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Aural and Behavioral Factor Research for Robot Design

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Abstract

In this research, the design factors of the robot's aural and behavioral interface and the level values were to be established through reference studies and case analysis. The aural interface, the voice factor was divided into the gender-male, female, and androgynous- and the age-middle-aged, young, juvenile- while the sound effect factor was categorized in accordance with the categorization of the prototype that actually made sounds. For the behavioral interface factors were to include gestures and movements; the gestures were grouped into the purposes and the degree of the freedom of joints while the movements were grouped into the possibility of movement and the methods of movement

Keywords: *Robot, Robot Interface Design, Aural Interface, Behavioral Interface*

1. Introduction

As the interface technology that enables the communication between human and robot ripens, the researches on the elements of the aural interface on which the voices interact and of the behavioral interface which interacts through movements are actively being conducted. To take a look at the existing aural interface researches, the aural interface can be roughly divided into verbal sounds and non-verbal sounds. Chae, et al. [1] had split this into the sound effects, the sound effects and the voice, and the voice to examine the usability of the home appliances with [1]a focus on the user's feelings received from different tones of the voice (i.e. the choices of the sentence final endings including polite expressions). Kwak et al [2] had added the verbal sounds and the non-verbal sounds to the personified sounds and the non-personified sounds to measure the degree of the human's sympathy on the composition relationships of these sounds. There had been some researches on the specific attributes of a sound. For example, Jee et al [3] had created three rules of the aural interface regarding the pitch range, intonation, and the tone of a sound. Jeong et al [4] had observed the influences of the frequency of a sound, the harmony of notes, the energy amount of the sound pressure, and the increase of the sound pressure and they especially analyzed the sounds that could deliver the exact meanings of the motions, the non-verbal information, in the emotional point of view. Lee et al.[5] had studied the user's feelings from the non-verbal sounds and focused on the pitch and the length of a sound. Kim, Ahn, and Lee [6] have measured the appropriate differences of the provided volume of the voice guidance and also evaluated the relevance of the information in accordance with the length of the sentence. As with the researches

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on the aural interactions types, Jeong, Kwon, and So [7] have classified the voice and sound effects as platform, monitoring, alerting, and feedback to examine the level of positive, neutral, and negative emotions that the humans feel. Hong, Hwang, and Kang [8] had proved that the usability differed depending on the methods of voice recognition and the combination of the feedback.

As the social robots come into the market, the study on the robot's gestures, the behavioral interface, has become more important. There had been some researches on the analysis of the correlation between the robot's characteristic factors and the emotional states. Hong et al. [9] had investigated the usability by selecting a representative sample of emotions and observing the basic characteristics and changes of the gestures towards the sample. Kim [10] had experimented on the gestures that could express the robot's individuality types as well as the relationship between the individuality and the tasks. To materialize the characteristics of the robot's gestures, Kim [11] had picked the direction, the speed, the size, and the number of repetition as the center of the movement factors and the dominant and amicable attributes as the characteristics factors. Lee [12] had built various motion databases dividing the gestures into the animal behavioral basis, the situational activity basis, and the experimental basis to analyze which gestures would be easily realized by users. In the researches about the movements in the robot's behavioral interface, there were many technical researches found regarding the stability. For the researches on the pedestrian type robot, the two-legged walking robots borrowed the human's structure [13][14] while four-legged walking robots borrowed the animal's structure [15] to stabilize. For the wheel-driven robots, multiple moving robots have been studied [16]. Other than the speed improvement or stability in the movement researches, the characteristics of the change of the speed and the direction are mainly discussed.

With the help of the robot technology's open source environment, the possibilities of the small business operators to enter into the market are growing; thus, not only the standardizations of the robot technologies but also of the design technologies are expanding. However, the detailed design factors that appear in the existing researches are either only partially discussed or different in classification criteria. As the first step of the robot design, it is necessary to systematize the robot interface design factors. Since the purpose of the systematization of the design factors is to enable them to be utilized in the market, reflecting the current market status is essential. In this research, the classification criteria for the aural/behavioral interface design factors that reflect the trends that are in are to be established by analyzing the design factors found in the service robot cases in the current market. The actual robot design cases are to be classified based on the factors that were mainly discussed in the existing references and to be adjusted inductively to reflect the current market status.

2. Design Case study Analysis

Out of the service fields, the aural and behavioral interface factors have been analyzed with the cases of the robot designs. In the aural interface, the voice and the sound effect have been selected as the factors while in the behavioral interface, the gesture and the movements have been determined to be analyzed.

2.1. Robot's Aural Interface Design Case Analysis

The characteristics of the robot's verbal sounds are called the voice factors and the percentage of the robots that provided the voice (45%) was lower than the one that did not. There were more female voices overall compared to the male voices and young adult

voices were found a lot. The young female voice (34%) had been used in the robots with various appearances throughout various service fields. The next popular voice was the young male voice (16%) to be found in the robots with the masculine appearance or characterized robots. The following voices were the juvenile voice (12%) and the juvenile female voice (12%) at about the same level and they were mostly used for the cute characters or small-sized robots. Some of the voices were hard to distinguish whether it was of female or male and for these voices, there is a limit to analyze whether it was purposely expressed in such way or it was due to the limitation of the mechanical sounds. The middle-aged voices were not used a lot with the male and androgynous voices, but the middle-aged female voices (12%) were found in human type robots.

The characteristics of the robot's non-verbal sounds are called the sound effect factors and the percentage of the robots that provided the sound effects (24%) was quite lower than the ones without them. When the robots offered sound effects, lots of personified or animated sounds (63%) were found such as hurray and ahem as for the human's exclamation or roaring and groaning sounds as for the animal sounds. These sounds were articulated using different nuances and usually found within animal or human types of the robots. Even if the robot had an abstract appearance, these sound effects could make it appear as alive if it had personified gestures. When the robots provided the mechanical sound effects (37%), the artificial sound effects such as ding-dong or ting-a-ling were used to reinforce the feedback. In the mechanical type robots as well as in the animal and human type robots, sometimes personified/animated sound effects were used together.

2.2. Robot's Behavioral Interface Design Case Analysis

The overall movement features that use each organ of the robot are called gesture factors and the robots with the gesture factors (53%) and the ones without the factors were about the same. The majority had the purpose of functional performance and information offer (48%). Among the offered services by the robot, they could move objects around or dance as to offer particular functions. They could also provide information using gestures as to guide a direction. When the robot is communication with the user, some gestures were used to reinforce the communication (30%). For example, the feedback gestures can be found when the robot turns around the head to see the user when speaking or nods to prove that the voice is being heard. Also, natural gestures from other living things can be seen when the robot is moving around the head while speaking or moves around the body Figure 3-3. When expressing the feelings (23%), different gestures indicate various feelings like sadness or happiness and the robots tend to use similar gestures of the humans or animals when feeling pleasant.

In order to understand how freely the robot can move to show gestures, the number of joints used in the gestures could be examined. The majority was using one or two joints to make a gesture so far and the more complicated the appearance the robot has, the more freely the joints can be moved around. Most of the time the robot using only one joint (37%) was dominant and the head or torso itself was used to make a gesture with an abstract appearance. If two joints were used (26%), mostly the head and arms were used to bring out a gesture and the appearance was usually simplified. When three joints were used (16%), the head, torso and either arms or legs were used and the appearance was a little simplified from its prototype. With four joints to be used, usually all of the joints, the head, torso, arms and legs, were used and they looked almost like a human or an animal. There was hardly any robots with five joints used (6%); for human robot types,

the head, torso, arms, legs and fingers were used whereas for animal types, the head, torso, legs, tail, and jaw(mouth) were used.

The movement factors that change the location of the robot were mostly found in the wheel-driven types (53%). Even if the legs physically existed, the robots moved around on the wheels; the wheels could exist as a part of the robot but sometimes they were hidden inside. The next majority was the standing type (34%), and it was often found in the robots with the simplified facial expressions or joint expressions. For the pedestrian type (9%), it could be divided into two-legged human type and four-legged animal type just like using the similar method of moving with the same number of legs of the prototype. The rest miscellaneous type (4%) was to include the robots that roll its body to move around.

3. Conclusions

In the robot's aural interface design factors, the voice and the sound effect, the following level values have been defined through the categorization of the references and case analysis. Firstly, the voice is grouped as gender (male, female, androgynous) and age (middle-aged, young, juvenile). Secondly, the sound effects have been organized with the standard of the categorization of the prototype Table 1.

Table 1. Aural interface design factor and the level values of each factor

Factor	No	Standard	Level Value	Definition
Voice	1	Gender-Age	Male-Middle-aged	A voice of a middle-aged male
	2		Male- Young	A voice of a young male
	3		Male- Juvenile	A voice of a juvenile male
	4		Female- Middle-aged	A voice of a middle-aged female
	5		Female-Young	A voice of a young female
	6		Female-Juvenile	A voice of a juvenile
	7		Androgynous-Middle-aged	An androgynous voice at the middle age
	8		Androgynous- Young	An androgynous young voice
	9		Androgynous- Juvenile	An androgynous juvenile voice
	10		None	Verbal sounds are not provided
Sound Effect	1	Categorization of the prototype	Personification, Animation	Non-verbal human or living things
	2		Simple electric sounds	Artificial electric sounds
	3		None	Non-verbal sounds are not provided

In the robot's behavioral interface design factors, the gesture and the movements, the following level values have been defined through the categorization of the references and case analysis. Firstly, the gesture has been divided into the purpose and the degrees of freedom of the joints. In the purpose factor, the types have been categorized according to the purpose of the gesture; and in the degrees of freedom of the joints, the types have been classified according to the number of joints that are used to deliver the gesture (head, torso, arms, legs, and extra joints). Secondly, the movements have been classified according to the possibility and methods of movement Table2.

Table 2. Behavioral interface design factor and the level values of each factor

Factor	No	Standard	Level Value	Definition
Gesture	1_1	Purpose	To provide function/information	A gesture to carry out and/or reinforce a certain function or information
	1_2		To express feelings	A gesture to convey feelings or reinforce the expressions
	1_3		To communicate	A gesture to reinforce communication between the user and the robot
	2_1	Degrees of freedom of joints	When only 1 joint moves	Only 1 joint moves to deliver a gesture
	2_2		When 2 joints move	2 joints move to deliver a gesture
	2_3		When 3 joints move	3 joints move to deliver a gesture
	2_4		When 4 joints move	4 joints move to deliver a gesture
	2_5		When more than 5 joints move	More than 5 joints move to deliver a gesture
	3	None	None	No gestures provided
Movements	1	Movement Method	Pedestrian type	Moves with the movement of the legs
	2		Wheel-driven type	Moves with the movement of the wheels
	3		Standing type	Moves only dependently by a person's physical action to be stood on a table or fixed
	4		Miscellaneous	Moves in other ways rather than walking, driving, flying

The results from this research would be applied as the reference values in the next researches to examine the relationship between the UX and the robot's interface design factors

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References

[1] H. Chae, J. Hong, M. H. Jeon and K. Han, "A study on voice user interface for domestic appliance". Emotion and Sensibility. 10, 1 **(2017)**

[2] S. S. Kwak, T. Goh, K. Park and J. Ahn, "The Usability of a Robot and Human Empathy by Anthropomorphic Sound Feedback". Archives of Design Research. 25, 3 **(2012)**

[3] E. S. Jee, Y. J. Jeong, C. H. Kim and H. Kobayashi, "Sound design for emotion and intention expression of socially interactive robots". Intelligent Service Robotics. 3, 3 **(2010)**

[4] J. Jeong, S. Heo, S. Hong and E. Kim, "Research on the Sound Effects Set Associated with Robot Motions". Archives of Design Research, 21, 4 **(2008)**

[5] H. Lee, Y. Jung, J. Rhim and M. Kim, “State Feedback Design for the Future Robotic Computer”, Proceedings of the HCI Society of Korea conference, **(2012)**

[6] Y. Kim, S. Ahn and T. Lee, “UX Guidelines for Designing Audio Guidance of Multimedia Contents for Low-Vision - With a Focus on Sound Level Difference and Amount of Auditory Information”. Archives of Design Research. 30, 1 **(2017)**

[7] E. Jeong, G. H. Kwon and J. So, “Exploring the taxonomie and associative link between emotion and function for robot sound design”. Proceedings of Ubiquitous Robots and Ambient Intelligence (URAI), 2017 14th International Conference, **(2017)** June

[8] E. Hong, H. Hwang and Y. Kang, “An Arrangement Method of Voice and Sound Feedback According to the Operation：For Interaction of Domestic Appliance”. Journal of the HCI Society of Korea. 11, 2 **(2016)**

[9] S. Hong, S. Heo, E. Kim and Y. Jang, “A Study on the Design of Human Robot Interaction for the Supporting Shopping Robot”. Proceedings of KSDS Conference, **(2006)** May

[10] H. Y. Kim, “A study on robot gesture design based on myers-briggs type indicator : focused on matching personality of a robot expressed through gestures to tasks”. Master's Thesis. Kaist. **(2008)**

[11] J. W. Kim, “Entertainment Robot Personality Design based on Basic Factors of Motions”. Master's Thesis. Kaist. **(2009)**

[12] D. K. Lee, “A Study on the Entertainment Robot Behavioral Structure and Reactive Motion Design”. Master's Thesis. Kaist. **(2003)**

[13] J. H. Kin, E. G. Kim, S. W. Jung, K. H. Bae and K. S. Choi, “A Study on Stable Walking Motion Pattern of Humanoid Robot”. Proceedings of The Korean Society of Manufacturing Technology Engineers, **(2013)** October

[14] J. J. Oh, “A Study on Stairs Walking of a Biped Robot”. Master's Thesis. Kyonggi University. **(2007)**

[15] Y. W. Sung and H. Seo, “A New Type of a Quadruped Robot”. Journal of the institute of signal processing and systems. 13, 2 **(2012)**

[16] S. J. Shim, “A New Wheel Arrangement of Three Wheeled Omni-directional Robot for Linear Motion Speed Improvement”. Master's Thesis. Seoul National University. **(2013)**

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