International Journal of Innovative Technology & Adaptive Management (IJITAM)
ISSN: 2347-3622, Volume-1, Issue-8, May, 2014

An Overview on Humanoid and its Current Challenges.

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Abstract.
*A **Humanoid** may be defined as something that resembles or looks like a human and having characteristics like opposable thumb, Ability to walk in upright position etc. Nowadays the concept of Humanoids is being widely implemented in Robotics and these robots are called Humanoid Robots or may be simply "Humanoids".[1]* Humanoids will interact socially with people in typical, everyday environments. We already have robots to do tedious, repetitive labor for specialized environments and tasks. Instead, humanoids will be designed to act safely alongside humans, extending our capabilities in a wide variety of tasks and environments.*[2] A **Humanoid** robot is fully automated as it can adapt to its surroundings and continue with its goals. In this paper, we discuss basic goal of humanoid,[3] mechanism system, design and recent challenges in Humanoids.*

Keywords: *-Humanoid, Robotics, Gynoids.*

1. INTRODUCTION:

Science fiction has led the field of robotics, like so many other disciplines, with visions of technology far beyond the contemporary state-of-the-art. The term "robot" was coined by Czech author Capek in his 1924 production of "Rossum's Universal Robots."[5] The robots were played by human actors, and dealt with the issues of slavery and subjugation that were metaphors for concerns held by human workers of the day. These first robots were also the first humanoids, at least in theater[6].
Humanoid Robotics includes a rich diversity of projects where 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. The goal is not, nor should it ever be, to make machines that can be mistaken for or used interchangeably with real human beings. Rather, the goal is to create a new kind of tool, fundamentally different from any we have yet seen because it is designed to work with humans as well as for them[8].
At present, Humanoid Robotics is not a well-defined field, but rather an underlying impulse driving collaborative efforts that crosscut many disciplines. Mechanical, electrical and computer engineers, roboticists, computer scientists, artificial intelligence researchers, psychologists, physicists, biologists, cognitive scientists, neurobiologists, philosophers, linguists and artists all contribute and lay claim to the diverse humanoid projects around the world. Inevitably, some projects choose to emphasize the form and mechanical function of the humanoid body. Others may focus on the software to animate these bodies. There are projects that use humanoid robots to model the cognitive or physical aspects of humans.[9] Other projects are more concerned with developing useful applications for commercial use in service or entertainment industries. At times, there are deep ideological and methodological differences. For example, some researchers are most interested in using the human form as a platform for machine learning and online adaptation, while others claim that machine intelligence is not necessary. How can we characterize such a broad range of efforts.[10]
Defining a humanoid robot is a lot like defining what it means to be human. Most likely, you'll know one when you see it, and yet have trouble putting the characteristics on paper. The physical constitution of the body is clearly crucial. Not surprisingly, some have chosen to define a humanoid robot as any robot with two arms, two legs and a human-like head. Unfortunately, such a definition says nothing about the ability of this robot to receive information, process it and respond. Moreover, many Humanoid Robotics projects spend the majority of their efforts on a portion of the body such as the head, the legs or the arms.

2. DEFINITIONS OF THE HUMANOID SYSTEM

Form and Function

Humanoids have been played by human actors in the movies, but are quickly being replaced by computer graphics. What remains a constant is that they work around humans safely (or intentionally not), doing tasks originally done by humans, in an urban environment and with tools designed for humans. the definition of the humanoid robot, as we try to balance form and function. The following definition is proposed as a harmony of both:

Humanoids are machines that have the form or function of humans.

3. Ethical Considerations

The world's population of real humans continues to steadily grow. One might ask why we would want to make a machine that looks, thinks and emotes like a human when we have plenty of humans already, many of whom do not have jobs or good places to live. It is important to re-emphasize that humanoids cannot and will not ever replace humans. Computers and humans are good at fundamentally different things. Calculators did not replace mathematicians. They did change drastically the way mathematics was taught. For example, the ability to mentally multiply large numbers, although impressive, is no longer a highly valued human capability. Calculators have not stolen from us part of what it means to be human, but rather, free our minds for more worthy efforts. As humanoids change the contours of our workforce, economy and society, they will not encroach on our sovereignty, but rather enable us to explore and further realize the very aspects of our nature we hold most dear.

So why should we have intelligent, emotion exhibiting humanoids? Emotion is often considered a debilitating, irrational characteristic. Why not keep humanoids, like calculators, merely as useful gadgetry? If we do want humanoids to be truly reliable and useful, they must be able to adapt and develop. Since it is impossible to hard-code high-utility, general-purpose behavior, humanoids must play some role as arbiters of their own development. One of the most profound questions for the future of Humanoid Robotics is, "How we can motivate such development?" Speaking in purely utilitarian terms, emotion is the implementation of a motivational system that propels us to work, improve, reproduce and survive. In reality, many of our human "weaknesses" actually serve powerful biological purposes. Thus, if we want useful, human-like robots, we will have to give them some motivational system. We may choose to call this system "emotion" or we may reserve that term for ourselves and assert that humanoids are merely simulating emotion using algorithms whose output controls facial degrees of freedom, tone of voice, body posture, and other physical manifestations of emotion.

Most likely, two distinct species of humanoids will arise: those that respond to and illicit our emotions and those we wish simply to do work, day in and day out, without stirring our feelings. Some ethicists believe this may be a difficult distinction to maintain. On the other hand, many consider ethical concerns regarding robot emotion or intelligence to be moot. According to this line of reasoning, no robot really feels or knows anything that we have not (albeit indirectly) told them to feel or know. From this perspective, it seems unnecessary to give a second thought to our treatment of humanoids. They are not 'real.' They are merely machines. Most likely, humanoids will never rise up and wrest control from our hands. Instead, we may give it to them, one home, one factory, one nuclear facility at a time until 'pulling the plug' becomes, at first infeasible and then eventually unthinkable. Even now, imagine the economic havoc if we were to disable the Internet. We are steadily replacing the natural world with the products of our own minds and hands. As we continue to disrupt and manipulate the existing state of our world (often for the better), the changes we make require successive intervention. Technologies engender and demand new technologies. Once unleashed, it is difficult to revoke a technology without incurring profound economic, social and psychological consequences. Rather, the problems that arise from new technologies are often met with more complex and daring technologies.

Yet, no matter how quickly technological progress seems to unfold, foresight and imagination will always play key roles in driving societal change. We cannot shirk responsibility by calling the future inevitable. It is difficult to direct a snowball as it careens down the slope; thus, it is now - when there are only a handful of functional humanoids around the world - that we must decide the direction in which to push. Humanoids are the products of our own minds and hands. Neither we, nor our creations, stand outside the natural world, but rather are an integral part of its unfolding. We have designed humanoids to model and extend aspects of ourselves and, if we fear them, it is because we fear ourselves.

4. CURRENT CHALLENGES IN HUMANOIDS

Design, Packaging and Power

There is a high cost of entry into the humanoid research domain. With few or no commercial products, the vast majority of research platforms were built in-house. The immature nature of these systems makes copying them for use by other researchers risky, as these secondary adoption groups will not have the knowledge needed to maintain or evolve them. This will change as packaging and power challenges are overcome by design and the maturation of component technologies. This integrated design work is led by corporate teams, such as Honda, Toyota and Sony, government/corporate teams such as National Institute of Advanced Industrial Science and Technology (AIST), Korea Advanced Institute of Science and Technology (KAIST), National Aeronautics and Space Administration (NASA), and the German space agency Deutschen Zentrum für Luft- und Raumfahrt (DLR), and university-led teams with long traditions in mechatronics such as Waseda, Massachusetts Institute of Technology (MIT), and Technical University Munich (TUM).

Component technology advances have come from beyond the robotics discipline, but these have had a dramatic impact on humanoid design. The development of small, power-efficient computers have made much of the modern robot possible. Humanoids have needed more than computation. Arm and leg embodiment have required torque and power densities that were enabled by lightweight direct current (DC) motors and geared speed reducers. In particular, DC brushless motors and harmonic drives have provided the highest torque densities in electromechanical systems. These high-power limbs have been further made possible by the evolution of modern batteries, able to make these systems self-contained for brief periods of duty. In particular, lithium batteries have enabled robots to carry their own power supplies for locomotion and upper body work. New research continues in hydraulic systems (Sarcos) and low-pressure fluid power (Karlsruhe).

These advanced computers, drive trains, and batteries were not developed by roboticists, but were eagerly adopted. Modern laptops, cell phones, and automobiles have driven these component markets with their large consumer bases. The fact that corporations now producing humanoids include Honda, Toyota and Sony is not a coincidence.

Rather than distinguish humanoids by their physical construction, we choose to identify several complementary research areas that, thus far, have stood out as distinct emphases. Eventually, a fully-fledged humanoid robot will incorporate work from each of the areas below.

4.1. Perception:

This area includes computer vision as well as a great variety of other sensing modalities including taste, smell, sonar, IR, haptic feedback, tactile sensors, and range of motion sensors. It also includes implementation of unconscious physiological mechanisms such as the vestibulo-ocular reflex, which allows humans to track visual areas of interest while moving. Lastly, this area includes the attentional, sensor fusion and perceptual categorization mechanisms which roboticists implement to filter stimulation.

4.2. Human-robot interaction:

This area includes the study of human factors related to the tasking and control of humanoid robots. How will we communicate efficiently, accurately, and conveniently with humanoids? Another concern is that many humanoids are, at least for now, large and heavy. How can we insure the safety of humans who interact with them? Much work in this area is focused on coding or training mechanisms that allow robots to pick up visual cues such as gestures and facial expressions that guide interaction. Lastly, this area considers the ways in which humanoids can be profitably and safely integrated into everyday life.

4.3. Learning and adaptive behaviour :

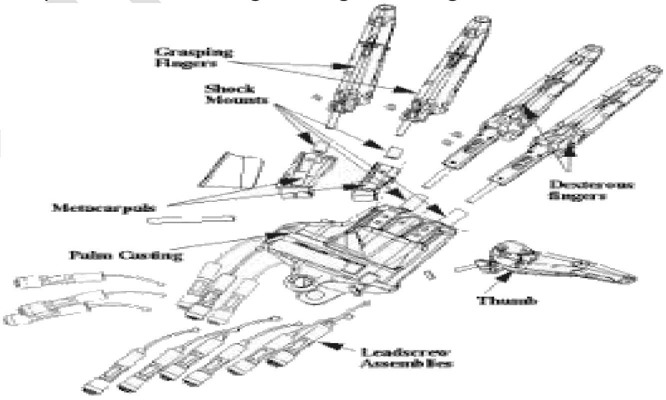
For robots to be useful in everyday environments, they must be able to adapt existing capabilities to cope with environmental changes. Eventually, humanoids will learn new tasks on the fly by sequencing existing behaviors. A spectrum of machine learning techniques will be used including supervised methods where a human trainer interacts with the humanoid, and unsupervised learning where a built-in critic is used to direct autonomous learning. Learning will not only allow robust, domain-general behavior, but will also facilitate tasking by hiding the complexity of task decomposition from the user. Humanoids should be told what to do rather than how to do it.

4.4. Legged locomotion:

For humanoids to exploit the way in which we have structured our environment, they will need to have legs. They must be able to walk up stairs and steep inclines and over rough, uneven terrain. The problem is that walking is not simply a forwards-backwards mechanical movement of the legs, but a full-body balancing act that must occur faster than real-time. The best approaches look closely at the dynamics of the human body for insight.

4.5. Arm control and dexterous manipulation:

Around the world, researchers are working on dexterous tasks including catching balls, juggling, chopping vegetables, performing telesurgery, and pouring coffee. From a mechanical point of view, robot arms have come a long way, even in the last year or so. Once large and heavy with noisy, awkward hydraulics, some humanoids now have sleek, compliant limbs with high strength to weight



ratios. While mechanical innovation will and should continue, the real hard problem is how to move from brittle, hard-coded dexterity toward adaptive control where graceful degradation can be realized. The humanoid body functions as a whole and consequently, small errors in even one joint can drastically degrade the performance of the whole body.

The University of Tokyo Department of Mechano-Informatics has developed a humanoid robot, Saika, with a two-DOF neck, dual five-DOF upper arms, a torso and a head. Saika is able to dribble a bouncing ball and catch a thrown ball. It can grope for and grasp unknown objects. Whereas many humanoids are heavy and require large, unwieldy off-board apparatus for actuation, Saika is designed to be lightweight and has almost all the motors built into the arms and torso. The head, torso and arms together weigh less than 17 pounds.

4.6. Bipedal Walking

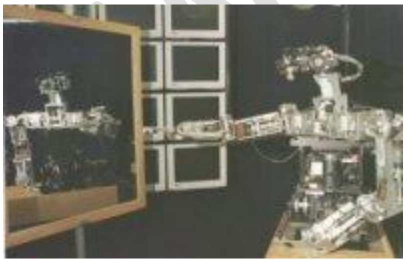
The majority of the biped walking systems are humanoid in form, and use the Zero Moment Point (ZMP) algorithm (Vukobratovic and Frank, 1969, Vukobratovic et al., 1970). In this algorithm, the tipping point of the system is managed forward or backwards to walk. Many of the most famous humanoids have pioneered the implementation of the ZMP algorithm. The robots at AIST Tsukuba and AIST Waterfront have used wheeled gantries as a safe testbed for developing and refining the ZMP walking systems. The Honda systems have many generations of success.

4.Wheeled Lower Bodies

Several labs are building new forms of lower bodies that use wheels for locomotion. These systems typically have small footprints, to allow their upper bodies to "overhang" the lower body and allow for interaction with the environment. Examples include statically stable wheeled bases, and dynamic balancing systems like a Segway. Three examples are shown in the figure below.

Mobile manipulation is achieved when combining a lower body able to position itself with ease, and a dexterous upper body able to perform value-added work. While this combination is not necessarily humanoid, people are ideal examples of mobile manipulators. Active balancing bases or legs have small footprints, allowing their upper limbs to get close to the environment, while maneuvering in tight urban environments. Dual and dexterous upper limbs offer primate-like workspace and grasping abilities that can work with the interfaces and objects in those same urban environments. This class of machine can redistribute force and position control duties from lower bodies to upper bodies, where differences in drive trains and sensors offer complimentary capabilities.

Research Issues



Cog, a humanoid developed at the MIT AI laboratory learns to recognize and respond to animate agents (including itself).

Will humanoid research propel robotics on to great heights, channeling ideas from diverse fields toward an ultimate goal? Or will the quest to model ourselves prove to be a stumbling block, or worse? We may be our best models of intelligence; but then again, we may also be our worst. Although cognitive neuroscience will continue to contribute much to our self-understanding, we by no means fully appreciate the myriad internal processes that actually produce our intelligence. Roboticist Rodney Brooks has long argued that our view of how we think and act is tainted with subjectivity. [8] We cannot wholly transcend our biased perspective. The best we can do is to neutralize its effect by bringing humanoid bodies in line with our own. Most likely, we will never fully understand, much less recreate everything that it means to be human. As the frontiers of our self-understanding expand, humanoid robots may simply follow (and, at times, propel) our continuously changing conception of what we are

A fully capable and embodied humanoid makes a strong research testbed. Such a system can serve to answer the following questions:

• What are the best leg, spine and upper limb arrangements, in both mechanisms and sensors, to enable energy-efficient walking?

• How should robots represent knowledge about objects perceived, avoided and handled in the environment?

• What are the algorithms for using upper body momentum management in driving lower body legs and wheeled balancers?

• How can a mobile manipulation robot place its body to facilitate inspection and manipulation in a complex workspace, where a small footprint and high reach requirements collide?

• How should vision/laser based perception be combined with tactile/haptic perception to grasp objects?

• What roles do motion and appearance have in making people accept and work with robots?

• How can people interact with humanoids to form effective and safe teams?

5. Applications

In every lab visited, the discussion turned to the question, "What is the killer app?" for humanoids. This slang phrase was used in all countries. In Japan, the work was motivated by support of the "Silver Society," a term used in several labs to describe the technology needs of an aging population. The humanoid form and function was proposed as ideal for this market, with Japan's cultural tendency to embrace robots and technology in general producing a "pull." Since our study tour, Waseda has demonstrated lifting a person from a bed, as would be needed in a nursing home.

In Korea, we were regularly welcomed with a description of the national programs for technology, where robotics was selected as one of the key technologies for advancing their national gross national product (GNP). This top-down strategy, and national goal, was unique in the world. Korean researchers were deeply interested in ubiquitous systems, and were looking at humanoids as a component of urban technology designed for service tasks.

A brief listing of applications being pursued by humanoid researchers includes:

• *Military & Security* Search and rescue, mine/improvised explosive device (IED) handling, logistics, and direct weapons use

• *Medical* Search and rescue, patient transfer, nursing, elder care, friendship

• *Home Service* Cleaning, food preparation, shopping, inventory, home security

• *Space* Working safely with space-walking astronauts, caretakers between crews

• *Dangerous Jobs* Operating construction equipment, handling cargo, firefighting, security

• *Manufacturing* Small parts assembly, inventory control, delivery, customer support.

6. Conclusions

This paper describes the form and function, and current challenges in Humanoids. Humanoids are now being developed in Asia, the U.S., and Europe, though a clear business plan has yet to emerge.

The lack of a clear business plan will not limit interest and investment in humanoids for two reasons. First, there is an emotional and cultural drive towards building machines that look and work like humans. Many of the current prototypes are viewed as "mascots," as symbols of the future and their developer's quest to lead. Wherever humanoids go, they will evoke strong emotions and opinions, from love to hate. But the drive to build them is strong, and not motivated by economics in the near term.

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