A Study on Infra-Technology of RCP Interaction System

Seungwoo Kim*, and Jaeil Choe**

Division of Information Technology Engineering, Soonchunhyang University 646,
Eupnae-ri, Shinchang-myun, Asan-si, Chungnam, 336-745, Korea
(Tel : +82-41-530-1369; E-mail : *seungwo@sch.ac.kr, **robotics_lab@sch.ac.kr)

Abstract: The RT(Robot Technology) has been developed as the next generation of a future technology. According to the 2002 technical report from Mitsubishi R&D center, IT(Information Technology) and RT(Robotic Technology) fusion system will grow five times larger than the current IT market at the year 2015. Moreover, a recent IEEE report predicts that most people will have a robot in the next ten years. RCP(Robotic Cellular Phone), CP(Cellular Phone) having personal robot services, will be an intermediate hi-tech personal machine between one CP a person and one robot a person generations.

RCP infra consists of $RCP^{Mobility}$, $RCP^{Interaction}$, $RCP^{Integration}$ technologies. For $RCP^{Mobility}$, human-friendly motion automation and personal service with walking and arming ability are developed. $RCP^{Interaction}$ ability is achieved by modeling an emotion-generating engine and $RCP^{Integration}$ that recognizes environmental and self conditions is developed. By joining intelligent algorithms and CP communication network with the three base modules, a RCP system is constructed.

Especially, the RCP interaction system is really focused in this paper. The $RCP^{interaction}$(Robotic Cellular Phone for Interaction) is to be developed as an emotional model CP as shown in figure 1. $RCP^{interaction}$ refers to the sensitivity expression and the link technology of communication of the CP. It is interface technology between human and CP through various emotional models. The interactive emotion functions are designed through differing patterns of vibrator beat frequencies and a feeling system created by a smell injection switching control. As the music influences a person, one can feel a variety of emotion from the vibrator's beats, by converting musical chord frequencies into vibrator beat frequencies. So, this paper presents the definition, the basic theory and experiment results of the RCP interaction system. We confirm a good performance of the RCP interaction system through the experiment results.

Keywords: Robotic Cellular Phone(RCP), Robot Technology(RT), Information Technology(IT), RCP interaction system

1. INTRODUCTION

Most recently, the CP(Cellular Phone) has been one of the most important technologies in the IT(Information Technology) field, and it is situated in a position of great importance industrially and economically. To produce the best CP in the world, a new technological concept and its advanced implementation technique is required, due to the extreme level of competition in the world market [1].

RT has been developed as the next generation of a future technology. Especially, entertainment robots, types of personal robots for amusement and education, are studied world wide currently. These robots do not work in fixed tasks but rather in flexible and various environments. So the toy robot should be an intelligent system with which emotional communication is possible as in humans. Therefore, this paper explains conceptual research for development of the RCP(Robotic Cellular Phone), a new technological concept, in which a synergy effect is generated by the merging of IT & RT as shown in the figure 1.

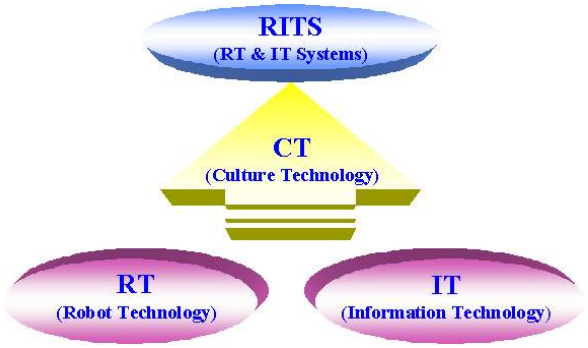

Fig. 1 RT and IT Systems, RITS

The RCP is an intelligent robot constructed with new technology, which can have both novel and convenient functions through grafting of IT & RT. The grafting technology is implemented by advanced design engineering. RCP consists of three sub-technologies, automatic mechanical motion, emotional expression and intelligent feeling, recognition of self-state and environments. This is shown in the figure 2.

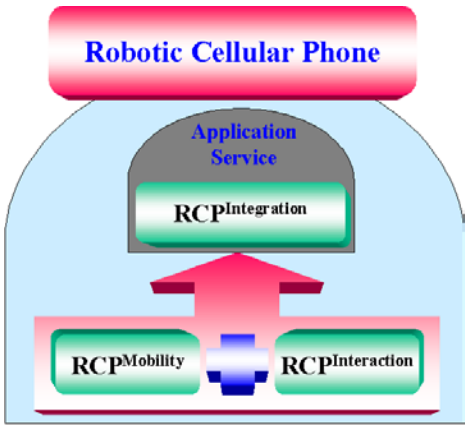

Fig. 2 Sub-Technologies of RCP

The $RCP^{Interaction}$(Robotic Cellular Phone for Interaction) is to be developed as an emotional CP as shown in figure 3. $RCP^{Interaction}$ refers to the sensitivity expression and the link technology communication of the CP. It was interface technology between human and CP through various emotional models [2-3].

This paper presents examples of emotion through patterns

of vibrator beat frequencies and a feeling system created by a smell-injection switching control. As the music influences a person, one can feel a variety of emotion from the vibrator's beats, by converting musical chord frequencies into vibrator beat frequencies.

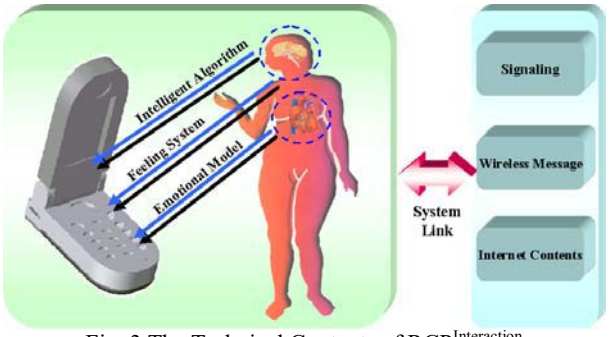

Fig. 3 The Technical Contents of RCP^{Interaction}

The infra-technology of RCP interaction system, including a technical configuration of an emotion-inference engine and perfume-injection and emotion-vibration modules, is explained in the section 2. The experiment results and considerations, including the experimental setup, are given in the section 3. Finally, it is concluded in the section 4 to confirm a good performance of the RCP through the experiments of the interaction module system.

2. The Infra-Technology of RCP^{Interaction}

2.1 Emotion-Inference Engine of RCP^{Interaction}

The emotion-inference engine refers to the function that inspects self-state and recognizes environments by using various sensors. The emotion-inference engine consists of various sensors and acquisition algorithms to recognize self-state and a variety of environments. It uses touch sensor technology, lead switch, and IR sensors. It also uses a CdS cell and tilt sensors.

Figure 4 shows the configuration of intelligent acquisition algorithms. RCP's intelligence is compound and dynamic from the point of view of a sensing environment, decision-making and computation. Intelligent algorithms consist of perceptual processing, environment modeling, action creation and value judgment. The input and output of the intelligence system passes through sensors and actuators. The intelligence system of the RCP includes knowledge engineering and computer science [4-8].

Fig. 4 The Configuration of Emotion-Inference Engine

Artificial intelligent(AI) feels surrounding environments with sensors and decides and constructs intelligent agents that take action. Intelligence algorithm can compute to use neural network(NN), fuzzy logic(FL) and evolution calculation(EC) etc. So, in this paper, intelligence algorithm is implemented by fuzzy logic, and we confirm its performance through the simulation results of the RCP system.

Figure 5 shows a block diagram of the controlled system, which can recognize the self-state and external environment of RCP. The intelligence algorithm, such as fuzzy logic, is used in the knowledge-base for a good decision-making from feedback signals of the sensors. The result is displayed on the RCP monitor and is transferred into another RCP through the wireless communication.

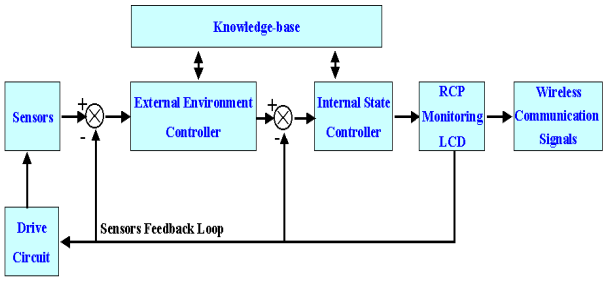

Fig. 5 Emotion-Inference Engine Control System

The emotion-inference engine of RCP is implemented by an intelligence algorithm, light sensors and touch sensors. That is shown in the figure 6.

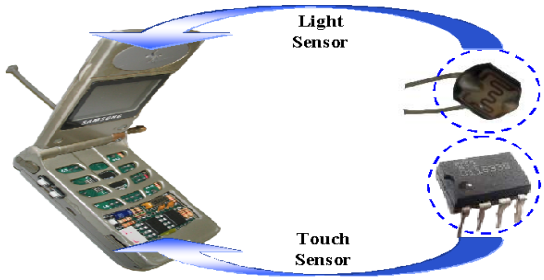

Fig. 6 Experiment of Emotion-Inference Engine

2.2 Perfume-Injection Module of RCP^{Interaction}

The RCP^{Interaction} refers to the sensitivity expression and the link technology of communication and CP. It is interface technology between human and CP through various emotional models. Details of the technologies are as follows. The first is a technology that jets various smells using a micro nozzle, which delivers impression by stimulating the user's sense of smell. The second is a technology that communicates sensitivity to the user through changes of the vibrator's beat frequency and chord frequency.

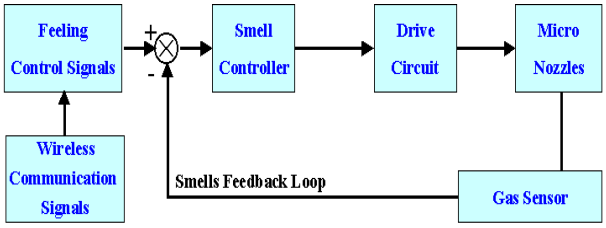

Fig. 7 Perfume-Injection Module Control System

Figure 7 shows a control block diagram of the micro nozzle control for the jetting of various smells. Feeling control signals, which can be changed in according to the calling RCP user, become the input to the smell controller of the called CP. The smell controller decides what kind of perfume is injected, how much amount and how many times, as a calling RCP user. Then the driver activates any one of the micro nozzles.

Figure 8 shows an implementation of perfume-injection functional module using the micro nozzle such as the one of inkjet printer. The amount and the number of the injected perfume are controlled by an electrical heating method of micro nozzle. The driving device uses the FET switching power TR.

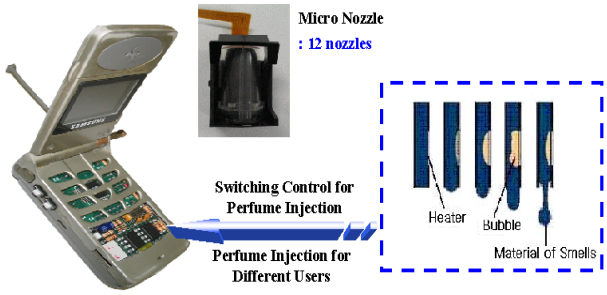

Fig. 8 Experiment of Perfume-Injection Module

2.3 Emotion-Vibration Module of RCP[Interaction]

Figure 9 is a block diagram of control system, which can express the emotion to the RCP users by using the variable frequency and pattern of mechanical vibration. The vibrator is control by using the PID control algorithm like as the mobility control system, because it is made by DC motors.

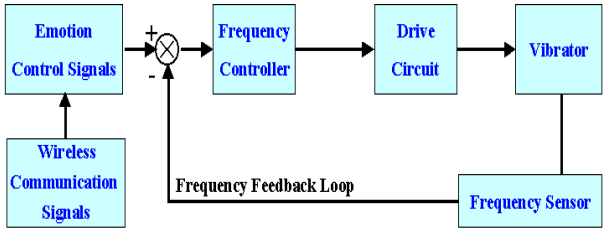

Fig. 9 Emotion-Vibration Functional Module Control System

That is an automatic system which can give a various kind of feeling to the RCP users by converting music's chord frequency to vibrator's beat one. The music chord consists of major harmony which can feel happiness and minor harmony which can feel sadness. The feeling of music harmony can be got in mechanical vibration harmony through the shift-down conversion of frequency. The implemented system is shown in figure 10.

Fig. 10 Experiment of Emotion-Vibration Module

3. RESULTS AND CONSIDERATIONS

3.1 Experimental Result of Emotion-Inference Engine

Figure 11 is a simulation of the emotion-inference engine using fuzzy logic. Basic theory for the design of fuzzy logic system used psychologist Izard's "MAX system's infant emotion expression rule" [9-10]. It executes decision-making using feedback data from a touch sensor and light sensor, making RCP's emotional state in real time. The animation and graph technique is used for the display of the results.

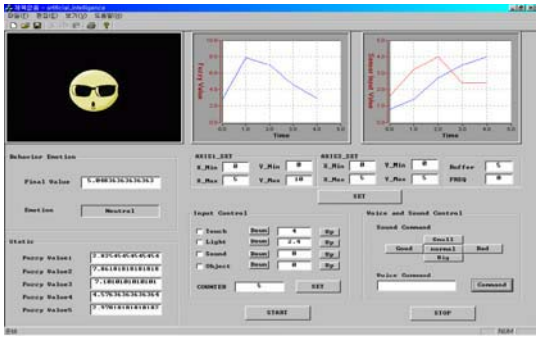

Fig. 11 Simulator for Emotion-Inference Engine

Figure 11 shows the data for feeling and mood, and derives the emotion through a fuzzy logic system. But the sensing data are seriously changeable. It can't ignore noise from outside environment. Therefore, for a precise experiment, we used 5 samples of input data of the fuzzy system to decide final emotion [11-15].

Figures 12~17 are the execution results of the simulation program. The graphs show input and output of three emotion states(anger, neutral, happy) made by using a fuzzy logic system, touch sensor(dash-dot line), and light sensor(solid line). We can know how human emotion is affected by outside environments through the simulation results.

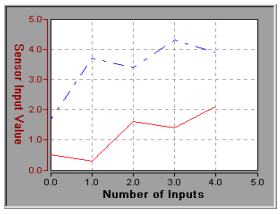

Fig. 12 Sensor Input (A)

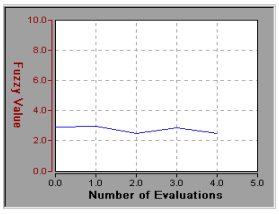

Fig. 13 Anger

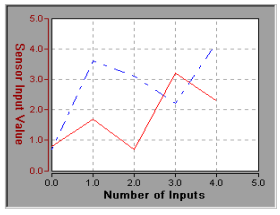

Fig. 14 Sensor Input (N)

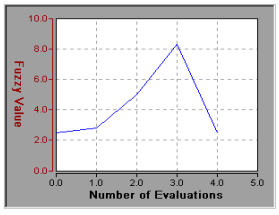

Fig. 15 Neutral

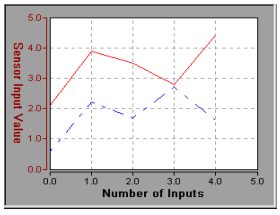

Fig. 16 Sensor Input (H)

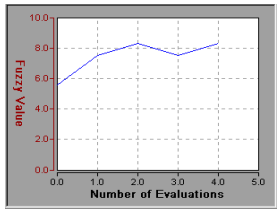

Fig. 17 Happiness

3.2 Experimental Result of Perfume-Injection Module

Figure 18~19 shows the experimental result of perfume-injection module using the micro nozzles. The driving device uses the P-channel FET and switching power TR. We controlled the perfume-injection amount and perfume-injection frequency using switching control of micro nozzles. Figure 18 shows a FET power(perfume-injection power)switching signals. And, figure 19 shows a switching control waveform of the micro nozzles.

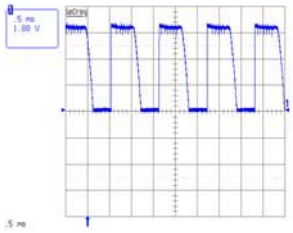

Fig. 18 Power Switching Signals

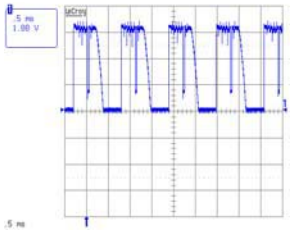

Fig. 19 Nozzles Control Signals

3.3 Experimental Result of Emotion-Vibration Module

Figure 20~23 shows the experimental results of music's chord frequency. Each waveform displays scale of do, mi, sol, semitone of re. Tonic code of major by do, mi, sol give happiness impression, and tonic code of monotone by do, semitone of re, sol give sad impression. Implementing the chord feeling on vibrator puts special feel of music's chord at user service by beat frequency.

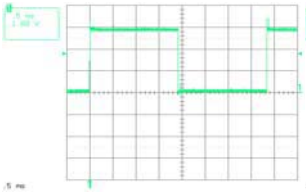

Fig. 20 Do(C)

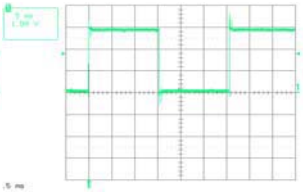

Fig. 21 Mi(E)

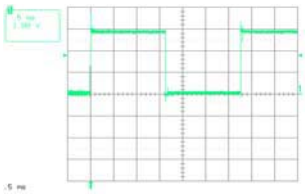

Fig. 22 Semitone of Re(Db)

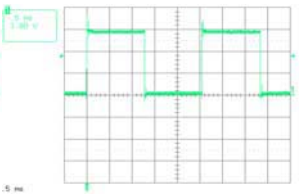

Fig. 23 Sol(G)

Figure 24 shows the experimental result that change of mechanical beat frequency by voltage that is input to vibrator. The feeling of music harmony can be got in mechanical vibration harmony through the shift-down conversion of frequency.

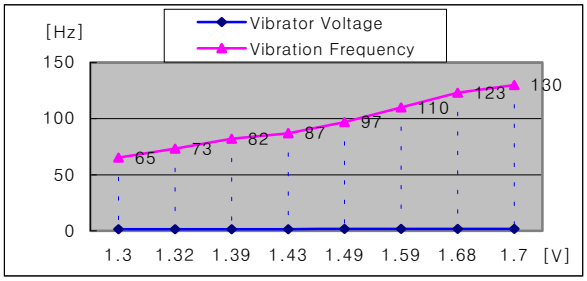

Fig. 24 Shift-Down Conversion of Vibration Frequencies

3.4 The Developed RCP Prototype

Figure 25 shows an electrical hardware prototype of RCP that is developed in this paper. The motor driver IC runs the micro DC geared motor, vibrator, and touch and light sensor is used in this prototype. RCP's operation power supply uses a 3.7V Li-ion Battery of cellular phone and the CPU uses an ADuC812, which is provided by an Analog Devices Inc., 8-bit micro controller.

Figure 26 shows the designed results of mechanical system for the RCP prototype.

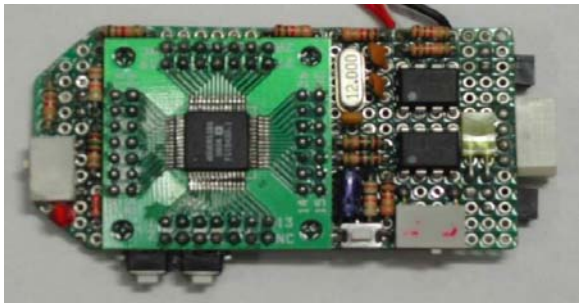

Fig. 25 The Developed RCP Prototype

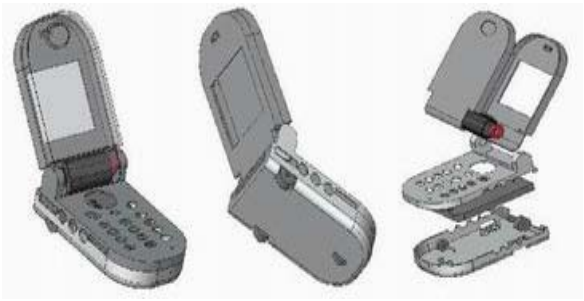

Fig. 26 The Mechanical System Design of RCP Prototype

4. CONCLUSION

RCP(Robotic Cellular Phone), a new technological concept which could make a synergy effect through merging of RT & IT, was proposed.

This paper presented the definition, the basic theory and experimental results of the $RCP^{Interaction}$, the sub-technologies of the RCP. The $RCP^{Interaction}$ was developed as an emotional model CP for sensitivity expression and link technology of communication of the CP.

The emotion-inference engine was successfully simulated and implemented through various sensors and acquisition algorithms to recognize self-state and a variety of environments.

A perfume-injection module, a functional module of $RCP^{Interaction}$, was explained in a view of new technological concept and was actually implemented in by the control of micro nozzles. The amount and the number of the injected perf ume are controlled by an electrical heating method of micro nozzle. The driving device used the FET switching power TR.

An emotion-vibration module, a functional module of $RCP^{Interaction}$, was explained in a view of new technological concept and was actually implemented in by a variety of vibration frequency patterns using music chord.

Finally, we confirmed a good performance of the RCP through the experiment results. We convinced that the technology of the RCP should progress.

ACKNOWLEDGMENTS

This research was supported by the Program for the Training of Graduate Students in Regional Innovation which was conducted by the Ministry of Commerce, Industry and Energy of the Korean Government.

REFERENCES

[1] Fujita, M., "Digital creatures for future entertainment robotics," *Proceedings of IEEE International Conference on Robotics and Automation, pp. 801-806 vol. 1, 2000*

[2] Breazeal (Ferrell), C. "A motivational system for regulating human-robot interaction, " In *Proceedings of AAAI 98. Madison, WI, 1998.*

[3] T.Shibata and K.Tanie, "Creation of Subjective Value through Physical Interaction between Human and Machine," *Proc. of The Fourth Int. on Artificial Life and Robotics (AROB 4th '99), Vol.1, pp.20-23 (1999).*

[4] N. Kubota, Y. Nojima, N. Baba, F. Kojima and T. Fukuda, "Evolving Pet Robot with Emotional Model," *Proc. of the 2000 Congress on Evolutionary Computation (CEC '00), Vol. 2, pp. 1231-1237 (2000).*

[5] Yoon, S.-Y. 2000. "Affective Synthetic Characters," *Ph D. diss. Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology. Forthcoming.*

[6] Yoon, S.-Y., Blumberg, B. M., and Schneider, G. E., "Motivation driven learning for interactive synthetic characters," *Proceedings of Autonomous Agents, 2000*

[7] Kline, C. and Blumberg, B. "The Art and Science of Synthetic Character Design," *Proceedings of the AISB 1999 Symposium on AI and Creativity in Entertainment and Visual Art, Edinburgh, Scotland, 1999.*

[8] Isla, D., Burke, R., Downie, M., and Blumberg, B., "A layered brain architecture for synthetic creatures," *Proceedings of the International Joint Conferences on Artificial Intelligence, pp. 1051-1058, 2001*

[9] Izard, C. E. (1979). The maximally discriminative facial movement scoring system. Unpublished manuscript, University of Delaware.

[10] Izard, C. E., Hembree, E. A., & Huebner, R. R. (1987). "Infant's emotion expressions to acute pain," *Developmental Psychology, 23, 105-113.*

[11] Funge, J., Tu, X. and Terzopoulos, D. 1999. Cognitive Modeling, "Knowledge, Reasoning and Planning for Intelligent Characters," In *Proceedings of SIGGRAPH 99, 29-38.: New York, NY. ACM SIGGRAPH.*

[12] H.Ushida, Y.Hirayama and H.Nakajima, "Emotion Model for Life-like Agent and Its Evaluation," *Proc. of The Fifteenth National Conference on Artificial Intelligent (AAAI-98), pp.62-69 (1998).*

[13] N.Kubota, T.Fukuda, "Sensory Network for Mobile Robotic System with Structured Intelligence," *Journal of Robotic and Mechatronics, Vol.10, No.4, (1998).*

[14] Kim, Y.-D., "Implementation of artificial creature and interactive learning using behavior set," *M.S. Thesis, KAIST, Korea, 2002*

[15] Miwa, H., Umetsu, T., Takanishi, A., and Takanobu, H., "Robot personality based on the equation of emotion defined in the 3d mental space," *Proceedings of IEEE International Conference on Robotics and Automation pp. 2602-2607, 2001*