VEHICLE ACTIVE STEERING SYSTEM

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Date	: 9 May 2008

For my beloved Mom and Dad

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ABSTRACT

For a better safety and stability in a vehicle, active steering system is developed. Active systems such as active suspension, antilock braking system and traction control have been developed since. Vehicle handling and ride characteristics combined with the mechanics of road-tire interaction are greatly influenced the vehicle stability. Thus, active steering control is needed to help the driver react in a sudden occurred of unexpected disturbance. This project will discuss about an active steering system using PID controller that capable of rejecting the external disturbances that will affect the vehicle stability using. Student will design and implement the appropriate control scheme in the simulation software.

ABSTRAK

"*Active steering*" dibangunkan untuk membolehkan sesebuah kenderaan mempunyai system keselamatan dan kestabilan yang lebih baik. System aktif yang lain seperti "*active suspension*", "*antilock braking system*" dan "*traction control*" telah pun dibangunkan untuk tujuan ini. Pengawalan dan ciri-ciri pengendalian sesebuah kenderaan beserta mekanik yang terlibat diantara tayar kenderaan dan jalan raya adalah faktor penting yang mempengaruhi kestabilan sesebuah kenderaan. Oleh itu, "*active steering*" diperlukan untuk membantu pemandu bertindak balas kepada gangguan luar yang datang secara tiba-tiba. Projek ini akan membincangkan tentang sistem pemanduan aktif menggunakan pengawal PID yang dapat menolak gangguan dari luar yang dapat memberi kesan kepada kestabilan kenderaan. Reka bentuk dan skema pengawalan yang sesuai akan dijalankan dalam perisian simulasi.

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CHAPTER I

INTRODUCTION

1.1 Project Introduction

As technology evolved, the use of electronics control in automotive applications has spread from power to the body of the car. Active systems such as active suspension, antilock braking system, traction control and active steering have been developed to improve a vehicle stability and safety. The vehicles are become unstable because of the disturbance injection torque caused by braking forces and side wind. However, the performance of the vehicle stability system has been greatly increased due to the increasing of the vehicle capabilities.

To ensure the vehicle stability, all four tires must always in contact with the road surface. Furthermore, the associated friction between the mediums also plays a role in vehicle handling and ultimately ride experience. All four tires of a car should have a uniform grip on the road. In adverse conditions, when there is water or loose gravel on the road, one or more tire may lose grip. This will make the car behave in the most erratic manner. It will twist and turn by itself and can cause skidding.

For the disturbance attenuation, the driver has to compensate such disturbance torque by counteracting at the steering wheel. This is a difficult task for the driver because the disturbance input is suddenly occurred and may take a second of reaction time to recognize the situation or overreact and make things worst.

Various control strategies such as robust decoupling of car dynamics with arbitrary mass distribution, H∞ control approach, model reference adaptive control, fuzzy logic control and sliding mode control have been proposed in the past years to control the active steering system. In this paper, a control scheme that can improve road handling and avoid skidding will be considered.

1.2 Objective Project

The main objective of this project is to propose a new control method in active steering for vehicle stability using PID controller. A single track car model is used in the study. Different road friction coefficients and various disturbances will be observed as the varying parameters to see the robustness and effectiveness of the proposed control. Performance of each case and its ability to attenuate disturbances in term of yaw rate as well as side slip angle will be simulated.

1.3 Problem Statement

As stated above, handling, ride characteristic and the mechanics of road-tire interaction will influenced the vehicle stability. To make the vehicle stable, all four tires should have an even grip with the road surface or the car will lose traction. This will make the car behave in the most unpredictable way. It will twist and turn thus causing the car to skid. Active steering system is an alternative that is a must in a vehicle for a better ride comfort and controllability of the vehicle.

1.4 Project Scope

Throughout this project, there are several guidelines and specification that must be followed to make sure the project progresses within the scope.

i. The scope of this project is to develop an Active Steering System using PID controller based on a single track car model.
ii. The project is started by understanding the concept of passive steering system which is the steering system of the vehicle itself without a controller.
iii. Then the project will continue with the study of the concept of active steering system.
iv. The mathematical model of an active steering system will be derived after understanding the concept of steering system and its characteristics.
v. The study and derivation of the mathematical model of PID controller for the active steering system
vi. All simulations are constructed and performed using Matlab/Simulink.

1.5 Methodology

1. Project Planning
    a. Get the exact information needed by consulting with supervisor, En. Amat Amir Basari.
    b. Prepare Gantt chart for guidelines and progress report.
2. Literature Review
    a. Study and understand about active steering system with PID controller.
    b. Active steering system has been used before but with other controller for example fuzzy logic controller, state feedback controller and using sliding mode control.
    c. Detailed information is gained by referring through journal, references book and also from the supervisor's point of view.
    d. Mathematical model will be derived and tested in the simulation.

3. Software Design
    a. Prepare the all mathematical models (for the steering system and the controller) and control design.
    b. Run the simulation and acquire the expected result.

CHAPTER II

LITERATURE REVIEW

2.1 What is Control?

Control is defined as using artificial means to manipulate the world with a particular goal.

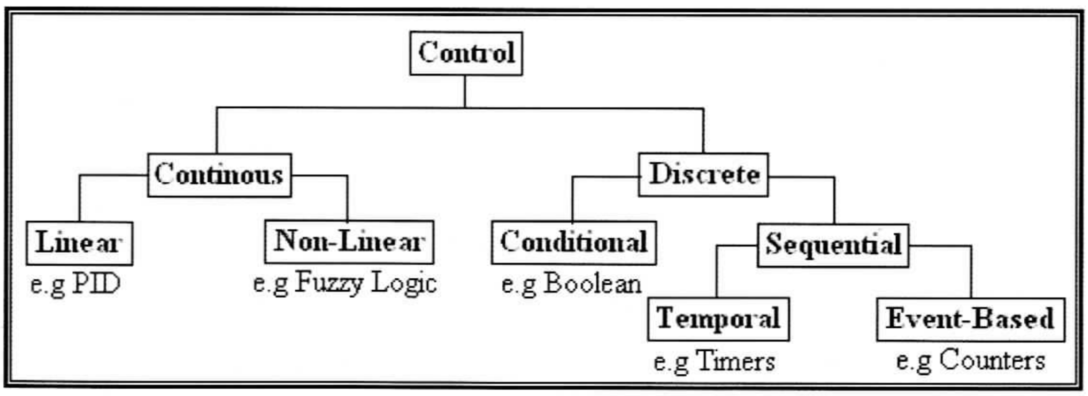

Figure 2.0: Types of Control

2.2 Control System

A control system is an arrangement of physical components connected or related in such a manner as to command, direct, or regulate itself or another system. Control system has two important terms, which is define as input and output. The input is the stimulus, excitation or command applied to a control system. Typically from an external energy source, usually in order to produce a specified response from the control system. The output is the actual response obtained from a control system. It may or may not be equal to specified response implied by the input.

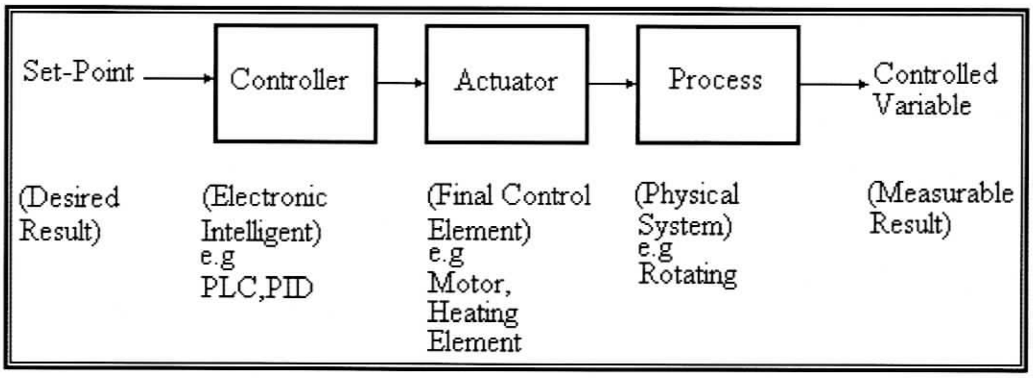

Figure 2.1: A Block Diagram of Control System

2.3 Open-Loop and Closed-Loop Control Systems

Control systems are classified into two general categories, open-loop and closed-loop systems. An open-loop system is one which the control action is independent of the output. A closed-loop control system is one in which the control action is somehow dependent on the output.

Open-Loop System is a control system that does not use feedback. The controller sends a measured signal to the actuator, which specifies the desired action. This type of system is not self-correcting. If some external disturbance changes the load on machine or process being performed, some degree of physical effort of human operator is required to make necessary modifications. The system manually controlled by the human. For example, the speed of a car controlled by a driver.

Closed-Loop System is a control system that uses feedback. A sensor continually monitors the output of the system and sends a signal to the controller, which makes adjustment to keep the output within specification. This automatic closed-loop configuration performs the self-correcting function by employing a feedback loop to keep track of how well the output actuator is doing the job it was commanded to d. A feedback signal is produced by a sensing component that measures the status of the output. This signal is then fed back to the controller. Since the controller knows what the system is actually doing, it can make any adjustments necessary to keep the output where it belongs.

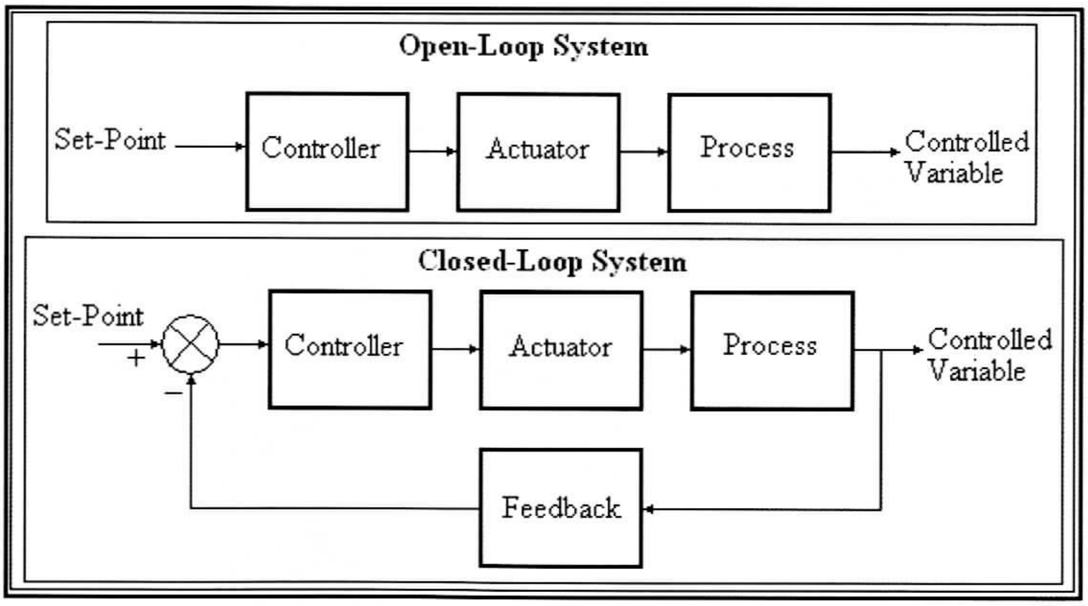

Figure 2.2: Open-Loop and Closed-Loop Control Systems

2.4 Steering

The design of the steering system has an influence on the directional response behavior of a motor vehicle that is often not fully appreciated. The function of the steering system is to steer the front wheels in response to driver command inputs in order to provide overall directional control of the vehicle. However, the actual steer angles achieved are modified by the geometry of the suspension system, the geometry and reactions within the steering system, and in the case of the front-wheel drive (FWD), the geometry and reactions from the drive train.

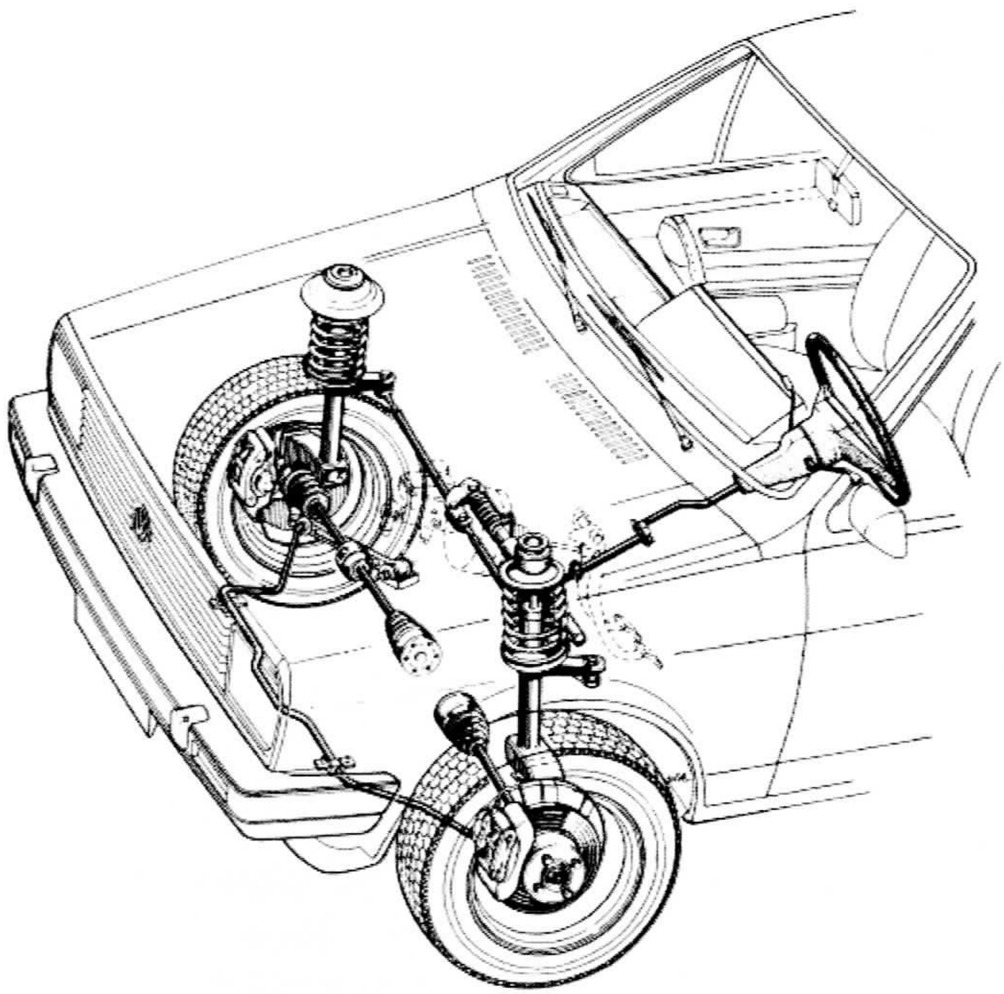

Figure 2.3: An example of a VW Polo (up to 1994) steering system (Courtesy of Volkswagen)

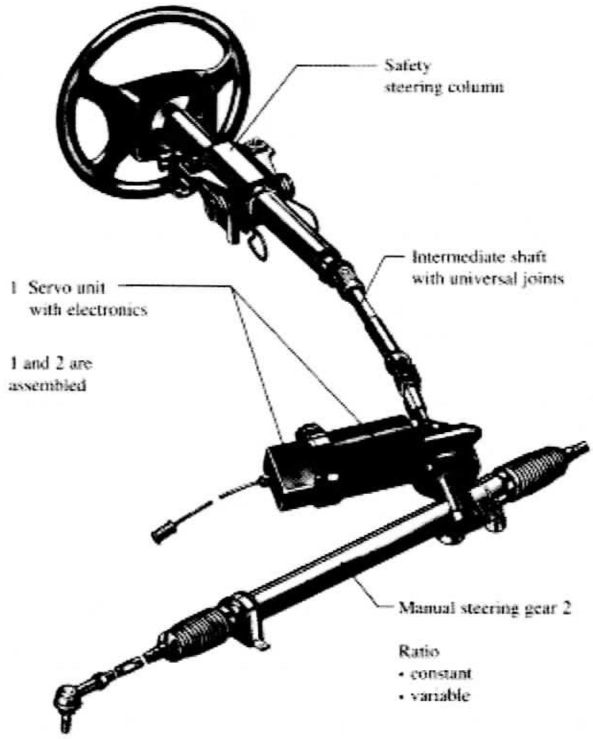

Figure 2.4: An example of an electrical power steering system by ZF (Courtesy of Volkswagen)

2.5 Evolution of automotive steering systems

The proliferation of electronic control systems is nowhere more apparent than in the modern automobile. During the last two decades, advances in electronics have revolutionized many aspects of automotive engineering, especially in the areas of engine combustion management and vehicle safety systems such as anti-lock brakes (ABS) and electronic stability control (ESC). The benefits of applying electronic technology are clear: improved performance, safety, and reliability with reduced manufacturing and operating costs. However, only recently has the electronic revolution begun to find its way into automotive steering systems in the form of electronically controlled variable assist and, within the past two years, fully electric power assist.

The basic design of automotive steering systems has changed little since the invention of the steering wheel: the driver's steering input is transmitted by a shaft through some type of gear reduction mechanism (most commonly rack and pinion or recirculating ball bearings) to generate steering motion at the front wheels. One of the more prominent developments in the history of the automobile occurred in the 1950s when hydraulic power steering assist was first introduced. Since then, power assist has become a standard component in modern automotive steering systems. Using hydraulic pressure supplied by an engine-driven pump, power steering amplifies and supplements the driver-applied torque at the steering wheel so that steering effort is reduced. In addition to improved comfort, reducing steering effort has important safety implications as well, such as allowing a driver to more easily swerve to avoid an accident.

The recent introduction of electric power steering in production vehicles eliminates the need for the hydraulic pump. Electric power steering is more efficient than conventional power steering, since the electric power steering motor only needs to provide assist when the steering wheel is turned, whereas the hydraulic pump must run constantly. The assist level is also easily tunable to the vehicle type, road speed, and even driver preference. An added benefit is the elimination of environmental hazard posed by leakage and disposal of hydraulic power steering fluid.

The next step in steering system evolution—to completely do away with the steering column and shaft—represents a dramatic departure from traditional automotive design practice. The substitution of electronic systems in place of mechanical or hydraulic controls is known as by-wire technology. This idea is certainly not new to airplane pilots; many modern aircraft, both commercial and military, rely completely on fly-by-wire flight control systems (Figure 2.5). By-wire technology paved the way for high performance aircraft designed to have a degree of maneuverability never before possible. If not for the intervention of flight control computers, some of these planes—because they are inherently unstable—could not be flown by human pilots without crashing.