Robot Localisation Using Natural Landmarks

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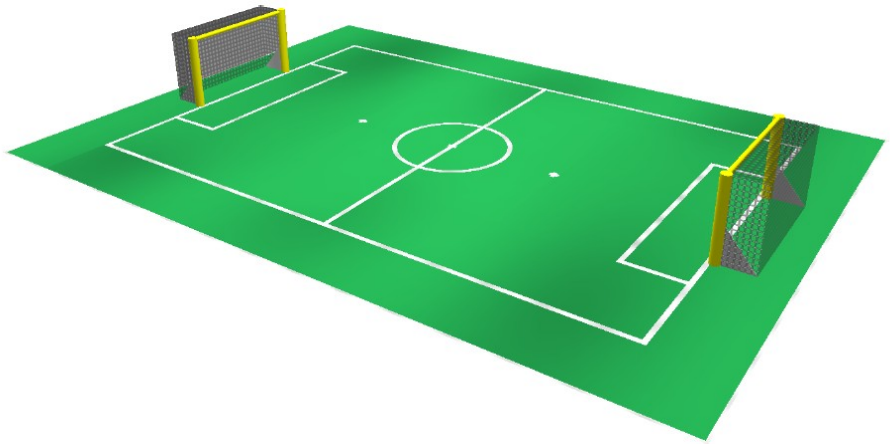
Motivation



- In the 2012 SPL competition, all goal posts are now yellow
- Kidnapped robots need to resolve this field-end ambiguity
- Natural landmarks around the field can be used for localisation

Background

- SIFT [1] and SURF [2] are effective feature detection and extraction techniques
- Both methods are too slow for use on resource constrained mobile robots in real time
- This paper contributes a fast 1 dimensional variant of the SURF algorithm (1D SURF) suitable for mobile robot navigation
- [3] implemented a 1D variant of SIFT on a robot with an omnidirectional camera. We use SURF and a standard camera

[1] D.G. Lowe. Distinctive image features from scale-invariant keypoints. International journal of computer vision, 60(2):91-110, 2004.

[2] H. Bay, T. Tuytelaars, and L. Van Gool. Surf: Speeded up robust features. Computer Vision-ECCV 2006, pages 404-417, 2006.

[3] A.J. Briggs, C. Detweiler, Y. Li, P.C. Mullen, and D. Scharstein. Matching scale-space features in 1d panoramas. Computer vision and image understanding, 103(3):184-195, 2006.

1D SURF Feature Detection

- Exploits the robots planar movement
- Sub-samples the horizon band to extract a single row of grey pixels
- Searches for features at various scales in the 1D image

1D SURF Feature Extraction

- Discards the orientation assignment and 3D quadratic curve fitting steps used in SURF
- Uses 3 subregions instead of 4 when calculating the feature descriptor
- Reduces the SURF 64 dimension feature descriptor to 6 dimensions

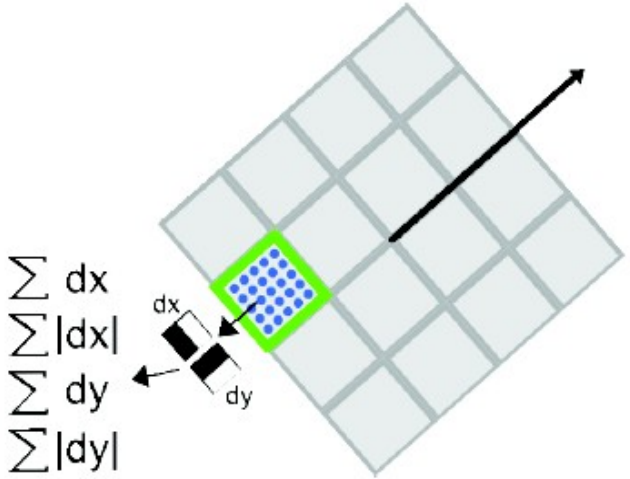
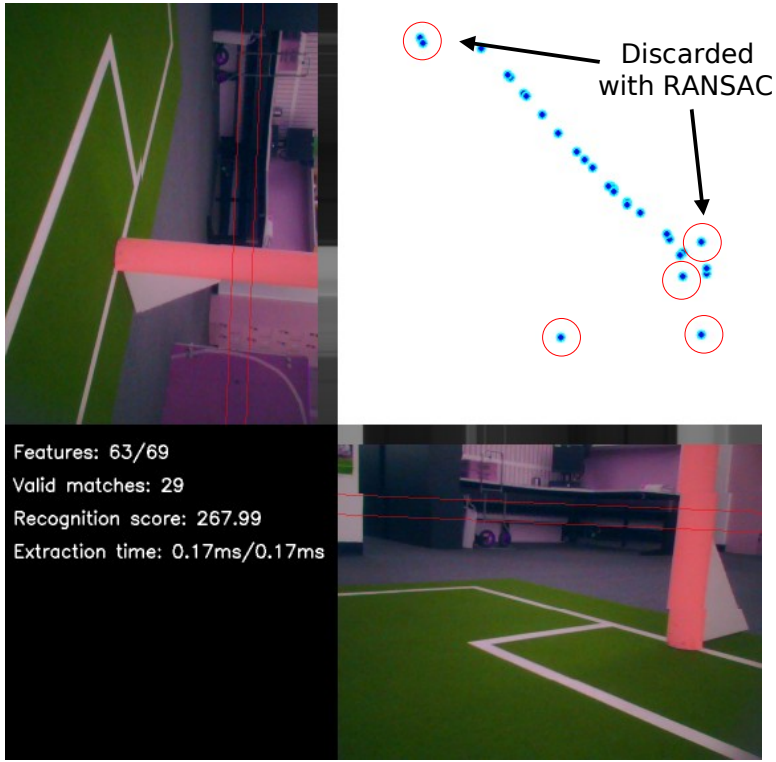


Image source: C. Evans. Notes on the OpenSURF Library. 2009.

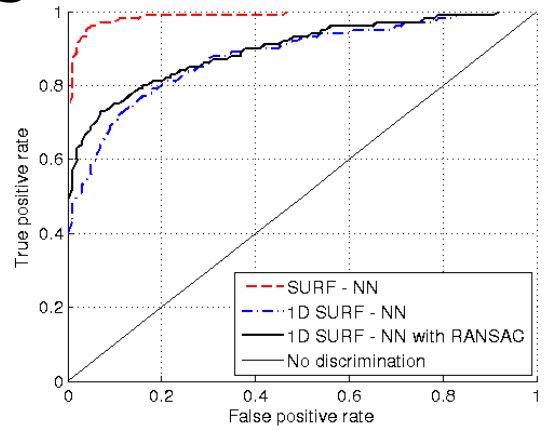
Classification Experiment

- An 'easy' test to compare 1D SURF to SURF
- No change in scale or viewing angle
- Capture 88 images at 4 degree increments from a single location
- Classify image pairs as matched (overlapping) or unmatched (non-overlapping)



Classification Results

- Run time evaluated on a 2.4GHz laptop
- 1D SURF clearly less robust than SURF (using OpenSURF), but more than 1000 times faster



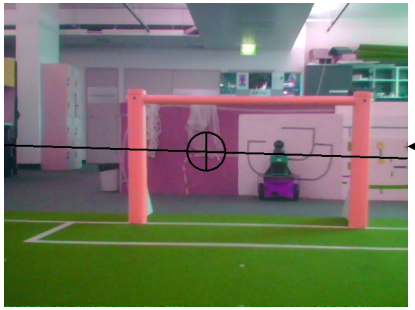
Feature extraction technique	Feature matching technique	Mean no. features	Mean extraction time (ms)	Mean matching time (ms)	Area under ROC curve
SURF	NN	429	222.3	19.1	98.8%
1D SURF	NN	59.2	0.158	0.069	88.0%
1D SURF	NN + RANSAC	59.2	0.158	0.076	89.6%

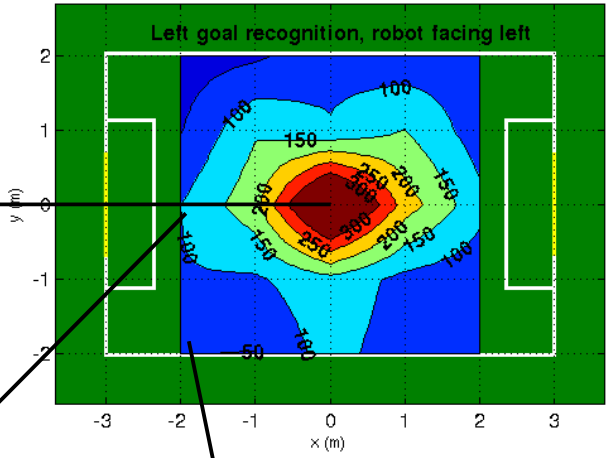
Recognition Experiment

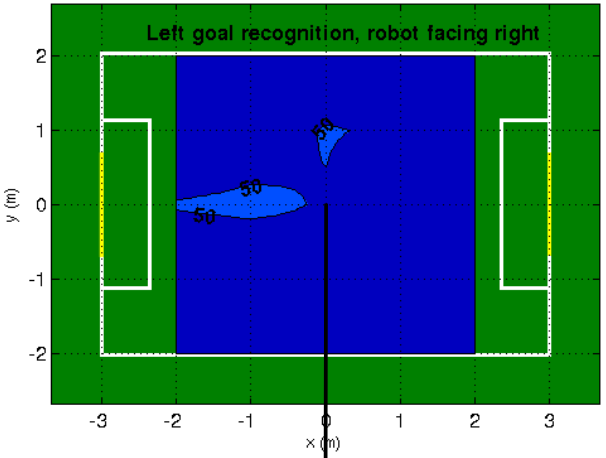
- Capture a single image of each goal area from the centre of the SPL field in our lab
- Check for recognition over a 4m x 4m field area (including scale and viewing angle changes)
- Scene changes are not tested in this experiment
- Mean feature extraction time:
  - Nao V3.2 12ms
  - Nao V4 2ms

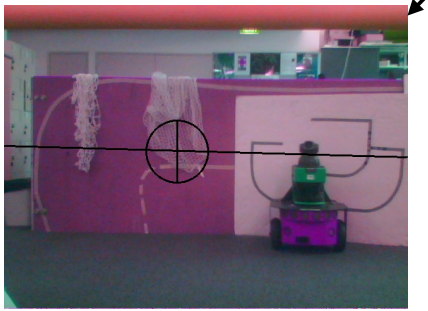
Recognition Results (Left Goal)

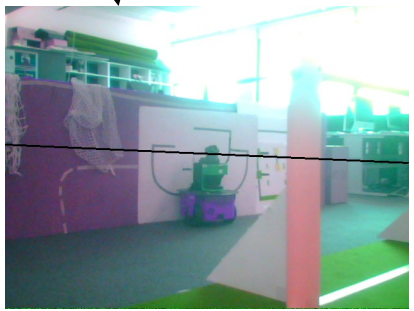
Stored image

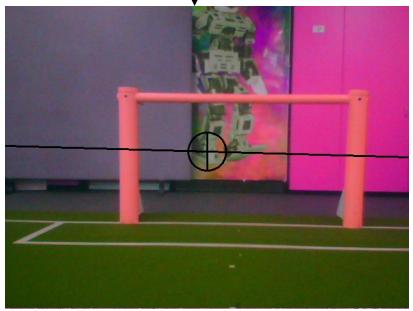




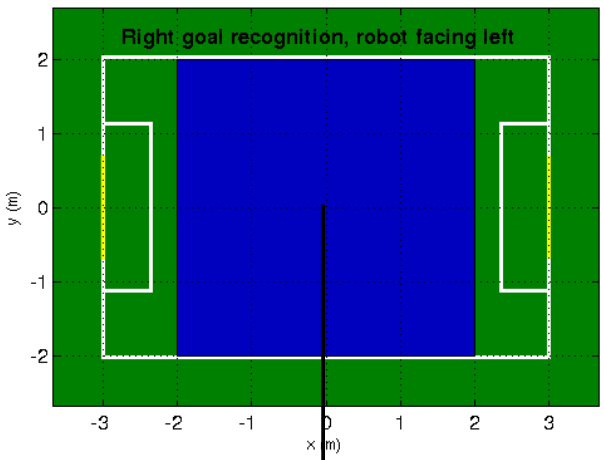


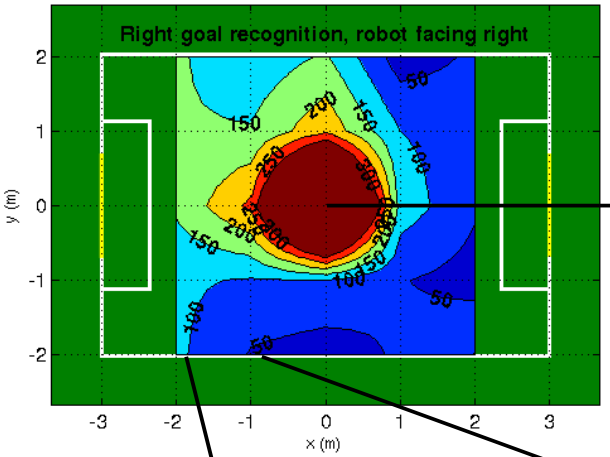




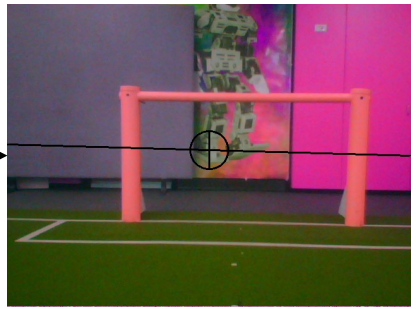


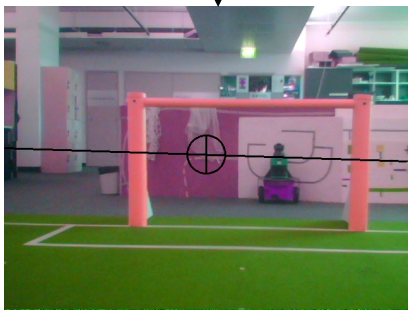
Recognition Results (Right Goal)





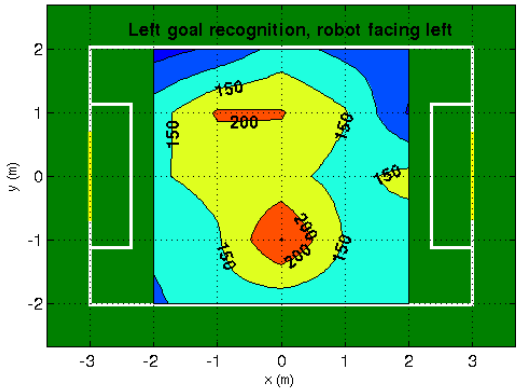
Stored image

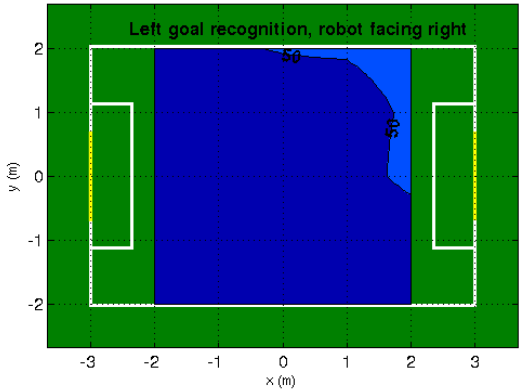


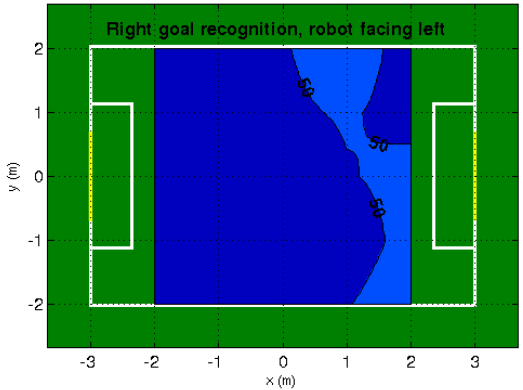


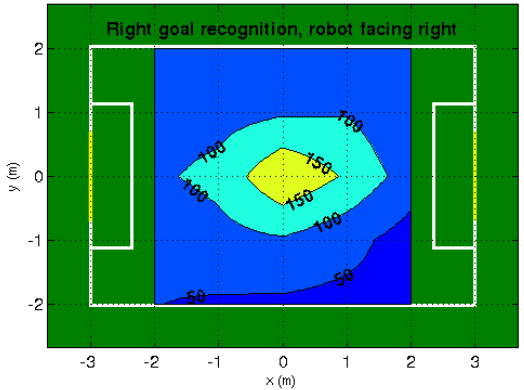
Recognition Results (Scene Changes)

- Overhead lighting turned off and goal posts removed



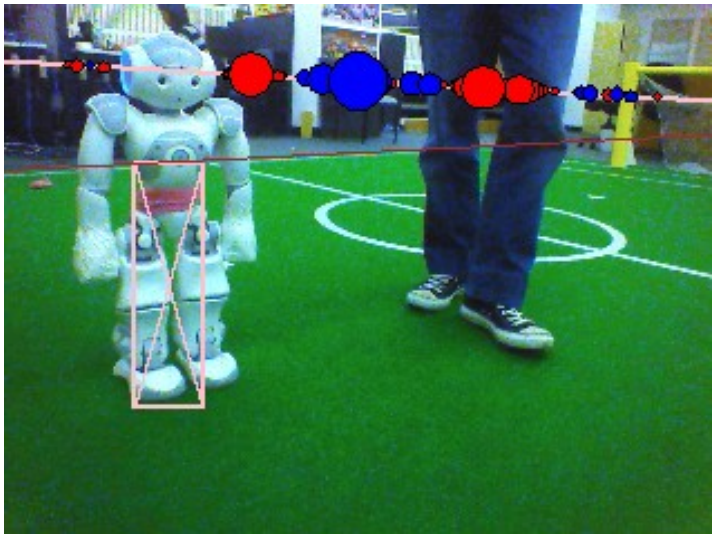


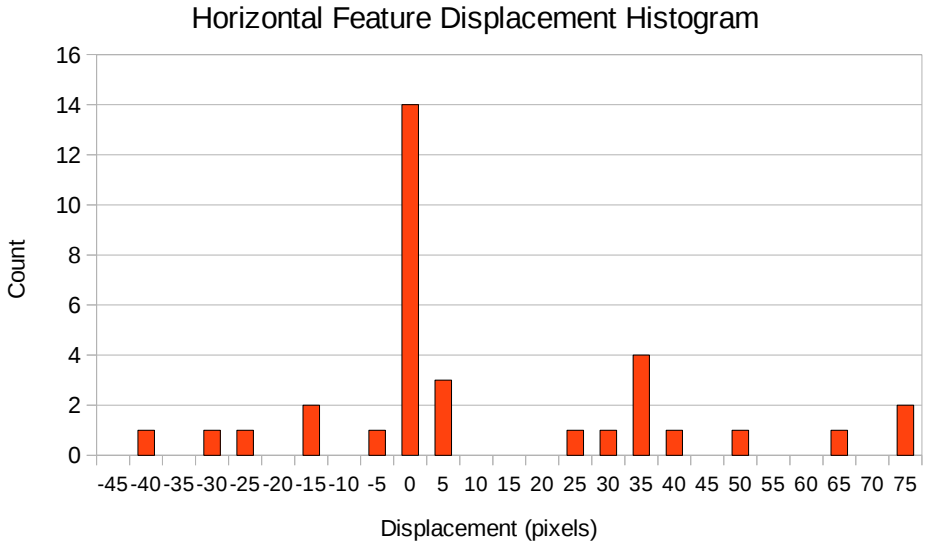




Feature Verification and Visual Odometry

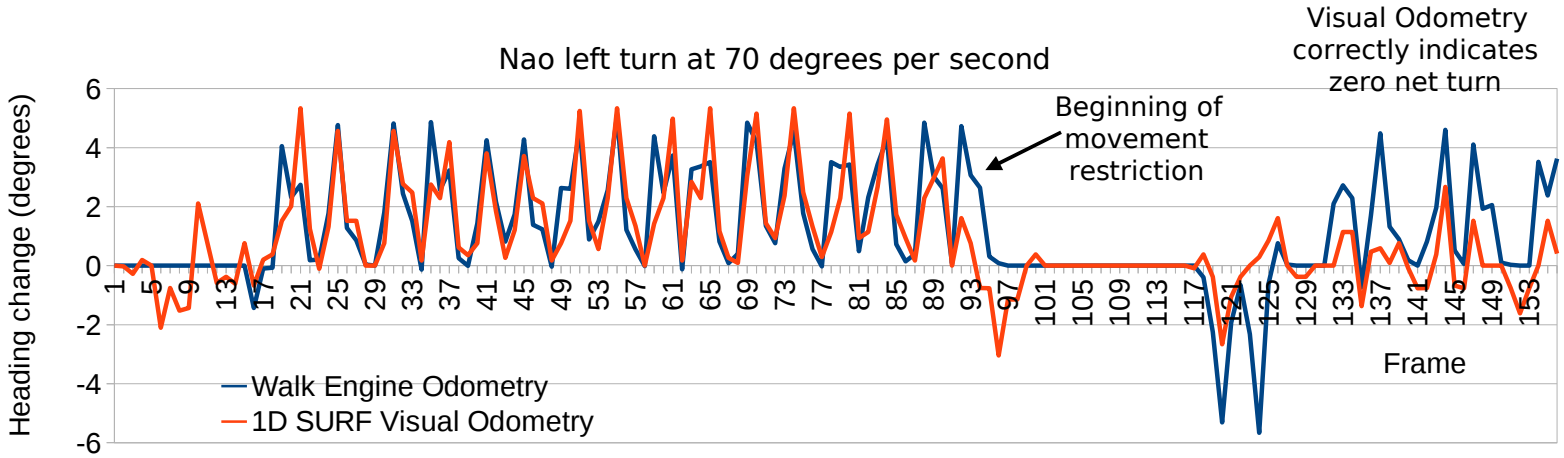
- Match features in each frame to the previous frame
- Remove features in detected robots and secondary modes





Visual Odometry

- Bipedal robots slip and get pushed while playing soccer
- Measure heading changes by matching 1D SURF features in subsequent frames, improving localisation and behaviour



Conclusion

- 1D SURF is an optimised method for extracting local features from 1D images of a mobile robot's horizon
- The extracted features are robust to small changes in lighting, scale, viewing angle, and scene composition
- Features can be used for navigation (e.g. resolving the SPL field-end ambiguity), and for accurately measuring heading odometry on robots that slip

Future Work

- Investigate feature matching methods that can scale to larger numbers of stored images
- Consider methods for updating stored images as natural landmarks change (simultaneous localisation and mapping)

Thank you

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Never Stand Still