A CRITICAL REVIEW OF DESIGN AND TYPES OF HUMANOID ROBOT

Shailendra Kumar Bohidar[1], Rajni Dewangan[2], Prakash Kumar Sen[3]

[1]*Ph.D. Research Scholar, Kalinga University, Raipur*

[2]*Student of Mechanical Engineering, Kirodimal Institute of Technology, Raigarh (India)*

[3]*Student of M.Tech Manufacturing Management, BITS Pilani*

ABSTRACT

This paper describes the different types of humanoid robot. The interest in assistance- and personal robots is constantly growing. Therefore robots need new, sophisticated interaction abilities. Humanlike interaction seems to be an appropriate way to increase the quality of human-robot communication. Psychologists point out that most of the human-human interaction is conducted nonverbly. The appearance demand for efficient design of humanoid robot, the mechanisms, the specifications, and many kind of humanoid robot are in also introduced.

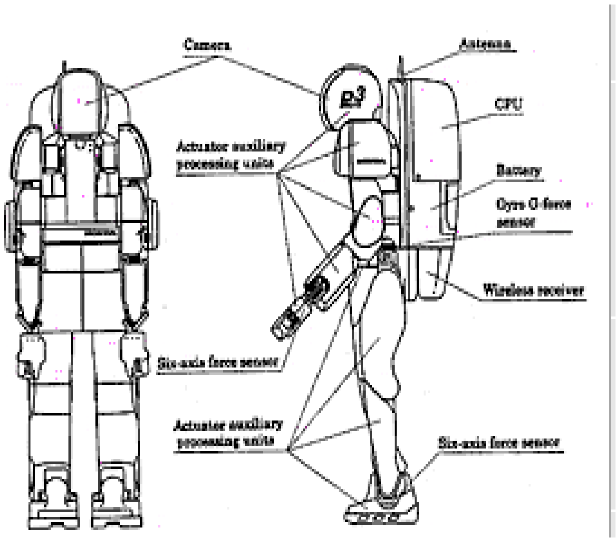
Keywords: Humanoid Robot, Human Robot Interaction, Arm, Leg

I. INTRODUCTION

The recent development of humanoid and interactive robots such as Honda’s [1] and Sony’s [2] is a new research direction in robotics . For many years, the human being has been trying, in all ways, to recreate the complex mechanisms that form the human body. Such task is extremely complicated and the results are not totally satisfactory. However, with increasing technological advances based on theoretical and experimental researches, man gets, in a way, to copy or to imitate some systems of the human body. These researches not only intended to create humanoid robots, great part of them constituting autonomous systems, but also, in some way, to offer a higher knowledge of the systems that form the human body, objectifying possible applications in the technology of rehabilitation of human beings, gathering in a whole studies related not only to Robotics, but also to Biomechanics, Biomimmetics, Cybernetics, among other areas. The development of a humanoid robot in the collaborative research centre 588 has the objective of creating a machine that closely cooperates with humans. The collaborative research centre 588 (SFB588) “Humanoid Robots – learning and cooperating multi-modal robots” was established by the German Research Foundation (DFG) in Karlsruhe in May 2000. The SFB588 is a cooperation of the University of Karlsruhe, the Forschungszentrum Karlsruhe (FZK), the Research Center for Information Technologies (FZI) and the Fraunhofer Institute for Information and Data Processing (IITB) in Karlsruhe. [3]

In 1986, Honda commenced the humanoid robot research and development program . Keys to the development of the robot included "intelligence" and "mobility. **.** Honda began with the basic concept that the robot "should *coexist and cooperate* with human beings, by doing what a person cannot do and by cultivating a new dimension in mobility to ultimately benefit society." This provided a guideline for developing a new type of robot that

would be used in daily life, rather tha a robot purpose-built for special operations. Joint alignment was determined to make it "equivalent" to the human skeletal structure. The movable ranges of joints while walking were defined in accordance with walking test measurements on flat surfaces and stairs.There are several reasons to build a robot with humanoid form. It has been argued that to build a machine with human like intelligence, it must be embodied in a human like body. Others argue that for humans to interact naturally with a robot, it will be easier for the humans if that robot has humanoid form. A third, and perhaps more concrete, reason for building a humanoid robot is to develop a machine that interacts naturally with human spaces. [4]
Humanoid robots are still a young technology with many research challenges. Only few humanoid robots are currently commercially available, often at high costs. Physical prototypes of robots are needed to investigate the complex interactions between robots and humans and to integrate and validate research results from the different research fields involved in humanoid robotics. The development of a humanoid robot platform according to a special target system at the beginning of a research project is often considered a time consuming hindrance. In this article a demand for the efficient design of humanoid robot systems is presented.[5]



II. DEMAND FOR EFFICIENT DESIGN OF HUMANOID ROBOTS

Industrial robots are being used in many manufacturing plants all over the world. This product class has reached a high level of maturity and a broad variety of robots for special applications is available from different manufacturers. Even though both kind of robots, industrial and humanoid, manipulate objects and the same types of components, e.g. harmonic drive gears, can be found in both types, the target systems differ significantly. Industrial robots operate in secluded environments strictly separated from human .
These machines and the tools they use are often designed for a special purpose. High accuracy, high payload, high velocities and stiffness are typical development goals. Humanoid robots work together in a shared space with humans. They are designed as universal helpers and should be able to learn new skills and to apply them to new, previously unknown tasks. Humanlike kinematics allows the robot to act in an environment originally designed for humans and to use the same tools as humans in a similar way.
Human appearance, behaviour and motions which are familiar to the user from interaction with peers make humanoid robots more predictable and increase their acceptance. Safety for the user is a critical requirement. Besides energy efficient drive technology, a lightweight design is important not only for the mobility of the

system but also for the safety of the user as a heavy robot arm will probably cause more harm in case of an accident than a light and more compliant one. Due to these significant differences, much of the development knowledge and product knowledge from industrial robots cannot be applied to humanoid robots.

To investigate these coherences, actual humanoid robots and experiments are needed. Currently only toy robots and a few research platforms are commercially available, often at high cost. Most humanoid robots are designed and built according to the special focus or goals of a particular research project and many more will be built before mature and standardized robots will be available in larger numbers at lower prizes. [6]

III. SOME TYPES OF HUMANOID ROBOT

3.1 Humanoid Robot Hadaly-2

• Hadaly-2 is a new concept Humanoid Robot to realize interactive communication with human. • Hadaly-2 has:

– environment recognition system by its vision,

– conversation system by voice generation and recognition,

– compliant motion system by mechanically compliant arm.

– mobile system by electric wheel.

Hadaly-2communicates with human not only informationally,but also phisically.

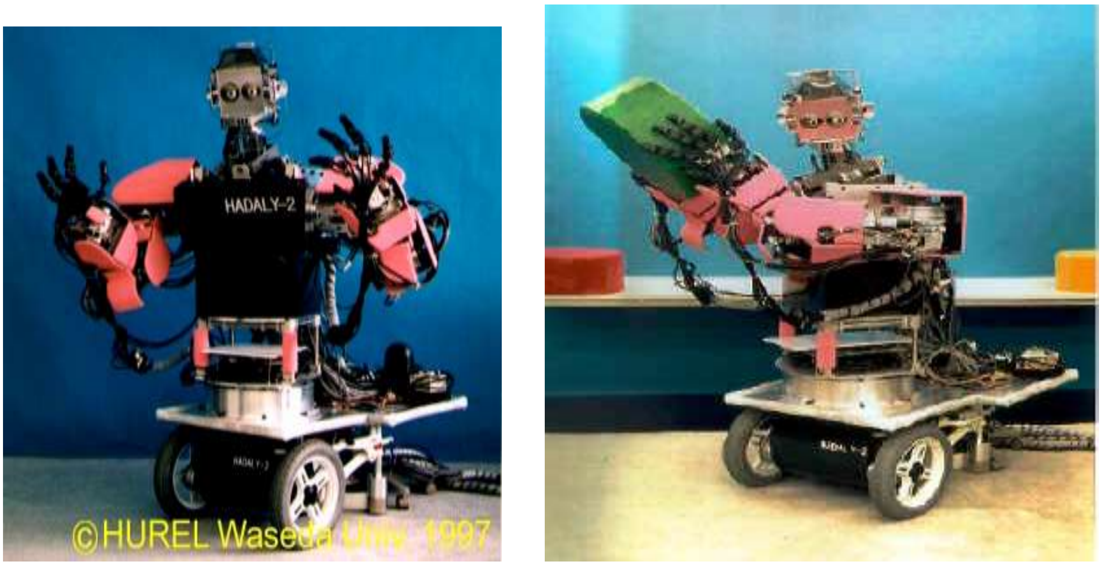


Fig I: Humanoid Robot Hadaly 2

3.2 Design of an Autonomous Humanoid Robot.

3.2.1 The GuRoo Project

The *GuRoo* project in the University of Queensland Robotics Laboratory aims to design and build a 1.2m tall robot with human proportions that is capable of balancing, walking, turning, crouching, and standing from a prostrate position. The target mass for the robot is 30 kg, including on-board power and computation. The robot will have active, monocular, colour vision and vision processing. The intended challenge task for the robot is to play a game of soccer with or against human players or other humanoid robots. To complete this challenge, the robot must be able to move freely on its two legs. It requires a vision sense that can detect the objects in a soccer game, such as the ball, the players from both teams, the goals and the boundaries. It must also be able to manipulate and kick a ball with its feet, and be robust enough to deal with legal challenges from human players.

Clearly, the robot must operate in a completely autonomous fashion without support harnesses or wiring tethers. These goals are yet to be realised for the GuRoo project. Currently the robot exists as a complete mechanical CAD model (see Figure2. 1). The dynamic simulation has been programmed to crouch, jump and balance. The progress to this stage has revealed much about the design considerations for a humanoid robot. [7]

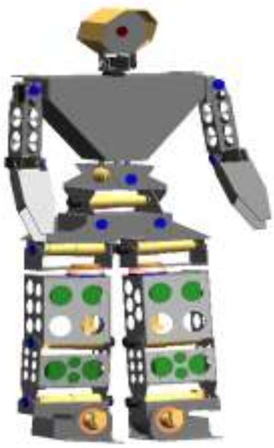


Figure ii(a): Full CAD model of the GuRoo humanoid robot

3.2.2 Bipedal Walking Humanoid Robots

There are few examples of autonomous biped walkers that resemble the structure of a human. The Honda company biped robots, P2 and P3 are two of the few examples of such robot . P3 can walk on level ground, walk up and down stairs, turn, balance, and push objects. The robot is completely electrically and mechanically autonomous. The Sony SDR-3X robot is another example with similar capabilities. [8]

3.2.3 Mechanics of Robot

The mechanical design of the humanoid requires careful and complex tradeoffs between form, function, power, weight, cost and manufacturability. For example, in terms of form, the robot should conform to the proportions of a 1.2m tall human. However, retaining the exact proportions compromises the design in terms of the selection of actuation and mechanical power transmission systems. Affordable motors that conform to the dimensional restrictions have insufficient power for the robot to walk or crouch. This section describes the final mechanical design and how the balance between conflicting design requirements has been achieved. [9]

3.3 Humanoid Robot HRP-2

3.3.1 Specifications of HRP-2

The humanoid robot: HRP-2, which has a ability to walk on narrow paths, to cope with uneven surface, to walk at two third level of human speed (2.5 [km/h]), to lie down, and to get up by a humanoid robot own self. Several distinctive mechanisms such as a cantilever type structure in hip joint and a waist joint mechanism are employed for HRP-2. The design concepts of HRP-2 are light, compact, but performable for application tasks like cooperative works in the open air . As a result, HRP-2 is designed to be feminine size As shown in Figure 3, HRP-2 inherits a mechanical configuration from its prototype HRP-2P. One of unique configurations is that the hip joint of HRP-2 has a cantilever type structure. The other is that HRP-2 has a waist with 2 D.O.F. The reason we designed so will be explained later. Table 1 shows the principal specifications of HRP-2.

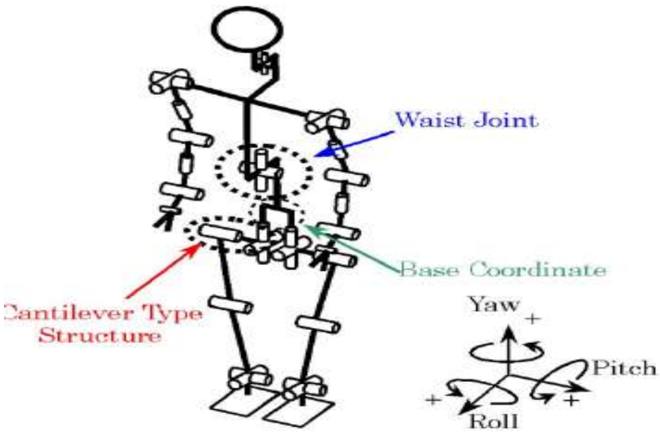


Figure iii. Configuration of HRP-2

Table iii. Principal Specifications of HRP-2

Dimensions	Height	1,539 [mm]
	Width	621 [mm]
	Depth	355 [mm]
Weight inc. batteries		58 [kg]
D.O.F.		Total 30 D.O.F.
	Head	2 D.O.F.
	Arm	2 Arms × 6 D.O.F.
	Hand	2 Hands × 1 D.O.F.
	Waist	2 D.O.F.
	Leg	2 Legs × 6 D.O.F.
Walking Speed		up to 2.5 [km/h]

3.3.2 Friendliness Upgrade

External appearance was designed by a mechanical animation designer to make a human feel friendly for HRP-2.

3.3.3 Performance Upgrade

Cooling systems incorporated in the leg actuators allow enhanced continuous walking endurance. Feet are re-designed for a high stiff structure. Links and axial stiffness are significantly upgraded to improve walking motion and operational performance.

3.3.4 Reliability Upgrade

Electrical device noise was reduced to improve system reliability. Cooling systems were installed in both computer and actuator drive systems to improve temperature control.

3.3.5 Compact-Size Upgrade

Electrical harnesses were made into ICs and specially designed battery units were developed to make the torso even more compact. The details of designs are presented in the followings sections. [10]

3.4 Android type Humanoid Robot Albert HUBO

Albert HUBO is our latest android type humanoid robot shown in Fig. 4. Its height and weight are 137cm and 57Kg. The robot has been upgraded from HUBO (KHR-3) platform. The body frame and the cover of KHR-3 platform are modified to connect with android robot head. The joint controller, motor drive, battery, sensors and main controller (PC) are designed to be installed in the robot itself.[11]

Fig. iv Android type humanoid robot Albert HUBO

TABLE I- SPECIFICATION OF ALBERT HUBO

Research term		2005.3 ~ 2005.11
Weight		57Kg
Height		1.37m
Walking Speed		1.25Km/h
Walking Cycle, Stride		0.95sec/step, 32cm/step
Grasping Force		0.5Kg/finger
Actuator		DC Servo Motor + Harmonic Reduction Gear Unit
Control Unit		Walking Control Unit Servo Control Unit, Communication Unit
Sensors	Foot	3-Axis Force Torque Sensor, Sensors Inclinometer
	Torso	Rate Gyro & Inclination Sensor

Power Section	Battery	6V-10A for servo motors in robot head Li-Polymer 24V-2h for motors and circuits in robot body
	External Power	12V, 24V (Battery and External Power Supply Changeable)
Operation Section		Laptop computer with wireless LAN
Operating System (OS)		Windows XP and RTX
Degrees of Freedom		66 D.O.F (Face and Neck parts: 31 D.O.F, Body part: 35 D.O.F)

IV. CONCLUSIONS

In this paper we described different types of humanoid robots such as Humanoid Robot Hadaly-2.Design of an Autonomous Humanoid Robot, Humanoid Robot HRP-2, Android type Humanoid Robot Albert HUBO .we shall increase the emotional expression patterns and robot behaviors. And, we also shall introduce the behavior model which autonomously determines and outputs the most suitable behavior or emotional patterns according to the situation which is one of the essential functionalities of an intelligent robot to interact with humans .

References

[1]. Y. Sakagami, R. Watanabe, C. Aoyama, S. Matsunaga, N. Higaki, and K. Fujimura, “The intelligent ASIMO: System overview and integration,” in Proc. IEEE/RSJ Int. Conf. Intelligent Robots and Systems, 2002, pp. 2478–2483.

[2]. M. Fujita, “AIBO: Toward the era of digital creatures,” Int. J. Robot. Res., vol. 20, no. 10, pp. 781–794, 2001

[3]. Albers Albert, Brudniok Sven , Sedchaicharn Korkiat, Design of Modules and Components for Humanoid Robots”, University of Karlsruhe (TH), Institute of Product Development Germany.

[4]. M. Chang, B. Browning and G. Wyeth. ViperRoos 2000. RoboCup-2000: Robot Soccer World Cup IV. Lecture Notes in Artificial Intelligence 2019. Springer Verlag, Berlin, 2001.

[5]. T. (2003). Sensomotorische Bewegungskoordination zur Handlungsausführung eines humanoiden Roboters, Dissertation Faculty for Computer Science, University of Karlsruhe (TH)

[6]. Häussler, P.; Emmrich ; D.; Müller, O.; Ilzhöfer, B.; Nowicki, L.; Albers, A. (2001). Automated Topology Optimization of Flexib-le Components in Hybrid Finite Element Multibody Systems using ADAMS/Flex and MSC.Construct, ADAMS European User's Conference, Berchtesgaden, Germany.

[7]. Golden, 1990,J. A. Golden and Y. F. Zheng. Gait Synthesis For The SD-2 Biped Robot To Climb Stairs. International Journal of Robotics and Automation 5(4). Pages 149-159, 1990.

[8]. Hirai, 1998, K. Hirai, M. Hirose, Y. Haikawa, and Takenaka. The Development of Honda Humanoid Robot. IEEE Conference on Robotics and Automation, 1998

[9]. KANEKO Kenji, KANEHIRO Fumio, KAJITA Shuuji , HIRUKAWA Hirohisa Humanoid Robot HRP-2 National Institute of Advanced Industrial Science and Technology 1-1-1 Umezono, Tsukuba, Ibaraki 305-8568, Japan.

[10]. K. Nishiwaki, T. Sugihara, S. Kagami, F. Kanehiro, M. Inaba, and H. Inoue, "Design and Development of Research Platform for Perception- Action Integration in Humanoid Robot: H6", in Proc. IEEE/RJS Int. Conf. on Intelligent Robots and Systems, pp.1559-1564, 2000 .

[11]. Jun-Ho Oh, David Hanson, Won-Sup Kim Design of Android type Humanoid Robot Albert HUBO ,international conference on intelligent robots and systems.