Dense and Accurate Omnidirectional Stereo

Using Graph Cuts and Sub-pixel Estimation

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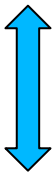
Shintaro Ono and Katsushi Ikeuchi

Obtaining 3D information of surrounding environment is required for mobile robot navigation, augmented reality, etc. Stereo vision is one of the most popular method used to obtain 3D information, and the omnidirectional camera provides great advantage due to its wide field of view. However, acquired image resolution is not sufficient enough.

In this research, we propose a method to increase accuracy of the omnidirectional stereo vision. In our method, first the graph cut algorithm is applied in order to obtain dense disparities. Then, sub-pixel level disparity is estimated to obtain more accurate range information. We compare the result to the ranges obtained by laser scanner. There are some range with large error in texture-less area, however the average difference is 26.56cm. This proves the efficiency of the proposed method.

Publication

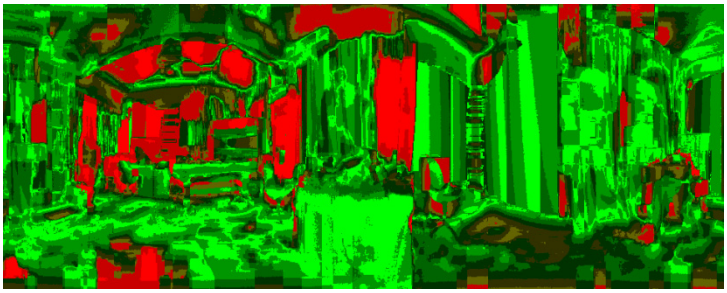
[1] R. Fukasawa, H. Koyasu, H. Maekawa, H. Kawasaki, S. Ono, K. Ikeuchi, "Dense and Accurate Omnidirectional Stereo Using Graph Cuts and Sub-pixel Estimation", The 27th Annual Conference of the Robotics Society of Japan, 3R2-05, 2009.



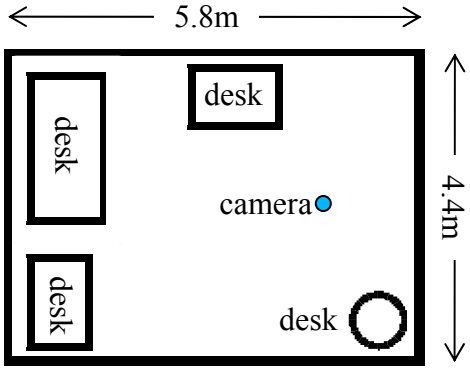
Perpendicular movement to obtain panoramic stereo image pair

An omnidirectional camera

Input panoramic image

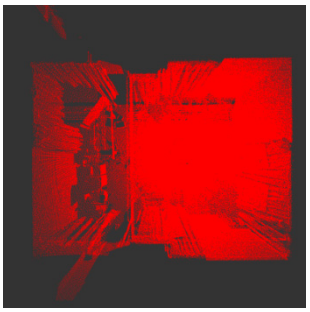


Comparison results: Colored pixels represent results between the proposed method and the laser measurements. Red in case the distance is larger than 50cm and green when the distance is smaller than 30cm



Environment of the experiment

3D model obtained by proposed method



3D model obtained by laser range scanner

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3D Localization and Reconstruction Technique

for Mobile Robot using Omnidirectional Stereo

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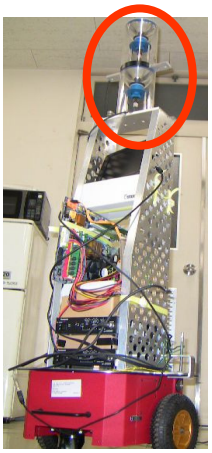
Simultaneous Localization and Reconstruction of working environments is one of the important problems in mobile robotics. For the problem, we use an omnidirectional stereo system. Although omnidirectional stereo system has a great advantage to acquire 3D-information of surrounding environment at a time, the resolution of the image is not sufficient for accurate depth information. This cause another problem to integrate each data during navigation into a total reconstruction.

In the method we have previously presented, the accuracy of each 3D-information by the stereo is improved by a sub-pixel estimation of disparities. Its wide field of view and accurate range data give us stable and accurate localization and reconstruction results. After applying noise reduction based on isolate points to the disparity image, these 3D-information during navigation are aligned by Iterative Closest Point (ICP). Finally, the estimated error of the ICP is corrected by Kalman Smoothing when the robot detects closed loop.

We implement this method to a mobile robot.

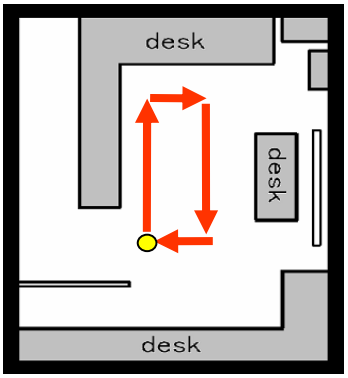
Publication

[1] H. Koyasu, Y. Furuya, R. Fukasawa, H. Kawasaki, H. Maekawa, S. Ono, K. Ikeuchi, "3D Reconstruction Using Omnidirectional Stereo with Sub-pixel Estimation", Meeting on Image Recognition and Understanding 2009, IS3-29, 2009.

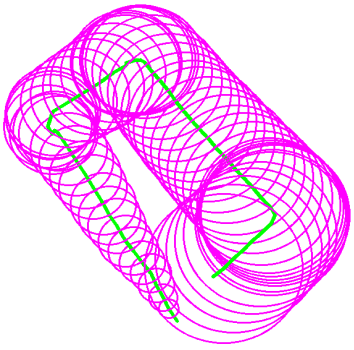


Omnidirectional camera on mobile robot

Omnidirectional stereo system

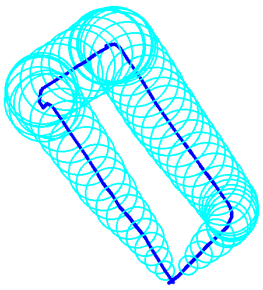


An environment for the experiment



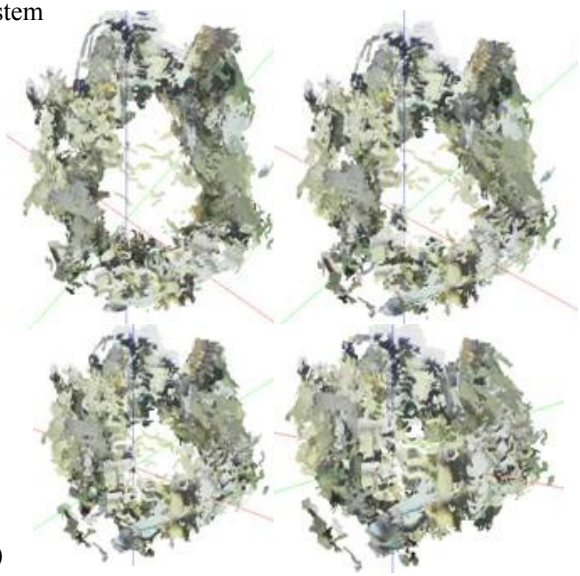
Estimated trajectory using Kalman Filter

(circle : probability ellipse)



Estimated trajectory using Kalman Smoothing

(circle : probability ellipse)



Reconstruction results

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