DIP Course Project 2020

Team Details

- Team Name: sky_hawkers
- Team Members:
  - Abhishek shah : 2018101052
  - Mrinal Khubchandani: 2018101053
  - Sai Tanmay Reddy Chakkera: 2018101054
  - Tirth Upadhyaya: 2018101069
- Project Name : Stereo Panorama Generation
- Team Mentor : Meher Shashwat Nigam
- Repo URL: https://github.com/Digital-Image-Processing-IIITH/project-sky_hawkers

Overview of the Project

The main problem aim of this project is to create depth perception from a given normal monocular panorama which has only a single viewpoint. To do this we take two images from each frame, one image corresponding to how the left eye will perceive that frame and the second image corresponding to how the right eye will perceive that frame as two perspectives are necessary for depth perception. Depth perception is an extremely important and an integral part of all virtual reality (VR) devices whose demand is gearing up in recent years. Along with depth perception , a complete 360° view is also necessary in VR devices, as a user can rotate their head to see around them, and hence a stereo panorama is required.

Understanding the Problems/Project

01 Extracting the right strip corresponding to the left eye and left strip corresponding to the right from each individual frame.

02 Generating two different panoramas, one formed by mosaicing all the right strips and the other formed by mosaicing all the left strips and then combining both the panoramas.

03 Creating a stereo panorama after applying automatic disparity control to control disparity.

Major Difficulty and Remedy

Creating a dataset was a very challenging task we had to accomplish. It was difficult because there were a couple of criterias which needed to satisfy. The criteria were:

1. Distance between optical center and axis of rotation should be considerably longer than a distance any camera stand could support.
2. The focus of the camera should remain constant throughout the video.
3. The camera should rotate 2-3 degrees per second.
4. It should cover 30 frames per second.

The researchers had constructed a special instrument in order to achieve this. Due to technical problems, we could not construct such instrument. Instead, what we did was we took images at every certain degree by making use of the fact that ultimately the video will be processed frame by frame which is nothing but an image.

Project timeline

Phase 1

Dataset

Created a dataset by a heuristic approach.

Strip calculation

Implemented a code for extracting and calculating strips.

Merging strips

Merge all the strips and generate a panorama.

Disparity control

Implement disparity control algorithm.

Final output

Run the algorithm on the new output to get stereo panorama.

Step 1: Data Generation

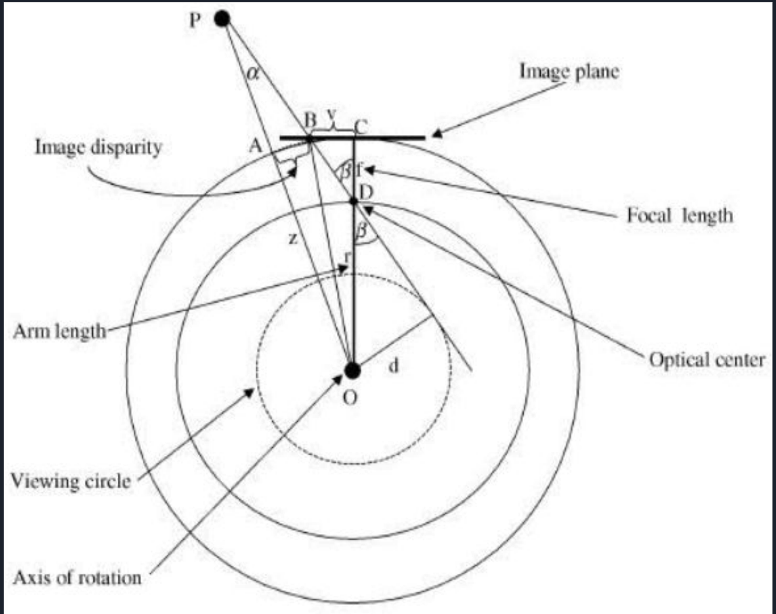
We created the input using a heuristic approach.

A line at every 1° difference was made(360 such lines). Concentric circles of radii 18 and 20 cm were made. The DSLR was place such that it's screen was tangential to the smaller circle, while the OC was placed on the larger circle. In the transition between 2 consecutive lines an average of 6-7 photos were taken. Thus achieving the results of a video taken steadily in a horizontal plane.

Step 1: Data Generation

- We created around 2200 images using the above method.
- Each image was of 1920x1280 pixel.
- For the sample dataset however , we have taken a smaller dataset with reduced resolution of images to allow for faster training.
- New images were of resolution 960x640 and number of images was reduced to 440 images.
- To reduce the images we did not compromise on angle covered by images instead we chose 1 image out of every 5 images by which we were able to maintain 360 degree view.

Step 2: Strip Location Calculation



In the next step we calculated the optimal strip size and location which will provide decent disparity variation so that our eyes can fuse the images together.

For calculating strip size, we take inter eye distance to be 6.5 cm.

We then calculate the left and right locations from the center of image taking the left strip as reference.

Step 3: Merging Strips to generate Panorama

- In the previous step we found out strip location using which we were able to find strips for left and right eye.
- We directly concatenated the strips found for left eye into one image and concatenated strips found for right eye in another image. Hence we were able to generate a Panorama.
- But we fixed the strip gap because of which disparity is also fixed which isn’t a proper approximation of our real world view.
- Hence we need to change disparity to improve our results

Left Panorama with constant disparity

Right Panorama with constant disparity

Step 4: Automatic Disparity Control Algorithm

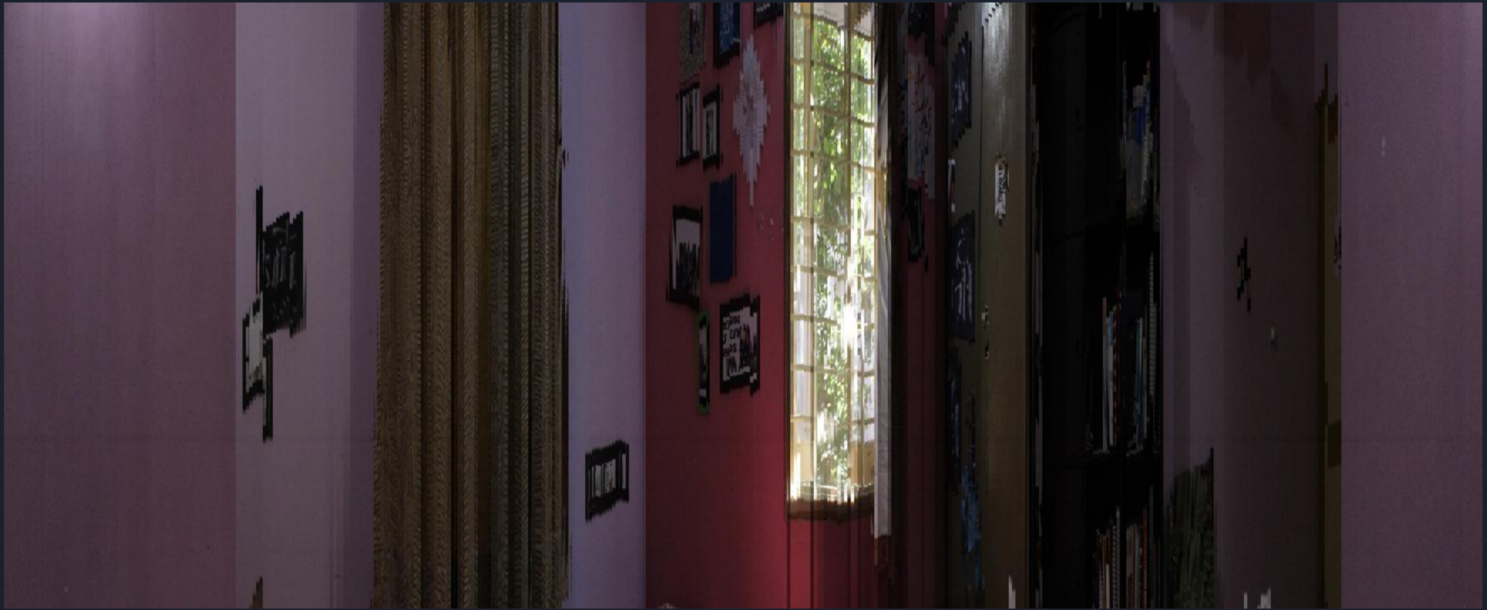
- In order to improve depth perception we apply a algorithm called “Automatic Disparity Control Algorithm”.
- This algorithm is taken from "Omnistereo: panoramic stereo imaging", a research paper from 2001.
- We first align the two images such that we have vergence at infinity
- Then we divide image into 3 parts and calculate the mean squared error between this image and the other image
- Maximum of the three is taken which tells us the range of depth variation in the scene
- This signal is filtered using a median filter in order to obtain a smoothened output which tells us about the regions where there is significant variation in depth. If there is significant variation in depth, we do not want to increase the disparity as it will end up in a situation where the eyes won’t be able to fuse the whole region appropriately. In the regions where there isn’t much variation in depth, i.e. the range is less, we can increase disparity which will help improving the depth perception in that region.

Step 5: Creating New Output

- After applying Automatic Disparity control algorithm we were able to receive new strip width and strip location.
- New strip Location and strip width now will help in generating panorama with improved perception of depth.
- We merge these strips generated using the same method described in step 3. Now the output generated will have better depth perception.
- To show the difference between both stereo images we also created a disparity image which shows disparity difference between both images.

New left Panoramas using ADC algorithm

New right Panoramas using ADC algorithm



Anaglyph image

Step 6: Disparity Image

- To show difference between both stereo images we also created a disparity image which shows disparity difference between both images
- Disparity image is basically finding each pixel corresponding to left image in the right image
- We calculate the distance between these pixels and store them in the new image.
- This new image is called disparity image.

Disparity Image Generated

Step 7: Depth Image

- From The Disparity Image we created Depth Image which shows depth difference between our right panorama image and left panorama image.
- Depth was calculated by the following formula

$$z = (f*b)/(x_l-x_r) = (f*b)/d$$

Here f is focal length which was 18mm in our case and b is distance between optical center which was taken as 6.5 cm and d is disparity.

Depth Image generated

Project timeline

Phase 1

Phase 2

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Shortcomings of this Project

The output is noisy because of the following reasons:

1. We were not able to capture images properly at a uniform rate because of lack of proper equipments. Because of this at some points input image shrunk at some points and got expanded at others. This affected the final output of our code.
2. Plane of images also got changed sometimes while capturing them because of technical difficulties.
3. We had to reduce resolution as well as number of images because of GPU constraints.

Our code will not give correct output if the input dataset is very small. We are moving a window of size 50 over the image in the code. So if the input dataset is very small and does not meet the boundary conditions then the correct output might not be produced.

Division of work

We divided ourselves into 2 parts. Abhishek and Mrinal worked together and Tanmay and Tirth worked together.

- Work done by Abhishek and Mrinal:
  - Extracting the strips from the input image and concatenating them to form panoramas for left eye and right eye.
  - Applied automatic disparity control algorithm on the obtained panoramas.
  - Created anaglyph image from stereo images.
  - Creating depth image from disparity image.
- Work done by Tanmay and Tirth:
  - Generating input dataset.
  - Made vergence at infinity 0 for improved depth perception
  - Computed disparity between images
  - Created disparity image from stereo images.

Thank you!

Made by:

Abhishek Shah (2018101052)

Mrinal Khubchandani (2018101053)

Sai Tanmay Reddy Chakkera (2018101054)

Tirth Upadhayaya (2018101069)