Fan Gongxiu Honors College

Use EEG signal monitoring system to warn disease outbreak in sleeping

The Cornerstone Project 2015-2016

Final Report

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Use EEG signal monitoring system to warn disease outbreak in sleeping

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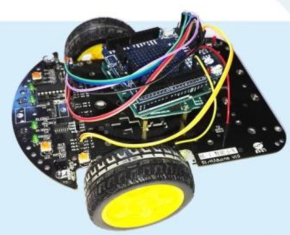
Introduction

EEG:	Electroencephalograph
KEY POINT:	Brain-computer interactive technology
Purpose:	Using "data acquisition, transmission, identification" in collecting and analyzing real-time EEG data.



Smart Car

This technology can be used on the EEG signal monitoring system, which uses sensors such as traditional sensors and EEG sensors, to monitor and record real-time data of people and articles indoor.

In order to directly show the technology, we make an EEG smart car. The smart car uses brain-computer interactive technology thus the operator wearing EEG could operate the smart car through EEG. The smart car could carry out the specific action like moving mode and moving direction according to the real-time data and program.

Research Ideas

1. Signal acquisition
   The Mindwave collect human EEG signals, the signal transmits them to the computer through the serial port.
2. Signal processing
   According to some generated actions we collect human brain waves, and use c # language to induct and reorganize the Brain waves.
3. Signal output
   Through the computer's serial port, the Bluetooth signal connect the car and the computer, then the computer send the action instruction to operate the smart car.

Research Methods

1. Using Mindwave collecting EEG signals.
2. Testing several people's signals and normalizing peak value into a specific range.
3. Using C# programming communication module between Bluetooth signals.
4. Using Arduino programming specific instructions for the EEG smart car.
5. Using C# programming filter module for peak value.

Mindwave

Project Progress

Part I: Preparation

Decide Arduino as the basic platform for building the smart car;

Purchase related hardware and software.

Part II: Learning

Learn Arduino IDE and learn how to use Mindwave;

Learn the company application program for mindwave.

Part III: Commission

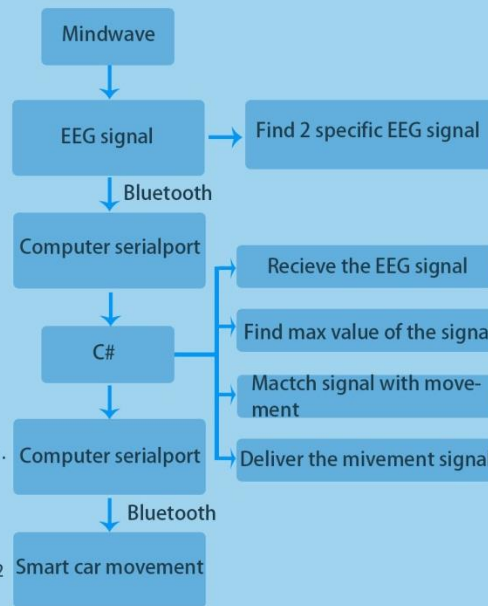
Write C# programming application;

Debug the program, collect data and analyze them.

Part IV: Comparison

Compare EEG signals to find peak value ;

Each peak value mach to a movement.



Project Achievement

1. Acquire, process and output the real-time brainwave data.
2. Control the car movement.
3. Find the specific action through the experiment which could bring an obvious change in EEG.
4. Analyze EEG data generated by certain behaviors and allow them to control the car movement .

Reference

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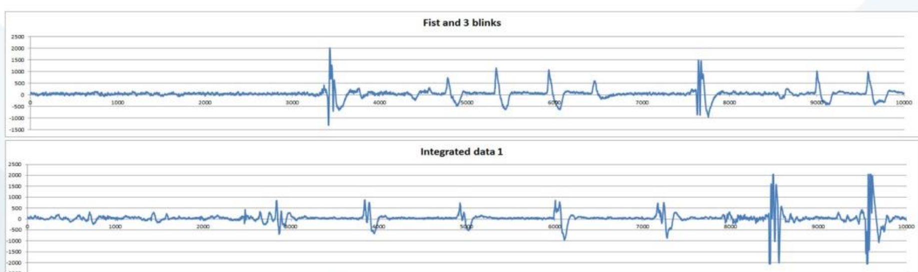
Bill Byron, PhD. Brain Monitoring Devices in Clinical Trials. Applied Clincial Trials, Apr 30, 2015

Experiment Data



1 EXECUTIVE SUMMARY

Due to the status quo of EEG signal monitoring system, our team utilize EEG sensor and brain-computer interaction technology to connect the Mindwave (EEG signal collection equipment). We are focused on the data analysis and application. The core of our project is to put data “collection-transmission-identification” model into real product in order to monitoring and analyzing real-time EEG signal.

We have achieved:

1. Build up the smart car with Arduino uno and an expansion board.
2. The connection of the Mindwave and Arduino Smart Car through Bluetooth serial port.
3. The Arduino program of “Forward, TurnRight, TurnLeft, Pause” actions.
4. The C# program of 2 threads which read and write data alternately.

With the outcomes of our project, we could put this system into medical science and help monitoring the EEG signal and figuring out people’s state. According to this system, the old may effectively avoid the tragedy of suffering from sudden illness while being ignored.

If we are able to get the great amount of EEG signal data of specific diseases according to the clinical trials, we could build up the complete disease EEG signal database to compare the collected signals with the peak values come from thousands of cases.

2 BACKGROUND

Domestic Research Status:

At present the domestic invention patent is: equipment of monitoring EEG in sleeping condition and its monitoring method. The patent outlines a device for detecting sleep EEG and monitoring methods of using EEG to monitor somatic function.

Another domestic system use EEG to monitor diseases: Smart epilepsy monitoring and alarm systems. Smart epilepsy monitoring and alarm systems first get epilepsy patients database, then use LVQ neural network model to train and simulate in Matlab environment. The conclusion is: when the EEG shows in a high frequency wave γ (medically known as "spikes") and it’s in large strength and repeated, the epileptic seizures easily.

Existing domestic research is at the preliminary development stage, only can use specific equipment under specific scenarios to apply its effect to specific people.

Abroad Research Status:

From the website under the US Department of Health hospitals (NIH) we could learn from published articles that in hospitals the research for wearable technology has reached the level of clinical trials; however, the study of family and personal monitoring systems just stay at the level of ideas and researches.

There are already foreign companies which have introduced commercial operation. For example, "finger wear monitoring measure peripheral arterial tone (PAT)”, this device is used to detect patient’s vasodilation and also provide the appropriate calculation based on artery tension. Other monitoring devices of heart rate such as Apple watch can clearly record deep sleep and light sleep, summarize sleep time to help users monitor their sleep quality.

The above two types of testing equipment has also been a corresponding commercial software, you can reach to identify and distinguish the level of sleep stages, sleep quality to provide a summary of statistical data, but the relationship between sleep quality and the disease has not been in an accurate and direct feedback.

In summary, foreign institutes and commercial companies which work for wearable monitoring system already has many aspects of attempts, but there is little precedent for the direct monitoring of EEG. Such companies haven’t take much time in analyzing the collected data and there is a little precedent of analyzing the EEG signals with the symptoms.

Rationale:

During sleeping, the blood flow is slow and is prone to cause cardiovascular disease. To be able to detect such diseases and immediately notify their families and health care centers, we use early warning monitoring system with EEG to warn suddenly disease attacks. The entire system is monitoring the changes of EEG in real time while people are in sleeping situation. Once the abnormal situation is about to happen, the system will notify their families and caregivers at the first time through mobile terminals with the fastest speed so that patients could receive treatment.

3 OBJECTIVES

1. Build up the smart car which could change its rate, direction, and turning.
2. Learn Arduino and C#.
3. Program the smart car of specific actions.
4. Learn Mindwave operating system.
5. Extract the EEG signal through Mindwave Bluetooth module.
6. Build up data management model and find the peak value.
7. Run the whole Brain-Computer Interaction model.

4 METHODOLOGY

According to the requirement and need of the project, we make the project structure to clarify the working process and timeline.

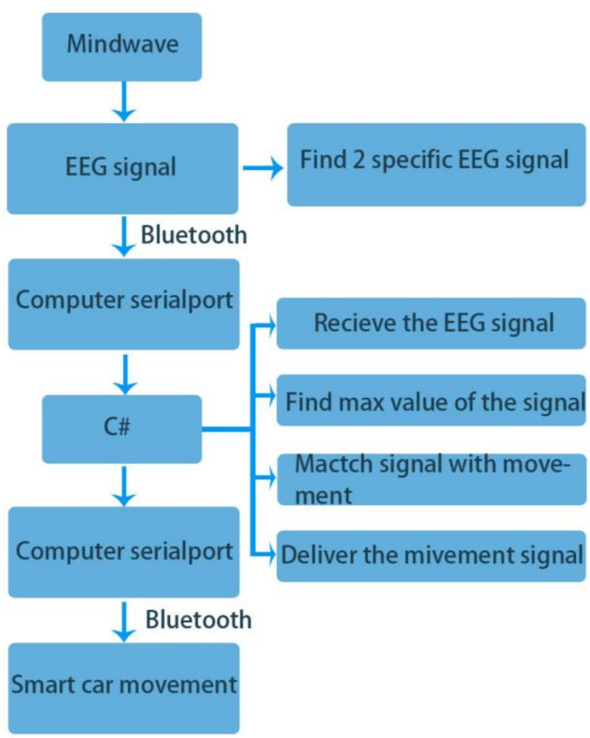


Figure 1 Project Structure

We divided our research process into three parts: Signal acquisition, Signal processing and Signal output.

1. Signal acquisition:

Firstly, we collect the EEG signals with the Mindwave device which is made by the NeuroSky Company. And the second step is to send the signal information to the computer through Bluetooth into the computer serial port, so that we could analyze this information detailed. So we write a c# program to receive the EEG signals.

```
public static void Main(string[] args)
{

    Console.WriteLine("Hello EEG!");

    // Initialize a new Connector and add event handlers
    //sw = new SerialWriter("COM4");

    // 定义一个连接
    connector = new Connector();

    // 当设备连接时执行
    connector.DeviceConnected += new EventHandler(OnDeviceConnected);
    // 当设备连接失败时
    connector.DeviceConnectFail += new EventHandler(OnDeviceFail);
    // 验证连接
    connector.DeviceValidating += new EventHandler(OnDeviceValidating);

    Connector.EKGPersonalizationEvent += new EventHandler(OnEKGPersonalizationEvent);

    heartRateRecovery = new HeartRateRecovery();
    heartRateAcceleration = new HeartRateAcceleration();
```

Figure 2 Estimate Connection

```
        static void OnDeviceConnected(object sender, EventArgs e)
        {
            Connector.DeviceEventArgs de = (Connector.DeviceEventArgs)e;

            Console.WriteLine("Device found on: " + de.Device.PortName);

            de.Device.DataReceived += new EventHandler(OnDataReceived);
        }

        /**
         * Called when scanning fails
         */
        static void OnDeviceFail(object sender, EventArgs e)
        {
            Console.WriteLine("No devices found! :(");
        }

        /**
         * Called when each port is being validated
         */
        static void OnDeviceValidating(object sender, EventArgs e)
        {
            Console.WriteLine("Validating: ");
```

Figure 3 Output the device connection situation

```
            /* Loop through new parsed data */
            for (int i = 0; i < tgParser.ParsedData.Length; i++)
            {
                if (tgParser.ParsedData[i].ContainsKey("Raw"))
                {
                    //Console.WriteLine("Raw Value:" + tgParser.ParsedData[i]);
                    //Console.WriteLine("Raw Value:" + tgParser.ParsedData[i]["Raw"] + ", " + DateTime.Now.ToString());
                    //Console.WriteLine(i);

                    dq.WriteData2Queue((int)tgParser.ParsedData[i]["Raw"]);
                    iNum++;
                    if (!bStart && iNum > 1000)
                    {
                        //dq.SetWriteIndex();
                        //dq.SetReadIndex();

                        //if (!bStart)
                        //{
                            rThread.Start();
                            bStart = true;
                        //}
                    }
```

Figure 4 Read in EEG signals into the computer

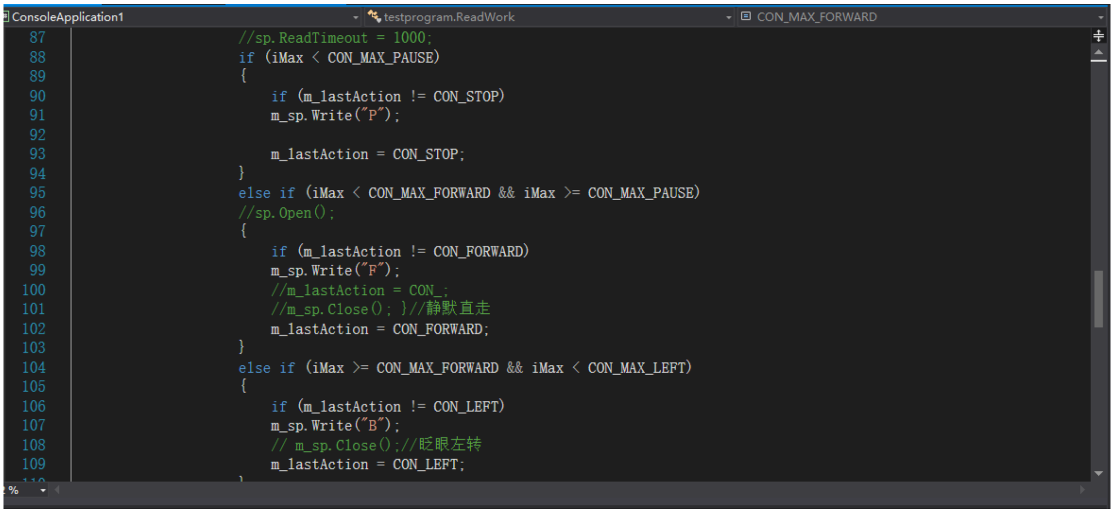
2. Signal processing:

According to some generated actions, we collect human brain waves, and use c # language to induct and reorganize the brainwaves.

After testing several people's signals and normalizing peak value into a specific range, we define two kinds of EEG signal to trig movements, while each one corresponds to a specific action of the smart car: blink - turn right, fist - Turn left.

```
        //public const int FORWORD = 50;
        //public const int BACKWORD = 100;
        public const int CON_MAX_FORWARD = 1000 ;
        public const int CON_MAX_LEFT = 2000;
        //public const int CON_MAX_RIGHT = 1600;
        public const int CON_MAX_PAUSE = 500;

        public const int CON_FORWARD = 1;
        public const int CON_STOP = 0;
        public const int CON_LEFT = 3;
        public const int CON_RIGHT = 4;

        private DataQueue m_data;

        // 记录上一次小车的动作，值为0表示stop， 1表示前进
        // 2表示后退，3表示左转， 4表示右转 等等，这一块你们做主
        private int m_lastAction = CON_STOP;

        // 定义端口句柄
        private SerialPort m_sp;

        // 构造函数
        public ReadWork(DataQueue dq, string strPortName = "COM11")
```

Figure 5 Define the data

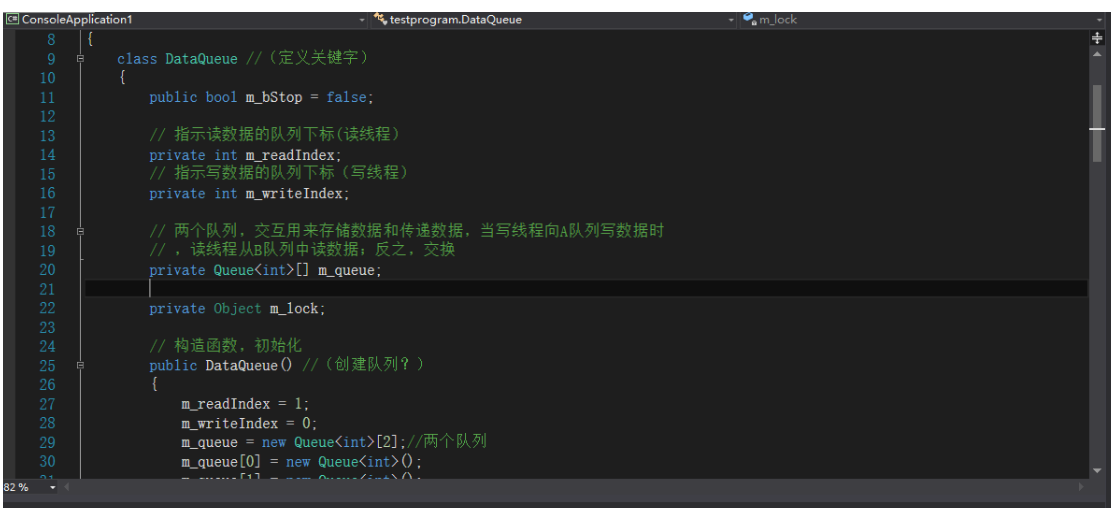


```
ConsoleApplication1        testprogram.ReadWork        CON_MAX_FORWARD
            //sp.ReadTimeout = 1000;
            if (iMax < CON_MAX_PAUSE)
            {
                if (m_lastAction != CON_STOP)
                m_sp.Write("P");

                m_lastAction = CON_STOP;
            }
            else if (iMax < CON_MAX_FORWARD && iMax >= CON_MAX_PAUSE)
            //sp.Open();
            {
                if (m_lastAction != CON_FORWARD)
                m_sp.Write("F");
                //m_lastAction = CON_;
                //m_sp.Close(); }//静默直走
                m_lastAction = CON_FORWARD;
            }
            else if (iMax >= CON_MAX_FORWARD && iMax < CON_MAX_LEFT)
            {
                if (m_lastAction != CON_LEFT)
                m_sp.Write("B");
                // m_sp.Close();//眨眼左转
                m_lastAction = CON_LEFT;
```

Figure 6 Signals correspond to specific actions instruction of the smart car

3. Signal output:

Through the computer's serial port, the Bluetooth signal connect the car and the computer, then the computer send the action instruction to operate the smart car.



```
ConsoleApplication1        testprogram.DataQueue        m_lock
{
    class DataQueue //（定义关键字）
    {
        public bool m_bStop = false;

        // 指示读数据的队列下标(读线程)
        private int m_readIndex;
        // 指示写数据的队列下标（写线程）
        private int m_writeIndex;

        // 两个队列，交互用来存储数据和传递数据，当写线程向A队列写数据时
        // ，读线程从B队列中读数据；反之，交换
        private Queue<int>[] m_queue;

        private Object m_lock;

        // 构造函数，初始化
        public DataQueue() //（创建队列？）
        {
            m_readIndex = 1;
            m_writeIndex = 0;
            m_queue = new Queue<int>[2];//两个队列
            m_queue[0] = new Queue<int>();
```

Figure 7 Two threads read and write data alternately between the smart car and the EEG signals

5 KEY RESULTS AND ACHIEVEMENTS

5.1 KEY RESULTS AND DISCUSSIONS

At the very beginning of our project, we discussed about using JavaScript or Arduino as the platform our data processing system. With information from the internet and practical experiments we have done, we finally chose Arduino as our platform due to its good compatibility and great practicality.

Figure 8 Smart Car

We build up our smart with Arduino Uno and one expansion board to make it possible to deliver the EEG signals though Bluetooth system.

Then we write the fundamental action instruction program to test the smart car and simulate the signal input module.

```
=Serial.read();//读取PC 机发送给Arduino 的指令或字符，并将该指令或字符赋给

: if (val='P')

erial.println("Pause!");
ause();

se if (val='R')

 turnright();
 Serial.println("Turn right!");
 digitalWrite(ledpin,HIGH);//点亮数字13 口LED。
 delay(500);
 pause();
 delay(1000);
 forward();
 delay(2000);
 digitalWrite(ledpin,LOW);//熄灭数字13 口LED
 pause();
 }

se if (val='L')

 turnleft();
 Serial.println("Turn left!");
 digitalWrite(ledpin,HIGH);//点亮数字13 口LED。
 delay(500);
 pause();
 delay(1000);
 forward();
 delay(2000);
 digitalWrite(ledpin,LOW);//熄灭数字13 口LED
 pause();
```

Figure 9 Arduino Program "F L P"

We learnt the open source code of Mindwave and understood it clearly. Then we write our preliminary program. Our preliminary program of collecting the real-time EEG signals and printing it out is base of figuring out the peak value though comparison and filter.

Next stage is the C# program we have shown above. This program aims to accomplish the connection between the smart car and Mindwave (the EEG signal collection headset).

Finally it comes to the optimization and debugging process. We have done a great amount of experiments to ensure the data is accurate and effective to show how the specific action could be decoded into action instructions then control the smart to move or change its operating status.

We define 3 states during the experiment: peace, shanking fist, and blink.

Figure 10 Experiment Data

While the operator is in peace state, the smart car will stay there, the waveform has no significant change with a peak value of 500;

While the operator is blinking, the smart car will do anticlockwise rotation, the waveform has a small change with a peak value of 1000;

While the operator is shaking fist, the smart car will do clockwise rotation, the waveform has a big change with a peak value of 2000.

5.2 THE ACHIEVEMENT AGAINST ACTIVITIES AND MILESTONES

Goal	Current situation	Performance
Find out a proper way to do the EEG research.	Use the smart car as a model to study the EEG signal; Learn how to use Mindwave.	Finished
Find out a certain platform to drive the smart car.	Assure Arduino as the basic platform for building the smart car; Purchase related hardware and software; Learn how Arduino works and write application program.	Finished
Learn how to use the EEG signal to trig the smart car.	Use C# programming application to test the program, collect data and analyze them; Compare EEG signals between collected ones and peak value of specific diseases to check the peak value and its characteristics; Connect the Mindwave data output module and smart car movement module to ensure the smart could receive data then do the comparison progress.	Finished

Build a platform for diseases.	Since we could hardly find an accurate EEG information despite corporate with some hospital. We haven't develop this part in our cornerstone project. But through the work we have done, we believe we could finish this part if we are able to get enough useful and accurate information.	Unfinished

6 IMPACTS

Scientific impacts:

After the finds of the project, we can put the EEG monitoring process into the medical science. Based on these, collect and handle the specific EEG signals of diseases for specific people is available. These diseases include myocardial infarction, disturbance in respiration and epilepsy. Characteristic EEG signal collected from this method can be saved as a database.

Community impacts:

Using these achievements in science, we can use EEG monitoring process to maintain the users' physical situation. That will help those people who are in the bad condition, including myocardial infarction, disturbance in respiration and epilepsy. Also, it will reduce the sudden death of series of diseases such as cerebral hemorrhage or myocardial infarction.

7 CONCLUSIONS AND RECOMMENDATIONS

The success of the Smart Car shows that the technique of extracting EEG signals and analyzing them in real time is successfully completed. Collect and handle the specific EEG signals of diseases for specific people are available. Characteristic EEG signal collected from this method can be saved as a database.

However, we were not able to create a database because of the lack of data (we could not get the EEG signals of various diseases). Also the control of the Smart Car requires the operator must be in a state of silence. Therefore, there isn't a feasible way to achieve the detection of specific diseases when the user is in a state of instability.

In the future, we will build the database of the EEG signals of specific diseases after we get enough data from the hospitals. Then we will modify program to improve accuracy and anti-jamming. Base on it, an early warning when any potential risk may do harm to the human body could be available.

8 ACKNOWLEDGMENTS

Johnson Chen guided us during the whole year, including technical support in Arduino and C#. Johnson Chen also helped us learn the relevant knowledge of computer science including data structure and computer composition principle.

Fan Gongxiu Honors College provided all the funds supporting us complete the project.

Thanks to the support from above.

9 REFERENCES

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10 APPENDIXES

Budget

Figures	Expense
Mindwave headset	1500
Arduino elements	500
Tool box	250
Related books	200
Supplies	150
TOTAL	2600