Using the Field Edge as a Localization Landmark in the Robot Soccer

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Introduction

In this project the focus is on the RoboCup SPL robot soccer software developed for the NAO robots. Current system utilizes the goal posts and the center circle as the main landmarks for the localization module. The problem occurs when those landmarks are not seen or detected by a robot. The aim of this project is to introduce the field edge as a potential new additional landmark for the localization of the robot on the field and answer the question "Can the field edge be efficiently used as a localization landmark?"

Calculating the distance to the Field Edge

First of all, field edge has to be detected in the camera frame. Secondly, detected edge has to be translated to the robot relative (RR) coordinate system, so that the distance to it can be calculated.

In this part of the project by analyzing the algorithms and conducting some experiments we answer the following questions: how fast can the edge be detected and how accurately can we calculate the distance to it.

Field Edge detection.
The camera frames are scanned column by column from the top until the point of significant patch of green is found and saved. As a result for each column we have a point of a potential field edge. In order to combine all the points in to one line equation, the RANSAC algorithm is applied to the points. As a result, the line is fit to the data points in such a way that the number of points close to the line is maximized. This way the outliers, caused by noise and objects on the field, do not introduce big error to the line equation.

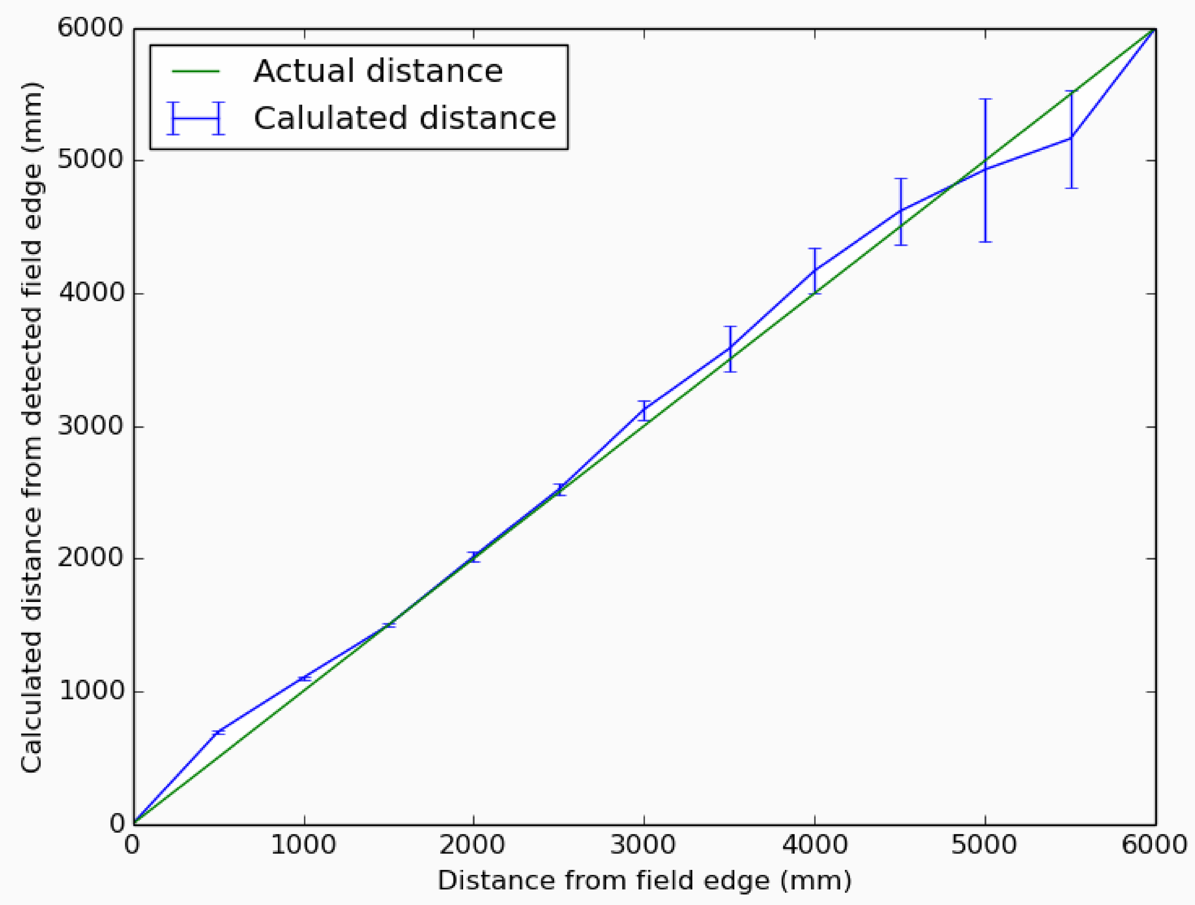
In this project an optimisation of the current field edge detection algorithm is proposed and studied. Namely, we propose to decrease the amount of sample points which are passed to the RANSAC algorithm in order to speed it up. However, this modification may have a negative effect on the field edge detection ratio (edge not detected) and accuracy (edge detected wrongly). In order to find out how much faster the optimised field edge algorithm will work and what will be the effect on detection ratio and accuracy, several experiments were conducted. The robot have been put on the centre of the filed where it was looking at the field edge. Common noise was introduced to the scene observed by robot, namely, goal, a robot and a ball. The variable controlling the number of scanned columns was changed in different experiments. Average time elapsed during the field edge detection and the number of correctly detected edges in 3 minutes were calculated. The result of the experiments can be seen at the right top figure.

Distance calculation. In order to calculate the distance to the field edge line obtained in the previous step needs to be converted from the camera coordinates to the RR coordinate system. The transformation matrix for this conversion is put together taking into account robot's height and the current pose (joint values), calibration values for camera offsets. As a result, we obtain the line of form $t_1x + t_2y + t_3 = 0$ which represents a line on the ground plane in RR coordinate system. To calculate the distance from robot to the field edge line, we use the following formula $d = |t_3|/\sqrt{t_1^2 + t_2^2}$. Several experiments have been conducted in order to evaluate how accurate is the value of the calculated distance. The result of experiments is shown at right bottom figure. The calculated distance from detected field edge is average value over 124 trials.

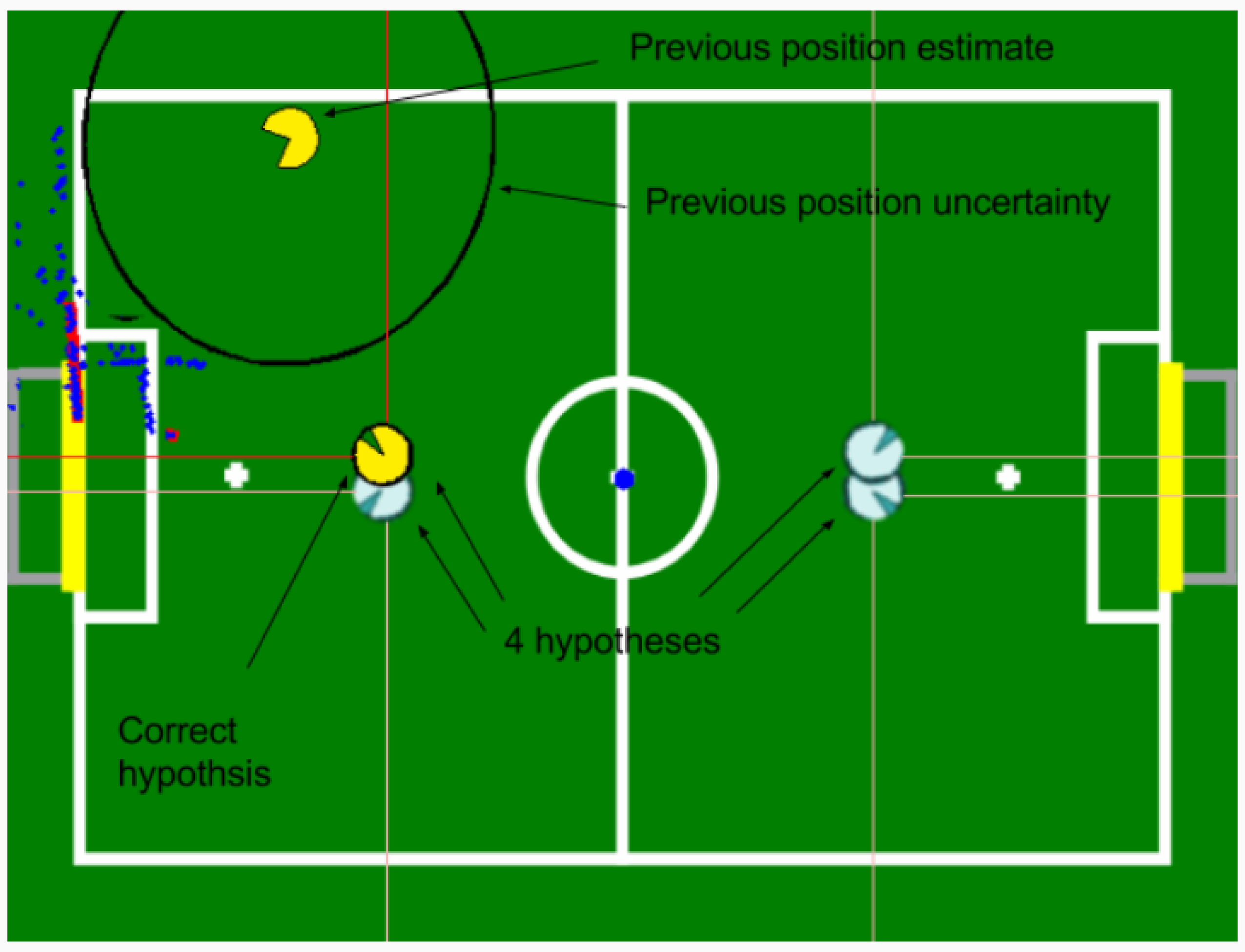
How fast can the algorithm be

# scanned columns	Correctly detected	Time elapsed (μs)
every column	23,82 edges/sec	7679,34
every other column	27,72 edges/sec	6545.44
every 3rd column	25,94 edges/sec	6265.93
every 4th column	**29,70 edges/sec**	**5924.41**
every 5th column	20,44 edges/sec	5730.16
every 10th column	15,16 edges/sec	5262.29

How accurate is the distance calculation



Position estimation example



Position estimation

Algorithm 1 Field Edge based localization of the robot on the Soccer Field

if 2 edges detected **and** localization.position_uncertainty > threshold **then**
  d$_1$← distance to edge 1;
  d$_2$← distance to edge 2;
  pos_hypotheses[4] ← $generate\_position\_hypotheses(d_1, d_2)$;
  prev_pos ← $localization.get\_previous\_position()$;
  prev_heading ← $localization.get\_previous\_heading()$;
  most_likely_hypothesis ← $get\_most\_likely\_hyp(pos\_hypotheses, prev\_pos, prev\_heading)$;
  localization.current_position ← most_likely_hypothesis;
  if d$_1$≤ 5000 **and** d$_2$≤ 5000 **then**
    localization.position_uncertainty ← 0;
  else
    ϵ ← uncertainty of field egde based position estimation;
    localization.position_uncertainty ← ϵ;
  end if
end if

Conclusion

As a result of this project work following conclusion can be made:

- The number of field edge points in detection algorithm can be reduced by factor of 4, which speeds up the algorithm by ≈ 2ms.
- The distance calculation to the detected field edge is quite accurate, but starts to decrease significantly when distance is greater than 5m.
- Field Edge can be efficiently used in localization in some situations, such as when 2 field edges are detected (<5m) and there is a previous position estimate.

Info

More information at **icv.ims.ut.ee/FELL-RS**   UT RoboCup Team Philosopher: **icv.ims.ut.ee/philosopher**   Contact: **anastasia.bolotnikova@ut.ee**