6D Localization for humanoid robotic soccer

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Abstract

Self-localization is one of the most basic skills needed to create an autonomous soccer team. As the learned behaviors become more complex and precise, the impact of the accuracy of the localization method becomes an inevitable subject. In the RoboCup 3D simulation league, there are several challenges that hinder the correct estimation of the robot's 6D pose. The visible elements of the field are 4 corner flags, 4 goal posts and 21 unidentified line segments. Self body parts and those of other robots are also visible, as well as the ball. The sources of uncertainty include a calibration error, a distance-dependent dynamic error, a rounding error introduced by the server, and the partial observability of the field at any given moment. Additional challenges include the field symmetry, multiple solutions, and the kidnapped robot problem, since the robot can be teleported.

The proposed solution attempts to extract the maximum information from all visible field elements to compute the 6D pose, using a map of the field, the known error distribution models and the last known position. First, we determine the z-axis transform through Singular-Value Decomposition, using all ground references (lines segments, corner flags, own feet when touching the ground). Secondly, we optimize the 6D pose estimate by iteratively maximizing its probability with gradient ascent.

Table 1 shows a comparison with the old localization method used by FCPortugal, while walking 30m across the field (youtu.be/cwb1YUGHXGA). The new 6D pose estimator has an average 3D translation error of just 6.3mm, a reduction of more than 97%. The estimate for the ball position can be used as a global metric to assess the accuracy of the position and orientation estimates. Other teams have developed and published solutions that combine visual information with odometry to estimate a 2D position and a heading angle. Therefore, it is not entirely fair to compare the results directly. However, our 2D position error is at least half of what was published by other teams [1–3].

Table 1. Comparison between the avg. error of previous and new localization methods

	Mean 2D Error ± SD (cm)	Mean 3D Error ± SD (cm)
Prev. Agent Position	3.90 ± 2.13	26.23 ± 32.69
New Agent Position	0.50 ± 0.34	0.63 ± 0.39
Prev. Ball Position [1]	5.20 ± 4.17	8.55 ± 5.56
New Ball position	2.84 ± 2.39	3.87 ± 2.90

References

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