UNIT V AI AND OTHER RESEARCH TRENDS IN ROBOTICS

5.6 Humanoid robots

Humanoid robots have been assisting humankind in various capacities. They have been broadly used in the field of Healthcare, Education, and Entertainment. A humanoid robot is a robot that not only resembles the human's physical attributes, especially one head, a torso, and two arms, but also can communicate with humans, take orders from its user, and perform limited activities. Most humanoid robots are equipped with sensors, actuators, cameras, and speakers. These robots are typically preprogrammed for specific actions or have the flexibility to be programmed according to the user requirement.

Generally, humanoid robots are designed according to their intended application.

Based on applications, humanoid robots can be broadly categorized into Healthcare, Educational and Social humanoid robot.

Healthcare humanoid robots are designed and used by individuals at home or healthcare centres to treat and improve their medical conditions. These robots either require a human controller or are pre-programmed to assist patients.

Educational humanoid robots are primarily designed and equipped for students and are used in education centres or home to improve education quality and increase involvement in studies. These robots are typically but not always manually controlled robots.

Social humanoid robots are used by individuals or organizations to help and assist people in their daily life activities. These robots are commonly pre-programmed to perform mundane tasks and are also known as assistive robots.

History and Overview

There is a long history of mechanical systems with human form that perform human-like movements. For example, Al-Jazari designed a humanoid automaton in the 13th century , Leonardo da Vinci designed a humanoid automaton in the late 15th century and in Japan there is a tradition of creating mechanical dolls called Karakuri ningyo that dates back to at least the 18th century In the 20th century, animatronics became an attraction at theme parks. For example, in 1967 Disneyland opened its Pirate's of the Caribbean ride which featured animatronic pirates that play back human-like movements synchronized with audio. Although programmable, these humanoid animatronic systems moved in a fixed open-loop fashion without sensing their environment.

In the second half of the 20th century, advances in digital computing enabled researchers to incorporate significant computation into their robots for sensing, control, and actuation. Many roboticists developed isolated systems for sensing, locomotion, and manipulation that were inspired by human capabilities. However, the first humanoid robot to integrate all of these functions and capture widespread attention wasWABOT-1, developed by Ichiro Kato et al. at Waseda University in Japan in 1973 .

The WABOT robots integrated functions that have been under constant elaboration since: visual object recognition, speech generation, speech recognition, bimanual object manipulation, and bipedal walking.

WABOT-2's ability to play a piano, publicized at the Tsukuba Science Expo in 1985, stimulated significant public interest. In 1986,Honda began a confidential project to create humanoid biped.

In parallel with these developments, the decade long *Cog project* began in 1993 at the MIT Artificial Intelligence laboratory in the USA with the intention of creating a humanoid robot that would, *learn to 'think' by building on its bodily experiences to accomplish progressively more abstract tasks.* This project gave rise to an upper-body humanoid robot whose design was heavily inspired by the biological and cognitive sciences. Since the inception of the Cog project, many humanoid robotics projects with similar objectives have been initiated, and communities focused on developmental robotics, autonomous mental development (AMD) and epigenetic robotics have emerged.

As of the early 21st century, many companies and academic researchers have become involved with humanoid robots, and there are numerous humanoid robots across the world with distinctive features.

Different Forms

Today, humanoid robots come in a variety of shapes and sizes that emulate different aspects of human form and behaviour. As discussed, the motivations that have driven the development of humanoid robots vary widely. These diverse motivations have lead to a variety of humanoid robots that selectively emphasize some human characteristics, while deviating from others. One of the most noticeable axes of variation in humanoid robots is the presence or absence of body parts. Some humanoid robots have focused solely on the head and face, others have a head with two arms mounted to a stationary torso, or a torso with wheels), and still others have an articulate and expressive face with arms, legs, and a torso. Clearly, this variation in form impacts the ways in which the robot can be used, especially in terms of mobility, manipulation, whole-body activities, and human–robot interaction.

Different Degrees of Freedom

Humanoid robots also tend to emulate some degrees of freedom in the human body, while ignoring others. Humanoid robots focusing on facial expressivity often incorporate actuated degrees of freedom in the face to generate facial expressions akin to those that humans can generate with their facial muscles. Likewise, the upper body of humanoid robots usually includes two arms, each with a one-degree-of-freedom (one-DOF) rotary joint at the elbow and a three-DOF rotary joint for the shoulder, but rarely attempt to emulate the human shoulder's ability to translate or the flexibility of the human spine .

In general, humanoid robots tend to have a large number of degrees of freedom and a kinematic structure that may not be amenable to closed-form analysis due to redundancy and the lack of a closed-form inverse. This is in contrast to traditional industrial manipulators that are often engineered to have minimal redundancy (six DOFs) and more easily analyzed kinematic structures.

Different Sensors

Humanoid robots have made use of a variety of sensors including cameras, laser range finders, microphone arrays, lavalier microphones, and pressure sensors.

Some researchers choose to emulate human sensing by selecting sensors with clear human analogs and mounting these sensors on the humanoid robot in amanner that mimics the placement of human sensory organs. Two to four cameras are often mounted within the head of a humanoid robot with a configuration similar to human eyes.

The justifications for this bias towards human-like sensing include the impact of sensing on natural human–robot interaction, the proven ability of the human senses to support human behaviour, and aesthetics. For example, with respect to human–robot interaction, nonexperts can sometimes interpret the functioning and implications of a human-like sensor, such as a camera, more easily. Similarly, if a robot senses infrared or ultraviolet radiation, the robot will see a different world than the human. With respect to behaviour, placement of sensors on the head of the robot allows the robot to sense the world from a van tage point that is similar to that of a human, which can be important for finding objects that are sitting on a desk or table.

Prominent humanoid robots have added additional sensors without human analogs. For example, Kismet used a camera mounted in its forehead to augment the two cameras in its servoed eyes, which simplified common tasks such as tracking faces. Similarly, versions of Asimo have used a camera mounted on its lower torso that looks down at the floor in order to simplify obstacle detection and navigation during locomotion.

Other Dimensions of Variation

Other significant forms of variation include the size of the robot, the method of actuation, the extent to which the robot attempts to appear like a human, and the activities the robot performs.