Post-plant: A Series of Non-humanoid Robots with Embedded Physical Non-verbal Interaction

The development of non-verbal human-robot interaction framework and input/output integrated motor interface

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Post-plant is a plant-like robot which communicates nonverbally through physical movements. Until now, robots have in most cases communicated with us by mimicking human speech and human/animal expressions and gestures. Post-plant takes a radically different approach by assuming a form inspired by plants; responding to touch instead of language, it nonverbally conveys simple emotions and information feedback. With post-plant as a starting point, robots of the future will communicate with us in their own way, without having to mimic human behavior.

CCS CONCEPTS • Human-centered computing • Human computer interaction (HCI) • Interaction paradigms

Additional Keywords and Phrases: Physical human-robot interaction, Tangible user interface, integrated motor interface

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1 MOTIVATION

Most of the Robots in Sci-Fi movies are humanoids. They communicate with voice, gestures, and facial expressions. What about real-life robots? Industrial robots have no face, and many of them only have arms or legs. Many social robots look like humans or animals, and few social robots have survived on the market. Some of them had managed to become consumer electronic products like JIBO, Kuri, and Vector, but all three projects are currently abandoned. There are several reasons why social robots do not enter everyday life.

First, it is difficult to form meaningful relationships due to technical limitations, and smart speakers with the same level of language communication ability have an advantage in terms of price. In addition to this, the purpose of everyday existence, including safety issues, is not clear. Nevertheless, there is a characteristic of a robot that a smartphone or speaker cannot have. It is the concept of physical embodiment. Robot ethics researcher Kate Darling says that humans perceive computers and virtual characters as social actors.[1] Also, robots are much easier to be recognized as social beings because of their physical presence and movement. Prof. Cynthia Breazeal of MIT Media Lab cited the research of Reeves and Nass, suggesting humans have evolved inherent sociality in the process of evolution.[2] Therefore, when a computer or an object with a complex mechanism exhibits a social attitude, they are treated as social entities. Robots that are recognized as agents, not objects, have the peculiarity that they can send and receive information such as emotions and intentions. It suggests the possibility that it can function in various fields including assistive technology, relieving the loneliness of an aging population, teaching a language for children, and many more.

Social attitudes don't just refer to the use of language. In human-to-human communication, verbal communication is accompanied by paralanguage expressions and nonverbal expressions, which constitute a significant part of the total communication information.[3] In the case of Kuri, semi-verbal expressions are expressed as sound effects and non-verbal expressions are expressed as head gestures, except for verbal communication. In the case of robots such as Quoboo, it does nothing but waving the tail. That only action exists to respond to the user's touch. Besides, in the case of the robot arm Bexter, there are eyes on the screen that do nothing functional for safety, which is said to give users a sense of stability. By utilizing non-verbal interactions such as movement, light, and sound, various types of robots can have richer communication with users. We considered movement and the change of physical shape as the most important non-verbal communication method for robots. This study aims to create an interactive platform through physical contact rather than on-screen touch.

2 HUMAN-ROBOT INTERACTION FRAMEWORK

Based on the circumplex model of affect proposed by psychologist Russell[4], the basic human emotions are classified as follows.

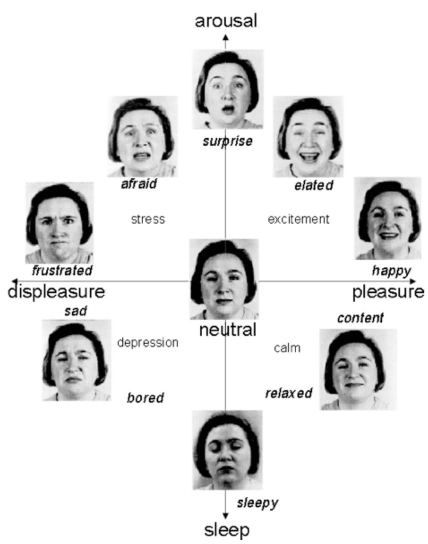

Figure 1: Emotion classification method by Russell's circumplex model of affect Posner, J., Russell, J. A., and Peterson, B. S. "The circumplex model of affect: An integrative approach to affective neuroscience, cognitive development, and psychopathology." Development and Psychopathology 17.3 (2005): 715-734. Print.

This model classifies human emotions based on the degree of arousal and the positive and negative attributes of the mood. For example, the most arousal and good mood is happy, and the less awakened and negative is bored. This logic is not a perfect taxonomy for human emotions, but it is certainly a powerful hint to make emotions correlate with variables to make robots that can communicate with humans.

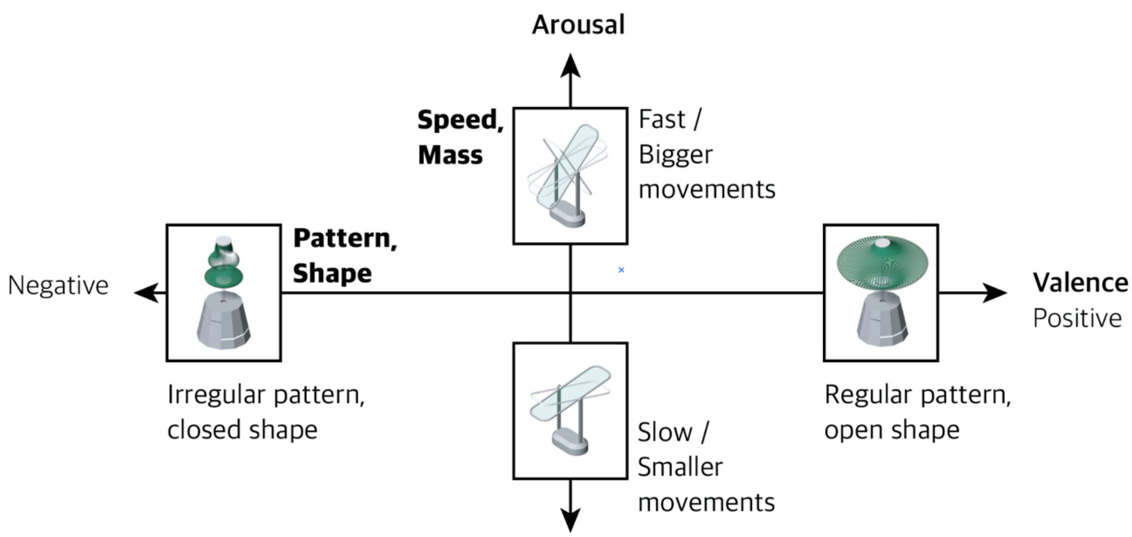

Figure 2: Applied model of Russell's circumplex model to explain the relationship between movements, shapes and emotions.

Non-human robots cannot use the gaze and gestures of humans or animals but can use other elements applicable to Russell's circumplex model of affect. For example, the speed of movement can be quickly expressed in order to show the aforementioned, that is, active activity, and if the range of movement can be increased, the person actively perceives the movement as the movement increases as much as possible. In addition, in the case of positive and negative expressions, if the shape is entangled in a complicated manner, such as shrunken or twisted, and if the pattern of movement is irregular or unstable, it is perceived as negative and, on the contrary, all structures in the eye move constantly or fully unfold When you come in, you perceive it positively. Based on this correlation between movement, emotion, and information, it is possible to create a framework for interactions from robots to humans, and on the contrary, in order to realize physical interactions that humans can give to robots, it is necessary to create an input/output integrated motor interface.

3 DEVELOPMENT OF THE INTEGRATED MOTOR INTERFACE SYSTEM

The stepper motor used in this study is TS3166N47 Stepper motor (400 Step / round), and the motor driver is A4988 Driver. The following experiment is conducted based on the above motor and driver.

Disturbance estimation research based on current amount change has been conducted by configuring the coil in a circuit and measuring the strength of a magnetic field that varies according to the change in the amount of current flowing through the motor with a Hall sensor (DC Current Transformer method). This method enables stable measurement by separating the current measurement circuit and the motor power circuit [5]. The current value is measured after passing through a low pass filter with 1KHz as a cutoff frequency to remove the high frequency fluctuation value caused by this.

Under the assumption that magnetic saturation of the motor does not occur, the torque has a linear relationship with the current in the steady state, so the disturbance value is to be estimated according to the current amount change. However, the motor used in this experiment is a stepper motor and has a characteristic that the torque-speed graph linearly increases in a low speed section (0rpm ~ 120rpm), and the amount of current linearly increases as the speed increases. Therefore, when calculating the disturbance by the amount of change in current, the current compensation and normalization process according to the driving speed are required, and the current-speed characteristic becomes an important characteristic value in the disturbance measurement in this experiment.

However, except for the macroscopically linear characteristic, the detailed characteristic values vary slightly depending on the motor output and manufacturers, and in the detailed section, there is a nonlinear section even in the low-speed section to grasp the speed characteristics. Therefore, the process to estimate the disturbance is as follows. First, the current-speed characteristics of the motor are identified, and the motor speed is increased with a constant acceleration to measure the amount of current accordingly. After that, a large number of sample data points are compressed to smoothly run in the Microcontroller. At this time, for compression, a 'variable length 2^N-section partial linear regression algorithm' based on linear regression was devised, and sample data points were expressed as trend lines for each section of variable length.

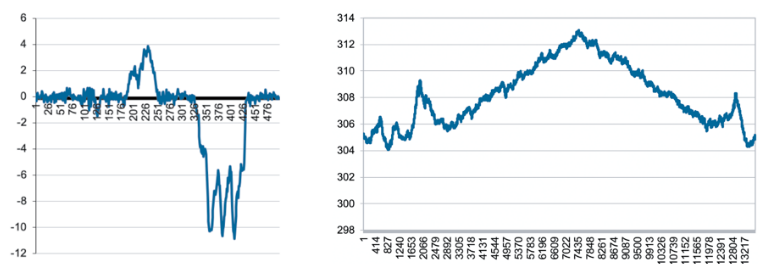

Figure 3: Current amount change when the speed of the step motor is changed linearly, and when interrupted while rotating.

Based on the above current-speed and current-torque characteristics, we designed an input-output integrated motor interface using a current sensor based on the STM32F446RET6 Microcontroller.

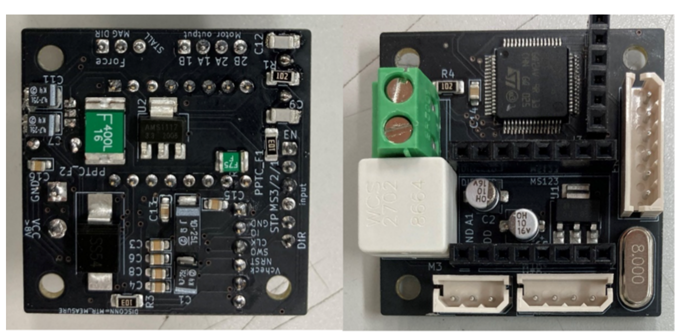

Figure 4: Input/output integrated motor interface unit

4 CONCLUSION

This study proposes the possibility that humans and robots can communicate in a wider variety of ways beyond the existing language and gesture-based interactions through a novel human-robot interaction method. This is technically efficient in that it enables communication with more diverse forms and functions of robots in various ways, since robots do not have to represent humans or animals. This human-robot framework can be the foundation for the non-verbal interaction between humans and robots in the future.

Figure 5: Final robot model, pp-1

Figure 6: Final robot model, pp-2

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