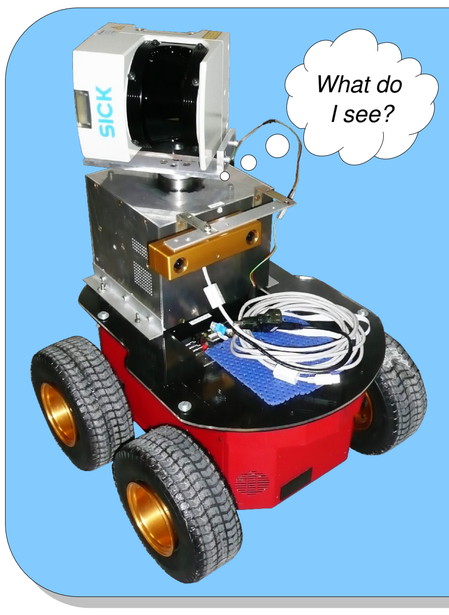
Boosting with a Joint Feature Pool from Different Sensors

Dominik A. Klein, Dirk Schulz, and Simone Frintrop

1 Motivation



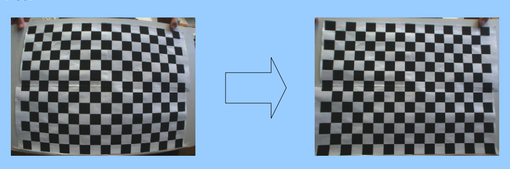
Task: Detect various types of objects near you, e.g. power sockets, cars or people. Use all your available sensors to improve detection.

Problem: How to combine different sensors strengths in a generic way, so that they efficiently complement one another.

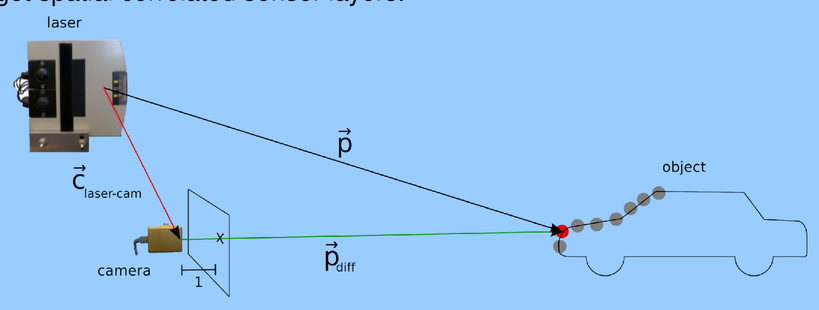
Solution: Use boosting to combine best weak-classifiers built from a joint feature pool from all sensors to a strong classifier cascade.

2 Sensor Fusion

Sensors are a rotating SICK LMS 291 lidar and a color vision camera. We correct barrel distortion of the camera.

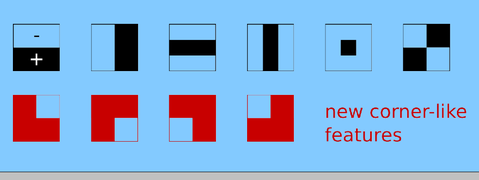


Than we project 3D points measured by lidar onto the image plane of the camera. This way we get spatial correlated sensor layers.



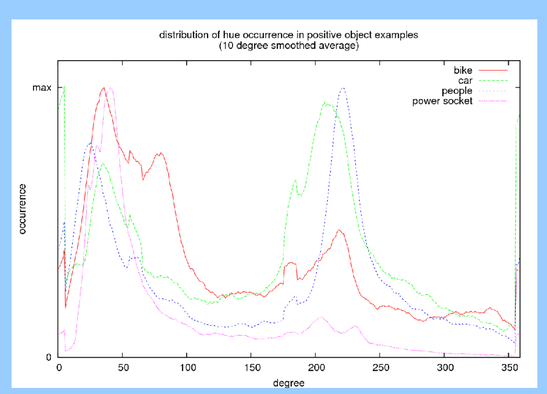
3 AdaBoost with Haar-like Features

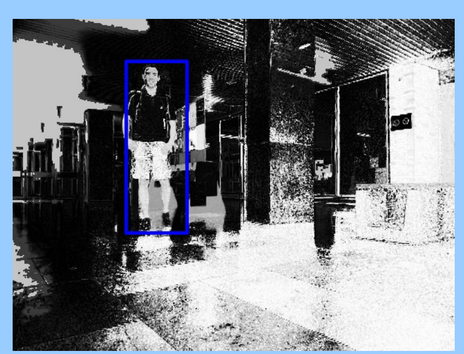
AdaBoost forms a superior strong classifier as a weighted sum of best performing weak classifiers out of a huge pool of candidates.
Weak classifiers are calculated from Haar-like Features. In general, they consist of a positive and a negative area, whose values add to a common sum. We introduce new corner-like features.



4 Color Features from Hue-Distance

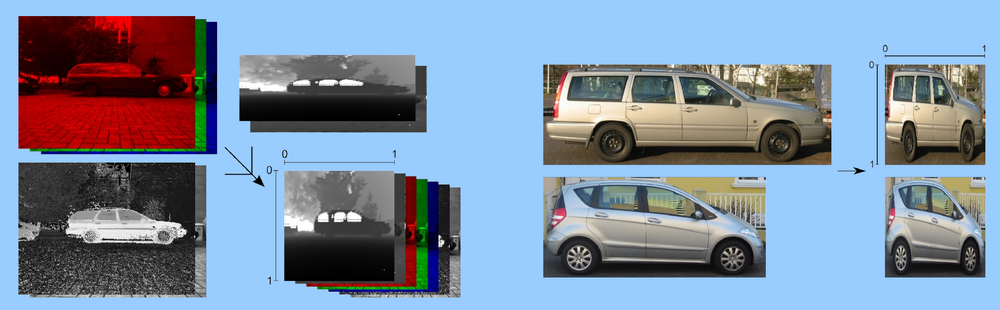
We use hue-angles from HSV color-space for Haar-like features that are able to capture pure color differences. To achieve a totally ordered set for calculation of weak classifiers, we use object category dependent distances to the most occurring hue-angle in positive training examples.



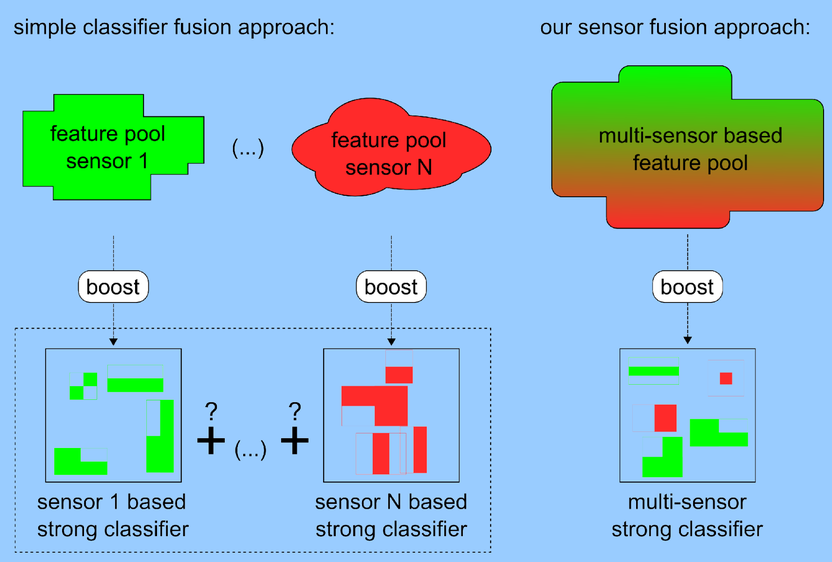


hue-distance sensor layer for people

5 Joint Feature Pool



We map sensor layer coordinate systems into unit square to deal with object windows in different physical sensor resolutions. Also we map object window coordinate systems to unit square to deal with differently stretched object instances.
A Haar-like features position and size is well defined in unit square coordinates for all sensor layers. Thus, we build a feature pool with same Haar-like features for every sensor layer.



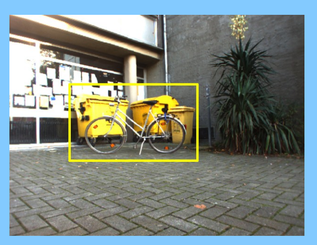
This way its up to AdaBoost to combine weak classifiers from different sensors into a multi-sensor strong classifier.

Advantages:

- AdaBoost guarantees choice of best weak classifiers, so sensors optimally complement one another
- strong classifiers boosted with a multi-sensor super-set of candidate features have at most same size than those boosted with a single-sensor feature pool => they are at least N times faster to evaluate.
- no special heuristic for combination of classifiers from different sensors needed

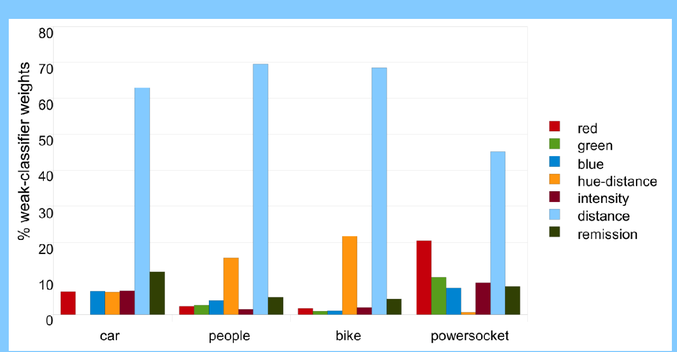
6 Experimental Results

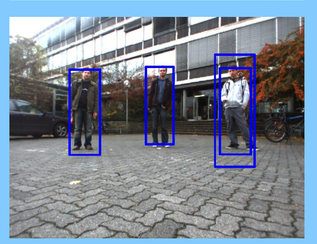
In experiments our approach outperformed results from single sensor based classifiers as well as results from a simple fusion of separately trained classifiers.
Moreover, we have shown that corner-like features and hue-distance layer are reasonable extensions.

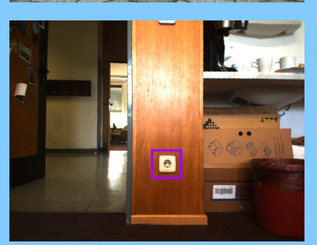


Size of training and test sets (num. pos. expl. / num. images)				
	car	people	bike	p.sock.
training	115/191	115/173	95/180	66/137
test	34/35	49/30	31/29	27/36

Results from classifiers trained with joint feature pool				
	car	people	bike	p.sock.
recall	1	0.98	0.94	1
precision	1	1	0.78	0.75
F-measure	1	0.99	0.85	0.86







universität bonn

Contact:
Dominik Alexander Klein
Dept. of Computer Science III
University of Bonn, Germany
kleind@iai.uni-bonn.de