

Establishment of New Electro-oculogram Measurement Technique by Integrating Virtual Instrument

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Abstract - In this research, a new electro-oculogram measurement technique is designed and constructed. The structure of virtual instrument built by software part, Labview hardware part, DAQ card and some external circuits is applied in the development process. This research integrates industry needing oriented technology – physiological measurement of medical industry, advanced technology – virtual instrument, and medical knowledge – physiology. Practical measurements have been carried out to demonstrate the capabilities of this new measurement technique.

Keyword-electro-oculogram; measurement; virtual instrument; Labview.

I. INTRODUCTION:

Physiological measurement systems require equipments for diagnosis in hospitals. They are used to measure patients' physiological status such as blood pressure, respiratory ventilation, heart conditions, and electrical activity of the brain. Doctors can use these measured information for diagnosis and treatment. These physiological measurement systems are extremely important in medical industry. Although diagnostic medical instruments have been widely used, combining virtual instrument technology to achieve the purpose of physiological measurement is a completely advanced technology. Utilizing virtual instrument to achieve physiological measurement will largely decrease the cost and increase the flexibility of instruments [1-3]

Electro-oculogram(EOG) is a valuable instrument in medicine used for the diagnosis of the Parkinson's disease, Alzheimer's disease, and epilepsy. In addition, EOG analysis could deliver significant information to quantitatively identify the sleep status and eye injury. Based on the classification of EOG signals, medical doctors could make diagnosis regarding patient's patterns, including Dyssomnias, Parasomnias, sleep disorders associated with medical/psychiatric disorders, and proposed sleep disorders [4]. In the past few years, the focus on the development of assistive devices for people with severe disability has increased by improving the traditional systems. The Video Oculography (VOG) system and Infrared Oculography (IROG), based on the detection of eye position using cornea or iris, are some of the developments made so far. Several possible methods of eye movements have already been reviewed by scientists. The physical energy drained in moving eyes being minimal when

compared to other gestures such as nodding head (dumb people), speaking or writing etc. also inspires the use of EOG signals for device control purposes. Lately, there have been much effort to develop EOG based assistive devices [5-8].

A virtual instrument, in combining with computer technology and modern acquisition measurement technology, is a novel high-tech product. The virtual instrument makes the best of active computer resource, matches with oneness constructive instrument hardware and proprietary software, and achieves all the functions of the traditional instrument as well as some superb specific functions that can't be carried out on the traditional instruments [9]. Currently, there are several systems for developing the virtual instrument such as LabVIEW, Look-Out, BridgeVIEW and LabWindows/CVI [10]. From these computer languages, LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a data-flow and graphic-based language and features an easy-to-use graphical programming environment, which covers these vital components [11].

In EOG analysis, SEM(slow eye movement) is laborious and time consuming and suffers particularly from inter-scorer variability because of the lack of standardized definitions [12]. The EOG signal contains not only eye movements and blinks, but also neural sources (including those seen at EEG electrodes) and other sources of artifacts such as facial twitches. Also, during a blink or large eye movement, EOG electrodes move along with the facial muscles around the eyes, introducing additional noise in the measurement [13]. Binocular rivalry which is a perception phenomenon in which left and right images are perceived alternately with one unstable image, has been report in [14]. Eventually, only one of the two images can be perceived. This will decrease the visibility but is not dependent on image quality. The measurement problems [12-14] can be overcome by the measurement technique established in this paper, the difficulty can be overcome,

II. METHOD

The measurement structure consists of three major parts: (1) external measurement circuits, (2) DAQ card, and (3) virtual electro-oculogram design

A. External measurement circuits

In figure 1, two sets of measurement circuits are used to measure the horizontal moving quantity and

vertical moving quantity of eyeballs simultaneously. When eyeballs moves to the right, to the left, up or down, the electrodes obtain signals due to muscle change. An isolated circuit is used to separate input signals and computer for safety concern.

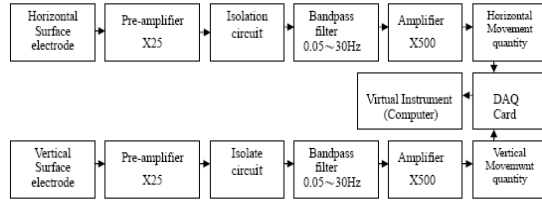


Figure 1: The block diagram for measuring the motion of eyeballs

B. DAQ Card

M Series PCI-6251 is used as data acquisition interface. Figure 2 shows the shape and pinout of PCI-6251. In the device, one side is connected to external measurement circuit and the other side is connected to the computer with Labview software. The installation of the DAQ card included: (1) Installation of the application software - Labview 7.1.(2) Installation of the DAQ card driver first, before assembling DAQ card into the desktop computer. This process can ensure WINDOWS to detect the DAQ card. (3) Install the necessary devices, accessories and cables. (4) Power on the computer. (5) Confirm that the device is recognized. (6) Run the test Panel.

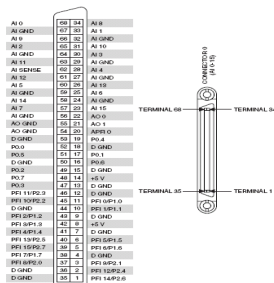


Figure 2: M Series PCI-6251 pinout

C. Virtual Electro-oculogram Software design

(1) Front panel design

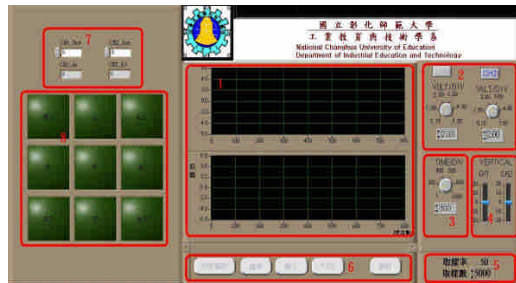


Figure 3: The front panel of virtual electro-oculogram design

Label 1: It is a display window for measuring signals. Waveforms are specified in channel A (CH A Source) and channel B (CH B Source). The signals are plotted amplitude versus time. Label 2: In this part, users can adjust the voltage range of display window in Y scale. Label 3: In this part, users can adjust measuring time in X scale. The time base setting determines the X-axis time scale in units of seconds/division. Label 4: Vertical Position Knob — Adjust the vertical position of the CH A and CH B traces by applying positive or negative vertical offset. The default is zero offset. The offset is referenced from the zero point of the graph. This offset value is not applied to the actual acquired data. Label 5: This part displays the total rate at which the SFP acquires the data. The units for this measurement are S/s. Label 6: This part contains run button—Starts or stops continuous data acquisition on selected channel sources, single button—Performs a single-sweep acquisition on the selected source channels and log button—Generates a comma-delimited text file with the data of the last acquired waveforms. Logging is available in the absence of acquisitions. Label 7: CH1_Test and CH2_Test are used to test if the instrument is functioning well. CH1_Av and CH2_Av are designed to show the average values of signals. Label 8: It is a designed nine-square division showing the instant moving status and created output signals for further control application use.

(2) Block diagram design

In the block diagram design, two major contributions are introduced. The first one is the design of error compensation in eyeball moving signals and the second one is the nine-square division design of eyeball movement.

a. The design of error compensation in eyeball moving signals

The real eyeball moving signals could be positive or negative. But, the measured signals are needed to be processed by A/D conversion to input into the computer. This makes the signals positive for easier signal processing. The signal from the moving eyeball is constructed by 8 bits; therefore, there are 256 different voltage changes. Moreover, the signal voltage inside the significantly higher than the real measured signals due to the signal amplification of external circuit, so an error compensation for the eyeball moving signal design is needed. Figure 4 is the block diagram of the error compensation for the eyeball moving signals.

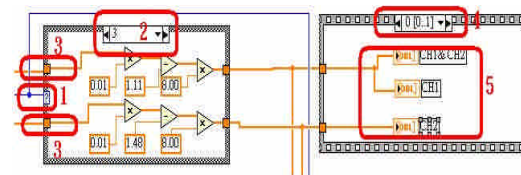


Figure 4: The block diagram of the error compensation for the eyeball moving signals

b. Nine-square division design for eyeball movement.

The nine-square division design of eyeball movement is constructed by three parts as shown in figure 5. The first part containing CH1_Test and CH2_Test are used to test if the nine-square division design for eyeball movement is working well. The second part is designed to transfer analog signals into digital signals for display use of part 3. The third part is used to show the measured average values and the display of nine-square division design for eyeball movement.

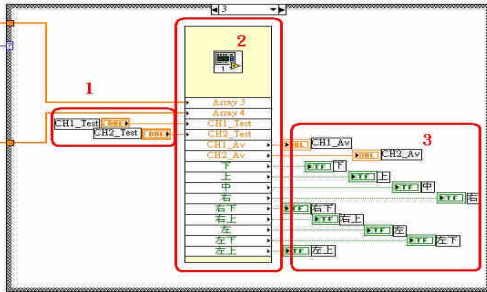


Figure 5: The block diagram of nine-square division design of eyeball movement.

Figure 6 shows the detail design of part 2 of figure 4. This particular A/D transforming design can also be divided into three parts.

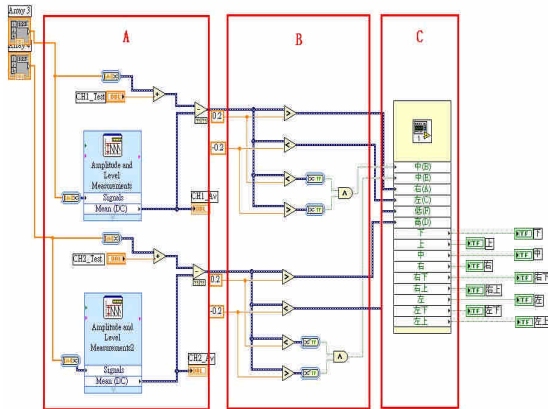


Figure 6: The block diagram of nine-square division design of eyeball movement.

The part 1 adjusts the measured signals into the DC offset to be zero. The Amplitude and Measurements.vi that is the express .vi in Labview is applied to measure the average DC values for completing the adjustment of DC offset. The part 2 transforms analog signals into digital signals. The upper limit of the voltage to decide as “high” is 0.2 voltage. The lower limit of the voltage to decide as “low” is -0.2 voltage. Between -0.2 and 0.2 is judged as “0”. The part 3 performs the logic judgment to decide which LED should be light in the nine-square division for eyeball movement. Table 1 shows the true table of logic judgment.

Table 1: The truth table of logic judgment

CH1(horizontal)			CH2(vertical)			LED display								
(R)	(M)	(L)	(H)	(M)	(L)	LH	H	RH	L	M	R	LL	L	RL
1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
1	0	0	1	0	0	0	0	0	1	0	0	0	0	0
1	0	0	0	1	0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	1	0	0	0	0	0	0	1	0	0
1	0	0	0	0	0	1	0	0	0	0	0	0	0	1
0	1	0	1	0	0	0	1	0	0	0	0	0	0	0
0	1	0	0	1	0	0	0	0	0	1	0	0	0	0
0	1	0	0	0	1	0	0	0	0	0	0	0	1	0
0	0	1	1	0	0	1	0	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0	1	0	0	0	0	0	0
0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0	1	0	0	0	0

By Boolean expression and simplification, these logic signals can be represented as

$$\begin{aligned}
 LH &= \bar{A} \bar{B} C D \bar{E} \bar{F}; & H &= \bar{A} \bar{C} D \bar{E} \bar{F}; \\
 R &= A \bar{B} \bar{C} D \bar{E} \bar{F}; & L &= \bar{A} \bar{B} C \bar{D} \bar{F}; \\
 M &= \bar{A} \bar{C} \bar{D} \bar{F} (B + \bar{B} E); & R &= A \bar{B} \bar{C} \bar{D} \bar{F}; \\
 L &= \bar{A} \bar{B} C \bar{D} \bar{E} F; & L &= \bar{A} \bar{C} \bar{D} \bar{E} F; \\
 L &= A \bar{B} \bar{C} \bar{D} \bar{E} F
 \end{aligned}$$

Then the above expressions can be applied to construct a logic structure using Labview as shown in figure 7.

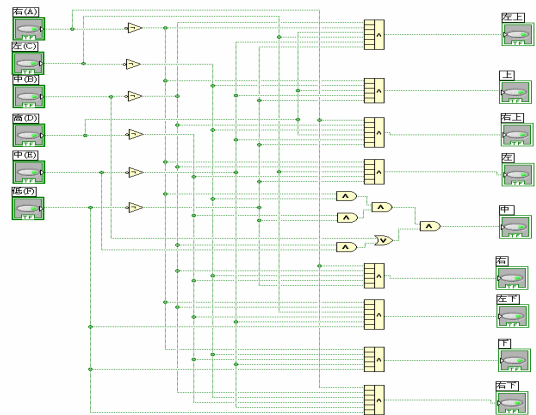


Figure 7: The structure of logic judgment by Labview

3. Practical electro-oculogram measurement test

Figure 8 shows the locations of the electrodes. Table 2 shows the different practical measurement tests by using the designed and constructed virtual electro-oculogram.

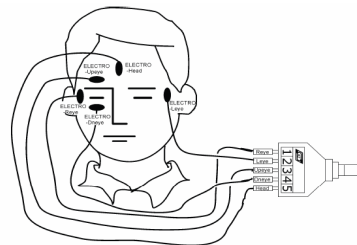


Figure 8: The location of the electrodes.

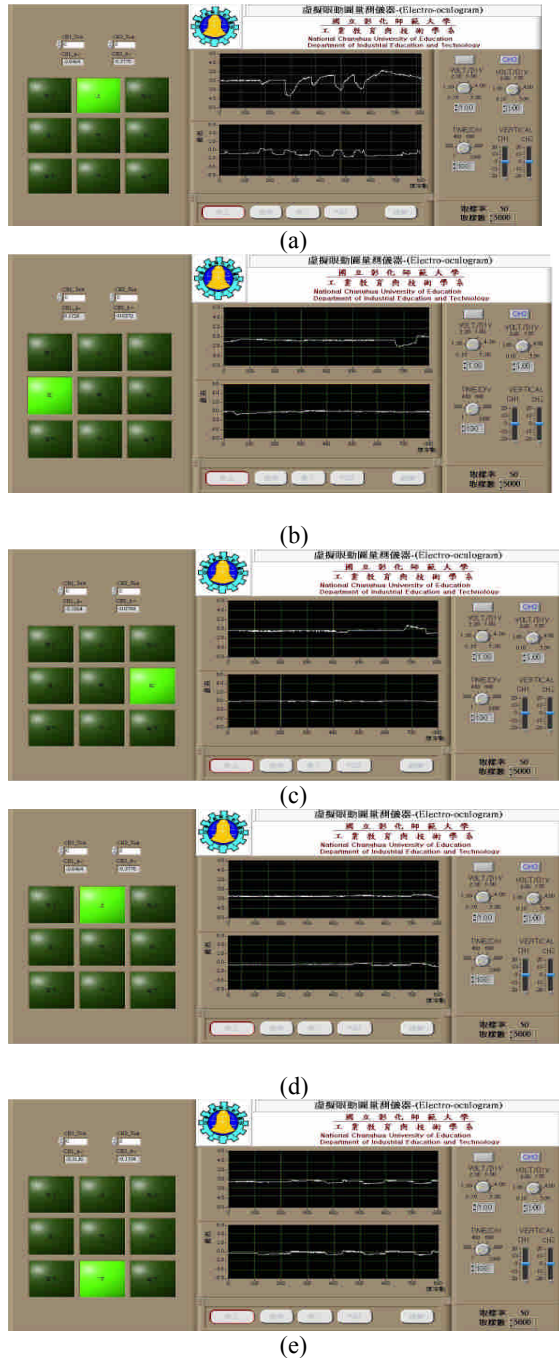


Figure 9:

- (a) The measurement test with blinking 5 times and 1 second interval
- (b) The measurement test with the eyeballs having right movement
- (c) The measurement test with the eyeballs having left movement
- (d) The measurement test with the eyeballs having up movement
- (e) The measurement test with the eyeballs having down movement

III. CONCLUSION

In this research, a new electro-oculogram measurement technique is designed and constructed by integrating virtual instrument possessing characteristics of flexibility, reusability and user friendly. The instrument can assist in the diagnosis of Parkinson's disease and Alzheimer's. Moreover, this instrument has a nine-square division design for the instant movement of eyeballs but also can produce nine signals for application use such as wheelchair control or computer mouse control for disability. When the embedded network function is enabled and set, the remote measurement and remote control can be enabled. The completion of this research will open the door for designing virtual physiological measurement instrument by Labview in all applications.

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