Operating Radio-Controlled Cars by a Computer

Chomtip Pornpanomchai, *Member, IACSIT*, and Phichate Sukklay

***Abstract*—The objective of this research is to operate a radio-controlled car by using a computer (ORCCC). The remote controller of a radio-controlled car or RC car is connected to a computer via a parallel port. The ORCCC converted a digital signal to a radio signal and then sent the radio signal to communicate with an RC car. The research was conducted on three types of operations, namely: 1) computer commands to operate an RC car by sending computer commands directly via a parallel port, 2) Thai voice commands to manage an RC car by applying a voice recognition technique, and 3) facial commands to control an RC-car by using an image processing technique. The experimental precisions are 100, 96.6 and 84.11 percent for the computer commands, the voice commands, and the facial commands, respectively.**

***Index Terms*—Computer parallel port, Controlled car (RC car), Facial commands, Image processing, Thai voice commands.**

I. Introduction

In the world of technology, there are two great human innovations, which are computer technology and robotic technology. We use a computer system to perform various difficult tasks, namely: 1) chromosome matching, 2) Internet communication, 3) e-commerce, and 4) robotic controlling etc. Based on the usefulness of computers, it is very difficult to imagine, how people will live without a computer system. The second great human innovation is a robotic system. There are many kinds of robots with such tasks as: 1) a robot arm to service an industrial purpose, 2) an army robot to detonate a buried bomb, 3) an android robot to do a human job, 4) a mobile robot to move around the environment like an automatic guided vehicle (AGV), and 5) children's toy car or an RC car that can be operated with a radio wave, etc. Normally, a robotic system needs some computer systems to manage it. The complexity of computer software depends on how difficult robotic tasks are. In the near future, we hope that we can integrate a computer with a robotic system to build a sophisticated machine, for example, an unmanned driving car.

This research uses a computer to control an RC car. The experiments are conducted on various types of commands, namely: 1) computer commands, 2) Thai voice commands, and 3) facial image commands. The system will convert a computer digital signal into an analog signal. Finally, the system operates an RC car through the converted radio signal. The reasons for using an RC car in this research are that: 1) it is an inexpensive car, 2) it is easy to modify a car, and 3) it needs a few commands to operate a car.

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II. Related Works

Based on the previous section, this research question is separated into two important parts: 1) how to recognize various types of commands, and 2) how to convert computer digital commands into radio wave commands and manage an RC car. The following research works try to answer both of the research questions.

A. Controlling an RC Car by a Computer

There is a group of researchers who develop an RC car controlled by a computer and apply it in many applications, for example, 1) Chomtip Pornpanomchai et al. controlled an RC car by using both the voice and facial commands. 2) Kenichi Aoto et al. controlled an RC car via the Internet network by putting the computer server on the second floor and using a client to manage the RC car on the eighth floor of the same building. 3) Masanori Yoshinaga et al. used four RC cars to play a mini-car-soccer game. They captured competition pictures by a video camera on the ceiling and used video pictures to operate the soccer game. 4) Christophe Coue and Pierre Bessiere applied a mobile robot for chasing an elusive target in an unknown and unconstrained environment. 5) Yeung Yam and Kai Man Tong scaled down a driver-tested performance by using an RC car as the output of the evaluation. [1][2][3][4][5][6]

B. Voice Recognition for Controlling ElectronicEquipment

There are many researchers who develop computer software that can recognize human voice commands in so many languages such as English, Japanese and Thai. There are many techniques that are used to recognize human voice commands, which are: 1) neural network method (NN), 2) fuzzy logic technique, 3) hidden Markov model (HMM), and 4) Gaussian mixture model (GMM), etc. Therefore, there is no consensus which method is the best for recognizing voice commands. [7][8][9]

Researchers transform a sound wave into a digital signal by a computer. After that they use the digital signal to manage many kinds of electronic equipment, for example: 1) controlling robot arm movement, 2) helping the handicapped to move a wheelchair, and 3) managing a radio-controlled car in its movement, etc.[10][11][12][13][14][15][16][17][18]

C. Facial Commands for Controlling Electronic Equipment

There are many scientists who develop computer software that can recognize human face commands in the form of a digital signal. After that they use the digital signal to help the handicapped to move a wheelchair, as the following: 1) Pedro M.F. et al. used a back propagation neural network to identify human face commands and move a simulation wheelchair with the precision rate of 81.9 percent. 2) L.M. Bergasa et al. proposed the Integral System for Assisted Mobility or ISAMO project. The system used face movement commands to guide an electronic wheelchair. 3) Yoshinori Kuno et al. presented an intelligent wheelchair which could be controlled by face direction. The system identified face direction by comparing the centroid of the face region and all the combination of face features. [19][20][21][22][23][24]

III. System Design

This part introduces our approach of creating a system of an RC car controlled by a computer. We will start with the overall framework of the system and the description of each component in the framework, and the basic understanding of the technique that we are using in each component.

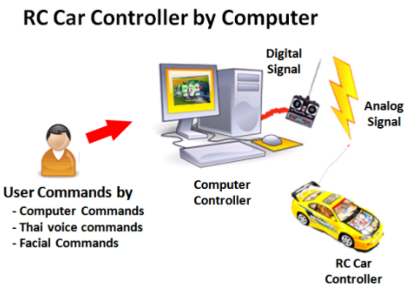

Figure 1. The system overview of the operation of the ORCCC system

A. System Overview

According to our study, we design a system overview shown in Figure 1. The research is separated into two parts: The first part is software part for computer command received by generating RC car commands by the following methods: 1) commanding directly via a parallel port, 2) using Thai voice commands, and 3) using facial commands. The second part is hardware part, which has the scope for a computer parallel port and the RC car communication. The system overview consists of three processes as follows: 1) getting user commands, 2) a computer controller, and 3) an RC car controller.

B. System Structure Chart

We have converted the system overview in the previous section into a structure chart. In our structure chart, we get three main categories of: 1) getting user commands, 2) a computer controller, and 3) an RC car controller, as shown in Figure 2. The details of each process are given below.

1) Getting User Commands

This process takes user commands by using the following methods:

a) Send user commands directly via a parallel port – the user screen of this method is shown in Figure 3.

b) Speak Thai voice commands via a microphone – the sound wave of each command is shown in Figure 4.

c) Take facial commands via webcam – the figure of each facial command is shown in Figure 5.

And then send the user commands to be stored in computer storage. The user commands consist of nine commands, which are: 1) Forward and turn left, 2) Forward, 3) Forward and turn right, 4) Turn left, 5) Stop, 6) Turn right, 7) Reverse and turn left, 8) Reverse, and 9) Reverse and turn right.

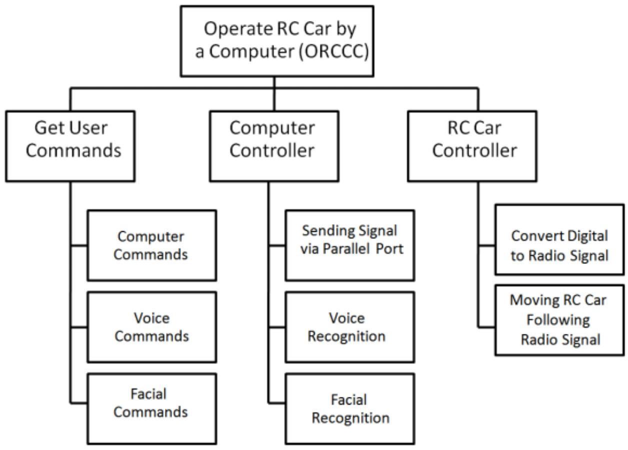

Figure 2. The system structure chart of the ORCCC system

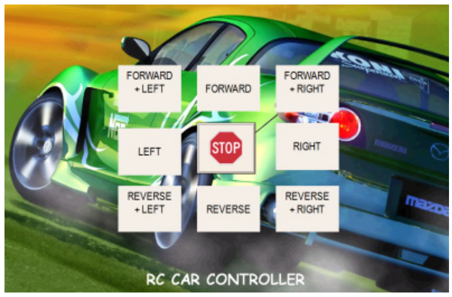

Figure 3. User screen for computer commands

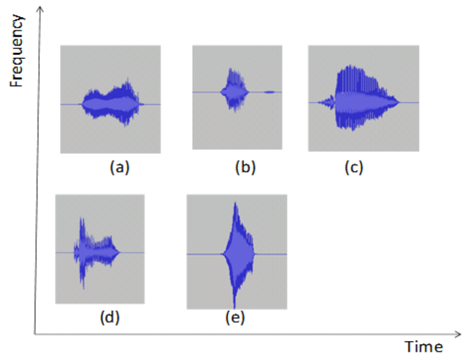

Figure 4. The sound wave frequencies of five Thai voice commands, which are: (a) Forward, (b) Reverse, (c) Left, (d) Right, and (e) Stop.

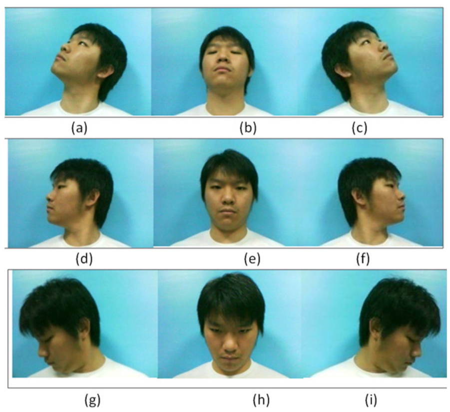

Figure 5. The face position of nine facial commands, which are: (a) Forward and turn left, (b) Forward, (c) Forward and turn right, (d) Turn left, (e) Stop, (f) Turn right, (g) Reverse and turn left, (h) Reverse, and (i) Reverse and turn right.

2) Computer Controller

This process has three sub-processes, which are: a) sending of signals to a parallel port, b) voice recognition, and 3) facial recognition. Each sub-process has the following details.

a) *The sending of signasl to a parallel port sub-process* - to transmit a digital signal to a parallel port by using the following hexadecimal numbers assignment, as shown in Table 1.

b) The voice recognition sub-process – to recognize Thai voice commands and convert a sound signal into a digital signal. If the system cannot recognize any command, the system will assign to the closed command. For the purpose of voice recognition precision, the Thai voice recognition sub-process uses only five singls-syllebel commands, which are (a) forward, (b) reverse, (c) left, (d) right, and (f) stop.

c) *Facial recognition sub-process* – to find the eyes position compared with a reference line, as shown in Figure 6. The reference line is a horizontal line where the eyes are located in a normal face position (as shown in Figure 6 (e)). The eyes detection has the following details:

▪ If the left eye is located above the reference line, a facial command is a forward-and-turn-left command, as shown in Figure 6 (a), and assigned to hexadecimal number AH.

▪ If the left eye is located on the reference line, a facial command is a turn left command, as shown in Figure 6 (d), and assign to hexadecimal number 2H.

▪ If both eyes are located on the reference line, a facial command is a stop command, as shown in Figure 6 (e), and assigned to hexadecimal number 0H..

▪ If both eyes are located above the reference line, a facial command is a forward command, as shown in Figure 6 (b), and assigned to hexadecimal number 8H.

▪ If the right eye is located above the reference line, a facial command is a forward-and-turn-right command, as shown in Figure 6 (c), and assigned to hexadecimal number 9H.

▪ If the right eye is located on the reference line, a facial command is a turn-right command, as shown in Figure 6 (f), and assigned to hexadecimal number 1H.

▪ If the left eye is located below the reference line, a facial command is a reverse-and-turn-left command, as shown in Figure 6 (g), and assigned to hexadecimal number 6H.

▪ If both eyes are located below the reference line, a facial command is a reverse command, as shown in Figure 6 (h), and assigned to hexadecimal number 4H.

TABLE I. HEXADECIMAL NUMBER ASSIGNMENT FOR PARALLEL PORT CONTROLLING

Hexadecimal No. Assignment	Command
1H	Right
2H	Left
4H	Reverse
5H	Reverse + Right
6H	Reverse + Left
8H	Forward
9H	Forward + Right
AH	Forward + Left
0H	Stop

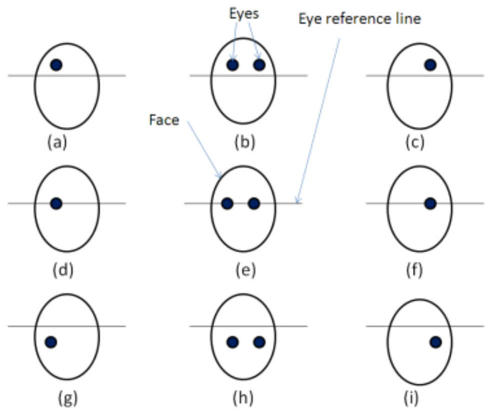

Figure 6. The eyes position compared with a reference line of nine facial commands, which are: (a) Forward and turn left, (b) Forward, (c) Forward and turn right, (d) Turn left, (e) Stop, (f) Turn right, (g) Reverse and turn left, (h) Reverse, and (i) Reverse and turn right.

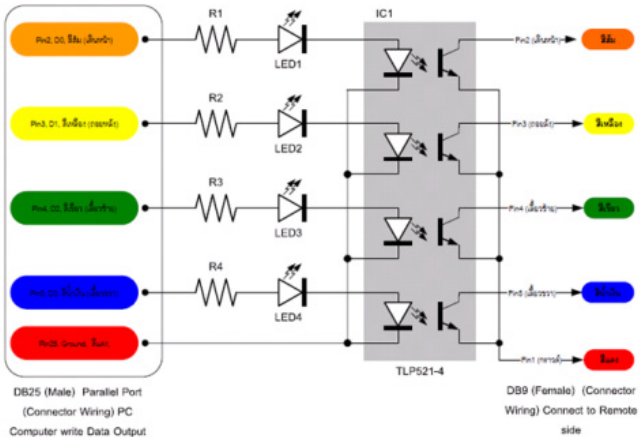

Figure 7. The circuit diagram of digital-to-radio signal converter

▪ If the right eye is located below the reference line, a facial command is a reverse-and-turn-right command, as shown in Figure 6 (i), and assigned to hexadecimal number 5H.

3) RC Car Controller

Car Controlling Instructing – This process has two sub-processes, which are converting a digital into radio signal, and moving an RC car based on a radio signal. The digital-to-radio signal converter circuit diagram is shown in Figure 7.

IV. SYSTEM IMPLEMENTATION

This section explains the system requirements for both hardware and software implementations, which have the following details.

A. System Hardware Implementation

An RC car is bought with a remote controller from children's toy shop for around 8 US$. The remote controller communicates with the RC car with the radio wave range of 27 MHz band. We connect the RC car remote controller with a digital-to-radio signal converter. After that, we connect the digital-to-radio signal converter to a computer parallel port. The system hardware is shown in Figure 8, which has the following details:

▪ RC car with the dimension of 17 X 9 X 8 cm. (label number 1)

▪ RC car remote controller with the radio wave range of 27 MHz (label number 2)

- Computer monitor to display graphic user interface (label number 3)
- Digital-to-radio signal converter (label number 4)
- RS-232 parallel port connection (label number 5).

Figure 8. System Hardware of the Operation of An RC Car by Facial Commands

B. *System Software Implementation*

The ORCCC uses Windows XP for the operating system and uses Visual Basic 2008 for parallel port communication. The system also uses Julius and the Hidden Markov Model Toolkit (HTK) software for recognizing Thai voice commands. The Julius is a high-performance, two-pass large vocabulary continuous speech recognition (LVCSR). The system performs based on word N-gram and context-dependent Hidden Markov Model (HMM). Moreover, the ORCCC uses Matlab 7.6.0 (R2008a) to develop a facial recognition system.

V. Experimental Results

This part presents an experimental result of the ORCCC, which is developed and based on the concepts and design mentioned in the previous part. In this system, the experiment's results are focused on the usability and the effectiveness of the system.

A. *Usability Proof*

In this section, we will analyze the usability of the ORCCC. The user enters commands via (a) putting computer commands, (b) using Thai voice commands, and (c) recognizing facial images. Then, the ORCCC system uses computer software to convert a digital signal to an analog signal and then change the analog signal to a radio wave signal. Finally, we operate an RC car by a radio wave signal. The usability concept is proved by observing that an RC car can operate in the same way by being controlled directly by an RC car remote controller and the ORCCC system.

B. *Effectiveness Proof*

The effectiveness test is done the same as that in the previous section, but we focus on the correctness of the final result. We have tested under three different types of commands, which are: (a) computer commands, (b) Thai voice commands, and (c) facial image commands, with the precision rates of the experiments of 100 percent, 96.6 percent and 84.11 percent, respectively (as shown in Table 2). The Thai voice commands are tested only on single-syllable commands for the purpose of easy word segmentation and recognition.

TABLE II. The Effectiveness Testing Result

RC Car Commands	Computer Commands		Voice Commands		Facial Commands	
	No. Testing	No. Success	No. Testing	No. Success	No. Testing	No. Success
1. STOP	100	100	200	190	100	86
2. RIGHT	100	100	200	186	100	97
3. LEFT	100	100	200	198	100	67
4. FORWARD	100	100	200	194	100	77
5. REVERSE	100	100	200	198	100	81
6. FORWARD + RIGHT	100	100	--	--	100	87
7. FORWARD + LEFT	100	100	--	--	100	66
8. REVERSE + RIGHT	100	100	--	--	100	97
9. REVERSE + LEFT	100	100	--	--	100	99
TOTAL	**900**	**900**	**1000**	**966**	**900**	**757**
PRECISION	**100 %**		**96.60%**		**84.11%**	

VI. Conclusion

Based on the experimental results in the previous section, we have fulfilled our research objective. We can conclude that the system can operate an RC car with many kinds of user commands. Nevertheless, the ORCCC has many limitations as the following.

- The RC car is a cheap toy car with some hardware performance limitation. We buy an RC car in children's toy shop for about 8 US$. Normally, the childern's RC car uses a simple motor (not a step motor) for driving.
- The radio signal of an RC car can be sent for a short distance. Therefore, the ORCCC system cannot operate an RC car far from a computer machine.
- The battery for an RC car needs to be set to the same power level of 3.0 volts in this research. The precision of an RC car will decrease if the batteries have lower power.

In the future, the ORCCC system can applied to many applications such as 1) an unmanned RC car, 2) the ORCCC via the Internet network, and 3) the RC car for a rescue and security mission, etc.

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