3D Reconstruction on a Mobile Device

Summer Undergraduate Research Award

Kartikeya Gupta
2013CS10231
Computer Science
Mob: 9899134337
CGPA: 9.78

Prateek Kumar Verma
2013CS10246
Computer Science
Mob: 9911577289
CGPA: 8.87

Subhashis Banerjee
Professor
Department of CSE
IIT Delhi

Introduction

- Camera Matrix or Camera Projection Matrix is a 3×4 matrix which describes the mapping of a pinhole camera from 3D points in the world to 2D points in an image. The camera parameters depend on 2 parts, intrinsic and extrinsic parameters. Intrinsic are dependent on the focal length and principal points. The extrinisic parameters are dependent on the rotations and translations between camera coordinate system and the world coordinate system.

- Given two different images of the same scene from different angles, the position of a 3D point can be found as the intersection of the two projection rays. This method is computationally expensive and hence done only for some number of points. Using these 'sparse' points, the Camera Projection Matrix is calculated. This is known as Sparse 3D reconstruction.

- IMU sensors are electronic devices which consist of a collection of accelerometers, gyroscopes, magnetometers which are present in modern day smart phones and other gadgets. The data from them can be used to obtain the orientation and other physical properties of the device.

- In the case of a smartphone or any device having a camera and IMU sensors, we wish to use the IMU sensors to obtain extrinsic camera parameters. This will help in reducing the load on conventional 3D reconstruction methods and get it in near real time.

1 Objectives

Our main objective is to perform 3D reconstruction in near real time on a mobile device. This can be further divided into following points.

1. To get accurate position and orientation estimate based on readings of IMU (Inertial Measurement Unit) sensors in smartphones.

2. To use the camera feed in smartphones to enhance the position estimate based on visual tracking of objects.

3. To do sparse 3D reconstruction based on sensor fusion data and image processing.

4. To enhance the quality and efficiency of 3D reconstruction by adding more detailing and moving towards dense 3D reconstruction.

5. We will ultimately be fusing digital signal processing and computer vision based techniques that will enable us to perform near real time 3D reconstructions on mobile or hand-held devices.

2 Approach to the Project

First, we shall perform accurate position and orientation estimation of the mobile device. Then we will move on to 3D reconstruction, which has two parts. First part is to obtain sparse 3D reconstruction and then use different tracking methods to obtain dense correspondence of points.

1. Position and Orientation Estimation
    (a) Get accelerometer data and orientation data at real time using the IMU sensors like: Accelerometer, Gyroscope, Gravity Sensor, Magnetometer present on the smart phone.
    (b) Making the orientation data more accurate by infusing the higher frequency components from the gyroscope orientation after drift correction.
    (c) Obtaining the displacement and orientation data from the camera feed on the device using visual tracking methods.
    (d) A comparative study is to be done between the position estimates obtained by the two methods along with the ground truth and fusing the results to obtain an enhanced position and orientation estimate.
2. 3D Reconstruction
    (a) Obtain sparse 3D reconstruction based on rotation and translation matrices obtained previously.
    (b) Use tracking data from different tracking methods like "Good Features to Track" or "KL Tracker" for obtaining dense correspondence of points.
    (c) Use guided matching by indirect computation of fundamental Matrix from estimated camera motion from sensors to further enrich the correspondences.
    (d) Triangulate the dense correspondences and do a final global refinement.
3. Further Possibilities
    - Getting a more detailed texture mapping of the object.
    - Making a object recognition software on the basis of this 3D reconstruction.
    - Improving the algorithm for a quicker and more efficient 3D reconstruction.
    - Releasing applications for Apple, Android and Windows platforms for near real time 3D reconstruction on the device itself.

3 Uses and Application

- Using the device as an accurate measuring device. This can be of particular interest to blind as they will be able to measure distances and angles accurately with great ease.

- Doing real time dense 3D reconstructions on mobile phones and other handheld devices.

- Allowing the user to generate a 3D printable file on his mobile device. As 3D printers are becoming cheaper and more common, this feature will reduce the need of the person to use a 3D scanner to be able to generate prototypes of objects. This will allow engineers and students to work more efficiently as they can generate copies of 3D objects easily.

- The project can have applications in the field of archaeology. It can be used to generate replica of artifacts and fragile objects for further studies, without harming its integrity.

- The project can also be applied in the field of medical sciences, especially for orthopedics and joint replacement surgery. The part to be replaced can be made with high accuracy using this project.

- The project can also be used by the astronauts up in the space. With the help of this project, the parts to be changed can be easily made using a 3D printer.

- Localisation at tourist sites and providing real time directions to landmark locations. This will involve the use of GPS(Global Positioning System) as well to get a rough location of the user.

4 Budget, Duration and Facilities

4.1 Budget

Rs.25,000 will be needed to purchase an android smart phone having high quality sensors and a high resolution camera.

4.2 Duration

We will try to complete this project by the end of the summer break i.e. the end of July, 2015.

4.3 Facilities

- Access to the Vision Lab.