Camera Path Calculation using IMU sensors

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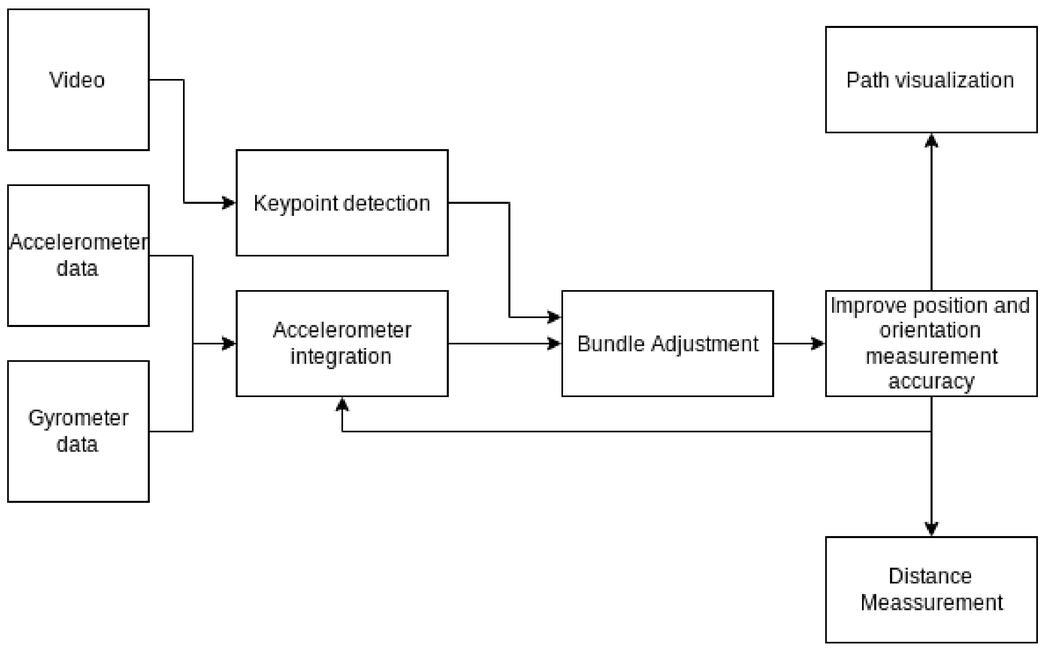
Abstract

Modern mobile phones are equipped with accelerometers and gyroscopes. Data obtained from the accelerometer can be used to estimate the position of the camera between frames of a video while the orientation can be determined from the gyroscope. An approximation of the camera path can be calculated from the combination of these data. However, the output of this process can be fairly inaccurate. To improve the approximation we use the IMU data as the input of a Bundle Adjustment. The Bundle Adjustment gives an improved position and orientation data of the camera for each frame which in turn gives a better camera path estimation.

Overview



Overview of our Pipeline

Methodology

The first step in our project is to obtain the IMU data required for the Bundle Adjustment. We use a recording app to obtain the data by ourselves.

We then detect the keypoints and compute their descriptors in each video frame using ORB. Keypoint matching is also performed in this step to identify the unique keypoints.

The accelerometer provides us with the acceleration of the camera. We calculate the velocity and position of the camera from this data. The gyroscope, on the other hand, gives us the angular velocity which is used to calculate the orientation of the camera. The values obtained from the first two video frames are used to initialize the Bundle Adjustment process.

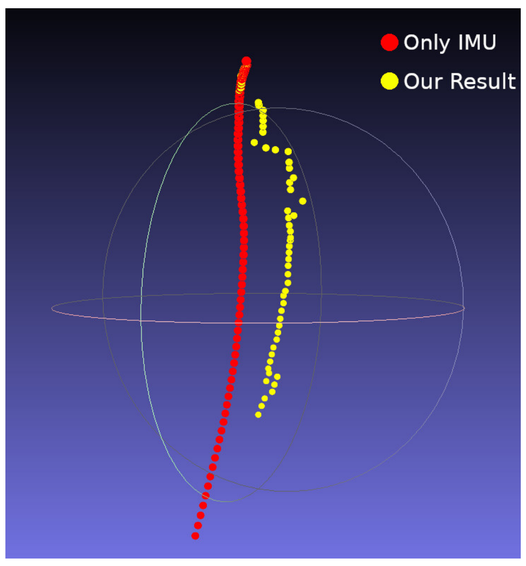
For each of the subsequent frames, the Bundle Adjustment outputs a corrected position and orientation value of the camera (see [1, 2]). These values are then used as the input for the Bundle Adjustment of the next frame. Performing this process over all the video frames gives us an approximation of the camera path which is fairly accurate.

Problems and Possible Errors

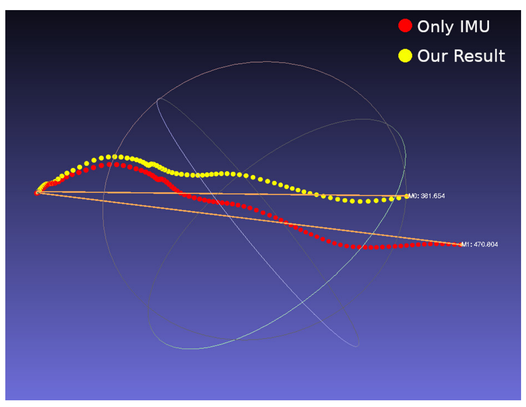
- Uncalibrated IMU and Camera
- Noise
- Gravity removal
- Unsynchonized IMU data and Video
- Integration erros

Experiments and Results

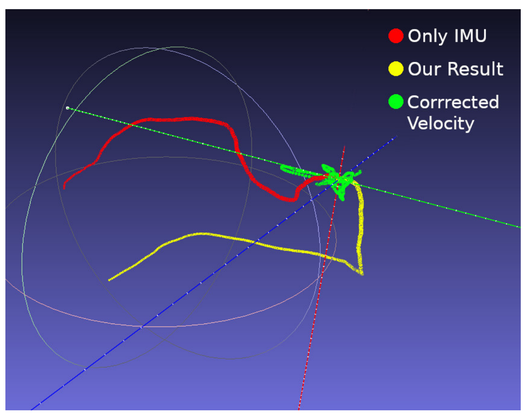
Distance measurement setup



Stationary measurement result



Distance measurement result



Staircase measurement result

Distance measurement: We moved the camera from one specified position to another at a known distance, while doing some other movement in between. Our hope was to be able to measure the accuracy of the distance between the start and end position. However, the uncalibrated IMU causes an undefined scale. The top-left image shows the setup used while the bottom-left image shows the measurement result.

Stationary: We kept the camera stationary during the entire recording. This was done to determine the accuracy of the IMU and the bundle adjustment algorithm. You can see the result in the top-right image. As we do not have any scaling, the gravity removal becomes difficult. You can see that the position moved downward over time though the camera is stationary. The bundle adjustment sometimes corrected the error.

Staircase: We recorded the path in a staircase moving down by two floors. Our hope was to evaluate the alignment between different floors. The bottom-right image shows the results. Unfortunately, the results were inconclusive. We also tried to correct the velocity of the IMU-Integration using the results from the bundle adjustments (green dots). However, this did not result in an improvement.

References

[1] Gaurav Gupta, Nishant Kejriwal, Prasun Pallav, Ehtesham Hassan, Swagat Kumar, and Ramya Hebbalaguppe. Indoor Localisation and Navigation on Augmented Reality Devices. In *2016 IEEE International Symposium on Mixed and Augmented Reality (ISMAR-Adjunct)*, pages 107–112. IEEE, sep 2016.

[2] E. Mouragnon, M. Lhuillier, M. Dhome, F. Dekeyser, and P. Sayd. Generic and real-time structure from motion using local bundle adjustment. *Image and Vision Computing*, 27(8):1178–1193, jul 2009.