful to adjust the height of the character controller when different environments needed to be loaded or added content was scaled differently. Scaling the view height allowed to adjust for on-the-fly changes while using the environment to make scenes and objects placed in the environment look more believable. Also, changing the orientation of the phone and the views of the screen were helpful features to comply with testing different mounting positions on the user's head. For testing purposes and also to allow switching scenarios and scenes quickly without reconfiguring or loading new digital environments we added the feature of switching to different locations or scenes within the environment so that e.g. for motion capture shoots, scenes can be switched in an instance and in real-time.

In Figure 5, the three locations that were implemented for testing and exploring our digital environment are depicted. To create the digital environment, a height map of an island was taken and modified to get the basic layout of the digital environment. Used content and textures to create the environment are freely accessible on the Internet or through the Unity Asset Store.

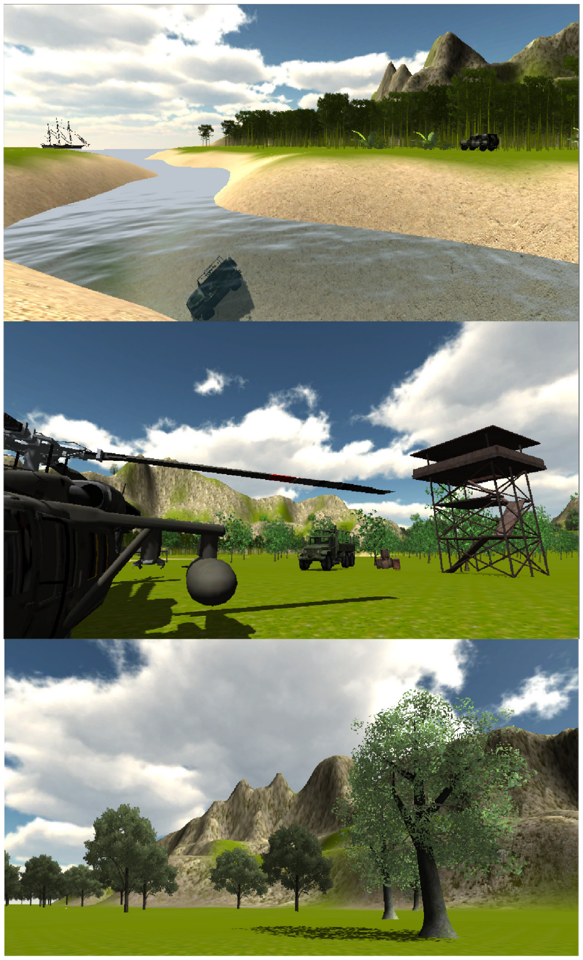

Figure 5. Screen-shots from the different locations in the digital environment.

The created scenarios depicted in Figure 5 were created to serve as a basis to test our prototype. To provide a slightly better perception of a more realistic environment, trees are animated through shadows and reactions to wind; water is animated through reoccurring wave cycles.

APPLICATION OF THE PROTOTYPE IN MOTION CAPTURE

Using our prototype in a motion capture studio revealed a few challenges and questions to be solved. We already mentioned the issue of a reflective material in a motion capture studio above but the light source of the pico projector can be detected by a motion capture camera as well. Even though this is true we found out that it is a fairly weak signal and mostly detected as noise in the motion capture system. As many motion capture shoots use skeletons and animation rigs to connect and mask the markers mounted on an actor, the detected light from the projector could even be neglected. Nonetheless, a better solution is to slightly decrease the sensitivity of the marker detection so that the motion capture system already filters the light from the projector.

Emitting light from the projector into the motion capture cameras could lead to a temporary malfunction of a camera. In our brief tests, this only happened when the projector is facing the camera directly and from a short distance (¡ 2 m). The capture of motions is not affected directly in such a situation because the motion capture system calculates the marker positions from multiple cameras and angles.

Acting for motion capture could mean that one or multiple actors need to act and interact at the same time. When using our HMPD prototype, light is constantly emitted. As the projector only has 15 lm other actors or persons on the shoot floor are not blinded when further away then 3 m. Nonetheless, there is an issue when 2 actors face each other directly like when having a dialog. Then the projectors would blind the actors and possibly interfere with facial motion capture recordings. This is a very specific but certainly occuring scenario and needs to be considered and further explored. One solution could be to simply stop projecting when actors face each other. An additionally head-mounted camera, detecting the presence of another user's face could be used for this which then only projects black pixels in regions of another user's face. In our prototype this functionality or a more advanced solution to the problem was not yet implemented.

A clear vision of real objects and persons is essential in motion capture acting especially for stunt, martial art and bodily demanding scenes. Even interacting with objects such as aiming a rifle needs to be performed as professional and believable as possible. Therefore, virtual reality or augmented glasses covering parts of an actor face and vision are usually impractical. Our prototype complies with these challenges and allows for this freedom of movement. The components mounted on the headband are stable and do not shake even during fast movements. Nonetheless, there are no housings that would make the prototype more rigid and shock proof so that an application for stunts or martial arts is safer.

For the above-mentioned hardware and software prototype we decided to collect feedback from users that were not familiar with our prototype and the environment to get an initial understanding which parts needed to be improved.

FUNCTIONALITY TEST

For our informal functionality tests and to get a first impression from users about our prototype, we conducted a test with 10 users, three female and seven male testers. The testers were in the range of $20 - 35$ years and 9 out of 10 testers have not experienced a wearable projector or display before. Three out of ten testers have an acting background. Nonetheless, for our initial tests we neglected to test the environment as a motion capture acting aid because it was more important at this stage to proof the functionality and to see how users react to the application we built.

In Figure 2, the test set-up can be seen. The tester is wearing a headband which holds the projector on the forehead, and holds the phone on the back side of the head. Walls with a retro-reflective foil that reflect the image of the projector into the eyes of the users were placed in front of the testers.

When conducting the tests, each user was given an introduction to the prototype and its functionality. Then, the users were asked to explore the environment, and to test the prototype on their own pace. Functionality possibilities and hints were mentioned during the tests and a dialog using the think aloud method was performed to understand what the user experiences while testing the prototype. The user tests were also videotaped as reference material and as another source of data collection to evaluate the user reactions and comfort or discomfort while using the prototype. In addition, a questionnaire was filled out by the users to help evaluating their experiences with the prototype.

Evaluating the questionnaires and video recordings revealed that there was a mixed opinion amongst the testers in terms of how comfortable the prototype was to wear. Half of the testers mentioned that they realized that they were wearing the prototype while performing the tests; the other half did not or rarely notice the worn hardware. When we asked if testers experienced any symptoms of nausea or discomfort while testing, none of the testers experienced any of the mentioned symptoms.

Qualitative feedback towards the question how immersed the testers felt into the environment while testing was also positive. On a Likert-scale, five testers answered with fully ”immersed” and five with ”immersed”. When we asked how realistic the environment felt, we need to report that the testers gave a fairly mediocre feedback. The reason for this lies within the fact that (i) the reflection area and explore able space needs to be enlarged and, (ii) the walking algorithm and the perception of movements in the digital environment needs to be improved as well.

The general feedback from the tests we performed was positive and the testers showed interest in the application. When we asked the testers if they could imagine using this application for private entertainment or training purposes, 4 testers answered on a Likert-scale with ”strongly agree”, 3 testers answered with ”agree” and 3 with ”undecided”.

Testing the prototype has also shown that the phone’s sensors do provide enough accuracy for simple navigation and movements. The gyroscope accuracy used for head movements was sufficient enough to provide smooth reactions when looking around in the digital world. There was no noticeable delay resulting from the gyroscope sensor. The accuracy of the phone’s built-in accelerometer was on the other hand quite limiting. Movements within the digital world have been rather unreliable. Natural movements where therefore not usable to create an immersive or natural feel for navigation in the digital world. Simple walk-in-place movements were possible to implement with the accelerometer sensor. Using more accurate sensors or even multiple sensors for navigation might be a way to improve this for future applications. Furthermore, our tests showed which parts of the application need to be improved to create an even better experience, especially for future work and entertainment applications.

CONCLUSION

In this paper, we have demonstrated a light-weight, low-cost, mobile and ergonomic head-worn projection display using off-the-shelf equipment. The used equipment was modified to create a compact and longer lasting prototype ($3-4$ hours). Our prototype uses a single $15\ lm$ pico projector, and does not require a cable connection to a stationary unit. Perceived images by the users are focus-free, bright and distortion-free. A perceived field-of-view of a viewer is 50^o in diagonal. The vision of the users is not occluded and no hardware is placed in the users field of vision. We have shown that exploring a virtual environment is possible with our prototype, and allows to create a fairly immersive experience. Multiple users can independently use the screen without experiencing crosstalk. Initial functionality tests have been successfully performed. Furthermore, the feeling of nausea originated from long-time usage was not observed through our initial testing. The prototype can also be used as a 3D stereo system using the same hardware by additionally mounting polarized glasses and an active polarization rotator. Our prototype is an inexpensive, lightweight and stand-alone MR HMPD that shows the potential to be used in motion capture studios as well as in other entertainment applications. This is especially the case because the system in not dependant on external tracking, computing or displaying systems.

FUTURE IMPROVEMENTS

As the goal is to use the prototype for motion capture acting aid and other entertainment applications, a few improvements and changes need to be done to allow the use of the prototype for such environments. Improving the controls of the prototype and the walking algorithm through better sensor data needs to be performed to receive a better output. Using different and possibly multiple sensors could be used to solve this issue.

To prepare the prototype for motion capture acting, the digital environment needs to be enriched with scenarios that are more suitable to test and support common acting tasks in a motion capture environment. This could e.g. include to add more animations and trigger able events.

The next version of the software is expected to provide interaction in between multiple users sharing the same digital content and same screen. Alternatively, there can be multiple screens used and shared by multiple users in remote locations.

Testing and preparing the prototype’s physical rigidness must also be performed to allow to wear the prototype for stunt motion capture shoots.

Our functionality tests conclude that different application areas are also exciting to be explored, apart from a motion capture application. Especially, in gaming and in collaborative interactions for entertainment applications, we see a great potential for our prototype.

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