Mobile Robot vision navigation and obstacle avoidance based on gist and saliency algorithms

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Introduction

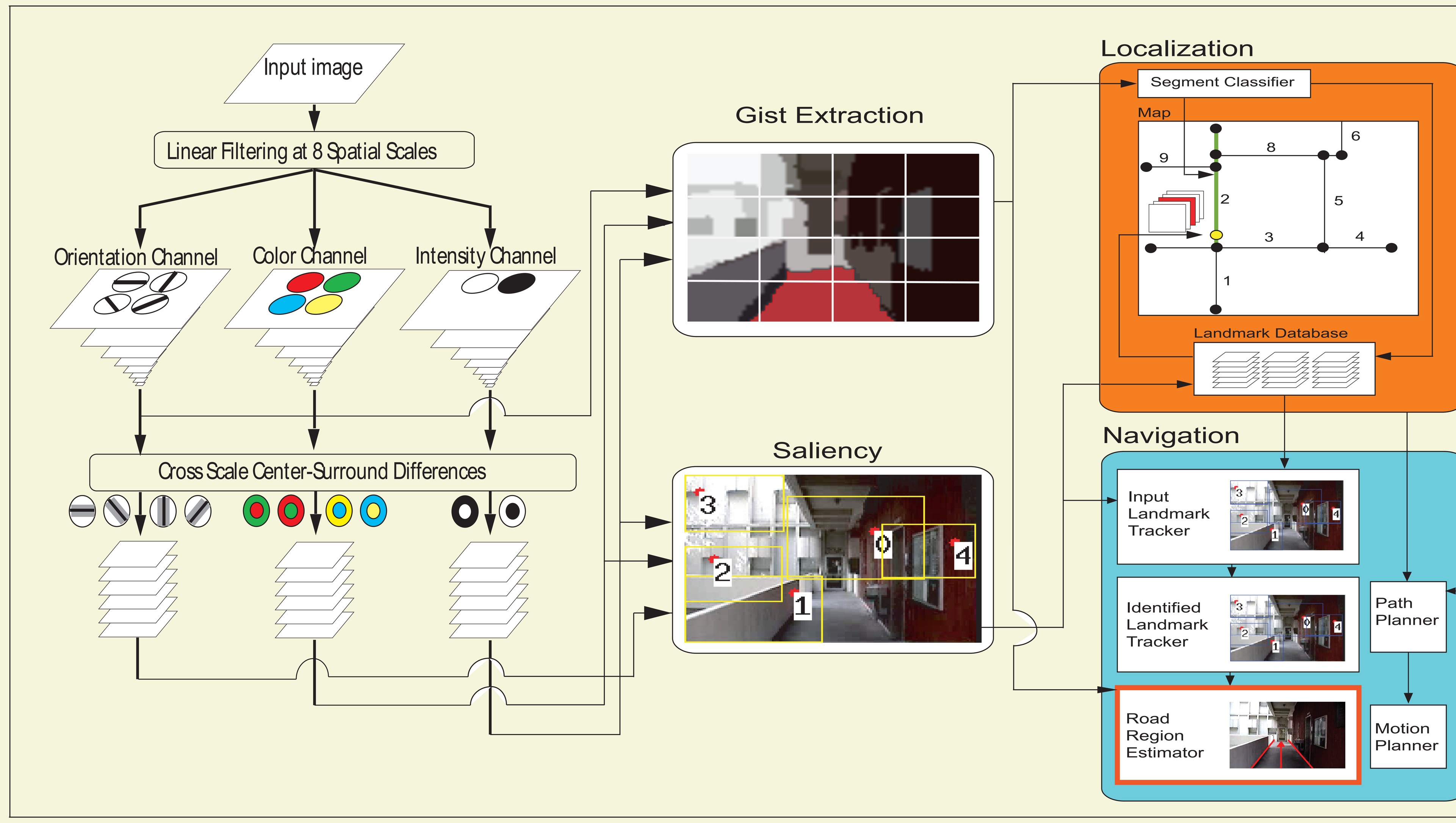
Vision is primary perceptual modality for people to navigate in the environment. Road finding / following is fundamental problem in navigation. We present a model to recognize the road utiliting visual features called the "gist" of the scene [1]. We compare our system performence against human-annotated ground truth of the segmented road region.

Our presented model extends our previous biologically-inspired mobile robot vision navigation and localization system[3,4], tested on the Beobot 2.0 mobile robot platform [2].

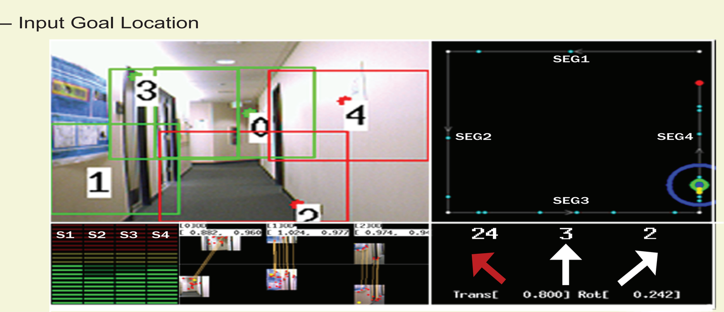
Beobot 2.0 Overview

Beobot 2.0 carries a high performance computing cluster of 16 processor cores, 2.2GHz each. The robot is equipped with various sensors such as camera, Laser Range Finder, sonar suite, IMU, compass, and GPS.

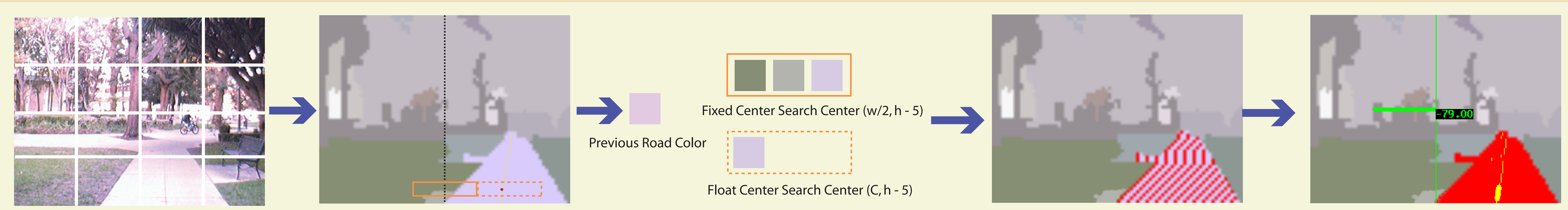
Visual Navigation & Localization System Overview



Our biologically-inspired system models two extensively studied human visual capabilities: (1) extracting the "gist" of a scene (a holistic statistical signature of the image, yielding abstract scene classification and layout) to produce a coarse localization hypothesis, and (2) refining it by locating salient regions in the scene to triangulate the current position of the robot.



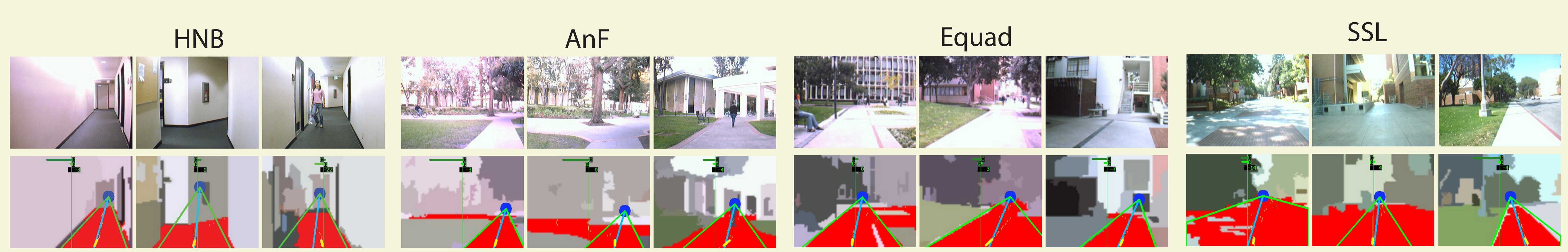
Road Region Estimator



Input image | Color segmentation | Road region selection | Road region extraction | Path determination

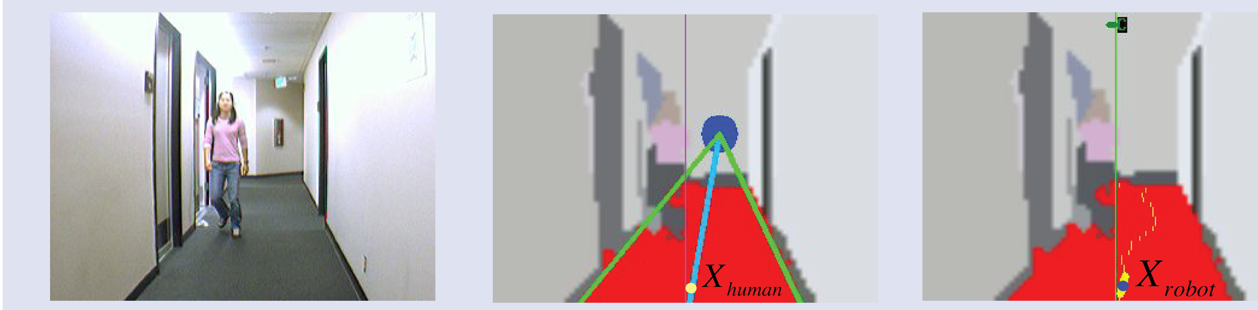
The algorithm downsizes the input image by a factor of 4 before performing a color segmentation [5]. It then examines which large regions directly in front of the robot is similar in appearance to the prior road region. Using this estimation, it then estimates the next direction to drive.

Indoor and Outdoor Environment



We selected various indoor and outdoor to test the system's robustness against lighting, road appearance and size, as well as obstacles in a form of walking pedestrians.

Human and Robot Model Comparison



Input Image | Human-annotated ground truth | Robot estimate position

$$Average\ Error = Average(|X_{humam} - X_{robot}|)$$

$$LRT = Average\left(\frac{W_{road} - W_{robot}}{2}\right)$$

$$PR = 1 - \left(\frac{AE}{LRT}\right)$$

$$FR = \frac{\#(|X_{human} - X_{robot}| > LRT)}{N}$$

Testing & Results

	HNB	AnF	Equad	SSL
Traversal Length	36.67m	105.75m	138.27m	326.00m
Total Frame Number (N)	3919	7217	5371	8569
Road Width (*Wroad*)	1.5m	2.12m	3.1m	4.47m
Lateral Road Tolerance(LRT)	47.5cm	106.25cm	155cm	223.47cm
Average Error(AE)	3.74cm	11.13cm	25.68cm	34.34cm
Performance Rate (PR)	92.13%	89.52%	83.43%	84.63%
Failure Rate (FR)	0.28%	0.79%	2.41%	2.05%

Discussions & Conclusions

We have implemented a model of road following using holistic visual features called the gist features. The algorithm efficiently estimate the shape of the road in the presence of shadows as well as obstacles, and was able to robustly keep the robot close to the center of the road allowing it to safely navigate in its environment. Furthermore we also report that the its ability in estimating the direction of motion close to human performance.

Reference

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[5] P. Felzenszwalb, D. Huttenlocher, Efficient graph-based image segmentation, International Journal of Computer Vision, 59(2):167–181, 2004.

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