ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 5, Issue 1, January 2018

Humanoid Robot: A Review of the its Architecture and Applications

[1] Usha Chauhan
[1] Department Of Electronics and Communication Engineering
Galgotias University, Yamuna Expressway Greater Noida, Uttar Pradesh
[1] gu1413912423@Galgotiasuniversity.edu.in

Abstract:As robotics advances, exoskeleton technology has come a long way since its beginnings in the late 60's. Scientists around the world have created their own designs of exoskeletons and some of the well-known exoskeletons include BLEEX, MIT exoskeleton, HAL, LOPES, ALEX and more. Although technology has improved since the 1960s, the exoskeleton design still faces challenges. In this study we will review various exoskeleton technologies as well as their role in the rehabilitation area. A humanoid robot is generally defined as a programmable machine which can imitate the actions as well as the appearance of human. A humanoid robot has two main functions, which are the ability in acquiring information from its surrounding and the ability to carry out physical work such as moving or manipulating objects. After years of research and study, the available humanoid robots nowadays have different sizes, weights,heights which are related to their several applications.

Keywords: Bioloid, Fuzzy logic, humanoid robot, Locomotion,Robot architecture and Robotic applications.

INTRODUCTION

Humanoid robots[1] behave as a human, where by moving their eyelids and mouths they can convey their emotion (Fig. 1). These also have hands and legs so that they can perform various tasks like humans and even have the ability to learn new information by using sensors and other such artificial intelligence technologies. In short, humanoid robot is in reality a robot fitted with sensors to perceive its environment and its effectors to perform an action. This research analysis was divided into three main sections: the architecture, applications and the pattern to come. The first segment deals with the hardware or device used for the humanoid robot. The humanoid robot has four main criteria that are robot head, facial expressive, robot eye, robot locomotion, and robot learning behavior. The second part of this paper deals with how humanoid robots are used in different fields such as home operation, entertainment, health care, sport, space exploration, construction, manufacturing and education. The final part addresses the future theme of the humanoid robot.

Fig. 1: Humanoid

ARCHITECTURE

A humanoid robot is a machine like a human duplicate. A humanoid robot[2] will appear as a human being and behave as a human being. Nowadays, with the development of the technology, the appearance and behavior of the humanoid robot is becoming increasingly similar to human. The following subsections discuss the technology being invented to make the robot look humanoid:

Facial expressive robot head:

The research on humanoid robot focuses on the interaction between human and robot. In order for a humanoid robot to act just like a human, the communication ability is always the important one. In our daily human-human communication, we always communicate to each other through facial expression, gestures with arms and hands, speech and other body language. These actions are carried out by humans easily and was started to practice since early childhood. In human-robot communication, we wish the robot can perform like what we are performing. Therefore, some researchers started to design the humanoid robot[3] of mimicking human behavior. The ability to express emotions in face is one of the important characteristics of human beings. Expression determines the personal characteristic in daily human communication, and it improves the effectiveness of communication. We always hope to communicate in a similar manner with robots as humans do. Researchers have therefore developed facial expressive robotic head systems e.g., the Robot Face character. In Japan, a human-like head robot named WE3RV was developed. The emotion of human such as happiness and anger is defined and loaded into the robot. When the robot has detected the external stimuli by using sensors, the information will be converted and the robot will express the emotion by moving the different parts on the face including eyebrows, ears, eyelids, lips and mouth like human. A robot called Kismet, for example, developed in Cambridge that can perform a variety of proto-social responses using CCD camera technology and can display expressions just like humans. The biggest challenge is that a humanoid robot's speech range isn't sufficiently covered. For instance, human happiness can be further divided into many different levels and each level of happiness has its own unique language. Human-like head robot development continues to advance so that the range of speech is close to that of man. Gazing is also a very important action in contact with humans.

Robot hand:

Hand is one of the important organs of a human in carrying out daily task. Without hands, human will not complete a task in an efficient way. This is also applied to a humanoid robot, so hands are equipped to a humanoid robot. The human hand is a complex system which is very difficult to be replicated in its performance and features. The important characteristics of the artificial hand that replicates human hand for a humanoid robot are the weight, dimensions, minimum number of fingers, essential degrees of freedom of the fingers[4] and others. The researches have carried out extensively in developing the artificial hand based on the important characteristics that gives the essential function to the hand which are usually driven by DC motors. Human's hand can perform different type of tasks with fingers. Human can control fingers easily because they have been awarded the skill since they were born. However, for a humanoid robot, it is very difficult to execute the action in order to carry out tasks such as stably pinching paper or needle with finger tips. A robot with four fingers, each having three degrees of freedom, has been developed for high performance remotemanipulation. However, the manipulation technique is still in the development stage. In Japan, researcher has made the robot's hand to pinch up the paper. They have added additional degrees of freedom of independent motion to the terminal fingers and the degrees of freedom of twisting motion to the thumb.

Robot locomotion:

As a human it is easy to walk by legs; however, introducing it to a humanoid robot is not an easy task. Today's humanoid robots[5] use bipedal locomotion technology. There are currently two approaches that are used in the bipedal walking field and one is the Zero-Moment Point Theory (ZMP). ZMP is known as the point on earth where at the net moment of inertial and gravity powers there are no part along the axes parallel to the ground. ZMP's trajectory plays an important role in directing the robots while walking. For a feasible walking pattern, the ZMP trajectory must lie within the supporting polygon defined by the location and shapes of the supporting feet.

There are a lot of humanoid robots are designed based on ZMP-based control, for example the Asimo by Honda and WABIAN bipedal humanoid robot developed in Japan. Another humanoid robot named QRIO was also developed in Japan. Apart from walking, it can perform activities such as running and jumping. The researchers used the ZMP stability criterion in order to achieve stable run and jump. It demonstrated the humanoid robot's motion is more human-like with this technology. Another approach is the passive dynamic walking method which introduced by McGeer. This method allows the humanoid robot walks down a slope without motors or controllers. The energetic efficiency of the robot using this method is higher and it is easy to control with the foot contact sensors. However, there are some limitations for this technology such as the inability to stand still due to the round feet used, the inability to start or stop walking and inability to change the speed and direction. Therefore, some improvements have been carried out such as installing the actuators to the walking robots and installing direct drive or elastic actuators at some of the joints of the biped of the robot.

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 5, Issue 1, January 2018

Robot learning behavior:

A humanoid robot with facial expression and hand gestures is able to communicate to humans. It may even use its hand to hold things and move from place to place. All of these in our daily activities are still not adequate, however, the humanoid robot should be able to adapt existing capabilities, cope with changes, and quickly learn new skills.

Several methods can be added to the humanoid robot to meet the requirement, such as learning to imitate. Learning imitation[6] involves repeating the motion instantly and maintaining it in mind when a motion is shown by a third party. The external motion captures system for humanoid robots which is dependent on special sensors. There are called markers that used to sense the motion. A humanoid robot sometimes has trouble mimicking human actions. For example, due to limitations of the joint angle or dynamic constraints, as well as lack of joints, certain human movements cannot be mimicked by the robot. There is another related method, called demonstrate programming.

The technique that optimizes the humanoid robot's learning behavior is reinforcement learning. This method allows a humanoid robot to improve their actions when it comes to sequential decision-making. Through this approach the robot's action will be strengthened as the disturbing step-by-step programming has been removed. There are a variety of strategies implanted with Decision Trees in this technique, such as reinforcement learning. Through model learning this approach will be actively generalized, so that the number of tests needed for testing will be reduced. Several studies applied the task of reinforcing learning in a discreet, low-dimensional state space.

APPLICATIONS

The development of humanoid robot advances from time to time. In the past, the humanoid robot is only used in home applications and for entertainment. However, the continuous improvement process of technology, nowadays, the humanoid robot can be applied in many fields such as healthcare, sport, space exploration, construction and industry and even education.The applications of humanoid robot in different fields are discussed in the following sections.

- Home applications:

This is the age in which people are busy with the job and always leave unoccupied their house. So in their absence there's a need to have a robot to look after their home. Researchers in Japan had therefore developed a system that allows users to remotely control one or more humanoid robots in their homes[7] with a mobile phone or the internet. It lets the users understand the conditions on the site of the device. Users can predefine certain locations in the house and assign certain operations to the robot, so that the humanoid robot can walk to the predefined locations and perform tasks based on the user's requirement while the house is unoccupied.

- Entertainment:

The humanoid robots are becoming more and more common for entertainment too. The humanoid robots are very strong with the facial expression, hand gestures and other body languages in contact with the human. Most humanoid robots are being built for the entertainment application. One example of this is the small humanoid robot form, SDR-4X. It has the ability to walk on the unbalanced surface and can avoid obstacles when walking in the home environment of the real world. SDR-4X's output involves energetic and smooth dancing and is composed of a program called SDR Motion Creator.

- Healthcare:

Humanoid robots have the human-like characteristics such as walking in a biped way and communicating with people just like people. Humanoid robot can be used in hospital as a service robot to assist nurses and patients in their activities, as well as helping people in the remote site communicate with people in hospital. In hospital, humanoid robot has become the avatar of the nurse because the robot can speak and understand the patient's needs. Humanoid robot helps to move patients which are inconvenient for the patient[8]. Also, patients can communicate to robot and view the robot as another user existence. Autism is one of the most common developmental disorders. Autism is one of the pervasive developmental disorders. There are many children with autism may have difficulties in their daily activities such as communication, social interaction and imagination. In this matter, robots can be used as the therapeutic tool.

There are two different types of humanoid robots which are especially developed to help the children with autism. The two humanoid robots are IROMEC and KASPAR. IROMEC is a mobile robotic platform and it has got an interface with a cartoon-like character. KASPAR is a small scale humanoid robot. Both humanoid robots engage children with autism in social interaction and communication skills.

- Sport:

Sport is yet another important human operation. For this reason researchers are also researching the probability of participation in sport by a humanoid robot. Quick and versatile walking is an important criterion for a humanoid robot playing in Robocop soccer. The main challenge to do so is the instability. The researcher proposed a new fuzzy-logic[9] control scheme to solve this problem, which allows the robot to achieve fast and flexible walking as well as high stability turning. This can be done by walking in incline and carefully setting the length of the step. A fuzzy algorithm is used to find the correct joint angle so that the robot responds correctly in different body circumstances.

- Space:

Another field in which the humanoid robot started to penetrate is the application in space. The researchers started to study the suitability of humanoid robot in replacing human to enter the space. It is because the human life support in space is very costly and space missions are always dangerous. The researchers have a vision to make humanoid robots in replacing human in future space exploration.

- Construction and industry:

Replacing humans with humanoid robots is necessary for dangerous work in the field. Building machinery and equipment, for example, play an important part in many on-site activities. Very often, when working the machinery and equipment, human proximity to the hazardous. If the machinery and equipment can be controlled by a humanoid robot and the robot can be communicated from a remote site then it will solve the problem of dangerous jobs. Humanoid robot also plays an important role in a disaster zone, where some large and heavy items need a construction machine to move away. Operating in a site of a catastrophe is dangerous to a human operator. The researchers created a humanoid in Japan.

- Education:

In addition to the above applications, several researchers have begun moving into the schooling. The robot manufacturer named Robotics in Korea has built a humanoid robot called Bioloid[10]. Bioloid is a hobbyist and educational robot kit aimed at providing students with an interactive learning environment to serve as a teaching assistant. The researcher also suggested to teachers an IDML method to produce teaching materials, and to schedule the motion of the humanoid robot. In addition, IDML tools provide students with a forum for communicating with the humanoid robot, including some learning activities. Bioloid, the educational robot, gives students a good impression and is able to capture the study.

CONCLUSION

Humanoid robot is a very interesting field of study with its ability to get information from its surroundings and perform physical work just like human beings. Using the facial expressive head, hands, body and legs, the general concept of humanoid robot uses different type sensors to acquire information and perform different tasks based on the information obtained. In the last four decades, the research of humanoid robot has begun, from years to years, new technologies will be implemented to replace or progress from old technologies.Most researches are inspired by science fiction film and series such as Star Wars, Real Steel and Transformers. The recently developed humanoid robots are becoming ever closer to human behavior. Some of the famous humanoid robots are Honda's ASIMO, which is a look-alike astronaut robot, Kawada's HRP-4, a small, fast, and advanced robot built by the Japanese government, one of the cleverest and smartest robots. All these humanoid robots behave justlike a human being.

REFERENCES

[1] C. Kawatsu, J. Li, and C. J. Chung, “Robot Intelligence Technology and Applications 2012,” *Intelligence*, 2013, doi: 10.1007/978-3-642-37374-9.

[2] T. B. Sheridan, “Human-Robot Interaction,” *Human Factors*. 2016, doi: 10.1177/0018720816644364.

[3] D. E. Orin, A. Goswami, and S. H. Lee, “Centroidal dynamics of a humanoid robot,” *Auton. Robots*, 2013, doi: 10.1007/s10514-013-9341-4.

[4] S. Balasubramanian, J. Klein, and E. Burdet, “Robot-assisted rehabilitation of hand function,” *Current Opinion in Neurology*. 2010, doi: 10.1097/WCO.0b013e32833e99a4.

[5] M. Calisti, G. Picardi, and C. Laschi, “Fundamentals of soft robot locomotion,” *Journal*

of the Royal Society Interface. 2017, doi: 10.1098/rsif.2017.0101.

[6] D. Barber, *Bayesian Reasoning and Machine Learning*. 2011.

[7] J. Burgner-Kahrs, D. C. Rucker, and H. Choset, "Continuum Robots for Medical Applications: A Survey," *IEEE Transactions on Robotics*. 2015, doi: 10.1109/TRO.2015.2489500.

[8] C. Heyer, "Human-robot interaction and future industrial robotics applications," in *IEEE/RSJ 2010 International Conference on Intelligent Robots and Systems, IROS 2010 - Conference Proceedings*, 2010, doi: 10.1109/IROS.2010.5651294.

[9] L. Ting, "Application of Virtual Reality Technology to Sports," 2015, doi: 10.2991/cas-15.2015.74.

[10] D. Conti, S. Di Nuovo, S. Buono, and A. Di Nuovo, "Robots in Education and Care of Children with Developmental Disabilities: A Study on Acceptance by Experienced and Future Professionals," *Int. J. Soc. Robot.*, 2017, doi: 10.1007/s12369-016-0359-6.

[11] T Kowshiga, T Saranya, T Jayasudha, M Sowmiya, S Balamurugan, "Studies on Protecting Privacy of Anonymized Medical Data", International Journal of Innovative Research in Science, Engineering and Technology Vol. 4, Issue 2, February 2015

[12] P Andrew, J Anishkumar, S Balamurugan, S Charanyaa, " Investigations on Methods Developed for Effective Discovery of Functional Dependencies", International Journal of Innovative Research in Computer and Communication Engineering , Vol. 3, Issue 2, February 2015

[13] R S Venkatesh, PK Reejeesh, S Balamurugan, S Charanyaa, "Investigations on Evolution of Approaches Developed for Data Privacy", International Journal of Innovative Research in Computer and Communication Engineering , Vol. 3, Issue 1, January 2015

[14] Vishal Jain, Dr. Mayank Singh, "Ontology Based Pivoted Normalization using Vector – Based Approach for Information Retrieval", IEEE Co-Sponsored 7th International Conference on Advanced Computing and Communication Technologies (ICACCT), In association with INDERSCIENCE Publishers, UK, IETE and Technically Co-sponsored by Computer Society Chapter IEEE Delhi Section, held on 16th November, 2013, organized by Asia Pacific Institute of Information Technology SD India, Panipat, India.

[15] Vishal Jain, Dr. Mayank Singh, "Ontology Based Web Crawler to Search Documents in the Semantic Web", "Wilkes100 - Second International Conference on Computing Sciences", in association with International Neural Network Society and Advanced Computing Research Society, held on 15th and 16th November, 2013 organized by Lovely Professional University, Phagwara, Punjab, India and proceeding published by Elsevier Science.

[16] Vishal Jain, Dr. Mayank Singh, "Ontology Development and Query Retrieval using Protégé Tool", International Journal of Intelligent Systems and Applications (IJISA), Hongkong, Vol. 5, No. 9, August 2013, page no. 67-75, having ISSN No. 2074-9058, DOI: 10.5815/ijisa.2013.09.08