Motion Optimization of Humanoid Robot Soccer "Goalkeeper" Using Behavior Based Coordination

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Abstract — **Accuracy and speed of movement is required for a goalkeeper robot in the Robocup soccer competition. Moreover, instability and robustness of goalkeeper robot is often a problem in itself that often arise especially if the robot is a humanoid robot. There are various methods on how to improve the performance of movement of humanoid robot have been actively studied. So now we propose how to optimize the movement of humanoid robot and research to this time is devoted to the movement of a humanoid robot goalkeeper by using behavior based coordination. In this paper, a stabilization algorithm is proposed using the balance condition of the robot, which is measured using accelerometer sensor during standing, walking, turning, getting up, etc. Then the information from the outside is obtained by using the other sensor that is webcam camera and also from this sensor the robot can decide and behave to respond the data information effectively. In order to generate the proper and fast reaction, so a behavior based algorithm is applied in finding the most effective movement when the robot responds some stimulus. The performance of the proposed algorithm is verified by walking, getting up and ball anticipating movement and this experiment is conducted on a 16-DOFs humanoid robot, called EEPIS Fußball Robot IO (EFuRIO) 2nd generation.**

Keywords : **Robocup, humanoid robot goalkeeper, behavior based coordination, EEPIS Fußball Robot IO (EFuRIO)**

I. INTRODUCTION

Humanoid robot is one of so many technology products that has high potential to help or support human's live and from year to year the quality of humanoid robot continues to increase. But still, until now the humanoid robot problem is in mobility. It's a fact that humanoid robot lacks in mobility. A technical reason lies in the fact that no control algorithm has been developed or implemented in a responsive form that allow the above- stated high-mobility.

There are several challenges in this research since this research is related to Humanoid League. The challenges are maintaining the dynamic stability of bipedal robot while they're walking, turning and perform the other tasks. Although the humanoid robot is a goalkeeper but still the robustness is needed to deal with the other players (contestants) and the field when the robot is fallen [2].

Many methods have been used to overcome the problems that arise on the humanoid robot and one such method is the behavior-based control. Behavior-based control is a control based on behavior or characteristic that have been sorted based on a predetermined hierarchy. This method has been introduced by Rodney A. Brooks in the mid 80s. After experiencing the developments then came one of the results of behavior-based development that is behavior-based coordination. By using behavior-based coordination the movement of the robot will be better because with this method a robot is given the ability to perform activities as efficient and flexible as possible. When the movement is more efficient and flexible then it'll make the humanoid robot goalkeeper moves more quickly and precisely. In addition, the robot will also be spared from severe damage when the humanoid robot goalkeeper saves their goal, such as when performing the fall motions to block the ball from the goal.

Objective of this paper is to provide the humanoid robot with a high level of movement ability, robust and also has the ability to keep the goal in soccer. Therefore to achieve that objective then the behavior-based method which is previously described will be applied to this robot. In fact we have selected to apply behavior-based coordination in humanoid robot goalkeeper and the coordination is a competitive coordination.

In this paper, competitive behavior coordination of the robot will be displayed in the form of hierarchies. These hierarchies will show the layers that determine the level of some behavior for the humanoid robot goalkeeper. Finally, we show the experimental results of the proposed method by falling motion to save the goal. The robot stands on the center of the goal then when the ball flows through the goal so the robot moves and anticipates the ball.

This paper is organized as follows. Section II explains the design and dynamic model of humanoid robot goalkeeper and proposes movements by using competitive behavior coordination. Section III shows several experimental results of EFuRIO 2nd generation and section IV concludes the paper.

II. CONSTRUCTION

A. Mechanical Construction

Mechanical construction is one of very important factor in this study because if the design is appropriate and whether the results will be good as well and in accordance with the original purpose of submitting this paper. Before we show EFuRIO 2nd generation's mechanical construction, let us show EFuRIO 1st generation's mechanical construction. EFuRIO 1st generation's mechanical construction will be shown by **Figure 1** as follows.

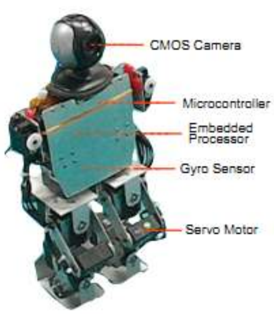


Figure 1. Humanoid Soccer Robot EFuRIO 1st generation (Indra Adji S. et all. 2010)

Now we'll show the EFuRIO 2nd generation's mechanical design and construction in **Figure 2** and **Figure 3** as follows.

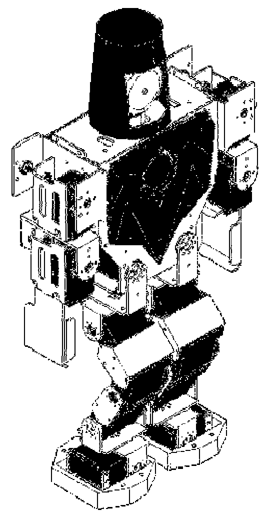


Figure 2. Humanoid Soccer Robot EFuRIO 2nd generation's mechanical design using software Autocad

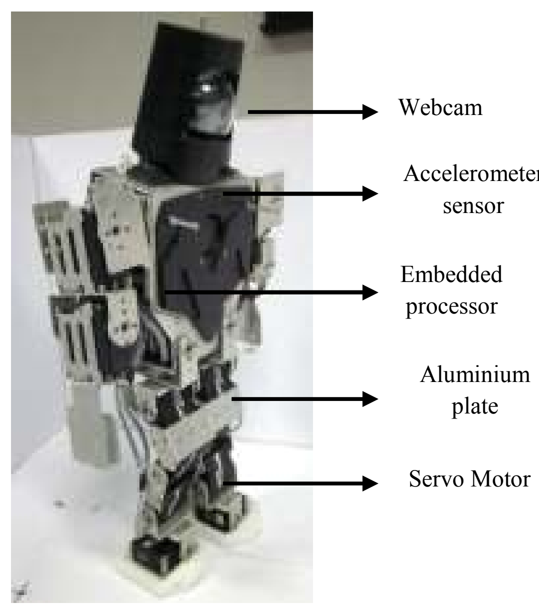


Figure 3. Humanoid Soccer Robot EFuRIO 2nd generation

There are many changes in the mechanical between the designs and construction of the first generation to second generation. This is done because for the first generation doesn't act as goalkeeper, but acts as an attacker (striker) while the 2nd generation acts as goalkeeper indeed. This is also distinguishes the movement that generated between the two of them.

B. EFuRIO

EFuRIO that stand for EEPIS Fußball Robot IO is the third generation of humanoid soccer robots developed in our lab. The previous work is T-HEX's, a biped walking robot that won a prize of "Best Innovation" in 2009 Indonesian Fire Fighting Robot Contest Senior Legged Category [1]. We use different kind of servo motors as the actuators, it depends on the function and location of each installation of the servo motors. We use two different sensors in this study, the first is single webcam camera to catch every information such as human eyes. And the second sensor is accelerometer which is used to get any information about positions and movements of the humanoid robot goalkeeper. RoBoard RB-110 was selected as the embedded processor because it's simple to use and very powerful to collect data from sensors and process data to actuators [6]. EFuRIO 2nd generation is constructed out of 1.8mm aluminum plate, with servo motors are used as structural components in the design. Furthermore, EFuRIO 2nd generation intends to compete at the international humanoid robotic competitions such as RoboCup and FIRA HuroSot. This means that EFuRIO 2nd generation should be able to balance the body not only for walking but also while performing other activities except when it wants to make safe and block the ball by activating the falling motion .

C. Behavior-Based Control System

This method has been introduced by Rodney A. Brooks in the mid 80s. In his paper he told that the Behavior-Based approach states that intelligence is the result of the interaction among an asynchronous set of behaviors and the environment (Brooks, R. H., 1985). A behavior is a reaction to a stimulus, this statement will be shown as in **Figure 4.**

Figure 4. A behavior is a reaction to a stimulus [5]

As the explanation before that in this study we select behavior based coordination (competitive coordination). There are various strategies or ways that included in the competitive coordination. So we decided to select one of them, and the one which is selected by us is priority-based or we can call it subsumption architecture. Priority-based or subsumption architecture that we select is to solve problems that have been appearing on bipedal robot and by using this method we can accomplish our objective to make humanoid robot goalkeeper as we explained before. The subsumption architecture will be shown by **Figure 5** as follows.

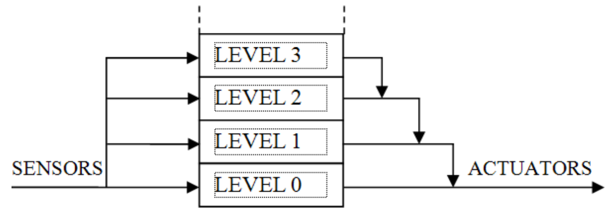


Figure 5. Subsumption Architecture [4]

Next, It'll be shown a picture of a flowchart which explains several system on a humanoid robot goalkeeper.

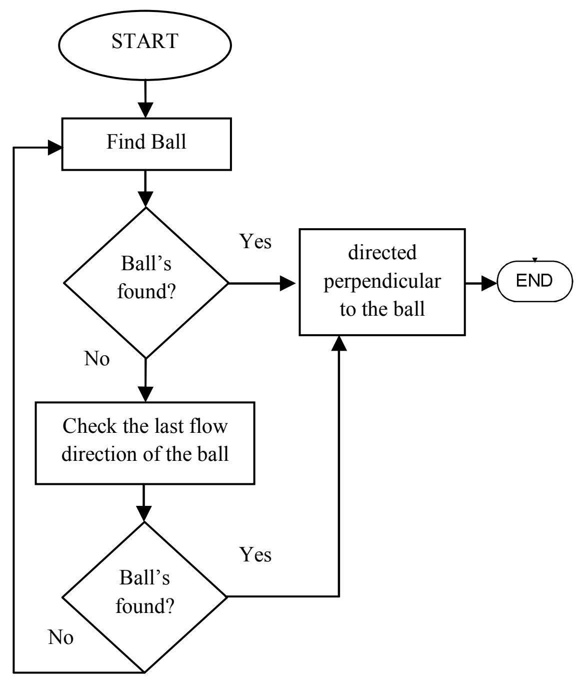


Figure 6. Finding ball flowchart

In **Figure 6.** we can see how the humanoid robot goalkeeper find the ball.

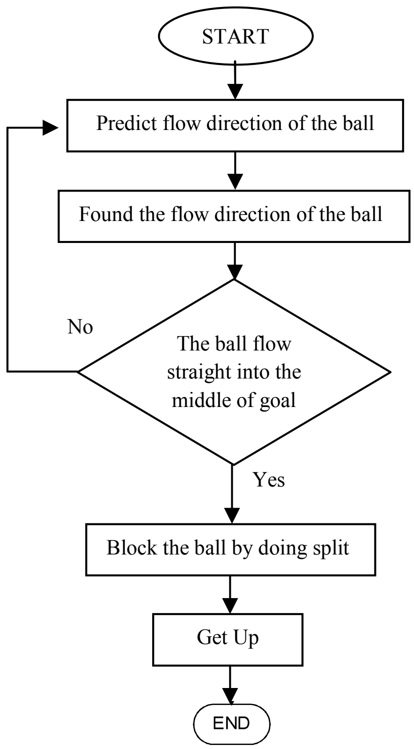


Figure 7. Behavior finding flow direction of the ball and react when the ball flows straight into the middle of goal

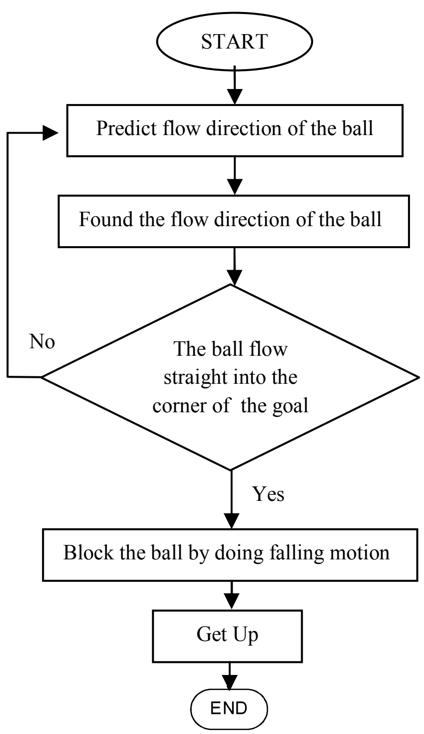


Figure 8. Behavior finding flow direction of the ball and react when the ball flows straight into the corner of goal

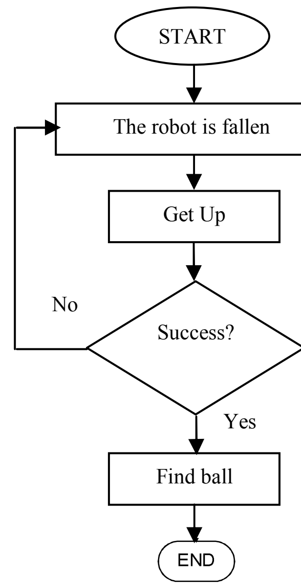


Figure 9. Behavior getting up after the robot is fallen

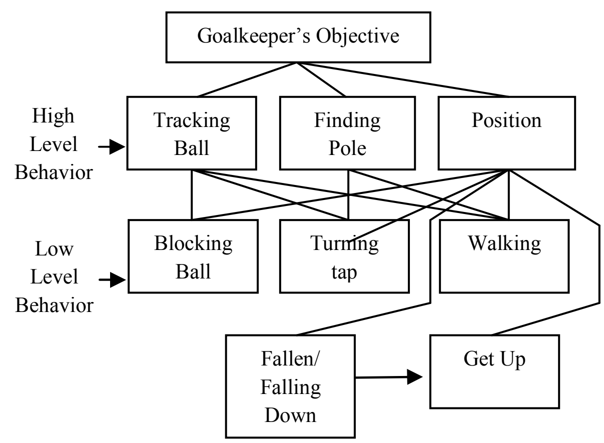


Figure 10. Hierarchy of Behavior Based Coordination

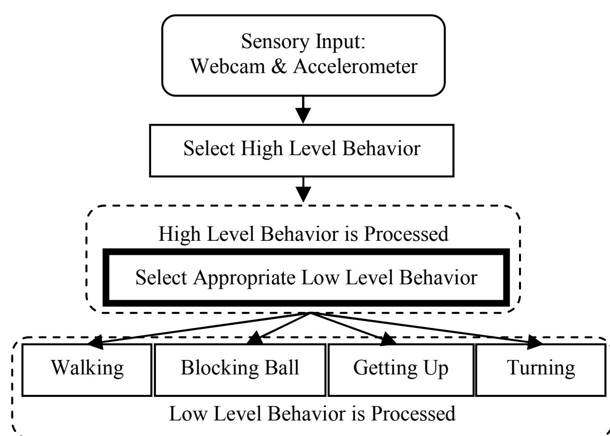


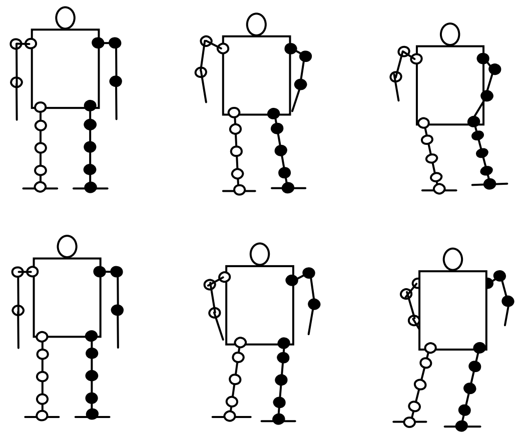
Figure 11. Architecture of Behavior Based Coordination

III. EXPERIMENTAL PLAN

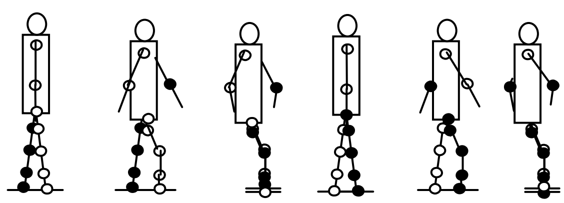
A. How The Robot Walking

1) Walking

Front



Side



Center of Mass

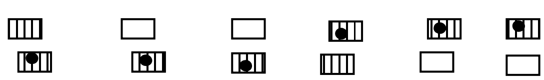


Figure 12. EFuRIO 2nd generation walking pattern

2) Turning Tap Right and Turning Left

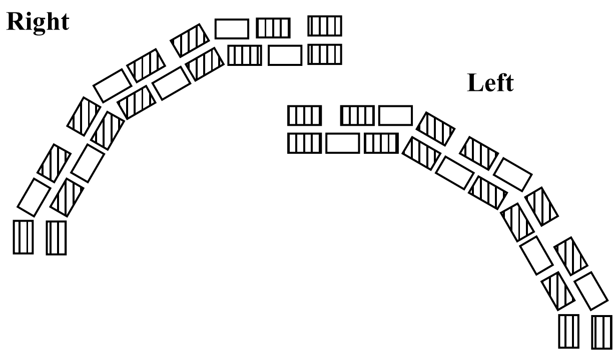
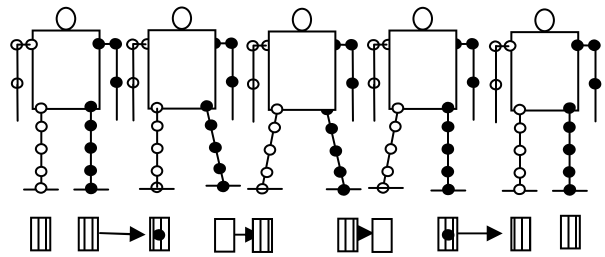


Figure 13. EFuRIO 2nd generation turning tap pattern

3) Walking Tap to right and left side

Left



Right

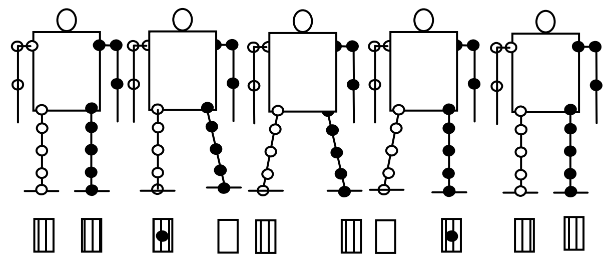
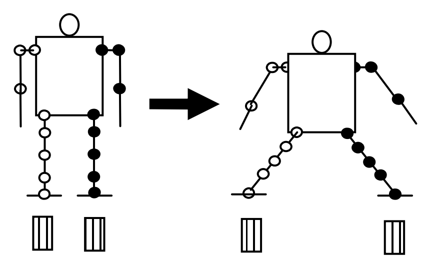


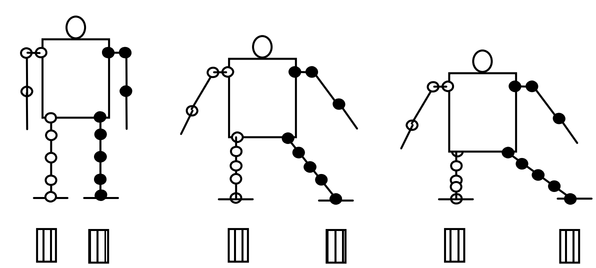
Figure 14. EFuRIO 2nd generation walking tap to right and left side

4) Alert Movements

If The Ball is in The Middle of Goal



If The Ball is in The Right of Goal



If The Ball is in The Left of Goal

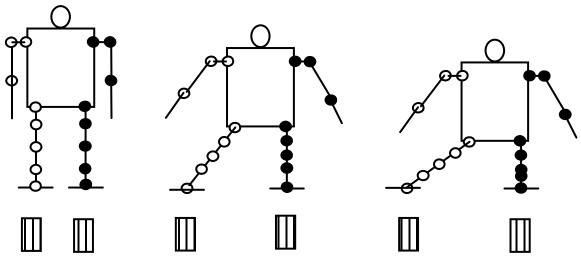
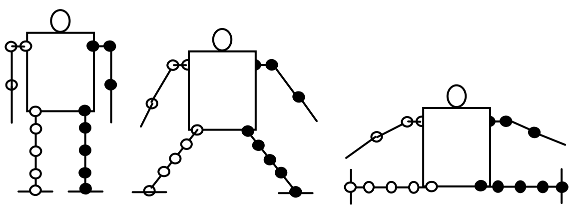


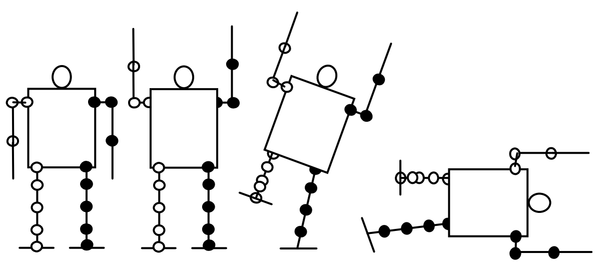
Figure 15. EFuRIO 2nd alert movement

5) Split and Block

Split



Block Left



Block Right

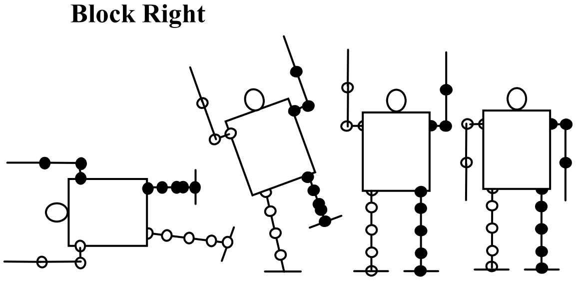


Figure 16. EFuRIO 2nd split and blocking movement

B. How The Robot Respond The Stimulus

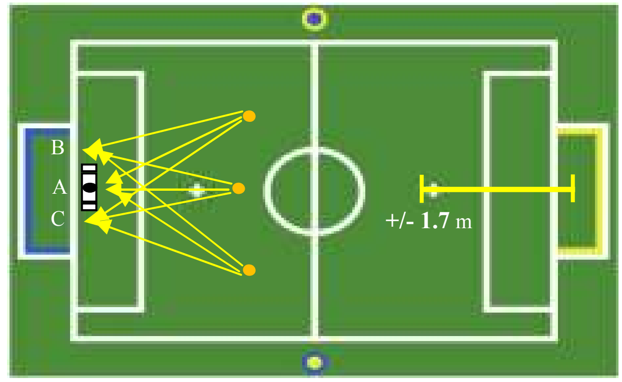


Figure 17. EFuRIO 2nd generation response on the field

In **Figure 18** if the ball flowing into the middle of the goal (area A) then the robot will automatically do a split like the one in the flowchart described earlier. whereas if the ball flowing into the top corner (region B and C) then the robot will automatically do falling motion to block the ball as described in the previous flowchart. The robot can make a safe and read the flow direction of the bal if the ball is kicked more or less 1.7 m from the goal as described on figure above.

IV. CONCLUSION

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