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A Man-machine Interaction System Based on the Advanced RISC Machines

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Abstract: The man-machine interaction technology is a key component which may directly result to the running efficiency and the serving quality of intelligent systems. A man-machine interaction system was proposed based on the advanced RISC machines. Experimental results suggest that the proposed man-machine interaction system features a quick response and provide a kind of method for improving and perfecting the intelligent system.

Key words: Man-machine interaction, intelligent transportation, optimal design

INTRODUCTION

The Intelligent Transportation System (ITS) is an efficient and accurate transportation system in the modern society. With the rapid development of transportation, the traditional transportation system was reformed by many modern technologies, for example, the electronic technique, information technology, sensor technology and systems engineering, to improve the operating efficiency of the system, its reliability and security (Liu *et al*., 2001). ITS will deeply affect the future world and meanwhile, bring a new challenge to researchers in information engineering of traffic engineering (Mei *et al*., 2002).

Man-machine interaction is to study the man, machine and their interactive technologies. It refers to the communication between users and the computer system, a bidirectional information exchange of various symbols and behaviors between the man and the computer (Wang *et al*., 2005). That is to say, either the man inputs information into the computer, or the computer feeds back to the user (Wright *et al*., 2000). The man-machine interactive system contains three major factors: interactive device, interactive software and human factor. Its development trend reflects it is of great importance to the human factor (Yao *et al*., 2003). This makes the man-machine interaction more closely to the natural form, users utilize their own skills to the maximum limit, thus reduce cognitive load and improve work efficiency. Such idea of user-centered is obviously embodied in the researches on human-computer interaction techniques.

INTELLIGENT TRANSPORTATION SYSTEMS

It is relatively simple for common vehicles driven by person, as their control devices are less. However, intelligent vehicles are driven automatically, many sensing and control devices are installed in them. The requirements of roads and the infrastructure construction also should be consistent with those of intelligent vehicles. Generally speaking, it includes the following parts:

- **Underlying control:** It is in charge of controlling the vehicle operating, such as speed-up, speed-cut, braking and veer, *et al*. This module accepts control command from upper path planning module and then performs behaviors accordingly to control the operating
- **Path planning:** It obtains information about the pose of a vehicle according to navigation module, calculates the target corner and velocity by an algorithm and then sends relevant commands to the underlying control module to ensure that the vehicle travels following the specified route
- **Visual navigation:** It obtains information about the actual pose through testing the white line on ground by the computer vision technology and then transmits the information to the path planning module
- **Magnetic navigation:** It tests the magnetic field intensity of the magnetic nail on ground by a specific magnetic sensor, obtains the actual pose by an algorithm and then transmits the information to the path planning module
- **Laser navigation:** It calculates the actual pose of vehicles through testing the positioning mark by the roadside by using the laser radar and then sends the information to the path planning module
- **Obstacle avoidance:** It detects the obstacle ahead within a certain distance by laser radar and makes the vehicle brake hard once found

- **Communication module:**. It takes responsible for data communication among various parts in the whole operation system of a vehicle, including the data, video and audio communication among the central control room, station and vehicles
- **Man-machine interaction:** It is in charge of receiving the request message from passengers and sending it to the central control module which feeds back timely. All these constitute the interaction between passengers and the intelligent transportation system
- **Central control room:** It is the core of the whole operation system of a vehicle. This module takes charge of scheduling and monitoring, a bridge connecting the other modules in the system

FUNCTIONAL REQUIREMENTS AND SYSTEM DESIGN

The CyberC3 intelligent transportation system should provide a man-machine interactive interface to users in a demonstration area, for example, calling the vehicles at a station. A terminal should be installed in each station to offer interaction services. On one hand, it interacts with the users. On the other hand, it can correspond with the computer in the central control room. Compared with personal computer, the devices based on embedded system are widely applied to all sides of life now. They are flexible, reliable, real-time and compact. In application of intelligent transportation, an embedded system based on ARM (Advanced RISC Machines) was selected as the core of the man-machine interactive terminal. On this basis, all kinds of interaction functions can be realized.

Application places: The application prospect of CyberC3 system depends on the degree the user requirements can be satisfied when combining with a special environment. At now, the potential places are public parks and campus *et al*. According to the analysis reports about different places, the characteristics and demand conditions of these places were summarized as below.

- **Public parks. Site conditions:** Net or single-track structure. Its site is much smaller and the facilities are relatively simple. The type of passengers: Tourists. The main purpose of tourists is sightseeing. So they do not have high requirements for vehicle velocity and punctuality. However, as a pilot project for other sites, its system should try to consider all possibilities and the design of man-machine interactive system must be the most comprehensive. Vehicle operations: At holidays, festivals and some time periods, the peak time comes. And in most cases, the number of tourists is relatively stable. The other factor: The test results and experience should be summarized for application to follow-up development
- **Campus. Site conditions:** Net or single-track structure. The road structure is the simplest, less external disturbance. The type of passengers: Teaching staff and students (for free). Vehicle operations: The peak time only comes in and out of class

Operational mode and functional requirements: The man-machine interactive system based on embedded system of CyberC3 is installed in stations, accepting vehicle reservations from passengers. Its working mode can be on-demand or regular service:

- **On-demand:** Under this mode, the system should have the following functional requirements. A request for vehicles: When passengers need a vehicle, push the button, the central control system will receive the instruction and then dispatch vehicles. When designing the passenger seat in stations (about 6 seats), an inferred sensor should be installed over the seat to automatically induce the passenger needs. The button or sensor signal can be sent to the I/O of chips by the level switch, to make the instruction executed by interruption or inquiry mode

Charging system: In order to identify the passengers, they must swipe RF card when using CyberC3 (to request a vehicle or a ride). The system will record the passenger ID and report to the central control room. Then the computer in the room will know the station demand for vehicles. (No need for schedulers to step in. The video provided by cameras in stations can be taken as monitoring, but out of the control and scheduling. The RFID technology can prevent a passenger to push the button several times which misleads the dispatching system).

Information tips: The display device can show relevant information (in Chinese and English), e.g., the arrival time of the next vehicle, the number of passengers reserving vehicles, welcoming speech and sightseeing guide. Besides, if combined with the characteristic of World Expo-humanization, it can also show the current temperature, humidity and weather forecast. The reflecting LCD, dot-matrix LED and LCD monitor have been widely applied to the buses and subways now, with good effect. This system can choose the reflecting LCD as the display device.

Early warning signal: When a vehicle is about to arrive and launch, the early warning equipment will give the warning information, such as spark, buzzing or voice, to warn passengers to be careful. Considering there may be deaf mutes or blind persons, it should provide both voice and vision prompt. The spark and buzzing can be driven by the I/O signal connecting relay. The voice prompt is realized by using the on-chip program. That is, the voice is output by IIS audio module on the ARM system and then broadcasted by speakers after power amplification. Site map: A tourist map should be fixed on the wall of stations or other areas for passengers to select the sites.

- **Regular service:** Under this mode, the vehicle route is usually single-track, namely the intelligent vehicle runs through all sites along fixed route in the demonstration area which is one-way traffic. The users do not need to submit call request to the system, only wait at the site. And the other prompt facilities work as usual. As to realize the above functions, the man-machine interactive system should improve the following interface devices. The interface devices accepting vehicle reservation should be offered, such as the button, RFID card reader or inferred sensor. The device displaying the information of vehicle arrival should be provided, such as the dot-matrix LED or LCD monitor. The early warning devices should be installed, e.g., the flashlight, buzzer and sound over the subway doors

SYSTEM OPTIMIZATION MODULE AND METHODS

In the man-machine interaction system, there exists an important system optimization module. The Orthogonal Genetic Algorithm with Quantification was applied as the optimization methods.

Initialization of the population:

- Divide the feasible region [L, U] of the problem to be optimized into B subspaces according to the following equation:

$$u_k - l_k = \max_{1\le i\le n}\{u_i - l_i\} \tag{1}$$

$$\begin{cases} L_i = L + (i-1)[(u_k - l_k)/B]1_k \\ U_i = U + (B-i)[(u_k - l_k)/B]1_k \end{cases}, i = 1, 2, \cdots, B \tag{2}$$

where, $L = [l_1, l_2\cdots, l_n]^T$ and $U = [u_1, u_2\cdots, u_n]^T$, respectively denote the lower boundaries and upper boundaries of n independent variables of the problem. B denotes the design parameter. 1_k is the n-dimensional vector of which the kth bit is 1 and other bits are 0. L_i and U_i denote n-dimensional vectors respectively similar to L and U. In this way, the feasible region of the problem can be divided intoB subspaces, namely $[L_1, U_1]$, $[L_2, U_2]$,···, $[L_B, U_B]$.

- Discretize each independent variable in each subspace according to the following equation. Suppose the domain of the independent variable x_i is $[l_i, u_i]$, then x_i can be quantized into Q_1 levels a_{i1}, a_{i2},···, a_{iQ1} and the detailed computation method for a_{ij} is:

$$a_{ij} = \begin{cases} l_i & j = 1 \\ l_i + (j-i)[(u_i - l_i)/(Q_1 - 1)] & 2 \le j < Q_1 \\ u_i & j = Q_1 \end{cases} \tag{3}$$

- Select M_1 chromosomes from each subspace. Construct an orthogonal table $L_{M1}(Q^N_1) = [a_{ij}]_{M\times N}$ in which N denotes the dimensionality of the problem, $M1 = Q^{J1}_1$ and J_1 denote the positive integers that satisfy the condition:

$$\frac{Q_1^{J_1} - 1}{Q_1 - 1} \ge N$$

Then select M_1 combinations from the Q^N_1 ones to form M_1 chromosomes

- Select the best G (the size of the initial population) chromosomes from the M_1B potential ones to form the initial population according to their fitness value

Crossover operation:

- Select two parent chromosomes for crossover operation according to the crossover probability. Suppose that the two selected parents are:

$$\begin{cases} p_1 = (p_{11}, p_{12}, \cdots, p_{1N}) \\ p_2 = (p_{21}, p_{22}, \cdots, p_{2N}) \end{cases}$$

and the defined solution space l_{parent}, u_{parent} is:

$$\begin{cases} l_{parent} = [\min(p_{11}, p_{21}), \min(p_{12}, p_{22}), \cdots, \min(p_{1N}, p_{2N})] \\ u_{parent} = [\max(p_{11}, p_{21}), \max(p_{12}, p_{22}), \cdots, \max(p_{1N}, p_{2N})] \end{cases} \tag{4}$$

- Discretize the solution space $[l_{parent}, u_{parent}]$ of two parent individuals for crossover operation into Q_2 parts
- Select some independent variables that will suffer crossover operations. The number of potential child individuals generated by each pair of parent individuals should be controlled to avoid a huge

evaluation on the populations during the crossover operation. In this paper, the crossover only operates on F genes of the parent chromosome. Discretize these F independent variables in each subspace

- Select potential child points from the solution space of parents according to the orthogonal table. Generate the orthogonal table L_{M2} (Q^F_2) = $[b_{ij}]_{M2\times F}$ in which Q_2 is an odd number, $M_2 = Q^{J2}_2$ and J_2 is the smallest positive integer that satisfies the condition:

$$\frac{Q_2^{J_2}-1}{Q_2-1} \geq F$$

Then select M_2 combinations from these Q^F_2 ones to form M_2 potential child individuals

- Select two with the best fitness value from the M_2 potential child individuals and two parents as the result of this crossover operation
- If the number of the implemented crossover operations has reached the preset value, stop crossover immediately, or turn to (1)

Mutation operation:

- Randomly select a parent chromosome for mutation operation according to the mutation probability
- Obtain the mutated child chromosomes according to the fine perturbation method. Here, the perturbation means generating four mutated child chromosomes through tuning the value of the selected parent gene, respectively to its original 1-2σ, 1-σ, 1+σ times and 1+2σ times
- Select the best one of the parent and child chromosomes as the result of this mutation operation
- If the number of the implemented mutation operations has reached the preset value, stop mutation immediately, or turn to (1)

SYSTEM SELECTION AND DESIGN

The man-machine interactive system based on embedded system is an interactive device installed in a fixed site. ARM is a novel microprocessor core, with low power dissipation and a high efficiency. Different types of ARM carry different function modules. And we can purchase ready-made ARM development boards since the network and audio resources have been integrated on them. What is more, the ARM above ARM7 is easy to be implanted to the embedded OS (e.g., uClinux), convenient for network application. For costs, as the ARM development boards are neither expensive nor cheap, they can be taken as the core of man-machine interaction.

ARM was developed by British ARM Limited Corporation, generally acknowledged as the industry leading 32-bit embedded RISC microprocessor architecture. It provides a whole set of design, including the circuit diagram, wiring diagram and layered mask diagram, for other manufacturers to produce CPU/MCU chips. The characteristics of ARM are: Small in size, low-power dissipation, low cost and high performance; 16-bit (Thumb)/32-bit (ARM) double instruction set; Shared kernel and most cooperative partners worldwide, easy for products to upgrade and transition. Considering the audio and network, the S3C44B0 processor from Samsung was employed. This processor uses the ARM7TDMI kernel, a chip without memory management units with 8 KB Cache, LCD controller, 2-channel UART, 4-channel DMA, 8-channel 12-bit ADC, RTC, IIC/IIS bus, SIO and PLL. It can work under the frequency 64 MHz and realize the arithmetic speed of 31.84 M BogoMIPS.

Key recognition: This part takes charge of recognizing the passenger requirements for the button, timely notifying them that the requirements have been received by the system and sending their requests to the long-distance central control room by networks. The function of key recognition can be realized through testing the state of the CPU port. The program of key recognition repeatedly checks the state of GPF0.1.5.6.7.8 ports. Its scanning sequences are 8-7-6-5-1-0. When pushing a button, this function will exit immediately which makes default settings of the priority of buttons. This ensures that when pushing multiple buttons simultaneously, return the higher-numbered buttons prior and error signals won't be sent out. If a button has always been pressed, the while loop will cause the function to wait for the button to be released, so as not to generate many keying signals.

The flow diagram of key recognition is displayed as Fig. 1. Now that the signals identified by keys can be transmitted to the communication process, so as to be sent to long distance. The connectionless communication between the communication process and the computer in the central control room is built based on UDP protocol for information transfer. The reason for selecting the UDP protocol is: In the field place applied by ITS, the network may be disturbed for a short time for environmental reasons. If TCP is applied, then the connection should be rebuilt after the communication interrupts. However, the communication based on UDP can make the connectionless network communication, ensuring the communication recovers after the network disconnects.

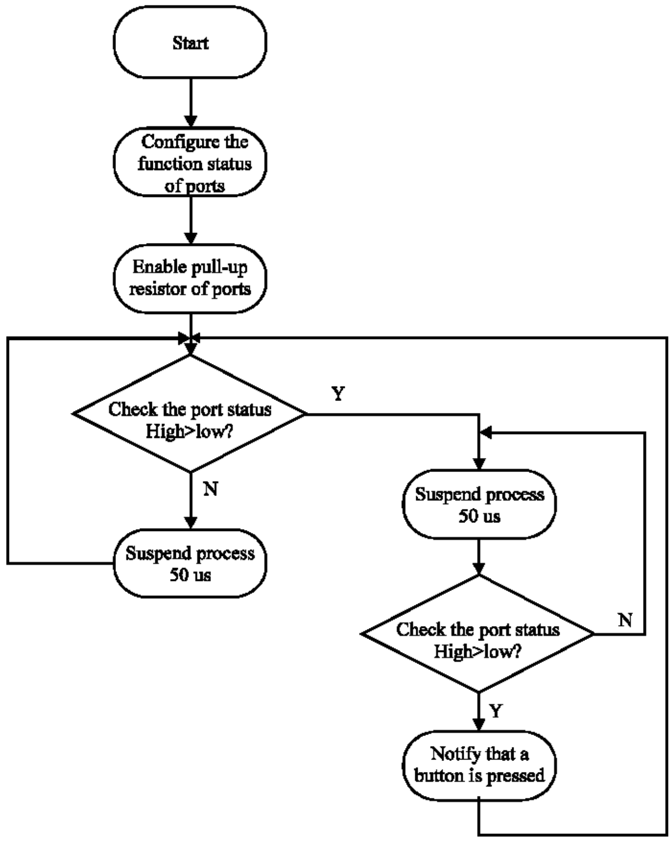

Fig. 1: Flow diagram of key recognition

Speech transmission: The upper computer software takes charge of audio acquisition and sending it to the distal voice terminal, developing the application program based on MFC by Visual C^{++} 2010. The transport layer of TCP/IP protocol provides the application program with the data transmission service. There are two paratactic protocols, namely the Transmission Control Protocol (TCP) and the User Datagram Protocol (UDP). TCP provides the application layer with a reliable connection-oriented transmission service by IP. And UDP provides the application layer with an unreliable but efficient connectionless transmission service by IP. Generally, the transmission of audio/video data of mass flow adopts the UDP protocol. And two ends also employ the UDP protocol for transmission. An application program based on the dialog box is built in the development environment of Visual C^{++} 2010.

In order to collect and play the voice at two ends of the network correctly, the audio format is unified to the format of PCM, 16-bit sampling and 22050 Hz sampling rate. Pad the above data structure of WAVEFORMATEX in the program, open the sound card device by the waveInOpen function and obtain the handle of the sound card. Add the memory applied previously by the waveInPrepareHeader function and the waveInAddBuffer function as the buffer of the sound card device and then start the sound card by the waveInStart function to collect the audio. When the buffer is filled up, Windows sends the information of MM_WIM_DATA automatically, add its corresponding function to the program and send the data of this audio data block to the network by the UDP protocol. At the end of program, close the sound card device by the waveInClose function and release two blocks of shared memory by the waveInUnprepareHeader function and the free function. In the experiment, we firstly used 1 kB shared memory and found that the noise is big which may be caused by frequent jump among shared memory. So later the shared memory size was changed to 16 kB and it is found that the noise is almost cancelled and the audio transmission is smooth.

CONCLUSION

This study discussed the design of the man-machine interaction system in the demonstration area of intelligent transportation systems. Firstly, it analyzed the functional requirements for the man-machine interaction by intelligent transportation systems. And on this basis, we discussed the type-selecting scheme of this interactive system. Experimental Results suggest that the proposed man-machine interaction system features a quick response and provide a kind of method for improving and perfecting the intelligent system.

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