RoboCup SS17

submitted
PRACTICAL COURSE

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Abstract

RoboCup is a competition for soccer robot held annually, which aims at promoting researches on robot and artificial intelligence. We work on the RoboCup Standard Platform League (SPL) by using humanoid robot NAO, based on the code framework from University of Bremen's team BHuman.

Self-localization is a very important task for NAO during the game. The action decisions, ball tracking and different team cooperation strategies are dependent on the precise location on the standard soccer field. Self-localization is also related computer vision and statistical signal processing. These topics are the foundations of autonomous robot. So this semester I focus on figuring it out, how does NAO localize itself on the soccer field by cameras and how could it be improved.

The current method in BHuman framework has been continuously developed, verified and implemented for several years and it has been considered as state-of-the-art method which is already very robust and compact. The main idea is to apply particle filter to estimate robot pose. But there are still some issues that when robot is walking, some shake noises from camera will cause deviations in visual odometry.

Contents

Chapter 1

Introduction

RoboCup, namely "**Robot Soccer World Cup**", is an annual international robotics competition which was founded in 1997. The aim of this game is to promote robotics and AI research in a public appealing way. In 2016, it was held in Leipzig with more than 35,000 participants and teams from over 45 countries and regions. There are mainly four major categories in the whole RoboCup, namely *RoboCup Soccer, RoboCup Home, RoboCup Rescue, RoboCup Industrial*. The original and still largest focus is the *RoboCup Soccer*, in which teams of fully autonomous robots from different teams compete with each other. The teams are typically supported by a technical university or a research institute and carry strong academic and industrial backgrounds.
From the summer semester 2016, practical course "Humanoid RoboCup" was first offered at the Institute for Cognitive Systems. Each team consists of 3-4 master students with three NAO robots from Aldebaran Robotics as in Figure 1.1.

Figure 1.1: NAO robots

1.1 Motivation

The courses in artificial intelligence like machine learning, computer vision, pattern recognition are given as fundamental knowledge for the students in "Kernbereich" of Automation and robotics . After learning these theoretical knowledge, a practical course like "Humanoid RoboCup" is a perfect choice for students to know how these knowledge are applied in real scenarios. The given robots, namely NAOs, are cute from its out-looking and powerful with its computing ability. Based on this platform, the students can choose their own tasks according to their different background knowledge.
Apart from technical knowledge, team-working, time-organization are also beneficial for the students involved in this course as they will work in small groups and decide when to work and how to work by groups.

1.2 Overview and goals

The course in winter semester of 2016/2017 is offered for the second time. It is divided into two phases, namely the lecture phase and practical phase.
In the lecture phase, about four lectures will be given as the introduction to different fields, such as control, vision, planning, or machine learning. In the second phase, the student will form individual teams for a soccer competition with NAOs, like yellow team or blue team. All the students in each team will do the basic setting up tasks together and then each student will choose his or her own task according to the on-hand knowledge. In this period, the student can come to the lecturers who given introductions in different field for more detailed help.
The goal of this semester is to establish the code framework and play a real robot game with each other. The code framework is developed based on the B-Human CodeRelease as in [?]. As the student from last semester only complete the match in simulation environments, more emphasis on real Robots were spent on testing and implementing designed algorithms.

1.3 My Contributions

Based on the problems found on real robots, the first task is to fix all these fundamental problems to make the robots be able to play a real game against another team.
The fundamental problems are discussed in detail in Chapter ??, which includes:

- Joint Calibration
- Camera and color Calibration
- Coding and Debugging in simulation

- Coding and Debugging on real robots

The insufficient calibration leads to some problems. To fix the problem of “bad” joint calibration, teammate Benno proposed a method called *moving towards a target*. To get a better localization, teammate Ahmed proposed a method for better self-localization. For the details of these proposals one can refer to their reports.
Based on these proposals for fixing calibration problems, the behavior improvement is the main work of me and also the emphasis of this report. More concretely, the following new behaviors are proposed and implemented both in simulation and on real robots:

- Defender: dynamic defense area
- Striker: dynamic kicking direction

These new behaviors are discussed in detail in Chapter **??**.

Chapter 2

Improvement of Visual Odometry

Above the procedure of self-localization was described in general. Both unscented Kalman filter and particle filter will require the pose information which provided by visual odometry part. So the accuracy of pose estimated by visual part will definitely have an obvious influence on the final result.

2.1 Visual Odometry Procedure

There are several sensors to acquire information from the environment on NAO: camera, microphone and sonar. From them only the camera is adopted, since the environment of the soccer match will be quite complicated, for example:

- The white border lines and green field are on the same plane.
- The goal posts are perhaps too far away from the robots sometimes.
- There are 6 moving robots on the field, which the opponents are distinguished from our temates only by colors.
- The ball is small and the detection of a ball requires high precision.

So based on above reasons, the another sensors are not qualified for the requirements. However, the camera is suitable for each specific task and the computer vision skill as well as visual odometry are being perfect so far.
There two cameras on the NAO's head shown in fig, which can provide large FOV. Several tasks such as image preprocessing, feature detection(including: line perception, penalty mark perception, ball perception) and data association will be performed on the image gathered by each camera. Based on feature detection and data association, the correspondence point pairs have been already found. For example the goal post in figure i.

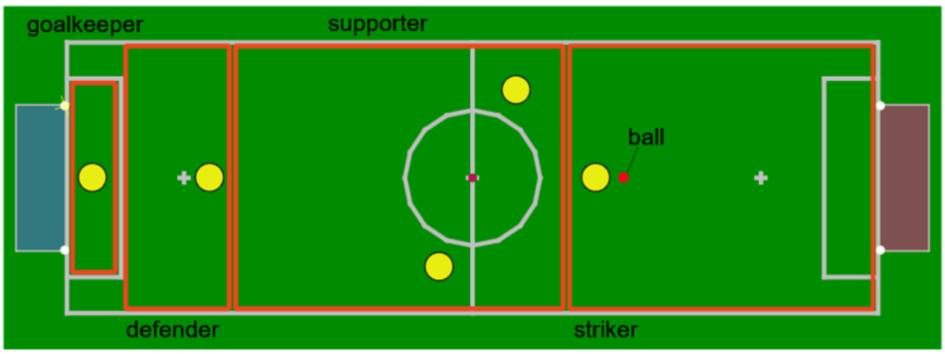


Figure 2.1: Roles in SPL

For the RoboCup at TUM, there are three robots in each team, namely the goalkeeper, defender and striker as shown in Figure **??**. The original behavior of these roles are from B-Human CodeRelease in [**?**].

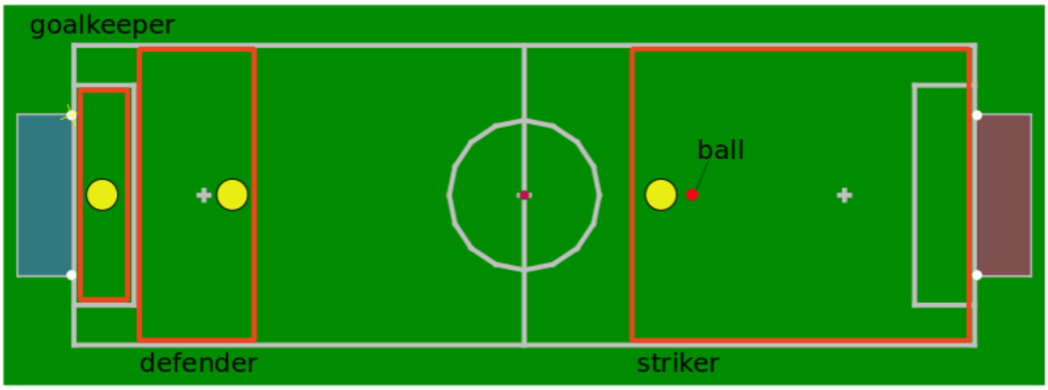


Figure 2.2: Roles at TUM

2.2 Defender

2.2.1 Defender Behavior

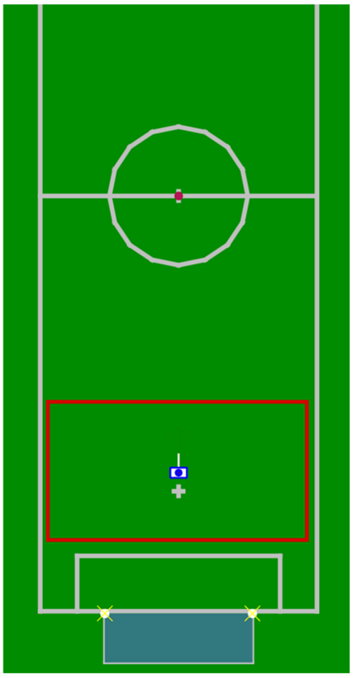
As shown in the field in Figure ??, defender will always start from one side of the field. Then he will walk to the defense area, face the opponent direction and defend in that area. If the ball is near it in some range, namely smaller than some threshold, he will walk to ball, align to the goal, align behind the ball and kick it out of that region. Then he will go back to the state defend. As a result, the defender will defend in the defense area most of his time as shown in the flow-chart in Figure ??. The original defense area is shown with red rectangle in the left of Figure ??.

2.2.2 Problems in Defender

As there are only 3 robots in each team, there is no supporter. The region between the defense area and the center is empty, where is dangerous as no one can stop the opponent striker.

2.2.3 Proposed Solution for Defender

To tactile this problem, a method called "dynamic defense area" is proposed as shown in Figure ??.
As shown in the flow-chart, the first procedure is the same as before: robots start from one side of the field and go to the defense area to defend there. If ball is near it, it will go and kick it out of that region. What we proposed is another condition, which is highlighted in the flow-chart with red lines: if the ball is far away to the defender, i.e. bigger than some threshold, defender will go to defend in some new region near the center of the field. So the defense area is enlarged until the center



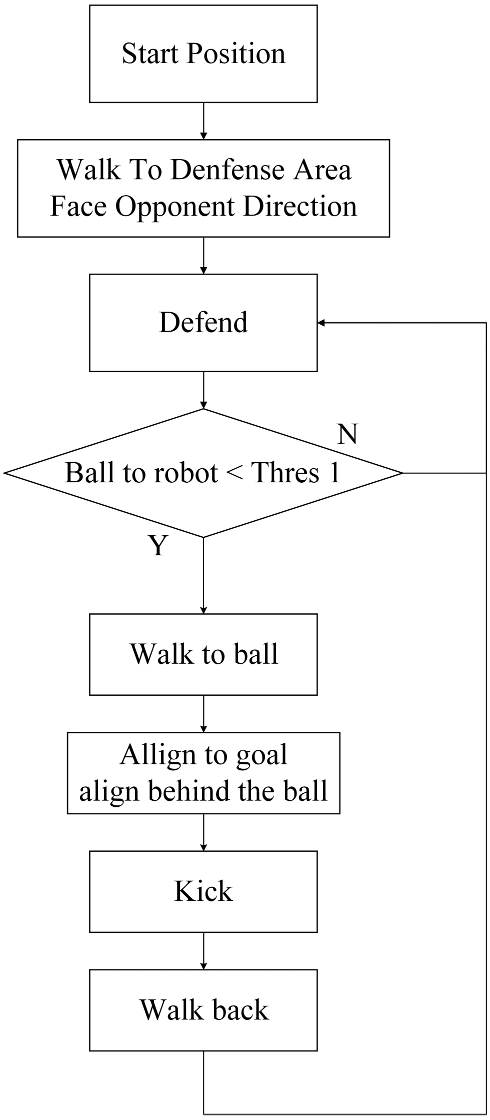


Figure 2.3: Defender: static defense area and flow chart

of the field. If the ball is suddenly behind the defender, the defender will come back to the original defense area like before. In summary, the defense area is dynamic as it will change according to the distance of the ball and the defender.
There are mainly two benefits of the proposed method:

- enlarged defense area
- compensation for the lack of supporters

Even if there are more robots given in the future courses, this behavior can still be kept as the region where the supporters take care is somewhere around the striker,

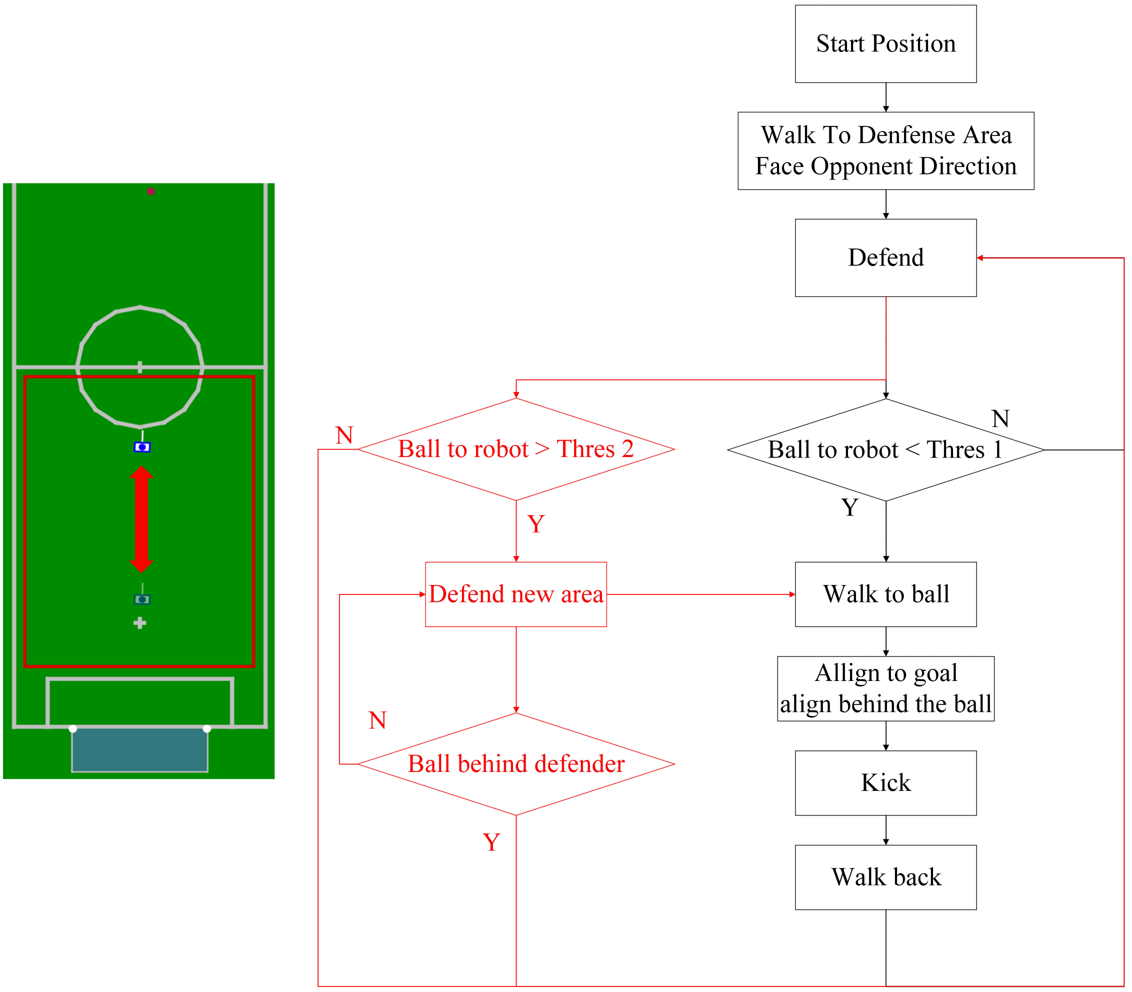


Figure 2.4: Defender: dynamic defense area and flow chart

so that they can focusing on supporting on strikers and do not care too much on the field before the center of the field. This can help the team to score more efficiently. The demonstration video for the "dynamic defense area" can be found at `https://youtu.be/XNjRpqoJ18c`.

2.3 Striker

2.3.1 Striker behavior

As shown in the flow-chart in Figure ??, the striker will always search for ball, align behind it and kick it in the direction of the center of opponent goal. The direction of the kicking is like the arrow shown in the left part of Figure ??.

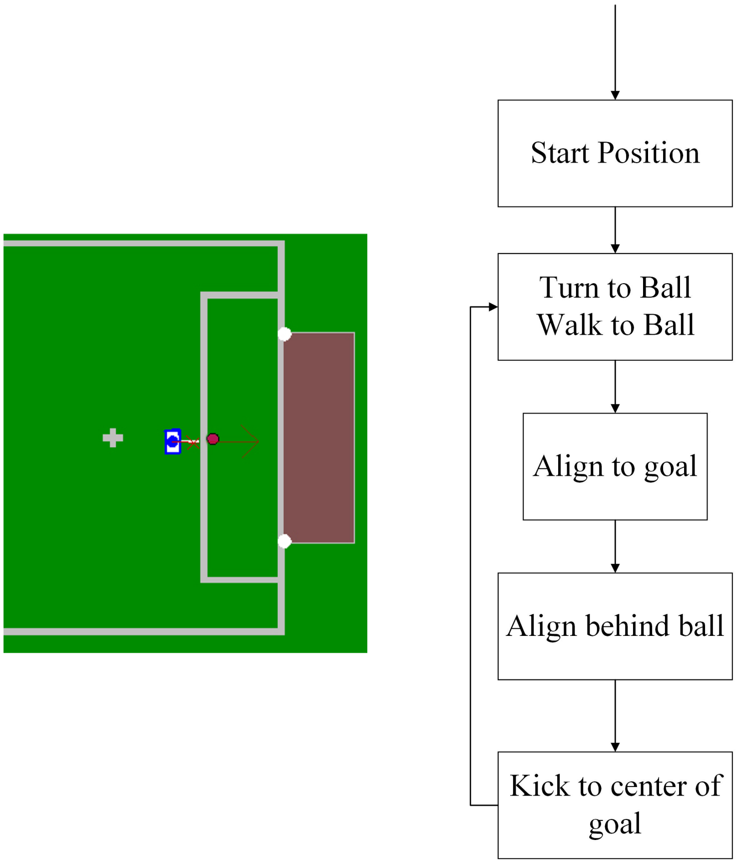


Figure 2.5: Striker: static kicking direction and flow chart

2.3.2 Problems in Striker

The behavior of goal-keeper is to put himself between the ball and the center of the goal. So if the direction of the score kicking is like the arrow shown in Figure ??, the ball will stopped by the body of Goalkeeper with high possibility. This is disadvantageous for the team to score the opponent.

2.3.3 Proposed Solution for Striker

To increase the possibility of the scoring kick, a method called "dynamic kicking direction" is proposed. The main idea is shown in Figure ??.

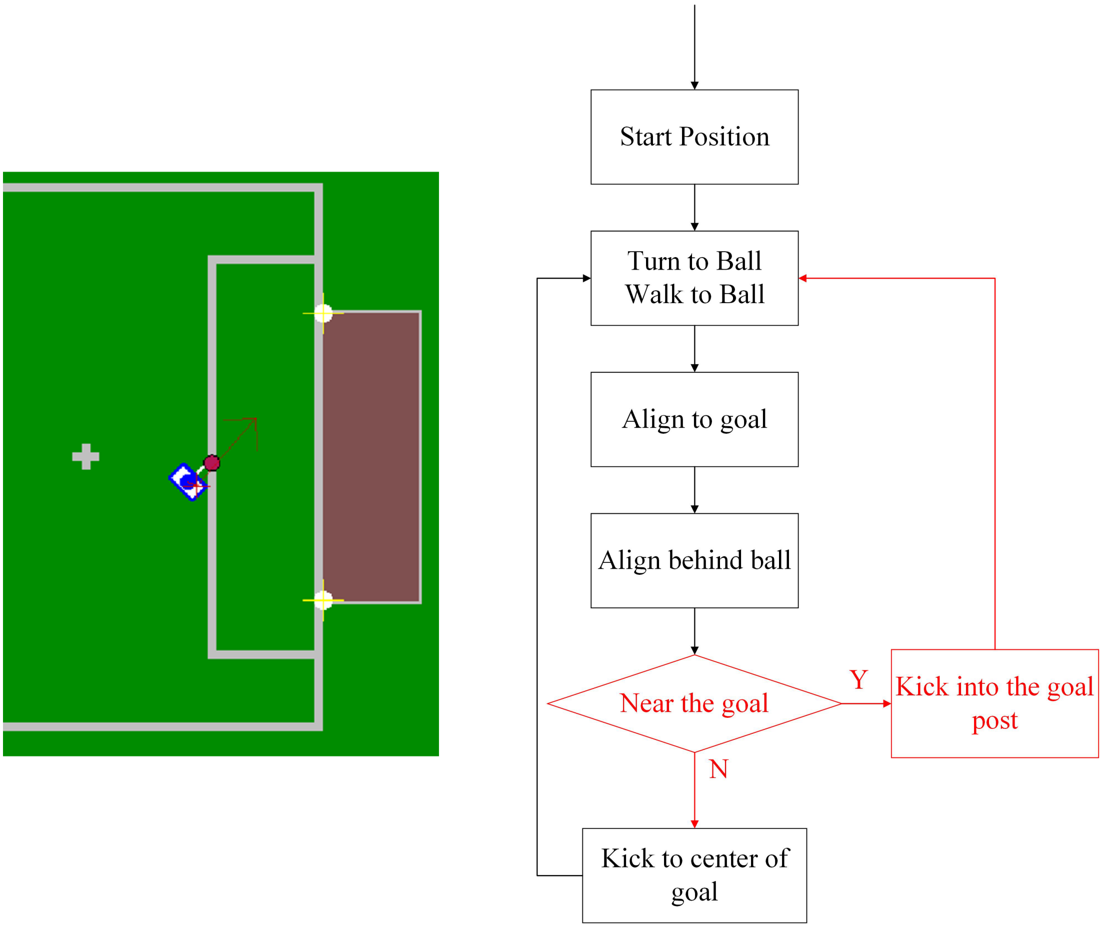


Figure 2.6: Striker: dynamic kicking direction and flow chart

The main behavior is identical to the previous. The striker will keep detecting the distance between itself and the center of the opponent goal. If they are near with each other to some threshold, the kicking direction will be changed to the far goal post, rather than the center of the goal, like the arrow direction shown in Figure ??. With the proposed method, the striker can score the opponent with higher possibility. The demonstration video for "dynamic kicking direction" can be found at `https://youtu.be/VrZ4jPr-9Os`.

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List of Figures

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