The Orient 2007: Team Description Paper

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Abstract. The orient is a RoboCup MSL team organized by Toyo University, Japan. The name is literal translation of the name of the university. We have been participating in RoboCup competition since the first competition in Nagoya in 1997. We were one group in UTTORI United from 1997 to 2002, and we are now independent team as The Orient from 2003 using the legacy of UTTORI United. We are the first team who used omnidirectional mobile mechanism with omnidirectional vision. This paper describes current science and technology that is used in our team.

Keywords: autonomous robot, omnidirectional mobile mechanism, omnidirectional vision

1 Introduction

The Orient is a robot soccer team for the middle size league of RoboCup, and is organized by Robotics Laboratory, the Department of System Robotics, Toyo University, Japan. The Orient is the successor of UTTORI United who participated from RoboCup 1997 Nagoya to RoboCup 2002 Fukuoka. The Orient utilizes the legacy of UTTORI United, namely, omnidirectional mobile robots with omnidirectional vision sensor.

2 Hardware configurations

Current hardware was first developed for the RoboCup 2005 competition in Osaka, as the third generation model of our omnidirectional mobile mechanism, as shown in Fig. 1. We have developed six robot altogether, of which the hardware configuration is the same, and the software configuration is different depending on the role in the team (i.e. FW, DF, GK.). In RoboCup 2006, they have two different types of kicking mechanism, but we use the same kicking mechanism for this year.

As for the omnidirectional mobile mechanism, we use 4 motors for 4 wheels as shown in Fig. 2, which is different from the model (3 motors for 4 wheels) that we used in UTTORI United team. Previous mechanism was fine but the main reason for the change is to reduce the total weight and to move it faster. The layout of the motors, transmissions, camera, and motor driving electronics was designed by 3D-CAD (Autodesk Inventor) as shown in Fig. 3.

The use of omnidirectional vision sensor is unchanged, but currently we use digital model (IEEE1394) instead of analog model.

From RoboCup 2005, note PC (Windows) is adopted for the system controller. Note PC is small and lightweight, and the big benefit is that it has a battery inside, which does not be affected from the servo power down of motors. The connection with external devices is now by USB and IEEE1394, and the wiring is now much simple and reliable. Comparing with the previous model that used desktop PC (Linux), now we have reliable system and faster software development, at the sacrifice of real-time functionalities offered by Linux.

Fig. 1 Front view of our robot

Fig. 2 Omnidirectional Mobile mechanism

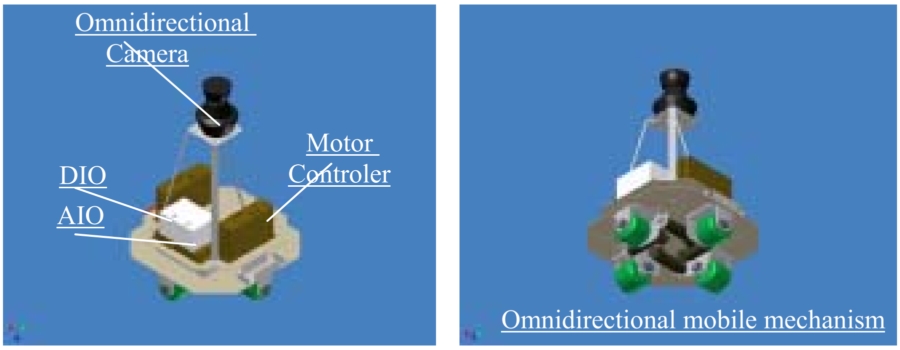

Fig. 3 Design by 3D-CAD

3 Localization Method

3.1 Main idea

Our localization algorithm is based on the simple geometry, using two landmarks. Currently we use two goals as the landmarks, and the distance and the direction to two goals is measured from the sensing data of omnidirectional camera. Our omnidirectional camera can cover almost all area of the field of middle size league until 2006, but we have to change the approach since the field size becomes twice as large as before and two goals cannot seen by our omnidirectional camera.

We explain the current algorithm below. First, the distances to two goals are measured as L_1 and L_2 respectively, and, directions between two landmarks is measured as θ, as shown in Fig. 4. Note that calculating distance from the omnidirectional vision data involves measurement error, and the reliability becomes lower if the distance is larger. And also, note that angle θ is more reliable than distance measured by omnidirectional vision sensor.

The centers of the goals A and B are measured as (X_a, Y_a), (X_b, Y_b) , respectively. If $L_1 < L_2$, circle M is drawn based on the distance L_1 which is more reliable than L_2. The robot is supposed to be on the circle. The equation of circle M that centers on point A and the radius L_1 is as follows.

$$(X - X_a)^2 + (Y - Y_a)^2 = L_1^2 \tag{1}$$

Next, circle N is drawn, that pass through point A, B and R, using angular difference θ of two goals. The radius Rc of circle N is defined as

$$R_c = \frac{X_b - X_a}{2\sin\theta} \tag{2}$$

Therefore, the equation of circle N is

$$(X - X_c)^2 + (Y - Y_c)^2 = R_c^2 \tag{3}$$

where the center of the circle N (X_c, Y_c) is

$$\begin{aligned} X_c &= \frac{X_b - X_a}{2} \\ Y_c &= Y_a - \sqrt{R_c^2 - X_c^2} \end{aligned} \tag{4}$$

The position of the robot is supposed to be the intersection of two circles. In fact, two intersections exist geometrically, one in the field, and the other out of the field. Then we choose the one in the field. From these calculations, the position of the robot is estimated.

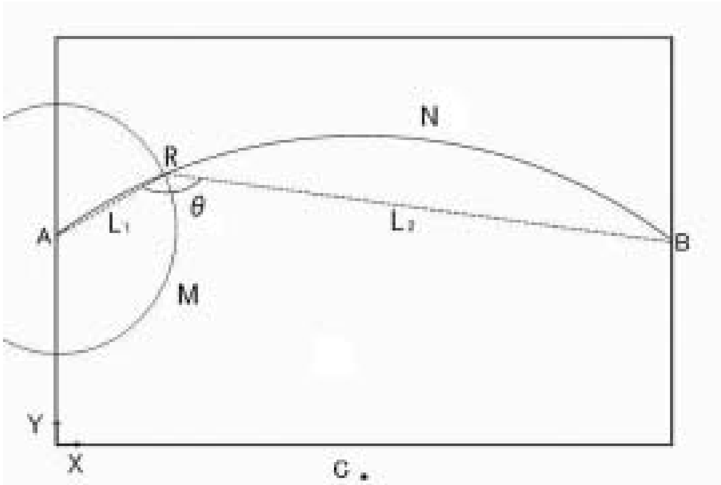

Fig. 4 Localization Method

3.2 Measurement results

The result of the measurement is as follows. By putting a robot for every 1m grid, we compared the calculated position with the known position for the evaluation of localization algorithm. The measurement error for X-axis is shown in Fig. 5, and error for Y-axis is shown in Fig. 6, where X-axis connects the both goals. Blue color means the value is bigger, and red means the value is smaller. The corner areas give relatively bad results because the opposite goal is enough far as to obtain fine distance measurement. It is an interesting result that Fig. 5 shows point symmetry, and Fig. 6 shows line symmetry. Line symmetry is understandable, but point symmetry is strange. The reason seems to be that there is a switching phenomenon in choosing nearer goal.

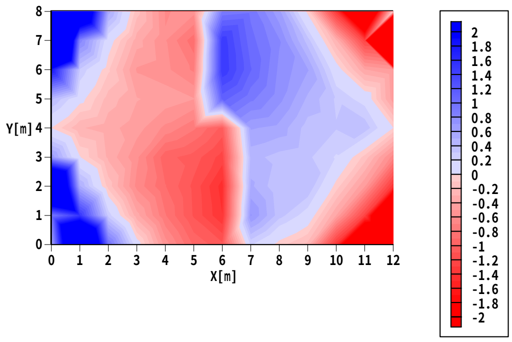

Fig. 5 Measurement Error of X-axis

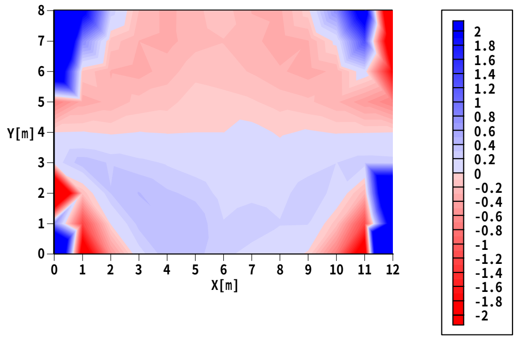

Fig. 6 Measurement Error of Y-axis

The result of localization was displayed in the following coach box, as shown in Fig. 7. And, the position that the robot recognized can be monitored, with some uncertainty of the results.

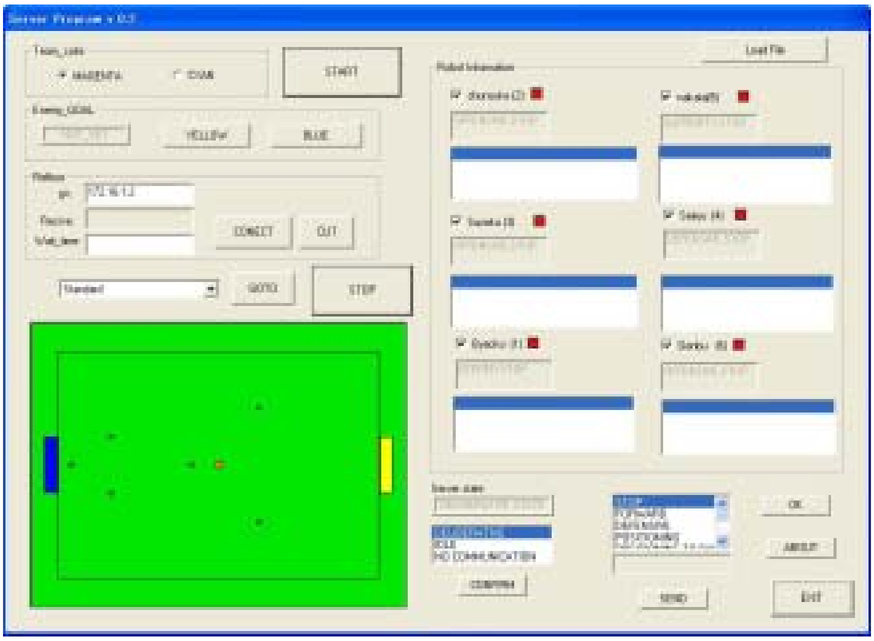

Fig. 7 Coach box that shows the positions of robots

3.3 Efforts to get more accurate results in the measurement of the distance

We use CMVision (thanks!) for the image processing of omnidirectional vision data. Original software is written for Linux C, so we implemented the software for Visual C++ on Windows.

As described before, the distance information is not so reliable but the angle information is reliable in the use of omnidirectional vision sensor. The algorithm explained in 3.1 is mathematically correct, but the measurement is not so correct as shown in 3.2.

Current algorithm is based on only geometry (no special consideration of uncertainty of measurement), so the key point is to get more accurate distance information to the goals.

The distance to the goal is calculated by the area size of a goal and the position of its centroid, then the relationships to the position and the distance to the goal is calibrated beforehand.

But we must be careful that the goal is, in most cases, hided by goalies or other robots. In that case, the area of the goal in the vision image is always smaller than reality, consequently the distance to the goal is measured farther than reality. In order to avoid such occlusion, we made a special trick in calculating the position of the centroid.

In CMVision, a colored area is selected as a rectangle. So we used the length of diagonal line of the rectangle. By the preliminary experiments for the length of the diagonal line, it is not so affected by occlusion, so we decided to use this method. Fig. 8 shows the diagonal line and the rectangle from the colored area of the goal.

Then, instead of using the position of the centroid, we use the length of the diagonal line, and the length expressed by the number of pixels is compared with the distance to the goal. This relationship is measured for every 1m grid, and the result of the preliminary experiment is shown in Fig. 9. The interpolation is used in run time, and we get the distance to the goal.

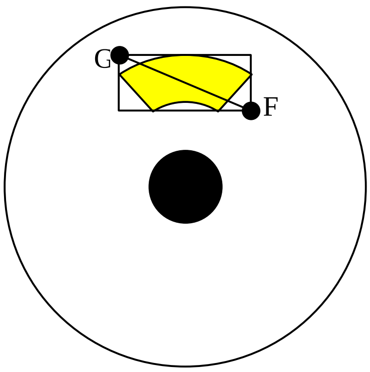

Fig. 8 Omnidirectional Image of a Goal

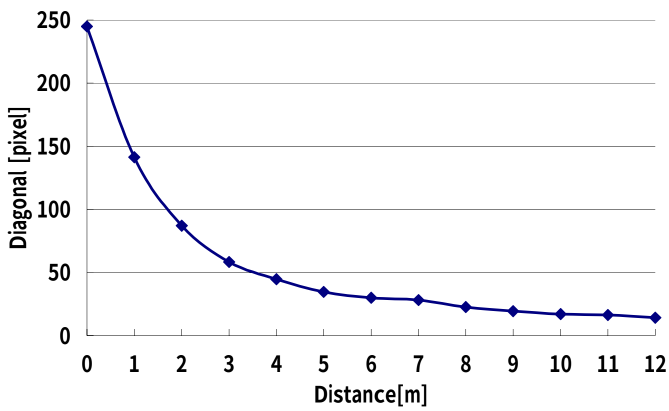

Fig. 9 Relation of Distance to Pixel in Omnidirectional Image

4 Behavior design

In our team, there is no difference of hardware of the robot. Therefore, the role of the robot can be easily switched by changing the program/paremeters of the robot.

FW
When FW is selected, FW player mainly works in the offensive area, i.e. enemy area of the field. Its role is to search ball, and if the ball is found and caught, the robot tries to carry/shoot the ball to the enemy goal.

DF
When DF is selected, DF player mainly works in the defensive area, i.e., ally area of the field. Its role is to search ball, and if the ball is found and caught, the robot tries to pass the ball for FW. Another important role of DF is to position between the opponent player and the ally goal in order to disturb opponent player.

GK
When GK is selected, the robot plays the role as goalie. Goalie mainly stays within the penalty area, and stands between the ball and the ally goal. Thanks to the omnidirectional mobile mechanism, goalie can always face to the ball during any lateral motion. When it lost sight of the ally goal, the goalie goes back to the initial position of goalie.

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