PHYSICAL MOVEMENT AS DESIGN ELEMENT TO ENHANCE EMOTIONAL VALUE OF A PRODUCT

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ABSTRACT:

Emotional interaction is important to improve user satisfaction in product design. People often create emotional attachments with the products they use. By providing emotionally rich interaction, the products can be more closely associated with the users and support better user experience. In human-to-human interaction, emotional interaction can be provided by sharing mutual expression of emotion, such as facial expressions, voice intonation, gestures and so on. Such expression is not provided when people interact with products. Therefore, it is important to provide a means to express emotion in the product side. One of the ways to enhance emotional interaction is to use dynamic attributes as a way of expressing functional or emotional states of products. The physical movement is a particular one among the dynamic attributes. We investigated physical movements as means of expressing functional and emotional states of interactive products. We present a framework of the relationship between emotional expression and physical movement. We also present a new interactive device in which we augmented physical movement for supporting emotional interaction based on the framework.

1. INTRODUCTION

Due to the rapid technology development, the limitations in product production are decreasing. At the same time, because the consumers' life styles and needs are becoming more varied, a product's technical characters such as number of functions, size or price can no longer be a product's differential element. For a successful business, developing a product that stimulates a user's emotion is becoming more and more important. Norman(2004) and Desmet(2002) mention the increasing importance in the role of design in maximizing a product's emotional value.

A traditional and typical method of maximizing a product's emotional value is to create aesthetic shape. This can be achieved by harmoniously composing various design elements according to principles of design form accumulated through designers' experience. Conventional design elements include things such as form, material and color. These usually have visual and static properties. With the development of digital technology, however, the properties of products are changing to be more and more intelligent and interactive. New dynamic design elements are used. For example, the interaction between user and product is considered as the principal design element for digital appliances. Integrating this into the product is becoming the main focus of design.

In addition to altering the static external form to create emotional value, dynamic and temporal design elements such as the usage behavior of a product is attracting attention. Physical movement is worth notice among the new dynamic and temporal design elements. Physical movement can be found easily around us and it has an interesting property of provoking various emotions. For example, the last leaf on a tree in fall, moving to the rain and wind can provoke pity emotional feeling. The slow swinging pendulum initiates a sense of profoundness. In addition, acts such as gestures are an important means of communication that humans use other than language to express emotions. Physical movement can easily attract people's attention by changing the environment visually, and it has the advantage over visual movement seen through a screen in that the product can be expressed independently from the space that it is in.

Nevertheless, Dealing with physical movement as a design element is difficult because of the limitations of size or shape due to the 3 dimensional form and material. There are also limitations

in technological realization. The application of physical movement to increase emotional value of products in design and related fields is yet fully studied.

The objective of this research is to investigate the dynamic elements of design, especially physical movement, to find a systematic method of applying it to increase emotional value of products. The focus of this research is on constructing a theoretical framework about the relationship between emotion and movement, then using this to develop a new interactive device that expresses emotion of products and finding applications for the device. In order for this, literature review was carried out to analyze research around the application of movement. The relationship between emotion and movement dealt in established researches is reviewed and looked in depth into the characteristics of emotion and movement in order to concretize this relationship. Further more, the relationship between movement and emotion we assimilated through field research. Based on the literature review and the field research, a framework of the relationship between emotion and movement was formed. As a scheme to apply this framework to product design, we proposed a new interactive device that expresses a product's emotions with physical movement and applications of it.

2. RELATED WORKS

Movement is a subject dealt with not only as an element of design but also as a means of understanding human behavior in the field of cognitive psychology and in areas where it is a means of expression as in the performance arts. In the field of visual design various researches increasing the meaning of static graphics by applying motion to it were carried out. Vaughan(1997) draws out that an understanding of expression of movement in theatrical arts helps apply motion as a design element to graphic interface. Peterson(2002) reinterpreted visual motion in films and used this as a guideline in applying motion to graphic interface. Uekita et al. (2000) proposed a method of increasing emotion in kinetic typography by linking the intended movements to the text. However, these researches do not present a concrete relationship as to what kind of motion should be created for a specific emotion.

In product design, various examples of using movement as a design element are appearing. Weedesteijn et al.(2005) are using a product that has a movement to express an emotion as an example of a subsidiary educational device with which children can learn to express emotion using their bodies. Ishii et al. (2001), Moen (2005) and Jafarinaimi et al. (2005) present methods

of applying motion in communication devices and ambient displays. Young et al.(2005) have accepted the technique of simulating motion in nature and converting this into animation sketch to design a moving part of a product. There have been various attempts to use movement as a design element but there still lacks research in systematic design methods or application for physical motion design.

On the other hand applying movement to a product can be divided into two ways. One is to embed the movement in a product itself and the other is to attach a separate addition that creates movement to enhance the emotional functional value. The example of the first type includes Tanks tail(1996) and Nabaztag(2006). But these still stagnate on the level where movement is used simply to attract attention. Non-design related fields have concentrated their efforts on trying to understand the relationship between movement and emotion. Demand for applying these researches (Boone and Cunningham, 2001; Camurri et al., 2005; Pollick et al., 2001) in design methods and examples are increasing but it is still difficult to find examples that have made appropriate applications. In consequence, in order to meet this kind of growing demand and to design physical movement that is more effective, research in systemizing the relationship between movement and emotion is needed. Moreover, research in applying this kind of system with a design perspective to development of products is required.

3. THEORETICAL BACKGROUND OF THE RELATIONSHIP BETWEEN EMOTION AND MOVEMENT

Many preceding researches mention that movement can express or convey emotion. For example, Vaughan(1997) suggested that in theatric arts, the route, direction and rhythm shown in man's body movements or posture can induce specific emotions for the spectators. Bacigalupi(1998) insisted that humans can interpret moving objects by empathizing with it based on the situation they are in. It can be said that emotions can be expressed in diverse ways using formal characteristics that compose movement, such as route or direction. And this kind of movement is affected by experiential conception depending on the context of the person.

3-1. FORMAL CHARACTERISTICS OF MOVEMENT

Movement is made up of a couple of formal characteristics. According to Bacigalupi(1998), Kepes and Moholy-Nagy classify the characteristics as follow.

1) Rhythm: Rhythm occurs as a result of the change in temporal space between one movement and the next movement.

2) Time/Beat : Rhythmic flow or pace of rhythm. Fast beat is usually associated with thin, narrow objects and slow beat is usually associated with thick and wide objects

3) Continuity: Related to both rhythm and time, continuity explains events in time.

4) Direction: When an object has continuous movement it always moves in space and this is when direction forms.

Other than the four characteristics mentioned above, route, volume in terms of change in size, and speed is also mentioned.

3-2. CHARACTERISTICS OF EMOTION

Picard (1997) divides emotion into the mental element and the physical element. The mental element is the cognitive experience of the situation or physiological reactions of others according to the culture or environment. Based on this kind of experience humans can feel a universally sympathetic feeling towards the physical reaction of another person. This supports the discovery that emotion is recognized by experiential perception. On the other hand, in order to comprehend the diverse emotions and their relationship with movement more structurally, it is important to understand under what criteria emotion can be divided.

In the field of emotion research there are two ways of dividing emotions, according to Basic Category and the Multidimensional way. The former is to compose similar emotions in discrete categories. The latter is looking at emotions divided in a 2 dimensional or higher emotion space. Here emotional space is formed with bi-polar dimensions with two adjectives of opposite meaning. Multidimensional division of emotion has been successfully applied to existing products as a basic design methodology. So in this research we apply such models to building a framework of the emotion-movement relationship.

Various models of multidimensional emotion space have been presented by many researchers. The most representative of all is the Circumplex model. Russell(1980) generalized the existing Circumplex model. The model that he suggested is a 2 dimensional space composed of two axes, 'pleasentness(or pleasure)' and 'activation (or arousal)' with various emotions. [Figure 1].

ACTIVATION

tense   alert

nervous

       excited

stressed

       elated

upset

       happy

UNPLEASANT ———————————— PLEASANT

sad   contented

       serene

depressed

       relaxed

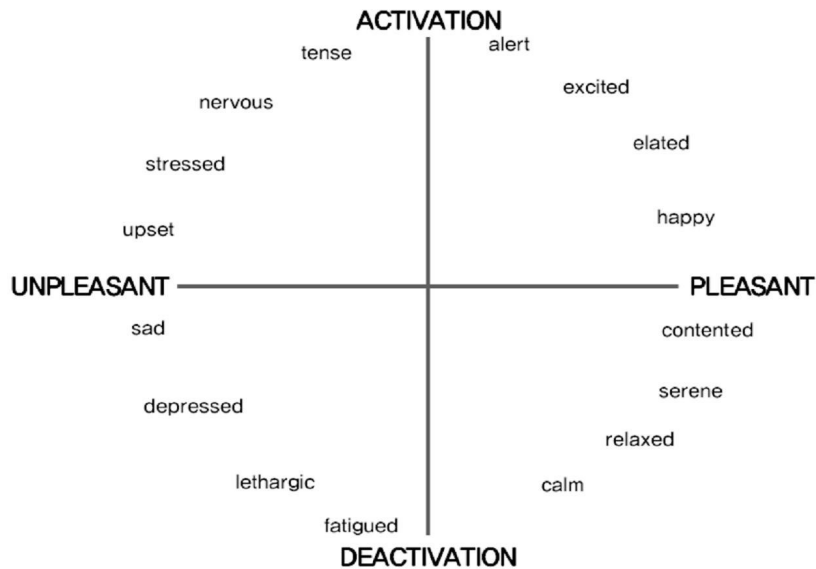lethargic   calm

fatigued

DEACTIVATION

Figure 1: Russell's Circumplex model

In the Circumplex model 'pleasantness' and 'activation' are two properties that distinguish emotion. These properties become criteria for indicating the relative degrees of each emotion perceived by external stimulus. So these two emotional properties can be the basis for structuralizing emotion and the external stimulus, movement. In order to structuralize emotions distinguished by these two properties and the formal characteristics of movement, analysis of preceding researches and a field research was carried out.

3-3. EMOTION-MOVEMENT RELATIONSHIP FRAMEWORK

3-3-1. Analysis of preceding researches of Emotion-movement relationship framework

Pollic et al.(2001) transformed movement of the arm into two dimensional movement by attaching point lights on the arm. They changed the speed of this transformed movement and experimented to find out emotions perceived at different levels of speed. According to the results of this research the speed of movement had a correlation with one of the emotion properties of the circumplex model: 'activation'. It can be summed up that the faster the speed of movement, the more activated emotion it expresses.

On the size and continuity of movement, Boon and Cunningham(2001) had people listen to music expressing a certain emotion and express this music in the form of movement and deduced a

correlation. The result was that with happy and pleasant emotion you make larger and smoother movements, and with sad or scary emotions people showed movement like scrunching up the body. Moreover, negative emotions were related with very variable movements in uneven rhythm.

The results of the preceding researches imply that two properties of emotion in the circumplex model can be substituted into the elements of movement. In other words, 'activation' has a correlation with the speed and size of movement and the two poles of 'pleasantness' can be expressed as smooth or jerky movement.

3-3-2. Field research through in-depth interviews

Field research in the form of in-depth interviews was carried out in order to further identify the relationship between emotion and movement that we understood through the review of preceding researches. Of the people who deal with movement, experts related to dance art who use movement as their main means of expressing emotions or messages were chosen to be the subject for interviews. The subject group consisted of choreographers who were in charge of the stage and teachers of dance academies and they were asked about expressing emotion through movement in their fields. We first asked them of the basic movement that are taught in dance and then discussed further focusing on the movement that are used to express emotion. Based on the results a relationship between movement and properties of emotion was deduced.

Through the in-depth interviews, we understood that the different genres of dance only differed in the style of expression but they all had in common that importance was placed on the line of movement. It was found that this kind of expression of emotion through basic movement is varied to suit one's physical traits. For example, when expressing a movement of the same size, a short and round person would have to move more than a tall and slim person. However removed from these kinds of external conditions, the properties of movement itself could be expressed in similar fashion. Happy emotions with full of joy is expressed by stretching the arts fast and large but at the same time movements are connected smoothly. Angry emotions are expressed with large movements as well but the movements are extreme and disconnected. The results suggest that the emotions classified by the two properties of emotion 'pleasantness' and 'activation' in the circumplex model could be expressed through formal qualities of movement such as speed, continuity, rhythm, and volume.

3-3-3. Emotion-movement relationship framework

The emotion-movement relationship understood through the analysis of preceding researches and field research was a basis to construct a refined relationship framework. Elements of movement needed for the expression of emotion can be classified into three types according to the features of attributes. Uniform rhythm or beat is related to fastness and can be seen as 'speed' altogether. Moreover, continuous or irregular rhythm can be interpreted into smooth predictable movement and unpredictable and disconnected movements which can be expressed as 'smoothness'. Directionality or volume can be seen as 'openness' which includes the meaning of contraction and expansion. The three proposed features, 'speed', 'smoothness' and 'openness' can be connected to the two properties of emotion, 'activation' and 'pleasantness', in the circumplex model.
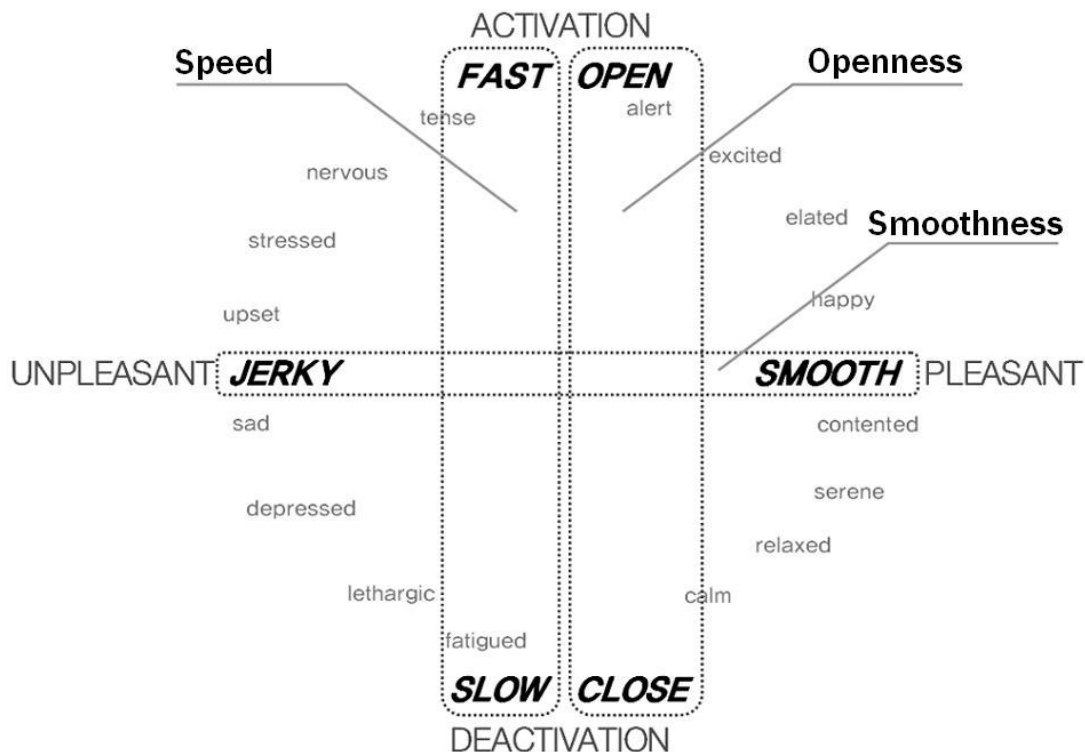

Figure 2: Proposed emotion-movement relationship framework

Figure 2 shows the proposed framework. It could be applied to movement design that communicates or expresses the desired emotion. The desired emotion is defined by the relative degree of two properties, pleasantness and activation. Depending on this definition of the two properties the three features of movement can be put together to express the desired emotion. According to this framework, smooth, fast and open movement is suitable for expressing excited and happy emotions. On the other hand, disconnected and slow movement is suitable for expressing oppressed and sad emotions. Fast, disconnected movements are fitting for tense and

stressful emotions and slow, smooth and closed or curled up movements are suitable for expressing stable and comforting emotions.

4. EMOTION PALPUS: INTERACTIVE DEVICE WITH PHYSICAL MOVEMENT FOR EMOTIONAL INTERACTION

4-1. EMOTION PALPUS OVERVIEW

In order to apply the proposed framework to real product design practice, it is necessary to express the attributes of speed, smoothness and openness in visual or physical design language. Especially, a physical interactive device is necessary for application and evaluation of physical movement for emotional interaction.

Emotion Palpus, an interactive device, was developed to express various emotions through physical movement based on the proposed framework. It is also a device to be applied directly to many existing products. Emotion Palpus is developed using the metaphor that a lot of living creatures including insects use their antenna or palpus to convey their own promised message or emotion through movement. The speed and type of movement of the palpus was made to control the 'speed' and 'smoothness' of the framework. And by making the palpus capable of contracting and expanding, it could control openness of the framework.

At the same time as being a prototype to design and evaluate physical movement suitable for the emotions of a user, Emotion Palpus can be applied as an interactive device added to existing products as a medium of expressing emotion. In addition to the hardware or Emotion Palpus, software to control the movement was developed. This software supports the user to control the three features of movement, speed, smoothness and openness, of a physical structure, by controlling the parameters in a graph editor. In this way the user can produce movement that is connected to emotion. Through this, the user can design a suitable movement based on the framework for the desired emotion.

4-2. COMPONENTS OF EMOTION PALPUS AND IMPLEMENTATION

Emotion Palpus consists of hardware that shows physical movement and a software that controls the movement of the hardware as a means of producing and playing the physical movement. Figure 3 shows the structure of the system between the hardware and the software.
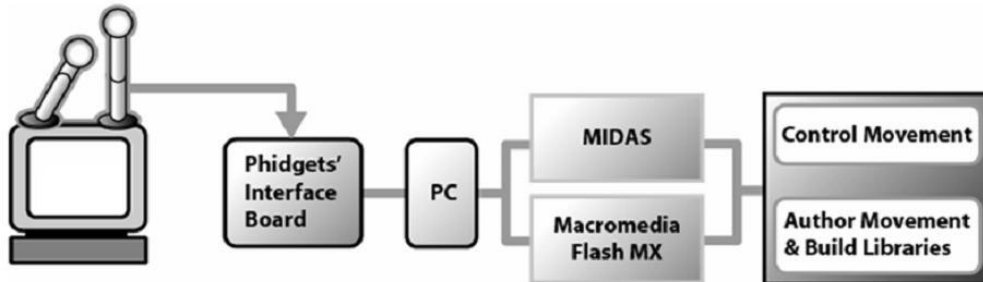

Figure 3: System structure of Emotion Palpus

4-2-1. Hardware Characteristics

Induction of emotion has a close relationship with external shape itself. Therefore, the hardware of Emotion Palpus was simplified to minimize specific emotions that may arise from the external form. Moreover, in order for various movements to be expressed with versatility with the least amount of difficulty in realization, making movements such as simple shapes, rotation and crouching was taken into account. Emotion Palpus can be used in multiple combinations. When it is used in pairs, expression of a larger variety of movement is possible.

4-2-2. Hardware Design

The hardware of Emotion Palpus is capable of expressing vertical piston movement (related to openness) and front/back and left/right movement around a fixed axis (related to speed and smootheness). For each movement a servomotor was used. The horizontal movement created by the rotation of the motor is translated to vertical movement and piston movement is realized through the coil spring's restoring power. Front/back and left/right rotation movement is expressed as rotation around the origin in the direction of the x and y axis in the three dimensional space of x, y, z axes. These two rotation movements can produce circular motion around the z axis. The hardware was connected to the PC via two '4-Motor Phidget Servo' boards (Phidget, 2007). Figure 4 shows the hardware structure.
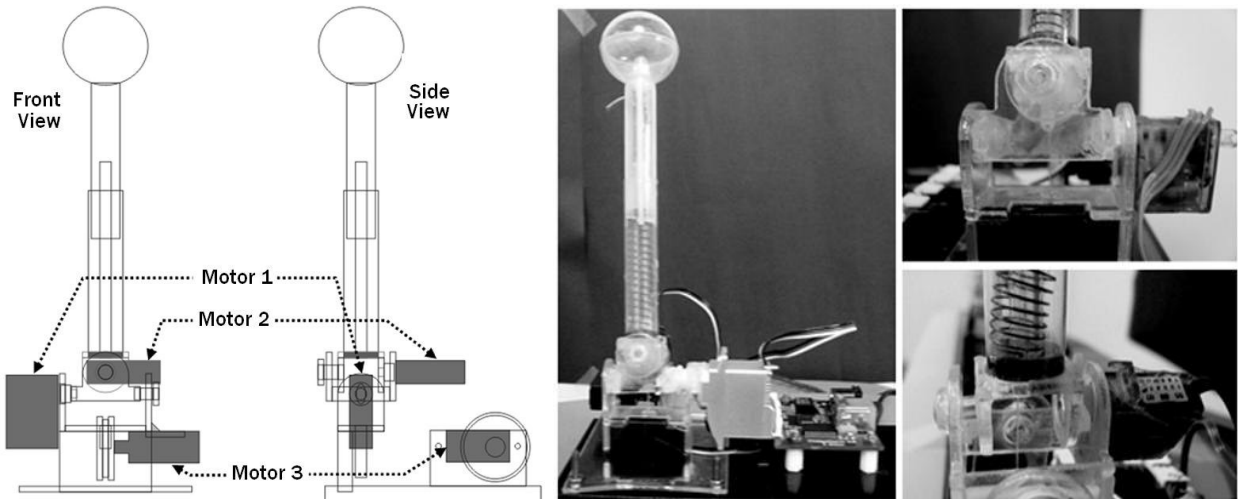
Figure 4: Hardware Structure of Emotional Palpus Prototype

4-2-3. Movement Authoring Software

Emotion Palpus' software provides the function of controlling the hardware through the GUI on the PC. Moreover, the movements made for specific emotion by a user can be saved and reused. The most important thing to consider when expressing speed, openness and smoothness with the movement of the hardware was time and the change of angle of the servomotor. In other words, by adjusting the angle of the servomotor in the flow of time the three attributed of the framework can be controlled.

In order to support these kinds of control functions with ease, the software is realized with a graph editor that is based on a time-line that takes the continuous change of angle into account. Due to the fact that the three servomotors connected to one Emotion Palpus have to be controlled through the software, considering the complexity of the control and future expansion possibilities, modules controlling one servomotor each was developed. These modules can be added depending on the number of motors.
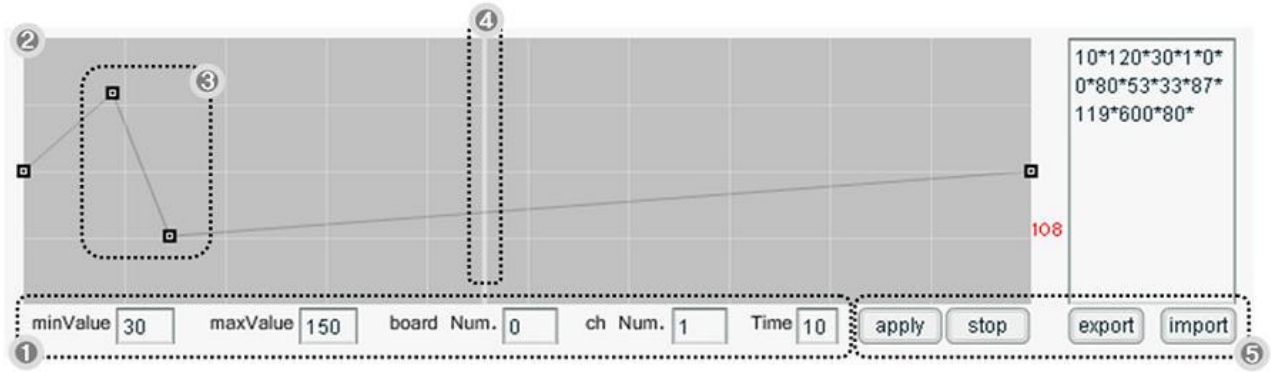
Figure 5: Software Screen of Emotion Palpus Software

Figure 5 shows the software screen shot. Explanation for each part of the screen is as follows.

① is the input field which indicate from left to right, the smallest value of the angle, the largest value of the angle, interface board number, channel number and playback time.

② is the main graph editor where the angle of the arms is specified along the timeline.

③ is the changing point of the graph which the angle changes. The points can be inserted by clicking and modified by dragging.

④ is the time bar which moves along the time-line and controls the movement.

⑤ are action buttons which carry out play, stop, print text code and input text code functions from left to right.

4-2-4. Software Implementation

Flash 8.0 and an interactive prototyping tool, MIDAS (Yim et al., 2007), were used. MIDAS facilitates the linkage between the hardware control board and Flash. Complicated programming procedures can be reduced to simple script programming with MIDAS. Each function of the GUI was written using MIDAS components and Action Script of Flash.

5. Application of Emotion Palpus

Emotion Palpus can provide new emotional experiences by itself or in liaison with various existing products. In other words Emotion Palpus can be applied in various design cases as below.

5-1. Emotion Palpus Cradle

When using mobile products, Emotion Palpus can be applied in order to provide a more advanced emotional experience. To link mobile products with Emotion Palpus a connection with a cradle that provides charging or storage functions can be proposed. Figure 6 shows a concept image of an Emotion Palpus Cradle.

Figure 6: Emotion Palpus Cradle concept

By providing a cradle with Emotion Palpus that could be used with various mobile products, the user experience of mobile products can be enhanced emotionally. For example, the cradle, linked with a mobile phone, can automatically differentiate alarm sounds, ring tones, text messages and etc to deliver the information provided by the mobile phone emotionally to the user. Moreover, with the current multi-functional mobile products that have DMB, MP3 player and etc, diverse emotional movement can be provided for different screens or sounds.

5-2. Physical Emoticons for Chatting

Due to the development of the network environment, online remote communication is growing. Numerous online expert companies are developing various chat sites and messengers, and they are moving away from static interaction through exchanging simple texts by providing graphic emoticons or animations. In this sort of environment, a more substantial expression of emotion for communication is possible with Emotion Palpus.

In connection with products with which online chatting is possible, such as PCs, UMPCs and mobile phones, by detecting the message that is sent, Emotion Palpus can be applied to express emotion with physical movements with physical emoticons. Through physical emoticons the user

can experience a more substantial emotional conversation with a message. Figure 7 shows a concept of chatting with physical emoticons connected to a laptop.

Figure 7: The concept of Emotion Palpus as Physical Emoticon

5-3. Various Concepts Linked with Other Product

The portable Emotion Palpus can be linked with home audio systems, TVs, video phones and car dashboards. For example, the Emotion Palpus linked to the dashboard detects the state of the driver using sensors. Depending on the state of the driver Emotion Palpus warns the driver of danger through sound and movement. With radios or car audios it can provide cheerful movement to exciting music. This can provide a more emotionally interesting experience to the bored driver. Linked to various products at home Emotion Palpus can convey various emotional values of the product to the user. Figure 8 shows a concept modeling of Emotion Palpus linked to a computer and an audio system.
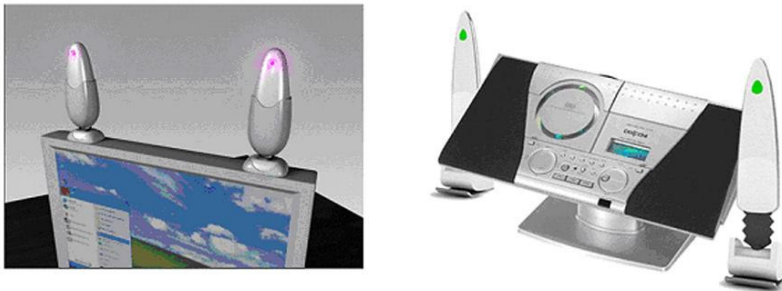

Figure 8: Connection to PC(left) and audio system(right)

6. CONCLUSION

Physical movement is recognized as an element to enhance the emotional value of a product. We presented a framework to apply this to design. In addition, Emotion Palpus which can express a product's information or status emotionally through physical movement was developed. The result of the research shows possibilities of applying physical movement as a new medium of expressing emotion. Linked with various products Emotion Palpus can enhance the emotional experiences of users.

The results of this research provide a basis to expand our vocabulary of design language, by introducing the movement as design element or attribute. This can be applied to many emerging design fields. For example in robot design, there can be a field of application for movement in emotional feedback in robot-human interaction. Moreover, in various interactive products, in the interface represented with just buttons and screens by providing a new interaction media in the form of movement, a wider application is possible. The results of this research can be used to be a basis in developing products that maximize the user's emotions. This can contribute in industrial spin-offs making a more intimate induction of emotional products possible.

For future researches, the proposed emotion-movement relationship framework needs to be further refined by user study. More movement cases needs to be generated while examining their relationship to specific emotions. The ways to overcome technical and structural limitations of the moving parts of Emotion Palpus should be further investigated in order to apply it to various products of different sizes.

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REFERENCES

Bacigalupi, M., (1998), The craft of movement in interaction design, Proceedings of the working conference on Advanced visual interfaces, L'Aquila, Italy

Boone, R. and Cunningham, J., (2001), Chidren's Exprssion of Emotional Meaning in Music through expressive body movement, Jounal of Nonverbal Behavior, Vol. 25, pp. 21- 41

Camurri, A., Poli, G., Leman, M. and Volpe, G., (2005), The MEGA Project: Analysis and Synthesis of Multisensory Expressive Gesture in Performing Art Applications, Journal of New Music Research, Vol. 34, pp. 5-21

Desmet, P. M. A., (2002), Designing Emotions, TUDelft PhD Thesis, http://www.designingemotion.nl

Djajadiningrat, T., Wensveen, S., Frens, J. and Overbeeke, K., (2004), Tangible products: redressing the balance between appearance and action, In Personal and Ubiquitous Computing, Vol. 8, pp. 294-309

Ishii, H., Ren, S. and Frei, P., (2001), Pinwheels: Visualizing Information Flow in an Architectural Space, In CHI '01

Jafarinaimi, N., Forlizzi, J., Hurst, A. and Zimmerman, J., (2005), Breakaway: An Ambient Display Designed to Change human Behavior, In CHI '05

Nabaztag(2006) http://www.nabaztag.com/

Nagamachi, M., (1995), Kansei engineering: a new ergonomic consumer-oriented technology for product development, International Journal of Industrial Ergonomics, Vol. 15, pp. 311-346

Norman, D. A., (2004), Emotional Design: Why We Love(or Hate) Everyday Things, Basic Books

Moen, J., (2005), Towards people based movement interaction and kinaesthetic interaction experiences, Proceedings of the 4th decennial conference on Critical computing: between sense and sensibility, pp. 121-124

Petersen, H., Nielsen, J., (2002), The eye of the user: the influence of movement on users' visual attention, Digital Creativity, Vol. 13 (2), pp. 109-121

Phidgets (2007), http://www.phidgets.com

Picard, R., W., (1997), Affective Computing, The MIT Press

Pollick, F. E., Paterswon, H. M., Bruderlin, A., and Sanford, A. J., (2001), Perceiving affect from arm movement, Journal of Cognition, Vol. 82, pp. 51-61

Raffle, H., Parkes, A. and Ishii, H., (2004), Topobo: a constructive assembly system with kinetic memory, Proceedings of the CHI '04

Russell, J., A., (1980), A circumplex model of affect. Journal of Personality and Social Psychology, Vol. 39, pp. 1161-1178

Tanks Tail (1996), http://www.petworks.co.jp/~hachiya/works/ThanksTail.html

Uekita, Y., Sakamoto, J. and Furukata, M., (2000), Composing motion grammar of kinetic typography. In Proceedings of VL'00, pp. 91-92

Vaughan, L. C., (1997), Understanding movement. Proceedings of CHI1997, pp. 548-549

Weerdesteijn, W., Desemet, P. and Gielen, M., (2005), Moving Design: to design emotion through movement, The Design Journal, Vol. 8, pp. 28-40

Yim, Y., Park, J. & Nam, T-J (2007), "A Simple Video Tracking Tool for Interactive Product Designers and Artists Using Flash", International Journal on interactive Design and Manufacturing Vol. 1, No. 1