DEVELOPMENT OF A REAL-TIME IN CAR PHYSIOLOGICAL ACQUISITION SYSTEM FOR MONITORING ATTENTION DRIFTING PHENOMENON

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MASTER OF SCIENCE IN ELECTRONIC ENGINEERING

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A thesis submitted
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DECLARATION

I declare that this thesis entitled "Development Of A Real-Time In-Car Physiological Acquisition System For Monitoring Attention Drifting Phenomenon" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : **ZULHILMI BIN ZAID**

Date : 22/6/2021

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science in Electronic Engineering.

Signature :

Supervisor Name : ***IZADORA BINTI MUSTAFFA***

Date :

DEDICATION

To my beloved parents and to my mentor

ABSTRACT

Road accidents is ranked as the fifth cause of death in Malaysia. Every year, almost 7,000 deaths were reported due to road accidents. The long-standing reason for cause of accidents is lost of attention. Lost of attention, also known as habituation, is highly undesirable while performing tasks which requires concentration for a long period of time such as long distance driving. There are several factors that contribute to habituation, such as familiar or monotonous driving routes and fatigue. As the number of accidents have reached to a number that concerns Malaysian Institute of Road Safety Research (MIROS), which is almost 7,000 deaths were reported, many solutions were suggested in order to tackle the growing issue. Hence, this research is to establish an objective of direct measurement method using encephalogram (EEG) to detect the occurrence of habituation while driving then to alert the driver. The development of this system involves the development of a real-time signal processing algorithm to acquire event related potentials (ERPs) from EEG for the detection of habituation; develop an in-car biosensors monitoring system and efficient data acquisition. Where most of the methods on detecting loss of attention are indirect, EEG provides a direct measurement of the level alertness of a person. This research is a significant endeavor in measuring the level of attention during driving as it capture the moment when the attention level begins to drift in the ERPs from the EEG signal in real-time. A low-power consumption of an EEG signal acquisition system has been designed to record the electrical activity of the brain non-invasively. The system consists of an amplifier with a bandwidth of 0.13 Hz – 12 Hz which was designed using low-power instrumentation amplifier AD620, low power and high gain operational amplifier CA3130. The resulting gain ranges from 20 µV to 5 V. The amplified acquired signal is then filtered using a notch filter to remove the power signal interference. The signal then goes into Arduino Due. Here the signal is segmented into 500 single-trials of 500 ms for further noise removal using the averaging technique. The output will be used to check on the habituation scale, known as Attention Degrading Scale (ADS). The scale is based on the threshold value obtained from fuzzy-rule based system, which is the value towards the negative threshold inteprets that the amplitude difference of N100 ERP component waveform decreased that brought the definition of the attention is degrading. The resulting signal is used for habituation detection.

PEMBANGUNAN SISTEM PEROLEHAN FISIOLOGI MASA NYATA BAGI PEMANTAUAN FENOMENA PERHATIAN HANYUT DALAM KERETA

ABSTRAK

Kemalangan jalanraya berada di tangga kelima sebagai penyebab utama kematian di Malaysia. Setiap tahun, hampir 7,000 angka kematian dicatatkan akibat kemalangan jalan raya. Kehilangan daya tumpuan, atau dikenali juga sebagai habituasi, ketika melaksanakan tugas yang memerlukan tumpuan yang tinggi dan dalam tempoh masa yang lama adalah sesuatu yang amat tidak diingini. Terdapat beberapa faktor yang menyumbangkan kepada habtiuasi, seperti laluan perjalanan yang sudah biasa, monoton atau keletihan. Oleh kerana angka kematian yang dicatatkan membimbangkan Institut Penyelidikan Keselamatan Jalan Raya (MIROS), iaitu hampir 7,000 kematian dicatatkan, pelbagai cara dan kaedah telah dilakukan untuk mengurangkan kadar kemalangan. Oleh yang demikian, objektif penyelidikan ini adalah untuk membangunkan satu kaedah pengesanan langsung menggunakan encephalogram (EEG) untuk mengesan kehadiran habituasi ketika memandu dan menyedarkan pemandu. Pembangunan sistem ini melibatkan pembangunan algoritma isyarat pemprosesan masa nyata yang digunakan untuk memperoleh acara-berkait potensi (ERP) daripada EEG bagi mengesan habituasi; membangunkan sistem pemantau penderia bio dalam kereta dan sistem yang mampu mencatatkan data dengan cekap. Kebanyakan kaedah mengesan habituasi adalah kaedah secara tidak langsung, EEG memberikan pengukuran secara langsung tahap data tumpuan seseorang.Penyelidikan ini menjadi usaha penting dalam mencatatkan tahap tumpuan seseorang ketika memandu kerana ia meraih saat ketika tahap penumpuan mula hanyut dalam ERPs daripada EEG yang diperoleh secara masa nyata. Sebuah sistem perolehan EEG berkuasa rendah telah direka untuk merakam aktiviti elektrikal otak secara tidak invasif. Sistem ini terdiri daripada penguat gandaan tinggi. Hasil gandaan akhir berada di antara nilai 20 µV hingga 5 V. Isyarat yang diperoleh setelah digandakan ditapis menggunakan penapis tanda genting untuk menyingkirkan interferen isyarat kuasa. Isyarat tersebut kemudian didigitalkan dan masuk ke dalam Arduino Due. Di sini isyarat tersebut akan disegmenkan kepada 500 purata perolehan percubaan yang berjulat 500 ms untuk dinyahhinggar lagi dengan menggunakan teknik pemurataan. Hasil pengeluaran tersebut akan digunakan untuk menguji skala habituasi yang dikenali sebagai Skala Pemerhatian Merosot (ADS). Skala tersebut adalah suatu nilai takat yang diperoleh berdasarkan sistem logik kabur, di mana nilai yang menghampiri kepada takat negatif akan dibaca sebagai nilai amplitud perbezaan bentuk gelombang komponen N100 ERP yang menurun, dan membawa kepada definisi perhatian yang merosot. Isyarat yang diperolehi akan digunakan untuk mengesan habituasi.

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LIST OF SYMBOLS AND ABBREVIATIONS

AC	-	Alternate Current
ADAS	-	Advanced Driver Assistance Systems
ADC	-	Analog-to-Digital Converter
ADCH	-	Analog-to-Digital Converter High
ADCL	-	Analog-to-Digital Converter Low
ADSC	-	ADC Start Conversion
ADCSRA	-	ADC Control & Register
ADEN	-	ADC Enable
ADIE	-	ADC Interrupt Enable
ADIF	-	ADC Interrupt Flag
ADS	-	Attention Degradation Scale
AEP	-	Auditory Evoked Potential
Ag	-	Silver
AgCl	-	Silver Chloride
ADMUX	-	ADC Multiplexer Selection Register
Ax	-	Analog Pin at pin A0 until A5
AR	-	Autoregressive
BCI	-	Brain-Computer Interfacing
BLE	-	Bluetooth Low Energy
C	-	Celcisu
C	-	Capacitor
C++	-	C++ Command Language
CAD	-	Computer Aided Design
CMRR	-	Common Mode Rejection Ratio
CPU	-	Central Processing Unit
CSI	-	Camera Serial Interface
CTIA	-	Cellular Telecommunications and Internet Association
dB	-	Decibel
DC	-	Direct Current

DIO	-	Digital Input Output
DIY	-	Do-It-Yourself
DDR	-	Data Direct Registration
DSI	-	Display Serial Interface
DUI	-	Driving Under Influence
ECG	-	Electrocardiography
EEG	-	Electroencephalograhy
EEPROM	-	Erasable Programmable Read-Only Memory
EMA	-	Exponential Moving Average
EMG	-	Electromyography
EP	-	Evoked Potential
ERP	-	Event-Related Potential
ESD	-	Electro Static Discharge
EWMA	-	Exponential Weighted Moving Average
FFT	-	Fast Fourier Transform
FIR	-	Finite Impulse Response
f_c	-	Cut-off Frequency
f_s	-	Sampling Frequency
g	-	Gram
G	-	Gain
GΩ	-	Giga-ohm
GPIO	-	General Purpose Inputs and Outputs
Hz	-	Hertz
IA	-	Instrumentation Amplifier
I^2C	-	Internal Integrated Chips
IC	-	Integrated Chip
ICs	-	Integrated Chips
IDE	-	Integrated Development Environment
IIR	-	Infinite Impulse Response
I/O	-	Input or Output
IoT	-	Internet of Things

LM	-	Language Model
kΩ	-	Kilo-Ohm
KB	-	Kilo Byte
mA	-	Milli-Ampere
mm	-	Milli-metre
MΩ	-	Mega-Ohm
MA	-	Moving Average
MCU	-	Microcontroller Unit
MIROS	-	Malaysian Institute of Road Safety Research
MUX	-	Multiplexer
nA	-	nano-Ampere
OPS	-	Operasi Sikap
R	-	Resistor
P	-	Period
PCB	-	Printed Circuit Board
P3-S	-	P300-Speller
PWM	-	Pulse Width Modulation
RAND	-	Random Noise
RC	-	Resistor Capacitor
S	-	Set
s	-	Second
SAS	-	Student Assessment System
SC	-	Stratum Corneum
SCL	-	Serial Clock
SDA	-	Serial Data
SMA	-	Simple Moving Average
SNR	-	Signal-to-Noise Ratio
SPI	-	Serial Peripheral Interface
SRAM	-	Static RAM
T	-	Time Constant
TTL	-	Transistor Transistor Logic

TWI	-	Two Wire Interface
UV	-	Ultra Violet
UART	-	Universal Asynchronous Receiver Transmitter
V	-	Voltage
VCC+	-	Voltage Supply Positive
VCC-	-	Voltage Supply Negative
$V_{p.p}$	-	Voltage Peak-to-Peak
WMA	-	Weighted Moving Average
µF	-	micro-Farad
µV	-	micro-Voltage
Ω	-	Phase
Π	-	3.142

LIST OF APPENDICES