The TJArk'Team Description for 2013

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Abstract. TJArk is Tongji University's Legged-league RoboCup team. They took part in RoboCup in 2006 for the first time and entered the quarter-finals in RoboCup 2007, 2008. All the members of this team are from Control Science and Control Engineering Department of Tongji University, China. This paper will provide a concise description of this team, including information about the research interests of its team members and the improvements on each part of TJArk's project.

1. Team Introduction

1.1 Team History

TJArk was established in 2004 as part of Lab of Robot & Intelligent System of Tongji University. We participated in RoboCup for the first time in 2006. By 2006, research interests of TJArk were focused on color-blob-based object recognition [1] and manual design of trajectories-based locomotion, leaving the behavior and localization modules really fragile. TJArk succeeded into the quarter finals in RoboCup 2007, 2008. In 2009, we shift our research platform from quadruped robot to humanoid robot, and some locomotion and behavior optimization related research. Since we got the robots in late April, this left us only two months to build the framework and carry out trials. In RoboCup 2009, it was our first experience in two-legged competition, and we got the entry of second round. In RoboCup 2011, we added many new elements and managed to the Second Round due to a vital success in the Intermediate Round. In RoboCup 2012, the communication module almost broke down due to the bad network condition, and we managed to the Second Round at last. Detailed information can be found at the team's website:
http://see.tongji.edu.cn/TJArk/English/index.html

1.2 Team Makeup

1.2.1 Team Leadership

The TJArk team is being supervised by *Prof. CHEN Qijun*, he is now the chancellor professor in the College of Electronic and Information Engineering (CEIE) of Tongji University. He is the Dean of the CEIE of Tongji University. Prof. Chen has been to University of Hagen in Germany in 2002 as a Guest Professor and UC Berkeley in United States in 2008 as a Visiting Professor. He is the member of National professional Standardization Technical Committee; the Standing Member of Intelligent Manufacturing Committee and the Standing Member of Intelligent Robot Committee of Chinese Artificial Intelligence Association. He had more than 80 papers published in journals and conferences. Prof. Chen's research interests are robotics control, environmental perception and understanding of mobile robot, bio-inspired control and Humanoid Robot, etc.

1.2.2 Team Members

The main part of researches and coding is done by the student researchers. Main student researchers:

WANG Xin, Control Science and Control Engineering M.S. students.

QIU Ying Xiang, Control Science and Control Engineering M.S. students.

WU Dong Yang, Control Science and Control Engineering M.S. students.

ZHANG Xu, Control Science and Control Engineering B.S. students.

WANG Han Bin, Control Science and Control Engineering B.S. students.

CHEN Zhong Yang, Control Science and Control Engineering B.S. students.

1.2.3 Numbers of NAO used by the team

Our team currently have 10 H25 NAO v4s, so it's totally enough for us.

2. Statements

RoboCup is a significant international platform for researchers of AI, robotics and related field to communicate and examine their researches. It directs our researches toward a more practical way for the socially significant problems and industries. Participation in such an international activity is always supported by Department of Control Science and Control Engineering and Tongji University. We apply to be qualified in for Standard Platform League in 2013 and participation of TJArk can be guaranteed if we passed the qualification.

3. Main Research in 2012

3.1 Locomotion

Locomotion is one of the main research interests of TJArk, and we have researched a lot on the trajectory based locomotion and self-learning of adaptive walking on AIBO, which was described in our previous TDPs[2]. The TJArk's locomotion module is based on the Cart-table model and preview controller architecture. After planning the footsteps according to the Behavior commands, the ZMP trajectory is generated using a linear interpolation and the center of mass (CoM) trajectory is calculated using the preview controller. However, we didn't use this module in RoboCup 2012 due to the slow speed. This year, we carried out many new experiments on locomotion.

We developed a Bio-inspired walking control strategy based on CPG. Walking control of biped robot NAO is realized based on the central pattern generator (CPG). Fig. 1 shows a control architecture which is proposed with a trajectory generator and a motion engine. The trajectory generator consists of a CoG (center of gravity) trajectory generator and a foot trajectory modulator. Fig. 2 shows the CPG network generates adaptive CPG trajectories online and the foot trajectories can be modulated based on the generated CPG trajectories. The motion engine which uses the designed mapping function will map the output of the CPG to NAO's foot trajectories. Coupled with feedback information, the proposed architecture is able to generate adaptive joint control signals online to realize biped adaptive walking. A biped platform NAO is used to validate the proposed locomotion control system. The experimental results confirm the effectiveness of the proposed control architecture.

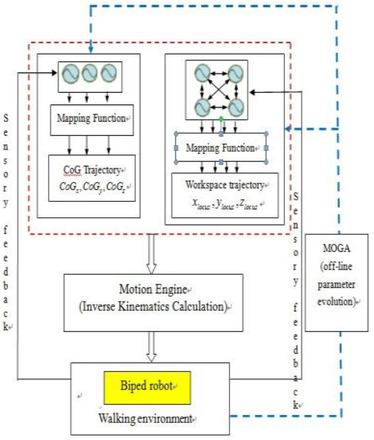

Fig. 1 Architecture of the biped walking control system

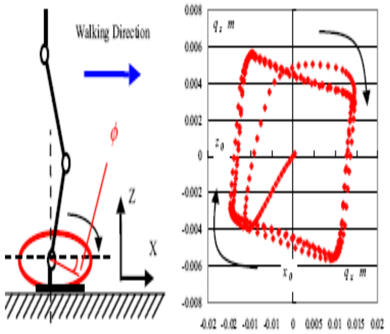

Fig. 2 foot trajectories generated by CPG

We are also trying to develop a new walking engine based on 3D-LIMP. Our main goal next year is to make our locomotion faster and more stable. The experimental walking of NAO can be seen in the video provided.

3.2 Real-time Imitation human movement

In the previous research, imitation human movement is developed to improve flexible motor skills or complex movements such as dancing, standings up and so on. In this year, more researches are focusing on real-time imitation in the whole body motion planning and stable reproduction on the redundant robot kinematic system with joint limit constraints and self-collision avoidance. Figure 3 shows the motion control architecture to imitate human movement, Kinect from Microsoft Company as the Human Movement Capture Device (HMCD) to capture end-effector's trajectories, considering redundant kinematic, Resolved Motion Rate Control method (RMRC)/Differential Inverse Kinematics (DIK) is introduced to track end-effector. Joints' range/velocity/torque is proposed to avoid unreachable trajectories. Self-collision avoidance which is mentioned in the official document is also developed in our motion control architecture, like the document, simple OBBs are used to represent 3D geometry of Nao Robot, but in our real-time experiment, task-oriented method which is faster is used instead of optimization method. In the future, we will focus on the stability in the real-time imitation planning.

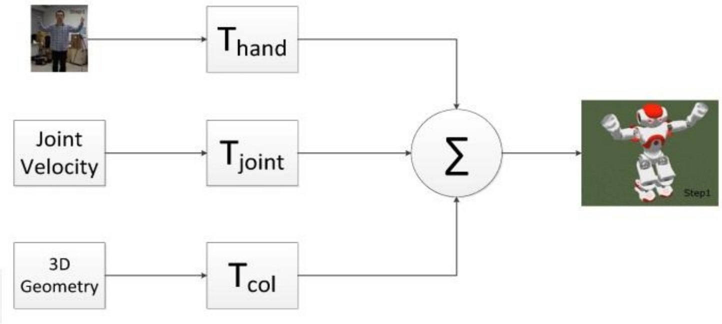

Fig.3 Motion Control Architecture to Imitate Human Movement

3.3 Self collision detection and avoidance

While imitating or other motion planning process, self-collision detection and avoidance are fundamental to humanoid robots. Some researchers have already investigated this topic. AABBs, OBBs and k-DOPs are used to solve collision detection. For the 3D Model of Nao, we just represent it by simple OBBs, divide it to many segments by joint connect, computer distances between every two segments and the jacobian matrix of the whole-body joints to the distance. Some popular methods of collision avoidance are for instance Potential field methods and Rapidly-exploring Random Trees. However these methods take a lot of computation time because they use configuration space. So we choose the method of task-oriented whole body motion and build a first-order dynamic IK control system to plan the robot motion.

3.4 Communication between robots

For a long time, we only have communication between robots and computers, which is used for debug. It turned out that the robots were often collided with its own teammates due to lack of communication. Our original solution is to divide the field into different areas. But proved to be not efficient enough. So we implement the communication module last year. The robots exchange information through UDP packages. So we would have a common world model. A global ball model helps the robot quickly locate the ball even the ball is out of vision.

However there are still some deficiencies need to be improved, which are discovered in large number of tests. We are now trying to eliminate the effect of communication delay by using the prediction and estimating method. Besides, we will also try to give a better solution to the problems such as network congestion, low message utilization ratio and so on.

3.5 Vision

Vision is crucial for a robot soccer game. As to vision module, our goal is to recognize all the objects on the Nao field: goals, ball, field lines, crossings, center circle. We still used the scanline based perception framework. .The basic method of our vision is a combination of scanning based on pictures and connecting blobs based on segmentation. During the vision processing, we utilized look-up table method to increase efficiency. However, given that the color table is easily affected by light changing, noises, and even cameras of different robots have distinct features, we have adjusted our vision algorithms more independent of color table and made the vision module robust to environment.

According to the changes to the rules, the Nao field becomes much bigger than before, so that we should recognize the objects, such as the ball, far away now. The wide field also makes the location more difficult. There are great connections between location module and vision module. To make the location module work, we should recognize the markers on field effectively. Therefore, we revise many parameters and update our vision algorithms this year to make the recognition more accurate and efficient. In addition, we have adjusted the vision algorithms of ball searching to reduce the effect on the ball recognition because of the movement of the ball. We use mathematical method to give a compensation for ball recognition. Figure 4 shows the difference when searching the moving ball by using this method.

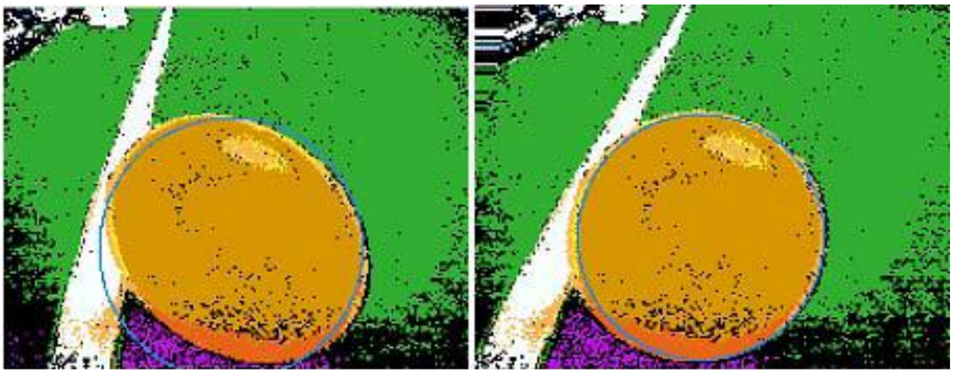

Fig.4: Ball recognition result. Left: use original algorithms; Right: use new method

3.6 Behavior

Our behavior module is programmed in python using an external python interpreter instead of Python Bridge.

3.6.1 Introduction of mechanism: DFSM

Based on the last year's behavior module, we still use the Decision-making System which named DFSM with a finite state machine. In this machine, all skills are defined as different states. We have two styles of FSM in the system. Given there is not just one state sometimes. For example, when the robot sees the ball, there should at least be running the trackBall state and the goToBall state simultaneously. And the trackBall state just relates with whether the robot sees the ball. So we decide to define two styles of FSM. One is that all states participate in state cycle (there is only one state in this style at any time). Another is that some states do not participate in state cycle, and these states will be pushed in the second state machine when some conditions are met. So at each frame of the system, it will run the current state of the first state machine and the states in the second machine. In order to form grapy visualization of state transfer machine, we use yapgvb module of Python which provides Python bindings to Graphviz, with an intuitive Python interface. It is convenient and intuitive for us to check out our states process whether is right or not.

3.6.2 Improvements

Last year, we added the teammate communication, anti-collision module, button control module to the behavior module and adopted the dynamic role-switching method to make decisions. As we all know, recently some changes have been made to the RoboCup rules, the size of the soccer field is decided to be extended from 4000mm*6000mm to 6000mm*9000mm, and the number of robot players each side becomes 5 instead of 4, which poses a great challenge to the existing localization module and behavior module. According to the changes, we are now first focusing on the decoration of the new experimental field .Then we will try to adjust our algorithm and strategy to fit the much bigger field and arrange a new role assignment for five robots to make the players work efficiently in the team .How to assign the roles of the five robots and make full use of the global communication message may be the key problem need to be solved. Of course, all the work above will be based on the existing behavior framework. In the coming days, we will continue to strengthen all base skills to adapt to the dynamic environment and make our behavior module work better at the same time.

References:

[1] Qijun Chen, Huali Xie, Pengyung Woo. Vision-based Fast Objects Recognition and Distances Calculation of Robots.2005 IECON.

[2] Jiaqi Zhang, Qijun Chen. Learning Based Gaits Evolution for an AIBO Dog. 2007 IEEE Congress on Evolutionary Computation:1523-1526.

[3] JiaQi Zhang, QiJun Chen. Lamarckian Evolution and Baldwin Effect in Neural Networks. DCDIS A Supplement, Advances in Neural Networks, Vol. 14(S1) 470—473.