

腦波意念控制於實際應用的研究
MINDWAVE BRAINWAVE MIND CONTROL IN PRACTICAL
APPLICATIONS RESEARCH

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摘要

針對腦波的非線性 α 波取樣系統，提出可以藉由 MindWave 腦波意念技術結合 LabVIEW 傳輸介面的系統控制方案，藉由 LabVIEW 所設計的高效能人機介面，以達到良好的追蹤特性。研究內容陳述如下：大腦是我們人體中的思考中樞，也是一切意識動作的命令來源，如何使用腦(電)波訊號，由大腦直接控制體外的世界，而不須經由四肢或身體，這就是意念控制。在計畫中將使用者的意念與外界作聯繫，設計與實現大腦人機介面作為溝通橋樑，並證明意念控制之可行性。在本文中，將舉出一些實際應用的例子，包含實際的電路系統，來說明所提方法之有效性。

關鍵字：LabVIEW 人機介面、MindWave 腦波意念控制系統、腦波(電)訊號

Abstract

For non-linear α -wave EEG sampling system can be put forward ideas MindWave brainwave technology combines LabVIEW transmission system control program, designed by LabVIEW efficient human-machine interfaces, in order to achieve good tracking characteristics. Research topics stated as follows: The brain is our body's thinking center, command source is also a switch consciousness movement, how to use the brain (electric) wave signals directly controlled by the brain in vitro in the world, not subject to the limbs or body, and this is the idea control. In the user program ideas will make contact with the outside world, the design and realization of human-machine interface as a communication bridge between the brain and demonstrate the feasibility of the idea of control. In the project, will give some examples of practical application, including the actual circuit system to illustrate the effectiveness of the proposed method.

Key Words: LabVIEW interface system, MindWave control system, brain waves signals.

1. INTRODUCTION

Over the past decades, there has been a growing interest in the singular system. The applications of singular systems in large-scale systems, circuits, power systems, economics, control theory, robots, and other areas [1-2] are extensively. Recently, many research results concerning about the singular system have successfully solved lots of complex problems such as impulsive modes [3], stability [4], controllability and observability [5], the sufficient and necessary condition for impulse controllability and observability of time-varying singular systems [6]. The stabilisation and control of a class of non-linear descriptor systems has been presented in [7]. Nevertheless, no tracker and fault tolerance control are given in this literature. Besides, [7] assumes the system model equation is known. Actually, the singular system can be converted into an equivalent regular system which may have a direct transmission term from input to output. Indeed, the singular system without the impulse mode is just a special class of the regular system with the direct transmission term from input to output. To the author's knowledge, the optimal tracker for the regular system containing the direct transmission term from input to output has not been proposed in literature. Over the past decades, there has been a growing interest in the brain wave control system. Brainwave control applications like the brain to control electrical appliances switch, no action by the human limbs, just thinking through the human will to accomplish a variety of things, is a new alternative thinking, but also the trend of the future control law, so If you can easily and correctly perform brain (electric) waves, both for the scientific application, or medical research will be of great help. Currently there are a variety of engineering applications in human-machine interface (Man-Machine Interface, MMI), human-machine interface is different from the traditional one, through speaking, sign language representation or communication with the outside world in order to affect the way the muscles, including the eye-tracking system, wink control system, head and facial motion control system, but each system has its shortcomings cannot be ignored, such as eye-tracking system to detect eye movements, although immediate situation, but often because of sweating, eye movements magnitude is too large, resolution low and the lack of flexibility and other factors affecting the signal sentenced reading, generating not recognize the situation, in addition to

the head and facial motion control system is also easy to produce fatigue and signals false positives [1]. In the man-machine interface using EEG as a man-machine interface control, human-machine interface to the brain (Brain Computer interface, BCI) is the best way to communicate without the aforementioned disadvantages of the man-machine interface. HMI is the use of brain signals the brain to allow users to communicate directly with the outside world, the basis of this technique is that when a particular activity in a brain, it will produce a corresponding change in brain waves, so the brain waves through monitoring and identifying targets changes can communicate with the outside world and control to achieve the purpose. The use of EEG and other non-muscle channel to help pass the message desired expression, to achieve some of the ideas expressed directly through the ideas and give us the opportunity to have an alternative order to communicate, and provides a new control functions, such communication and control methods the new model is also a manipulation of the machine [2].

2. THE MIND CONTROL

2.1 Brainwave Generation

Pacemaker for the brain waves of a weak potential of nerve cells in the brain and nerve fibers in the conduction of nerve impulses, the resulting changes. Because the brain is far less than the energy of the electromagnetic activity of the body other telecommunications numbers, so its existence was discovered at the latest. The earliest in the year 1875 by the British University of Liverpool Professor Richard • Cartoon (Prof. Richard Carton) from the surface of the cerebral cortex discipline records rabbits or monkeys coming out. This wave has nothing to do with breathing or heartbeat, is a physiological change in the brain, and the animals died immediately after the disappearance. Experiences over several animal experiments later, known as the father of the German scientists Hansbrough EEG (Hans Berger), and finally in the year 1924 under the successful record of human brainwaves. Electrical activity was issued by the brain electroencephalogram (Electroencephalogram, EEG), look at the meaning of words starting with electro-electrical-power; encephalo-brain-brain; gram (ma)-picture-image, referring to the brain wave activity at the time of recording the change [3].

Generally in the cerebral cortex brain waves

can be measured to about 10 mV size. In fact, the human EEG measurements are mostly measured in the scalp, thus EEG to record the activities of the majority of potential changes in cortical surface is galvanic current fluctuations in cortical cells formed by the dendrites and cell bodies between formation. The already small signal, and then, after cerebrospinal fluid, subarachnoid, subdural, skull and scalp decay, so the scalp EEG measurements to normal, the signal is a little more size to about 0.5 ~ 100 μ V, and its frequency range between about 0.5 ~ 100 Hz [1]. Thus EEG waveforms can be used to determine whether the normal brain functions important basis.

2.2 Types of Brainwave

People with eyes , eyes closed , conscious or unconscious , the vibration frequency of brain waves will be significantly different changes between about 1 ~ 40Hz, the International Society of brainwaves (International Organization of Societies for Electrophysiological Technology) according to different frequencies the EEG into α (alpha) waves , β (beta) waves , δ (delta) waves , and θ (theta) waves four. When people focus on thinking , reasoning , or stress, nervousness , uneasiness , anxiety , etc., easily measured β -wave (13 ~ 38Hz), β -wave frequency is highest in the EEG is " conscious " level of brainwave . Decline in concentration , relaxation, fugue Quartet, venting, absent-minded , the eyes closed, will be measured α wave (8 ~ 13Hz), α waves can be said to be a bridge " conscious and unconscious " between . Once into sleep , brain waves become the low-frequency waves θ wave (4 ~ 8Hz) and δ wave (0.5 ~ 4Hz), θ waves are " unconscious " of the wave, such as memory , perception, emotions, attitudes, beliefs , dreams or meditation etc. ; δ wave is " unconscious " level, need sleep to recuperate in time . Combination type α , β , δ and θ waves can reflect the performance of human behavior and learning.

2.3 Brainwaves with The Weight of Analyze

EEG is the electric field in the brain nerve cells and nerve fibers in the conduction of nerve impulses generated, with a variety of frequency bands of the typical EEG α , β , θ and δ wave, are described as follows [4]

(1). α wave: wave, also known as the relaxation frequency of 8 ~ 13Hz, which is great and the slower brainwaves, most people in the quiet, relax the body,

so there will be a period of rest of the brain wave state, if we just close your eyes and imagine the calmness of the screen, then there will be an increase of less than half a minute α wave, whether fixed or mobile, will puncture paragraphs shock compared with the rest, all will find α wave energy decline, began to appear is a bridge between the conscious and subconscious level, its potential is about 50 μ V, in the occipital portion of the brain (occipital region) and parietal Department (parietal region) the most obvious.

(2). β wave: Also known as thinking wave, frequency of 13Hz and above, is small and fast brain waves, rarely higher than 40Hz. Particularly evident when awake and alert, but also logical thinking, calculating, reasoning needed when the wave, if abnormal anxiety or tension, then there will be too high β -wave generator. Using EEG and event-related potentials detected when subjects were accepted stimulus, β wave will be significantly increased, the level of consciousness of belonging to the wave. In the parietal and prefrontal Department (frontal region) would be more obvious potential of about 20 μ V.

(3). θ wave: frequency of 4 ~ 8Hz, a low voltage, not a legal nature section, there are two standards, the lower-order 4 ~ 6Hz basically represents the state of waking and sleeping between fuzzy, is extremely calm, serene floating state. Mainly in the children's department and temporal parietal lobe Department (temporal region) will appear in a deep sleep dreaming, deep meditation is especially evident when, belonging to the subconscious level of the wave, can be found in many brain diseases θ waves.

(4). δ wave: brainwave frequencies below 4Hz frequency, high amplitude low frequency, a high voltage, when the EEG during sleep and when to engage itself began to recuperate, δ waves also occur, with serious sexual organs who is particularly evident in patients with the disease, mainly in the occipital portion of the child, and the frontal portion of adults.

Figure 2.1 shows the brain wave pattern on the schematic diagram of four different frequencies [5].

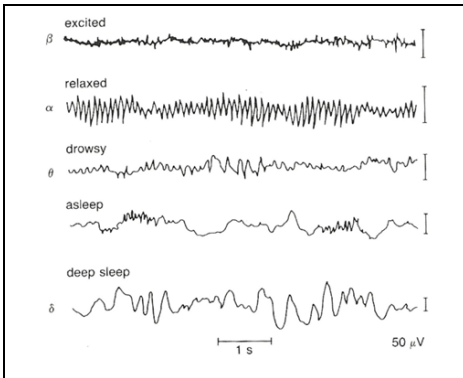


Figure 2.1 shows the brain wave pattern on the schematic diagram

EEG signals by the experiments that have a close relationship and thinking, and in the spirit of relaxation time when people are in the focus or mental tension, brain waves in the α wave is suppressed or disappeared, some people may appear β wave, α wave significantly enhanced; mental relaxation to a certain stage, but the emergence of weariness when, α wave is gradually disappearing, while θ wave energy enhancement. Thus, α -wave indicators index became emotional stability, and may reflect the people's emotional expression, emotional stability of human α -wave index higher, while the emotional impulse or in a state of anxiety people α -wave suppression more.

2.4 How do get Brainwave

When the neuron in the conduction signals will produce some electrical activity, different stimuli have different state to pass signals. Cells in the stationary state, the sodium ions outside the cell membrane and membrane potassium ions more more, resulting polarization (Polarization). At this point the potential difference between the inside and outside of the cell membrane called the resting membrane potential (Resting membrane potential). Only when the cells are effectively stimulated and excited, the cause changes in the nature of the cell membrane, sodium ion order to a large number of outer membrane into the membrane, not only was offset potential inside and outside of the cell membrane is poor, and even the electrical and outside of the membrane change occurs another and stationary. Instead of the potential difference, namely polarization destroyed (Depolarization), and then revert to the original state (stationary state) [4]. Cells are valid irritation caused excitement, but also to

generate action potentials (Action Potential), and this action potential by changes in membrane electrical properties of conduction in nerve fibers, through a liaison office nerve and nerve are called neural synapse, then passed to other nerve cells.

Many of the human brain in the activity of nerve cells, causing a change in electrical resistance, which is the potential of the individual EEG brain cells occurs by the scalp, or directly on the collecting electrodes of the cerebral cortex, through the amplifier to the postscript recording person. So EEG signals mainly from potential changes in cortical layer produced by rhythmic electrical signals and transient signals consisting of discharge, but in different locations of the brain cortex, in charge of the different physiological functions. As the head hinder hair, easy fixed electrodes on the head, so to select the Fp1 electrode position and lower lobe position A1 and A2 forehead as a reference potential, shown in Figure 2.2

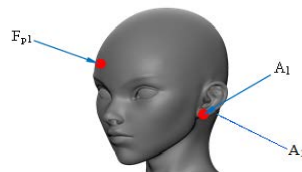


Figure 2.2 sticky texture electrode position

EEG analysis method is mainly using signal processing or graphics recognition technology to detect, in this EEG signal processing, using wavelet transform instead of the Fourier transformation, wavelet (Wavelet) this term, as the name suggests is a small wave. The so-called "small" means it has a decay; rather call it "wave" refers to its volatility, its amplitude shocks in the form of positive and negative phases. Compared with the Fourier Transform, the wavelet transform is localized analysis time (space) frequency shift operation on it by stretching signal (function) Multiscale gradually refined, and ultimately achieve high frequency time segments, low frequency frequency segments, can automatically adapt to the requirements of time-frequency signal analysis, which can focus on any detail of the signal, to solve the difficult problem of Fourier transformation, becoming the Fourier Transform since a major breakthrough in the scientific method. Some of the wavelet transform is called "mathematical microscope." Wavelet transform is a long on scales can signal analysis (Multi-resolution Analysis) conversion method, the

surface EMG often contains many non-stationary signals (Non-stationary Signal) as drift and sudden changes in trend, the use of wavelet conversion, can effectively distinguish these distributions in different frequency band signals [5] .

Instead of using wavelet transform, to conduct spectral analysis of researchers in the use of Fourier transform must accept the steady-state resistance (Stationary) basic assumptions, experimental records any 10-minute brainwave, when you perform Fourier Transform must assume (or accept) periodic wave component which is within 10 minutes will not change, such as α this period, β , and γ -wave activity level, etc. should be fixed, so that it can obtain the intensity ratio between each band. However, if the researchers are concerned about time, is not a fixed component of each band unchanged (such as the ever-changing visual awareness qualification process), then the traditional Fourier Transform convenience unsuitable. Important aspects of the wavelet transform of the image and signal processing, signal processing purposes is: accurate analysis, diagnosis, and the quantization encoding compression, transmission or storage quickly and accurately reconstructed. From the perspective mathematically, signal and image processing can be seen as a unified signal processing (image can be seen as a two-dimensional signal), the wavelet analysis to many many applications analysis, can be attributed to the signal processing problems.

Now, for its nature is stable and unchanging over time signal processing is still the ideal tool for Fourier analysis. However, in practice the vast majority of the signal is unstable, and the wavelet analysis tool is particularly suitable for non-stationary signals in. The difference between the wavelet transform and traditional Fourier Transform is Fourier Transform cannot accurately assess the signal frequency changes of time, due to the Fourier transformation only consider the frequency variable, the spectrum is only apparent frequency difference relations without time. The wavelet transform scales because while there are two variables and location, so the signal can be displayed by the wavelet transform relationship between time and frequency (Time-Frequency) [6]. Simply speaking, the wavelet analysis is based on a section of the selected mother wavelet (mother wavelet) and time series data of conduct convolution (convolution). If the two were similar shape, convenience will get a larger convolution; If not, then the convolution value is smaller, shown in Figure 2.3 (a) selection of a

particular frequency diagram shows the mother wavelet time-specific location of the serial signal conducting volume plot, in which the results can be table (b) the relative position of the chart of [7].

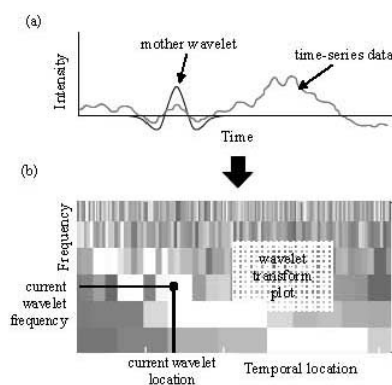


Figure 2.3 Schematic wavelet transform

There are two key advantages of wavelet transform and is closely related to the study, this must be specifically stated:

(1). Wavelet transform window (window) size can be changed. To detect low-frequency component can use a larger window. When the high frequency component to be detected, a smaller window is changed, in order to improve the accuracy of the time position. This feature is for the moment (transient) changes in visual awareness qualification process may occur speaking, is indeed a very important consideration. Because the analysis tools must have a high degree of time resolution, in order to reflect the composition of the wave changes extremely fast qualification process.

(2) The relationship between the number of wavelet transform and complex space. Simply speaking, each wavelet transform result 都 number can be expressed as a complex vector (complex vector). And the length of the vector geometry that represents the result of the wavelet transform intensity values (amplitude), which is a specific frequency intensity at a particular point in time. As the angle between the vector and the axis of the constitution, that is, the frequency at which point in time the phase angle (phase angle). Therefore, wavelet transform results can be written as:

$$\tilde{x}(f, t) = a(t) e^{j(f(t) + \varphi(t))} \quad (1)$$

Where, $a(t)$ on behalf of intensity, and $\varphi(t)$ on behalf of the phase. Intensity and phase can be two factors distinguish the future. Consider this feature

註解 [1]:

for those who want a simple two-phase relationship between the two channels of EEG researchers speaking, the advantages of a different nature is indispensable.

3. THE STRUCTURE OF THE BRAIN HMI

3.1 Signal Processing

Analysis of EEG method is mainly using signal processing or graphics recognition technology to detect, such as: Fourier Transform (Fourier Transform, FT), wavelet transform (Wavelet Transform, WT), independent component analysis (Independent Component Analysis, ICA), Hilbert-Huang Transform (Hibert-Huang Transform) and neural network techniques (Neural Network) and other methods. In part this signal processing, we use Neurosky developed ideas of headphones used to obtain brain (electricity) experiment wave signals such as α , β , θ and δ waves. Brain (electric) wave signal transmitted signal to the computer via a Bluetooth interface. The analysis and interpretation of EEG signal, the user wants to express the intent to understand, then according to the object to be controlled, converted to the appropriate control instructions or communicate messages to interpret the user wished to express command, and used to control different auxiliary devices.

EEG measurement block diagram as shown in Figure 3.1, the surface of the electrode to measure very weak α -wave potential change, which is stimulated and excited by the light eyes brainwave signals. Therefore, when the eyes are open or closed, α -wave wave rate of change will occur (Arrhythmic) phenomenon. Pre-amp amplifier, for EEG signal acquisition vector extracted unipolar signals, which magnification is 50, and the JFET type op amp used to improve impedance matching. Bandwidth band pass filter is set to 1 ~ 20Hz, then filter them through a weak signal 1000 times magnification, you can take to EEG signals.

3.2 Interface and Software Design

The system is designed to capture brainwave-owned software and data storage interfaces section, but using a graphical language LabVIEW (7.1, National Instruments) design is complete, using Bluetooth in LabVIEW system requirements to apply to LabVIEW 7.1 or later in LabVIEW graphical interface to connect the Bluetooth settings shown in Figure 3-2. Translation of the relevant part of the spectrum and analysis algorithms computing, then

using MATLAB (7.0, MathWorks) software to develop the design, shown in Figure 3-3.

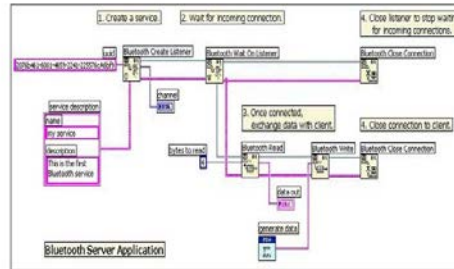


Figure 3.2 LabVIEW graphical interface to connect the Bluetooth settings

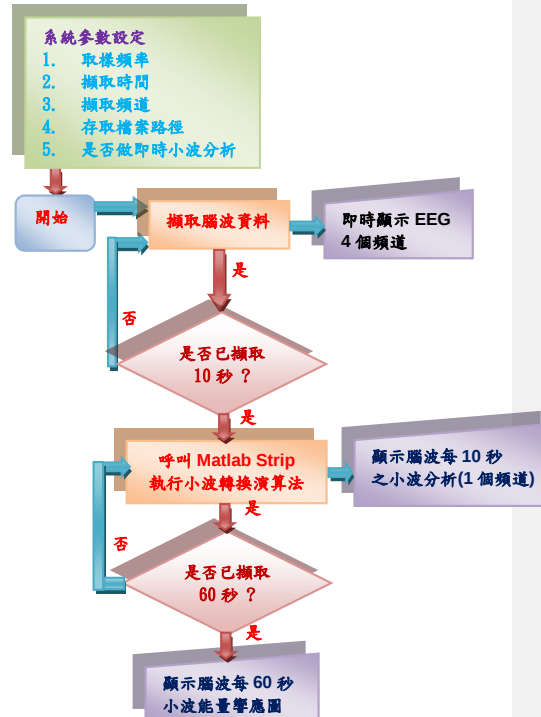


Figure 3.3 LabVIEW call MATLAB program Wavelet analysis of real-time execution flow chart

Call MATLAB-based system using LabVIEW program execution instant wavelet analysis software flow chart. The aim of EEG signals captured using LabVIEW program man-machine interface, its wavelet energy map and time-domain signals are displayed directly on the screen. In this paper, the use of LabVIEW graphical language to planning and writing of this system has the following advantages: (1)Through instrument drivers provide data

acquisition module, you can quickly select a desktop or portable computer for signal acquisition.

(2) Use LabVIEW to call MATLAB program, developers can significantly save time in the development of digital signal algorithms (wavelet transform, time-frequency characteristics analysis, etc. ...) when required, can also be an effective basis for different physiological signals characteristics, to write analytical element time domain and frequency domain parameters.

(3) Friendly graphical user interface that allows users of the system easy to understand system operation.

(4) Such development methods that can help developers to expand the number of channels, and for future feature upgrades is quite convenient. Therefore, this real-time EEG monitoring and analysis system that can be immediately captured signal data parameter analysis, results are presented, thus effectively provide users with the necessary information.

3.3 System Synthesis and achieve

The system hardware capture brainwave measurement instruments record EEG brainwave idea of MindWave headset, this instrument provides its measurement electrode placement but using three sensors in contact with the skin of three locations: two below the ears and forehead, the EEG measurement signal amplifier via specific conduct amplified through the noise filter processing interference, then the ratio of EEG analog signals into digital signals, and finally with USB interface transfer to send digital signals to a computer. In the receiving computer, then the LabVIEW graphical development language User Interface, showing the captured EEG signals to the screen, but also do real-time analysis of wavelet analysis and presentation of results to the screen.

4. RESULTS

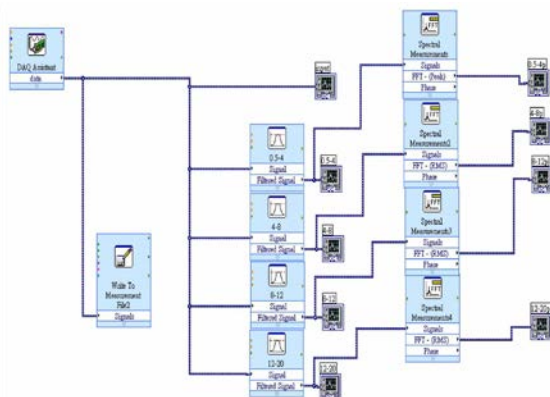


Figure 4.1 (a) LabVIEW obtained by the Bluetooth brainwaves by virtual instrument control

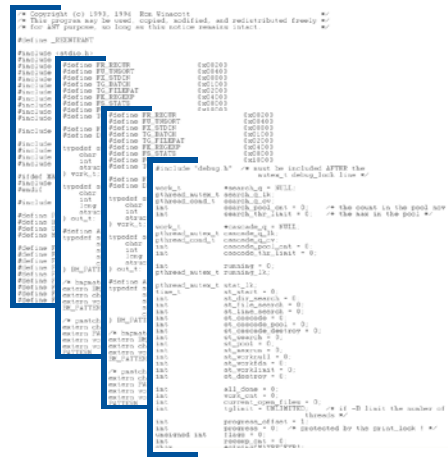


Figure 4.1 (b) LabVIEW-Matlab Stript program

The Figure 4.1 shows the LabVIEW obtained from a Bluetooth brain waves via a virtual instrument control display, the brain wave filter, depending on the frequency divided (α , β , δ , θ) from high to low frequencies are ≤ 3 Hz, $4 \sim 7$ Hz, $8 \sim 12$ Hz, $\geq$ received within 13 Hz waveform spectrum analysis of virtual instrumentation. Figure 4.2 (a) Left brain waves when eyes open, eyes closed when the EEG right picture, the right of the waveform represents the time when the eyes are closed when α than the left eye open to dispute is large. Figure 4.2 (b) EEG during meditation left when the right is sleep EEG, because it will relax during sleep, so θ Potter else is low.

5. ACKNOWLEDGEMENT

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