

DESIGN GUIDELINES FOR DEVELOPMENT OF HUMANOID ROBOT DESIGN

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ABSTRACT

The amount of robot is increasing and getting more and more ambient in our daily environments. Robot has expanded its role and service and adapted to human beings through the development of integration and convergence of technology. Intelligent service robots, especially humanoid robots are supposed to be intelligent, adaptive, interactive and intimate in use, because they will be applied to human lives. In design, concerns on the development of robots have been growing, because the role of design is making things such as robots easy and comfortable.

In this paper, we introduce design guidelines about the features of categorization of robot design and present a framework of humanoid robot design that builds the design methods and process.

Keywords : Humanoid Robot, Appearance design, Character design, Interaction design, Humanoid robot design framework, design process

1. INTRODUCTION

A humanoid robot is made for human beings. Its role, compared with other robots, is humane by performing things such as an assistant's task or showing friendship. In the context that Design optimizes things for human, the role of design has been recognized in the development of a humanoid robot. Moreover humanoid robots have the features of being an integration of high technologies, interface or interaction, and understanding human's preferences. Therefore researchers have found the possibility of a design field and a design approach, which is aimed to study the methods to perform the roles effectively in robot design. Designers should do human-robot interaction design considering the operation and structure of robot behavior as well as appearance design.

Particularly, it is more important to communicate with humans emotionally. To do this, the definition of robot's characteristic is needed in the design process.

In this paper, we proposed guidelines in two ways to design humanoid Robots. First, consideration of the scale and importance of robots is needed for the classification of robot design to build up professional skill and frameworks that show methods and process at each level. Appearance design, character design and interaction design developed in to a practical process through interdisciplinary approach.

Second is the robot design out-put visualization. In the results of appearance design as the first step of design, we would like to evaluate a complement of appearance design through the engineering specification.

Questionnaires about the structure and proposition of robot's components, image mapping and abstraction of adjective words were used to define the design concepts and directions. We represented idea sketches, 3D rendering of two types by the design guidelines.

2. ROBOT DESIGN

Robot design belongs to industrial design, however it is distinguished from consumer product design by the integration of high technology and the scale and degree of human interaction. Therefore robot design can be classified into three groups and three approaches: appearance design, character design and interaction design.

Table [1] Classification of Robot design

Robot Design		
Appearance Design	Character Design	Interaction Design
Structure & Mechanism Shape Material and Color	Role & Characteristic Design Scenario	Behavior Model Visual Interaction Auditory Interaction Haptic Interaction

These groups are correlative and have effect on each other. Humanoid robot design can not be accomplished without any one of these. First, we started from appearance design in this project, and as result of this step, proposed version 1 design.

2.1. Appearance Design

Appearance design means the style of the exterior view such as Asimo, Qurio and Pino. In this field, the designer should consider engineering specification for practical performance and the design out-put is defined by role and character. This design level includes structure and mechanism, shape, material and color.

We defined these factors as the following in table[2] by referring to engineering part.

Table [2] Appearance Factors of Humanoid Robot

Appearance Factor	Research part	class	component
Structure mechanism	engineering	Body proportion	Component ratio Bust Vs. leg Leg Vs. arm Leg ratio
Shape	Engineering	Battery position	Battery position
	& Design	Joint structure	Presence(hip) Shoulder Neck, knee, elbow Hand, foot
		Joint type	
	Design	Face Image	Face shape Presence (eye, ear, nose, mouth)
cosmetic			Color, material

2.2. Character Design

Character design is the type of feature such as Pino which was motivated by Pinocchio. In this design level, the designer defines the role and characteristic of the robot and then builds a design scenario to represent detailed personality. We separated robots by the type of execution space and role. Space was divided into: home, work and public space; and role was divided into: entertainment, information, help, security and chores.

As robot technology develops with increasing application, robots will move from public, safety and chore to home, entertainment and information. Thus, We focused on characteristic of ‘Infotainment (information + entertainment) robot for public use’ as the first step.

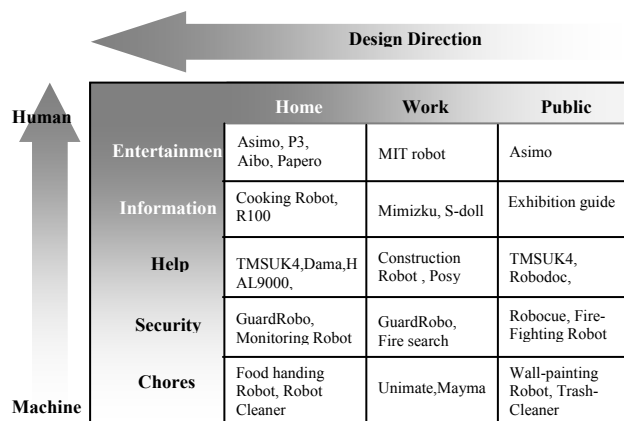


Fig.1 Classification of Robot’s role and character

2.3. Interaction Design

Interaction design finds the robot’s appropriate behavior model and method in visual, auditory and haptic interaction.

To realize easy, speedy and natural interaction, we will need simulation skill.

3. ROBOT DESIGN PROCESS AND METHODS

Research of intelligent service robot is, and will be interdisciplinary for a long time. This project, differing from the existing process (first engineering, last designing), has developed concurrent engineering design process, that is, the design part proposed image concepts and design specifications and was able to communicate with the engineering part.

Fig.2 shows the process and methods of appearance design level in a framework of humanoid robot design. In table[2] we can see the concurrent approach.

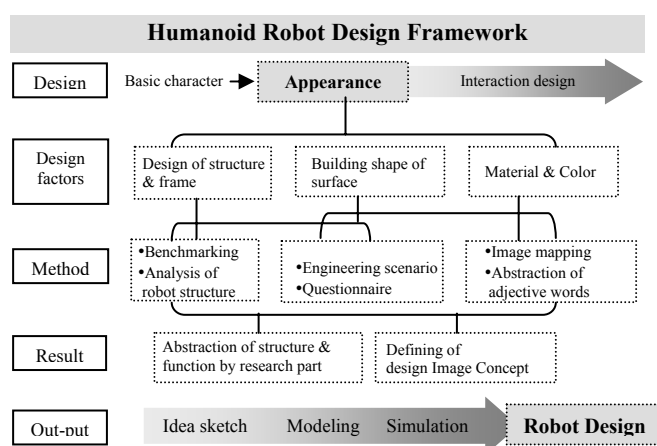
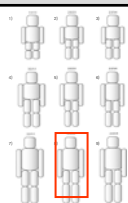
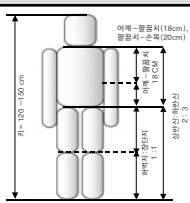
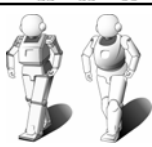
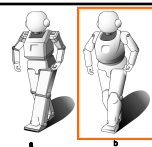


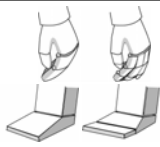
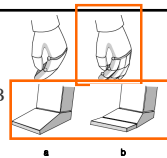
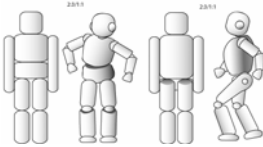
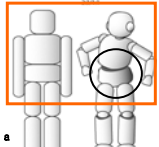
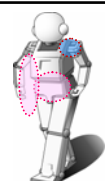
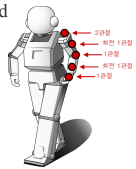


Fig.2 Humanoid Robot Design Framework

The process and methods are as follows:

- Definition of the basic character of the robot
 - Benchmarking: Qrio, Asimo, Pino
 - Analysis of the basic robot structure
 - Definition of the basic structure and frame for design
 - Abstraction attributes on basic structure and frame
 - Questionnaire to the engineering part: size, sex, age, human or machine type and so on
 - Request of engineering scenario to the engineering part
 - Variation of basic body proposition and combination
 - Questionnaire to the engineering part: table[3]
- Application results on design direction
 - Building shape of surface
 - Image mapping
 - Definition of the design image concept
 - Abstraction of adjective words
 - Ideation and visualization of images
 - Clustering and making detail
 - 3D Modeling
 - Simulation and evaluation for practical performance
 - Rendering

Table[3] Questionnaire : lists and results

Question		Result and direction
Proposition	<ul style="list-style-type: none"> •Head : body •Bust : leg •Upper leg : lower leg 	<ul style="list-style-type: none"> •Head : body = 1 : 6 •Bust : leg = 2: 3 •Upper leg : lower leg •Shoulder ~arm = 19cm •Arm~ wrist = 20cm 
Surface	<ul style="list-style-type: none"> •Smooth, rounded •Straight, solid 	<ul style="list-style-type: none"> •Smooth, rounded •Modified round considering inner spec 
Joint type	<ul style="list-style-type: none"> •Visualized •Hidden 	<ul style="list-style-type: none"> •Hidden joint •Soft elements •Solving shape to working in design developing 
Hand Foot	<ul style="list-style-type: none"> •Finger joint •Simplification level •Foot joint 	<ul style="list-style-type: none"> •Finger joint •Simplification level •Foot joint •Foot : top A + bottom B =>Easy to walk 
Hip	<ul style="list-style-type: none"> •Closed to bust (Hip joint) •Closed to leg (Not hip) 	<ul style="list-style-type: none"> •Hip joint •Able to rotate for flexibility 
Battery	<ul style="list-style-type: none"> •Back •Chest •Other 	<ul style="list-style-type: none"> •Mainly focus on back •Other (Hop, leg, - considering the center of gravity)
Other suggestion	<ul style="list-style-type: none"> •Necessary points by technology constrains 	<ul style="list-style-type: none"> •Arm joint(6 degree of freed •Enough space in bust 

4. VISUALIZATION OF HUMANOID ROBOT DESIGN

4.1. Design Concept

4.1.1. Image Mapping

Based on research, Robot image is divided into joint, color, whole image, and face. In detail, joint and color is divided into machine and toy style, while the whole image and face is divided into animal and human type. Existing robots are grouped into four regions by the above factors (Fig. 3).

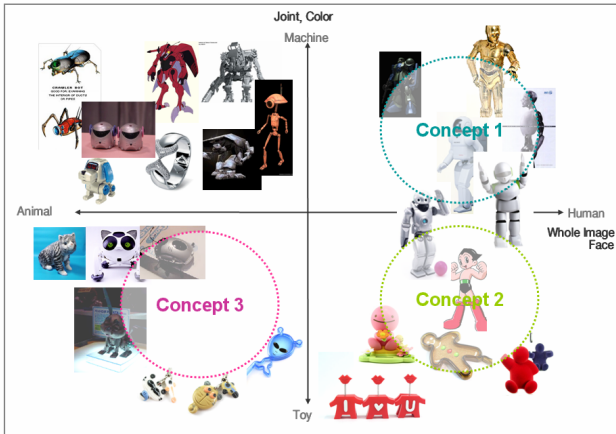


Fig.3 Image Mapping of Robot and Direction of Concept

4.1.2. Concept making

We defined humanoid robot design concepts into three types: concept 1 pursues image that is mechanic in joint and color, and human in the whole image and face look, concept 2 has a toy image in the joint, color, whole image and face, and concept 3 has an animal and toy shape.

4.1.3. Abstraction of adjective words

Abstracting of adjective words, which is a usual method in design works, is to help the designer ideate and visualize in the idea sketching process. This step has advantages to understanding, expanding concept and communicating with other fields.

Whole image	Face	Joint	Color
straight, male Square, mature	Simple, strong	exposure	Mono tone, silver

Fig.4 Adjectives of Concept 1

Whole image	Face	Joint	Color
round, smart speedy	familiar cute, young	exposure	pastel tone, silver

Fig.5 Adjectives of Concept 2

Whole image	Face	Joint	Color
round, speedy	characteristic cute	exposure	vivid color, white

Fig.6 Adjectives of Concept 3

One of the most important design points is exposing joints on the grounds of questionnaire and conclusion. Consequently we focused on expressing of each joints, especially at the shoulder and knee part.

The face image is a major factor because it decides whether people feel familiar with the robot or not. Concept 1 is a male, strong, and simple mood, concept 2 is a round, cute and young mood and concept 3 is a humanoid, but has characteristics of an animal such as a cat or dog. Silver and white Colors which are popular and acceptable in robots and appliances were applied on all concepts. However pastel tone or vivid colors were used in concept 2 and 3 as accent points.

4.2. Idea sketch

Ideation and sketching was performed on each concept after defining the concepts and directions in detail.

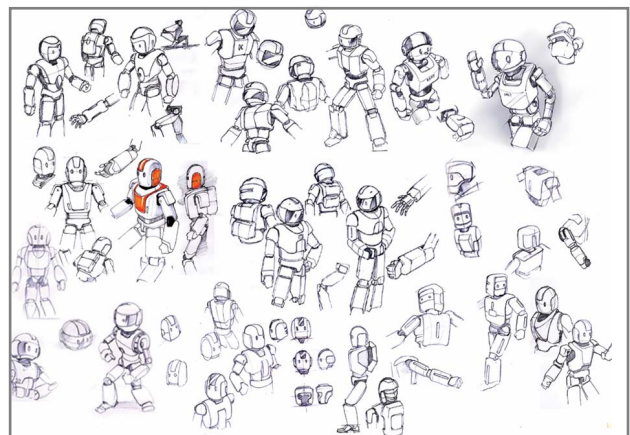


Fig.7 Idea sketch

4.3. Rendering

The next process is drawing by dimension. In our project, we developed concept 1 as type A and concept 2 as type B, which is merged with the characteristics of concept 3.

4.3.1. Drawing

The height and width is both 1400cm and 550cm respectively. See the Fig. 8, 9 shown below. We did not apply engineering specification directly on to the design. We proposed a new size to achieve the most harmonious appearance, though we demanded them from the engineering part in the first step. But the new size is mainly modified to realize practice by technology on its basis.

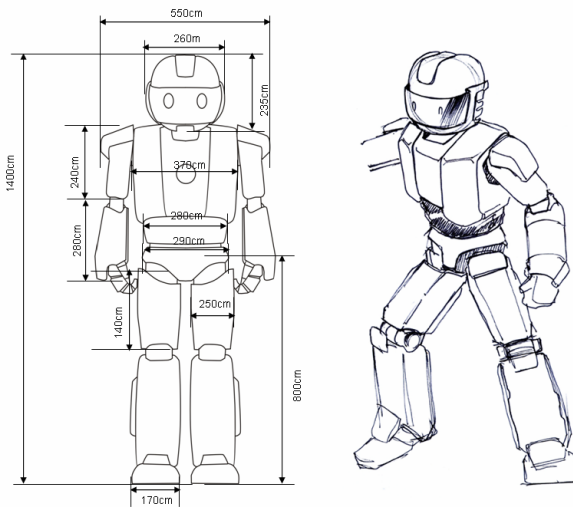


Fig.8 Drawing of type A

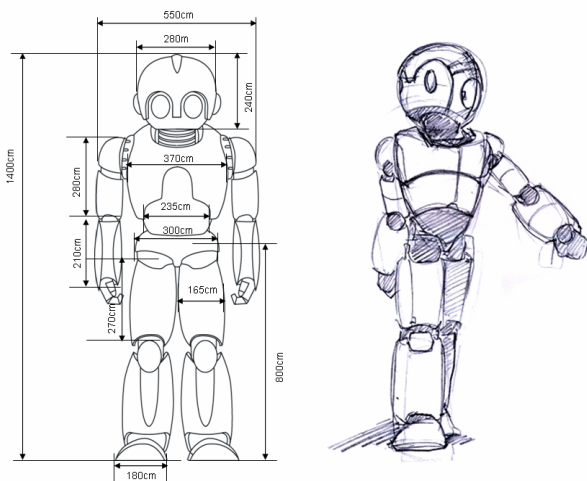


Fig.9 Drawing of type B

There have been many cases up to now where a part of the robot, such as head, bust, or arm and leg are unbalanced. This is the reason why they developed engineering spec. oriented robot housings.

Engineers connected with our project will consider the size of the design parts at the next step. These process have value of interdisciplinary research to find out the most idealistic image of a humanoid robot.

4.3.2. Rendering

Alias was used for modeling works.

The features of type A

- Body shape : square, flat, and strong solid
- Face : swing goggle (open, closed by hinge)
- Color and material: silver and dark gray
- Unique point : sturdy from cornered surface

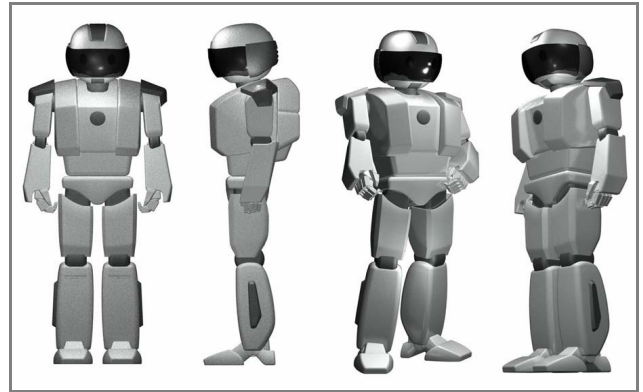


Fig.10 Rendering of type A

The features of type B

- Body shape : round and sleek volume
- Face : big eyes and embodied ears such as monkey toy
- Color and material: white and blue as accent
- Unique point : dynamic form joint of round units

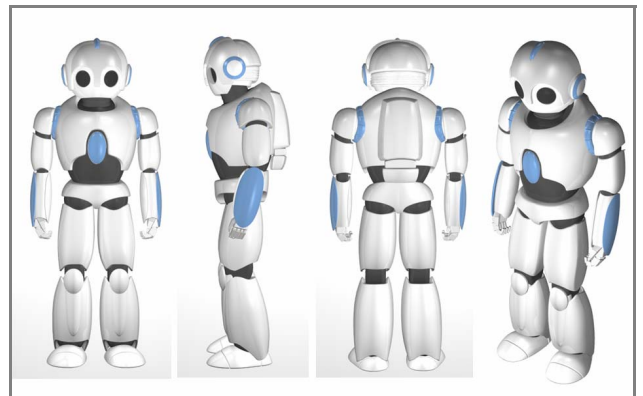


Fig.11 Rendering of type B

4. CONCLUSIONS

As humanoid robots diffuse in to the world and take effect on human life, interests and efforts will be concentrated and increased constantly. Thus, the amount of research group associated to this field will try to propose and acquire the standard technology of robots through various approaches and methodologies.

Overall, the most important aspect is that human beings experience familiarity from the figuration of the robot and on whether it can serve amenity and convenience to human.

This project, aimed to realize an intimate and comfort robot, was emphasized on design with focus on appearance design and study on the guidelines as the first level.

A further direction of this project will be to research the role, character, and interaction design through the behavior model of a humanoid robot.

5. ACKNOWLEDGMENTS

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