INTRODUCTION

1.Introduction:

Robotics:

Robotics is a branch of science and engineering dealing with the study of robots. It is involved with a robot's design, manufacture, application, and structural disposition. Robotics is related to electronics, mechanics, and software.

Robot:

A robot is a virtual or mechanical artificial ageant. In practice, it is usually an electro-mechanical machine which is guided by computer or electronic programming, and is thus able to do tasks on its own. Another common characteristic is that by its appearance or movements, a robot often conveys a sense that it has intent or agency of its own.

Humanoid robots:

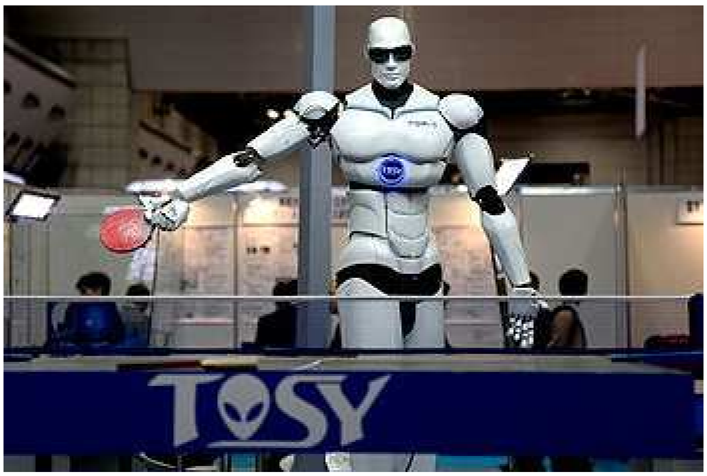
A humanoid robot is an autonomous robot because it can adapt to changes in its environment or itself and continue to reach its goal. This is the main difference between humanoid and other kinds of robots. In this context, some of the capacities of a humanoid robot may include, among others:

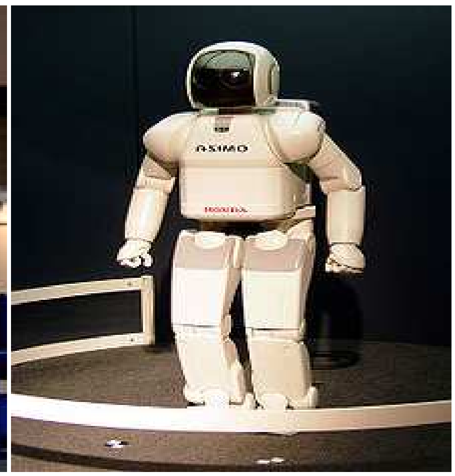
- self-maintenance (like recharging itself)
- autonomous learning (learn or gain new capabilities without outside assistance, adjust strategies based on the surroundings and adapt to new situations)
- avoiding harmful situations to people, property, and itself
- safe interacting with human beings and the environment

Like other mechanical robots, humanoid refer to the following basic components too: Sensing, Actuating and Planning and Control. Since they try to simulate the human structure and behavior and they are autonomous systems, most of the times humanoid robots are more complex than other kinds of robots.

This complexity affects all robotic scales (mechanical, spatial, time, power density, system and computational complexity), but it is more noticeable on power density and system complexity scales. In the first place, most current humanoids aren't strong enough even to jump and this happens because the power/weight ratio is not as good as in the human body. The dynamicallybalancing*Dexter* can jump, but poorly so far. On the other hand, there are very good algorithms for the several areas of humanoid construction, but it is very difficult to merge all of them into one efficient system (the system complexity is very high). Nowadays, these are the main difficulties that humanoid robots development has to deal with.

Humanoid robots are created to imitate some of the same physical and mental tasks that humans undergo daily. Scientists and specialists from many different fields including engineering, cognitive science, and linguistics combine their efforts to create a robot as human-like as possible. Their creators' goal for the robot is that one day it will be able to both understand human intelligence, reason and act like humans. If humanoids are able to do so, they could eventually work in cohesion with humans to create a more productive and higher quality future. Another important benefit of developing androids is to understand the human body's biological and mental processes, from the seemingly simple act of walking to the concepts of consciousness and spirituality.





There are currently two ways to model a humanoid robot. The first one models the robot like a set of rigid links, which are connected with joints. This kind of structure is similar to the one that can be found in industrial robots. Although this approach is used for most of the humanoid robots, a new one is emerging in some research works that use the knowledge acquired on biomechanics. In this one, the humanoid robot's bottom line is a resemblance of the human skeleton.

PURPOSE

2.Purpose:

Humanoid robots are used as a research tool in several scientific areas.

Researchers need to understand the human body structure and behavior (biomechanics) to build and study humanoid robots. On the other side, the attempt to simulate the human body leads to a better understanding of it.

Human cognition is a field of study which is focused on how humans learn from sensory information in order to acquire perceptual and motor skills. This knowledge is used to develop computational models of human behavior and it has been improving over time.

It has been suggested that very advanced robotics will facilitate the enhancement of ordinary humans.

Although the initial aim of humanoid research was to build better orthosis and prosthesis for human beings, knowledge has been transferred between both disciplines. A few examples are: powered leg prosthesis for neuromuscularly impaired, ankle-foot orthosis, biological realistic leg prosthesis and forearm prosthesis.

Besides the research, humanoid robots are being developed to perform human tasks like personal assistance, where they should be able to assist the sick and elderly, and dirty or dangerous jobs. Regular jobs like being a receptionist or a worker of an automotive manufacturing line are also suitable for humanoids. In essence, since they can use tools and operate equipment and vehicles designed for the human form, humanoids could theoretically perform any task a human being can, so long as they have the proper software. However, the complexity of doing so is deceptively great.

They are becoming increasingly popular for providing entertainment too. For example, Ursula, a female robot, sings, dances, and speaks to her audiences at Universal Studios. Several Disney attractions employ the use of animatrons, robots that look, move, and speak much like human beings, in some of their theme park shows. These animatrons look so realistic that it can be hard to decipher from a distance whether or not they are actually human. Although they have a realistic look, they have no cognition or physical autonomy.

Humanoid robots, especially with artificial intelligencealgorithms, could be useful for future dangerous and/or distant space explorationmissions, without having the need to turn back around again and return to Earth once the mission is completed.

BASIC COMPONENTS

3.Basic Components:

Like other mechanical robots, humanoid refer to the following basic components too:

- Sensing
- Actuating
- Planning and Control

1. Sensors:

A sensor is a device that measures some attribute of the world. Being one of the three primitives of robotics (besides planning and control), sensing plays an important role in robotic paradigms.

Sensors can be classified according to the physical process with which they work or according to the type of measurement information that they give as output. In this case, the second approach was used.

Proprioceptive Sensors:

Proprioceptive sensors sense the position, the orientation and the speed of the humanoid's body and joints.

In human beings inner ears are used to maintain balance and orientation. Humanoid robots use accelerometers to measure the acceleration, from which velocity can be calculated by integration; tilt sensors to measure inclination; force sensors placed in robot's hands and feet to measure contact force with environment; position sensors, that indicate the actual position of the robot (from which the velocity can be calculated by derivation) or even speed sensors.

ExteroceptiveSensors:

Exteroceptive sensors give the robot information about the surrounding environment allowing the robot to interact with the world. The exteroceptive sensors are classified according to their functionality.

Proximity sensors are used to measure the relative distance (range) between the sensor and objects in the environment. They perform the same task that vision and tactile senses do in human beings. There are other kinds of proximity measurements

Arrays of tactels can be used to provide data on what has been touched. Tactile sensors also provide information about forces and torques transferred between the robot and other objects.

In humanoid robots vision is used to recognize objects and determine their properties. Vision sensors work most similarly to the eyes of human beings. Most humanoid robots use CCD cameras as vision sensors. Sound sensors allow humanoid robots to hear speech and environmental sounds, and perform as the ears of the human being. Microphones are usually used for this task.

2. Actuators:

Actuators are the motors responsible for motion in the robot.

Humanoid robots are constructed in such a way that they mimic the human body, so they use actuators that perform like muscles and joints, though with a different structure. To achieve the same effect as human motion, humanoid robots use mainly rotary actuators. They can be either electric, pneumatic, hydraulic, piezoelectric or ultrasonic.

Hydraulic and electric actuators have a very rigid behavior and can only be made to act in a compliant manner through the use of relatively complex feedback control strategies .

Piezoelectric actuators generate a small movement with a high force capability when voltage is applied.

Ultrasonic actuators are designed to produce movements in a micrometer order at ultrasonic frequencies (over 20 kHz). They are useful for controlling vibration, positioning applications and quick switching.

Pneumatic actuators operate on the basis of gascompressibility. These actuators are intended for low speed and low/medium load applications. Between pneumatic actuators there are: cylinders, bellows, pneumatic engines, pneumatic stepper motors and pneumatic artificial muscles.

3. Planning and Control:

In planning and control the essential difference between humanoids and other kinds of robots (like industrial ones) is that the movement of the robot has to be human-like, using legged locomotion, especially biped gait. The ideal planning for humanoid movements during normal walking should result in minimum energy consumption, like it happens in the human body. For this reason, studies on dynamics and control of these kinds of structures become more and more important.

To maintain dynamic balance during the walk, a robot needs information about contact force and its current and desired motion. The solution to this problem relies on a major concept, the Zero Moment Point (ZMP).

Another characteristic about humanoid robots is that they move, gather information (using sensors) on the "real world" and interact with it. Planning and Control have to focus about self-collision detection, path planning and obstacle avoidance to allow humanoids to move in complex environments.

There are features in the human body that can’t be found in humanoids yet. They include structures with variable flexibility, which provide safety (to the robot itself and to the people), and redundancy of movements, i.e., more degrees of freedom and therefore wide task availability. Although these characteristics are desirable to humanoid robots, they will bring more complexity and new problems to planning and control.

ASIMO

4.ASIMO:

Introduction:

ASIMO is a humanoid robot created by Honda.ASIMO was created at Honda's Research & Development Wako Fundamental Technical Research Centerin Japan.ASIMO resembles a child in size and is the most human-like robot Honda has made so far.

The name is an acronym for "**A**dvanced **S**tep in **I**nnovative **MO**bility".

ASIMO is part of Honda’s long standing program of research and development into robotics and human mobility. Honda’s goal is to develop a robot that will be able to help people in their everyday lives; a robot that will take on some of the tasks that would help make all our lives easier and more pleasant.

The benefits of such a humanoid robot may not be limited to the home environment, but could include any situation where people need support and assistance.

Honda is now focusing its research on the development of intelligence as well as improving the understanding about the ideal interaction and relationship between people and humanoid robots.

ASIMO Features:

ASIMO was conceived to function in an actual human living environment in the near future. It is easy to operate, has a convenient size and weight and can move freely within the human living environment, all with a people-friendly design.

- Compact & Lightweight
- More Advanced Walking technology
- Wider Arm Operating Parameters
- Easy to Operate
- Friendly Design

5.ASIMO's Life Story:

Honda began development of its humanoid helper robot in 1986. Honda engineers knew the robot had to be able to easily navigate around a house or building, and that meant the walking technology had to be perfect. Therefore, their first attempts were basically boxes with legs. Once the walking mechanism was mostly developed, arms, hands and finally a head were added.

The ASIMO Timeline:

1986 - Static walking
The first robot Honda built was called **EO**. EO walked very slowly, taking sometimes 20 seconds to complete a single step. This was because EO did what was called "static walking." In static walking, after the robot begins moving one foot forward, it has to wait until it has its weight balanced on that foot before it begins to move the other foot forward. Humans don't walk that way, so the research continued.

1987 - Dynamic walking
By now engineers had developed a method for "dynamic walking," which is much more human-like. With this walking technology, the robot (now called **prototype E1**, soon followed by **E2** and **E3** as research progressed) leaned into the next step, shifting its weight and moving the other foot forward to catch itself so that rather than falling forward, it walked forward.

1991 - Walking like a pro
In prototypes **E4**, **E5** and **E6**, Honda's engineers perfected the walking mechanism to the point where the robot could easily walk on an incline, up stairs and on uneven terrain. Because truly walking as a human actually requires the use of the body, arms and head, engineers had to move on to the next step and add the rest of the body.

1993 - A more human-looking robot
With a body, arms, hands and a head, the next generation of prototypes (**P1**, **P2** and **P3**) looked more like a "humanoid." P1, however, was a looming 6 feet 2 inches (188 cm) tall and weighed 386 pounds (175 kg). P2 was scaled down slightly in height, but weighed an even heavier 463 pounds (210 kg) -- not something you want stepping on your toes in the kitchen. However, it could walk very well on uneven surfaces, inclines, and could even grasp objects and push carts. P2 could even maintain its balance when pushed. Finally, P3 was built at a more comfortable (and less frightening) 5 feet 2 inches (157 cm) tall. Weighing 287 pounds (130 kg), P3 could walk faster and more smoothly than its predecessors.

1997 - ASIMO
Even more improvements were made to the walking system, allowing ASIMO to walk gracefully and easily in almost any environment. Sophisticated hip joints allowed ASIMO to turn smoothly something other robots have to stop and shuffle in order to do.

In thinking about how ASIMO was to be used, the engineers made the decision to further reduce ASIMO's size to 4 feet (122 cm) so that not only would it not be intimidating to people who were seated (or standing, for that matter), it would actually be at **eye level**. This height also made it possible for ASIMO to work at table height or at a computer, reach light switches and turn door knobs. ASIMO's very strong but lightweight **magnesium-alloy** body, covered in plastic "skin," weighed in at only 115 pounds (52 kg).

Technology called "**predicted movement control**" allowed ASIMO to predict its next movement automatically and shift its weight to make a turn. ASIMO's stride could also be adjusted in real time to make it walk faster or slower. P2 and P3 had to use programmed walking patterns.

2005 - Better, Faster, Stronger
Engineers further refined ASIMO's motion system, boosting its walking speed from 2.5 to 2.7 kilometers per hour and giving ASIMO the ability to run at speeds up to 6 kilometers per hour. Honda increased ASIMO's height to 4 feet 3 inches (130 centimeters), and the robot put on a little weight, tipping the scales at 119 pounds.

The engineers switched ASIMO's power supply to a **lithium battery** that doubles the amount of time it can operate before recharging. They also implemented the **IC Communication** card technology that helps ASIMO interact with people. New sensors allowed ASIMO to move in sync with people while holding hands.

6.Recognition technology:

With 2000's ASIMO model Honda added features that enable ASIMO to interact better with humans. These features fall under 5 categories:

1.Moving objects:

Using the visual information captured by the camera mounted in its head, ASIMO detects the movements of multiple objects, assessing distance and direction. Common applications of this feature would include: the ability to follow the movements of people with its camera, to follow a person, or greet a person when he or she approaches.

2.Postures and gestures:

ASIMO interprets the positioning and movement of a hand, recognizing postures and gestures. Because of this ASIMO can react to and be directed by not only voice commands, but also to the natural movements of human beings. This enables it to, for example, recognize when a handshake is offered or when a person waves and respond accordingly. It can also recognize movement directions such as pointing.

3.Environment:

ASIMO recognizes the objects and terrain of its environment and acts in a way that is safe for both itself and nearby humans. For example, recognizing potential hazards such as stairs, and by stopping and starting to avoid hitting humans or other moving objects.

4.Distinguishing sounds:

ASIMO's ability to identify the source of sounds has been improved, and it can distinguish between voices and other sounds. It responds to its name, faces people when spoken to, and recognizes sudden, unusual sounds such as that of a falling object or a collision, and faces in that direction. It can respond to questions, either by a brief nod, a shake of the head or a verbal answer.

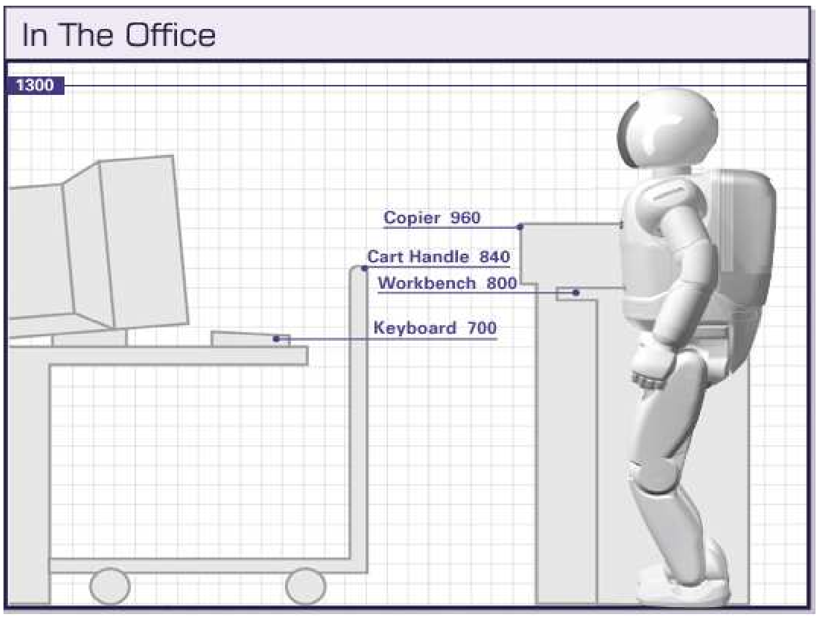
5.Facial recognition:

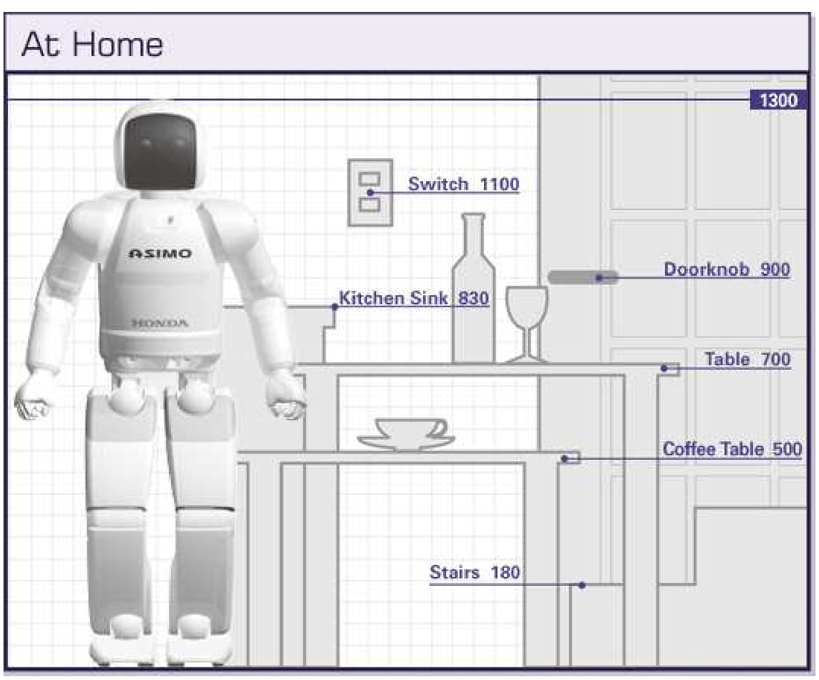
ASIMO can recognize faces, even when ASIMO or the human being is moving. It can individually recognize approximately 10 different faces. Once they are registered it can address them by name.

7.Design Concept:

The robot's size was chosen to allow it to operate freely in the human living space and to make it people-friendly. This size allows the robot to operate light switches and door knobs, and work at tables and work benches. Its eyes are located at the level of an adult's eyes when the adult is sitting in a chair. A height of 130cm makes it easy to communicate with.
Honda feels that a robot height between 130cm and that of an adult is ideal for operating in the human living space.

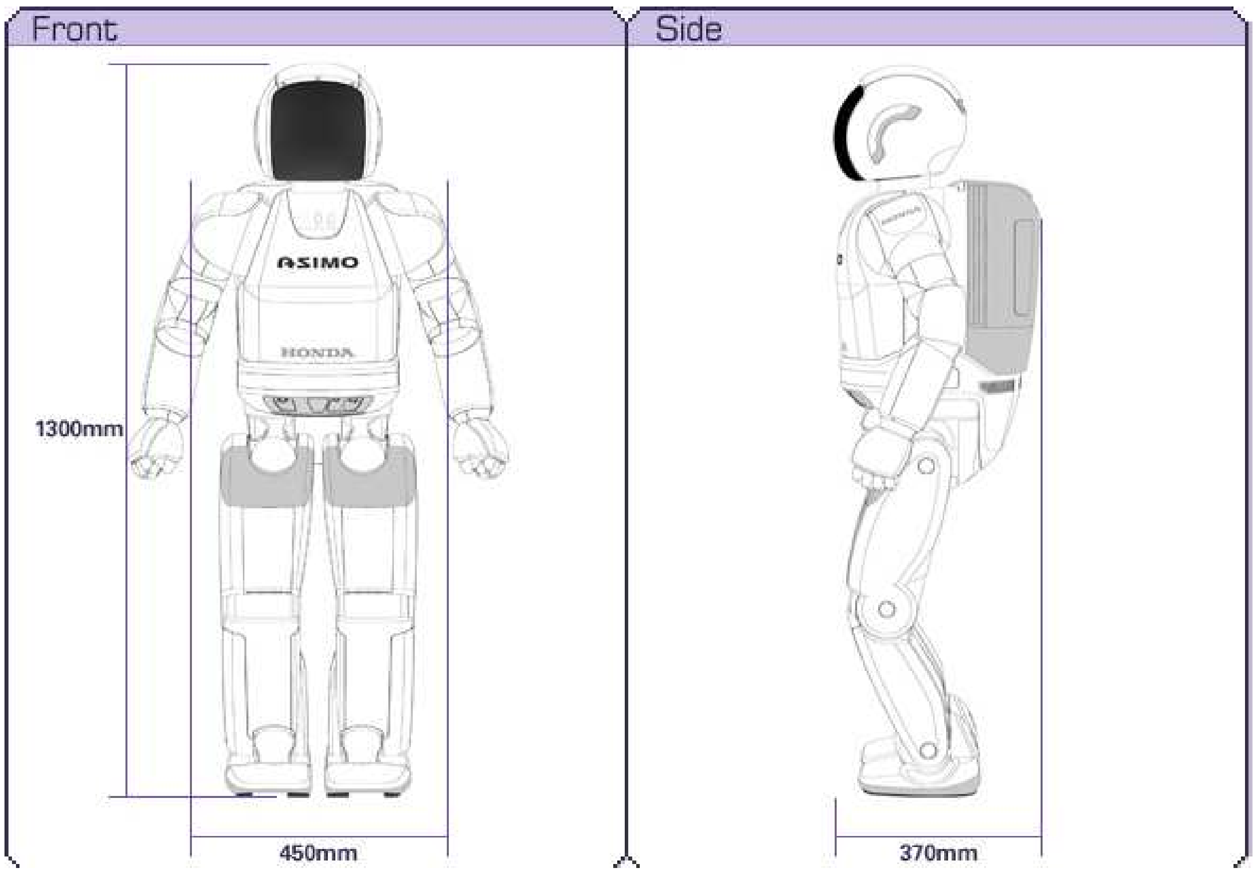
The People-Friendly Robot-small,usefull size





8.ASIMO'S Specifications:

The specifications of the humanoid robot ASIMO are as follows



Specifications:

Total Height	130cm
Weight	54kg
Running Speed (Straight)	6 km/h
Running Speed (Circular Pattern)	5 km/h (2.5m radius)
Walking Speed (Normal)	2.7 km/h
Walking Speed (While Carrying ObjectWith)	1.6 km/h (carrying object weighing 1kg)

Degrees of Freedom:

Head	Neck joint (U/D, L/R RT)		3 DOF
Arm	Shoulder joints (F/B, U/D, RT)	3 DOF	
	Elbow joints (F/B)	1 DOF	
	Wrist joints (U/D, L/R, RT)	3 DOF	
		7 DOF x 2 arms = 14 DOF	
Hands	4 fingers (to grasp objects) / Thumb	2 DOF	
		2 DOF x 2 hands = 4 DOF	
Hip	RT		1 DOF
Legs	Crotch joint (F/B, L/R, RT)	3 DOF	
	Knee joints (F/B)	1 DOF	
	Ankle joints (F/B, L/R)	2 DOF	
		6 DOF x 2 legs = 12 DOF	
TOTAL			34 DOF

*1
F/B : Forward/Backward U/D : Up/Down L/R : Left/Right
RT : Rotation DOF : Degrees of Freedom

Battery:

ASIMO works on the Lithium ion Battery 51.8V / 6 kg 3 hours to fully charge and the continuous operating time is 40 mins to 1 hour (walking).

A lithium-ion battery (sometimes Li-ion battery or LIB) is a family of rechargeable battery types in which lithium ions move from the negative electrode to the positive electrode during discharge, and back when charging. Chemistry, performance, cost, and safety characteristics vary across LIB types.

Lithium-ion batteries are common in consumer electronics. They are one of the most popular types of rechargeable battery for portable electronics, with one of the best energy densities, no memory effect, and a slow loss of charge when not in use. Beyond consumer electronics, LIBs are also growing in popularity for military, electric vehicle, and aerospace applications.

9.Walking Technology:

The introduction of intelligent, real-time, flexible-walking technology allowed ASIMO to walk continuously while changing directions, and gave the robot even greater stability in response to sudden movements.

Earlier Ways of Walking:

- In the past, different patterns were used for straight walking and for turning, and a slight pause was required during the transition.

- Walking strides (time per step) were limited to only a few variations.

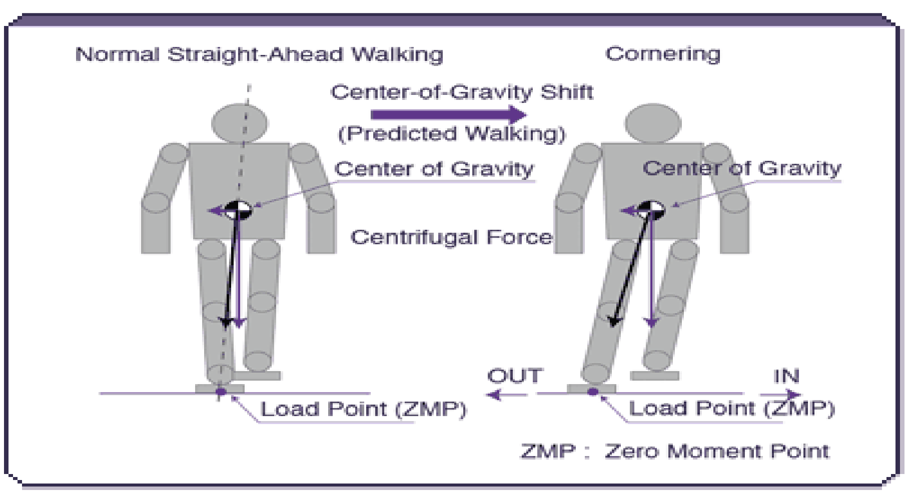
  Because each walking pattern has a different stride(time per step),
  the robot could not change its stride(time per step) flexibly.

Intelligent Real-Time flexible Walking=i-WALK

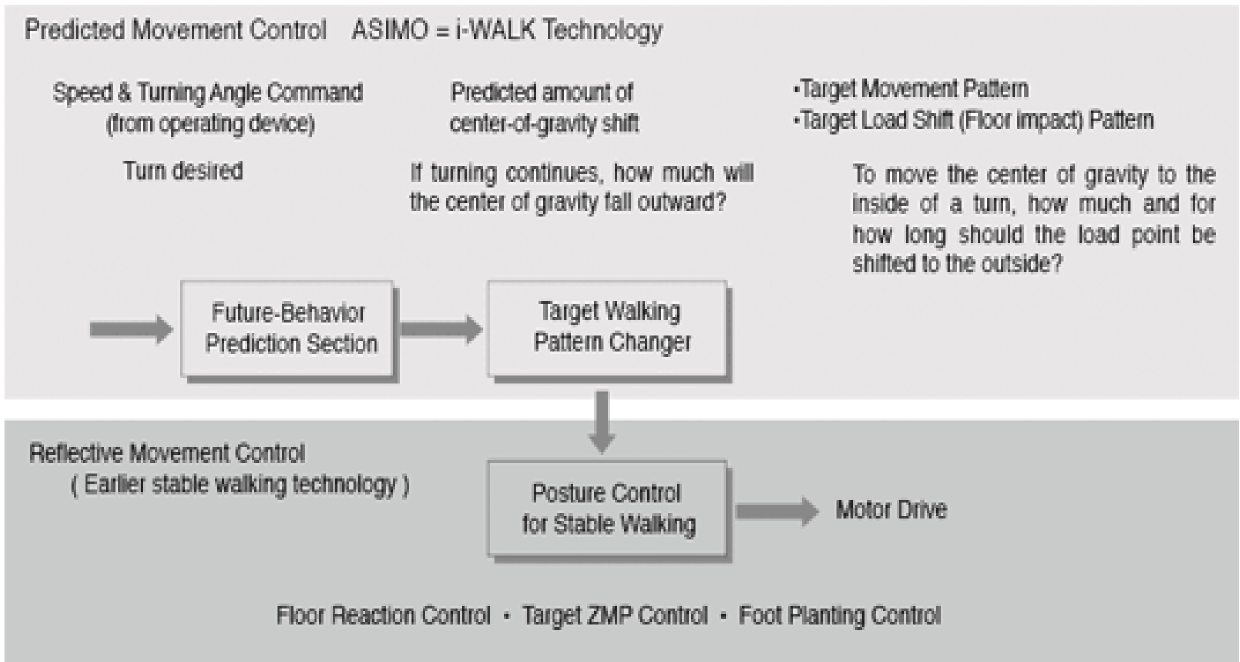
i-WALK technology features a predicted movement control added to the earlier walking control technology. This new two-legged walking technology permits more flexible walking. As a result, ASIMO now walks more smoothly and more naturally.

Creating Prediction Movement Control:

When human beings walk straight ahead and start to turn a corner, before commencing the turn they shift their center of gravity toward the inside of the turn.
Thanks to i-WALK technology, ASIMO can predict its next movement in real time and shift its center of gravity in anticipation.



Control Block Map from i-WALK Technology:



Intelligent, Real-Time, Flexible Walking Achieved!

- Continuous movement is possible without pauses.

- In addition to changes in foot placement and turning, the stride (time per step) can be freely changed

Because continuous flexible walking is possible, ASIMO can move and walk rapidly and smoothly at all times.

Robots up to the P3 turned according to combinations of stored walking patterns.
ASIMO creates walking patterns in real time and can change foot placement and turning angle at will. As a result, it can walk smoothly in many directions. In addition, because stride (time per step) can also be freely changed, ASIMO's movements are much more naturally.

10.ASIMO Featuring Intelligence Technology:

Honda added intelligence technology to ASIMO which is capable of interpreting the postures and gestures of humans and moving independently in response. ASIMO's ability to interact with humans has advanced significantly, it can greet approaching people, follow them, move in the direction they indicate, and even recognize their faces and address them by name.
ASIMO is the world's first humanoid robot to exhibit such a broad range of intelligent capabilities.

1. Recognition of moving objects:

Using the visual information captured by the camera mounted in its head, ASIMO can detect the movements of multiple objects, assessing distance and direction.

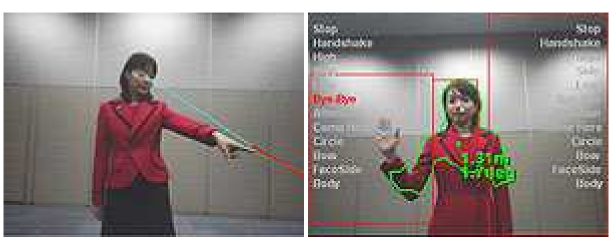

Recognition of the distance and direction of movement of multiple objects

Specifically, ASIMO can:

- Follow the movements of people with its camera
- Follow a person
- Greet a person while he or she approaches.

2. Recognition of postures and gestures:

Based on visual information, ASIMO can interpret the positioning and movement of a hand, recognizing postures and gestures. Thus ASIMO can react not only to voice commands, but also to the natural movements of human beings.



For example, ASIMO can:

- Recognize an indicated location and move to that location (posture recognition)
- Shake a person’s hand when a hand shake is offered (posture recognition)
- Respond to a wave by waving back (gesture recognition)

3. Environment recognition:

Using the visual information, ASIMO is able to assess its immediate environment, recognizing the position of obstacles and avoiding them to prevent collisions.

Specifically, ASIMO can

- Stop and start to avoid a human being or other moving object which suddenly appears in its path;
- Recognize immobile objects in its path and move around them.

4. Distinguishing sounds:

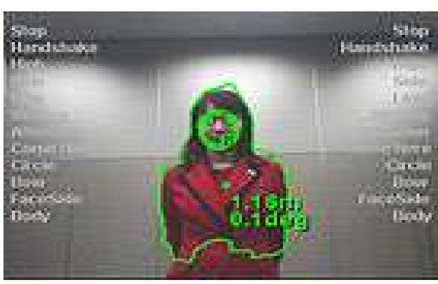
ASIMO's ability to identify the source of sounds has been improved, and it can distinguish between voices and other sounds.

For example, ASIMO can:

- Recognize when its name is called and turn to face the source of the sound
- Look at the face of the person speaking and respond
- Recognize sudden unusual sounds such as that of a falling object or collision and face in that direction

5.Face recognition:

ASIMO has the ability to recognize faces, even when ASIMO or the human being is moving.



Distinguish between registered faces.

For example, ASIMO can:

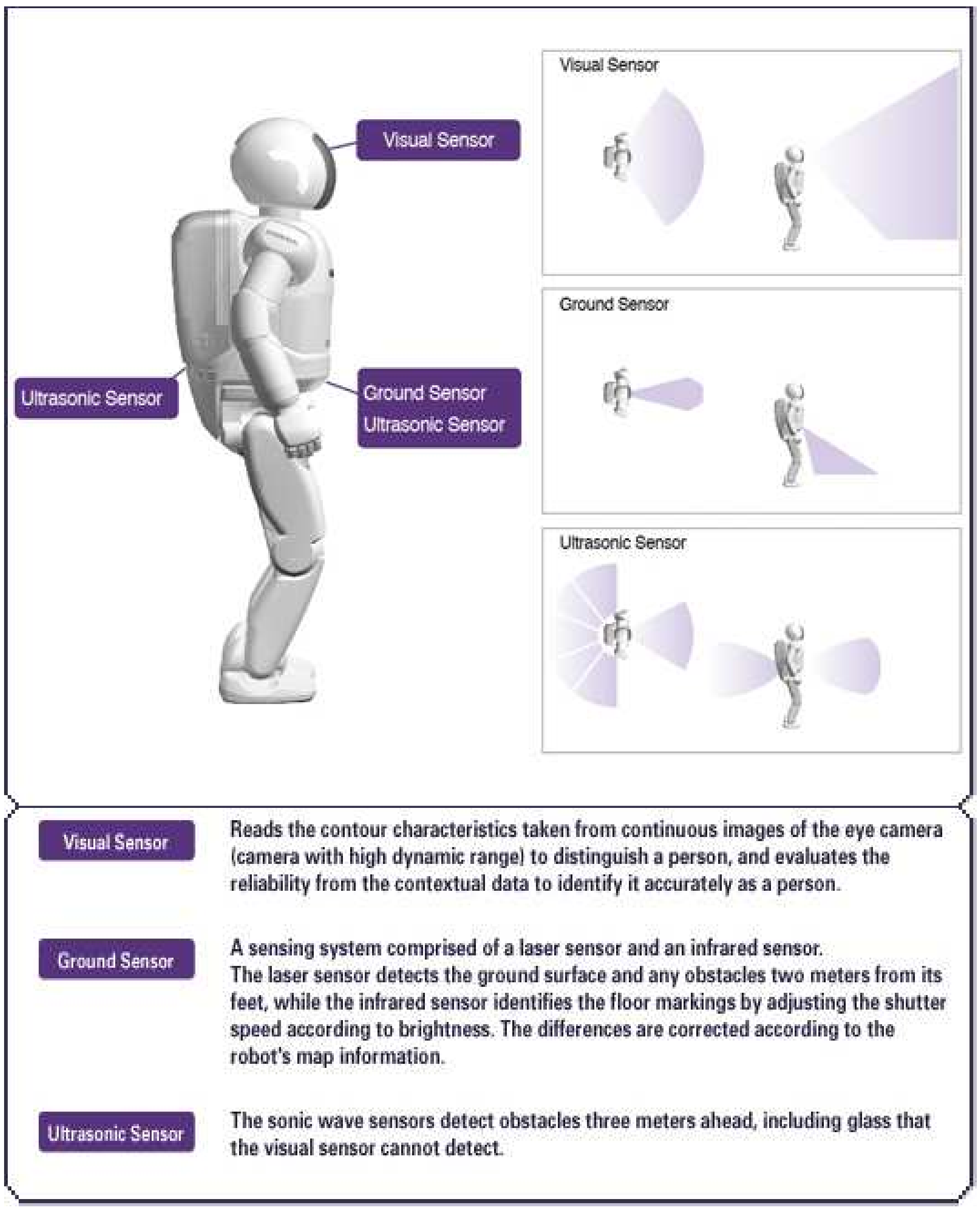
- Recognize the faces of people who have been pre-registered addressing them by name communicating messages to them and guiding them
- Recognize approximately ten different people

11.Environment Adaptability Improvements:

ASIMO's autonomous features:

ASIMO can maneuver toward its destination without stopping by comparing any deviation between the input map information and the information obtained about the surrounding area from its floor surface sensor.

ASIMO’S Environment Identifying Sensor:

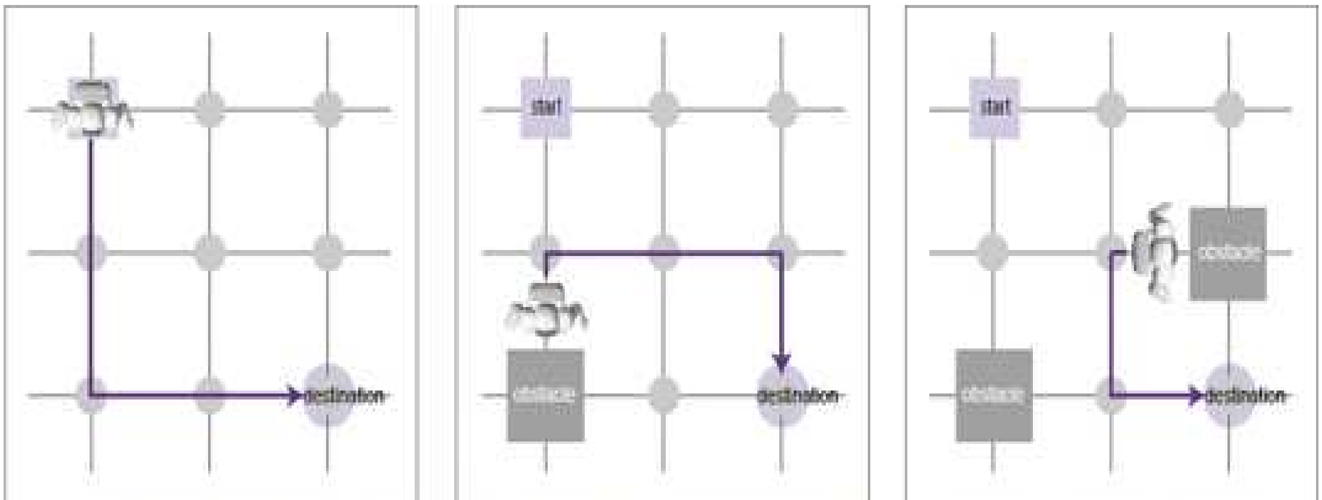


Identifying Obstacles:

ASIMO selectively use its multiple sensors based on its own judgments, and adjusts the sensitivity of the sensors according to the surrounding circumstances in order to consistently identify obstacles.

Automatic Detour Function:

When its ground sensor or the visual sensor on its head identifies an obstacle, it ASIMO selects a different route using its own judgment.



1) Establishes the shortest route from the origin to the destination.

2) Diverts to an alternative route when it finds an obstacle on the shortest route it established.

3) When it finds an obstacle on its alternative route, it diverts to another alternative route.

Identifying moving subjects:

From the characteristics of images obtained from its visual sensor on its head, ASIMO extracts multiple moving subjects, and identifies the distance and direction to those subjects and likelihood of those subjects being people.

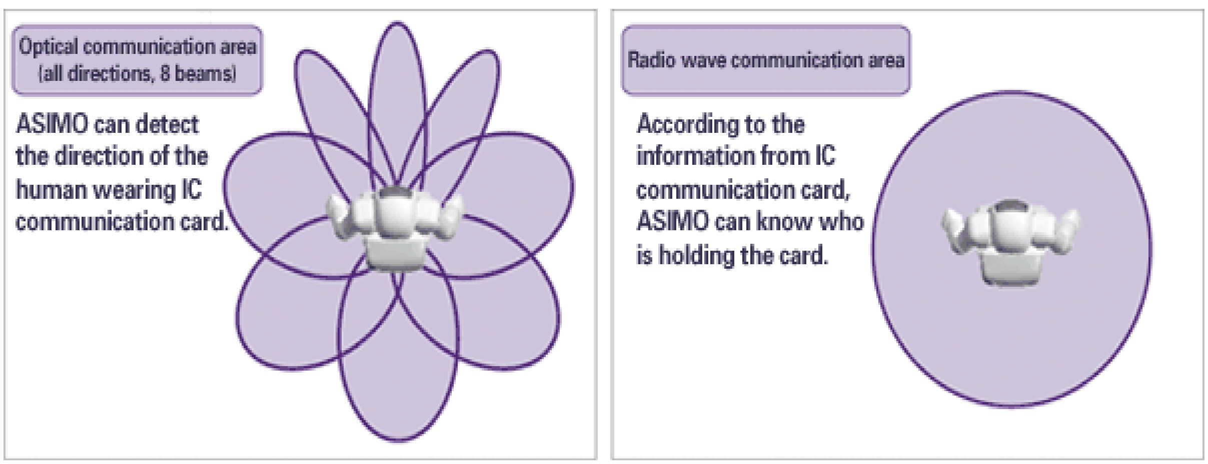
Shakes hands in sync with the person's motion:

By detecting people's movements through visual sensors in its head and force (kinesthetic) sensors on its wrists, ASIMO can shake hands in concert with a person's movement. During hand shaking, ASIMO steps backward when the hand is pushed and steps forward when the hand is pulled. ASIMO moves in concert with a person by taking steps to the direction of the force.

IC Communication Card:

In collaboration with Honda's unique IC communication card, an IC tag with optical communication functions, ASIMO autonomously selects and executes its tasks.

Based on customer information pre-registered in the IC communication card, ASIMO identifies the characteristics and relative position of its target person. Even with multiple people around, ASIMO can determine their positions and who they are, and respond to each person individually.



Attending to a person while recognizing the person:

Based on the information in the IC Communication card, ASIMO recognizes the individual and attends to the person accordingly.

When passing a person who carries an IC communication card, ASIMO identifies the card information and greets appropriate for the person.

12.Object Handling Improvements:

Handing the tray:

By detecting the movement of the person through the eye camera in its head and force sensors on its wrists, ASIMO can move in concert with the person and accurately receive or hand over the tray.

Walking with the tray:

While carrying the tray, ASIMO uses its entire body to control the tray to prevent spilling of the objects on the tray. Even if the tray slides and is about to fall, ASIMO’s wrist sensors detect the weight differences on its hands and automatically stop walking before it drops the tray.

Putting the tray on a table:

When the force sensors on its wrists detect reduction of the load on the wrists as the tray touches the surface of the table, ASIMO sets the tray on the table. By using the entire body to set the tray down, ASIMO can work with tables of different heights.

Handling a cart:

It can transport heavy loads by handling a wagon in a flexible manner.

Being able to handle a cart freely, ASIMO is now capable of carrying heavy objects ASIMO is capable of handling a cart freely while maintaining an appropriate distance from the cart by adjusting the force of its arms to push a cart using the force sensor on its wrists. Even when the movement of the cart is disturbed, ASIMO can continue maneuvering by taking flexible actions such as slowing down or changing directions.
(The maximum load is 10 kg.)

Pictures of ASIMO handling objects

CONCLUSION

13.Conclusion:

Hence the above points describe briefly the basic components and their working in the humanoid robots.

The ASIMO humanoid robot developed by the Honda company is the advanced humanoid robot when compared to the existing ones.

ASIMO is the best example taken and is explained briefly. The features, specifications, technologies used in the humanoid robot ASIMO are best explained above with suitable pictures diagrammatic and graphical representations. The applications of these robots are in every field.

14.References:

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