Title

Stereo Vision Aided Navigation for Robotic Boats (MAS 10)

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Stereo Vision-aided Navigation for Robotic Boats

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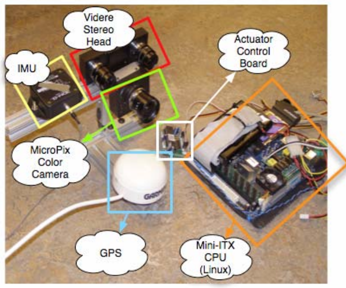
Stereo Vision to localize a Robotic Boat

Hardware

- Mini-ITX form factor, Linux Computer
- GPS
- 3DMG IMU
- Videre Stereo Head
- Micropix Color camera



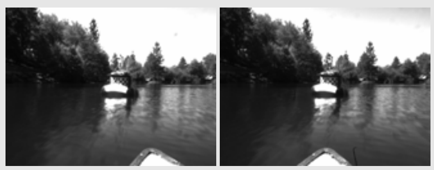
Above: Buoy as Imaged by the Color Camera.

Above: Buoy and Robot Boat at Lake Fulmor.

Why Stereo? Isn't GPS enough?

Stereo for Navigation

- Satellites can drop out of sight resulting in a loss of a GPS fix. Stereo ranging can be used as a ***localization*** aide.
- Range information can be used for ***obstacle avoidance***.
- The vision system can be used to help in autonomous boat ***docking***.
- Simultaneous Localization and Mapping (***SLAM***) of lakes may be possible.



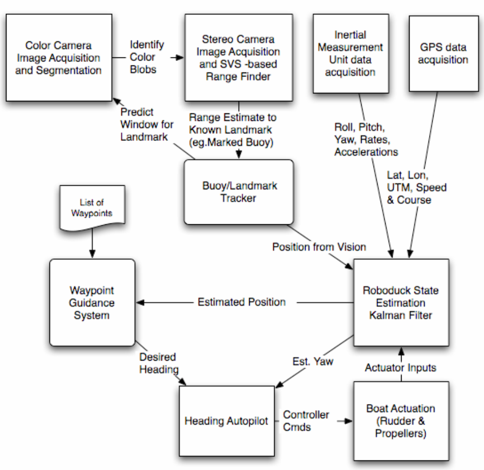
Above: Left and Right Views from Stereo Camera

Can it even *work*?

- Visual Odometry on the Mars Exploration Rovers used Stereo feature tracking quite successfully.
- Previous work [1] indicates long range stereo can work in Marine Environments.
- Improvements in cameras and efficient computation will make real-time implementation possible.

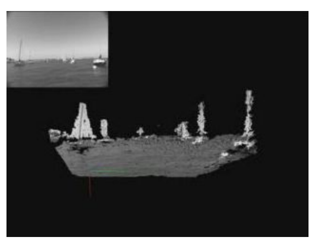
Preliminary Design and Initial Results

System Block Diagram

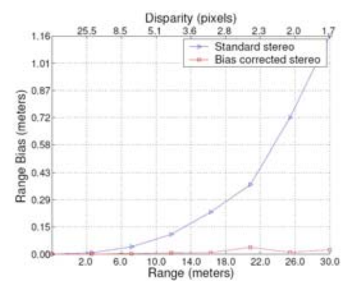


Methodology

- Segment buoy using color blob and edge-detection.
- Use this information to identify buoy in stereo images.
- Compute average distance to buoy.
- Use heading information and global location to compute global estimate for boat position.
- Use a statistical filter to deal robustly with errors in estimating stereo distances.

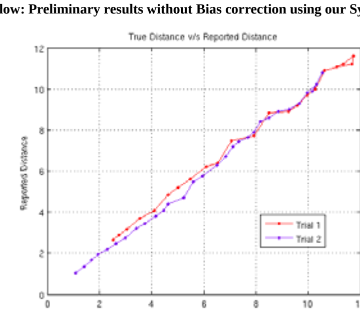


Above: 3D-reconstruction of Long range stereo. [1]



Above: Comparison of Standard stereo & Bias corrected stereo. [1]

Below: Preliminary results without Bias correction using our System.



Challenges

- Light intensity variations result in large, possibly non-linear swings in image intensities. This adversely affects stereo estimates.
- Lower light exposure and boat movements result in motion blur which also hampers good stereo feature matching.
- Error in depth estimates goes up as a square of the range. Here 'r' is range, b is the baseline, f is the focal length and d is the pixel disparity.

$$\Delta r = \left(\frac{r^2}{bf}\right)\Delta d$$

Ongoing and Future Work

- Stereo bias removal and configurations with larger stereo base-lines, Higher resolutions are being explored.
- A Kalman filter to estimate boat state and a particle filter for landmark tracking is planned.
- Stereo vision produces range maps which are useful for obstacle avoidance. This will be implemented to give navigation and actuator outputs.
- A docking system for a robotic boat using stereo vision for positioning and alignment.

[1] Gabe Sibley, Larry Matthies, and Gaurav S. Sukhatme, "Bias Reduction and Filter Convergence for Long Range Stereo," In *12th International Symposium of Robotics Research*, 2005.