High Resolution Motion Capture

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Project Aim

Multi-camera technology is increasingly finding applications in a large number of fields starting with security surveillance systems to film making industries. With multiple cameras working together, we can build a detailed 3D model as well as capture dynamic motion. However, this new technique requires a deep understanding of computer systems and computer vision knowledge.

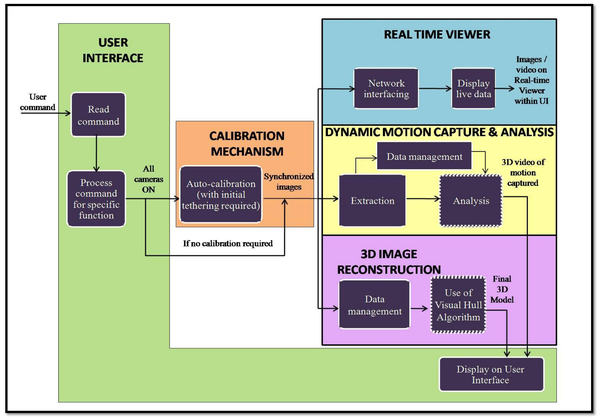
For our project we aim at using these techniques to ease the use of a multi-camera system by:

- Automating the calibration and reducing its set-up time
- Reducing the error in calibration to less than one pixel
- Performing 3D reconstruction using Visual Hulls in real time
- Designing an intuitive and easy to use GUI to help any user use of all of the above without any knowledge of the system

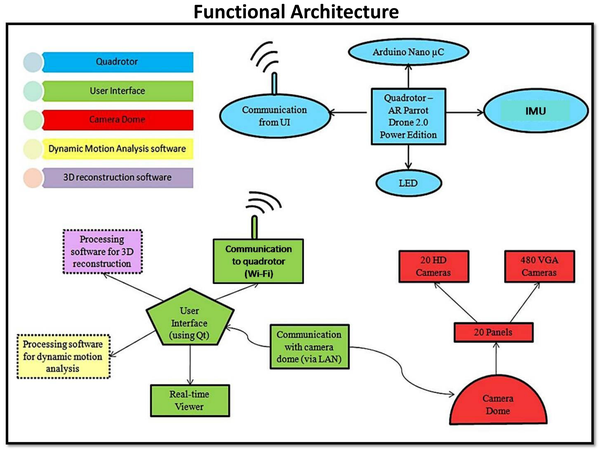
We developed these functionalities for the 'Virtualization Studio' in NSH B510 which is a multi-camera network comprising of 480 VGA cameras.

System Specifications – Use Case

Our system aims to reduce the amount of time taken by the users in the 'Virtualization Studio' to set-up the calibration system and run it for all the cameras. We also wanted to display a real-time building of a 3D model using the visual hull algorithm on this system.

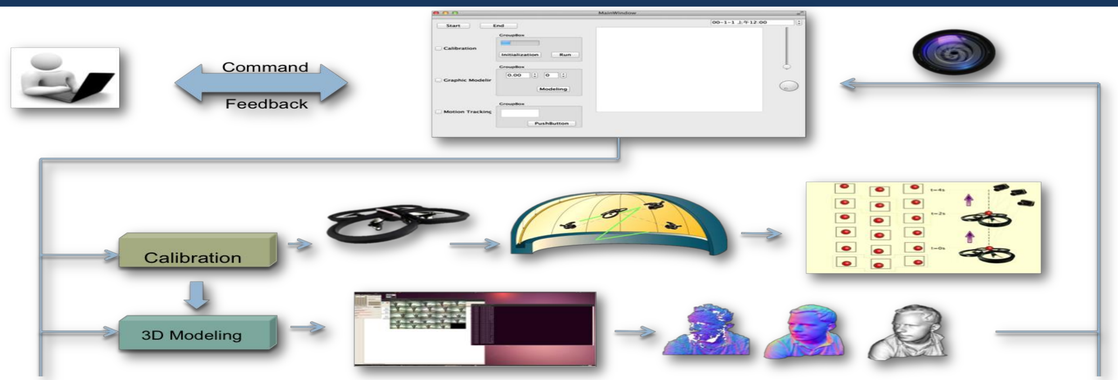


Functional Architecture



Physical Architecture

System Overview



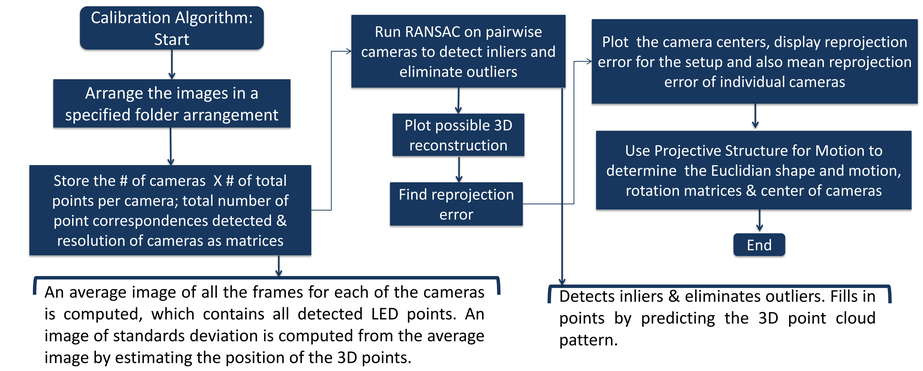
System realization using various subsystems

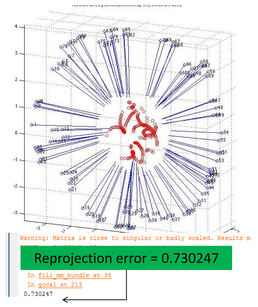
The quadrotor is set up according to the instructions on the GUI

Then, it is placed inside the dome in the given configuration. It has an LED powered by a PCB on board.

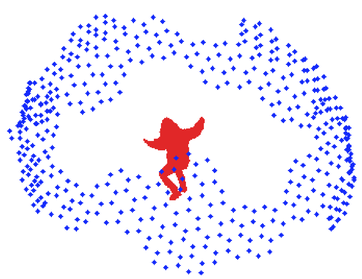
Next, it is automated to fly in a pre-determined path with all the required parameters displayed on the GUI

This is the path of a red LED mounted on the quadrotor that is captured by all the cameras and used for calibration

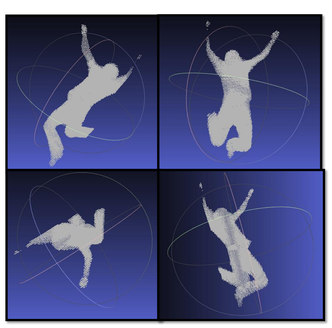




An image capture of the subject is done inside the dome of the 'Virtualization Studio'.



The 3D reconstruction of the subject is done using the Visual Hull Algorithm and images from all 480 cameras.



Using this, we can produce a high-resolution 3D model within an error of 5 mm

Challenges

Calibration Subsystem:
Automating the movement of the quadrotor inside the confined space of the dome structure was a major challenge due to the increased air-thrust and turbulence in an enclosed space. Another major challenge we faced was integrating the huge amount of data into a form that could be processed by the calibration algorithm effectively, and have it run within the stipulated time constraints. This subsystem was by far the one we faced the most unexpected challenges in as well

Graphical User Interface:
Making the GUI intuitive was a long and iterative process. We conducted user studies with people from several different technical backgrounds who did not have any knowledge about our system and changed the GUI to make it intuitive enough for all users irrespective of their backgrounds.

3D reconstruction:
The imperfect result of background subtraction and expensive computational cost were the main challenges faced while implementing the 3D reconstruction.

Results

With this project, we accomplished the task of building an easy to use multi-camera system with some added functionality. As per the requirements given to us, we designed:

- Calibration using an automated quadrotor with an accuracy of 0.5 pixels on an average for all cameras
- Calibration of the setup of 480 cameras in 8.6 hours with significantly lesser set-up time as compared to the previous implementation
- 3D reconstruction using visual hull at real time speeds

Conclusions

As seen from the results, we were able to meet all of our mandatory requirements barring the time taken for the calibration algorithm to run due to some changes in the final folder structure of the image extractions.

We also added in 3D reconstruction using the Visual Hull algorithm which was initially a desirable requirement, and were able to display it real-time.

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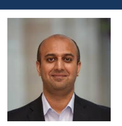
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