ACTIVE SUSPENSION SYSTEM WITH FUZZY LOGIC CONTROLLER

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Tajuk Projek : ACTIVE SUSPENSION SYSTEM WITH FUZZY LOGIC CONTROLLER

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DEDICATION

Special dedication to my beloved father and mother, my brother and sister, and my kind hearted supervisor Mr. Amat Amir bin Basari also to all my dearest friends.

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In the name of ALLAH SWT, the most gracious, who gave me the strength and ability to complete this study. All perfect praises belong to ALLAH SWT, lord of the universe. May His blessing upon the prophet Muhammad SAW and member of this family and companies.

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ABSTRACT

Suspension system design plays an important role in improving passenger ride comfort. Traditionally automotive suspension designs have been a compromise between the two conflicting criteria of suspension travel and road handling ability. Demand for better ride comfort and good car handling have motivated researchers to develop new type of suspension systems. Road holding ability is associated with the contact forces of the tires and the road surface. These contact forces are assumed to depend linearly on the tire deflection. Suspension travels refers to the relative displacement between the sprung and unsprung masses. The present work aims at developing an active suspension system for the quarter car model of a passenger car to improve its performance by using a Fuzzy Logic Controller. To verify the performance of the active suspension system we simulate it using MATLAB and compare the performance of both systems.

ABSTRAK

Sistem suspensi memainkan peranan penting dalam memperbaiki keselesaan perjalanan penumpang. Secara tradisionalnya, rekabentuk sistem suspensi automotif telah dipengaruhi oleh dua faktor penting dalam memenuhi keselesaan penumpang. Permintaan yang tinggi dalam keselesaan dan pengawalan sesuatu kenderaan telah membuka minda untuk mencipta sistem suspensi yang lebih baik seperti sistem suspensi aktif. Suspensi aktif menggunakan elektrik untuk pemantauan keadaan kereta, digabungkan dengan sesuatu pengawal untuk mengawal pergerakan kereta dengan lebih baik. Bagi perojek ini, ia menekankan tentang rekabentuk model suspensi kereta yang berfungsi dengan satu tayar untuk menambah baik prestasi dengan menggunakan kawalan Fuzzy logic. Untuk membuktikan prestasi sistem aktif suspensi ini kami simulasi model ini di dalam MATLAB serta membuat perbandingan antara aktif suspensi dengan sistem suspensi pasif serta suspensi aktif menggunakan kawalan LQR

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INTRODUCTION

1.1. Suspension System

When designing vehicle suspension system, the objectives are to minimize the vertical forces transmitted to the passengers for passenger comfort, to minimize suspension travel and to maximize the tire-to-road contact for road handling and safety [1]. Generally a vehicle suspension system may be categorized as either passive, semi active or fully active systems. Passive suspension system includes the conventional springs and shock absorbers used in most cars as shown in Figure 1.1. The springs are assumed to have almost linear characteristics while most of the shock absorbers exhibit nonlinear relationship between force and velocity. In passive system, these elements have fixed characteristics and, hence, have no mechanism for feedback control. When the suspension system must operate over a wide range of conditions, there should be a compromise in choosing the spring stiffness and damping parameters. In other words, it is desirable that the above parameters could be adjustable to improve the performance of the system [2].

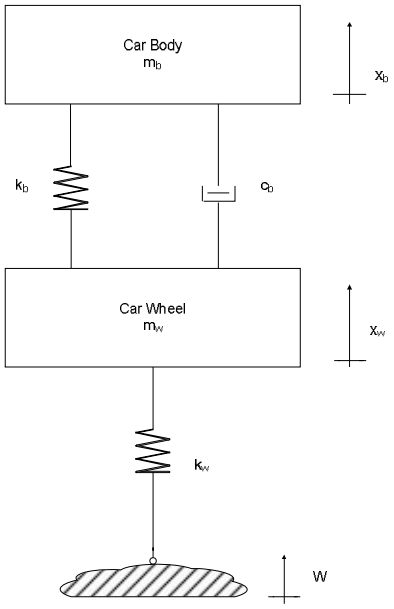

Figure 1.1: Passive Suspension System

Semi active suspension system provides control real-time dissipation of energy. For an automotive suspension this is achieved through a mechanical device called active damper, which is used in parallel with a conventional spring as shown in Figure 1.2. The main advantage of this system is to adjust the damping of the suspension system, without any use of actuators. This type of system requires some form of measuring devices with a controller board in order to tune damping properly [1].

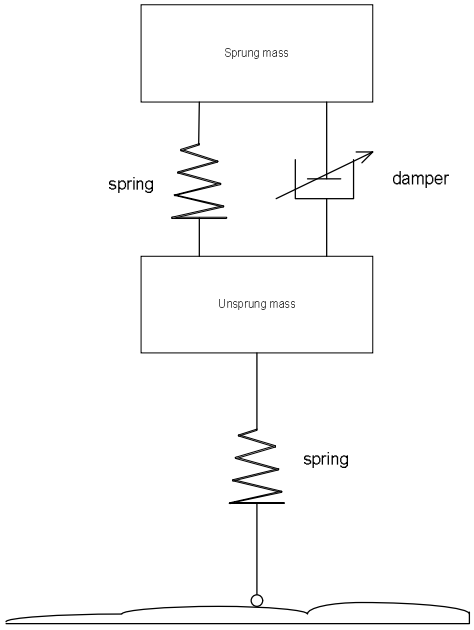

Figure 1.2: Semi-active Suspension System

The demand of better ride comfort and controllability of road vehicles has motivated many automotive industries to consider the use of active suspension. Active suspension employs pneumatic or hydraulic actuators which in turn creates the desired force in suspension system as shown in Figure 1.3. The actuator is secured in parallel with spring and shock absorber. Active suspension requires 2 accelerometers that mounted at sprung and unsprung mass, and a unit of displacement transducer to measure the motions of the body, suspension system and unsprung mass. This information is used by the online controller to command the actuator in order to provide the optimum target force. Active suspension may consume large amounts of energy in providing the control force. Therefore, in the active suspension system the power consumptions of actuator should also be considered as an important factor. In analysis of suspension system, there are variaties of performance criteria which need to be optimized. There are three performances criteria which should be considered carefully in designing a suspension system; namely body acceleration, suspension travel and wheel deflection. The performance of the system can be further improved by introducing the suitable controller into the active suspension system.

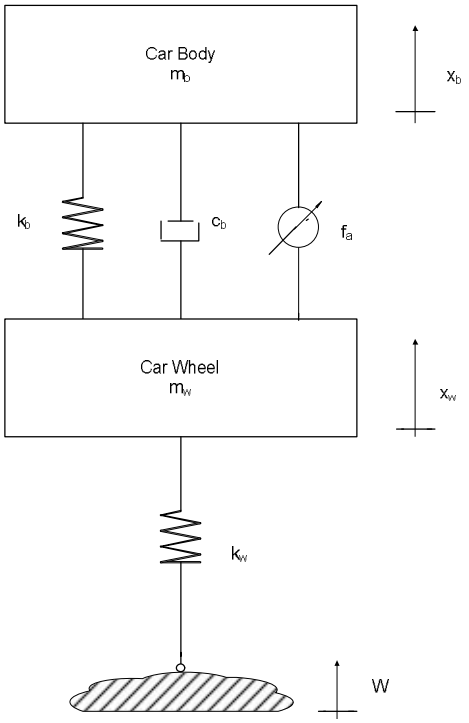

Figure 1.3: Active Suspension System

1.2. Active Suspension System Control Strategies

The objective of the active suspension system is to improve the suspension system performance by directly controlled the suspension forces to suit with the performance characteristics. There is various linear control strategies have been established by previous researchers in the design of the active suspension system. Amongst them are a fuzzy reasoning, robust linear control, andH_∞ .

1.3. Objective of Study

The objectives of this project are as follows:

I. To develop the mathematical model of quarter car passive suspension system.
II. To develop the mathematical model of active suspension system.
III. To develop the fuzzy logic control strategy for the system.
IV. To simulate and control the active suspension system.

The performance of the active suspension system will be observed by using extensive computer simulation that will be performed using MATLAB software and SIMULINK Toolbox subjected to various types of road profiles and parameter value.

1.4. Problem Statement

The main function of vehicle suspension system is to provide effective isolation from road surface unevenness, stability and directional control during handling maneuvers without loss of ride comfort and vehicle support. Traditional vehicle suspension systems are composed of two parallel components which are spring and dampers. Suspension system designers are faced with the problem of determining suspension spring and damper coefficients. Two important factors conflicting with each other must be compromised. These are the ride comfort and road handling.

1.5. Scope of Work

The scopes of work for this study are as follows:

I. Familiarization of a quarter car active and passive suspension system.
II. Mathematical derivation of quarter car active and passive suspension system.
III. Design fuzzy logic controller for the active suspension system.
IV. Perform a simulation works for the passive and active suspension system in MATLAB/Simulink.
V. Compare the performance of passive and active suspension system with fuzzy

This project will involve four phases of work:

i) First Phase : Literature Review

ii) Second Phase : Design and Simulation

iii) Third Phase : Implementation

iv) Fourth Phase : Thesis Writing

i) First Phase : Literature Review

- Information gathering about the project via internet, journals, magazines, published work and reference books.
- Study of the software implementation (Simulink, Matlab).
- Make research to know more detail about active and passive suspension system and Matlab.

ii) Second Phase: Design and Simulation

- The mathematical model for both active and passive suspension system of a quarter car model will be derived.

- The state space representation of the dynamic model for both active and passive suspension system is outlined.
- The various road profiles that represent the uncertainty will be used as the disturbance to evaluate the performance of the designed controller.
- Use MATLAB/Simulink software to simulate passive and active suspension system.

iii) Third Phase : Implementation

- The simulation results will be observed and presented.

iv) Fourth Phase: Thesis writing

- State all the ideas concentrated regarding to this project.
- Show flow of ideas during the implementation of this project.
- State the project conditions (from the beginning until the end of the project).

Details explanation of the project methodology will be explained in Chapter III (Project Methodology).

1.6. Structure and Layout of Thesis

Summarization of each chapter included in the report:

i) Chapter 1 : Introduction

ii) Chapter 2 : Literature Review

iii) Chapter 3 : Project Methodology

iv) Chapter 4 : Results and Discussion

v) Chapter 5 : Conclusion and Recommendation

i) Chapter 1: Introduction

This first chapter is more on the general overview of the project. In this chapter, the background of the problem and the emergence of the project are stated first. Besides, the project objectives, scope of project and the methods used are also included.

ii) Chapter 2: Literature Review

This second chapter discusses the background of study related to the project. This chapter consists of the evidence with the broad (e.g. books, internet, lecture notes etc) and focus (previous PSM, thesis, journal papers etc) areas of the study. In this chapter, the trend, direction and research issues are also identified. It can be said that this chapter is more on the evidence of not repeating what others have done.

iii) Chapter 3: Project Methodology

In project methodology, the materials, subjects, and equipment or apparatus used are identified. Besides, the methods or procedures during the project

implementation are also stated. Insufficient, the justification for choosing the method or approach is also stated.

iv) Chapter 4: Results and Discussion

In this chapter, the observation and result obtained from the data analysis are presented. Then, the project discovery is arranged tidily using the aid of figures and tables. Besides, the result or discovery is explained and compared with previous studies. Then, the result from the comparison is discussed.

vi) Chapter 5: Conclusion and Recommendation

The conclusion part is about the summarization of main findings of the projects. A brief recommendation for future study is stated at the recommendation part.