SIMULATION STUDY ON ACTIVE AMBULANCE STRETCHER

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I have read this thesis

and from my opinion this thesis

is sufficient in aspects of scope and quality for awarding

Bachelor of Mechanical Engineering (Automotive)

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Name of Supervisor II: …………………….

Date : …………………….

"I declare this report is on my own work except for summary and quotes that I have mentioned its sources"

Signature :

Name of Author :

Date :

To my beloved family

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ABSTRACT

The aims of this research are to establish to non-linear mathematical model and active control technique of the hydraulically actuated active suspension system for a full stretcher ambulance ride model. It is characterized by a special-purpose 3-degree of freedom parallel structure. This compact mechanical architecture is able to compensate the shocks caused by road unevenness while performing pitch and roll rotations during accelerating, braking and curving phases. Stretcher loading and unloading operations have been considered. Direct and inverse kinematics and control strategy are discussed, and the system effectiveness is shown by simulation results. A simulation study is performed to proof the effectiveness and active control approach. The result thus compared with the passive suspension system. The simulation will be performed in *MATLAB Simulink.* The purpose of this research is not to create a better suspension, but to investigate how active control can improve ambulance stretcher ride and also to reduce this undesirable effect of the input vibration from road and driving behavior. A theoretical model of two-dimensional active control for ambulance stretcher suspension is proposed. Numerical calculations are carried out to examine the effectiveness of active control strategy, which is synthesized to minimize the mean square vertical and pitching response whilst considering the relative displacement of stretcher suspension. It shows that the active control with disturbance feed forwarded provides significant reduction of vertical and pitch angular acceleration of stretcher compared with the passive stretcher suspension. The relative displacement and resonance peak values of vibration components in the sensitive frequency range of human body are effectively suppressed in comparison with the passive stretcher.

ABSTRAK

Kajian ini bertujuan mengetengahkan model matemetik tak linear dan teknik kawalan aktif dalam pemodelan dan kawalan ke atas gantungan aktif dengan dinamik hiraulik untuk model pengusung ambulan. Ianya berpandukan ciri-ciri yang digunakkan pada 3-darjah kebebasan rangka selari. Melalui senibina mekanikal kompleks, gegaran yang terhasil daripada ketidakrataan permukaan jalan raya ketika berlakunya situasi kecondongan, kegolekkan semasa memecut, membrek dan pada tahap kelengkungan. Proses menurunkan dan menaikkan beban pada usungan ambulan. Perulangbalikan kinematik dan strategi kawalan dibincangkan, dan sistem keberkesanan ditunjukkan dalam keputusan simulasi. Kajian simulasi dilakukan untuk membuktikan keberkesanan dan perkaitan sistem kawalan aktif. Hasil kajian kemudiannya dibandingkan dengan sistem kawalan pasif. Simulasi akan dijalankan mengunakan *(Matlab Simulink).* Tujuan kajian ini dijalankan bukannya untuk membina suatu sistem gantungan yang baik, tetapi menyiasat bagaimana kawalan aktif ini dapat meningkatkan pemanduan pada usungan ambulan serta mengurangkan kesan yang tidak diinginkan daripada gegaran dari keadaan jalan dan tingkah laku permanduan. Model teori dua-dimensi dicadangkan bagi sistem gantungan gantungan pada usungan ambulan. Pembentukan persamaan saringan berkadar dengan masa dikembangkan bagi melangkapkan anggaran kepada ganguan dinamik. Pekiranan nombor di bawa keluar untuk menyelidiki keberkesanan strategi kawalan akif, yang mana dapat mengurangkan purata seimbang pada keadaan lurus dan kecondongan semasa mempertimbangkan sesaran relatif penggantungan usungan. Ia menunjukkan yang kawalan aktif dengan suapan gangguan dihantar bagi menyediakan pengurangan signifikasi tegak dan pecutan sudut kecondongan usungan berbanding dengan usungan gantungan pasif. Sesaran relatif dan nilai-nilai puncak gema bahagian-bahagian getaran dalam julat frekuensi sensitif badan manusia adalah berkesan dalam perbandingan dengan usungan pasif.

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LIST OF SYMBOLS

a = Distance of sprung mass C.G. from front axle

b = Distance of sprung mass C.G. from rear axle

C_{sfl} = Front left suspension damping coefficient

C_{sfr} = Front right suspension damping coefficient

C_{srl} = Rear left suspension damping coefficient

C_{srr} = Rear right suspension damping coefficient

F_{fl} = Front left suspension force

F_{fr} = Front right suspension force

F_{rl} = Rear left suspension force

F_{rr} = Rear right suspension force

F_{sfl} = Front left spring force

F_{sfr} = Front right spring force

F_{srl} = Rear left spring force

F_{srr} = Rear right spring force

F_{dfl} = Front left damper force

F_{dfr} = Front right damper force

F_{drl} = Rear left damper force

F_{drr} = Rear right damper force

h = Height of vehicle C.G.

I_p = Pitch moment of inertia

I_r = Roll moment of inertia

K_{sfl} = Front left suspension stiffness

K_{sfr} = Front left suspension stiffness

K_{srl} = Rear left suspension stiffness

K_{srr} = Rear right suspension stiffness

K_{tfl} = Front left tire stiffness

K_{tfr} = Front right tire stiffness

K_{trl} = Rear left tire stiffness

K_{trr} = Rear right tire stiffness

l_f = Distance of vehicle C.G. from front axle

l_r = Distance of vehicle C.G. from rear axle

m_s = Sprung mass

m_{ufl} = Front left unsprung mass

m_{ufr} = Front right unsprung mass

m_{url} = Rear left unsprung mass

m_{urr} = Rear right unsprung mass

w = Track width

Z_{rfl} = Front left road profile

Z_{rfr} = Front right road profile

Z_{rrl} = Rear left road profile

Z_{rrr} = Rear right road profile

$\ddot{Z}_s$ = Sprung mass vertical acceleration at body C.G.

Z_{sfl} = Front left sprung mass displacement

$\dot{Z}_{sfl}$ = Front left sprung mass velocity

Z_{sfr} = Front right sprung mass displacement

$\dot{Z}_{sfr}$ = Front right sprung mass velocity

Z_{srl} = Rear left sprung mass displacement

$\dot{Z}_{srl}$ = Rear left sprung mass velocity

Z_{srr} = Rear right sprung mass displacement

$\dot{Z}_{srr}$ = Rear right sprung mass velocity

Z_{srl} = Rear left sprung mass displacement

Z_{ufl} = Front left unsprung mass vertical displacement

$\dot{Z}_{ufl}$ = Front left unsprung mass vertical velocity

$\ddot{Z}_{ufl}$ = Front left unsprung mass vertical acceleration

Z_{ufr} = Front right unsprung mass vertical displacement

$\dot{Z}_{ufr}$ = Front right unsprung mass vertical velocity

$\ddot{Z}_{ufr}$ = Front right unsprung mass vertical acceleration

Z_{url} = Rear left unsprung mass vertical displacement

$\dot{Z}_{url}$ = Rear left unsprung mass vertical velocity

$\ddot{Z}_{url}$ = Rear left unsprung mass vertical acceleration

Z_{urr} = Rear right unsprung mass vertical displacement

$\dot{Z}_{urr}$ = Rear right unsprung mass vertical velocity

$\ddot{Z}_{urr}$ = Rear right unsprung mass vertical acceleration

θ = Pitch angle at the body C.G.

$\dot{\theta}$ = Pitch rate at the body C.G.

$\ddot{\theta}$ = Pitch acceleration at the body C.G.

ϕ = Roll angle at the body C.G.

$\dot{\phi}$ = Roll rate at the body C.G.

$\ddot{\phi}$ = Roll acceleration at the body C.G.

CHAPTER I

INTRODUCTION

1.1 Project Background

For seriously injured patients the ambulance transport is often very dangerous. During about 10% of journeys some patient deterioration occurs. In order to avoid this risk, it's often necessary to remarkably reduce the ambulance speed, but obviously this also may be dangerous. The most harmful vibrations to patients lying down are between about 2 and 8 Hz, close to the natural frequency of the human body. The vibrations caused by the road unevenness and transmitted through the vehicle suspensions are quite strong in this frequency range; the use of a device to isolate the patient can bring important benefits. Moreover, also the accelerations due to the ambulance trajectory (curves and speed variations) are harmful to patients (Source L.E. Bruzzone and R.M. Molfino, 2003).

For this project I am using Matlab SIMULINK to design mechanism of the active ambulance stretcher of ambulance for full car model. The block diagrams are drawn in Matlab Simulink based on the full car model according to the parameters. The block diagrams will drawn from the car model which was consider on body, damper, spring, actuator and wheel and describes of the Active Ambulance Stretcher, including control system design and performance evaluation. From the results of driving experiments and simulation, it shows that the Active Ambulance Stretcher is able to reduce the vibration acting on a patient.

1.2 Scope

The objective of this project is to propose control mechanism of the active ambulance stretcher for ambulance in Malaysia.

1.3 Research Objective

MATLAB Simulink Software will be chosen as a computer design tools used to simulate the dynamics behavior and evaluate the performance of the control structure. The research methodology implemented in this project takes the following steps of works: literature review on related fields, study some previous works and the latest development on active ambulance stretcher, development of equation of motion, simulation and comparison with the passive system.

The Active Suspension System is divided into three main categories:

- Study about software called SIMULINK
- To study about passive suspension system in full stretcher ambulance ride model.
- To study about active suspension system in full stretcher ambulance ride model.
- To do the comparative study between passive suspension and active suspension.
- To simulate the system using software called SIMULINK.

1.4 Problem Statement

An ambulance transfer service is required to take a patient to hospital as quickly and safely as possible. However, it is difficult to meet this requirement since there is essentially a trade-off between quickness and safety, quick transportation exposes a patient to large vibration acceleration or inertial acceleration, which causes strong pain, feeling of discomfort or sometimes critical damage for seriously injured persons. It is possible to reduce the acceleration by driving an ambulance carefully, but it usually results in a longer delay until hospital arrival.

Passive control method has a disadvantage of disturbance rejecting when used to control suspension system**.** Active control is believed can give a better control for active suspension system in term of maintaining a smooth drives for the drivers. The pneumatic tire is the first line of defenses and is the most important of all the suspension mediums.

1.5 Structure and Layout of Report

This project work towards developing active suspension and passive suspension for quarter car, using *Matlab Simulink* is presented in five chapters. As the development progress can be divided in to 5 main categories.

The first chapter introduces the active suspension system and details the problem statement and objective of this project.

The second chapter reports on the review of literature on passive and active suspension system that inspires the scope of the present report.

Chapter three proposes a method of design of the system in software by using *Matlab Simulink* software.

Chapter four, deals with result and discussion of active suspension system's operation and design. Application of this suspension is also discussed. A compressive summary of the project efforts and the conclusions derived from this project work is presented in chapter five. Constraints and future research potential of the passive and active suspension system are also presented.

Gantt chart for PSM I

NO.	TASK	WEEK															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Confirming title	■															
2	Literature review	■	■														
3	Collect The Data From Previous Study			■	■	■											
4	Solving problems				■	■											
7	Collecting raw data from the actual ambulance stretcher						■	■	■								
8	Preparation of progress report							■	■								
9	Develop mathematical equation							■	■	■							
10	Ambulance stretcher concept design									■	■	■					
11	Preparation on technical report										■	■					
12	Edit technical report											■	■	■	■	■	■
13	Submission of technical report													■	■	■	■

Gantt chart for PSM II

NO.	TASK	WEEK													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Survey form/questionnaire														
2	Simulation passive and active suspension														
3	Comparison results														
4	Discussion of comparison results														
5	Validation results														
6	Preparation on technical repot														
7	Submission of technical repot														

CHAPTER II

LITERATURE REVIEW

2.0 Introduction

Basicaly the ambulance stretcher is very basic stracture to carry out the patient. It may be dangerous trauma to the patient with the accelerations due to a fast ambulance journey. A special active control system, interposed between the ambulance frame and the stretcher, and a possible control strategy have been designed in order to compensate the road profile and the accelerations due to the ambulance trajectory. In order to avoid this risk, it's often necessary to remarkably reduce the ambulance speed, but obviously this also may be dangerous.