

Ain Shams University  
Faculty of Engineering

**Autonomous & Manual Controlled Upper Humanoid Robot**

Submitted by : Mechatronics dept.

|  |  |
| --- | --- |
| Robeir Remon Farid | 1500594 |
| Rami Wafik Attia |  |
| Hassan Sami Fahmy |  |
| Alaa Ayman Elremaily |  |
| Aya Ayman Elremaily |  |

Supervised by :

**Dr. Mohammed Ibrahim Dr. Shady Ahmed Maged**

1. INTRODUCTION
   1. BACKGROUND
   2. HISTORY BRIEF
   3. MOTIVATION
   4. AIMS
   5. OBJECTIVES
2. SYSTEM OVERVIEW
   1. SYSTEM SCHEMATIC
   2. HUMAN MOTION
   3. VDI ENGINEERING DESIGN THEORY
3. CONCEPTUAL DESIGN
   1. INTRODUCTION
   2. DESIGN CONSIDERATION
   3. REQUIREMENTS
4. INMOOV
   1. INTRODUCTION
   2. MECHANICAL
      1. MECHANICAL DESIGN
         1. UPPER PART
         2. LOWER PART (BASE DESIGN)
   3. URDF MODEL
   4. ELECTRICAL
      1. CIRCUIT DESIGN
      2. PCB LAYOUT
         * 1. HAND PCB LAYOUT
           2. WRIST PCB LAYOUT
           3. SHOULDER AND ELBOW PCB LYOUT
           4. HEAD PCB LAYOUT
           5. VOLTAGE REGULATING PCB LAYOUT
           6. FINAL PCB LAYOUT
      3. WIRING
      4. CIRCUIT SCHEMATIC
      5. POWER CALCULATION
   5. SENSOR SELECTION
   6. GPU SELECTION (NVIDIA JETSON NANO DEVELOPMENT KIT “B01”)

1. MANUAL ARM CONRTOL
   1. INTRODUCTION
   2. EXOSKELETON
      1. ARM CONTROL
      2. FINGERS CONTROL
   3. WIRELESS JOYSTICK
   4. KINECT CONTROL
   5. HEAD CONTROL USING VR
2. AUTONOMOUS ARM CONTROL
   1. BALL CATCHING
      1. INTRODUCTION
      2. BALL DETECTION AND TRACKING
         1. BALL DETECTION USING OPENCV
         2. CALCULATING THE DEPTH OF THE BALL
            1. USING TWO WEBCAMS BY TRANGULATE METHOD
            2. USING KINECT
      3. TRAJECTORY PATH ESTIMATION
         1. USING EULER METHOD
      4. INVERSE KINEMATICS SOLVING
         1. MOVEIT
         2. VREP
         3. GRAPHICAL METHOD
      5. CONNECTING JETSON NANO WITH SERVOS
   2. OBJECT DETECTION AND TRACKING USING NEURAL NETWORK
      1. INTRODUCTION
      2. DETECT PERSON AND DOG TESTING

1. **INTRODUCTION**
   1. **BACKGROUND**
2. Over millions of years, Nature produced through the process of evolution an incredible pool of inventions that are
3. solutions that work well and are durable. These inventions are serving as models for mimicking and inspiration and
4. the field is known as biomimetics [Bar-Cohen, 2005]. From the early days of human civilization the value of these
5. inventions was well recognized and it led to the development of many effective tools. Recent advances in
6. technology are enabling a significant rise in seeking more complex possibilities of mimicking biology. Making
7. humanlike robots is the ultimate challenge to biomimetics and it is exciting to point out that such robots are
8. becoming incredibly more effective and sophisticated. As opposed to any other human made development, if the
9. capability of these robots is advanced to the point that makes them very smart with self-identity and cognitive
10. behavior they will not be just another tool anymore
11. Over millions of years, Nature produced through the process of evolution an incredible pool of inventions that are
12. solutions that work well and are durable. These inventions are serving as models for mimicking and inspiration and
13. the field is known as biomimetics [Bar-Cohen, 2005]. From the early days of human civilization the value of these
14. inventions was well recognized and it led to the development of many effective tools. Recent advances in
15. technology are enabling a significant rise in seeking more complex possibilities of mimicking biology. Making
16. humanlike robots is the ultimate challenge to biomimetics and it is exciting to point out that such robots are
17. becoming incredibly more effective and sophisticated. As opposed to any other human made development, if the
18. capability of these robots is advanced to the point that makes them very smart with self-identity and cognitive
19. behavior they will not be just another tool anymore

Over millions of years, Nature produced through the process of evolution an incredible pool of inventions that are

solutions that work well and are durable. These inventions are serving as models for mimicking and inspiration and

the field is known as biomimetics [Bar-Cohen, 2005]. From the early days of human civilization the value of these

inventions was well recognized and it led to the development of many effective tools. Recent advances in

technology are enabling a significant rise in seeking more complex possibilities of mimicking biology. Making

humanlike robots is the ultimate challenge to biomimetics and it is exciting to point out that such robots are

becoming incredibly more effective and sophisticated. As opposed to any other human made development, if the

capability of these robots is advanced to the point that makes them very smart with self-identity and cognitive

behavior they will not be just another tool anymore

Humanoid robots, while being one of the smallest groups of service robots in the current market, have the greatest potential to become the industrial tool of the future.

It has been well documented that there will be increase in the number of robots over the next decade. According to the Boston Consulting Group, by 2025, robots will perform 25% of all labor tasks. This is due to improvements in performance and reduction in costs.

Before the coronavirus pandemic and the economic uncertainty, Statistics Market Research Consulting expected that the Global Humanoid Robot Market would reach $13 billion by 2026. While future market behavior is now unclear, robot usage is on the rise: Chinese companies were rushing to deploy robots and automation technology, as doctors were grappling with COVID-19.

Developing a humanlike robot involves copying the appearance of humans as well as emulating the capabilities, expression of emotions and possibly even having thoughts. Making such robots involves advances in many disciplines including mechanical and electrical engineering, materials science, computer science, artificial intelligence, and control. To make such smart machines that look and act like a human there is a need to integrate capabilities that are at the cutting edge of the related technology. The materials to be used need to be resilient, lightweight and multifunctional.

These robots need sensors to visualize the train, hear sound, as well as sense touch, pressure and temperature. The robots need to use light batteries or generator for power that can be operated over a long time without recharge. In addition, the robots need to interpret the information that is measured by the sensors to perceive and be aware of the surrounding terrain and to sense hazards and risks. Humanlike robots need to have effective control and artificial intelligence algorithms in order to be operated like humans and interact with its environment and humans.

Developing a humanlike robot involves copying the appearance of humans as well as emulating the capabilities,

expression of emotions and possibly even having thoughts. Making such robots involves advances in many

disciplines including mechanical and electrical engineering, materials science, computer science, artificial

intelligence, and control. To make such smart machines that look and act like a human there is a need to integrate

capabilities that are at the cutting edge of the related technology [Bar-Cohen and Breazeal, 2003; Bar-Cohen and

Hanson, 2009]. The materials to be used need to be resilient, lightweight and multifunctional. Further, the mobility

system that is used needs to allow walking via two legs and maintain stability while able to traverse complex terrains

(e.g. climb stairs and avoid obstacles). These robots need sensors to visualize the train, hear sound, as well as sense

touch, pressure and temperature. The robots need to use light batteries and/or generator for power that can be

operated over a long time without recharge. In addition, the robots need to interpret the information that is measured

by the sensors to perceive and be aware of the surrounding terrain and to sense hazards and risks. Humanlike robots

need to have effective control and artificial intelligence algorithms in order to be operated like humans and interact

with its environment and humans [Plantec, 2003]. The produced robots need to have body parts and related

functions similar to a human as much as possible

machines were driven by mechanical energy that was stored in a spring. Examples include the "The Flute Player"

that was produced by the French engineer Jacques de Vaucanson in 1737 and the “Writer” that was made by the

Swiss clockmaker Jacquet-Droz and completed in 1772. The era of robotics as we know it today where the machine

is equipped with artificial intelligence has began in 1946 with the first introduction of the digital computer, the

ENIAC computer, which was the first large-scale general-purpose electronic computer [McCartney 1999]. The first

time that the possibility of building thinking and learning machines was raised was in 1950 [Turing, 1950]. Progress

in developing powerful microprocessors with high computation speed, very large memory, wide communication

bandwidth, and more effective software tools made the most impact on the development of intelligent robots. With

the advancements in microelectronics and intelligent software more sophisticated robots have been emerging with

concepts and methodologies that are inspired and guided by nature [Arkin 1998; Bar-Cohen and Breazeal, 2003;

Bar-Cohen and Hanson, 2009; Gould, 1982].

With the advances in technology, humanlike robots are increasingly becoming easier to make as lifelike using

effective autonomous operation algorithms, humanlike materials, and the capability to emulate the movement and

functionality (seeing, hearing, smelling, etc.) of humans. Using state of the art microprocessors, materials, sensors,

software, and many other technologies are leading to increasingly more capable robots. These advances are

allowing them to perceive, interpret, respond, and adapt to their environment. Robotic products are already being

developed for entertainment, education, healthcare, home security, military, and many others. Currently,

entertainment applications are the most beneficiary of this technology where humanlike robotic toys are

commercially available in many stores. Further, industry has begun to collaborate with scientists to make their

characters in movies appear more realistic and to move more like people. Also, robotics researchers are increasingly

collaborating with artists to make their robots appear more expressive and believable.

3. MAKING A HUMANLIKE ROBOT

Developing a humanlike robot involves copying the appearance of humans as well as emulating the capabilities,

expression of emotions and possibly even having thoughts. Making such robots involves advances in many

disciplines including mechanical and electrical engineering, materials science, computer science, artificial

intelligence, and control. To make such smart machines that look and act like a human there is a need to integrate

capabilities that are at the cutting edge of the related technology [Bar-Cohen and Breazeal, 2003; Bar-Cohen and

Hanson, 2009]. The materials to be used need to be resilient, lightweight and multifunctional. Further, the mobility

system that is used needs to allow walking via two legs and maintain stability while able to traverse complex terrains

(e.g. climb stairs and avoid obstacles). These robots need sensors to visualize the train, hear sound, as well as sense

touch, pressure and temperature. The robots need to use light batteries and/or generator for power that can be

operated over a long time without recharge. In addition, the robots need to interpret the information that is measured

by the sensors to perceive and be aware of the surrounding terrain and to sense hazards and risks. Humanlike robots

need to have effective control and artificial intelligence algorithms in order to be operated like humans and interact

with its environment and humans [Plantec, 2003]. The produced robots need to have body parts and related

functions similar to a human as much as possible

Developing a humanlike robot involves copying the appearance of humans as well as emulating the capabilities,

expression of emotions and possibly even having thoughts. Making such robots involves advances in many

disciplines including mechanical and electrical engineering, materials science, computer science, artificial

intelligence, and control. To make such smart machines that look and act like a human there is a need to integrate

capabilities that are at the cutting edge of the related technology [Bar-Cohen and Breazeal, 2003; Bar-Cohen and

Hanson, 2009]. The materials to be used need to be resilient, lightweight and multifunctional. Further, the mobility

system that is used needs to allow walking via two legs and maintain stability while able to traverse complex terrains

(e.g. climb stairs and avoid obstacles). These robots need sensors to visualize the train, hear sound, as well as sense

touch, pressure and temperature. The robots need to use light batteries and/or generator for power that can be

operated over a long time without recharge. In addition, the robots need to interpret the information that is measured

by the sensors to perceive and be aware of the surrounding terrain and to sense hazards and risks. Humanlike robots

need to have effective control and artificial intelligence algorithms in order to be operated like humans and interact

with its environment and humans [Plantec, 2003].

Developing a humanlike robot involves copying the appearance of humans as well as emulating the capabilities,

expression of emotions and possibly even having thoughts. Making such robots involves advances in many

disciplines including mechanical and electrical engineering, materials science, computer science, artificial

intelligence, and control. To make such smart machines that look and act like a human there is a need to integrate

capabilities that are at the cutting edge of the related technology [Bar-Cohen and Breazeal, 2003; Bar-Cohen and

Hanson, 2009]. The materials to be used need to be resilient, lightweight and multifunctional. Further, the mobility

system that is used needs to allow walking via two legs and maintain stability while able to traverse complex terrains

(e.g. climb stairs and avoid obstacles). These robots need sensors to visualize the train, hear sound, as well as sense

touch, pressure and temperature. The robots need to use light batteries and/or generator for power that can be

operated over a long time without recharge. In addition, the robots need to interpret the information that is measured

by the sensors to perceive and be aware of the surrounding terrain and to sense hazards and risks. Humanlike robots

need to have effective control and artificial intelligence algorithms in order to be operated like humans and interact

with its environment and humans [Plantec, 2003]

The main applications for which these robots are being considered include health-care, entertainment, home or office security, and military. Humanoids are also suitable for some procedurally-based vocations such as operating like hospital workers, receptionists, guards, and more, and they can speak in various languages, dance to the sound of music, and play musical instruments.

Companies like [**Softbank Robotics**](https://www.softbankrobotics.com/us/) have created human-looking robots to be used as medical assistants and teaching aids. Currently, humanoid robots are excelling in the medical industry, especially as companion robots.

However, companies are now using humanoid robots to fill engineering tasks. A four-year joint research project was conducted by [**Joint Robotics Laboratory**](https://jrl-umi3218.github.io/index.html)and [**Airbus Group**](http://www.airbus.com/) to use humanoid robotic technology in aircraft manufacturing facilities. By using humanoid robots on aircraft assembly lines, Airbus looks to relieve human operators of some of the more laborious and dangerous tasks. The human employers could then concentrate on higher value tasks. The primary difficulty is the confined spaces these robots have to work in and being able to move without colliding with the surrounding objects

**1.2 HISTORY BRIEF**

**1967**

****

Waseda University started the WABOT project in 1967. The WABOT-1 robot was completed in 1972 and was the world’s first full-scale android humanoid robot. It was the first robot able to walk and communicate with people in Japanese, navigate a room and grip and transport objects. They later went on to create WABOT-2 which was capable of reading a musical score and playing an electric keyboard.

**2010**

****

[**NASA and General Motors revealed Roboaut 2**](https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-robonaut-58.html), a highly advanced humanoid robot that was part of the Discovery shuttle launch in 2011. Robonaut was designed to assist NASA with space walks and has enough dexterity to use tools and work alongside astronauts in future space expeditions.

NASA later went on to develop [Valkyrie](http://valkyrie.inf.ed.ac.uk/), a robot that has been developed with the ability to ultimately setup habitats on Mars prior to human arrival.

**2014**

[**Softbank Robotics release Pepper**](https://www.softbankrobotics.com/emea/en/pepper), which quickly became the leading commercially available social robot. Pepper was rolled out in Softbank’s mobile stores in Japan and has since been use in Carrefour and Renault stores across France.

**2016**

[**Hanson Robotics release Sophia**](https://www.hansonrobotics.com/sophia/), a social robot with silicone skin, and the ability to interact with people and display more than 50 facial expressions. Sophia has been covered my media around the world and has participated in many high-profile interviews. The Sophia robot is also the first ever robot to be granted citizenship of a country.

**2020**

At a time when healthcare workers at hospitals are prone to coronavirus infection, humanoid robots at AIIMS has mitigated risk by performing contactless monitoring of patients

Milagrow human tech has installed humanoid Milagrow ELF at dedicated COVID-19 wards.

**1.3 MOTIVATION**

Our motivation for this project is to advance research in this area as it is needed for our country at this moment especially at the coronavirus pandemic because as the virus spreads to the rest of the world, robots are being deployed in many countries.

This project can be used for research and space exploration, personal assistance and caregiving, education and entertainment, search and rescue, manufacturing and maintenance, public relations, and healthcare.

Also, to advance our abilities in the control theory, machine vision and artificial intelligence to be graduated as a modern mechatronics engineers, this project was perfect as it accomplishes this goal.

**1.4 AIM**

Our aim is to design, manufacture and control a robot that mimics human appearance which can be controlled from a remote location instantly providing a virtual presence and also can perform some human functions like object detection and catching objects on the fly taking into consideration the safety aspect as it will be working in the vicinity of humans.

**1.5 OBJECTIVES**

Our objective is to provide a relatively cheap humanoid robot with a differential base structure. It can be used among various medical and social or educational applications so that it can be used as a nurse for people infected with coronavirus and also can be used for catching flying objects.