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Communication of Cost Oriented Humanoid Robots

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Abstract: The term "Cost oriented humanoid robots (COHR)" was introduced some years ago, These robots will be able to support humans in everyday life like on the working place, in the household,in leisure and entertainment, and should be available on the market for a reasonable price.

This paper describes a communication method used to operate in industry where multiple robots are required. In this configuration one of the robots is considered as the lead while the other one performs as a follow. The operations performed from the collective operation of the two robots aim to reach a coherence to allow applications that require multiple robots to be performed seamlessly. The development of this work was based on humanoid robots though it can be expanded to any robot platform based on a given application.

Keywords: Humanoid Robot, Synchronized Communication, Cost Oriented Robots.

1. INTRODUCTION

A humanoid robot is a robot with its overall appearance based on that of the human body. Perception, processing and action are embodied in a recognizably anthropomorphic form in order to emulate some subset of the physical, cognitive and social dimensions of the human body and experience. Humanoid Robotics is not an attempt to recreate humans. In general humanoid robots have a torso with a head, two arms and two legs, although some forms of humanoid robots may model only part of the body, for example, from the waist up. Some humanoid robots may also have a 'face', with 'eyes' and 'mouth'. The definition of a humanoid is as simple as "having human characteristics."
The humanoid robots available today can be assigned to three categories:
Professional humanoid robots developed by large companies with a huge amount of research resources, both in turns of people and money. The idea is to develop robots that assist humans in tasks of their everyday life, serve for entertainment, leisure and hobby and can be "personal robots". They are usually very expensive and are only partially available on the market.
Research humanoid robots: The robots in this category are usually prototypes developed by scientists to implement and test new ideas. These types of robots are very popular – approximately 1000 research labs work in the related areas. Theoretical scientists from mechanical engineering implement walking mechanisms, control scientists implement new control strategies, computer scientists implement new ideas in AI and computer vision, social scientists implement human machine interfaces (HMI) for efficient communication between humans and robots. Usually they have a very poor mechanics and a "closed" software.
Humanoid "Toy" robots: There are a lot of humanoid toy robots, mostly developed by small or medium sized companies, available on the market. Usually they have extremely limited capabilities in hard- as well as in software. Because of the limited market and the high price of professional humanoid robots, the availability of research humanoid robots, and the limited capabilities of humanoid toy robots, in this contribution a new fourth category – *Cost Oriented Humanoid Robots (COHR),* was introduced in 2011 (Kopacek (2011).

2. COST ORIENTED HUMANOID ROBOTS

These robots will be able to support humans in everyday life e.g on the working place, in the household, in leisure and entertainment, and should be available on the market for a reasonable price. These goals could be reached by standardisation of the hard- and software platform, using the latest technologies, applying modern control concepts as well as methods of AI for increasing the autonomy of the robots.

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A COHR can be conceived by using industrial components with a robust simple mechanical design, easy operation through flexible programming. The use of such kind of components may decrease the complexity of design. Therefore, low-cost components are a very good expedient for reducing the cost and time of designing humanoid robots. Nevertheless, such a low-cost design will yield to a humanoid robot with limited capability both in mechanical versatility and in more complicated assignments of tasks.

To support humans in everyday life like working place, household, ... , cost oriented humanoid robots (COHR) must have an appropriate size (minimum 1.2m) as well as much more functionality then the currently available toy robots. The software has to be "open" for easy adapting according to the special demands of the user. The price should be not more than the price of a currently available, expensive toy robot. Probably COHR are a first step to one of the oldest dreams of the humans – the Personal Robot. (Linert, Kopacek; 2018).

3. THE BIOLOID ROBOT

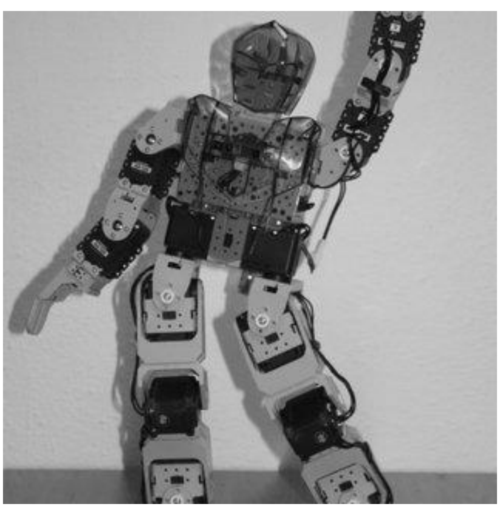

Fig 1. Bioloid humanoid robot (Robotis, 2019)

The Bioloid Premium Robot (Fig.1) is one of the top performing humanoid robots available today. The new CM-530 is the improved version of the CM-5 Bioloid Controller, complete with the new Robo-Plus software that combines the ease of use of 'building-block' style programming with the logic and flow of the 'C' programming language. A 11.1V 3S LiPo battery pack provides a higher operating voltage which results in stronger & quicker performance from the AX-12A Robot Servos. The Bioloid Premium Kit brings all of these features along with a pleasant aesthetic design, providing one of the most functional and comprehensive humanoid robot kits on the market today.

The *Premium Kit* has a microcontroller (CM-530 controller (ARM Cortex -32bit)), 18 servo motors (AX-12+), IR , DMS and Gyro sensors, as well as a sound counter. Furthermore, it can be controlled through a remote controller, either through IR or through ZigBee.

Tab. 1 Specifications Bioloid

Specifications	
Height	39,7 cm
Weight	1,7 kg
Controller/CPU	CM 530 (ARM Cortex 32-Bit)
Operating System(OS)	RoboPlus
Compatible OS	Windows, Android, Mac OS
Programming languages	RoboPlus, C/C++
External Power Supply	12V, 5A
Battery	Lipo 11,1V; 1000 mAh
Operating time	unknown
Degrees of Freedom	18
Sensors	IR (object detection), Touch sensor (contact or impact detection), DMS (measurement of distance between robot and obstacle), Gyro sensor (used to determine angular velocity and therefore adjustment of the servo motors), sound buzzer (alarm clock, melody playing), LED module, Bluetooth communication module
Connectivity	USB, serial
Actuators	Dynamixel AX-12+ (stall torque 1,5Nm at 12V, 1,5A)
Basic functions	Walking, dancing, playing music
Special abilities	29 different robot examples can be built from one kit
Operation	USB to microUSB, buttons on the back, Remote control by IR or ZigBee
Structure and materials	plastic
Languages	unknown
Location	unknown
Constructor	Robotis (South Korea)
Year	2009
Costs	1100-1300€
Aim	Edutainment (schools, university), competition

The humanoid version is built of all 18 actuators (Fig. 2), which can be individually positioned. The robot can be programmed through the provided software called RoboPlus. Data exchange results from connecting the CM-530 controller (ARM Cortex -32bit) through USB to Mini USB cable to the computer. Using a wireless module set it is also possible to use Bluetooth communications. Thereby the robot is also controllable from an Android Phone.

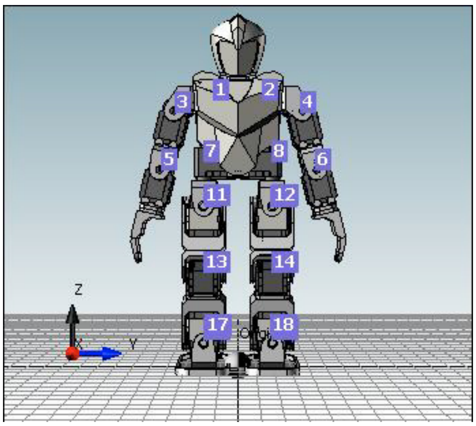

Fig 2. Bioloid Premium DOFs (Robotis, 2019)

4. COMMUNICATION

In this paper, two humanoid robots from Dynamixel (Bioloid) have been used to demonstrate the capabilities of humanoid based synchronized collaborative operation. One of the robots performs as the lead while the other one is the follow. The lead robot generates the required motions for itself as well as the follow robot.

In order to achieve the described scheme, both robots' main controller has been redesigned based on the open source Arduino based Arbotix-M controller shown in Fig. 3, preserving the AX-12A servo motors and the humanoid mechanism from the Dynamixel Bioloid robot (Fig. 1).

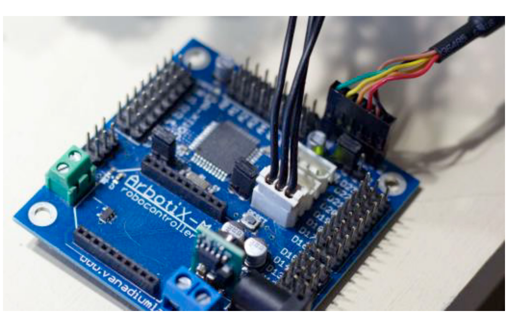

Fig 3. Arbotix-M opensource robot controller (Trossenrobotics 2019)

The motion for both robots has been generated using the open source pypose tool. Both robots' motion has been designed with a global time stamp and stored on the controller of the lead robot.
The communication between the two robots is performed using a pair of XBee 1mW modules shown in Fig 4. The two modules use a 802.15.4 stack to establish a simple serial communication with a 250kbps max datarate, sufficinet for this application. The communication package includes the position angles of each servo motor for the follow robot followed by a CRC-checksum. Upon receiving the data package the follow robot calculates the checksum and compares it with received checksum to assure the accuracy of the incoming data.

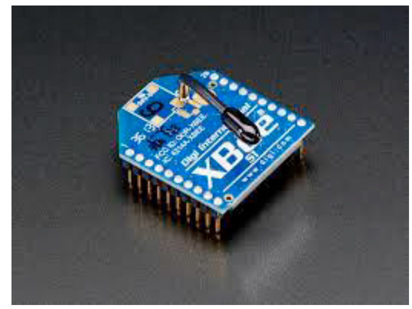

Fig 4. XBee module (Robotshops, 2019)

5. TESTS

5.1 Previous Tests.

The first step for robots to communicate is as a matter of course being able to control each robot separately. A convenient Arduino Mega 2560 was used as replacement because of its low price after one robot did not have a properly working controller whose production was already discontinued. For commanding the robot in this way one had to unchain at least 8 of 18x3 cables of servos and link them to the pins of Arduino, which would cause a pretty cable tangle. For the sake of avoiding this a shield called Smart Arduino Digital Servo Shield for Dynamixel (Fig. 5, a printed integrated circuit to fulfill specific applications with Arduino) was used.

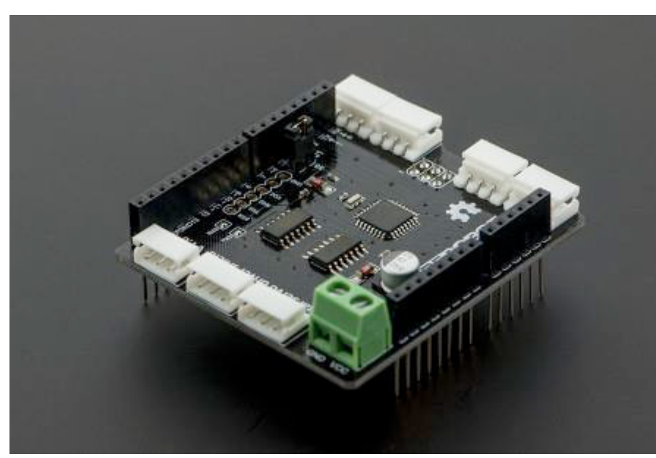

Fig 5. Smart Servo Shield (Dfrobot, 2019)

The aim was to move different servos of the robot in sequence. It worked without big difficulties with one or two servos except the fact that the power supply part of the shield was noticed to be overheated. After adding a third servo to the sequence the bootloader of the shield was damaged. Repeating the same experiment 3 times ,we came to the conclusion that the Arduino controller cannot supply the sufficient power. The power for the servos should be provided externally which would cause the cable tangle we trying to avoid when working with humanoid robots.

5.2 Tests

The robots are able to execute the same kind of movement synchronously. On the other hand it can be handled to establish communication between robots through the operating system software over the remote control of the robots.

The two robots are trying to walk a straight path, holding a stick from the two ends (each robot holds one end). In order to perform this task successfully, both robots need to perform synchronized, temporally and specially.

The experiment was performed successfully as both robots operated synchronized and the task was achieved.

6. SUMMARY AND OUTLOOK

Performing synchronized collaborative tasks using multiple robots has the potential to be used as an alternative for human centric applications. For this sake the communication between robots is from increasing interest. After we are working with COHRs technical capabilities to communication between robots are restricted. There is a software solution for connecting two robots where one acts as master during the other one takes the role of slave. An additional module from Robotis gives the possibility to synchronize the actions of multiple robots.

Other methods to establish a cost oriented communication between robots are subject of currently running research.

Furthermore, because of the cost orientation, these robots could be used also for education in developing countries. This is an example for one of the tasks of TECIS "implementing cost oriented high technology" in such countries.

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