Object Interaction of a Humanoid Robot

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Abstract. Teaching a humanoid robot the object identification, object location and object interaction is one of the most challenging tasks in the field of robotics. This paper presents some important improvements for our self-developed humanoid Robot "HWM". A completely new walking control algorithm along with the new object recognition module has been developed to allow the Robot the interaction with an object that has been located. Thereby, the paper describes a cost-effective and easy to implement method of object identification, object location and object interaction for a humanoid robot. Furthermore, software improvements, which are necessary for the proposed hardware changes, are presented.

Keywords: Biped robot, object identifying, object location, walking control.

1 Introduction

Humanoid robots are currently one of the most exciting topics in the field of robotics and many projects on the topic exist for example in [1] and [2]. One of the most important organizations that provides a platform for research groups to develop humanoid robots is the "RoboCup Federation". The well-known goal of this institution is to design fully autonomous humanoid robots, which should be able to win against the human world soccer-champion team by 2050.

Each year championships take place in different countries. Last year, we participated in the RoboCup in the Humanoid Teen Size League in Atlanta. It has been recognized that many units of our Robot need to be updated, especially the image processing unit and the walking control algorithm.

Walking robots have been studied extensively by Behnke [3]. Their famous robots, which are driven by servomotors, perform various actions, including dynamically walking with large steps. Müller described a robot that has been designed for playing soccer in the RoboCup Humanoid League [4]. With a low weight of 2.2 kg and quite a significant speed of 0.2 m/s the robot possesses soccer skills.

Comparing to our Robot, two questions emerge "Can the HWM Robot walk variable step lengths?" and "Is it possible to let the Robot walk curves?" We now focus on the improvements to our Robot so that we will be able to demonstrate the new features on the RoboCup 2009 competition held in Graz, Austria.

2 Previous Work

The Humanoid Walking Machine (HWM) Robot has been created by the robot research group of the Carinthia University of Applied Sciences. This team consists of several student groups and robot interested members of the scientific staff. A student group has built the prototype of the Robot during a one-year lasting project as part of the study program [5]. The Robot is able to stand, balance on each leg and walk in a stable manner on its own.

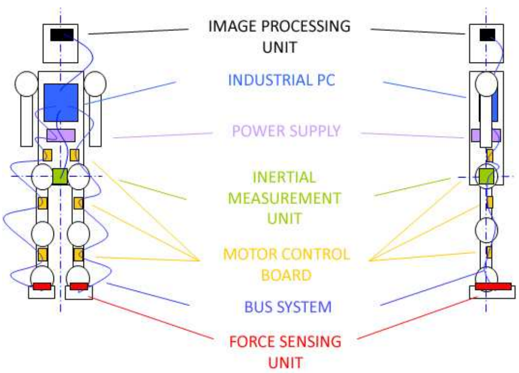

Fig. 1. Architecture of the Robot.

The Robot is based on a distributed architecture as it is shown in Fig. 1. It consists of an Industrial PC and several smaller units, like sensors and actuators as members of the high-speed serial bus. Additionally, an image processing unit and the possibility to communicate with an external PC or laptop over a network interface has been developed.

3 Image Processing

The former image processing unit was constricted because of the use of a static camera. Using this solution, the Robot had to turn in order to change the field of view. This movement had to be turned out relatively slow to prevent the Robot from damaging itself. During the competition in Atlanta, it has been realized that the use of a moveable camera is necessary to allow the Robot recognition of different objects in an adequate time without the need of complex movements.

The Compact Vision System from National Instruments has been used as hardware for the proposed improvements. It consists of an embedded high-performance processer especially designed for image processing tasks [6]. The software has been developed using NI LabVIEW 8.2.1 and NI Vision Assistant 8.2.1.

3.1 Moving Head

To ease the object identification and location, a moveable head has been designed as can be seen in Fig. 2. Two servomotors control the new moveable head. Each motor is capable of driving up to four kilograms load. The pulse width signal is generated by the user programmable, internal FPGA of the CVS. The construction consists of a base plate, an upper mounting that carries the camera and the camera itself. The base plate and the upper mounting are a proprietary design, made of plastics via fused deposition modeling. The camera is a standard FireWire device by Sony. Up to 30 frames are captured per second at a resolution of 640x480 pixels [7].

Fig. 2. The head including camera.

3.2 Object Identification & Location

Because of the used components and software tools from National Instruments, image processing is quite easy. Fig. 3 shows the object identification algorithm that consists of three consecutive blocks. First, the image is converted into a grayscale image. Next, the image is prepared for shape detection. Finally, the shape detection block may find a ball or other predefined objects.

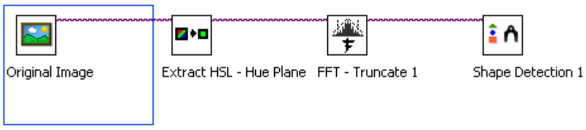

Fig. 3. Used algorithm for object identification.

Moreover, as an output of the algorithm above, the pixel coordinates of the center and the dimensions of an object are returned. To get the real-world coordinates, the new moveable camera is used to center the object in its field of view. Therefore, the image coordinates of a recognized object are transformed into angle values to drive the cam-era directly towards the object. The object then will be in the center of the view and the angles of the head correspond to the angles of the object relative to the Robot. In the case of finding a ball, the distance can now be calculated from the measured diameter of the object. Finally, it may be transferred via a serial connection to the Robots main computing unit. The preprocessed data can now be used for a Robots task, e.g. for generating a walk control pattern.

4 Walking Control

The exact location of an object allows the Robot to generate a path for walking towards the object. This section explains the implemented ideas of our walking control algorithms.

The software for the Robot has been developed in Microsoft Visual Studio .NET 2003 using C/C++ as main programming language and libraries of TenAsys INtime, as it is used as real-time operating system on the Robots embedded industrial PC.

4.1 Variable Step Length

Previously, the walking pattern files have been calculated using Matlab on a desktop PC. Then the files were uploaded onto the Robots flash memory where the software loaded them every time on startup. This method did not allow variable step lengths thus exact positioning was not possible. The variable step length computation has been developed allowing the Robot to walk any distance within a centimeters precision, see Fig. 4. Therefore, the algorithms for interpolating the trajectories developed with Matlab had to be ported to run on the Robots real-time operating system. Now, walking 25 centimeters is split into a step with 17 centimeters, since this the maximum physical step length, and a second step with the remaining 8 centimeters.

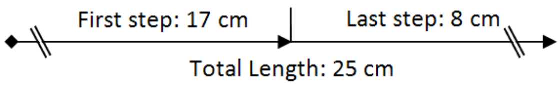

Fig. 4. Variable step length example.

4.2 Curve Walking

Curve walking is a completely new feature of the HWM Robot, allowing the Robot to approach an object without the need of turning itself before. The Robot needs to know the distance and the angle of the object to compute the incremental angle that is added to the twist of each foot during it is lifted. This results in a simple curve walking behavior, as can be seen in Fig. 5.

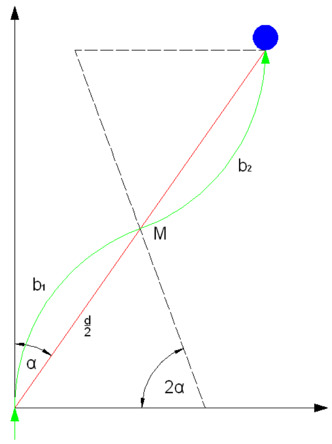

Fig. 5. Schematics of walking towards an object.

The green arrow in lower left corner is the position of the Robot when it locates the blue object. The coordinates are transmitted in polar form, thus the software receives the distance and the angle to the object. The red line corresponds to the shortest distance to the object. However, walking on the red path consumes much time, because the Robot needs to turn to the object. Instead, the Robot will now follow the green course.

5 Results & Discussion

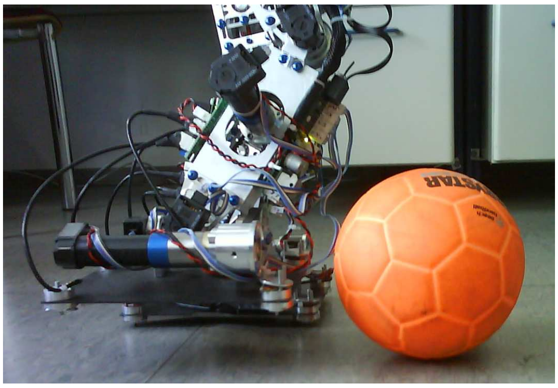

Fig. 6. The Robot is standing in front of the recognized ball.

With the new implemented improved features, object identification, object localization, variable step length and curve walking, the Robot is able to position itself directly in front of the recognized object. The picture in Fig. 6 has been taken moments before the ball was kicked.

Additionally, the feature may be used to prevent the Robot from collision with other objects by avoiding getting too close. A current work concentrates on a more robust head construction and on the extension of the procedure to obstacle avoidance using both new image processing and walk control algorithms.

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