The Research on Automatic Test System of Human-death-time Based on Virtual Instrument Technology

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Abstract: *The automatic test system (ATS) is widely used in the field of industrial production, scientific research and national defense construction. This paper introduces an ATS for time estimation of human death, in which the host computer runs the detecting software to do data analysis and drive the hardware taking acquisition, and makes the use of forensic temperature estimating algorithm to calculate the death time. The temperature sensing module adopts rope shape design which is convenient for requirements of detecting scenarios, and the communication between host computer and temperature sensing module is realized through 1-Wire bus protocol. The system can estimate the body's time of death quickly and conveniently which plays a key role in the forensic laboratory and criminal scene of the death time measurement, and the temperature sensing module has the advantages of small size for convenient carrying.*

Keywords: *Automatic test system, Death time estimation, 1-Wire bus protocol, Data processing.*

Introduction

Estimating the death time of human body is an important part of the murder case investigation and a common experiment in forensic laboratory. It can indicate important clues for the police in the investigation of the case if the death time is estimated quickly and accurately. The common estimating methods for human body death time are human tissue assay [1, 4, 10] and temperature detecting method [3], and the human tissue assay is often used in the laboratory to accurately judge the time of death, but the experiment time consuming is large and the more the requirement of experiment conditions is strict. The temperature detecting method can be used in the experiment as well as in the field of criminal cases, whose accuracy is inferior to human tissue assay, but the detection speed is high and the detection experiment requirement is low. The traditional way of temperature detection method is inserting thermometer into the body's rectum to do temperature measurement, and then calculate the time of death by calculating temperature data. This traditional way of temperature detection method is not convenient enough, so an automatic test system of human death time based on Virtual Instrument Technology is proposed in this paper.

With the development of electronic industry, electronic products are widely used in biomedical systems and bioinformatics [2, 9], and digital measurement platform is application of the electronics and computer technology in the field of automatic test system, especially the successful development of virtual instrument at the end of 1980s, which represents a new direction of instrument development [6, 8, 11]. The virtual instrument is a new instrument model of combination of computer technology and electronic technology, which is usually

composed of PC, modular and software for data analysis, process communication and visual interface application. In the virtual instrument the computer has become a measurement function digital test platform, a variety of instrument panel is generate on the software screen of this digital test platform, which complete the processing, expression, transmission, storage and display of data [1]. The host computer ATS proposed in this paper runs the detecting software to do data analysis and drive the high-performance hardware module taking acquisition, which realizes death time estimation conveniently and rapidly, the whole ATS is characteristic compacted structure and carrying convenience.

Materials and methods

Through the analysis of the implementation process of the temperature detecting method, it can be divided into three key steps:

1) temperature data acquisition;
2) data transmission between host computer and temperature detecting module;
3) data analysis and processing.

The system working principle is shown in Fig. 1.

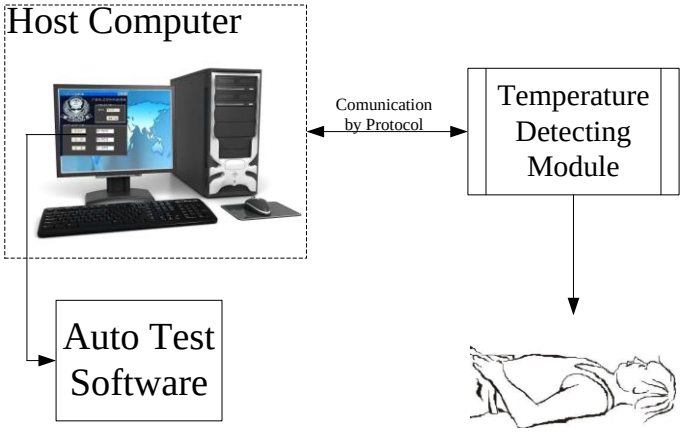

Fig. 1 System working principle

The design of automatic test system is divided into two parts: hardware design and software design. Through the process of detecting, the hardware design should be taken in advance by choosing proper temperature detecting component. The common temperature detecting components include thermocouple and thermistor, which are able to test temperature value and convert it into resistance value or voltage value, but the host computer needs analog detection function unit to read resistance value or voltage value, which is not conducive to the realization of system function. The temperature detecting sensor which can communicate by protocol should be chosen, when the measurement is completed the data can be sent to host computer's I/O interface in accordance with the communication protocol, and the front end of the sensor should meet shape for rectal temperature detection. The host computer acquires the measurement data through the I/O interface, and the data is processed by the software of the automatic test system. When design the software, the communication protocol between host computer and temperature detecting module should be considered, which means the protocol should be coded to control the temperature detecting component and read the temperature data from it. Then the death time is calculated with the data according to forensic algorithm. In addition, the software also should have some functions of data management for verifying the accuracy of new measurement method.

Temperature detecting module design

According to the system principle, the temperature detecting module should have the following functions:

1) measure the temperature range for the test;
2) transmit data out through communication protocol;
3) accuracy of one decimal place;
4) small size.

The DS18B20 temperature sensor is selected for this module, and the DS18B20 digital thermometer is a single bus device produced by DALLAS, with a simple circuit and small size. The temperature measuring range is from –55 °C to +125 °C, and the resolution is programmable from 9 bit to 12 bit accuracy. Normal body temperature is 0 °C to 38 °C, but the temperature of dead human body is influenced by external environment factors, thus the temperature detecting method is only applicable to non extreme climate conditions. The DS18B20 fully meets the requirements of the development of temperature detecting method.

The DS18B20 communicates by the 1-Wire bus protocol, that is, one data line can achieve two-way data transmission, it requires the data read and writing with a strict timing. The 1-Wire bus protocol has a strict communication protocol to ensure the correctness and integrity of the data transmission, the protocol defines the timing: initialization timing, read timing, write timing. All of the sequence requires the host computer to be the main equipment, and every transmission command or data transmission is started by host computer.

In order to communicate with DS18B20, the host computer must have a suitable I/O interface to implement the single bus communication protocol. The I/O interface of the universal computer usually includes the serial interface and parallel interface. The serial interface generally performs the RS232 protocol or the USB communication protocol, which can not directly execute the 1-Wire bus protocol; the LPT parallel communication protocol interface does not support a single bus protocol as well. Thus, the 1-Wire bus protocol must be coded in serial interface or LPT parallel interface for implementation of communication between general-purpose computer I/O interface and the DS18B20. Considering the electrical characteristics of DS18B20's TTL logic, the serial interface is RS232 interface, its electrical characteristics does not fit TTL; USB interface signal input and output voltage is 3.3 V, which does not match the data transmission voltage DS18B20; LPT parallel interface takes TTL as the output logic level, so it is reasonable to realize the 1-Wire bus protocol in LPT parallel interface. If the contemporary PC is not equipped with LPT interface, the protocol converting device, which converts USB communication protocol to LPT communication protocol, is able to be utilized to solve the problem. It is necessary to set up the computer parallel port in EPP/ECP mode to achieve two-way data read and write. As shown in Fig. 2, when making communication interface, DS18B20 which is extended with the wire is weld on the LPT parallel pins interface, which is the plug connection device with convenient disassembling and assembling. The GND pin of DS18B20 and is connected to LPT port 18-25 pins to ensure stable ground wire; the data read and write pin DQ is connected to the 2 pin of LPT parallel port, and VDD pin and 16 pin are connected. And then each pin of LPT parallel port are controlled through the automatic test software by computer, to realize the power supply and 1-Wire bus protocol for DS18B20. The temperature detecting module image is shown in Fig. 3.

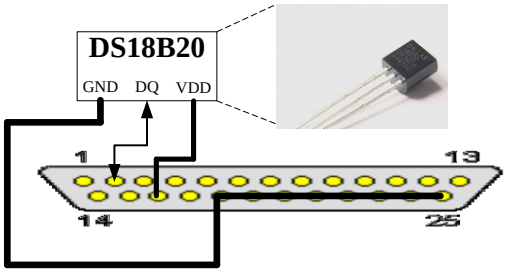

Fig. 2 Structure of LPT parallel pins interface

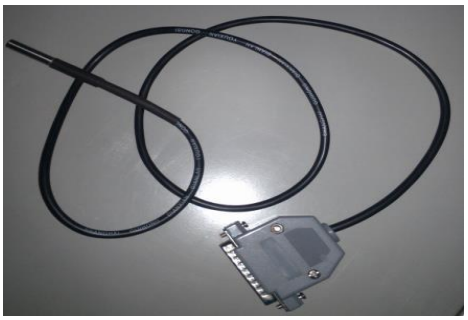

Fig. 3 Image of temperature detecting module

Algorithm and software design

Protocol design

DS18B20 communication has its own unique timing and commands, so it must be carried out according to the communication protocol:

Initialization → ROM function commands sending →
data memory operation commands sending → data processing.

Because there is only one DS18B20 used in this ATS, the ROM function command step can be cancelled, which means directly sending DS18B20 temperature conversion instructions. As the 1-wire bus protocol only allow sending data by bit serially, it is necessary to convert serial data from binary data to decimal data. The communication protocol process is shown in Fig. 4.

From the analysis before, DS18B20 is operated by changes in different pin level LPT parallel interface, so in software development the dynamic link library file "INPOUT32.DLL" must be called, which provided data read and data write function to control the LPT port. The 16 pin is required to be high to provide power for the DS18B20, and the 2 pin has to change the level in accordance with the requirements of the 1-wire bus protocol to achieve the configuration of the DS18B20 and the data register read and writing.

Data processing

After analyzing, the original data is obtained, and the original data need to be filtered to eliminate the uncertain factors in the detecting process before the data is used to calculate. The median filtering method is adopted and it can eliminate the interference of accidental factors on the measurement, which is applicable to slow changing physical quantity such as temperature [5]. Its core idea is arranging the continuous sampling data according to the order of value, and then takes the median value as the effective value measurement. The pseudo code of algorithm is in Fig. 5.

The death time can be calculated after median filter by using the temperature data, as for the death time estimation method, the forensic and criminal technology researchers have taken a deep research and gotten a lot of achievements, here we use the algorithm in criminal scene technology with Eq. (1) [7]:

$$T = (37 - value)X / 0.83 \quad (1)$$

In Eq. (1) *value* represents the measured temperature value. X is on behalf of the seasonal coefficient: when the body is in spring and autumn seasons, $X = 1$; in summer – $X = 1.4$; in winter – $X = 0.7$.

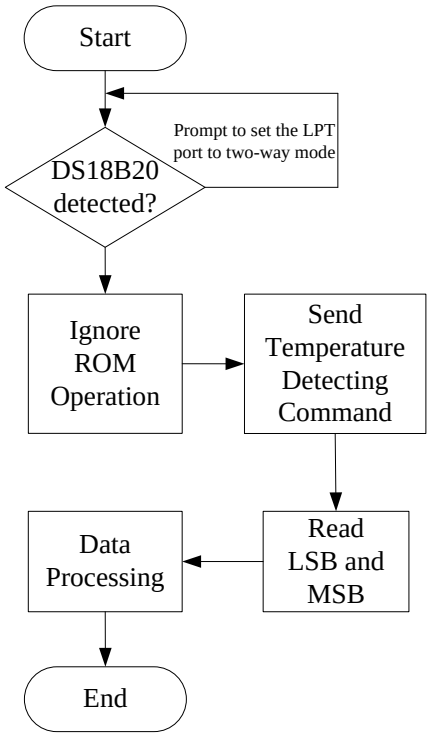

Fig. 4 The communication protocol process

```
Float MiddlevalueFilter()
{
    Float value[x], temp;
    int i, j, k;
    for (i = 0; i < x; i++)
    value[i] = get_temperature();
    for (j = 0; j < x - 1; j++)
        {
        for (k = 0; k < x - j; k++)
        {
            if(value[k] > value[k+1])
        {
            temp = value[k];
            value[k] = value[k+1];
            value[k+1] = temp;
            }}}
return value[(x - 1)/2];
}
```

Fig. 5 The pseudo code of median filtering

Conclusions

In this paper, we analyze the requirement of rapid death time detection in the field of criminal technology, and introduce a kind of automatic test system for human body's death time based on virtual instrument technology. The detection process of temperature is analyzed, and the system is divided into host computer and temperature detecting module. The host computer is for processing the data and displaying the result of estimation, which is composed of general computer and ATS software. The temperature detecting module is composed of digital temperature sensor DS18B20 and peripheral circuits. The communication between the host computer and the temperature detecting module is realized by LPT parallel port according to 1-wire bus protocol. Finally, median filter method is used to process the original data, and the death time calculating algorithm in forensic science is implemented. The system can quickly measure and calculate the death time human body, and it has a high practical value in the field of criminal investigation. The precision of the system depends on the temperature detection accuracy and the death time estimation method which are provided by the forensic experts. Because the DS18B20 is a digitally communicating sensor with ±0.5 °C accuracy from −10 °C to +85 °C, the temperature detection accuracy of the system is determined by it with filtering algorithm, and the death time estimation method by temperature detecting is only reasonable to estimate the death time with 30-120 minutes errors under the 0-30 °C environment temperature. Thus, this system is more suitable for the death time estimation in the forensic lab and non-extreme detecting scene.

Acknowledgements

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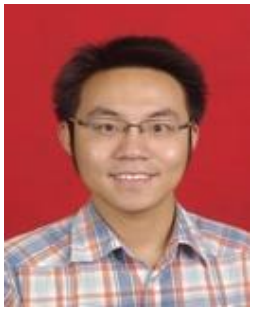

Sheng Li is a teacher in Railway Police College and he is a Ph.D. candidate for Computer Science. His research interests are in embedded systems design and information security.