CHAPTER I

INTRODUCTION

1.1 Background

Soccer has been a well known sport amongs human, everybody knows it and there are numerous competition to be the champion of that sport. Every continent have their own league and there's a world cup to make it even bigger. What makes it good is that it needs strategy, colaboration, and team work other than skills and personal efforts. Technology has made it possible for robots to play soccer, hence robot soccer game was made. However in the game, strategy is not used as well as in a real soccer game. To apply strategy to the soccer robot game with certain approaches is a challenge for every soccer robot competitors.

Robot soccer can be categorized in multi-agent system, which has 3 approaches in controlling the system: decentralized approach, centralized approach, and the combination between the two of them, which is hybrid approach (Demetriou, 2009). Most people came up with a decentralized approach, equiping each robot with a visual feed to detect the ball and then dribble it towards the goal (Parker & Zhang, 2010). By doing this, there is a probability that those robots will collide when all of them are moving towards the ball. This is seen as a flaw to the approach. The flaw can be compensated by having a supervisor that oversees the situation and make the game plan, just like by having a coach in a human soccer game. With that done, the action that needs to be taken by each robot will be

considered by the supervisor. This control approach is known as centralized approach, where the supervisor can make up a strategy based on the position and the orientation and then tell the robots to execute the strategy.

In order to achieve the centralized approach. The single visual feed will be processed with image processing and computer vision methods (Dutkiewicz & Kielczewski, 2005). The image processing algorithm is the key core to this strategy, because a mere image of the arena situation can not bring out important information to be processed as a strategy. OpenCV library exists to serve this purpose for it packs every image processing methods needed to detect the arena and the robots. The application of this centralized approach strategy using image processing can enhance the winning rate as it applies strategy and game plan to the robots team. This will eliminate the primitive brute strategy and make the game more civilized.

After the provision of the position and orientation by image processing is ready, the information then will be processed through strategy algorithm which results in movement commands for each robots. These commands will then be distributed by the supervisor by using a wireless system. The wireless system between the supervisor and the robots will use personal area network (PAN) where the supervisor will function as the coordinator of the PAN and the robots will function as end devices. The PAN coordinator task is to specify PAN ID and channel, and also verifying the robots which inquire to join. End devices subsequently can join PAN based on valid PAN ID and the verification of the supervisor. With the supervisor and the robots joined in one PAN, the command then can be distributed by the supervisor (Kurose & Keith, 2013).

From the processes above, the writer focuses in acquiring the position and orientation of the robots to support the successive processes towards achieving the end goal, which is robot soccer with a good strategy. For the visual feed positioning, the writer uses high-angle shot as an alternative to bird-eye angle.

1.2 Problem Formulation

Soccer robot has three main objects: The arena, the robots, and the ball. A high-angle visual feed with specific angle and distance will produce perspective image of the arena. A normalized version of the arena is needed for the detection to run correctly. To detect position and orientation of the robots from a visual feed, each robots should be provided with a cue. The detection of the cues needs image processing methods and mathematical operations. The same thing goes with the ball detection. After the detection has been conducted and the important features has been gathered. A simulation is needed to simulate the robots movement. The above processes should be packed into single image processing application.

From what has been described above a list of problem formulations are listed below:

1. The objects in soccer robot and the visual feed needs a physical setup which determines the distance and the angle of the visual feed. How to get the best physical setup which can conduct accurate detection?
2. The image of the arena acquired through high-angle will be a perspective view. The image also contains other items which are not needed in the

detection and accounted as noise. How to distinguish the items from the arena?

3. For the detection to run correctly, a perspective view of the arena is not enough. A normalized version of the arena needed to be obtained. How to get a normalized version of the arena from a perspective version?
4. Position and orientation are the important features to be acquired from the robot detection. To ease up the detection, a cue or marker has to be designed. How to design the cue or marker of the robots which holds the important features?
5. There are multiple robots in the arena, IDs should be distributed between them in order to distinguish one from another. How to implement ID to the cue design so that the ID of the robots can be distinguished in the detection?
6. To detect the designed cue or marker, image processing operations are needed. What image processing operations are needed to detect the designed cue or marker?
7. The detection of the cue or marker are not enough, the important features should be extracted from it. How to extract the important features from the detected cue or marker?
8. To detect the ball, a cue is needed. What cue should be used for the ball detection?

9. For movement simulation, the gathered features: Position and orientation of the robots and the ball should be integrated. How to integrate the gathered information in order to make a movement simulation?

1.3 Application Boundaries

The development of the image processing application will have certain boundaries used as a guide. The boundaries are divided into two sections: physical system boundaries and application boundaries. The physical system boundaries are as follows:

1) The robots should have a square aspect ratio on their surfaces which are visible to the camera.
2) Five robots will be used and the robots are represented by their markers.
3) There are no enemy team robots.
4) The ball should be orange in color.
5) The camera should be able to cover the perspective view of the arena.
6) The arena should be rectangular and distinguishable in color (green is recommended).

The application boundaries are as follows:

1) The application only runs in windows operating system with OpenCV library installed in it.
2) The application will be developed using static image.

3) The application will be limited to acquiring the position and orientation of the robots and the ball in respect to the arena, the strategy algorithm will be developed in the next phase of the research.
4) The simulation only shows the movement of the robots in approaching the ball.
5) The movement of the robots will not calculate collision with each other.

1.4 Objective

This research and application development has one main objective, which is to acquire the position and orientation of multiple soccer robots using high angle shot of a camera. This main objective can be achieved through four lesser objectives: apply perspective transformation onto the soccer robot arena, acquire the positions and orientations of multiple robots which is in the arena, acquire the position of the ball, and make a simple trajectory planning of the movements with the gathered information.

1.5 Methodology

The methods used to accomplish development of this application and research is as follows:

1) Perform a study on soccer robot environment and image processing methods that needed to cover all problem formulation.
2) Design a physical system of soccer robot game with high-angle camera position.

3) Plan and develop an image processing application to acquire the position and orientation of the robots' patterns from a static image acquired from the high angle camera using OpenCV library in Microsoft Visual Studio 2010 Express.
4) Add a simple robot movement simulation to the application.
5) Application requirements and plan may vary and change according to needs as development progresses.

1.6 Writing Structure

This report will consist of five chapters, and will be arranged according to the following format:

CHAPTER I. INTRODUCTION

The first chapter introduces this report. It explains the background of the topic chosen for this final assignment, the problem formulation, application boundaries, research objectives, and methodologies to accomplish those objectives. The chapter is concluded with a description of the report writing structure.

CHAPTER II. THEORETICAL FOUNDATION

The second chapter explains the theories used as the foundation for the writing of this report from the general case that invoke the problem, the methods that are used to resolve the problem, mathematical operations that

supports the methods, the tools used later in the design, and the testing theory that is used later as the testing scheme.

CHAPTER III. SYSTEM ANALYSIS AND DESIGN

The third chapter analyzes the formulated problem and its solution. Discussions regarding the resulting system requirements and the algorithms used to achieve the solution are found here, step by step.

CHAPTER IV. IMPLEMENTATION AND TESTING

The fourth chapter discusses the implementation of the system and the algorithm. The implementation goes through testing phases and the analysis of calculations and algorithm implementation from the result of testing phases will also be discussed in this section.

CHAPTER V. CONCLUSION AND FUTURE DEVELOPMENTS

The last chapter which summarizes the entire research. It is concluded with suggestion for further improvements or future development.

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