Technical solution of a camera system for 3D video.

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Abstract: The objective of this paper was to design and build solution for stereo camera system, which purpose is observing objects of different sizes in horizontal line. Where the camera system is in remote location, and it sends data to the second 3D displaying capable device. Main data processing is done in the first device with help of minicomputer, that sends data to the second device, which process and visualize the data. In the theoretical part we will analyze image processing and equipment that suits our purpose. The practical part is focused on the designing and implementing commercially available equipment and evaluating results for the possible future improvements.

Keywords: 3D modeling, Virtual reality, Unity.

1 Virtual reality

1.1 Introduction

For those who are not familiar with the term virtual reality, in simple terms it is simulated experience that place user in virtual environment that can be similar or completely different from the real world and often user can interact with it.

1.2 Types of VR

In this section we will go through VR types that suits our purpose most, compare their advantages and disadvantages and create possible use cases for each type.

Immersive VR.

It is what people most often connects with VR, using some sort of "head-set" as displaying device with one or multiple screens close to your eyes for immersive feeling of virtual world. But let us start from the ground and build up what are the reasons that it is great for our use case and at the same time it has some downfalls. Firstly in our use case with six camera setup with pairs of two for each section it is most logical because two cameras represents human eyes and can be easily implemented in VR as inputs for displaying screens downfall of this solution is that if we are ok with slow refresh rate in radius of ten pictures per minute or static picture for observing even small low power computers like Raspberry PI can handle task like this but if we want real immersive feeling of world and capture moving object or fast response times in changing directions we need stronger hardware to power our setup with this comes penalty for flexibility, ease of use and price for creating such a device. In this direction future might change thing a lot because every year there are more powerful and cheaper devices on the market. Our target for frame rate is ninety frames pers second which looks like unreachable goal in comparison with our current ten frames per minute but is necessary for comfortable observing of moving objects.

Table 1. Target frame rate for best user experience.

Refresh rate	User experience	
>90	Good	This is best what current hardware can do to power high resolution displays and it can be used for extended periods of time.
90 – 60	Moderate	With older hardware we can still achieve great results but for long term use It can create headaches for users.
60 - 30	Bad	At this point it is not recommended to capture moving objects and make fast transitions between changes of FOW
<30	Static image	It is great for static image and can be powered by small compact computer

Desktop-based VR.

Involves displaying 3d world on basic screens without using any specialized VR equipment, we can move around selected object in panorama like image. This was also viable solution but requires more image processing and it is also more demanding on raspberry by because it must take picture from all cameras not just the selected pair as in the immersive VR. On the other hand, it is cheaper because it can be displayed on any device and there is no requirement for 3D headset.

2 Technical solution

In this section we will go through thoughts behind creating optimal design, 3D modeling and possible variations, technical solutions, and

2.1 Cameras

Before we start discussing design let us have a closer look on our selected cameras to understand choices and steps behind our solution. We are using small industrial cameras with parameters shown in table 2.

Table 2. Camera parameters.

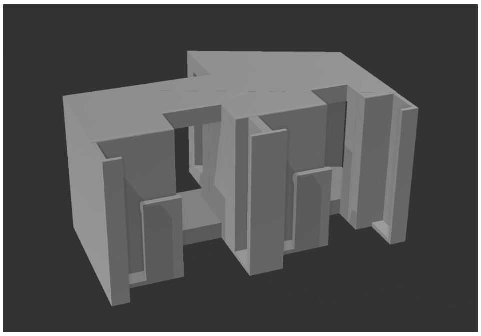
Model	ELP-USB500W05G-FD100
Lens Size	1/2.5 inch（4:3）
Max. Resolution	2592(H) X 1944(V)
Dynamic Range	70dB
Connecting Port type	USB2.0 High Speed
Lens Parameter	Size: 1/2.5, Iris: F2.4, Focus: 3mm, FOV(D): 100 Degree
Power supply	USB BUS POWER 4P-2.0mm socket
Operating Voltage	DC5V
Board size	38X38mm（compatible 32X32mm）

Selected camera type allowed us to use it wide warranty but for simplicity and hardware limitations we chose to use six cameras in par of two to represent huma eyes. Next step was to decide on lens distance in general it depends on object that you are observing it can warry from few centimeters to meter in our use case we decided to use four centimeter as it is our hardware limitation, and it works great for our observing distance around half meter to one and half meter in greater or lesser distances picture my become distorted and not suitable for use as panorama or fisheye effect will occur.

2.2 Design

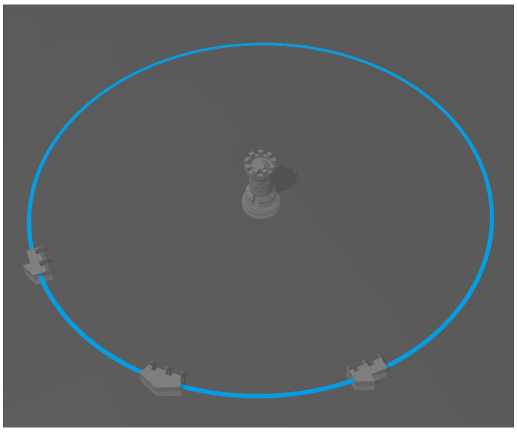
In the Picture 1. we can see model of holder four our camera system custom designed in 3D modeling software to meet expectations and needs for lens distance, cable management and modularity that can provide observing in variety of distances.

Picture 1. Camera holder



Next step was to connect and focus all cameras at one point in such way that non other camera can interfere in displaying image and its noticeable change between switching the view. Manufacture provides information about one-hundredth degree horizontal view angle but in real world tests we calculated that view angle is less than ninety-two degrees which gives us option with some image processing to create camera system around the object with ninety-degree view angle and three possible view angels parallel to object.

Picture 1. Camera holder



2.3 Construction

In case of mounting hardware, we choose basic photographic tripod mounting plate for its simplicity and wide variety of options to mount camera system, the mounting plate is connected to the middle part which has built in photographic screw thread. the remaining three pieces are connected by lightweight aluminum U profile with dimensions 30mm x 25mm and length of 7500mm which is strong enough to hold cameras and provide sufficient internal space for cable management that way we can achieve clean look and mor robust and solid construction. And it provides us whit resizable camera system as the camera holders can slide on the profile and can be set to optimal observing distance. All the cables are led to the circular opening of the middle part where they are connected to the USB-Hub and to the raspberry pi. There is also mounting solution for our raspberry pi as it can be attached to the middle part for easy handling.

2.4 Raspberry PI

For connecting cameras, we must use USB-Hubs as the computer has only 4 usb port witch two are usb2 and two are usb3 usb2 throughput speed are sufficient to handle one camera so we split usb 3 ports with hubs into 4 additional usb slots that gave as six ports to operate with. As we mention before raspberry pi is not very powerful and it struggles running all cameras and stable framerates and not crashing at the same time, so we decided to address one camera at time to take picture and switch to another with this solution our frame rate drop significantly but it was necessary to have enough power left for simple image processing and data transfer.

2.5 Image processing

Image processing is not handled by raspberry by because of its limitations but we were able at least pair right photos crop them in requested way and send them to the displaying device in our case next computer.

3 Conclusion

We were able to design and construct functional camera system with commercially available parts. With help of 3d modeling and printing we created compact and perfectly fitting components for our use case. Downside was limited computing power of small computes that cannot provide enough resources to completely process images and we like but this was necessary for us to make it small functional, easy to transfer and setup.

In the future we can see some potential upgrades in cameras itself for better image quality and computer unit for more computing power. In conclusion objective of our paper was fulfilled with some limitations which can be addressed in future upgrades od the system.

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