

Styling and Design of New ASIMO

– Evolution for Continuing Engagement with People –

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ABSTRACT

The new ASIMO was developed as a step toward achieving “a robot that coexists and cooperates with people and performs useful functions in society.” The purpose was to make it capable of sensing changes in the circumstances of real-life environments where people are present, to take action autonomously, and to continue acting. It has new functionality from multi-axis hands capable of independently moving five fingers to enable manipulation of objects, legs and feet made more highly responsive for the purpose of continuing operation in mixed environments with people, and light-emitting displays at its ears and chest to induce interactions with people. With all this, a weight reduction of 6 kg was achieved without changing the robot’s total height.

This design assimilates the basic concept of “harmony between being advanced and being people-friendly” at a higher level. Placing importance on people’s perception of ASIMO, and taking into account its state of movement using 3D software, the design was carried forward with an emphasis on the three perspectives of gentleness, comprehensibility, and distinguishability. The result was achievement of a design that conveys the friendly image cultivated ever since ASIMO was first announced in 2000, and that embodies “evolution for the purpose of continuing engagement with people” by means of new functions and mechanisms.

1. Introduction

Honda has conducted research on humanoid robots as one innovative form of mobility that adds new value by functioning usefully in society through coexistence and cooperation with people. This work yielded the creation of ASIMO at the end of October 2000^{(1),(2)}, and it has enabled occasions for exchange with people in Japan and various other countries around the world. In December 2005, a model change was made for the purpose of enhancing the robot’s ability to perform autonomous work in offices and other such real-life environments as well as its other physical capabilities^{(3),(4)}. Operation tests were conducted of ASIMO as a reception guide and in a delivery service and other such duties, yielding deeper knowledge. One lesson learned was that people tend to take actions that are not envisioned in advance, and automatic machines that act in line with predetermined scenarios are not able to respond adequately to those actions. Therefore the new ASIMO was developed with the aim of achieving an autonomous machine with the capability for autonomous decision-making and behavior in changing circumstances so that it would be able to recognize people and sustain interactions with them in a real-life environment. The new model was

announced in November 2011⁽⁵⁾ (Fig. 1). Continuing pursuit of research and development led to the public unveiling of this ASIMO at the Honda Welcome Plaza Aoyama and other locations in 2012.

The demand made of design is that it achieves new functions and mechanisms fully as needed without losing the knowledge gained through the continued development of ASIMO through three generations over some 10 years or



Fig. 1 Humanoid robot New ASIMO

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the world view of people and ASIMO as a machine but one they can nevertheless have friendly contact with.

Here the design development of the new ASIMO will be introduced.

2. Basic Concept of ASIMO Design

Humanoid robots have forms that resemble people, but they are not people, they are machines. One approach is to design the robot as an artificial object kept always on the leading edge. In order to coexist with people, however, a design that is too radical gives a sense of incongruity in everyday living spaces, so that people will be unlikely to receive it sympathetically. A design that seeks to give a familiar appearance and aims for cuteness like that of a stuffed toy will be taken as trying too hard to please, and will also tend not to be well received.

The ultimate aim with ASIMO is to achieve “a robot that coexists and cooperates with people and performs useful functions in society.” This requires a design that gives a comfortable feeling of distance that takes the audience into consideration, neither too close to people nor too distant, so it can be approached with a friendly feeling. The optimal design will have a state of harmony between the robot’s advanced position as a machine and its friendliness as a partner to people. This is the basic concept of the “harmony between being advanced and being people-friendly” in ASIMO design (Fig. 2).

The quality of being advanced is something that changes over time, so it is evolved by means of new functionality, while the quality of being people-friendly fosters an affection that deepens over time. It is important to maintain these aspects in harmony with each other while assimilating them in the design at a higher level.

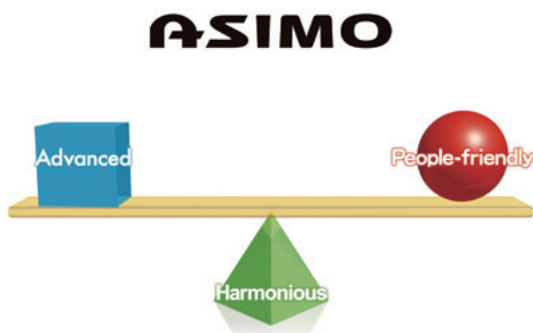


Fig. 2 Basic design concept

3. The Design Process

3.1. Design Techniques

A humanoid robot contains large numbers of mechanism parts (Fig. 3). The feasibility of the mechanisms is naturally a key consideration. Static and dynamic examination of all parts as well as of the whole is essential in order to produce

an appearance that is not incongruous when in motion as well as to give a sense of safety and security.

The new ASIMO has a total of 57 degrees of freedom, with the addition of one axis to the joint axes in the waist portion of the previous ASIMO and 11 axes to each of the two hands. In order for the robot to operate in close proximity to people, the gaps and misalignments between parts that occur in operation have to be drastically reduced, and the robot needs to be given an external appearance that does not expose its internal mechanisms and metal parts. ASIMO design development therefore brought together the styling designers and engineering designers as a combined team that used 3D software as a tool to carry out design work that took full account of the robot’s operational states. The state of movement was confirmed using animation by computer graphics (CG), and the robot’s presence in actual spaces was confirmed using full-size mockups, before completing fabrication of the actual machine. This enabled achievement of a highly precise design (Fig. 4).

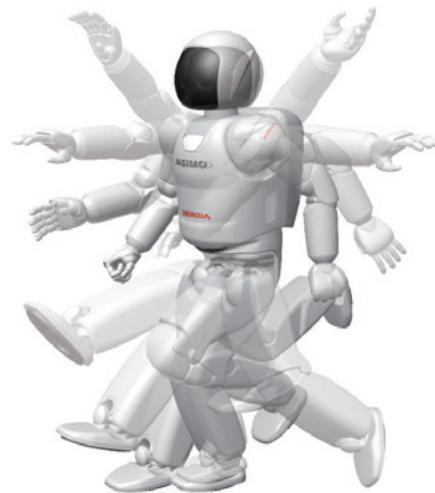


Fig. 3 Many movable parts in humanoid robot

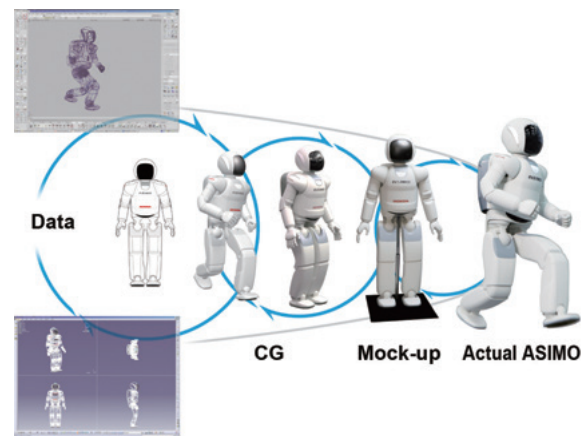


Fig. 4 Digital design process

3.2. Design Studies

Studies were made of the following aspects of ASIMO to determine how people felt about them.

(1) Interviews

Interviews were held with users who had actually operated the previous ASIMO at special events and other such occasions, and the following results were obtained:

Positive points

1. It has been made to evolve while carrying on the image it has acquired so far.
2. The displays that emit light using LEDs are a plus.
3. The overall form has rounded, giving it a soft appearance.

Negative points

1. There is something incongruous in the proportions.
2. It is not as cute, and it has become muscular seeming.
3. The backside looks like it is protruding, making it seem unstable.

(2) Perception of distinguishing characteristics

Drawings by children sent to Honda display tendencies showing that the following are perceived as three distinguishing characteristics of ASIMO:

1. Tinted shield over the face
2. Backpack
3. Geometric physique

(3) Comparative study proposal

Proposed designs include designs emphasizing the

quality of being advanced, emphasizing friendliness, suggesting gender difference, showing facial expressions, and so on. A number of such designs that convey an entirely different external image from the previous ASIMO were developed and interviews about them were held. The results in all cases were responses that the weaker continuity with designs up to this point made these designs seem incongruous for the new ASIMO.

3.3. Design Directions

Given these findings, ASIMO image can be considered to have become fixed to some extent by activities conducted since the robot was announced in 2000. In order to foster further relationships with people, it was determined to be undesirable for model changes to bring a completely different form and appearance. Priority was given to designs that have continuity as ASIMO, rather than being taken up by differences between old and new generations. It was decided to place importance on the friendly image while incorporating functional evolutions into the form. Figure 5 shows ASIMO generations for purposes of comparison.

4. Aims of the Design

The new ASIMO seeks to achieve “a robot that coexists and cooperates with people and performs useful functions in society,” and the design aims to embody “evolution that continues to relate to people.” The three perspectives of gentleness, comprehensibility, and distinguishability explained below were emphasized in developing this design.

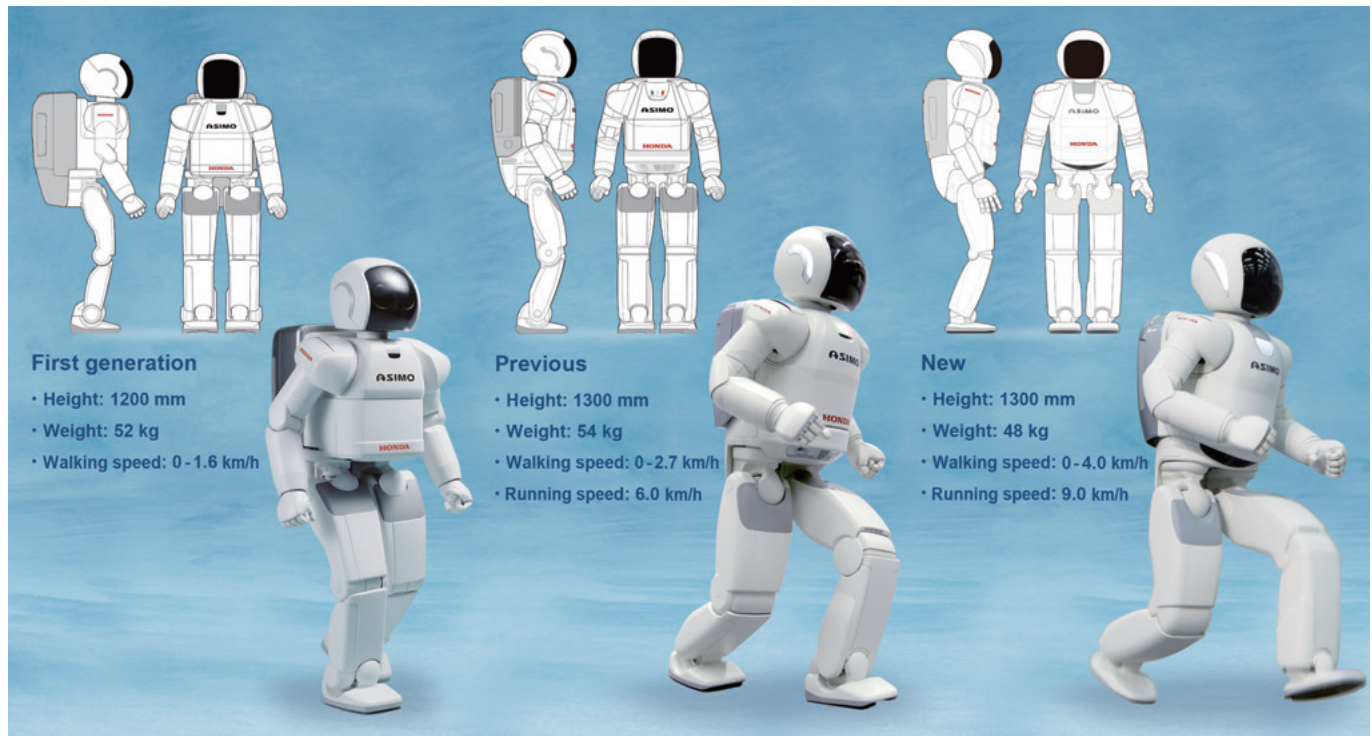


Fig. 5 Evolution of ASIMO

4.1. Gentleness

The roundness of the entire body was heightened relative to the previous ASIMO and the friendliness was increased. Structural lines that appear mechanical and complicated were put in order for a soft, gentle configuration. Parts with functions, such as the LED panels for the ears and chest were designed to embody their functions sharply and clearly. Details of each area are as follows:

(1) Proportions

The offset of head, shoulders, and legs that is created to balance the weight of the upper body was 40 mm in the previous ASIMO. In the new ASIMO this was reduced to 20 mm, enhancing the posture that had felt incongruous [Fig. 6 (a)].

(2) Torso

Efficient placement of the batteries and reduction in size of computers and other internal parts yielded a slim appearance. Compared to the previous ASIMO, there was a reduction of 30 mm on the back and 10 mm in the abdomen, for a total of 40 mm [Fig. 6 (b)].

The waist area was provided with a yaw axis for balance when running, as incorporated from the previous ASIMO, and a pitch axis was also added [Fig. 6(c)]. This also expanded the robot's expressiveness as well as its range of operation when grasping an object. The design was made to minimize the divergence of torso and waist when both these axes are in operation simultaneously (Fig. 7).

The lower part of the backpack on the rear of the robot was equipped with a heat vent and a power port for automatic charging in a unified design (Fig. 8).

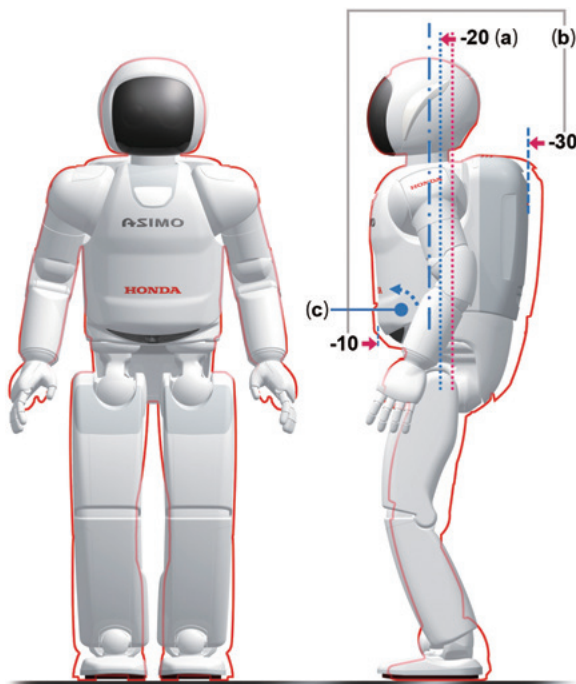


Fig. 6 Proportion (Red line: previous ASIMO)

The available angles of motion in the neck were increased from 22 degrees up and 19 degrees down in the previous ASIMO to 26 degrees up and 32 degrees down. This was an increase by a factor of 1.7. The design was made to avoid interference of the lower head, upper back, and chest, and to have the chest out.

(3) Head

ASIMO's face is covered with a shield that is tinted to a percentage that suggests the presence of eyes. The aim is to not reveal the facial features clearly so that viewers will be able to freely imagine ASIMO's expression.

The new ASIMO design projects greater friendliness by increasing the roundness of the head as a whole. The ratio of the vertical and horizontal components of the shield was brought closer to unity and the four corners were rounded. The shape of the profile was also given greater roundness.

The cameras that are placed in the position of eyes inside the shield have been spaced farther apart and moved down in order to achieve the effect of a mild expression. In order to assure the angular field of view of the cameras, the protrusions and indentations on the face have been toned down. The molded lines that can sometimes be glimpsed as corresponding to eyebrows and a mouth, depending on



Fig. 7 Rotatable waist



Fig. 8 Backpack

the angle of the light, have been made wider and shorter in order to provide greater expression.

The ears have the function of displaying how well the robot is hearing by emitting LED light. The amount the ears protrude from the head has been increased relative to the previous ASIMO so that they are more visible from the front when emitting light. The microphones that are placed to collect sound from all directions for voice recognition are concealed from outside view by arranging them at eight locations around the head inset within slits made at places where parts of the head are joined together. Figure 9 shows a line drawing of ASIMO head.

(4) Arms

The previous ASIMO had hands with a two-axis structure that were only capable of opening and gripping. In the new ASIMO, hydraulics are used to make the five fingers of each hand into independently movable mechanisms. The range of movement of the thumb has also been increased. Tactile sensors are embedded in the fingertips. These enable the robot to remove the lid from a flask and pour a beverage into a cup (Fig. 10), use sign language expressions, and so on. The design is a human fingertip motif with added roundness. The joints were also

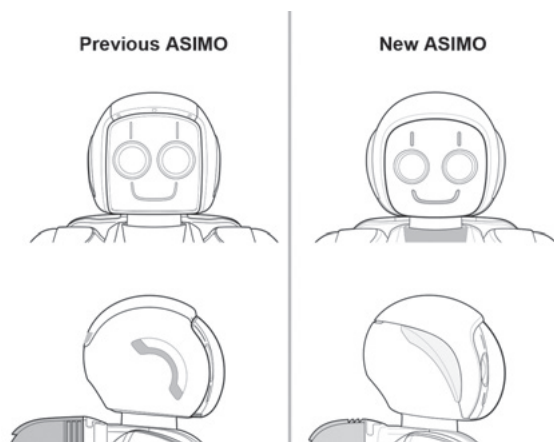


Fig. 9 Line drawing of head



Fig. 10 Action that opens lid of flask

formed so that the internal mechanism is not exposed even when the fingers are bent (Fig. 11).

The wrists, which had an elliptical cross-section in the previous ASIMO, were given a round cross-section in the new robot, and the available angles of motion have been increased.

The arms are structured to hold tubing that hydraulically transmits the driving force of motors built into the chest to move the fingers. They were given a unified design in which no gaps or misalignments occur between parts even when the elbow is bent.

(5) Legs and feet

The new ASIMO was given significantly upgraded physical capabilities, including a walking speed of 9 km/h and the ability to jump with both feet.

The design of the legs and feet as a whole was basically simplified with a smooth surface. The knees are equipped with rotating exterior facing mechanisms that are coupled to the movement of the knees. Sliding exterior facing mechanisms were also developed for the heels, and the available angles of motion for the ankles were expanded from ± 24.5 degrees in the previous ASIMO to ± 32.5 degrees. The feet were rounded at all four corners to eliminate interference and enable larger movements of the feet (Fig. 12).

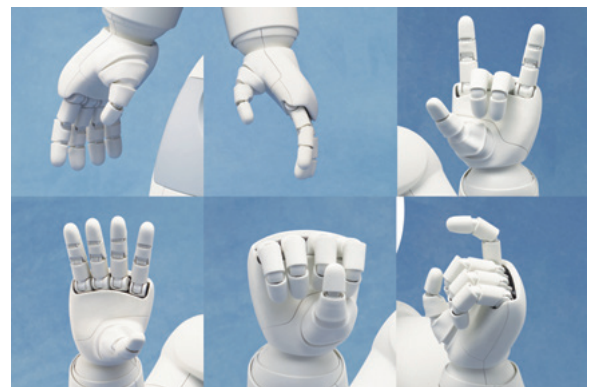


Fig. 11 Compact, hydraulic multi-axis hand



Fig. 12 Legs that move more freely

4.2. Comprehensibility

As occasions for ASIMO and people to have encounters and interact directly increased in number, circumstances began to occur in which people would wonder whether or not ASIMO was listening to them, or whether or not it was in a state ready for them to talk to it, and in which people could not readily know what state ASIMO was in at that time.

The robot's expressions made with gestures, therefore, were augmented by supplementary use of light emission by LEDs. The aim was to draw people in by using changing lights to provide opportunities to initiate interaction. It was decided, therefore, to implement displays by readily understandable light emission in locations that are readily understandable to people in an intuitive manner, as described below.

- (1) Light-emitting display at the front of the top of the head indicates that the robot is aware

The robot was given the capability to react to a person's inquiry by emitting continuous light as though flowing. The light is projected from behind the exterior facing so that people will not sense the presence of LEDs when the lights are not on.

- (2) Light-emitting display at the front of the ear indicates how the robot is hearing

ASIMO makes these lights blink when it is ready to listen. This gives people active encouragement. The use of phased lights in accordance with the robot's sound collecting state also indicates the level at which ASIMO is listening to a person's voice.

- (3) Light-emitting display in chest indicates ASIMO's current state

In order to convey a harmonious, cooperating feeling when the robot is talking with people or operating close to people, it emits a pale green light. When ASIMO is carrying out a task on its own, it conveys a sincere, calm feeling by means of a pale blue light. At other times, it emits a neutral white light. It indicates waiting time by a gentle alternation of light and dark that is like breathing.

A process of searching for better illumination designs is under way while these light-emitting displays are used in actual operation. Figure 13 shows images of the lights in use.

4.3. Distinguishability

It has been found that when multiple ASIMOs are operating simultaneously in the same office, lobby or other such space, they can be difficult to distinguish one from the other because they are the same in external appearance. Accent colors of light blue, light green, and light yellow were therefore applied at the chest, shoulders, and thighs in a way that is readily identifiable and in line with ASIMO image, to make it acceptable to anyone. These colors are used in conjunction with the regular ASIMO colors (Fig. 14 and Fig. 15).



Fig. 13 Expression of the light



Fig. 14 Two new ASIMOs receiving a visitor

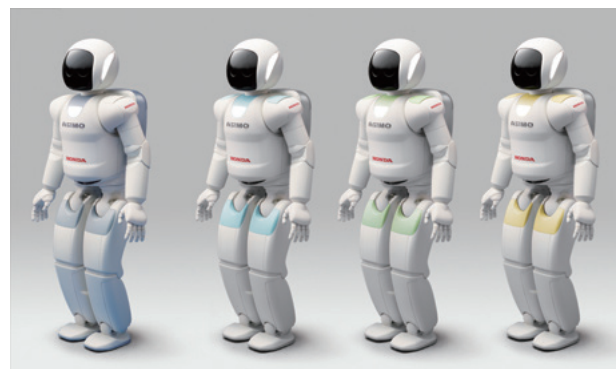


Fig. 15 Normal color and accent colors

At the same time, the basic overall colors of white, grey, and silver used for ASIMO from the beginning to express the qualities of being advanced and people-friendly, as well as to look at home in a variety of different environments, were updated to more refined, cleaner, and brighter color tones.

5. Conclusion

Design development for the new ASIMO further assimilates the basic “harmony of being advanced and being people-friendly” concept at a higher level. The design was carried forward with an emphasis on the perspectives of gentleness, comprehensibility, and distinguishability.

As a result, the new ASIMO has taken a step toward the goal of functioning around people less as an automatic machine and more as an autonomous machine. This was achieved by a design that people will receive sympathetically.

6. Closing

In November 2011, Honda decided on “Honda Robotics” as the collective name for its development of applied robot technology. This name embodies Honda’s powerful commitment and desire to contribute to society through robot research.

The “Honda Robotics logo mark” is placed on this technology (Fig. 16). It has ASIMO’s profile, head tilted slightly up to gaze into the bright future, as its graphic motif. This graphic symbol is accompanied by the “Honda Robotics logotype” in lower case letters with initial capitals. The image resonates with the “ASIMO logotype” that is in all capital letters. This logotype expresses the quality of being advanced and friendly, and a line in the red that is Honda’s corporate color expresses the expansiveness of robotics.

Consonant with the thoughts and feelings embodied in these marks, Honda’s desire is to further evolve ASIMO toward the conception of its goal as “a robot that coexists and cooperates with people and performs useful functions in society.”



Fig. 16 Honda Robotics logo mark

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