Humanoid Robots – From Fiction to Reality?

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Humanoid robots have been fascinating people ever since the invention of robots. They are the embodiment of artificial intelligence. While in science fiction, human-like robots act autonomously in complex human-populated environments, in reality, the capabilities of humanoid robots are quite limited. This article reviews the history of humanoid robots, discusses the state-of-the-art and speculates about future developments in the field.

1 Introduction

Humanoid robots, robots with an anthropomorphic body plan and human-like senses, are enjoying increasing popularity as research tool. More and more groups worldwide work on issues like bipedal locomotion, dexterous manipulation, audio-visual perception, human-robot interaction, adaptive control, and learning, targeted for the application in humanoid robots.

These efforts are motivated by the vision to create a new kind of tool: robots that work in close cooperation with humans in the same environment that we designed to suit our needs. While highly specialized industrial robots are successfully employed in industrial mass production, these new applications require a different approach: general purpose humanoid robots. The human body is well suited for acting in our everyday environments. Stairs, door handles, tools, and so on are designed to be used by humans. A robot with a human-like body can take advantage of these human-centered designs. The new applications will require social interaction between humans and robots. If a robot is able to analyze and synthesize speech, eye movements, mimics, gestures, and body language, it will be capable of intuitive communication with humans. Most of these modalities require a human-like body plan. A human-like action repertoire also facilitates the programming of the robots by demonstration and the learning of new skills by imitation of humans, because there is a one-to-one mapping of human actions to robot actions.

Last, but not least, humanoid robots are used as a tool to understand human intelligence. In the same way biomimetic robots have been built to understand certain aspects of animal intelligence, humanoid robots can be used to test models of aspects of human intelligence.

Addressing all of the above areas simultaneously exceeds the current state of the art. Today's humanoid robots display their capabilities in tasks requiring a limited subset of skills. After some brief historical notes, this article will review the state-of-the-art in humanoid robotics and discuss possible future developments.

2 History

The concept of human-like automatons is nothing new. Already in the second century B.C., Hero of Alexander constructed statues that could be animated by water, air and steam pressure. In 1495 Leonardo da Vinci designed and possibly built a mechanical device that looked like an armored knight. It was designed to sit up, wave its arms, and move its head via a flexible neck while opening and closing its jaw. By the eighteenth century, elaborate mechanical dolls were able to write short phrases, play musical instruments, and perform other simple, life-like acts.

In 1921 the word robot was coined by Karel Capek in its theatre play: R.U.R. (Rossum's Universal Robots). The mechanical servant in the play had a humanoid appearance. The first humanoid robot to appear in the movies was Maria in the film Metropolis (Fritz Lang, 1926). Westinghouse Electric Corporation exhibited at the 1939 and 1940 World's Fairs the tall motor man Elektro. Humanoid in appearance, it could drive on wheels in the feet, play recorded speech, smoke cigarettes, blow up balloons, and move its head and arms. Elektro was controlled by 48 electrical relays and could respond to voice commands.

Humanoid robots were not only part of the western culture. In 1952, Ozamu Tezuka created Astroboy, the first and one of the world's most popular Japanese sci-fi robots. In 1973 the construction of a human-like robot was started at the Waseda University in Tokyo. Wabot-1 was the first full-scale anthropomorphic robot able to walk on two legs. It could also communicate with a person in Japanese and was able to grip and transport objects with touch-sensitive hands. The group of Ichiro Kato also developed Wabot-2, which could read music and play an electronic organ. It was demonstrated at the Expo 1985 in Tsukuba, Japan. Wabot-2 was equipped with a hierarchical system of 80 microprocessors. Its wire-driven arms and legs had 50 degrees of freedom.

Many researchers have also been inspired by the movie Star Wars (George Lucas, 1977) which featured the humanoid robot C3-PO and by the TV series Star Trek - The Next Generation (Gene Roddenberry, 1987) which featured the humanoid Data.

In 1986 Honda began a robot research program with the goal that a 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." After ten years of research, Honda introduced in 1996 P2 to the public, the first self-contained full-body humanoid. It was able to walk not only on flat floors, but could also climb stairs. It was followed in 1997 by P3 and in 2002 by Asimo.