Syrian Arab Republic

Ministry of education

National Centre for distinguished

ASIMO BEYOND THE FUTURE

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Introduction

Our life is a journey started billions years in the past until we reached this moment. Our minds were weapons and our ideas were solutions to our biggest problems that we faced in human kind revolution.

Today, I am standing in front of masterpiece trying to study this masterpiece from the starting point to predict how it will affect our lives in future. This masterpiece is ASIMO Robot.

In this research I am aiming to answer these two questions:

The first one is: **Will ASIMO be used in military sections?**

The second one is: **Is it safe to live with ASIMO?**

ROBOT ID

What is a robot?

A robot is a machine whose behavior can be programmed. This is a broad definition it includes things like VCRs and microwave ovens, a far cry from the talking androids you might be thinking of.[1]

Robots have five fundamental components:

1. A *brain* controls the robot's actions and responds to sensory input. Usually the brain is a computer of some kind.

2. A robot's *body* is simply the physical chassis that holds the other pieces of the robot together.

3. *Actuators* allow the robot to move. These are usually motors, although there are many other possibilities, such as hydraulic pistons.

4. *Sensors* give a robot information about its environment. A touch sensor, for example, can tell a robot that it has come in contact with something else.

The last component is not always obvious:

5. A *power source* supplies the juice needed to run the brain, actuators, and sensors.

For example, think about a robot that spray paints cars in a factory. Its brain is probably a garden-variety desktop computer. The body is a big arm with a paint sprayer at the end. The actuators are motors or pneumatic pistons that move the arm around. Position and rotation sensors are used so the robot knows where the sprayer is and what direction it's pointing. The whole thing is plugged into a wall socket for power.

Kinds of robots:

Robots are usually categorized by the way of movement into different categories:

Mobile Robots:

mobile robots are robots that can move from a place to another by its self, they are usually used to reach places which humans cannot reach. NASA uses this kind of robots to explore other planets like mars. They are divided into two kinds by the way of movement:

Rolling robots:
this kind of mobile robots uses wheels to move quickly, but it is hard to a rolling robot to move on rocky terrain.

Walking robots:

This kind of robots uses legs to move around but it is hard to make them balanced especially if they have not many legs like humanoid robots, walking robots are usually used to move on rocky terrain.

[1] The Unofficial Guide to LEGO Mindsortms Robots

Stationary Robots:

Those robots usually work on dais; they are usually used in production lines in factories.

Mobile Robot challenges:

Mobile robots present special challenges. These robots can move their bodies around from place to place. Why is this capability difficult? Many more things can go wrong if your robot is free to move around rather than being bolted to one place. Being mobile multiplies the number of situations your robot needs to be able to handle.
Mobile robots actually come in two varieties: *tethered* and *autonomous.* A tethered robot "cheats" by dumping its power supply and brain overboard, possibly relying on a desktop computer and a wall outlet. Control signals and power are run through a bundle of wires (the tether) to the robot, which is free to move around, at least as far as the tether will allow.
Autonomous mobile robots are even more challenging. These robots need to bring everything along with them, including a power supply and a brain. The power supply is typically an array of batteries, which adds a lot of weight to the robot. The brain is also constrained because it has to fit on the robot, not weigh a ton, and be frugal about sucking power out of the batteries.[2]

This is tough stuff:

The field of autonomous mobile robotics is extremely challenging. Have you ever seen an autonomous mobile robot, besides in the movies? Probably not. If you have been lucky enough to see such a robot, was it doing something useful? Probably not. If the robot was supposed to do something useful, did it work? Probably not.

If it wasn't so hard to make autonomous mobile robots, the world would be full of them. Wouldn't it be nice to have a robot do your laundry or drive you to the airport? But the cold truth is that it's unbelievably difficult to make a robot that can do even the simplest of tasks. It all comes down to one fact: *it's very hard to deal with the real world.*

Big is beautiful:

The big robot people believe that the robot should understand its environment and "think," more or less the same way that a human does. This is the traditional Artificial Intelligence (AI) approach to robotics. In this approach, the robot takes input from its sensors and tries to build a map of its surroundings. This process alone is very complicated: the robot might use a pair of video cameras or some more exotic sensors to examine its surroundings, while heavy-duty computers analyze all the sensor data and attempt to build a map. Finally, in a process called task planning, the robot tries to figure out how it will accomplish an objective—getting from one point to another, or picking up an object, or some other simple task. In this respect, again, the robot is expected to think like a human being. The heavy computing requirements of the AI approach consume a lot of power, which implies a bulky, heavy power supply. Hence, the robot can be pretty big and expensive, too.

[2] The Unofficial Guide to LEGO Mindsortms Robots

Small is beautiful:

Little robot people like to tease the big robot people for building tremendously large, tremendously expensive machines that don't have the dexterity of a six-month-old baby. The little robot people make small mobile robots based around inexpensive, off-the-shelf parts. They like to see themselves as mavericks, achieving decent results at a fraction of the cost and complexity of big robotics.

One of the interesting ideas behind small robot research is the idea that quantity might get the job done rather than quality. Instead of building a single bulky, complex robot to explore the surface of Mars, why not send a thousand robots the size of mice to do the same job? So what if a few of them fail? Small robots offer a new and innovative way to approach big problems.

Humanoid Robots:

In recent years there has been a growing research and commercial interest in humanoids, and this is witnessed by the latest developments in the field, and many new robots have been presented to demonstrate advanced skills in performing very specific tasks. However, these robots do not yet approach the generic flexibility and agility of humans. One possible solution is to develop robots that imitate humans in both their design as well as their behavior. This is considered by many researches in the robotics community to be the best way to guarantee a good adaptability to perform the highest number of human-oriented tasks a robot can possibly face in an everyday scenario of coexistence with humans.

Honda Started Working in this field in aiming to create a partner for people, a new kind of robot that functions in society.

The main concept behind Honda’s robot R&D was to create a more viable mobility that allows robots to help and live in harmony with people.

Research began by envisioning the ideal robot form for use in human society. The robot would need to be able to maneuver between objects in a room and be able to go up and down stairs. For this reasons it had to have two legs just like a person.

In addition, if two-legged walking technology could be established, the robot would need to be able to walk on uneven ground and be able to function in a wide range of environments. Although considered extremely difficult at the time, Honda set itself this ambitious goal and developed revolutionary new technology to create a two-legged walking robot.[3]

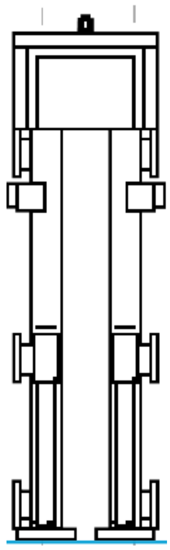
[3] PIC Robotics by john Lovine.

Battles to achieve stable walking

Old models

1986

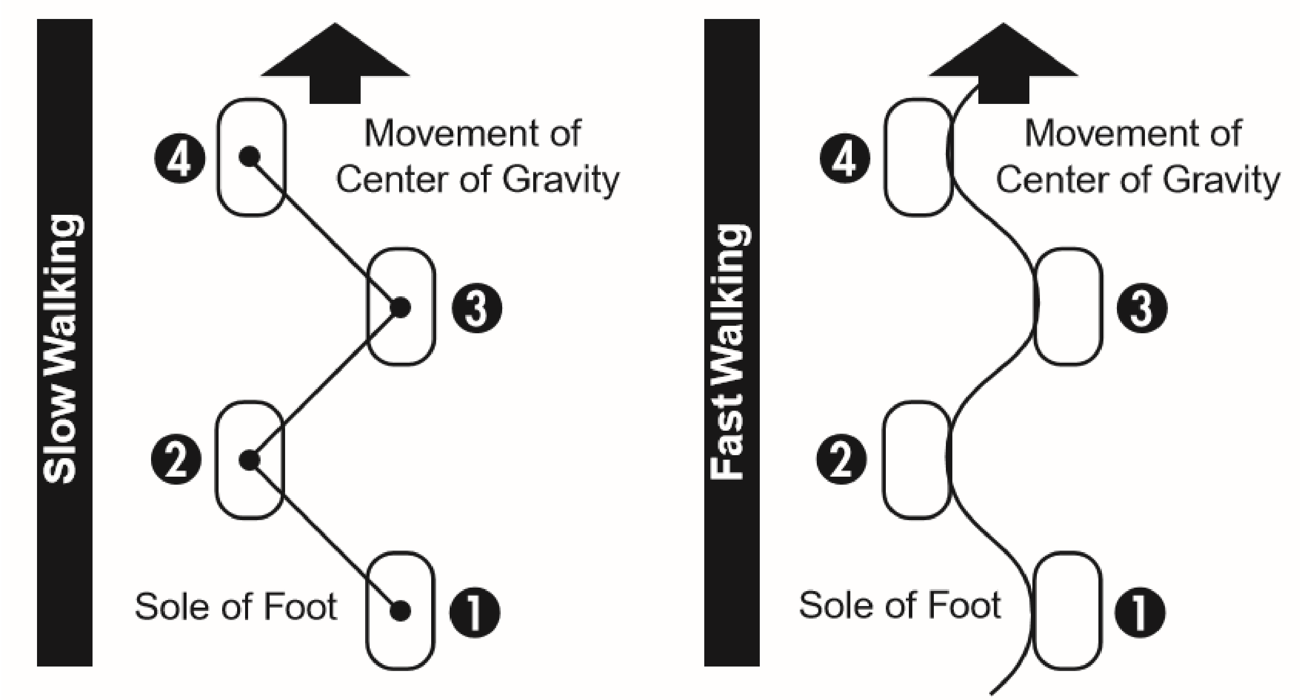
Examining the principles of two-legged Locomotion



E0

First, a two-legged robot was made to walk.

walking by putting one leg before the other was successfully achieved. However, taking nearly five seconds between steps, it walked very slowly in a straight line.[4]



During slow walking, the body's center of gravity remains always centered on the soles of the feet.
When body movement is used for smooth, fast walking, the center of gravity is not always on the soles of the feet.

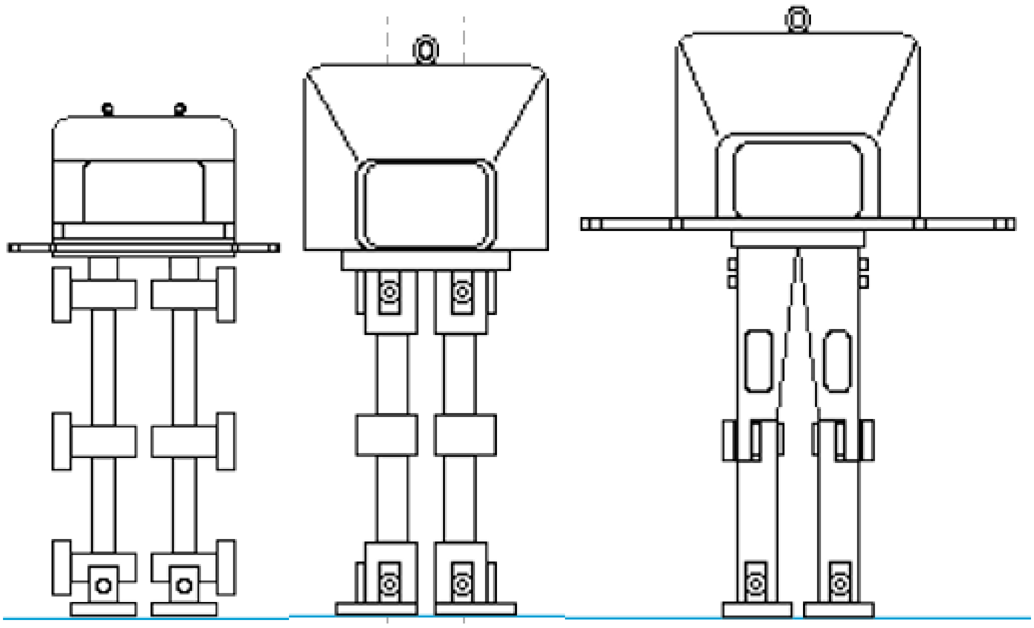
[4] ASIMO Technical Information September 2007

1987 – 1991

Realizing rapid two-legged walking

E1-E2-E3

To achieve a fast walking pace, it was necessary to study how human beings walk.
Human walking was thoroughly researched and analyzed. In addition to human walking, animal walking and other forms of walking were also studied, and the movement and location of the joints needed for walking were also researched. Based on data derived from human walking, a fast walking program was created, input into the robot and experiments were begun.
The E2 robot achieved fast walking at a speed of 1.2 km/h on flat surfaces.
The next step was to realize fast, stable walking in the human living environment, especially on uneven surfaces, slopes and steps, without falling down.[5]



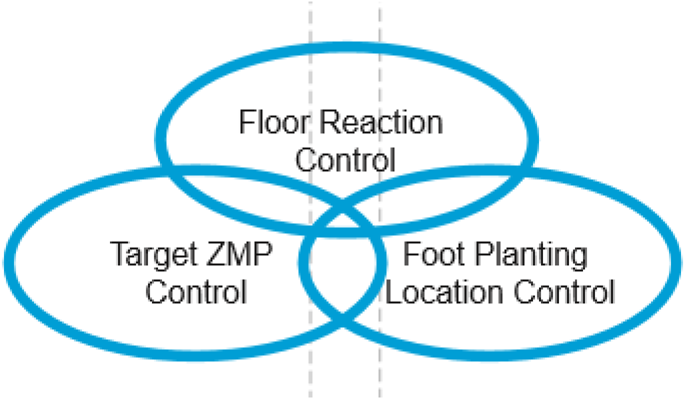
[5] ASIMO Technical Information September 2007

1991 – 1993

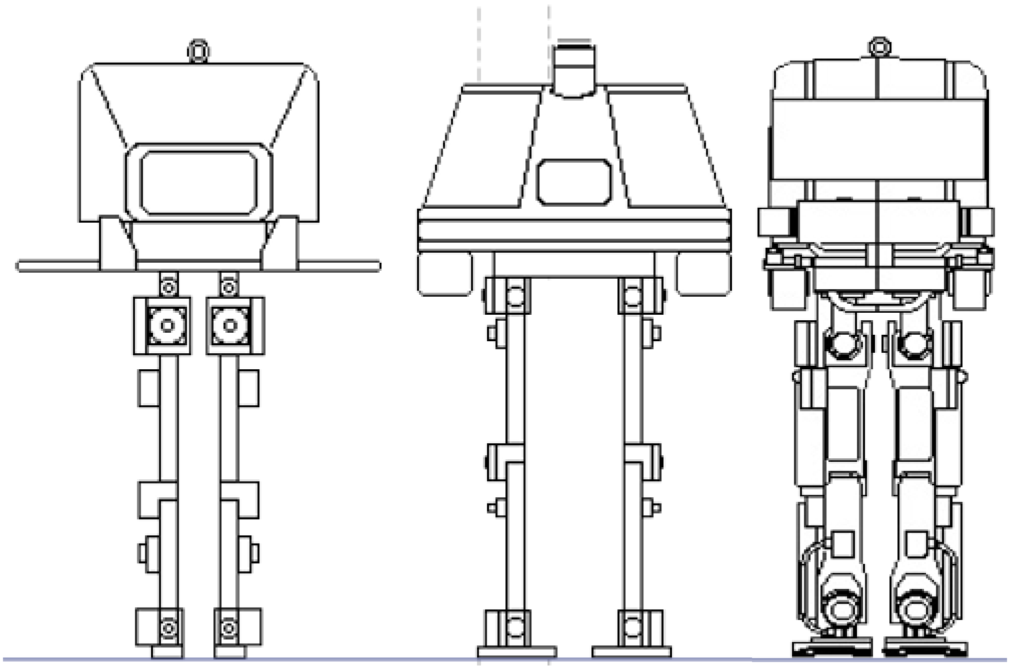
Completing the Basic Functions of Two-Legged Walking

E4-E5-E6

Establishing Technology for stable walking:
Honda investigated techniques for stabilizing walking, and developed three control techniques.
The 3 Posture Controls Needed for Stable Walking:



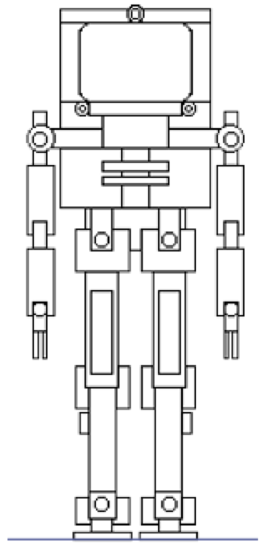
The walking mechanism was established with the E5. Honda's E5 robot achieved stable, two-legged walking, even on steps or sloping surfaces.
The next step was to attach the legs to a body and create a humanoid robot.



1993 – 1997

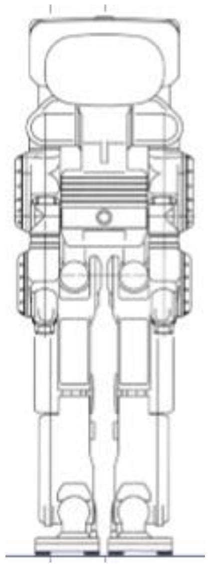
Research on Completely Independent Humanoid Robots

P1-P2-P3

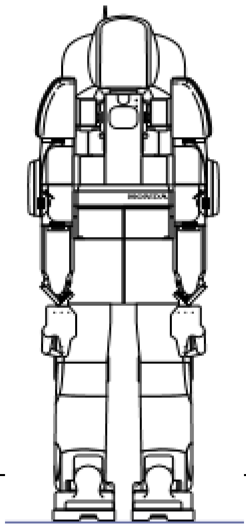


Advances in Humanoid Robots

P1: Humanoid Robot Model #1 Height: 1,915mm, Weight 175kg. The robot can turn external electrical and computer switches on and off, grab doorknobs, and pick up and carry things. Research was also carried out on coordination between arm and leg movements.



P2: The world's first self-regulating, two-legged humanoid walking robot debuted in December, 1996. Height: 1,820mm, Weight: 210kg. Using wireless techniques, the torso contained a computer, motor drives, battery, wireless radio and other necessary devices, all of which were built in. Independent walking, walking up and down stairs, cart pushing and other operations were achieved without wires, allowing independent operation.



P3: The first completely independent, two-legged humanoid walking robot was completed in September, 1997. Height: 1,600mm, Weight: 130kg. Size and weight were reduced by changing component materials and by decentralizing the control system. Its smaller size is better suited for use in the human environment.[6]

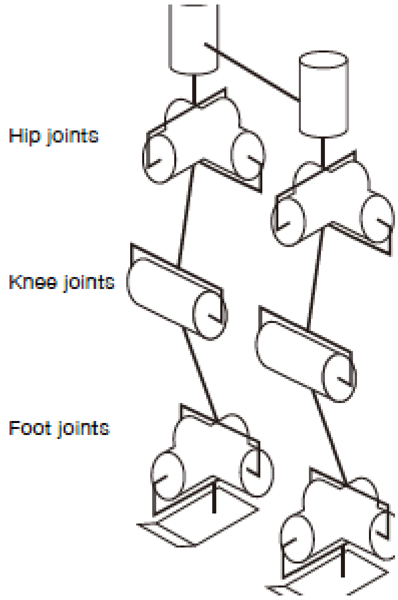
[6] ASIMO Technical Information September 2007

The robot’s walk is modeled on a human being’s

In studying the fundamental principles of two-legged walking, Honda researched both human and other forms of walking, performed numerous experiments and collected an immense amount of data. Based on this research, Honda established fast-walking technology just like human’s.

I. Leg Joint placement

The human skeleton was used for reference when locating the leg joints.
Regarding the toes’ influence on the walking function, it became clear that location where the toes were attached where the heel joint was positioned were very important in determining how the robot’s weight was supported.
Contact sensation from the surface come the foot joints.
Because the foot joint turn from front to back, and left to right, there is stability in the longitudinal direction during normal walking, and feel for surface variations in the lateral direction is enhanced when traversing a slope at an angle.
The knee joint and hip joint are needed for climbing and descending stairs, as well as for straddling.
The robot system was given many joint functions such as hip joints, knee joints and foot joints.



II. Range of joint movement

Regarding the range of joint movement during walking, research was carried out on human walking on flat ground and on stairs. Joint movements were measured, and this determined the range of movement for each joint.

III. Leg dimensions, Weight & center of gravity location

To determine the location of each leg’s center of gravity, the human body’s center of gravity was used for reference.

IV. Torque exerted on leg joints while walking

To determine the ideal torque exerted on the joints while walking, the vectors at the joints during human walking and during occasional floor reaction were measured.

V. Sensors for walking

Human beings have the following three senses of balance

- Speed sensed by the otolith of the inner ear.
- Angular speed sensed by the semicircular canals.
- Deep sensations from the muscles and skin, which sense the operating angle of the joints, angular speed, muscle power, pressure on the soles of the feet, and skin sensations.
- To "comprehend" the foot's movement during walking, the robot system is equipped with a joint angle sensor, a 6-axis force sensor, and a speed sensor and gyroscope to determine position.

VI. Impact force during walking

Human beings have structural elements such as soft skin and heels, as well as arch structures consisting of toe joints. These combine with moveable parts which absorb bending impacts to the joints when the foot contacts the ground, softening the impact force. Experiments and analyses of human walking have shown that when walking speed increases, floor reaction increases even when the impact reduction functions are at work. At walking speeds of 2~4km/h, the impact is 1.2~1.4 times body weight; at 8km/h, the load increases to 1.8 times body weight. With the robot, impact-absorbing material on the soles of the feet and compliance controls are used to reduce the impact.[7]

[7] Footstep planning for the HONDA ASIMO humanoid. The robotics institute Carnegie Mellon university

To achieve stable walking

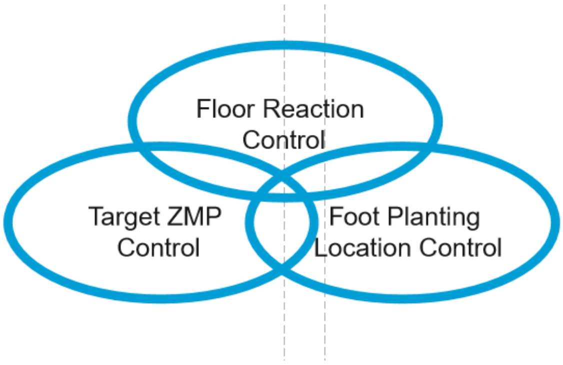
Issues to be address in order to achieve stable walking...

- Not falling down even when the floor is uneven.
- Not falling down even when pushed.
- Being able to walk stable on stairs or slopes.

Posture Controls to Achieve Stable Walking:

ZMP: Zero Moment Point: The point when total inertial force is 0.

Floor Reaction Control: Firm standing control of the soles of the feet while absorbing floor unevenness.

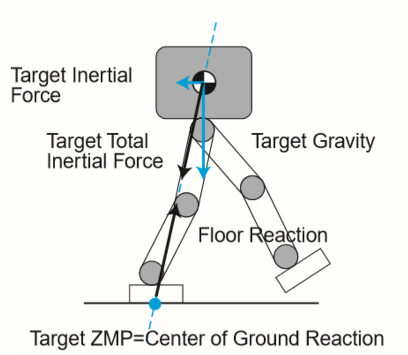


Target ZMP Control: Control to maintain position by accelerating the upper torso in the direction in which it threatens to fall when the soles of the feet cannot stand firmly.

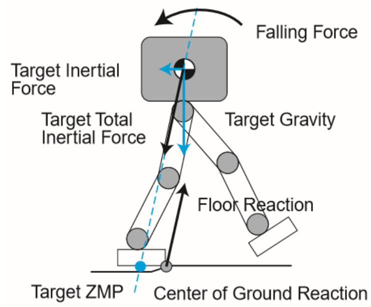
Foot Planting Location Control: Control using side steps to adjust for irregularities in the upper torso caused by target ZMP control.

3 Position-Control Arrangements:

When the robot is walking, it is influenced by inertial forces caused by the earth's gravity and the acceleration and deceleration of walking. These combined forces are called the total inertial force. When the robot's foot contacts the ground it is influenced by a reaction from the ground called the floor reaction force.

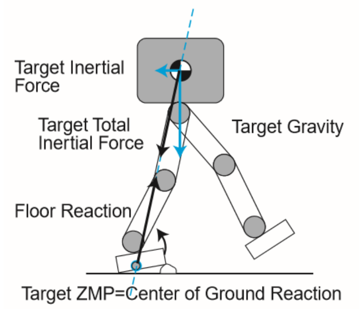


The intersection of the floor and the axis of the total inertial force has a total inertial force moment of 0, so it is called the Zero Moment Point. The point where the floor reaction force operates is called the floor reaction point. Basically, an ideal walking pattern is created by the computer and the robot's joints are moved accordingly. The total inertial force of the ideal walking pattern is called the target total inertial force, and the ZMP of the ideal walking pattern is called the target ZMP.



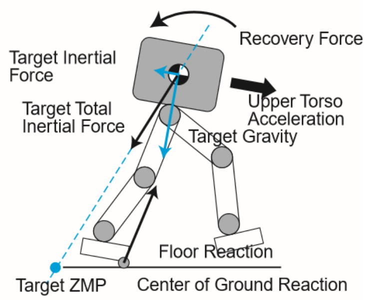
When the robot is maintaining perfect balance while walking, the axes of the target total inertial force and the actual floor reaction are the same. Accordingly, the target ZMP and the center of ground reaction are the same. When the robot walks across uneven ground, the axes of the target total inertial force and the actual floor reaction force are out of alignment, balance is lost and falling force is generated.

This falling force is comparable to the misalignment of the target ZMP and the center of ground reaction. In short, the misalignment between the target ZMP and the center of ground reaction is the main cause of loss of balance.



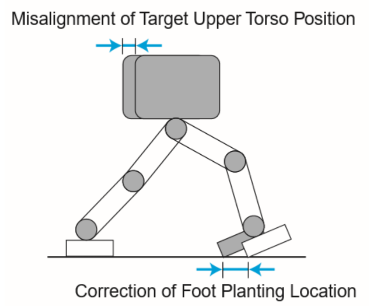
When the Honda robot loses its balance and threatens to fall, the following three control systems operate to prevent the fall and allow continued walking.

floor reaction control: The floor reaction control absorbs irregularities in the floor and controls the placement of the soles of the feet when falling is imminent. For example, if the tip of the robot's toe steps on a rock, the actual center of ground reaction shifts to the tip of the toe. The floor reaction control then causes the toe to rise slightly, returning the center of ground reaction to the target ZMP.



Another example would be if something caused the robot to lean forward, the tips of the toes would be lowered, placing more pressure on them and the actual floor reaction action point would be shifted forward, generating a position recovery force. However, because the center of ground reaction cannot exceed the scope of the foot sole contact patch there is a limit to the position recovery force, and if the robot leans too far forward it will fall. forward it will fall.

Target ZMP Control: If the robot leans too far over, the target ZMP control operates to prevent it from falling. As stated above, misalignment of the target ZMP and the actual floor reaction action point generates a falling force. However, the target ZMP control maintains the robot's stability. For example, in the diagram to the left, if the robot starts to fall forward, its walking speed is accelerated forward from the ideal walking pattern. As a result, the target ZMP is shifted rearward from the actual floor reaction action point and a rearward falling force is created which corrects the robot's position.



Foot Planting Location Control: When the target ZMP control operates, the target position of the upper torso shifts in the direction of acceleration. When the next step is taken in the ideal step length, the feet will fall behind the torso. The stepping placement control idealizes the stride to ensure the ideal relationship between torso speed and length of stride is maintained.[8]

[8] Footstep planning for the HONDA ASIMO humanoid. The robotics institute Carnegie Mellon university

Creating a Humanoid Robot

After establishing the two-legged walking technology, work was begun on combining an upper torso with the legs and developing humanoid robot technology. Studies were carried out to determine what a humanoid robot should be like to function in society and in a human living environment, and a prototype model of almost human size was completed.

Basic Structure

Movement by Two-Legged Walking Mechanism

Work by Two-Armed Mechanism

Basic Functions

Target Point Movement: From the erect position, a camera is used to recognize two markers placed on the floor or other spots. After the robot estimates its present location and direction, it designates a target point. It then calculates the method giving the minimum amount of walking required to move from its present location to the target point. The gyroscope is used for inertial navigation as it moves to the target point, correcting for irregularities caused by slippage, etc.

Climbing/Descending Stairs: A 6-axis force sensor is used to measure steps, so the robot can negotiate even long stairways continuously without missteps.

Cart Pushing: The robot can push carts at a set speed, but if the cart encounters some kind of resistance the robot shortens its stride in response to avoid excessive pushing.

Passing Through Doorways: The robot can open and close doors while passing through doorways. As in cart pushing, its steps are regulated in response to the door's opening/closing condition.

Carrying Things: Each arm can carry up 2kg while walking.

Working Via Remote Operation: The robot can tighten bolts and perform other tasks with the master arm while sensing hand operating pressure.

Degrees of freedom for Human Joints:

Arm	Shoulder Joint (F/B,U/D,RT)*1	3 DOF
	Elbow joint (F/B)	1 DOF
	Wrist joint (F/B,L/R,RT)	3 DOF
		7 DOF x 2 arms = 14 DOF
Hand	Grasping movement	1 DOF x 2 hands = 2 DOF
Foot	Pelvis joint (F/B,L/R,RT)	3 DOF
	Knee joint: (F/B)	1 DOF
	Ankle joint: (F/B,L/R)	2 DOF
		6 DOF x 2 legs = 12 DOF

Degrees of freedom (DOF) are the directions in which the hands and feet can move. For example, the human wrist joint can move in three directions: up, down, left, right, and twist, so it has three degrees of freedom.

*1

F/B: Forward/Backward

U/D: Up/Down

L/R: Left/Right

R/T: Rotation

DOF: Degree of Freedom

Let us take P3 Robot as an example:

1) **Antenna**: Data is transmitted between the robot and the operating computer via wireless communication.
2) **Battery:** The nickel-zinc battery allows approximately 25 minutes of operation.
3) **Gyroscope & Acceleration Sensor:** these sense body lean and acceleration.
4) **Camera:** Images from the camera show the operator how to direct the robot and detect the target location.
5) **Body:** The body is made of a very lightweight and tough magnesium alloy.
6) **6-Axis Force Sensor:** This senses the direction and amount of force on the hand.

7) **Actuator:** A brushless DC servomotor and harmonic drive speed reducer perform the functions of human muscles.
8) **6-Axis Force Sensor:** Images from the camera show the operator how to direct the robot and detect the target location.
9) **Compact & Lightweight:** Light weight and compactness were achieved using lightweight materials and decentralizing the controls.

ASIMO is born!

As exemplified by P2 and P3, the two-legged walking technology developed by Honda represents a unique approach to the challenge of autonomous locomotion. Using the know-how gained from these prototypes, research and development began on new technology for actual use. ASIMO represents the fruition of this pursuit on November 20, 2000.

ASIMO stands for Advanced Step in Innovative Mobility. It means advanced innovative mobility for a new era.

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.[9]

Compact & Lightweight

More Advanced Walking Technology

Wider Arm Operating Parameters

Easy to Operate

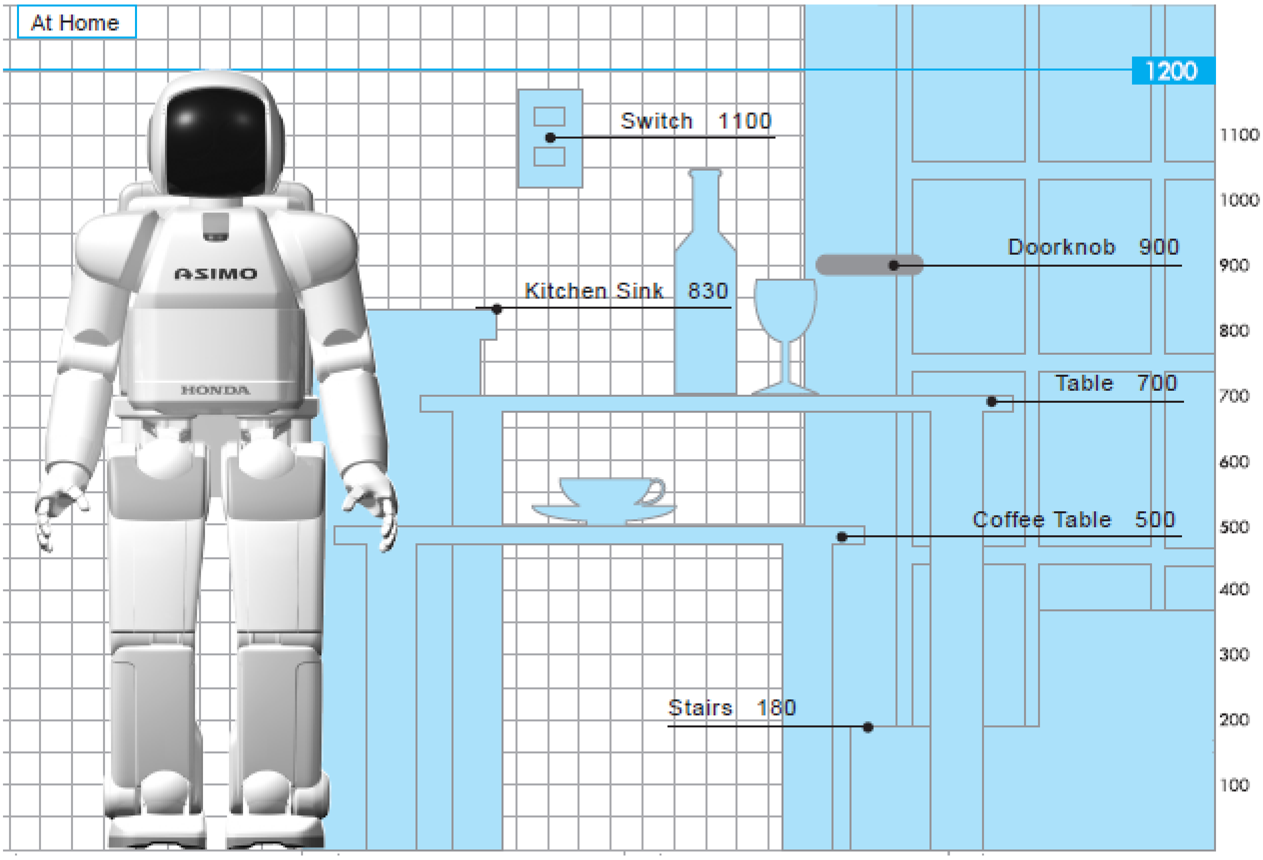
Friendly Design

Design Concept:

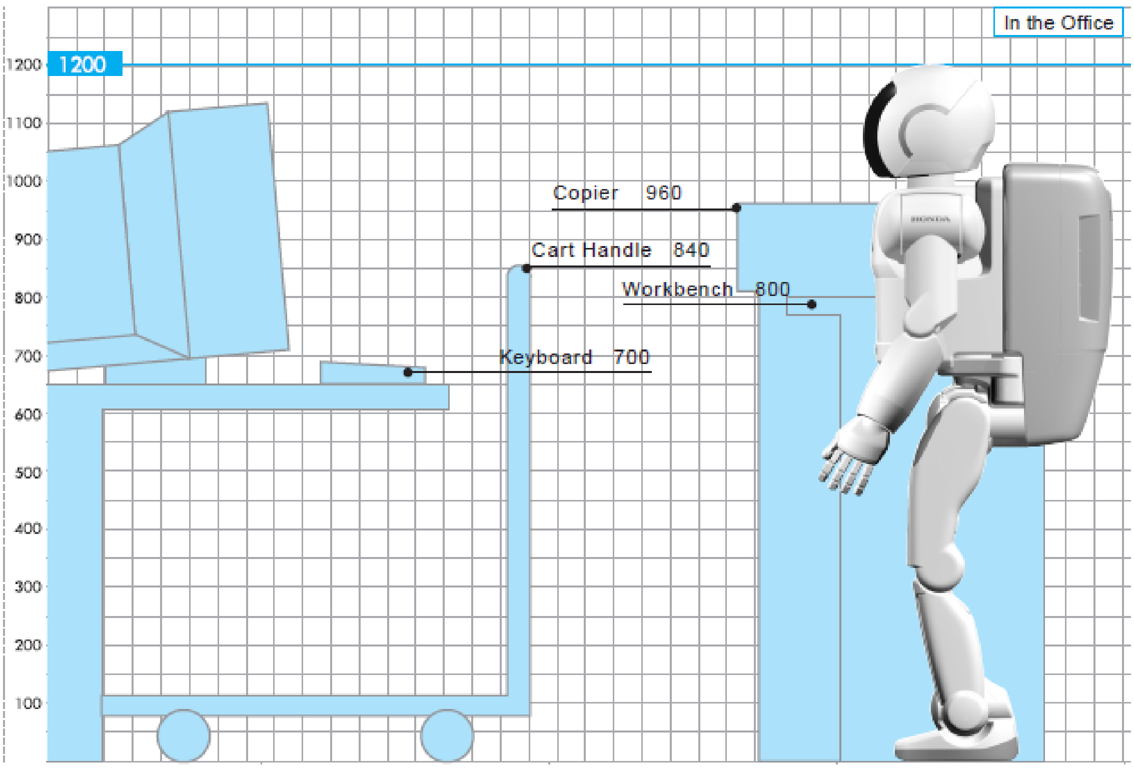
ASIMO is called People-Friendly Robot, He has a small, useful size. The robot's size was chosen to allow it to operate freely in the human living space and to make it people-friendly. This size allows the robot to operate light switches and door knobs, and work at tables and work benches. Its eyes are located at the level of an adult's eyes when the adult is sitting in a chair. A height of 120cm makes it easy to communicate with. Honda feels that a robot height between 120cm and that of an adult is ideal for operating in the human living space.

[9] ASIMO Technical Information September 2007

ASIMO at home:



ASIMO in the office:



Smoother and more stable walking

The introduction of intelligent, real-time, flexible-walking i-WALK 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:

1. In the past, different patterns were used for straight walking and for turning, and a slight pause was required during the transition.
   For robots up to P3

Straight(A) ⇒ Temporary pause ⇒ Turn (B) ⇒ Temporary pause ⇒ Straight(C)

For example, when the P3 robot turned sharply when walking straight, its movement was awkward because it had to stop to make the turn.

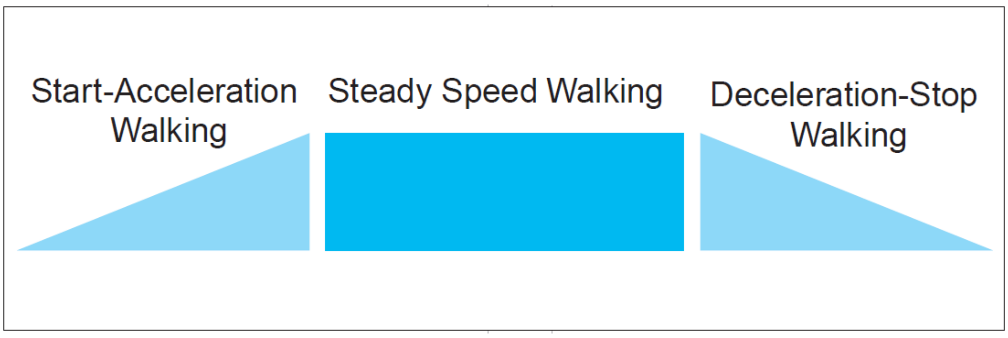
2. Walking strides (time per step) were limited to only a few variations.
   Because each walking pattern has a different stride (time per step), the robot could not change its stride (time per step) flexibly.

Creating earlier walking patterns:

Earlier walking technology allowed roughly two different walking patterns.

A. Straight (foot lifting with toes upward and landing on heel)

   When walking in a straight line, the robot followed an ordered pattern of start-acceleration walking, steady speed walking and deceleration-stop walking, all of which was stored as time series data.[10]

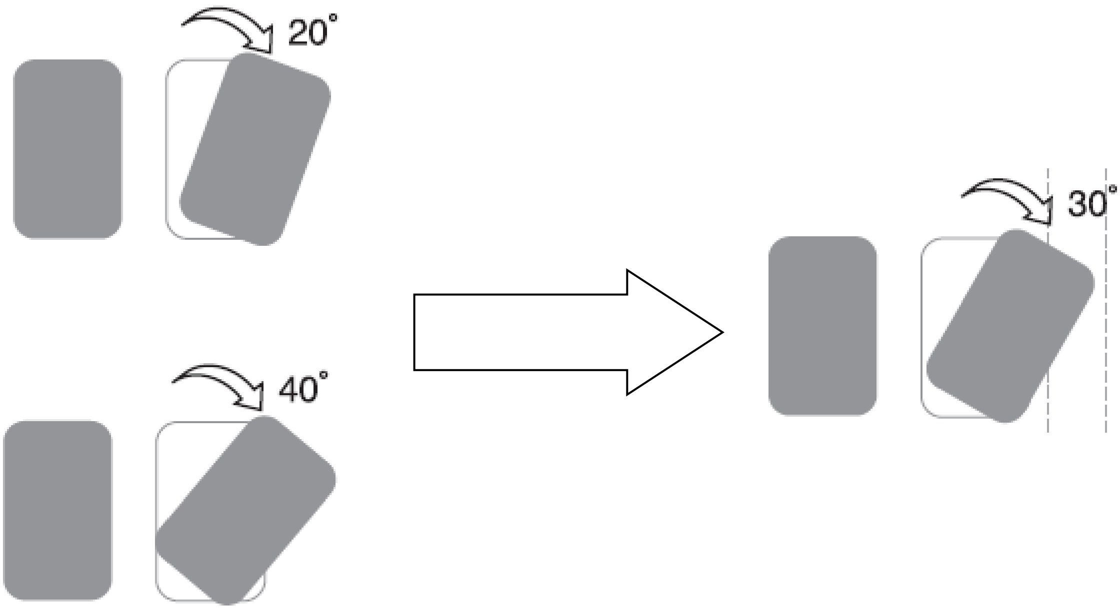


[10] ASIMO Technical Information September 2007

B. Turning (Direction-Changing Walking)

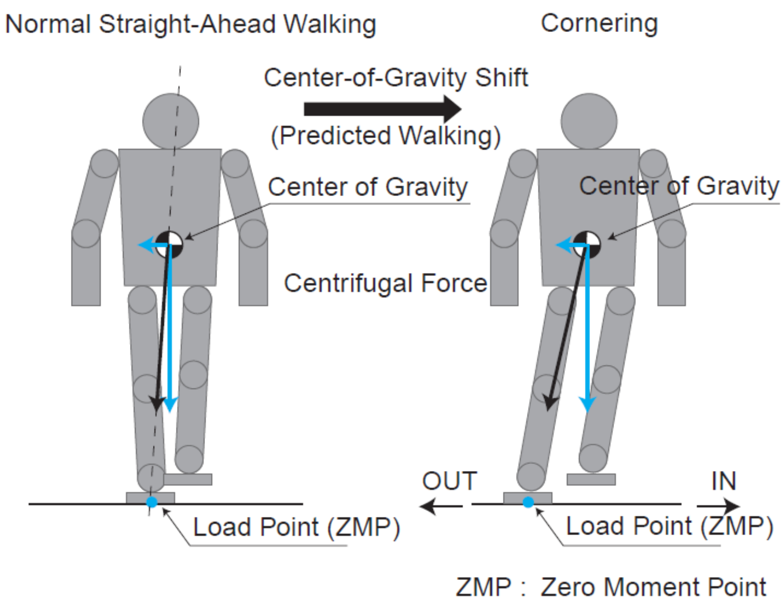
Turning was accomplished by initiating multiple, different, turn-walking patterns based on strides (time per step) stored as time series data.

For example, the P3 robot combined 20û and 40û Composite walking patterns to turn at 30û.[11]



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

[11] Semester project II: Mobile Robot modeling, Simulating and Programming. New ASIMO

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.

Intelligent, Real-Time, Flexible Walking Creating Prediction Movement Control Achieved!

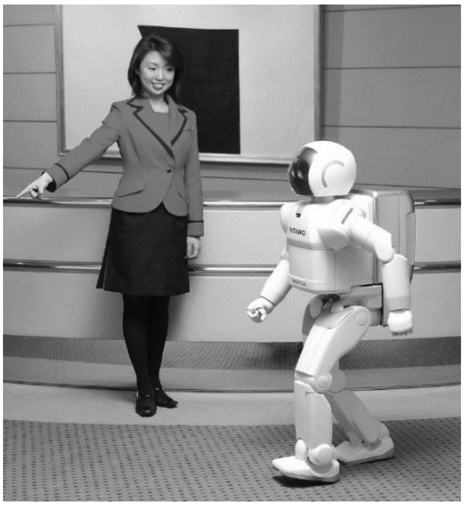
Straight ahead	Turning	Straight ahead

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

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

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 natural.

+



December 5, 2002 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. Further, utilizing networks such as the Internet, ASIMO can provide information while executing tasks such as reception duties. ASIMO is the world's first humanoid robot to exhibit such a broad range of intelligent capabilities.

Movement in response to a gesture (posture recognition).

Advanced communication ability:

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.

Specifically, ASIMO can:

follow the movements of people with its camera.

follow a person.

greet a person when he or she approaches.

Recognition of postures and gestures

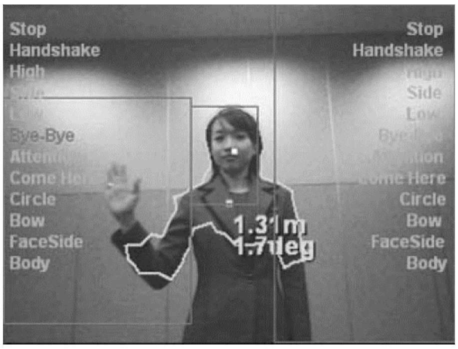
Based on visual information, ASIMO can interpret the positioning and movement of a hand, recognizing postures and gestures. Thus ASIMO can react not only to voice commands, but also to the natural movements of human beings.

For example, ASIMO can:

recognize an indicated location and move to that location (posture recognition).

shake a person's hand when a handshake is offered (posture recognition).

respond to a wave by waving back (gesture recognition).



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.

Distinguishing sounds

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

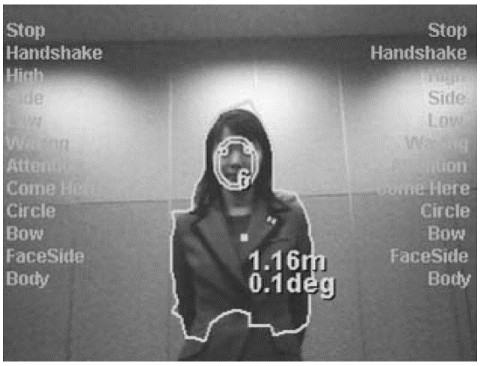
For example, ASIMO can:

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 a collision, and face in that direction.

Face recognition



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

For example, ASIMO can:

recognize the faces of people which have been pre-registered, addressing them by name, communicating messages to them, and guiding them.

recognize approximately ten different people.[12]

Network integration

Integration with user's network system

ASIMO can:

execute functions appropriately based on the user's customer data.

greet visitors, informing personnel of the visitor's arrival by transmitting messages and pictures of the visitor's face.

guide visitors to a predetermined location, etc.

Internet connectivity

Accessing information via the Internet, ASIMO can become a provider of news and weather updates, for example, ready to answer people's questions, etc.

[12] ASIMO Technical Information September 2007

New ASIMO Debut

Honda debuted a new ASIMO humanoid robot which features the ability to pursue key tasks in a real-life environment such as an office and an advanced level of physical capabilities. Compared to the previous model, the new ASIMO achieves the enhanced ability to act in sync with people - for example, walking with a person while holding hands. A new function to carry objects using a cart was also added. Further, the development of a "total control system" enables ASIMO to automatically perform the tasks of a receptionist or information guide and carry out delivery service. In addition, the running capability is dramatically improved, with ASIMO now capable of running at a speed of 6km/hour and of running in a circular pattern.

Major Advancement of New ASIMO

Improved Running Ability

Enhanced Ability to Act in Sync with People

Function to Carry Objects Using Tools

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)

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

Further advanced walking function

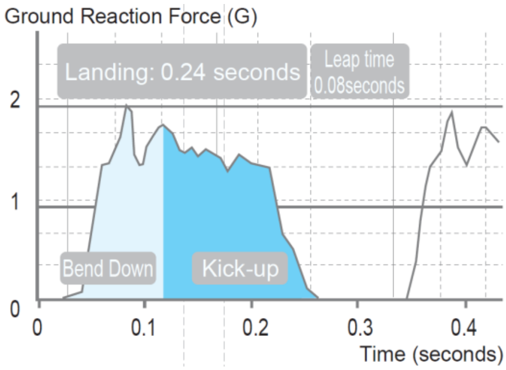
To maintain balance while increasing walking speed and preventing the feet from slipping or rotating in mid-air, we developed new posture control logic that employs active use of the bending and twisting of the upper body, as well as highly responsive hardware. This has enabled ASIMO to run at 6 km/h, and also improved the walking speed to 2.7 km/h.

High Speed Running

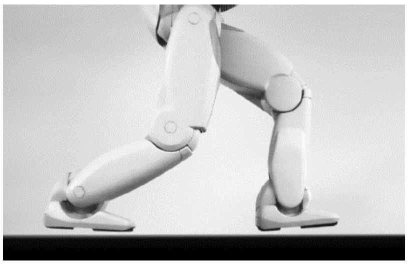
There were two challenges in making ASIMO run. One was to obtain an accurate jump function and absorb shock when landing, and the other was to prevent the rotation and slipping as a result of the increased speed.

Accurate leap and absorption of the landing impact

In order for ASIMO to run, it had to be able to repeat the movements of pushing off the ground, swinging its legs forward, and landing within a very short time cycle and without any delay, absorbing the instantaneous impact shock of landing. ASIMO is a hardware equipped with a newly developed high-speed processing circuit, highly-responsive and high-power motor drive unit, and light-weight and highly rigid leg structure.



Prevention of spinning and slipping

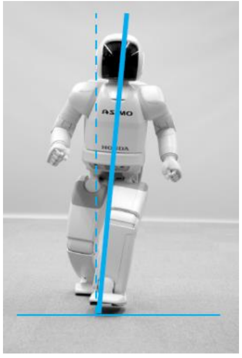


Due to reduced pressure between the bottom of the feet and floor, spinning and slipping are more likely to happen right before the foot leaves the floor and right after the foot lands on the floor. Combining Honda's independently developed theory of bipedal walking control with proactive bending and twisting of the torso, ASIMO achieved stable running while preventing slipping. When a human runs, the step cycle is 0.2 to 0.4 seconds depending on one's speed, and the leap time, when both feet are off the ground, varies between 0.05 to 0.1 seconds. The step cycle of ASIMO is 0.32 seconds with a leap time of 0.08 seconds, which are equivalent to that of a person jogging.[13]

[13] Semester project II: Mobile Robot modeling, Simulating and Programming. New ASIMO

Speed	Stride	Leap distance*	Leap time
6km/h	525mm	50mm	0.08sec

*Distance ASIMO moves forward while both feet are off the ground.



High-Speed Running Turn in a Circular Pattern

Running in a circular pattern at high speed was achieved by tilting the center of gravity of ASIMO's body inside of the circle to maintain balance with the amount of centrifugal force experienced. The tilting. ASIMO changes its speed according to the radius of the circle and controls its tilted posture.

Coordination of the Entire Body

The development of highly responsive hardware enables ASIMO to freely change speed while it is in motion. This allows ASIMO to conduct flexible and rapid movements using the entire body while maintaining its overall body balance.

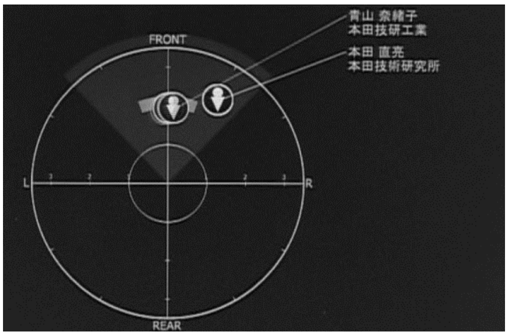
Movement in concert with human motion

Identifying moving subjects

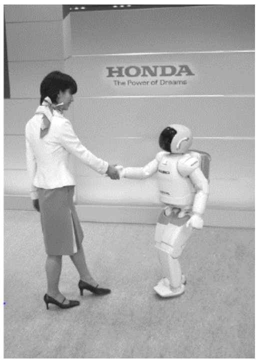
From the characteristics of images obtained from its visual sensor on its head, ASIMO extracts multiple moving subjects, and identifies the distance and direction to those subjects and likelihood of those subjects being people.

Recognizes people

Based on the information on the IC Communication Card, the position of the person is identified, and ASIMO adjusts its own position to face the person.

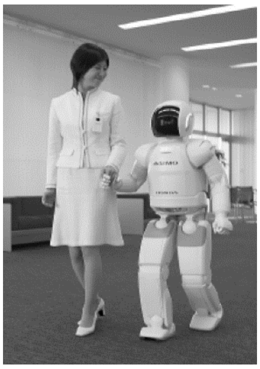


Shakes hands in sync with the person's motion



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.

Walking hand-in-hand



With its force sensors on the wrists, ASIMO detects the strength and direction of the force applied to its hand and adjusts the walking speed and direction. ASIMO takes steps in any direction according to the strength and direction of the force applied to its hand, therefore a person can walk ASIMO in any direction.

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.

Attending to a person while specifying the position of the person

Attending to a person while measuring the distance to the person

Calculating the relative distance between ASIMO and the person to attend, ASIMO adjusts its walking speed. If the distance becomes too great, ASIMO waits until the person comes closer.

Greeting people as they pass by

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

Conclusion

To be able to predict the future you have to understand the past and the present, because of that I wanted to study ASIMO from the zero point to answer the main two questions in this research.

Now I am able to say that ASIMO will not be used in war or any military uses but I believe that new technology which it is using and featuring, and the idea of AI will be used in military robots, and there is a lot of robots in Boston Dynamics are being developed on these basics.

For living with ASIMO, We all know that ASIMO still being developed until now but all experiments shows that living with ASIMO is not dangerous but I think that ASIMO did not reach the point to be able to live with in my home or to work with anyone in the office, but I am sure that we will be able to reach this point in the future.

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