Faculty of Manufacturing Engineering

DEVELOPING REGRESSION MODELS OF DRIVER FATIGUE USING AN ERGONOMICS APPROACH

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DECLARATION

I declare that this thesis entitled "Developing Regression Models of Driver Fatigue using An Ergonomics Approach" 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 : .....

Date : .....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Manufacturing Engineering.

Signature : .....

Supervisor Name : .....

Date : .....

DEDICATION

I dedicated this thesis tp my parents. I hope that this achievement will complete the dream that they had for me all those many years ago when they chose to give me the best education they could.

ABSTRACT

Nowadays, driving activity has become more important as this medium being practically, faster and cheaper in connecting human from one to another places. However, driving activity can cause disaster or death to human in daily life as they get fatigued while driving. Driver fatigue is a top contributor to the road crashes. Psychophysical factors and biomechanical factors were identified as the causes of driver fatigue among Malaysian. The primary aim of this research is to develop the regression models based on psychophysical and biomechanical factors that contributes to fatigue, which the models can predict the relationship between the input parameters and output responses. Regression analysis was used, as this being practical, easy, user friendly and cost effective methods to develop a model. This research investigated the hand grip pressure force for the right hand and left hand while driving through different road conditions, study the relationship between the road conditions with hand grip pressure force and muscle fatigue, study the interaction between road condition with seat pressure distribution force and whole body vibration (WBV), heart rate monitoring, and developed the regression models of psychophysical factors and biomechanical factors for driver fatigue. The input parameters evaluated were time exposure, type of road, and gender; the output responses being muscle fatigue (voltage), heart rate (beats per minutes), hand grip pressure force (left hand), hand grip pressure force (right hand), seat pressure distribution force, and vibration (root mean square). Six regression models were successfully developed and validated. The modelling, validation runs were within the 90% prediction interval of the developed models and their residual errors compared to the predicted values were less than 10%. The significant parameters that influenced the output responses were also identified. Muscle fatigue, hand grip pressure force (left hand), and hang grip pressure force (right hand) were influenced by time exposure, type of road, gender, interaction between time exposure and type of road, and interaction between type of road and gender; heart rate was influenced by time exposure, type of road, and gender; pressure distribution force was influenced by time exposure, type of road, gender, interaction between time exposure and gender, and interaction between type of road and gender; and WBV was influenced by time exposure, type of road, gender, interaction between time exposure and type of road, and interaction between time exposure and gender.

ABSTRAK

Pada masa kini, aktiviti memandu menjadi amat penting kerana ia menjadi medium dalam menghubungkan manusia dari satu tempat ke satu tempat yang lain. Walaubagaimanapun, aktiviti memandu boleh menyebabkan bencana atau kematian kepada manusia dalam kehidupan harian sekiranya mereka mengalami keletihan semasa memandu. Keletihan ketika memandu merupakan penyumbang utama kepada nahas jalan raya. Faktor-faktor psiko fizikal dan faktor-faktor biomekanikal telah dikenal pasti sebagai penyebab kepada keletihan memandu dikalangan rakyat Malaysia. Tujuan utama penyelidikan ini adalah untuk membina model regresi berdasarkan faktor-faktor psiko fizikal dan faktor-faktor biomekanikal yang menyumbang kepada keletihan, yang mana regresi model tersebut dapat meramalkan hubungan antara parameter masukan dan tindakbalas keluaran. Analisis regresi telah digunakan untuk membina model kerana ia dikatakan mudah diguna, mesra pengguna, dan kaedah yang kos efektif untuk membina model. Penyelidikan ini menyiasat daya genggaman tangan kanan dan kiri semasa memandu melalui keadaan atau jenis-jenis jalan yang berbeza-beza, mempelajari hubungan antara keadaan jalan atau jenis jalan dengan daya genggaman tangan dan kelesuan otot, mempelajari interaksi antara keadaan jalan atau jenis jalan dengan taburan tekanan kerusi, dan getaran seluruh badan, pengawasan kadar denyutan jantung, dan membina model regresi untuk faktor-faktor psiko fizikal dan biomekanikal bagi keletihan memandu. Parameter masukan yang dinilaikan ialah dedahan masa, jenis jalan atau keadaan jalan, dan jantina; tindakbalas keluaran pula ialah kelesuan otot, kadar denyutan jantung, daya genggaman tangan kanan dan kiri, taburan tekanan kerusi, dan getaran seluruh badan. Enam model regresi telah berjaya dibina dan disahkan. Pengesahan model menunjukkan model berada diantara 90% prediction interval (selang ramalan) dan residual error (ralat sisa) model yang dibandingkan dengan nilai ramalan kurang daripada 10%. Parameter penting yang mempengaruhi respon keluaran juga dikenal pasti dalam penyelidikan ini. Kelesuan otot, dan daya genggaman tangan kanan dan kiri, dipengaruhi oleh dedahan masa, jenis jalan, jantina, interaksi antara dedahan masa dan jenis jalan , dan interaksi antara jenis jalan dan jantina; kadar jantung dipengaruhi oleh dedahan masa, jenis jalan , dan jantina; daya taburan tekanan kerusi dipengaruhi oleh dedahan masa, jenis jalan, jantina, interaksi antara dedahan masa dan jantina , dan interaksi antara jenis jalan dan jantina; dan Getaran seluruh badan dipengaruhi oleh dedahan masa, jenis jalan, jantina, interaksi antara dedahan masa dan jenis jalan , dan interaksi antara dedahan masa dan jantina.

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LIST OF ABBREVIATIONS

2FI	-	Two Factor of Interaction
AAC	-	Average Accuracy
ANOVA	-	Analysis of Variance
ATP	-	Adenosine Triphosphate
AS	-	Australian Standard
ASCII	-	American Standard Code for Information Interchange
BNC	-	Bayonet Neil-Concelman
BPM	-	Beats Per Minute
CF	-	Crest Factor
CI	-	Confidence Interval
CMRR	-	Common Mode Rejection Rate
DR	-	Detection Rate
DSS	-	Decision Support System
EAV	-	Exposure Action Value
ECG	-	Electrocardiogram
ELV	-	Exposure Limit Value
EMG	-	Electromyography
EU	-	European Union
FAR	-	False Alarm Rate

FLX	-	Facelift Extra
HA	-	Head Acceleration
HAV	-	Hand Arm Vibration
HGCZ	-	Health Guidance Caution Zone
HR	-	Heart Rate
HRV	-	Heart Rate Variability
HVM	-	Human Vibration Meter
IEPE	-	Integrated Electronics Piezo Electric
ISO	-	International Standard
LBP	-	Low Back Pain
LED	-	Light Emitting Diode
LH	-	Left Hand
MIROS	-	Malaysian Institute of Road Safety
MPF	-	Mean Power Frequency
MPV	-	Multipurpose Vehicle
MSD	-	Musculoskeletal Disorder
NHTSA	-	National Highway Traffic Safety Administration
PI	-	Prediction Interval
P-P	-	Peak Acceleration
PVD	-	Physical Vapour Deposition
RH	-	Right Hand
RMS	-	Root Mean Square
SD	-	Suspension Deflection
SEMG	-	Surface Electromyography