Reducing the dizziness when using a video-see-through head-mounted display via focus adaptation and DoF blur

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1 INTRODUCTION

THE past summer during my internship I developed a basic video-see-through viewer for a head mounted display(HDM) prototype developed in the CVC[1], the main goal is to improve this viewer making it expandable for future modules and reduce the adverse physical reactions that it can produce to the users[2]. It has to be said that this research project is focused mainly in the software, the prototypes and other hardware aspects will be out of our concerns and will be developed by others researchers of the CVC. A communication channel though is opened to discuss about the development of the whole project.

2 OBJECTIVES

A objectives tree **??** was done to recap all the possible goals that this project may want to archive, as we will see in 4 not all of this goals will be reachable because of the reduced amount of time available.

First we will be developing a software that will be capable of capture an stream from a stereo camera and display it in real time. The software will show one camera stream in each half of the screen, also the headset will enable only to each eye to see one half of the screen, all of this will simulate the stereo effect, creating a depth effect. Another goal is to prepare this software to be easily expandable with new modules in the future.

Secondly, as is reported in [2], using head mounted displays can cause a variety of adverse physical reactions, since this headset will be used while working, these symptoms will reduce the concentration and the effective working hours. For that reason reducing these adverse physical reactions is a priority. To archive this goal, we will try to apply two techniques:

- Accommodation-Vergence: As is reported in these [2][3] articles the mismatch between accommodation and vergence in head mounted displays causes a conflict on the expected depths increasing the feeling of discomfort and dizziness. One idea to reduce this effect is to dynamically move the position of screen frames as the focus changes from closer to distant objects and vice versa. To archive this we will use a neuronal network that will be able to discern between indoors and outdoors, also we will need the depth map obtained via the stereo camera setup.
  In addition to this, a progressive change from one focus to the other may be needed, as a big change in focus can induce sickness to the user.
- Depth of field (DoF) blur: Recent investigations[1] suggest that applying a DoF blur to a scene viewed using a head-mounted display can reduce visual discomfort, the challenge here is that our project has to make this DoF blur in real time in a real world environment, in contrast to the developed in that investigation that were computer generated scenes. To archive this we are going to use disparity map and the information obtained by a neural network that discerns between indoor and outdoor environments.

Thirdly, as the headset will be used in workplaces, the idea of adding data to the environment, could improve the work-flow and the work efficiency. For this reason we think, that adding a third camera to the headset can add valuable information that can be mixed with the environment. A similar idea can be found here [4] where a third camera is used to add information to the real world. For example with adding a infrared camera, we can warn to the user highlighting objects too hot to be touched.

Along all the development, user testing sessions will be taking place in order to check the improvements made between the different versions of the developed software and the different headsets developed. The main goal of this sessions will be to evaluate if the developed software works and if it reduces the sickness feelings of the users. The procedure used in the user testing will be similar to the performed in [1], where the Simulator Sickness Questionnaire[5] where used to evaluate de symptoms.

3 METHODOLOGY

Scrum and its variants are one of the most spread work methodologies nowadays. The scrum methodology is the selected to be used in this project, however, as this project will only be done by one person, some changes have to be made.

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[1]Computer Vision Center located in the UAB campus.

First as there is only one developer de daily meeting will be substituted with a weekly meeting with the stakeholders, in this case the tutor and the boss of the laboratory department in the CVC, in these meetings we will evaluate the development done, the issues faced that week and the problems solved. In addition to that we will discuss and review future milestones and the progress towards them.

Secondly, a backlog will be prepared at the beginning of the project and will contain the main goals divided in tasks, these tasks will be organized in groups of sprints easily done in a week. As each sprint has a backlog of task to be done, a tool can be used to organize this backlog, in this case Trello[6] will be used.

Thirdly, each iteration over the documentation and the development will be kept by a version tracker, in this case, github[7] and its desktop client[8].

Keeping the main scrum methodology, I think it's interesting to grab some ideas from the Lean software development[9]. The idea of removing the so called "Muda", non important extra features and processes, could be beneficial for this project because it could reach an overwhelming dimension for the limited time that is have.

Involving the tools that will need to be used develop the project, first of all, the current viewer version is made in C++ using the QT libraries[10], therefore any tools that would be used need to be compatible with the current version of the viewer. MORE THINGS NEED TO BE ADDED

4 PLANNING

The planning timeline is on the Gantt diagram **??**.

4.1 Research, documentation and planning

This stage of the project can be split in two parts:

1. Initial documentation: the documentation process will start at the beginning of the project and it includes, recap information about the state of the art, do the planning and search about the different technologies involved in this project.

2. Progress documentation: this will be written along all the project and will consist in document every change and issue that can happen. When a part of the project changes its orientation or a milestone is archived the documentation will be updated with the changes.

4.2 Accommodation-Vergence

In this stage, a neural network will be trained to detect de distance of the focus and the necessary vergence in the screen placement to help the user a more comfortable experience. This will, alongside with the DoF blur, be the main time-consuming stage of the project and will have the following parts:

1. Preset creation: In this task, the current viewer will be expanded with the creation of multiple and easy to change presets that will allow further user testing.

2. User testing, presets: In this first user testing session after the finalization of task 1, the users will be told to configure their own focus settings and to try to change between them to adapt the focus to closer or distant objects. The goal here is to acknowledge whether the user feels better accommodation with the focus between objects.

3. Progressive preset change: After the development of 1 and 2, if the users report sickness because of the sudden change between presets, a smooth transition between them will be developed to reduce the issue.

4. Disparity map: In parallel with the development of the tasks 1,2 and 3, a disparity map creator(matcher?) from a stereo pair is required to continue with further development. As this subject is complex per se and is not the main goal of this project, a library that already implements a good stereo matcher, like LIBELAS[11], will be used.

5. Neural network with camera streams: This task will start after the analysis of the data collected in the task 2, an the main goal will be to create a neural network capable of returning the value of the vergence. To archive this several architectures will be tested and compared, with one, two or three streams from the cameras and including the disparity map information when developed.

6. User testing: In this user session, the goal will be to check if the development done in this stage has reduced the sickness feelings of the users, and with which solution the user feel more comfortable.

4.3 Depth of field blur

This stage will be developed after the finishing of the previous Accommodation-Vergence phase 4.2 and shares some development with it.

This problem can be resolved in to ways, using a disparity map only to create the DoF and using Neural network to aid the creation of it.

1. Mock up blur: to ensure that the results of [1] are applicable to real world scenarios, a mock up blur photo dataset will be made, and a user testing session will take place.

2. Designing de pipeline: this task goal is to design, both pipelines, the disparity map only and the neural network aided.

3. Disparity map version: this version will generate the DoF blur using only the disparity map to get the depth and using the center point of the cameras as the focus point.

4. Neural network adaptation: this task will take the neural network developed in the previous phase and will modify it to make it usable in this phase of the project. The idea is that this network will produce an indicative value of the blurriness needed using the camera images to determine whether it is an indoors space or outdoors

4.4 Dataset

To be able to develop this project a dataset will be necessary to train the neural networks and to check the depth map. In this case as we have available three hardware prototypes, a data collection procedure will be possible and simple. For that reason a dataset caption session is planned.

Also a dataset will be used to make sure our dataset is correct and to encompass a broader range of environments. For that reason we selected first the Middlebury stereo dataset[12] because it has a great dataset of stereo images and the groundtruth of their depth map. Additionally a dataset with indoors and outdoors scenes is recommended. Several dataset could be used with that purpose, for example the MIT's places dataset[13] and the INDSECS indoors only dataset[14].

4.5 Third camera

This stage will have as a main goal the integration of the third camera in the viewer software and the highlighting relevant information obtained using the third camera on stream viewed by the user. NEED More Work

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APPENDIX