JoiTech-SPL Team Description 2017

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Abstract. Here we describe our RoboCup team ”JoiTech-SPL”. We commit to participate in Standard Platform League for the RoboCup 2017 competition. The RoboCup competition is a challenging scenario to apply our expertise in robotics. Our interest is to propose a computational mechanism that enable robots to improve the ability to estimate self-localization. We propose a mechanism to enable robots to predict temporal decrease of accuracy in their location estimation. The same mechanism enables robots to perform actions that lead to an increase of the environmental information. Doing so, robots will improve the estimation of its location in an active way. Our ongoing research is expected to bring substantial contribution for the self-localization performance of robots in the Standard Platform League.

1 Team Background

Team JoiTech-SPL is composed of master and doctoral students at Emergent Robotics Laboratory, Osaka university. Team “JoiTech” is a derivative of team JEAP. It was started up as a new team in cooperation with students at Osaka Institute of Technology in RoboCup Japan Open 2010. The team JoiTech focused on Humanoid League Adult Size for several years. In RoboCup 2013 Eindhoven, it took the 1st place in Humanoid League Adult Size and also was awarded the Louis Vuitton Best Humanoid Award [4, 5]. Finally, the team shifted its focus to Standard Platform League by adding “SPL” to the original team name “JoiTech”.
In our laboratory, we aim to understand the cognitive developmental process of humans based on synthetic approaches. The goal of our participation in RoboCup Standard Platform League is to foster the understanding of cognitive skills acquisition through robots and to enhance the background of our members in robotics technology.

1.1 Team Members

Currently, our team is comprised by graduate students and researchers as listed below.

Minoru Asada (*Professor*)
Yuji Kawai (*Specially Appointed Assistant Professor*)
Jorge Luis Copete Vasco (*PhD Student,Team Leader*)
Masaka Kataoka (*Master Student,Team Leader*)
Yuki Yamashita (*Master Student*)
Koki Ichinose (*Master Student*)
Wu Binyi (*Master Student*)
Kazuki Tachikawa (*Master Student*)
Kyoichiro Kobayashi (*Master Student*)
Naoki Umeda (*Master Student*)
Kohei Fukuda (*Bachelor Student*)
Niaty Rawal (*Bachelor Student*)

1.2 Robots

Our team currently has five H25 NAO v4s robots for the RoboCup competition.

1.3 Acknowledge of Team Code

We acknowledge the usage of the code release of B-Human team to participate in Japan Open 2016. Until now we have been employing the code release of B-Human team and we plan to use B-Human's code as the base code for participating at RoboCup 2017. In section 3.1 we describe the research advancement in self-localization we are currently pursuing and working on. This advancement will improve B-Human code. Regarding technical advancements, we modified the original code and added a function to detect white-and-black balls.

1.4 Impact of the team's participation in RoboCup

Regarding the impact of our participation in SPL league, we are preparing in our team to be competitive and contribute to the development of skills for robots. Playing soccer has many interesting challenges and our ongoing research is focused on dealing with environmental changes generated by the interaction of multiples factors like field environment and player movements, as will be explained below in ongoing research section.
Regarding the impact for our university, we consider that participating at RoboCup 2017 will stimulate the interest of students in robotics. Also, the public in general will recognize the activities that Osaka University is engaging in. This recognition helps Osaka University to get more support in its research activities, and to consolidate Osaka University as a leading institution in robotics fields.

1.5 Importance of participating in RoboCup

Participating in RoboCup is relevant for the research and educational aims of our team. We aim to develop robots capable of interacting smartly in real environments. Therefore, attending RoboCup will allow us to deal with this complex problem and to get feedback from the performance of our approach. The opportunity to play matches against other teams with similar goals in their research work enables us to learn from their approaches and strategies. Additionally, we aim to prepare competent and qualified people in robotics and artificial intelligence who will contribute to the development of the field in coming years. Therefore, participating in RoboCup stands as an enriching experience for the members of our team.

2 Team's participation in RoboCup Open SPL competitions

RoboCup
- July 2015 (Hefei), Result: 22nd place (Drop-in), 18th place (Technical Challenge)

Japan Open
- Japan Open, May 2017 (Result: First place)
- Japan Open, March 2016 (Result: First place)
- Japan Open, May 2015 (Result: Second place)
- Japan Open, May 2014 (Result: Fourth place)

3 Research and Activities

In our laboratorywe carry out research to develop mechanisms that enable robots to acquire the ability to behave smartly in the real environment. We regard Robocup competitions as a valuable test bench to assess performance of the developed robots.

3.1 Ongoing Research

Improvement of active self-localization by predicting reliability Currently, we are working in improving the ability of the robot NAO to estimate selflocalization. One issue with robot players is that they continuously lose accuracy of their self-localization when they move around the field. To address this issue, recent studies employed probabilistic approaches like a particle filter. In particular, a recent work by [3] introduced an idea of reliability for location estimation based on the particle filter. The reliability represents the degree of confidence in the estimated location and is calculated as the probability of having a successful estimation using n particles. In their experiments, when a robot moved around the field and detected low reliability, the robot changed its behaviors to correct the location estimation. Their experiments showed that a robot improved the location estimation by detecting the loss of estimation confidence. However, the actions executed by the robot were reactive (i.e., the robot changed its behavior after detection of the loss of reliability). Also, the estimated location still showed deviations as large as one meter. Here, we propose a model to improve the accuracy of self-localization by introducing the concepts of active sensing and reliability prediction, as illustrated in Fig. 1. The key idea is that robots learn to predict and continuously estimate the temporal tendency of the reliability. If a robot predicts a future decrease in the reliability, the robot will purposely execute a gazing action toward a known landmark (e.g., objects external to the field) in order to preserve the self-localization accuracy. We consider this predictive and active approach will contribute to enhance the self-localization performance of robots.

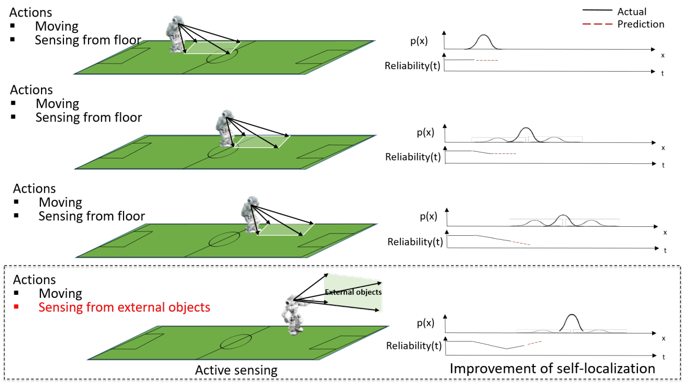

Fig. 1. Improvement of self-localization through active sensing based on reliability prediction. $p(x)$ represents the probability distribution for the robot location x. A robot is moving in the field while getting information from the environment to estimate self-location (above scene). However, when the robot moves, the estimation loses the accuracy and the reliability also decreases. In a certain moment, the robot predicts a decrease of reliability in the location estimation. Then, the robots performs an action to change its field of view towards a potential known view (i.e., active sensing). This active sensing enables the robot to confirm its current location and improve the estimation of its location (below scene) in an active way.

Reliability prediction and active sensing Currently, a robot estimates self-localization using odometrical and visual information. The odometry-based self-localization requires less computing time, but it often exhibits poor accuracy due to integrated error. In contrast, the self-localization based on visual information is unaffected by the integrated error, but it needs much computing time. Therefore, it's important to determine the reset timing of the integrated odometry error. We propose a self-localization algorithm based on reliability prediction that uses visual information to reset odometry-based estimation when the reliability prediction decreases. Our approach could reduce computing time and prevent false self-localization. In the previos research[3], the reliability of self-localization was defined as a probability of having a successful estimation using each particle:

$$R = \sum_{i=1}^{n} \frac{p(x_i|S)}{n}, \tag{1}$$

where x_i denotes the ith particle, S denotes a successful estimation, and n denotes the number of the particles. We propose that the robot predicts a decrease in the reliability using a simple autoregression model (Eq.2) The R_t at the next time step $t+1$ is estimated from the current and past reliability (from t to $t-T$) values and coefficient parameters a_τ:

$$R_{t+1} = a + \sum_{\tau=0}^{T} a_\tau R_{t-\tau} + \varepsilon_t, \tag{2}$$

where, ε_t denotes an error at a time t. If the predicted reliability a threshold, a robot looks toward the nearest landmark. This visual information enables the robot to correct the odmetric error and to realize more accurate localization.

3.2 Progress

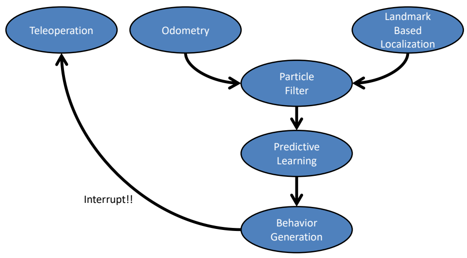

Fig. 2. Modules of the proposed localization system.

We usually control our robots through the teleoperation module. While controlling a robot, the odometry module (naoqi driver) collects odometry information and a partical filter combines the information with a result from the landmark-based localization module. The predictive learning module then detects a future decline of reliability and the behaviour control module interrupts the teleoperation module. Thus, the robot moves its camera towards the nearest landmark to correct its pose.
We are developing the localization system shown in Fig.2. As Fig.3 shows, we have already developed the teleoperation module for nao on the Robot Operation System. Then, we connect that to landmark-based localization module known as the ArUco mapping package in the ROS. Although we tested our system using the ArUco markers as landmarks, we will apply the system to natural scenes in the future. We are developing the particle filter, predictive learning and behaviour control modules. When the predictive learning module anticipates a decline in reliability, the behaviour control module kills commands of teleoperation and forces to stop the robot. The robot then moves its camera toward the nearest landmark to correct its pose. After recovering the reliability of self-localization, the behaviour control module kills itself and reboots the teleoperation module.

3.3 Past Research

Estimation of Players' Actions in Soccer Matches Based On Deep Autoencoder

The ability to predict tactical movements of opponent players, or the ability to perform in a non-easily

Fig. 3. Our teleoperation module and localization system.

predictable way for opponents are useful for improving team performance in soccer competitions. We proposed a framework for analyzing the predictability of behaviors in multi-agent environments using a deep autoencoder. In our experiment we employed data from the RoboCup 2D Soccer Simulation League and showed the potential of our model [1].

Throwing Skill Optimization through Synchronization and Desynchronization of Degree of Freedom Our previous research work [2] regarding motor learning is another significant achievement of our team to be implemented for SPL. Humanoid robots have a large number of degrees of freedom (DoFs), and therefore, finding the optimal parameters for behaviors is difficult. We hypothesized that heuristic exploration through synchronization and desynchronization of DoFs accelerates motor learning of humanoid robots. First, all motors related to a skill are actuated in a synchronized manner, but later the DoFs are released gradually, which allows the robot to search for the best timing to actuate the motors of all joints. The real robot experiments showed that the proposed exploration method was fast and practical because the solution in low-dimensional subspace was approximately optimum.

3.4 Basic description of team strategies for playing soccer

Self-position estimation A common issue in soccer competitions that requires special attention is the degradation of the estimation of the self-position after robots have moved or rotated during a certain period of time. Our current implementation for playing games checks whether the accuracy of self-position estimation goes below a chosen threshold. If so, NAO rotates and turns around its neck slowly, which increases the certainty parameter and makes the estimation accurate enough.

Entering ReadyState An important requirement for current SPL competitions is an ability of robots to look for their initial positions when they are still outside the field and then moving toward there without manual assistance. We programmed our robots so once the formation is decided, each NAO moves to its initial position in accordance with its correspondent role. First, when GameController is set to ReadyState, each player looks around the surroundings to roughly determine its self-position. Then, by continuously correcting self-position, each player goes towards its initial position.

Color Calibration One of the most severe problems we faced when starting to work with NAO was the loss of visual recognition accuracy when lightning conditions in the environment change. Currently, we are able to set hue, saturation and brightness for each of 4 designated colors (Orange, green, white and yellow). As a result, even if the environmental lightning conditions change, we obtain adequate visual recognition from NAO.

Role selection Each of 5 NAOs has been assigned a role as an attacker, defender or goalkeeper. Basically, the attacker chases the ball and kicks it towards the goal line. In case of the defender, when the ball crosses the center line, it kicks the ball to return it to the opponent's side of the field. Finally, the goalkeeper's role consists of following the ball parallel to the direction of ball's movement to prevent the opponent from reaching the goal line.

Ball Passing For our next step, we will develop a behavior and strategy of ball passing. By combining different techniques to solve issues of current technology, we aim to develop strategies that let robots surpass humans in playing soccer.

3.5 Related Activities

Practice Matches and Workshop, September 2016 We attended a rehearsal with "Camellia Dragons" and "Fukui University" at Aichi Prefectural University, Japan. The purpose was to test our code for recognition of goals and a ball. We also organized a workshop session to share the current state of each team regarding perception (recognition of goals and a ball) and motor control (walking and kicking engine).

Practice Matches and Workshop, October 2014 We arranged a match with "Camellia Dragons" at October 2014 in Aichi Prefectural University, Japan. The purpose of the match was testing the latest changes to improve the code of both teams. Among our results, we fixed the code for robots to estimate their self-location and the color calibration when lighting conditions change. We also organized a workshop session to share experiences regarding strategies and capabilities of both teams.

4 Concluding remarks

We JoiTech-SPL work continuously to improve our skills and become highly competitive participant based on our experience acquired in SPL league competition.

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