Stereoscopic Vision for Autonomous Navigation

Functional Requirements List and
Performance Specifications

By:
John Hessling

Advisor:
Dr. Huggins

November 12, 2009

Introduction

The goal of this project is to design and implement a self contained Stereoscopic vision system for use in slow moving autonomous applications. The hardware design is simple consisting of two cameras and a central processing unit. Therefore, this project will focus on the software for implementation.

Goals

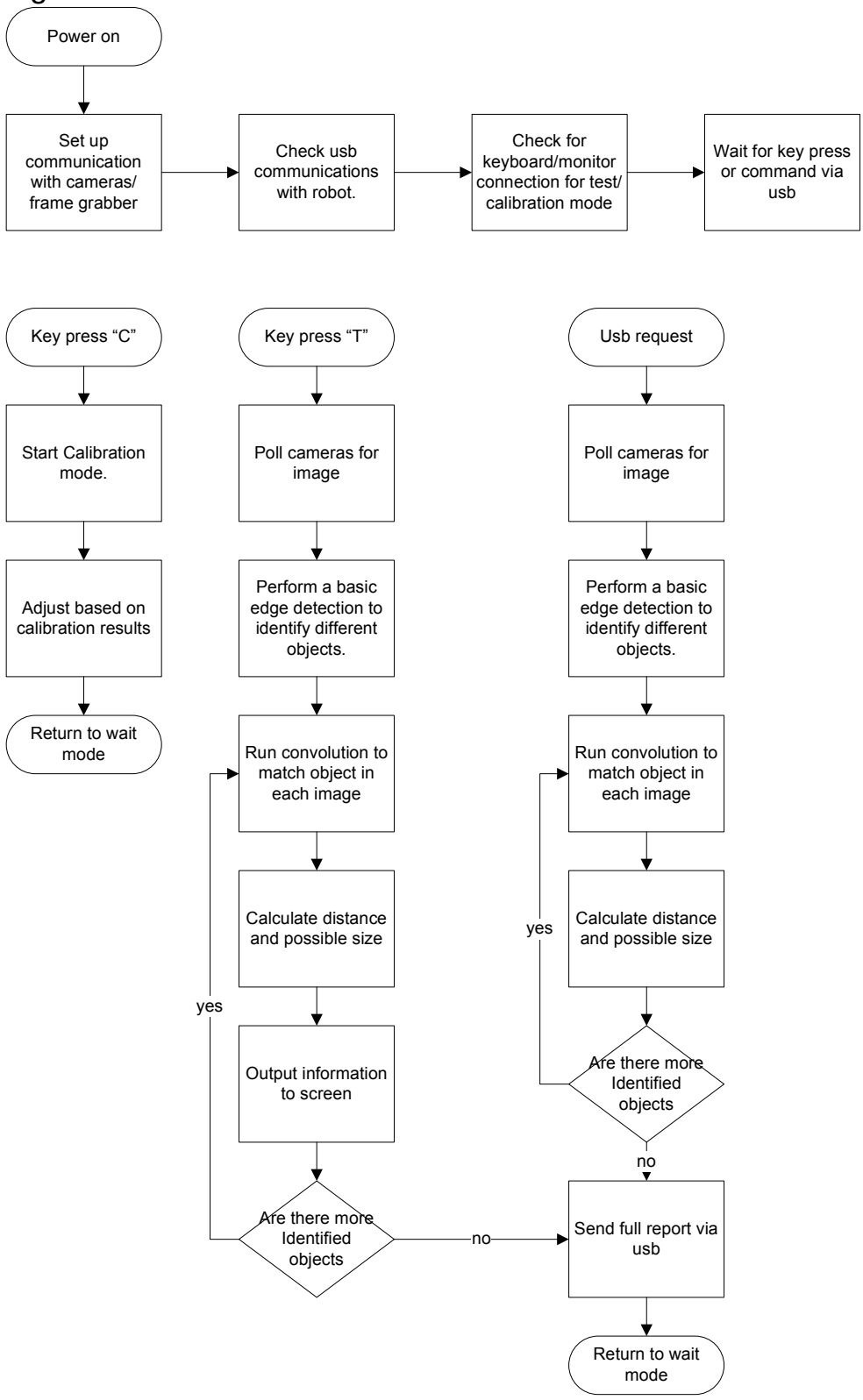
This is a basic goals list for the project but ultimately a fully functional self contained unit with precise object distance detection in the field of view.

- Field of view greater than 35 degrees
- Field of view will be from 1 meter to 10 meters
- Communication to client unit
- Detect multiple objects in the field of view
- Distance accuracy shall be 5 cm per meter distance
- Three separate run modes: Calibrate, Test, and Run mode

Software System

The software is the main focus of the project. The basic design shall be as follows. There shall be one startup routine the starts the cameras and preloads values. Then depending on the requests made from the keyboard of client unit the program will run one of three possible modes as listed below.

Figure 1


Power on
Set up communication with cameras/ frame grabber
Check usb communications with robot.
Check for keyboard/monitor connection for test/ calibration mode
Wait for key press or command via usb
Key press “C”
Start Calibration mode.
Adjust based on calibration results
Return to wait mode
Key press “T”
Poll cameras for image
Perform a basic edge detection to identify different objects.
Run convolution to match object in each image
Calculate distance and possible size
Output information to screen
Are there more Identified objects
yes
no
Usb request
Poll cameras for image
Perform a basic edge detection to identify different objects.
Run convolution to match object in each image
Calculate distance and possible size
Are there more Identified objects
yes
no
Send full report via usb
Return to wait mode

Calibration mode

The calibration mode is designed to ensure that the measurements taken in later modes will be accurate. There will be two parts to the calibration mode. The first being a basic camera alignment and this will be to ensure the cameras are pointing directly forward. Properly aligned cameras will ensure the largest field of stereo vision. The adjustments will be made onto the physical camera mounts by the user. This portion of the calibration can be skipped by user override. The second will require a special calibration object to be centered three meters away from the cameras. The system will then capture a picture from both cameras. Then use this information to adjust color differences and distance calculations. The user will be asked to accept changes to adjustments. If the user declines the previous calibration will be used.

Testing mode

Testing mode will be used mostly for development and proof of operation. This mode will perform all the same tasks as Run mode, but will also display all the information to the user screen for verification. The raw images will be saved in addition to the intermediate processing steps. This will allow for full testing, development, and debugging. These images will not need to be outputted during Run mode. Therefore, this will increase the overall speed of the stereo vision unit.

Run mode

Run mode will be the main operation mode for the stereo vision unit and will only be accessible through usb connection. The run request and the desired format request will be sent to the stereo vision unit. If a desired format is not sent a default format will be selected. The stereo vision unit will grab the images from the two cameras and retrieve orientation information from the sensor. The images will then be processed to extract object information from the field of vision. This will be adjusted based on the sensor orientation information. The object information will be formatted as requested and sent back via

usb connection. Although speed is not the primary concern for this project, every effort will be made to minimize the time delay between request and completion. To this end one request mode will include a less accurate but faster format.

References:

[1] D. Scharstein and R. Szeliski. A taxonomy and evaluation of dense two-frame stereo correspondence algorithms. *International Journal of Computer Vision*, 47(1/2/3):7-42, April-June 2002. Microsoft Research Technical Report MSR-TR-2001-81, November 2001. http://vision.middlebury.edu/stereo/taxonomy-IJCV.pdf