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Team A: Aware

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Individual Progress

During the last week, I was in charge of transplanting stereo vision program from Matlab to OpenCV and researching on how to improve the performance of stereo vision system.

Stereo Vision:

I am transplanting our stereo vision system from Matlab to C++. The stereo vision system algorithm I am going to use is called Semi Global Batch Matching (SGBM) algorithm. This is a local method used to compute the depth. You may find the detail description of how the algorithm works in the following paragraphs.

Calibration:

The purpose of calibration is to compute the extrinsic and intrinsic parameters for both of the cameras. The calibration process also computes the relative position and rotation of two cameras. The most important thing is to compute the radial distortion and tangential distortion of the cameras.

Un-distortion:

Using the distortion parameters that we get from the calibration process. We could un-distort the images captured from two cameras. The reason why we need to un-distort the images is stereo vision system assumes the cameras are pin-hole structure. However, for modern cameras, usually the cameras are not pin-hole structure. That's the reason why we need to un-distort the image, so that the un-distorted image looks as the same as the image captured by a pin-hole structure camera. Otherwise, it may lead to severe error.

Matching:

For each point on the left image, it corresponds with an epipolar line on the right image. The algorithm could find the best match by looking for the best point on the epipolar line. The criterion for finding the best match is to compare the surrounding 7*7 window between the point in the left and right images. The algorithm repeats this procedure at each location and find the best matches. The algorithm repeats this procedure on each pixel. Then we could get the disparity map of the image.

Projection:

As long as we get the disparity map of the image. We could use the projection matrix to compute the real depth of the environment. You may find the generated depth map in Figure 1.

Figure 2 is the scenery in a parking lot. As you can see from the image, the brighter the pixel is, the less distance it presents. The darker the pixel, the more distance it presents. As you can see from the image. There are a lot of holes in the image. This kind of error was due to the fact that the window size is too small. If the

pixel is featureless, then the algorithm may find out the similar window on several position on the epipolar line, which would lead to matching ambiguity, thus holes in the image. The percentage of these holes increase when the environment is full of featureless and symmetric objects. That is the reason why in Figure 2, we could not detect the depth information of the vehicle.

Solution:

There are two ways to solve these problem.

1. Increase the window size of the matching window. This solution seems to work because it gives the algorithm more information to distinguish similar features. However, increasing the size of the window could lead to latency of the algorithm.
2. Change to another algorithm called: ELAS. This is the algorithm I am going to use in the next two weeks. There are three reasons behind it. The first one is that the algorithm provides dense depth map, which means that there are no holes in the depth image. The second reason is that the algorithm works very fast. According to the author, the algorithm could work 7 fps on a single core computer. Last but not least, the algorithm has won several competitions on stereo vision field. You may find the demo for this algorithm in Figure 3.

Challenges:

Speed of Stereo Vision Algorithm:

At this stage, our stereo vision algorithm works very slow, usually it would take several seconds to compute an image. There are two possible reasons. First, we don't use the GPU accelerate tool CUDA. Second, the algorithm is run in Visual Studio debug mode. It is said that in this environment, the algorithm works pretty slow.

Object Detection Algorithm

Also our object detection system works in python. However, our whole system is built in C++. We still need to do research on how to compile C++ and Python in the same project.

Teamwork:

Zihao worked with me on stereo vision. Harry and Amit worked on getting data from radar. Menghan combined the depth map with RGB image.

Plans:

In the next week. We will improve our stereo vision algorithm. The next thing we would like to do is to get sensible data from radar. Also I am planning to do research on object tracking algorithms. We also need to research on combine object detection python code with C++ code.

Figures:

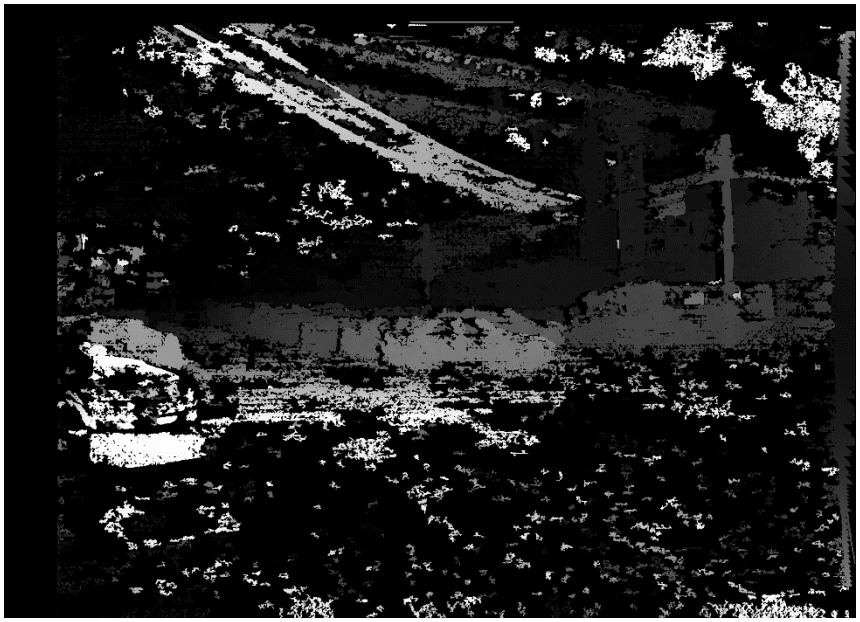

Figure 1. Depth Map for Parking Lot

Figure 2. Parking Lot

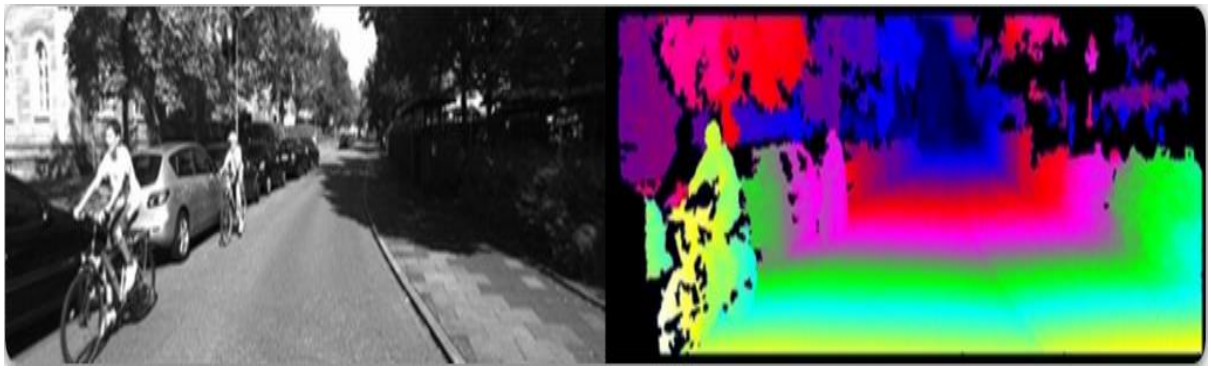

Figure 3. Demo for ELAS