Localization without camera calibration

Thomas Reinhardt Rico Tilgner Daniel Borkmann
Tobias Kalbitz Stefan Seering Robert Fritzsche
Sandra Unger Christoph Vitz Manuel Bellersen
Hannah Müller Samuel Eckermann Martin Engel

Nao-Team HTWK / naohtwk@gmail.com
Faculty of Computer Science, Mathematics and Natural Sciences
Leipzig University of Applied Science

June 12, 2011

In last year's Open Challenge, we presented an image processing algorithm that copes with changing light conditions. The algorithm is able to provide robust segmentation results without prior calibration, even in challenging light situations.

However, to prepare a Nao robot for the game, there is still the necessity to calibrate the camera matrix, which is used for the projection of the recognized field lines.
This calibration is very time consuming and may even need to be re-done after the robot has fallen, as the cameras can move slightly inside the head on impact on the ground. Also, it is difficult to align the sensor data (body and head angles) with the camera image in situations of fast movement, which also produces considerable errors in some situations.
Both phenomena lead to wrongly projected line segments with estimated distances ranging from less than half to more than double the real value.

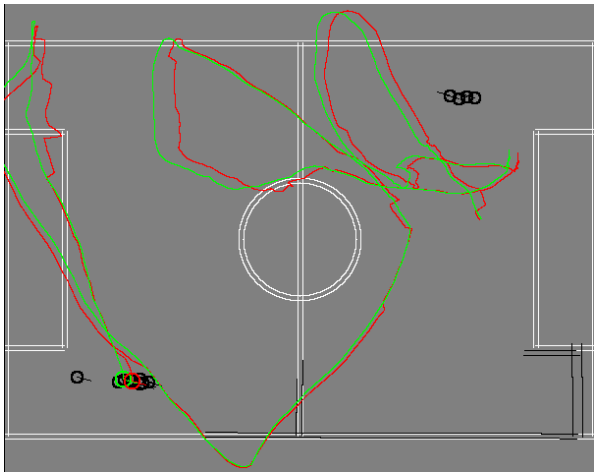

Figure 1: Comparison of actual (green) and estimated (red) trajectories as well as current projection and position hypotheses (black)

In this years Open Challenge we present a novel localization method, which calculates the camera's inclination with the help of the recognized line segements of a given picture. Hence, we do not need any knowledge about the joint or camera positions of the robot. Using just the information contained in a single camera image, our method is able to produce a reliable estimation of the camera matrix.
To accomplish a good estimation, we incorporate the features contained within the field lines hemselves:

- all field lines are straight and either parallel or orthogonal to each other
- all field lines have a width of 5 cm

To then generate a position estimation, we use a combinatoric approach combined with odometry.

The resulting method can estimate a position based on the segmented lines of a 640x480 image within 7 ms on the Nao. The estimated positions are mostly within 12 cm of the actual position of the robot.

With this method, we are able to eliminate the most common sources of error in localization methods:

- inaccurate joint angles (e.g. pitch/yaw of the head)
- inaccurate angles of the camera (e.g. pitch/yaw/roll of the camera)
- fast movements (e.g. time shift in image and sensor data)