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Hybrid Architecture for Kick Motion of Small-sized Humanoid Robot, HanSaRam-VI

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Abstract: This paper presents a hybrid architecture designed for the kick motion of a humanoid robot. The principal components of this architecture are vision system, path planner and motion generator. The vision system utilizes captured images for calculating ball and goal positions and simple self-localization using a proposed image preprocessing technique. Based on this information, appropriate path and motion procedures are calculated in the path planner and motion generator embedded within the PDA. As all deliberative decision is made in above three modules, there is temporal independence between deliberative layer and reactive layer of robot control. By virtue of this, all procedures of behavior selection and execution could be done efficiently according to the situation. The performance of the proposed scheme is demonstrated through the kick behavior using small-sized humanoid robot, HSR-VI, developed by RIT lab in KAIST.

Keywords : Humanoid, Hybrid Architecture, Path generation, Vision System .

1. INTRODUCTION

Research in the development of Humanoids represent the cutting edge in Robotics. Honda ASIMO [1], WABIAN of Waseda University [2], HRP [3], and HanSaRam [4] stand testimonial to the rapid progress and development in this area.

Current research on generating walking pattern gene-ration is mainly based on the inverted pendulum model [4]. From the predefined model, several stability maintenance algorithms such as impedance control [5], online (real-time) balance control during walking [6] and time domain passivity control of the landing impact force have been proposed [7]. For stable walking, force control and walking pattern planning algorithms were developed, and their efficiency was shown [8].

Apart from the research topics related to walking algorithms, path planning and vision processing also remain important research issues. For a wheeled robot, many solutions on localization and object detection are developed, including those with omni-vision camera [9]. However, for a humanoid robot, sensor capabilities are limited, in order to mimic the human way of sensing.

In most cases, humanoid robot uses stereo vision to obtain depth information from captured images [10]. By using the result, appropriate paths are generated according to landmarks or heuristics based on the information of lines on the screen [11].

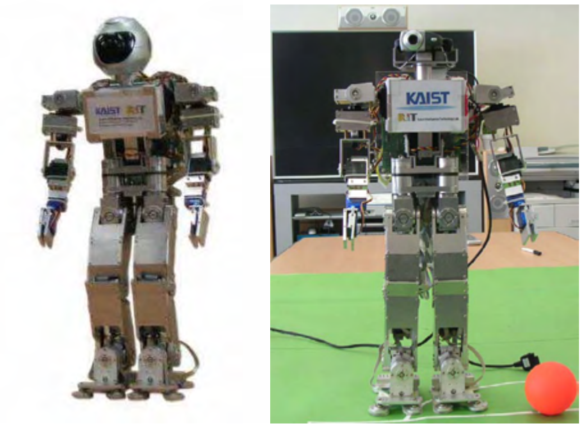
This paper describes the recent progress and development in humanoid robot, HSR-VI, especially focusing on its hybrid architecture. The derivative layer including the vision module, situation detector, path planner and motion planner is implemented in a PDA mounted on the head of a small-sized humanoid robot. The walking pattern generation is completely performed in the embedded computer, which is installed on the back of HSR-VI. Therefore the deliberative layer operations could be performed independently on the executive layer.

In vision processing, edge and color based detection algorithms are combined for the performance of detecting ground area. Using the result, landmark based localization is performed and behavior selection and scheduling are also performed according to the situation. The validity of the proposed hybrid architecture is confirmed through penalty kick experiments of HSR-VI developed in RIT Lab., KAIST in 2004.

The reminder of this paper is organized as follows: Section 2 shows the HSR-VI. Section 3 explains the whole scheme of hybrid architecture. Section 4 presents the vision system implemented in deliberative layer. Section 5 shows the experiments, the penalty kick, through the snap shot of movie clip. Finally, concluding remarks follow in Section 6.

2. HanSaRam-VI

HSR-VI developed in 2004, as shown in Fig. 1, had 25 DOFs and consisted of 12 DC motors for a lower body and 13 RC servo motors for a upper body. Its height and weight were 52 cm and 4.6 kg, respectively. The design of its lower body was focused on the delivery of sufficient torque and zero backlash with DC motors and harmonic drives. The main difference of HSR-VI compared with past versions of HanSaRam series was in the design of lower body. It was simplified by designing the harmonic drive and DC motor as a single module. Its walking motion was generated on-line through three-dimensional linear inverted pendulum mode [3]. Since it effectively represented the whole dynamics of humanoid by the inverted pendulum, walking pattern could be generated online. Moreover, turn and stop motions could be easily generated. Since the width between two z-axis of pelvis was designed to be narrow, it could walk properly with less shakes on hip compared to the previous HSRs' walking. Moreover, initial positioning of its posture was automatically setup by using a photo interrupter and a revolving disk for the DC motor control. RTLinux was used for the control of HSR-VI, and four FSRs per each sole of foot were used to measure the ZMP. HSR-VI had the ability for fully independent sensing, processing, and locomotion.



(a) HSR-VI (b) HSR-VI with PDA head

Fig. 1 HanSaRam-VI

3. HYBRID ARCHITECTURE

The control architecture of HSR-VI in Fig. 2 is composed of two components; one is an embedded computer which generates appropriate walking patterns and the other is a PDA, having CMOS camera, which captures and processes image for localization and object detection.

As the two components of the architecture are implemented independently, walking pattern generation and perception of situation could be performed in parallel.

The situation detector, which is implemented in the deliberative layer in PDA, decides current situation by the relative location of the robot, ground borders, ball, and goal. Subsequently, appropriate path and motion set are generated by path planner and motion planner, respectively. It also selects proper vision modules to use according to the detected situation.

In order to follow the path, appropriate motion procedure is generated by the motion planner, which is also implemented within the PDA. Through the predefined motion set and its elapsing time per each motion, deliberative layer sends proper motion codes to executive layer one by one.

Recognition of the current situation, decision on the next motion set, and process of the images are all performed in the deliberate layer like how humans do so in their head.

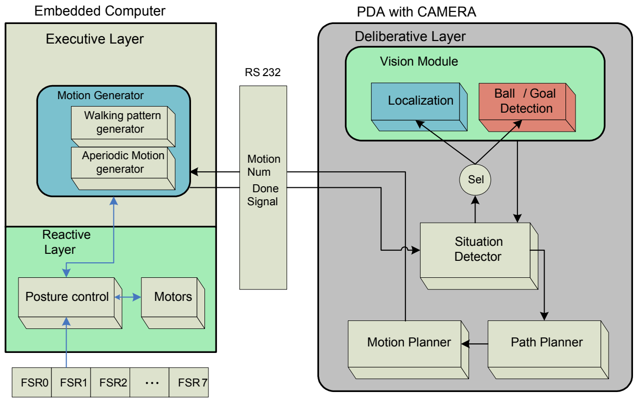


Fig. 2 Hybrid control architecture for HSR-VI

4. VISION SYSTEM

4.1. System structure

In case of the FIRA HuroSot, global vision systems are not approved. Therefore, there are some limitations in the selection of appropriate sensors for the league. Moreover, computing power is also limited by the size of robot body. Therefore, a PDA having CMOS type camera is chosen to decrease the centralized computing cost as a vision processing module.

The image processing module, which is implemented within the PDA, is composed with two sub-modules to localization and detection modules like Fig. 2 Between these two vision processing modules, one is selected according to the state of robot by situation detector, which is also realized in the PDA. Basically, all the used images are captured when the robot is in stable status after completion of procedural behaviors

4.2. Self-localization using landmarks

Fig. 3 shows the whole process of self localization. The purpose of this process is to estimate the position of the robot by finding specific landmarks such as corners of the ground or a goal. If any corner is found in a captured image, relative distance between the robot and the two borders that compose the corner could be computed through Eq. (9). After calculating relative distances against the two perpendicular borders, the goal direction can be determined using suitable heuristics.

For instance, if there was no goal shown on the screen, the robot turns according to the gradient of detected border lines of playground. After finding landmarks such as a corner or a goal, location