University Jean Monnet

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Computer Vision - Project Report

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1 Introduction

Computer vision is an interdisciplinary field that deals with how computers can be made for gaining high-level understanding from digital images or videos. From the perspective of engineering, it seeks to automate tasks that the human visual system can do. "Computer vision is concerned with the automatic extraction, analysis and understanding of useful information from a single image or a sequence of images. It involves the development of a theoretical and algorithmic basis to achieve automatic visual understanding." As a scientific discipline, computer vision is concerned with the theory behind artificial systems that extract information from images. The image data can take many forms, such as video sequences, views from multiple cameras, or multi-dimensional data from a medical scanner. As a technological discipline, computer vision seeks to apply its theories and models for the construction of computer vision systems.[1]

1.1 Kinect V2

Kinect is an easy to use and affordable RGB-D acquisition device that provides both spatial and color information for captured pixels. That makes it an attractive alternative to regular 3D scanning devices that usually cost significantly more and do not provide color info. Second generation of Kinect (v2) provides even better quality depth and color images to use.[2]

1.2 3D reconstruction using Kinnect V2

The 3D reconstruction using Kinnect V2 uses the color and the depth images for the same scene at different positions and than feeding the depth information to reconstruct the 3D scene from 2D images. Camera calibration in Binocular Stereo Vision refers to the determination of the mapping relationship between the image points P1(u1,v1) and P2(u2,v2), and space coordinate P(xp, yp, zp) in the 3D scenario. Camera calibration is a basic and essential part in 3D reconstruction via Binocular Stereo Vision.

[1] Wikipedia

[2] Lembit Valgma:3D reconstruction using Kinect v2 camera

2 Methods Implemented and Tasks Performed

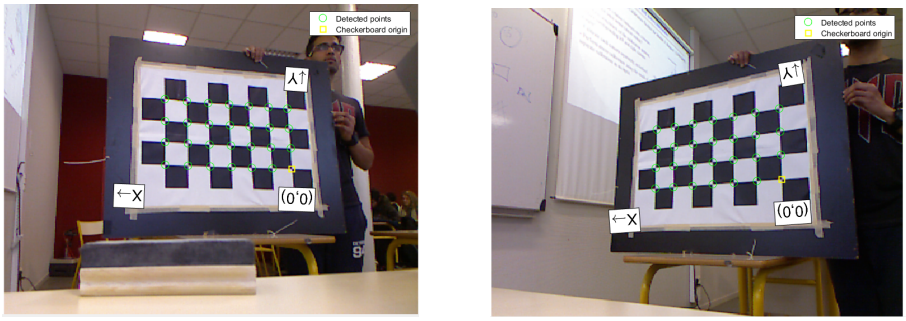
2.1 Task 1: Calibrate the two RGB cameras using the checkerboard calibration technique.

The following methods were implemented:

1. The corner points were selected using Camera Calibration Tool Box and the results were accordingly produced with the square size of 8.9*8.9 cm square shown in results section.

2. The calibration of each set of images that were taken by left and right camera were done and the intrinsic parameters were produced for each camera separately.

3. The last task was performed using stereo calibration toolbox to get the extrinsic parameters that gave the normal and world centered view of the stereo vision and also the translation vector and rotation matrix which were used in later task given.

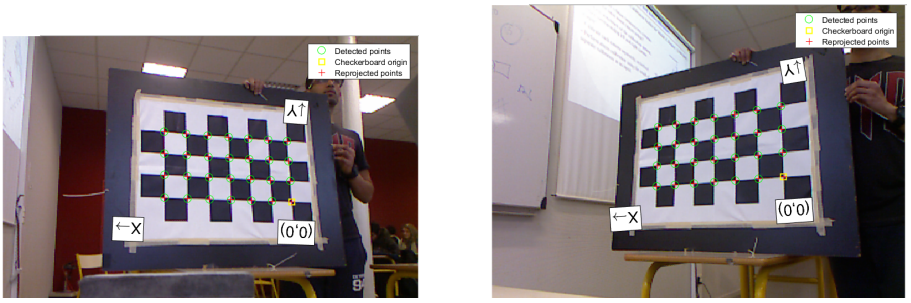


(a) Left Camera (b) Right Camera

Figure 1: After selecting the four corners before re-projecting it.

2.2 Task 2: Calibrate the two depth cameras with respect of RGB data

The method that was supposed to be performed to complete the task was tried to be followed but there was a critical obstacle which was duly reported to the professor through an email.



(a) Left Camera (b) Right Camera

Figure 2: After selecting the four corners after re-projecting it.

```
cameraParams =

  cameraParameters with properties:

   Camera Intrinsics
                    IntrinsicMatrix: [3×3 double]
                        FocalLength: [540.1656 539.3324]
                     PrincipalPoint: [316.0161 248.6396]
                               Skew: 0
                   RadialDistortion: [0.3077 -0.8347]
                TangentialDistortion: [0 0]
                          ImageSize: [480 640]

   Camera Extrinsics
                    RotationMatrices: [3×3×18 double]
                TranslationVectors: [18×3 double]

   Accuracy of Estimation
              MeanReprojectionError: 0.3314
                 ReprojectionErrors: [28×2×18 double]
                  ReprojectedPoints: [28×2×18 double]

   Calibration Settings
                         NumPatterns: 18
                        WorldPoints: [28×2 double]
                         WorldUnits: 'millimeters'
                       EstimateSkew: 0
    NumRadialDistortionCoefficients: 2
       EstimateTangentialDistortion: 0
```

(a) Left Camera

```
cameraParams =

  cameraParameters with properties:

   Camera Intrinsics
                    IntrinsicMatrix: [3×3 double]
                        FocalLength: [514.7264 515.3067]
                     PrincipalPoint: [305.4592 267.1152]
                               Skew: 0
                   RadialDistortion: [0.1896 -0.4219]
                TangentialDistortion: [0 0]
                          ImageSize: [480 640]

   Camera Extrinsics
                    RotationMatrices: [3×3×17 double]
                TranslationVectors: [17×3 double]

   Accuracy of Estimation
              MeanReprojectionError: 0.3723
                 ReprojectionErrors: [28×2×17 double]
                  ReprojectedPoints: [28×2×17 double]

   Calibration Settings
                         NumPatterns: 17
                        WorldPoints: [28×2 double]
                         WorldUnits: 'millimeters'
                       EstimateSkew: 0
    NumRadialDistortionCoefficients: 2
       EstimateTangentialDistortion: 0
```

(b) Right Camera

Figure 3: Intrinsic Parameters of both cameras.

2.3 Task 3: Perform 3D reconstruction

This task was performed by writing a MatLab code which considered the focal length and principle points of both cameras and than using the Kinect Depth parameters obtained/given in task 2. The other important values used were the extrinsic parameters of Camera 2(Right Camera) with respect to Camera 1(Left Camera).

The 3D reconstruction was first done for first camera on left and the point cloud in 3D is reported and than same procedure is followed for right camera. The results are combined for both the reconstruction to report the quality

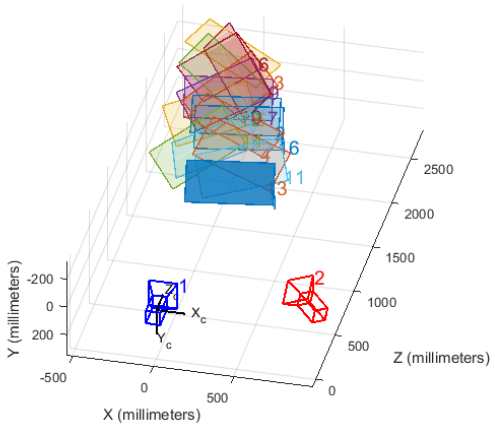


Figure 4: Extrinsic Parameters in Normal View

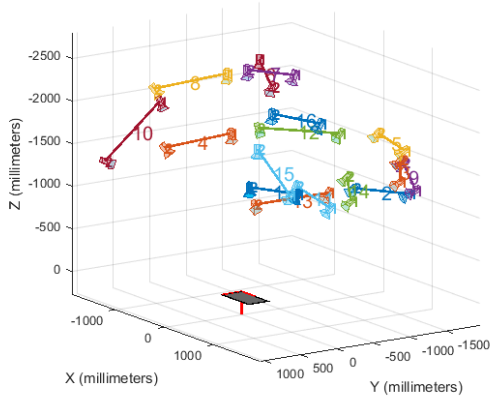


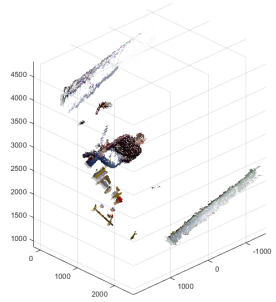
Figure 5: Extrinsic Parameters in World Centered View

of 3D reconstruction done.

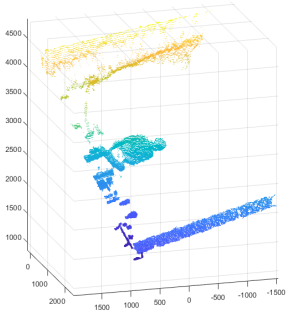
3 Results

3.1 Task 1

1. The following corner points were observed before and after re-projection process in figure 1 and 2



(a) 3D reconstruction

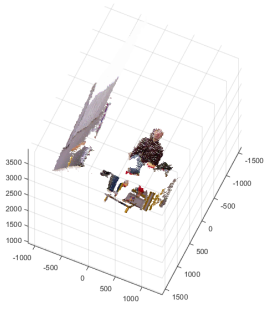


(b) Colored Point Cloud for the 3D Reconstruction

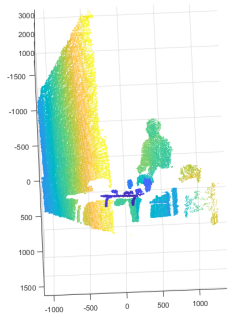
Figure 6: 3D Reconstruction for left camera

2. The intrinsic parameters of both the cameras are as follows in figure 3

3. The extrinsic parameter of the both the cameras are given in figure 4 and 5. The translation vector is given by [-865.531,110.919,378.475].



(a) Left Camera



(b) Right Camera

Figure 7: Intrinsic Parameters of both cameras.

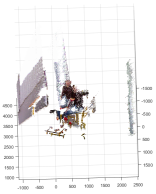
3.2 Task 3

The following figures shows the results obtained during 3D reconstruction process:

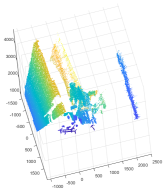
1. The figure 6 shows the 3D reconstruction with the help of color and the depth information from left camera.

2. The figure 7 shows the 3D reconstruction with the help of color and the depth information from right camera.

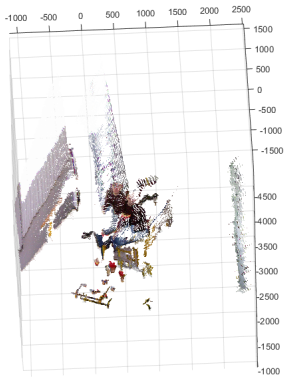
3. The figure 8 shows the 3D reconstruction with the combined results from left and right 3D reconstruction.



(a) Combined 3D Reconstruction



(b) Point Cloud



(c) Combined 3D Reconstruction with point cloud

Figure 8: Intrinsic Parameters of both cameras.

4 Problems Faced and Conclusions

The problem faced during the project was mainly in Task 2 which was being reported to the professor by email. Other problems were at starting the time management but it effectively later sorted out. Everything went smooth during the course of this project.

Over the course of this project we got to apply the theoretical concepts surrounding camera and stereo calibration taught in class onto real world calibration tasks and dived deeper into the overall understanding of 3D reconstruction which is very useful in everyday things and having successfully completed the defined objectives, we now have gained a more holistic understanding on this topic and are looking forward to apply this new found knowledge towards realizing the new challenges in future.