Styling Design of the Humanoid Robot ASIMO

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ABSTRACT

The Honda humanoid robot ASIMO was developed as a challenge to create robots with a higher level of mobility than has existed before. For the first, the automotive styling division took part in this project from the initial planning stages. Furthermore, this humanoid robot is a product in a brand new category that does not have an established market. We proceeded in our development with our own unique proposals while at the same time we listened to the opinions of people, both inside and outside Honda, in order to determine our styling direction. Also, as ASIMO is a humanoid robot comprised of a multitude of moving elements, we made maximum use of computer technology from the initial stages of development. We were able to simulate, for example, walking motions with computer graphics to achieve an overall balance between styling and structure. By adding automotive styling experience to the robotic development cultivated to date, and by including new styling methods, we achieved a unique sense of value as well as familiarity and friendliness with the ASIMO styling.

1. Introduction

No commercial market for humanoid robots has yet been established. However, the development of many robots were announced at the end of the 20th century, prominent among them the AIBO[1] in the entertainment sector, re-igniting the dream of coexisting with robots. Honda has been moving forward with research on humanoid robots since 1986 as part of its program for innovative mobility (mobile equipment). The styling design division first joined this development effort in connection with the P2 (Fig. 1), which was announced in 1996. The Honda humanoid robot, including its styling, is gradually gaining the awareness of society at large, and the styling design is also becoming an extremely important element of the project in addition to the world-class technologies involved.

Honda's objective from the beginning has been to develop a humanoid robot (Fig. 1) that would coexist and collaborate with human beings and serve a useful function in society. The thinking was that in order for it to actually become useful, the robot should more easily blend into society, so it was necessary to give it a greater sense of friendly appeal with people. Development of ASIMO[2] accordingly proceeded with the goals of further advanced innovativeness and approachability. ASIMO is the new general name that Honda is applying to its humanoid robots, and at the same time we have also designed it as a logo (Fig. 2) that expresses the creation of new value, which is the key ASIMO concept. This represents one further step in laying the groundwork for Honda's challenging project of taking the humanoid robot out of the laboratory and positioning it as a new industrial product accepted by the world at large.

Industrial products developed during the 20th century, as typified by the automobile, evolved through the pursuit of such qualities as efficiency. In the 21st century, the robot will attain a much greater presence with human beings, and it will require new criteria for value. This motivated research for the appearance of humanoid robots created by Honda. This paper introduces the ASIMO styling design development effort and the techniques we employed, which included making the greatest possible use of computer technology, in the course of that effort.

2. Styling design concept

The goal for ASIMO was for it to be a gentle companion for people that has a real practical use. The basic conceptual approach to the styling design, therefore, was "to make a humanoid robot, which embodies the dream-like mobility, a gentler and closer presence."

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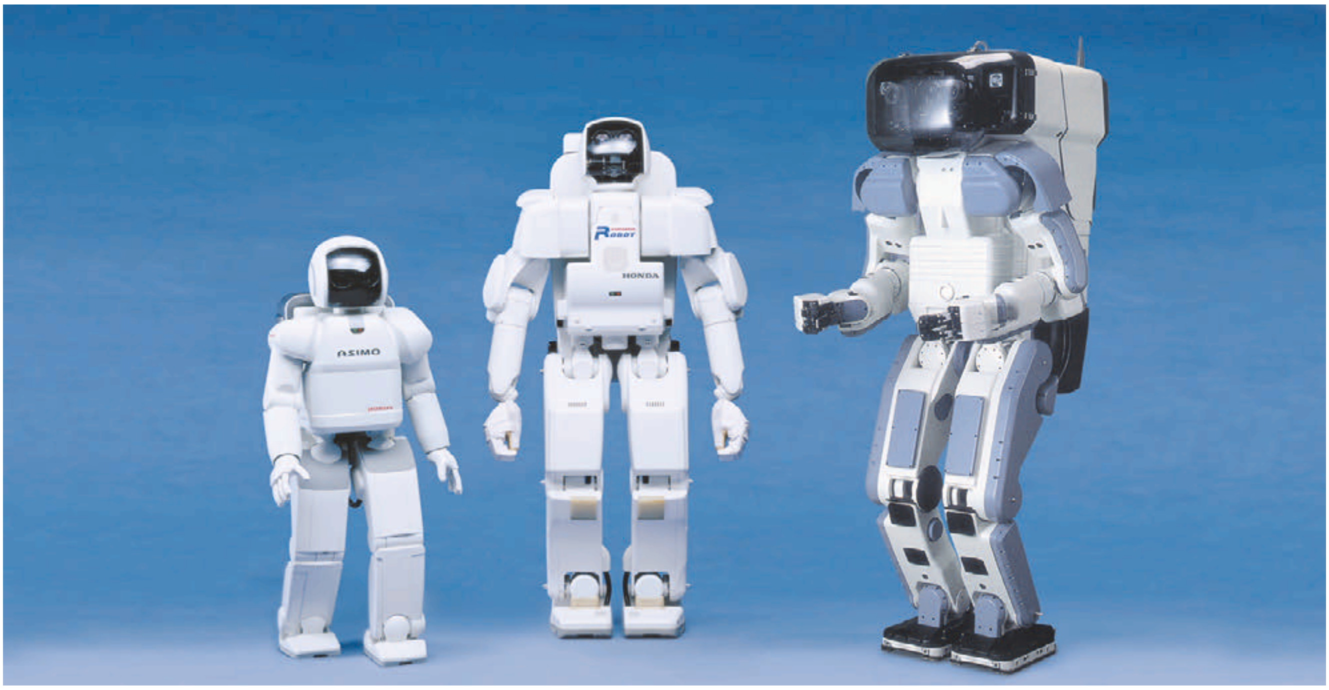

Fig. 1 The Honda Humanoid Robots Left: ASIMO (2000), Center: P3 (1997), Right: P2 (1996)

ASIMO

Advanced ····· 新しい時代
Step in ····· ステップ
Innovative ····· 革新
Mobility ····· モビリティー

Fig. 2 ASIMO Logo styling design

One answer to achieving a mobility that is suited to coexisting with human beings in their life environment is to give the humanoid robot a form close to that of human beings. The robot should be able to go wherever people can go, and it should also embody possibilities that transcend time and space. Such a humanoid robot will, of course, be equipped with the same motor functions as humans, but the eventual goal is for it to surpass human capabilities.

Although the external styling design takes the human form as a motif, opinions differ on whether it is most appropriate for the robot to be given a realistic human appearance. It should go without saying that human beings should remain in the dominant role. The relationship between human beings and humanoid robots, which are machines, must remain comfortable, without being either too close or too distant.

With ASIMO, our basic approach was to avoid a rote anthropomorphism while creating a smooth and simple form that emphasizes a sense of integration and that avoids any superficial features. This approach would utilize the styling approach we had cultivated in our work on automobiles and make it part of the mobility design. We also eliminated any intimidating or fearsome aspects, and pursued a styling design for a cheerful, enjoyable approachability that would be acceptable to anybody.

3. Styling design development

3.1 Preliminary studies

Before beginning the ASIMO styling design, we examined its size and proportions from the perspective of friendly appeal, which is one of the ASIMO concepts. In light of that data, we also used computer graphics (CG) to create walking animations in order to develop preliminary design proposals.

3.1.1 Size

As shown in Fig. 3, we built mockups that more or less replicated Honda's previous humanoid robot, the P3, in reduced scale, and studied their fit and feel in actual living spaces. We also took accessibility to the environment and functionality into consideration, and settled on a height of 120 cm[2] to give a sense of approachability within a human living space. In addition, the selection of this size eliminated any potential intimidation that might be caused by the robot when in motion.

3.1.2 Proportions

The proportions were studied in two ways. One method was to try changing the overall balance using CG. The other method was to try different sizes of heads on the mockups. The P3, which is 160 cm high overall, is close to the ideal proportion of eight head-lengths for overall height, but when the mockup modeled on it was reduced in size, the proportions did not seem quite right. However, when only the size of the head was changed to create a body with a height of approximately six head-lengths, the result gave a sense of approachability. The proportions were ultimately those of an elementary school first or second-grader. The importance of proportions was confirmed in the course of studies using 3-dimensional models as mockups, in addition to this study of synthesized images made using CG, as shown in Fig. 4.

3.1.3 Preliminary styling proposals

The P2 and P3 models were a development of Honda's image of a humanoid robot, which was clean and simple and built on the previous astronaut image (Fig. 5). Based on this styling design, a walking animation (Fig. 6) was created by CG using P3 behavior data. This allowed visualization of the possibility, though only as a screen image, of a compact robot walking together with the P3.

3.2 Idea development

The styling concepts from the preliminary studies and the previous data on proportions were used as the basis for hand-drawn or CG image ideas developed by a number of stylists (Fig. 7). The proposals in CG form were not only realistic with static views, but they could also be presented in motion. These images therefore carried considerable persuasive force and had an impact even at the initial stage of development.

3.3 Transitional proposals for mockups

Styling proposal A, shown in Fig. 8, addressed the issue of friendly appeal, which was a major issue in the initial planning. By contrast, styling proposal B, shown in Fig. 9, went in a more neutral, simple direction. These proposals were put together, and both were taken to the next step of mockup model creation (Fig. 10). The aims of proposals A and B are as shown below.

Aims of styling proposal A:

- Presentation of a cheerful, enjoyable atmosphere that would be acceptable to anybody
- Embody the motif of a child that expresses cuteness, buoyancy, and a sense of future potential
- Create a facial expression to allow eye contact and enhance communicative qualities

Aims of styling proposal B:

- Instantly recognizable as being in the Honda humanoid robot lineage
- A sense of unlimited application possibilities embodied in a simple, neutral image
- Pursuit of the functional beauty of a machine

3.4 Styling design clinic

Obviously, as a completely new product, the humanoid robot does not yet have an established market. Therefore, image surveys were conducted concerning ways it would be used in the market, and styling design clinics were also conducted to hear views inside and outside the company. Models of both styling proposals were built as 1:1 mockups, and CG walking animations were presented. The following results were obtained:

Reactions to styling proposal A:

- Very cute, approachable, and good communicative quality
- Distinctive mascot-like character means reactions are swayed by personal taste
- Possibility that its image and uses will be limited
- Image as the Honda humanoid robot is weak
- Seems to contradict the typical robot image

Styling proposal A will work best when the product use and purpose are narrowed down.

Reactions to styling proposal B:

- Cute despite having an industrial design (ID) look, and it has a strong sense of friendly appeal
- Acceptable to many people, and conveys good basic quality
- Gives a feeling of embodying implicit potential and universal use
- Anyone who looks at it will recognize it as Honda's humanoid robot
- Has a fully realized robot quality

Styling proposal B is acceptable to many people, and it quickly conveys the image of a Honda humanoid robot.

3.5 Final styling proposal

Opinions diverged regarding styling proposals A and B. Overall, however, a vigorous discussion was carried out that gave a renewed sense of the heightened attention directed at humanoid robots. With regard to styling proposal B, in particular, the opinion that "it is a cute humanoid robot despite its industrial design (ID) approach," made a strong impression. We confirmed that the goal of friendly appeal could be fully realized by size, proportions, and simple facial structure even without making an overt point of the robot's approachability.

In addition, the kinds of TV commercials and events shown in Fig. 12 provided opportunities to display the P3 to many more people. The image of the Honda humanoid robot was in the process of taking shape. Given these circumstances, among other factors, the styling was converging on styling proposal B and we reached the point of the final proposal. The course of events is shown in Fig. 13.

3.6 Development of variations

The styling design clinics were also used as an avenue for future studies regarding diverse needs. The final proposal was set as the basic model. This effectively allowed the possibility for a broad variety of choices that could be offered by changing the head design and the color coordination without altering the basic body. Thus, variations of the model were built by the methods shown in Fig. 14.

The styling design development of ASIMO took place as described above. The characteristic design features are shown in Fig. 15.

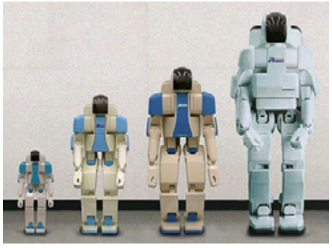

Fig. 3 Size study (Mockup)

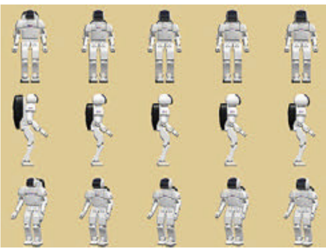

Fig. 4 Proportion study (CG)

Fig. 5 Styling design study (CG)

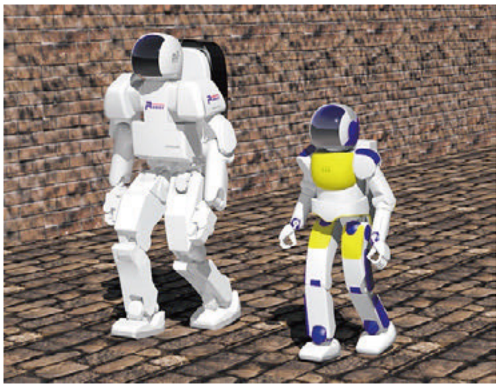

Fig. 6 Styling design study (CG animation)

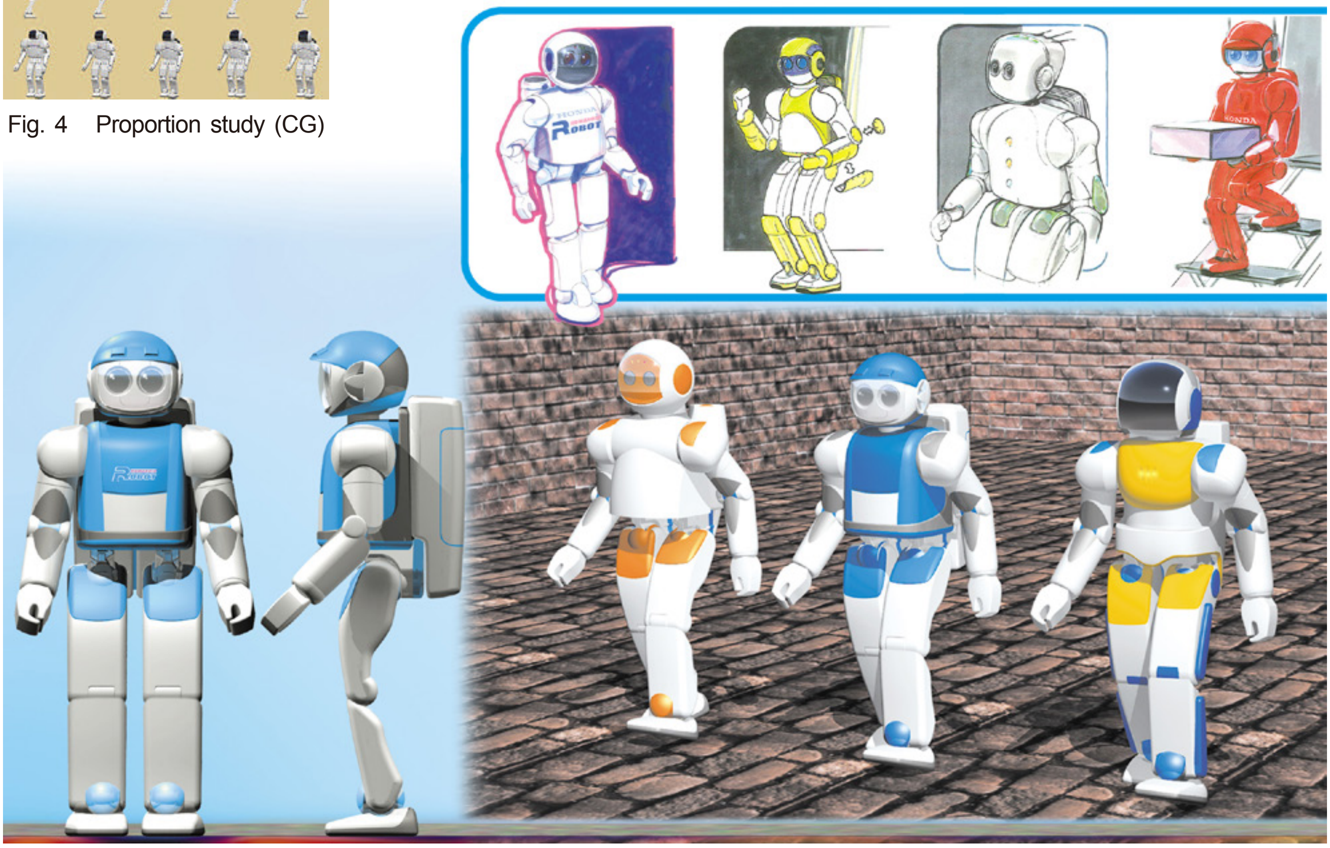

Fig. 7 Styling design ideas (Sketch and CG)

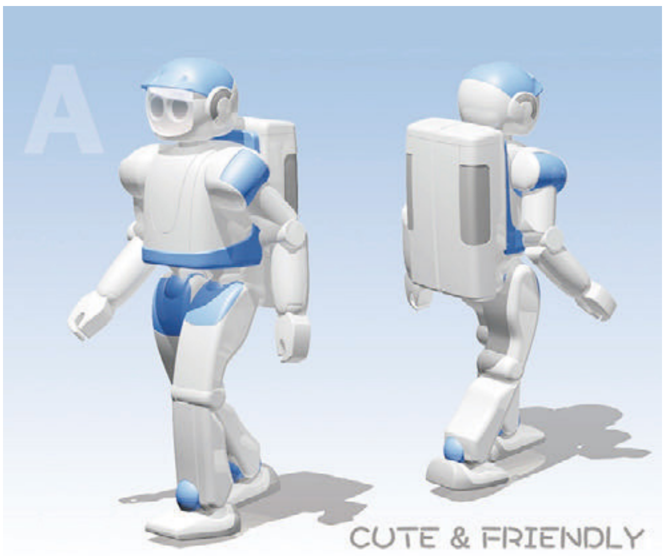

Fig. 8 Proposal A (CG)

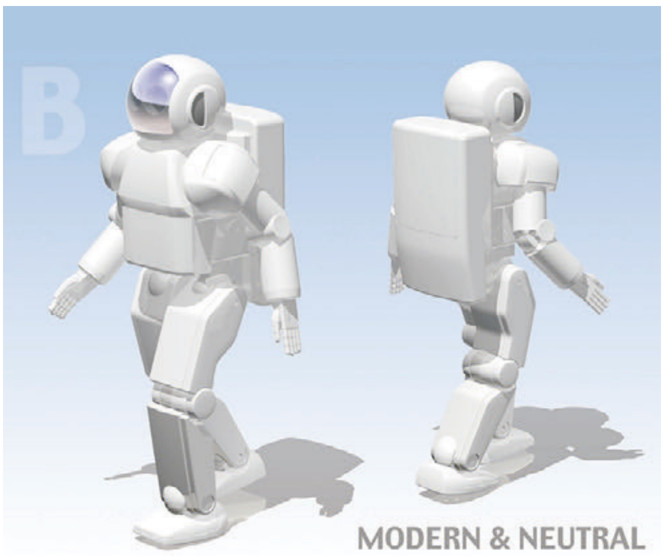

Fig. 9 Proposal B (CG)

Fig. 10 Proposal A, Proposal B (Mockup)

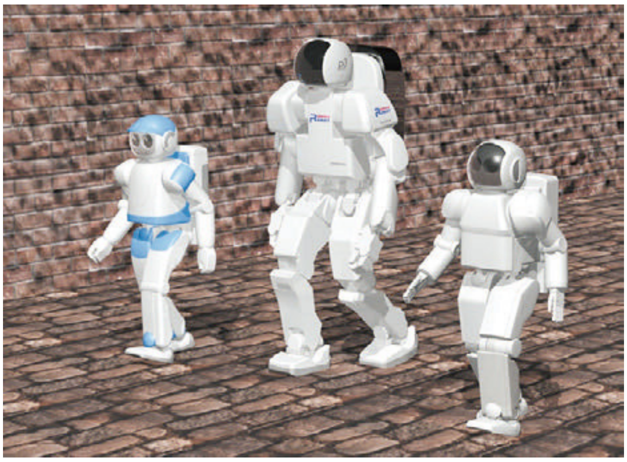

Fig. 11 Proposal A, Proposal B (CG animation)

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Fig. 12 P3 image

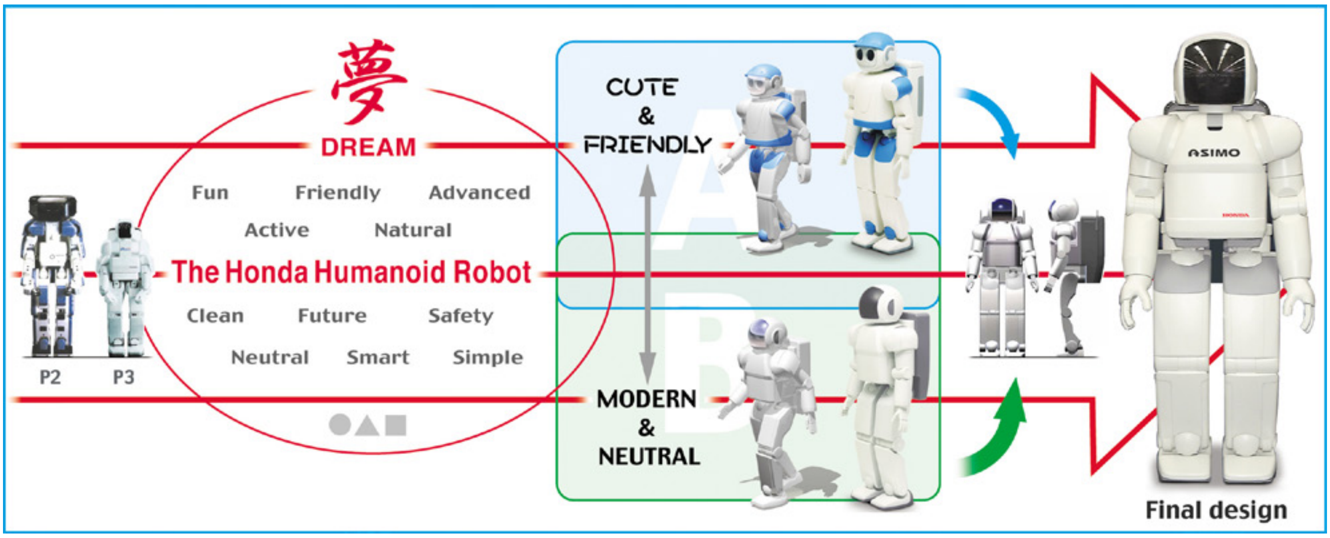

Fig. 13 Styling design process

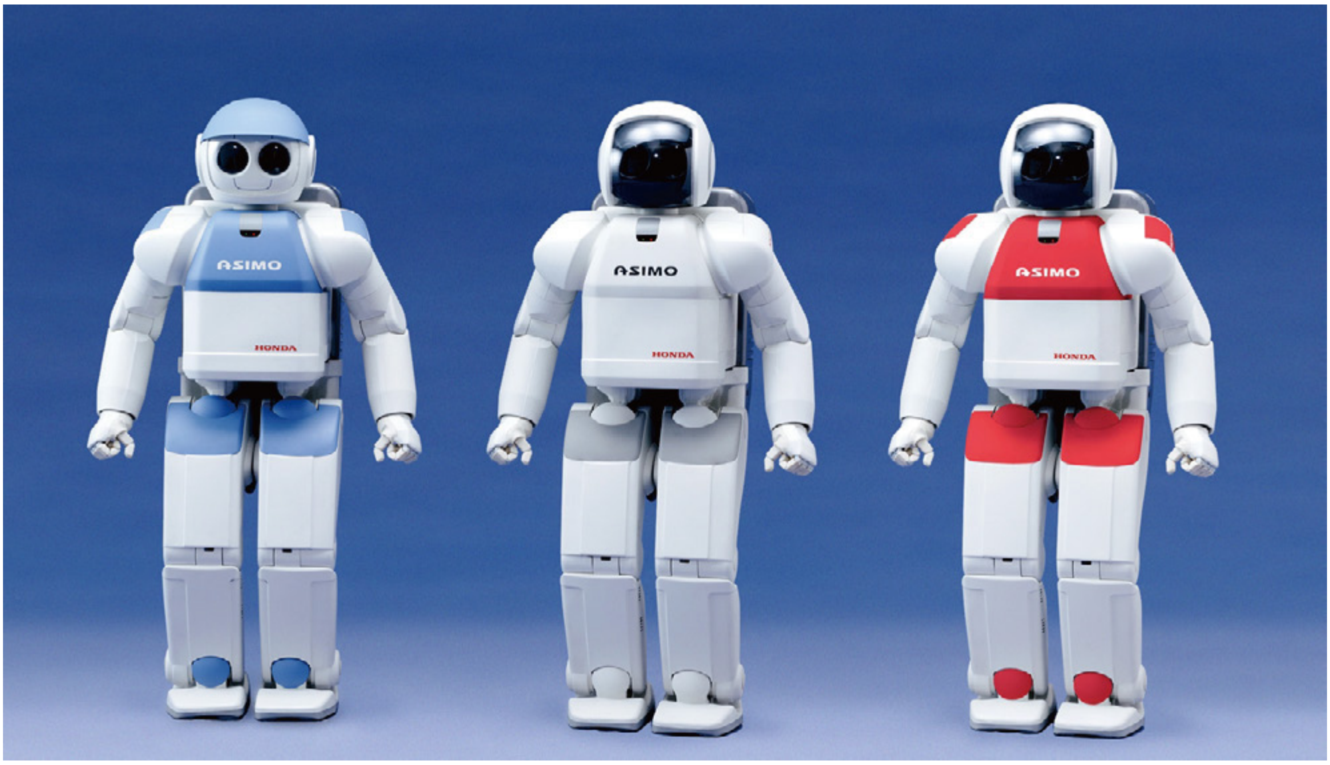

Fig. 14 Variations of the final styling design Left: Face and color variation model, Center: Basic model, Right: Color variation model

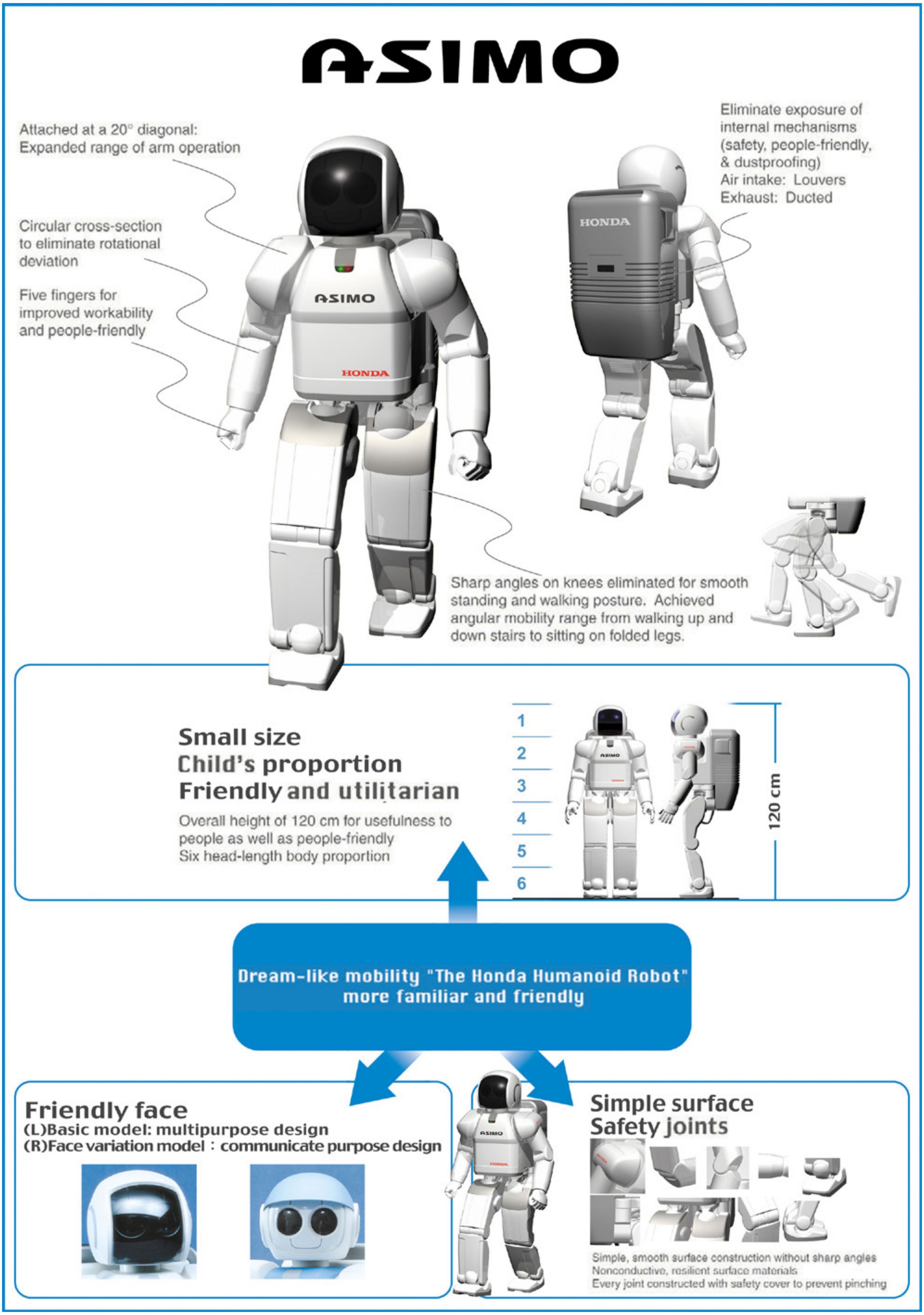

Fig. 15 Concept and final styling design

4. Styling design utilizing computer technology

The major difference in construction between a humanoid robot and an automobile, as shown in Fig. 16, is that the robot has more observable complex movable parts. An automobile receives its basic character through packaging design. The surrounding body is designed to be aerodynamic, and the overall automobile is expressed as a basically monolithic mass. Moreover, the constituent elements are not very different, and there is a limited number of openings used for access. The movement of doors and other parts is in two dimensions, and in general, parts with different shapes are only rarely built up from elements in ways that involve complex movements.

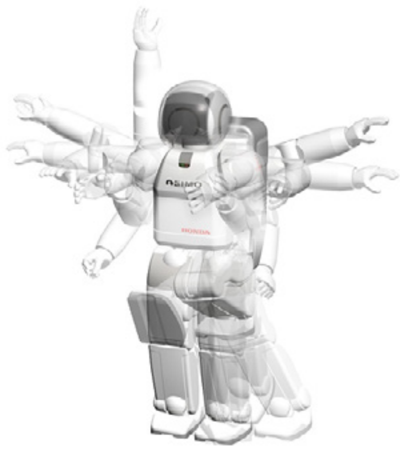

Fig. 16 Movable parts in the humanoid robot

In contrast, the humanoid robot has multiple movable parts. (The ASIMO body has 26 degrees of freedom.) The styling design had to establish the mechanisms and the overall form while envisioning the diverse states of these many movable parts. In this sense, too, it had already become too cumbersome to provide adequate simulation by means of hand-drawn sketches alone. For this project, the stylists themselves used computers directly to carry out the styling design, and doing this yielded significant results under the four headings below:

(1) Increased speed and accuracy through coordination with engineering design
(2) Styling design that takes dynamic states into consideration
(3) Effective presentation
(4) Smooth transition to 3-dimensional form

4.1 Increased speed and accuracy through coordination with engineering design

The styling designers received study data provided by the engineering designers. They then used Alias software, which has seen widespread use in automobile design, to develop their styling ideas in the form of 3D data while taking engineering design requirements into consideration.

The engineering designers, on the other hand, received 3D data from the stylists at an early stage and used CATIA to design structures and mechanisms. This made it possible for them to incorporate styling design at the stage when they are engineering the skeletal structure, something that used to be more difficult to do.

As shown in Fig. 17, the styling designers and engineering designers proceeded with development through the shared language of data. This made the exchange of information smoother and served to raise development efficiency. As a result, there was an increase in speed and accuracy in the move toward project completion while compatibility was maintained between styling design and mechanisms.

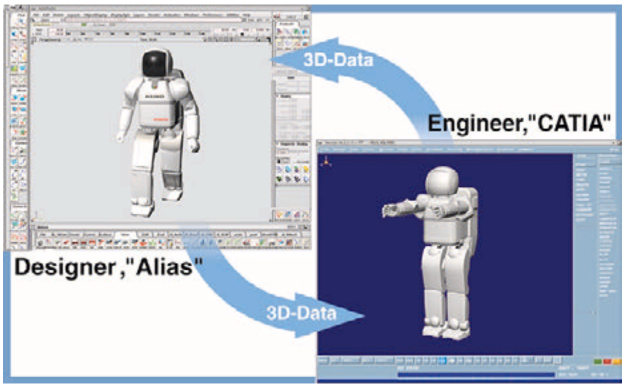

Fig. 17 Digital styling design

Fig. 18 contrasts wire-frame data, a CG image, and an actual robot. The styling design process is not simply about creating shapes and ideas. It is vital that the styling reflect a variety of requirements while creating a simulation of the final form. As shown clearly in this figure, we were able to represent a finished form realistically and very accurately from the initial stage by developing a data-centered styling design in coordination with the engineering designers.

4.2 Styling design that takes dynamic states into consideration

As mentioned earlier, the humanoid robot requires styling design that takes into consideration not only its static states, of course, but also its moving states. Up to the P3, styling designers and engineering designers had no technique for confirming moving states until the actual robot was completed and walking. Styling design of ASIMO proceeded while also making use of computers to envision the robot's moving states. This design work was carried out in ways that made the robot's posture when walking, in particular, more easily visible. The walking posture is not subject to improvement by styling design alone. However, as shown in Fig. 19, we worked out ways in the styling design to use shape processing on every part possible, in other words, to draw in the chin, to straighten the back, to throw out the chest, to minimize the bend in the knees, and so on. The engineering designer in charge of robot behavior also wrote a program to make the robot walk more energetically and with better posture. It is possible to verify that the ASIMO walking posture is improved relative to the P3.

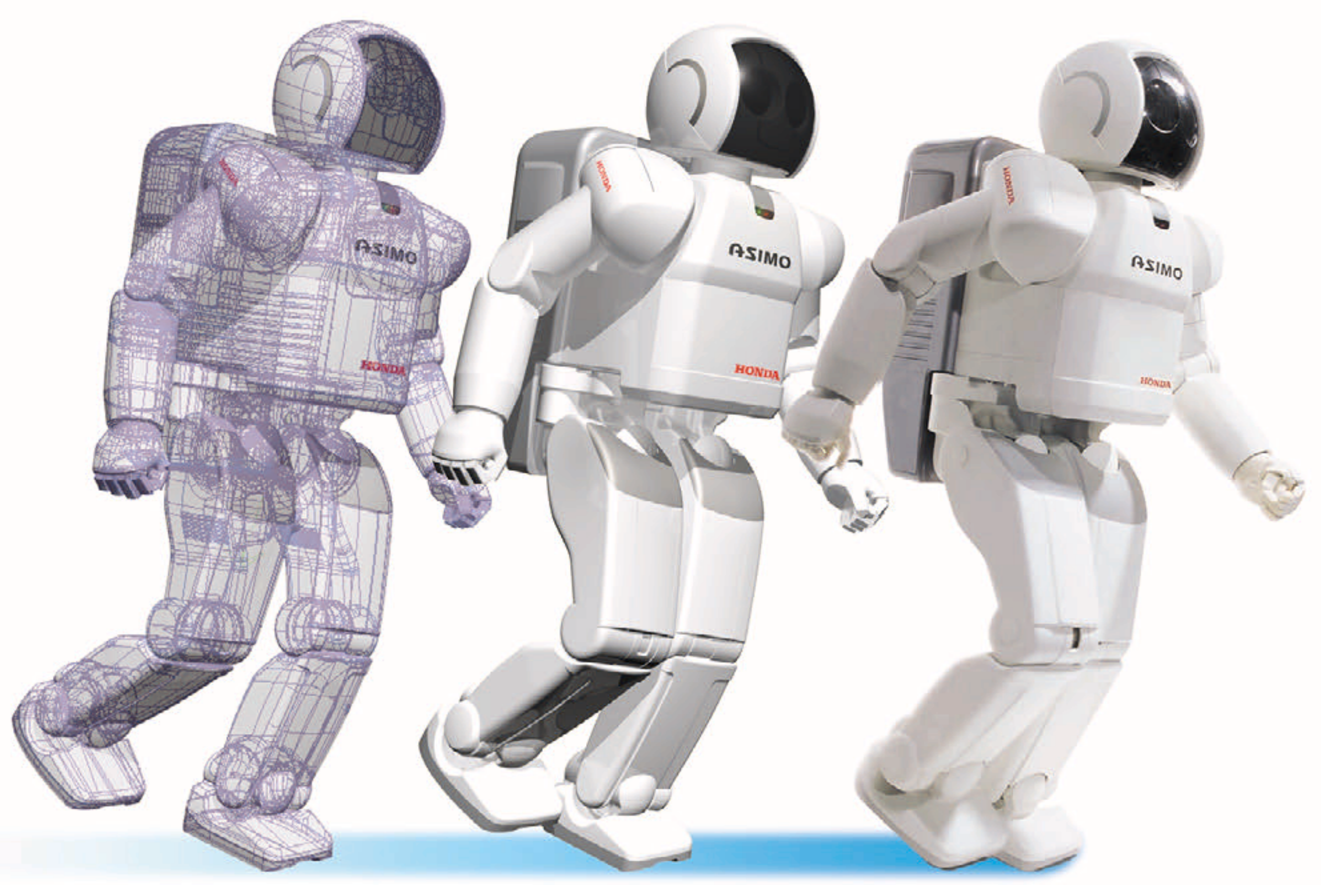

Fig. 18 Digital styling design process

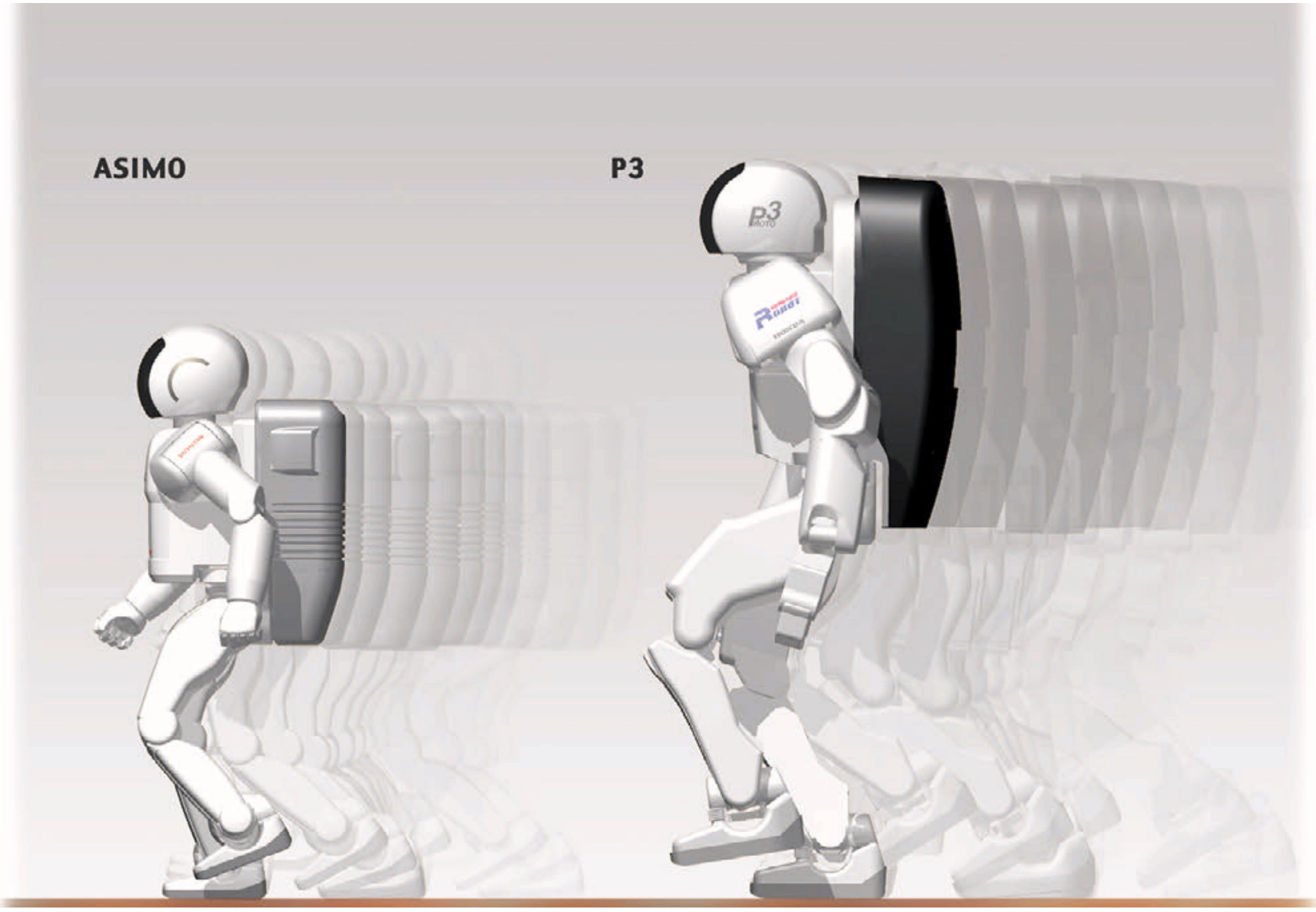

Fig. 19 Dynamic robot walking styling design

4.3 Effective presentation

A three-dimensional image projector used by automobile designers to check their data was used to project CG images of ASIMO. We thus verified images of walking and other behavior in nearly life size. As a result, it became apparent that the walk lacked sufficient energy, so that program was improved and in the actual robot we achieved an ASIMO that has a cute, energetic walk. Such applications of CG made it possible to expose problems at an early stage.

Fig. 20 shows ASIMO's distinctive bowing gesture. For this, too, we used the CG image on the left to generate the proposal, and it was reflected in the gesture performed by the actual robot, as shown on the right.

We also created images of different uses for ASIMO in many different settings (Fig. 21). This allowed us to give more effective presentations. These same images ended up being used at the time of the public announcement with only some partial adjustments being made.

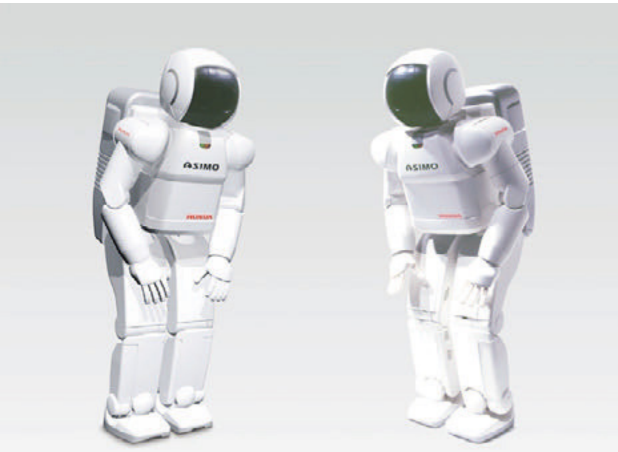

Fig. 20 Dynamic robot bowing styling design

There was not enough time for taking photographs and creating printed press materials for use when the public announcement was made. However, use of CG screen images made it possible to handle Web pages, technical information, press materials, advertisement formats for use in sales promotion (Fig. 22), presentations at exhibition sites (Fig. 23), and other media presentations, in a short time frame.

4.4 Smooth transition to 3-dimensional form

As explained above, this project used CG for styling development methods that yielded many results. Ultimately, however, the final styling verification has to be done with full-scale models that provide a sense of size and presence so that the styling designs can be judged by their immediate impact. The last stage in creating a 3-dimensional form also involves final finishing work done by a seasoned hand. Those measurement data are reflected in the final data. At the present time, therefore, the creation of 3-dimensional models is an essential process.

The fabrication of clay models like those well-known in automobile design development took place up to the development of the P3. With the ASIMO development, however, verification of the shape was done on the CG screen and with mockup models, and the result was fed back to generate data for the following process. The humanoid robot design project required prompt and flexible responses to engineering design changes and the study of designs in motion. Therefore this method is more efficient.

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Fig. 21 Image movie

Fig. 22 Advertisement format

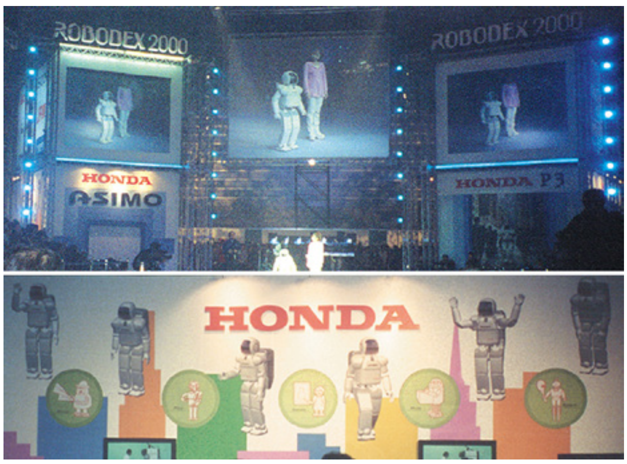

Fig. 23 Presentation for ROBODEX 2000

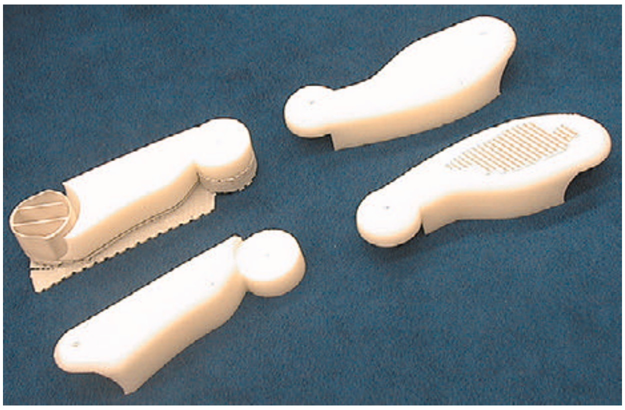

Fig. 24 Rapid prototyping (FDM)

Fig. 25 Rapid prototyping (SLA)

In the interest of making mockup models lighter and easier to fabricate, different fabrication methods were assigned to different parts. The main body was made by working resin with a milling machine. The head, arms, legs and other such hollow, enclosure-like sections, as shown in Fig. 24, were fabricated by the fused deposition method (FDM), which involves lamination of melted ABS. Stereolithography (Apparatus) (SLA), as shown in Fig. 25, involves directing a laser beam onto liquid resin that hardens when exposed to ultraviolet light in order to build up the part by lamination. These and other such methods were combined for greater efficiency and speed.

5. Summary

From the initial stages of the ASIMO styling design development project, we utilized the maximum extent of computer technology. The design data was generated by building on styling image proposals. The final verification was also carried out using 3-dimensional 1:1 mockups. In this way, the advantages of both digital and analog methods were used effectively together to further the project. As a result, a high-order of compatibility was maintained between styling design and mechanisms, and we were able to realize the initial aim of a more familiar, approachable design that has a novel sense of value.

6. Conclusion

Let us share something that happened at a styling design clinic. Thinking nothing of it, during the clinic, we casually removed the head from the mockup so it could be studied, when, all of a sudden, one of the participants screamed in shock. This illustrates the anomalous character of the humanoid robot, which has the form of a human being even though it is a machine. Humanoid robots should be designed not just because such robots would be handy to have around, but because their presence strikes a chord in the human spirit. The humanoid robot is assigned parameters that cover a broadened deep range. Clearly, it is expected to become something more than the typical industrial product of the 20th century. Born at the end of the 19th century, the automobile underwent striking development as a vehicle that is useful to people. It may be that the humanoid robot, like the automobile of the past, will have both successes and failures, bringing both joy and sadness as it evolves. Nevertheless, we are committed to this development effort, and we realize as we proceed that the creator's responsibilities are by far greater when the product is such a familiar presence in people's lives.

References

(1) Sony, AIBO public relations materials (1999)
(2) Hirose and Takenaka, "Development of the Humanoid Robot ASIMO," Honda R&D Technical Review, Vol. 13, No. 1, p. 1-6 (2001)

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