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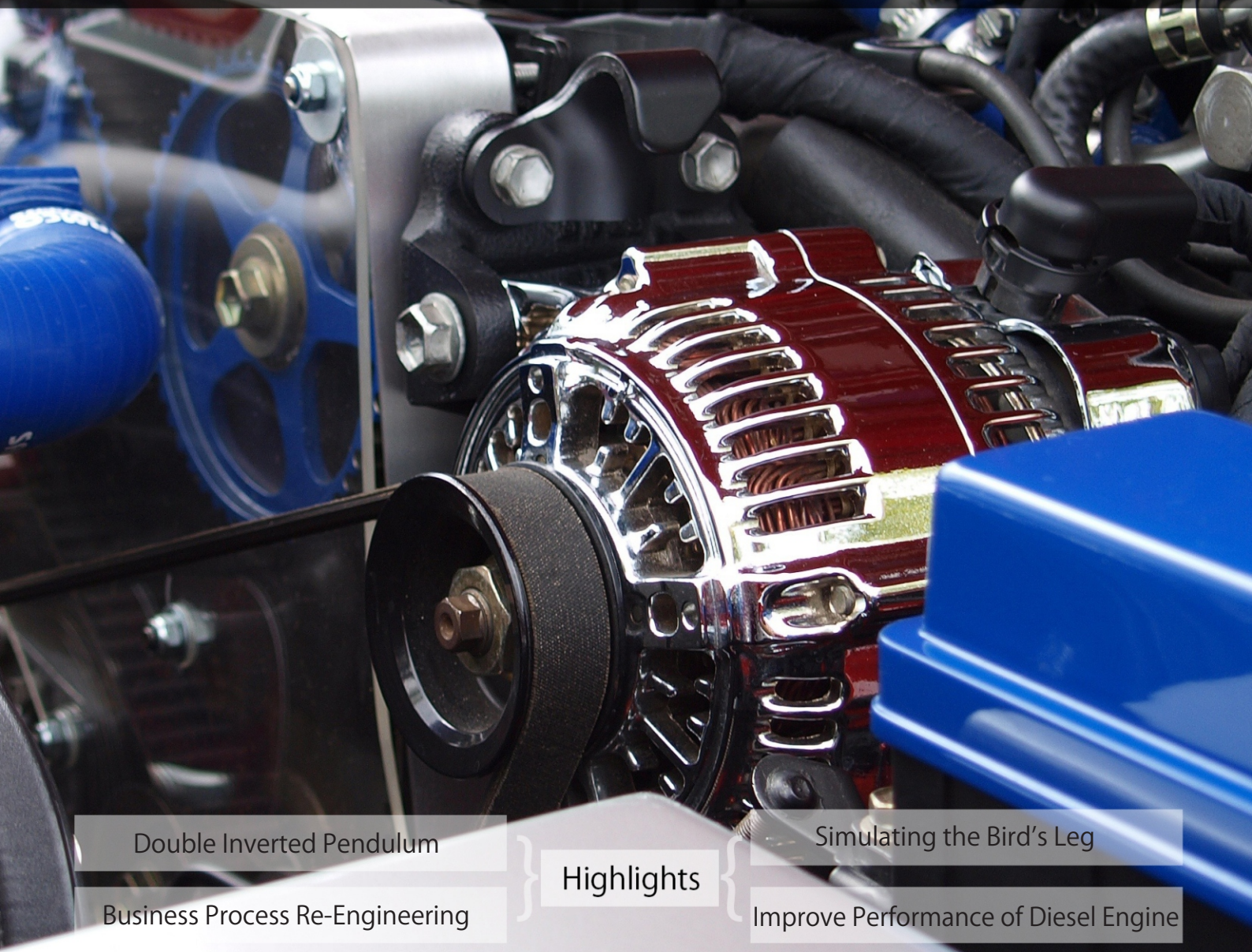

Highlights

- Double Inverted Pendulum
- Business Process Re-Engineering
- Simulating the Bird's Leg
- Improve Performance of Diesel Engine

Discovering Thoughts, Inventing Future

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Development of Controller for Te in Force Adjustable Damper

By Md. Nasir Uddin, MM Rashid, MG Mostafa, Belayet H, SM Salam, NA Nithe, MW Rahman & S Halder

International Islamic University Malaysia

Abstract- In this report, pole placement controller has been developed for hydraulic semi-active force adjustable damper: 2DOF quarter car model together with 5th order differential equations of damper model is considered. For the purpose of minimizing the car body vertical acceleration in order to improve the ride quality of the car the controller is developed. Four states were investigated. The car body displacement, car body velocity, wheel displacement and wheel velocity. Controllability and stability analysis were performed for the open-loop non-linear and linearized model which lead to the necessity of developing the controller as open-loop system appeared to be unstable. Various control theories on suspension system were investigated in this report, where the challenging part is to improve riding quality while maintaining good handling characteristics subject to different road profile. While developing the pole placement controller, the closed –loop poles were to be placed for both rebound and compression models of the system via MATLAB software. Through simulation, the developed controller proved to be achieving the aims of this project by minimizing the car body vertical acceleration consequently ride quality and comfort can be achieved.

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Development of Controller for Te in Force Adjustable Damper

Md. Nasir Uddin [α], MM Rashid [σ], MG Mostafa [ρ], Belayet H [ω], SM Salam [¥], NA Nithe [§], MW Rahman [χ] & S Halder [ν]

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Chapter 1

I. Introduction

a) Review

Vehicle suspension system is one of the most parts in a vehicle. It plays a significant role in physically separating the vehicle's body from the wheels. Hence it supports the vehicle weight, isolate the vehicle body from the wheels. Hence it supports the vehicle weight, isolate the vehicle body from road disturbance and also maintain the traction force between the tire and the road surface (Sam, 2006). A popular and complex problem appears when designing passive vehicle suspension system is the criteria of the system whether it is designed for vehicle handling performance or for passenger ride comfort. When the design of the passive suspension system focuses on increasing the passenger comfort, it's also decreasing the vehicle's abilities to handle road disturbances.

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b) Problem Statement

Passive suspension system is commonly used in passenger's vehicles. The main problem for passive suspension system is the inability give comfort to the passengers without sacrificing the traction force between the tire and the road. Figure (1) describes the relationship between ride quality and vehicle stability or handling performance in a vehicle's passive suspension system. In a addition to that, the performance of a passive suspension system is variable subject to road profile and added passengers weight. That is because the damping force of a passive suspension system is fixed and not adjustable as it has a fixed spring constant and damping coefficient. In this project, hydraulic semi-active suspension system is used with an adjustable damping force.

The main focus is to make the vehicle passenger feel more comfortable without sacrificing the vehicle handling abilities.

c) Objectives of the project

- To develop the mathematical model of a quarter car model
- To develop a controller for a TEIN force adjustable damper
- To evaluate the performance of the controller

d) Methodology

Methodology in conducting project contains a number of steps that must be followed properly in order to achieve project's objectives.

At the beginning, information is to be collected about the project either by literature review or supervision and/co-supervisor's about researching.

Mathematical model is then developed using dynamic motion equation is two mass system with a spring and an adjustable force damper.

After that, MATLAB software is implemented in the system to analyze system stability and to design the controller as well.

Then controller will b collected to the system which will allow both the system and controller to communicate with each other as overall system integration.

Finally, testing analysis in performed where of both precision and accuracy is required in order to

analyze the performance of the controller to control the system.

e) Report Outline

This report is divided into four chapters. Chapter one is about the background, problem statement, objectives and methodology steps of this project. Chapter two presents the literature review and what other researchers have done in related areas. Chapter three is focuses on the methodology to achieve the project's objectives in details. Finally chapter four is conclusion and recommendation where hardware materials are presented for future work.

f) Gantt chart

A: Registration and title selection.
B: Literature review and research.
C: Mathematical model.
D: Simulation and studies.
E:controller and design.
F:Submission.

Chapter 2

II. Literature Review

a) Introduction

This chapter presents literature review on what other researchers have done in areas are related to this project.

b) What is Modeling and Simulation?

Modeling is developing a level of understanding of the interaction between the system as a whole and some parts in it (Bellinger, 2004). A promote an understanding of the model intends to real system by simplified representation of a system at some particular point in time or space , where simulation is the of a model in such a way that it operates under certain control commands to compress it, thus enabling one to perceive the interactions that would not otherwise be apparent.

c) Vehicle Suspension System

Such a system that contains springs, shock absorber and linkages that connect the wheel to the vehicle body and allows relative motion between the two is called a suspension system (Jazar, 2008). There are three categories of suspension system which are active, semi-active and passive suspension systems. This criteria deepen upon the external power input and/or the control band width into the system.

i. *Passive suspension system*

For a passive suspension system, the damping criteria (spring constant and damping coefficient) are fixed since it consists of non-controlled spring and shock-absorbing damper. Those two elements which are the energy dissipating element (damper) with a fixed –size orifice, and the energy- storing element (spring stiffness) cannot supply energy to the system 9such as fixed –size orifice generates a damping force that is only dependent on the relative velocity of the suspension system), therefore it cannot provide enough control force to improve the handling performance and ride quality for different road disturbances.

To achieve the desired ride characteristics, passive suspension system limits the relative velocity of the sprung mass (car body) and the un sprung mass (wheel) to control the motion. This is done by placing some type of damping element between the body and the wheels of the vehicle, such as hydraulic shock absorber. Properties of the conventional shock absorber establish the trade off between isolating the car body and from the road disturbances to achieve ride quality which is achieved with a soft damping (larger suspension deflection) and at the same time maintaining good wheel-road contact by using hard damping (not allowing unnecessary suspension defection). These parameters are coupled and conflicting. That is, by using a soft damping , it will limit the body acceleration for a comfortable ride , but this reduces the handling performance by allowing more variation in the tire- road contact force. On the other hand, to improve handling it is desirable to minimize the relative velocity by designing a stiffer or higher rate shock absorber.

This stiffness increases the body acceleration but at the same time it decreases the ride quality performance, detract what is considered being good characteristics(Sam, 2006).

ii. *Active suspension system*

The main difference between passive and active suspension system is that active suspension has the ability to supply energy to the system as well as store and dissipate it. Crolla (1988) has categorized the active suspension into two; the low bandwidth (soft) active suspension and the high bandwidth (stiff) active suspension (Sam, 2006). In low bandwidth active suspensions, an actuator is placed in series with the damper and the spring; thus, Wheel hop motion is controlled passively by the damper. Therefore, ride quality is only improved in low-bandwidth active suspension whereas in high-bandwidth active suspension, the actuator is places in parallel with the damper and the spring. High bandwidth active suspension differs from low-bandwidth in controlling both the body motion as well as the wheel hop since the actuator links the un sprung mass to the body.

Therefore, it can improve both handling performance and ride quality simultaneously. Most studies on active suspension system utilize the high –bandwidth type.

iii. *Semi- active suspension system*

According to the control input generation mechanism to the active suspension system, it can be further categorized into another two types which whether

to be fully active system or a semi active system. In semi-active suspension system a varying damping force is used as a control force. For example, an electro-rheological (ER) damper or a magneto-rheological (MR) damper applies various level of electrical or magnetic field that causes the various viscosities of the ER or MR fluid. In a hydraulic continuous-damping control (CDC), which is modeled in y thesis, the damper varies the size of an orifice in the hydraulic flow valve driven by a solenoid or stepper motor that is to generate the desired damping forces. To compare between a semi- active and fully active suspension, the weight and cost of a fully active suspension is an obstacle in medium size car since it produces the control force with a separate hydraulic-pneumatic unit. A semi-active suspension is simple, consumes less energy than an active suspension an active suspension and provides better vibration isolation capability than a passive suspension at the body mass resonant frequency.

Two types of dampers are used in a semi-active damper which are the two state dampers and the continuous variable dampers. In the two state dampers, there is a rapid switching in state under a closed-loop control. As for the damper to perform its function of damping the body motion. It is necessary to apply a force that is proportional to the sprung mass velocity. The damper is switched to high state if the body velocity is in the same direction as the damper velocity and switch to low state is the two velocities are in the opposite direction as in this state, the damper is transmitting the input force rather than dissipating energy. The disadvantage of this system is that the rapid switching between states when there are high-velocities generates high –frequency harmonics which lead to undesirable noise (Hasan, 2010).

The characteristic of the continuous variable dampers can be rapidly changed over a wide range. If both damper and body velocity in the same direction, the damper force is controlled to emulate the skyhook damper while if the two velocities are opposite to each other, the damper is switched to its lower rate, which is the closest it will get to the ideal skyhook force. This system has a disadvantage of the difficulty to find devices that have the capability to generate high force at low velocity and low force at high velocity and the rapid changing between those two states. (Hasan, 20d10)

d) Magneto-Rheological (MR) Damper

MR dampers are classified as semi- active dampers. MR fluids are widely spreading in industrial applications such as car suspension, seat suspension, washing machine vibration control and bridge vibration control. MR dampers have been recognized as having a number of attractive characteristics for use in vibration control applications. The fluid properties of MR dampers are not sensitive to contaminates which make MR dampers relatively not expensive to manufacture. In addition to that, MR dampers are reliable, stable and required less power (20-50 Watts) to operate. Because by varying the magnetic field strength can adjust the damping force, so there is no need for mechanical valves which makes the device high reliable. Additionally, the fluid itself responds in milliseconds, allowing the development of devices with a high bandwidth (Laura M.Jansen, 2000).

e) Vehicle Suspension System Control Strategies

This subchapter investigates the various control strategies that have been proposed by numerous researchers to improve the trade-off between ride comfort and handling performance. The search included the areas of semi-active control, MR fluid devices and semi-active dampers. In the following, some of these control approaches will be presented.

i. *Skyhook control*

The skyhook control strategy was introduced by karnopp in 1974 (D.C. Karnop, 1974), which considered as one of the most effective control theory in terms of the simplicity of the control algorithm. Basically, the idea of the skyhook control is linking the sprung mass (vehicle body mass) to the stationary sky by controllable 'skyhook' damper, which can reduce the vertical vibrations by road disturbance as well as generate the controllable force (fskyhook). In their original work, it uses only one inertia damper between the inertia frame and the body mass. Practically , the skyhook control law was designed get an approximation of the force that can be generated by a damper fixed to an inertial reference as the 'sky'.

The skyhook control strategy plays an important role in significantly reducing the resonant peak of the sprung mass so a good ride quality would be achieved. But, in order to improve ride quality and handling performance of the vehicle as well, both of the resonant peaks of sprung mass and unsprung mass need to be reduced. However, the skyhook damper alone cannot reduce both of them simultaneously (Chen, 2009).

(Ahmadian, 1997) discusses how advantage-eous is using a skyhook damper for secondary suspensions. His study shows that the skyhook damper offers more control at one body at expense of less control on the other body. Furthermore, he also introduces hybrid control which is an alternative semi-active control policy that can provide better control of both bodies.

ii. *Semi-active suspension*

Ahmadian, in his study on 1993 (Ahmadian, 1993) examines the effects of semi-active damping on class 8 trucks. Under various damper configurations, the truck was tested on both city streets and highway. It was proven in his study that a configuration of placing semi-active dampers on the front axle and passive dampers on the rear axle is better than placing semi-active

dampers on the rear and passive dampers on the front axle. As for the ride quality, the result shows nearly equality between placing semi- active dampers on the front axle and passive dampers on the rear axle and placing semi- active dampers on all axles.

In a paper by Yi Chen, he proposed a skyhook surface sliding mode control to the control a semi-active vehicle suspension system for its ride comfort enhancement, in his simulation of the two degree of freedom dynamic model, the results were showing that there was an enhanced level of ride comfort for the vehicle semi-active suspension system with the skyhook surface sliding mode controller (Chen, 2009).

Chapter 3

III. Methodology

a) Introduction and Methodology Process

This chapter discusses in details the modeling and simulation of the non-linear semi active suspension system, linearization of the sytem to obtain the state – space model, analysis of the stability and controllability of the linearized system. Finally, the chapter presents the controller design and simulation.

b) DOF Quarter car model of the non-linear system

……

The quarter car model is of the 5th order, here are the equations of motion describing the dynamics of the system:

……..

……..

Where:

= car body mass
= car body acceleration
= Coil spring constant
= tire mass
= tire acceleration
= tire spring constant
= road displacement (road profile)

f (v,c) = adjustable damping force of the semi-active damper

The adjustable damping force is a function of the relative velocity of the body and the tire (v=……) and the number of clicks (c), it is obtained by curve fitting method of the following graph:

The model of the damper is different in rebound and compression, in case of rebound, the relative velocity of the body and tire is going to be positive; the damper model (5th order) is going to be:

……..

……

While in case of compression, the relative velocity of the body and tire is negative; the damper model (5th order) is:

Reference: (the 5th order damper model was given to me by my co-supervisor Dr. Fadly Jashi Darvison Bin Ridhuan Siradj)

c) The state space representation of the non-linear system

By letting are going to be the states of the plant, the following table describes the normal parameter values used in simulation; the values are approximations of an average car suspension system.

d) Linearization of the non-linear model

In this section, we are trying to find the linear approximation of the state space model at the local stability points (equilibrium points)

e) Controllability and Stability Analysis of the Linearized Model

In this section, controllability and stability analysis is performed to check whether the new linearized model is stable and controllable.

i. *Controllability and Stability Analysis of Rebound Model*

An important matter is to check whether the open loop system (without any control 0 is stable. To do that, all we need to do is to get the eigenvalues of matrix A, such that those eigenvalues are the poles of the transfer function. To get he transfer function poles, we can simply type –in the MATLAB command eig (A). Figure (11) shows open-loop eigenvalues.

We notice that the open –loop system is unstable since it consists of two poles on the right –half plane.

A system is controllable if there exists a control input that transfers any state of the system to zero in finite time (Introduction: State-Space Methods for Controller Design). Controllability can be proven if and only if the rank of the controllability matrix equals the number of states (Introduction: State-Space Methods for Controller Design). Figure (12) shows (12) shows the controllability of the system:

ii. *Controllability and Stability analysis of compression model*

We can perform the same analysis for the compression model to check whether the open loop system (without any control) is stable. To do that, all we need to do is to get the eigenvalues of matrix A, such that those eigenvalues are the poles of the transfer function. To get the transfer function. To get the transfer function poles, we can simply type in the MATILAB command eig(A). Figure (13) shows the system eignevalues.

f) Controller Design Using Pole Placement

Pole placement control method is the placing of the closed-loop poles of a plant in pre-determined locations in the s-plane (Sontag, 1988). The location of the poles plays significant role in controlling the characteristics of the system response. In order to implement this method, the system must be controllable which has been already proven in previous sub-sections (3.4.1 and 3.4.2).

In the controller design, we are going to assume a zero reference (r=0), as the controller would be a regulating controller which stabilizes the system and minimizes the overshoot and settling time of the car body vertical acceleration (x2). The control input of pole placement control (u=-kx), sour state space equations would be

$$X=(A-BK)x$$

$$Y= (C-DK)x$$

i. *Controller Design Using Pole Placement for rebound*

Suppose the criteria of the controller were settling time (Ts <0.4 sec) and overshoot (P0%<7%)from these two factors, we can obtain two poles by solving the second order transient response equation:

……

……

By solving equation (17) , we can obtain the first two pole placement method

$$P1 = -10 + 12i$$

$$P2 = -10 – 12i$$

As for the other two poles, they can be placed at -57 and -58 with the consideration of two important factors:

1. Not to choose the closed loop poles far away the open loop poles, otherwise it will demand high control control effort.
2. Not to choose the closed loop poles very negative, otherwise the system will be fast reacting (i.e. it will have a small time constant), as a consequence, it will lead to the amplification of noise and large control effort.

Moreover, all of the four poles can be changed depending on what the closed-loop response would be; hence, the selection of poles has a disadvantage of spending time and effort to obtain the obtain the optimal solution which achieves the minimum overshoot of the body vertical acceleration. However, the previous selection is our final one since it achieves our goal, we would see that in the simulation and results section.
MATLAB was used to obtain the controller gain K.

ii. *Controller Design Using Pole Placement for compression*

Suppose the criteria of the controller were settling time (Ts <o.2 sec), and overshoot (P0%<9%), from these two factors, we can obtain two poles by solving the second order transient response equation:

As for the other two poles, they can be placed at -57 and -58; the controller gain for compression is obtained using MATLAB.

$$K= [73.6563 \quad 936.2196 \quad -859.9053]$$

g) Simulation and results

In this section, we will present our data and results for non- linear system model in both rebound and compression. In addition to that, results and simulations of the closed –loop linearized model after adding the pole placement control in both rebound and compression.

i. *Simulation of non-linear model*

In figure (15) the block diagram represents equations (3), (5), (6), (7) and (8) which describes the non-linear model in case of rebound.

Figure (16) shows the non-linear model in case of rebound is unstable, as the vertical acceleration which we need to minimize goes to an extreme large value which is multiplied by 10^{17} in (m/s2), which makes it a challenge to develop the controller to stabilize the system and minimizes the car body vertical acceleration.

As in case of compression, figure (17) show the block diagram which describes equations (4), (5), (6), (7) and (8).

We notice from figure (18) that the system is unstable as well in case of compression, it is obvious that the current model need to be controlled, otherwise it would be dangerous to ride in a car consisting of an unstable suspension system where the vertical acceleration goes to around (9×10^{7} g)

ii. *Simulation of closed –loop linearized model*

This subsection presents the results and simulation after adding the pole placement controller to the system. By referring to section (3.5.1) and (3.5.2). We can see that the pole placement control gain has been obtained in both rebound and compression cases.

In figure (19), the block diagram shows the building of SIMULINK blocks after adding the pole placement gain K and after linearization of the system as well.

We can see from the above figures (figure (Error! Reference source not found) and figure (21) how adding the pole placement control stabilizes the system, where we can see the car body vertical acceleration has been obviously minimized. Hence, ride quality is achieved. Furthermore, the settling time and overshoot are being significantly minimizes.

h) Summary of chapter three

At the beginning of this chapter 5th order differential equations describing the car suspension system have been modeled, the 5th order model has been linearized to1st order model after that. Stability and controllability tests wetr conducted for the new model. Then a pole placement controller was designed for both rebound and compression force of the semi-active damper, finally, simulation and results were presented at the end of this chapter.

Chapter 4

iv. Conclusion and Recommendation

a) Conclusion

In a conclusion, all different suspension systems have been studied. Advantages of using a semi-active suspension system were clearly stated over using passive or active suspension system. Various control theories were investigated. The model was non-linear which required lengthy calculations to linearize it using equilibrium (operating) points. Pole placement controller has been implemented.

MATLAB software was used to:

- Model the non-linear system using block diagram in SIMULINK
- Stability and controllability analysis using MATLAB command window
- Develop the pole placement controller using command window
- Obtain the scope of closed –loop system using SIMULINK

From the results of MALTLAB simulation, implementation of the pole placement controller indeed improves the performance of the system due to the decrease in settling time and overshoots percentage which will reduce body vertical acceleration and improve ride quality.

During the project there were some problems encountered, modeling of a non-linear system where the damper's model is in the 5^{th} order was tedious which required a lot of time and effort. MATLAB errors were hard to overcome and required weeks of research to find people encountered similar errors. As for the current time, the scope of this project focuses only in designing the controller for the suspension system and evaluates it using MATLAB software. For the second part, the project will continue on the implementation of controlling the force adjustable damper, so that the experiments can be conducted including simulations and codes. An advantage of my project is that TEIN force adjustable damper has been developed and ready to be used in the lab.

b) Bills of Materials

Components	Quantity	Price
TEIN force adjustable damper	1	Provided in the lab
stem motor (KT35FMI-030)	1	provided in the lab
Arduino UNO board	1	RM79
Motor driver (L298N)	1	RM22
Accelerometer	1	RM 366
DC to DC concerter	1	Owned
LIPO Rechargeable Battery 11.1V 2200mAH	1	RM 85
TOTAL		Total = RM 552

c) Components Selection

i. TEIN force adjustable damper

Inside a TEIN force adjustable damper in figure (22), there is a piston moving within an oil filled tube as the car suspension moves. As the piston moves either up or down, the oil flows through an orifice in the piston. A big orifice opening leads to low damping and vise versa. The damper has a knob on it that can be connected to a stepper motor with a series of click to adjust soft to hard damping.

ii. Stepper motor

The step motor in figure (23) is mounted on the damper's knob to control the damping stiffiness. It can be connected to the controller through a motor driver because the controller might bum if connected directly to a motor.

iii. Motor driver (L298N)

In order to control the large amount of current flow of the stepper motor, a high current motor driver is used which is (L298N). The L298 is a high voltage, high current dual full-bridge driver.

iv. Accelerometer

A one –dimensional accelerometer in figure (25) can be used to measure vertical acceleration.

References Références Referencias

1. Ahmadian, M. (1997). A hybrid semiactive control for secondary suspension applications. Proceedings of the Sixth ASME Symposium on Advonced Auomotive Technologies. Dallas, TX.
2. Ahmadian, M (1993) Ride Evaluation of a class 8 Truck with Semiactive Suspensions. Pp. 21-26.
3. Arjon Turnp, K, -S. a. (2008). Control of a Semi-active MR-Damper Suspension system: A New Plynomial Model. 4683-4688.
4. Bellinger, G (2004). System thinking.
5. Chen, Y. (2009). Skyhook Surface Sliding Model Control on Semi-active Vehicle Suspension System for Ride-Comfort Enhancement.
6. D.C. Karmopp, M. J (1974) Vi-bration control using semi-active force generators. Journals of Engineering for Industry, Transactions of the ASME, vol. 94, pp. 619-626.
7. Hasan, A. Z. (2010). Modelling and Simulation of Modified Skyhook.
8. Introduction: State-Space Methods for Controller Design. (n.d.). Retrieved from Control Tutorials for MATLAB and Simulink:
9. http://ctms.engin.umich.edu/CTMS/index.php?example=Introduction & section = Control State Space
10. Jazar, R. N. (2008). Vehicle Dynamics: Theory and Applications.

11. Laura M. Jansen, S.J. (2000). Semi-active Control Strategies for MR Dampers: ASCE journal of Engineering Mechanics, Vol.126, No.8, pp. 795-803.
12. Sam, Y.M (2006). Robust Control of Active Suspension System for A Quarter Car Model.
13. Sontag, E.D.(1988). Mathematical Control Theory: Deterministic finite Dimensional Systems (S. Edition, Ed.)

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Continuous Improvement in Business Process Re-Engineering & Six Sigma

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Abstract- In this paper the author predicts that the overwhelming majority of BPR initiatives now underway, or starting in the next year, will fail to achieve their intended result. With reference to his seven axioms of economic-quality he explains why and offers recommendations to guide better practice based on people practices; knowledge; systemic understanding and an appreciation of the importance of variation. The BPR method is defined by Hammer and Champy as "the fundamental reconsideration and radical redesign of organizational processes, in order to achieve drastic improvement of current performance in cost, service and speed". At it's turn, the Kaizen method is an management concept for incremental change. The key elements of Kaizen are quality, effort, involvement of all employees, willingness to change and communication. When BPR is compared with Kaizen method, the BPR is harder to implement, technology – oriented, enables radical change. On the other hand, Kaizen method is easier to implement, is more people – oriented and requires long term discipline.

Keywords: business processes reengineering (BPR), kaizen method, incremental improvement, technology, standardization.

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Continuous Improvement in Business Process Re-Engineering & Six Sigma

Shyam Lal Sharma [α] & Kamlesh Kumari [σ]

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I. Introduction

One of this nation's most famous attempts to re-engineer a vital process took place in 1855. The place was HMG's Board of Ordnance Armoury at Enfield in Middlesex. Enfield Armoury had been founded in 1813 by the government after two decades of exploitation by assorted private armouries centred in Birmingham and, to a lesser degree, London.

It had been decided by the Board of Ordnance that the only way to secure value for money in the procurement of small arms was to take over the production process itself.

At the end of 1815 production began at Enfield, just as England was entering a period of peace following 22 years of war in Europe and three in America. Accordingly, the armoury was promptly retired for maintenance and storage duties!

During the French wars, the Ordnance-Department had instituted 100% inspection because of inferior workmanship. In so doing it assumed the responsibility for assembly of finished muskets by contracting with another firm for that work. The logical next step, particularly since it was increasingly receiving unacceptable offers for the manufacture of the various components of an improved design of muskets (the Minié), was to expand the Enfield Armoury into a full manufacturing centre. Work began in the spring of 1855 with preliminary production trials taking place in 1857. For the first time interchangeable manufacture, long since practised in America under the leadership of Alfred C Hobbs (locksmith) and Samuel Colt (gunsmith), was established in England. Enfield Armoury became a national benchmark for advance production techniques. No longer was the manufacturing process divided into specialist material makers and a similar number of even more specialised 'setters-up' or 'fitters'. Because of the practice of universal inter changeability production became a relatively seamless flow-line from selected raw materials to reliable end products. The process had been re-engineered and productivity and reliability significantly improved. The endless shaping, filing, smoothing, polishing and adjustments necessary to complete a musket in the mid-1850's gave way to the calm, ordered assembly of the new Minié musket from finished component parts selected at random. As Henry Ford was to say some 50 years later writing in the Encyclopædia Britannica on the subject of modern manufacturing techniques for motor cars: "*In mass production there are no fitters*. " At Enfield the process of rifle production had with much difficulty been re-engineered along American lines as a result of the chronic pressures of war on three continents (Europe, North America and India). Now, 140 years later new chronic pressures - this time of an economic rather than a military nature - are building to invite as radical a change to our way of doing business as the step change from the craft production to the mass production had on the making of muskets and rifles. Quite often it is necessary for an organization to revise and re-examine it's decisions, goals, targets etc., in order to improve the performance in many ways and this activity of re-engineering is called as Business Process Re-engineering which is also known as Business Process Re-design or Business Process Improvement.

II. Philosophy

This talk was invited to provide a keynote to the day's discussions about improved business efficiency and the new corporate entities that are needed to achieve sustainable economic-quality. Respecting, as I

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do, the primary importance of operational definitions I would suggest we reflect upon the meaning of the word 'keynote' - a term taken from the world of music. (We are well advised, I maintain, to respect the precedent of music since I am not alone in claiming that the symphony orchestra is the finest model available on which we can base our vision for the new corporate entity - one obsessed with harmony and teamwork.) In music a keynote is the primary note of the fundamental scale from which the musical composition is 'factured' or made. Thus in a keynote presentation we might reasonably expect there to be a primary marker of the fundamental theme from which all subsequent improvement in 'facture' can be derived. Our fundamental theme is business process improvement or re-engineering. It matters not what we make - be it buildings or bankers drafts; mint creams or mortgages; vehicles or virtual reality. I give you my keynote as 'sigma' - the primary symbol of the fundamental theme which paces all progress. I speak of the basic statistical measure of deviation from target. So long as we confine ourselves to the realm of the natural world we may say with absolute confidence that "*Nature operates in cycles and systems, not by chance and incident*" This is my First Axiom. My Second is: "*Nature decrees variation in all things*".

I recommend that you will accept these statements, rooted as they are in the primacy of natural material science or knowledge, and upon which mankind is as ultimately dependent as any other aspect of the universe. Since the purpose of all business (I would prefer that we now equate commercial activity with the word 'carefulness' rather than 'busy-ness' for reasons which will become apparent shortly) is the facturing of products and services I strongly recommend an understanding of variation if sustained and substantial improvement is sought. Note however that "*Variation is both a virus which destroys order as well as the source of catalytic variety which ensures survival through evolution.*" (Third Axiom). And so let's end this section on philosophy with a statement, partly self-evident, that is rarely acknowledged in business circles "We cannot know what we do not know, and we can only learn from others by invitation." (Fourth Axiom). Note the open minded emphasis and the vital importance of invitation.

III. Concepts

The key concept is and always has been one of knowledge - scientia potestas est as the Romans well knew. However when the love of money and the mirage of power that follows becomes the focus of human effort, as it has in the west since the mid-fifties, then knowledge gets overlooked - worse even, forgotten. For knowledge to flourish there must be respect for theory, since without theory there can be no prediction and without prediction there can be no sound and lasting improvement. After all the job of management is fundamentally one of prediction - not hoping for the best! The eminent British philosopher Karl Popper reminds us that the primal activity of life is problem solving. And the primal problem is survival. "All organisms are constantly, day and night, engaged in problem-solving; and so are all those evolutionary sequences of organisms - the phyla which begin with the most primitive forms and of which the now living organisms are the latest members." Of course the "latest" living organisms conventionally comprise the human species. Until the last war it was powerful individuals who dominated socio-technical development and stood at the top of the organic pile. Today that summit position is increasingly becoming a plateau rather than a peak and the topmost position will increasingly be occupied by those networks and organisations of individuals who can, by their combined efforts, operate dominantly on the global stage. It is therefore a case of the organisation seen as an organism rather than as a machine. My Fifth Axiom reflects the natural imperative of our long biological development: "We best understand those things we can do ourselves; to shape our practice with theory magnifies our capabilities. Co-operation leads to unimagined synergies while confrontation only proliferates entropy." In other words we must all stay in touch with reality - I suggest that the progressive loss of tactile skills is one of the major contributors to our decline. For countless centuries man has programmed his brain through his hands; it would be odd if we suddenly could dispence with this dextrous skill at no penalty to our intellectual development and rely on the view of the computer screen. Now business process improvement focuses, by definition, on process in contrast to function and in so doing avoids hierarchy in favour of heterarchy. The emphasis is on connectivities rather than entities. It is to do with the weft rather than the warp of an organisation's fabric. It is this great vector shift from instruction to information which is taking place in all western businesses that are struggling for survival. Today centralised command and control is being replaced by local autonomy; confrontation is being replaced by co-operation; the boss is deferring to the customer as being the employee's most important consideration. Process oriented management is even beginning to replace financially oriented management in various enlightened organisations.

But all these changes are but reflections of a more fundamental paradigm, or pattern, shift. That change is the move away from reductionist thinking in favour of holistic thinking - the imperative to "*Only connect...*" in the words of E M Forster. The eighties produced ample evidence to show how our nation's decline has been management led. The nineties continued to rout as rank financial dishonesty

overwhelmed the efforts of incompetent managers. And throughout an overwhelming truth prevailed where it mattered - amongst the vital majority that is "*No one willingly goes to work to do a bad job or produce faulty work.*" (Sixth Axiom). And no one ever has. But many a time people have found arbitrary barriers placed in their way, by their superiors, that have literally prevented them from doing good work or required them to do dishonest work. The organic emphasis in business management increasingly rests on thinking in systems rather than structures; working on processes rather than puzzling over ill defined problems. Going - albeit slowly - are the days of macho-management, fire fighting and free-wheeling - the era of busy-ness, 'hard'-work and easy windfall profits. Coming-equally slowly - are the days of leadership, never-ending improvement and coaching - the era of carefulness, 'smart'-work and sustained profits.

The re-inforcing concepts which have led to the deep understand standing of the superior characteristics of process oriented management were all set down from the 1920's by such writers as Broad, Smuts, Woodger and Bertalanffy in their treatises on biological systems and the fundamental principles or organisation in the natural world. Similarly Norbert Wiener, investigating the problem of shooting down fast moving aircraft in the man-made horrors of WW2 developed his pioneering theories about cybernetics and control which are now seen to have universal application. The single biggest contribution to process management however came from a quiet spoken, "*hard boiled engineer*" at Bell Laboratories by the name of Walter Shewhart. Shewhart had been charged with devising a method whereby his superiors could take confidence that telephone components coming off the production lines at Western Electric's Hawthorne plant outside Chicago could be relied upon to be consistent in operation and durability. In May 1924 he reported with an elegant and simple solution to their problem - it was a simple technique to chart his natural process performance or behaviour - better known as 'the control chart'. The chart reveals the signature of the process and also can, with competent interpretation reveal, in real time, the beginning of any significant problem arising within the process. Instead of a day's production being rejected by 100% end-of-line inspection it was suddenly possible to monitor performance on the line by the operator as it happened and ensure that nothing was made that did not conform to the stated requirement. Thus the concepts that are central to facturing consistent, reliable and economic products and services are founded on knowledge developed around the late 1920's. A body of theory was now able to rigorously explain why the practice of interchangeability developed by American armament manufacturers in the early 1800's was so successful wherever and by whoever it was adopted.

IV. Implications

The implications of the foregoing are profound and they explain why failure attends the majority of quality management initiatives which have been established without the deep understanding of natural-systems behaviour and variation. (The widespread use - but narrow application - of the word "*system*" by the IT community suggests perhaps that we should, in the wider holistic sense, emphasise the importance of "*natural systems*" thinking.)

We can summarise the capital concepts that are vitally important to the new-style of process oriented management by contrasting them with the old-style financially oriented concepts of business, thus:

PEOPLE processes v Autocratic bureaucracy

A theory of KNOWLEDGE v Rule-of-thumb and tampering

A SYSTEMS based approach to thinking v A piecemeal reaction to emotion

Understanding VARIATION v Massaging visible financial numbers

Each of these four capital facets interlocks with the other three, thus forming a robust jigsaw when imagined in two dimensions or, better still imagined in three dimensions, a triangular pyramid. We call this exemplary triangular pyramid a Tetrad (a grouping of four related aspects) as it manifests the systemic integrity of the holistic approach to management. The implications of these concepts are significant and important. Since the world has irrevocably shifted from the seller's market place of the sixties to the buyer's marketplace of today (and the foreseeable future) the customer now dominates and suppliers have to face increasing competition. Quality may be the fashionable catchword of the management marketplace but the principles of world class economic customer-preference enshrined within the above are rarely evidenced in popular usage. Let me now demonstrate why, in view of the foregoing, I predict the failure of the majority of business process inprovement or re-engineering initiatives that ignore the foregoing. The target aim of any business must be world class performance, a concept casually used in the context of marketing but one rarely understood operationally as "on target with minimum variation", as specified in 1960 by the Japanese statistician Genichi Taguchi. The measurement of this variation from aim ideally should be independent of the supplier and as experienced by the customer. One test would be product or service failure rates where a failure is defined as any incident or event that disappoints the customer - regardless as to whether it is reasonable. (After all advertising can be misleading!) In the old economic era (pre-1970) failure rates were thought of generally as being tolerable so long as they measured in decimals of a percentage. Today, for success, customers will not for long tolerate

low percentage failure rates, expecting rather rates best expressed in values of less than 100 parts per million. Namely many orders of magnitude smaller. When we recall that one per cent is equivalent to 10,000 ppm the size of the step change becomes apparent. (It is convenient to remember that 100 ppm = 1/100 of 1%). Let us take just 0.1 percent (or 1,000 customer disappointments per million experiences) as the status-quo level of performance today for a company that believes it is doing all the right things, i.e. it has got ISO9000 and/or similar! Depending upon attitudes towards continuous improvement - kaizen - such a company may be seen as developing along a characteristic kaizen trajectory. With time error rates progressively drop. A smooth continuous sequence of beneficial, or virtuous, changes lead it forward efficiently and profitably. By introducing pro-forma business process re-engineering the aim appears to be to achieve a step change that will boost performance either with new processes and/or new products. The hype surrounding this and related new management fad (such as 6- Sigma) certainly can be seen to offer casual observers the promise of an instant pudding solution to their meal-ticket problem. Imagine how Company A can make a short-lived gain by such implementations as BPR and 6-Sigma, but in the absence of a significant kaizen profile, will be overhauled by a steadily improving competitor, Company B. Company B simply out-performs Company A with its more determined kaizen profile and without sole relianace on the strict, reductionist methodology of the package approach. The point I wish to make is this - without kaizen BPR and 6-Sigma will simply be a step change to nowhere very special after a brief period of top-management, fad-driven excitement has passed. And as with TQM before it a new fashion will have to be found to crank up the ever declining performance of the 'ignorant' organisation. Already the snake oil sale men of such potent brews as 6-sigma are on the look-out for yet another new medicine with which to at least bathe if not heal the corporate underperformers.

V. Conclusion

If we accept that world class economic-quality (that is quality for which no premium is paid by the customer) is our ambition - better, our obsession - then we need to remember and act upon Dr Genichi Taguchi's definition of "*On target with minimum variance*" It was made in the days of a seller's market. Today with the shift in market emphasis to the buyer we must remember that no longer does the seller determine the validity of the target. Today the target can only be validated by the customer. What has not changed, however, is the fact that variance still can only be minimised by the supplier. Now it is impossible to define the target, let alone achieve it, without recourse to systems thinking and process working. No customers will be long attracted to a target rooted in financial greed on the part of the supplier. Also, to minimise variation and constantly improve the capability of an organisation's processes is impossible without appreciating the importance of understanding natural process performance and statistical thinking.Which brings us back to our musical analogy and the keynote symbol of 'sigma'. Our coda is simple, brief and powerful. It is that all lasting improvement must be knowledge-based and rooted in established theory. No number of well expressed hopes for a better tomorrow or exhortations of "Good Luck!" can make any difference now. Tomorrow's future will be determined by people who seek deep understanding of how socio-technical systems perform within an holistic framework. Schumarker said "*Think globally; act locally*". For those of us interested in economic quality, by whatever route (and under whatever acronym), the best recommendation is that contained within my Seventh Axiom with which I conclude this paper: "*Thinking in systems and working on processes, aware that knowledge and the customer are the co-equal and ultimate sources of all power in the new global marketplace, is the only way to minimise the risk of corporate failure within the next decade.*"

References Références Referencias

1. Berger, A., (1997). Continuous improvement and Kaizen: Standardizations and organizational designs, Integrated Manufacturing System, 8(2), 110-117.
2. Brunet, A. P. and New, S. (2003), Kaizen in Japan: an empirical study. International Journal of Operations & Production Management, 23(12), 1426-1446.
3. Carpinetti, L., Buosi, T., and Gerolamo, M., (2003), Quality Management and improvement. A framework and a business-process reference model. Business Process Management Journal, 9(4), 543-554.
4. Dahlgaard, J. J., and Dahlgaard-Park, S. M., (2006), Lean production, six sigma qualities, TQM and company culture. The TQM Magazine, 18 (3), 263-281.
5. Davenport, T. H., and Short, J. E., (1990). The new industrial engineering: Information technology and business process redesign. Sloan Management Review, 31(4), 11-27.
6. Davenport, T. H., (1993). Process Innovation: Reengineering work through information technology. Boston MA: Harvard Business School Press.
7. Elbo, R.A.H., (2000). Inside's Japan Kaizen Power Houses. Business World Philippines, 13, 1-2.
8. Farley, C., (1999). Despliegue de Políticas del KAIZEN. In: CINTERMEX, ed. XI Congreso Internacional de Calidad Total, noviembre 1999.

Monterrey Nuevo León México: Fundación Mexicana de la Calidad Total y Centro de Productividad de Monterrey.
9. Gondhalekar, S., Babu, S., and Godrej, N., (1995), Towards using Kaizen process dynamics: a case study, International Journal of Quality & Reliability Management, 12(9), 192-209.
10. Imai, M., (1986), Kaizen: The key to Japan's Competitive Success, NY: Random House.
11. Imal, M., (1997), GEMBA KAIZEN. A common sense, low cost approach to management. Kaizen Institute, Ltd.
12. Juran, J., (1990)., Juran y el Liderazgo para la Calidad. Un Manual para Directivos. Madrid: Editorial Díaz Santos.
13. Lillrank, P., and Kano, N., (1989). Continuous Improvement: Quality Control Circles in Japanese industries. Ann Arbor MI: University of Michigan.
14. Mintzberg, H., and Westley, F., (1992).Cycles of organizational change. Strategic Management Journal 13, 39-59.
15. Newitt, D. J., (1996). Beyond BPR & TQM - Managing through processes: Is kaizen enough? In: Proceedings Industrial Engineering, London, U.K: Institution of Electric Engineers.
16. Pettigrew, A. M. (1990). Longitudinal Field Research: Theory and Practice. Organization Science, 1(3), 267-292.
17. Robinson, A., (1991), Continuous Improvement in Operations. Cambridge, MA: Productivity Press.
18. Sheridan, J., (1997). Kaizen Blitz. Industry Week, 246(16), 19-27.
19. Tanner, C., and Roncarti, R., (1994), Kaizen leads to breakthroughs in responsiveness and the Shingo Prize at Critikon, National Productivity Review. 13(4), 517-531.
20. Van de Ven, A. H., and Poole, M. S. (1995), Explaining Developments change in organizations. Academy of Management Review, 20(3), 510-540.

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Development of Automatic Fish Feeder

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Abstract- An automatic fish feeder is a device that automatically feed the fish at a predetermined time. In a way, it is to control the fish feeding activity by using a fish feeder that combined the mechanical system and electrical system to form a device instead of manually feeding the fish by hand. Fish owners whom are away for a long time will have trouble knowing the situation of the pond or aquarium. Thus such device is very convenient. At the same time, the environment needs to be monitored. For this paper, I will monitor the environment in term of water temperature. First of all, the device will consist of a motor, stand, fish storage, PLC (Programmable Logic Circuit) and a GSM (Global System for Mobile). The device will feed the fish by dropping the feed from the storage through a hole. The size of the hole is controlled by a piece of block connected to a motor. A timer is used to control the number of feeding time at an interval of time. Plus, there is a feedback system that sense the level of feed left in storage. It will give warning to the user through SMS (Short Messaging Service) so the user will put new feed into the storage. With this, the user or the owner can be away from home with the device monitoring the aquarium condition.

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Development of Automatic Fish Feeder

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Abstract- An automatic fish feeder is a device that automatically feed the fish at a predetermined time. In a way, it is to control the fish feeding activity by using a fish feeder that combined the mechanical system and electrical system to form a device instead of manually feeding the fish by hand. Fish owners whom are away for a long time will have trouble knowing the situation of the pond or aquarium. Thus such device is very convenient. At the same time, the environment needs to be monitored. For this paper, I will monitor the environment in term of water temperature. First of all, the device will consist of a motor, stand, fish storage, PLC (Programmable Logic Circuit) and a GSM (Global System for Mobile). The device will feed the fish by dropping the feed from the storage through a hole. The size of the hole is controlled by a piece of block connected to a motor. A timer is used to control the number of feeding time at an interval of time. Plus, there is a feedback system that sense the level of feed left in storage. It will give warning to the user through SMS (Short Messaging Service) so the user will put new feed into the storage. With this, the user or the owner can be away from home with the device monitoring the aquarium condition.

I. Introduction

Food and feeding are the important elements for growth and production, their management being one of the main challenges for aquaculture development, survivability and maintenance. The adjustment of food delivery to ensure the survival of the fish is important for fish owners, whether as pet or aquaculture. Related to economic aspect, especially for highly invested aquaculture project, the control of fish feeding will also determine the survivor of the company involved. However for this paper, I will focus on the fish reared by home owners.

In order to solve this problem, several direct and indirect techniques have been developed. Self-feeders may be used for direct adjustment, whereas indirect methods have also been used based on using automated device to deliver the feed to the fish. Therefore, the aim of the present study is the development of a feeder that can handle good control of fish food feedings.

a) Background

Recently, there has been increase of number of people who kept fish as a pet at their own home. Be it a hobby or for business purposes. Those who do it for business purposes, in statistic, in Asia itself, the production of aquaculture dominate the market, contributing around 91% of the world's total by volume and 82d% by value. Asian countries, such as Thailand, have been the top ten aquaculture producers in the world. The region has the highest variety of cultured species. Asia has also been the highest seafood-consuming region of the world, accounting for two-third of the world's food fish supply, the increase of which mainly came from aquaculture in recent years (Endan, Mazlina, Talib & Yeoh, 2010).

As stated by Endan et al (2010), the fisheries sector in Malaysia has provided direct employment to 89,453 fishermen and 21,504 fish culturists. The consumption of fish in Malaysia is expected to increase by 14% by 2010 and currently, the country is producing 89% of the fish supply for its own consumption. With the marine harvest almost stagnating, the industry is dependent on the aquaculture to cater for the growing demand. Currently, the aquaculture industry contributes to about 13.2% of the total fish produced. Malaysia has the potential to become a major player in the aquaculture industry in Asia Pacific, if more companies enter the sector.

One parameter that involve in a feeder is time management controller that act as main part of a feeder. Many industrialists in aqua field and also fish owner seem to have trouble with this timely operation. Traditional method of feeding fish either for fish in pond, cage or even small lake is by use of man power. For the worker, they sometime face difficulties to do the feedings at the same exact time during some unexpected event especially when raining. If the they continue the job, the only result are not just the pellet ending at the bottom of the pond as waste faster or lead water to pollute, but the main critical problem is the unfed fish. This matter will even grow bigger during raining season and will cost a lot of trouble to the industrialist. This is a very clear example to show how important is timing variation, that determine when is the meal time for the fish. The meal time usually can be change depends on the user coincide with some specific condition such as type of fish, size of the pond, quantity of fish and many other aspect which selected by the programmer or ser to set the time. Moreover, the running period for each feeding also determine by this timer that is also programmed by the user. The feeding device includes means on the control means to vary the length of each predetermined interval. Plus, there is also

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a need for warning for user if the storage reach a low level of fish feed, such as sending SMS to user phone.

At the same time, monitoring the environment of the aquarium is also important in some part of the country. Some places have constant temperature all year round but there are also some places that the temperature will go from extreme to another. Such cases will definite carry huge risk to wards the fish. If such cases occur, the fish will probably die. Thus, there is also need to update such situation via SMS. Same as previously mention situation.

b) Problem Statement

In these modern times, there are many aquarists or fish owners of the home based aquarium leads a busy life especially those who are away on business or vacation. They are often difficult to maintain a regular feeding schedule. However, for the fish survival, the fish require regular care in order to remain healthy. If fish are not constantly fed small amounts of food at regular intervals, there can be significant loss of fish due to starvation. But, at the same time, too much food in the water can easily clog up important filters and cause the owners to spend more time cleaning the aquarium tank. Moreover, monitoring the internal environment such as the temperature of the water is a plus point. There are some aqua life that cannot live if the temperature is too cold or too warm. Thus, they might need to take a certain action by recruiting a reliable helper to ensure that the fish are properly fed and taken care of while they are away.

As such, a device can replace the helper instead. The system of the device must be able to be controlled or adjusted by user according to their demand and needs. As referring to “automatic” word itself, the device or more appropriate, the feeder should be able to be operated without supervision of human at least at certain interval of time. At the same time, the water temperature can also be monitored.

There are many different designs and brands on automatic fish feeders on the market, but there are some limitations on the existing fish feeders need to be improved. Therefore, some improvement or new invention needs to develop to solve these problems. However, when it comes to a total cost of this design, it is a bit expensive as this invention requires higher cost of parts.

Usually modern aquariums have their own automatic fish feeder that used to give food to the fish by following the timer that is set by the user. However, the problem with an automatic fish feeder is that there may be a time a user forgot to resupply the fish feed into the device and there not many feeders that have their own temperature sensor. For this project I need to design the automatic fish feeder with a warning system so the amount of food in the aquarium can be replenished and the water temperature can be monitored at all times.

c) Research Objectives

The aim for this research is to develop fish feeder to automatically dispense flakes twice a day or more according to user interest every day. The system should also able to keep the flakes dry and should monitor the total amount of the flakes. The system should be able to send SMS notification to the owner if the flakes amount goes below preset minimum amount. The system should also monitor the overall environment of the aquarium using different sensors and update the user by SMS communications.

The objectives of this paper are:

1. To design and develop automatic fish feeder for indoor aquarium.
2. To monitor the environment of the aquarium and update the user by sending SMS.
3. To evaluate the performance of the developed mechanism.

d) Research Problems

Here are the research problems that must be overcome in order to complete this research. The questions are:

1. What kind of material is suitable for the feed storage to avoid moisture?
2. How to control the amount of fish feed into the pond or tank?
3. What a kind of sensor is suitable for the warning system?
4. How to create a system so that are able to communicate properly with the GSM for SMS sending?

e) Research Methodology

In order to complete the objectives of this research, the following methodology are used. The first stage is the literature review, in which I study about the previous research about devices made previously, what are their advantage and disadvantages and so on. In second stage, I consider the component used and to optimize cost with the usage due to the wide array of items available in the market. Third, I need to study on how the servo motor works and how to control it. I will also need to study about coding to control the motor properly according to the user input. Then I have also need to learn about controlling the opening area, plus the amount of time it will operate in day. After that I also need to find out what kind of sensor is suitable to warn about low storage. Later, I will need to know how to interface the warning system with the GSM to send a message to the user. Last but not least, I also need integrate all the system together before doing documentation for all the gathered information.

Then the selection of component will be needed to be done and tested by stages. This involves programming the Arduino board with selected components. Each stage will be tested accordingly until the project succeeds. The complete timeline for the

whole project is shown in the project Gant chart as in Appendix A.

II. Literature Review

a) Automatic Fish Feeder Concept

Basically, there is a lot of inventions had been made and been classified as "automatic fish feeder". From those previous designs, a few are chosen due to their criterions which are quite interesting and also useful.

The first design is by David C. Smeltzer which is patented in 4th April 1985. His design is capable of dispensing feed having various sizes of grains over a wide range of dispensing volumes with a high degree of accuracy. The device was able to do this by utilizing an adjustable counterbalance weight which the amount of water required are changeable to produce a dispensing action and simultaneously adjusts the vibration movement made by the fish feeder to differentiate the amount of food given out.

Consequently, both the frequency of feeding and amount can be controlled by the counterbalancing the weight. Furthermore, the number of feeding can also be adjusted by changing the rate flow of the water supply by using a valve and the water supply line, plus an additional water container which is capable of measuring the volume of water supplied to the water container so as to provide an additional degree of accuracy in degree of accuracy insetting the frequency of feeding.

However, as stated by Mohapatra, Sarkar, Sharma and Majhi (2009) and Noor, Hussian, Saaid, Ali and Zolkapli (2012), for most automatic fish feeder, it is not easy to control the amount feed released. Too much will pollute the water in the pond or the tank. Plus, the constant speed to deliver the food pallet limited its usage. At the same time, it is also a waste of food. The size of the device will depend on the location it will be used or install, whether the device is used for normal aquarium or pond. For indoor aquarium, a small device will work well and the outer pond will require a bigger device with a big storage. The size of the storage will determine the number of trips the user needs to do to replenish the feed. Not to mentioned, for most of the time, the cost are proportional the size of the device.

A research conducted by Faridi, Ezri, Saidin and Faizal (2011) has stated that there are two types of automatic fish feeder. There are fixed fish feeder and also mobile fish feeder. From this statement, I can infer these two types have their own usefulness based on the situations. A fixed is useful for owners that have a single pond or and aquarium. On the other hand, mobile feeders are useful to owners who have more than two or more ponds. Faridi et al. (2011) also stated, controlling the feeders will requires high precision programmable logic circuit (PLC) and also efficient.

Furthermore, instead of feeder that are situated in pond, there are also automatic fish feeder feed feeder that are placed on the ocean by installing inside a buoy (James & Stanley, 2006). It is understandable that by placing the feeder inside a buoy on the ocean, by installing a camera, microphone or any other appropriate sensor, oceanic aquamarine life can be easily monitored. As long the ponds are large enough, such fish feeder can be used.

b) Servo Motor

Servo motors have been around for a long time and are utilized in many applications. They are small in size but unlike normal motor, be it AC or DC, these motor pack a big punch and at the same time, very energy-efficient. Due to these features, they can be used to operate radio-controlled or remote-controlled toy cars, robots and airplanes. Servo motors are also used in industrial applications, robotics, in-line manufacturing, pharmaceutics and food services.

Different than normal motor, servo motor can only rotate in a specific angle, whereas a normal motor are able to rotate 360°. In a paper written by Ahmed, Chellali and Zahir (2013), in these recent times, servo will be an important device in industrial application. Plus, this field will require high dynamics on position control. Example of such application are; numerically controlled machinery, robotics, automation and other mechanism where the staring and the stopping functions are quickly and accurate. For robotic application, this motor is used to move the robotic arm to a desired position by means of controllers in the automated manufacturing lines of industries. Special ability of the servo motor is that the rotor construction is made of special material with less weight to decrease inertia of armature but at the same time, it is capable of producing the necessary magnetic flux. The capability of immediately starting and stopping during the on-off conditions increases due to low rotor inertia. Below is the equivalent circuit of DC servo motor:

There is also a brushless DC servo motor. A research by Ku (2006) shows that this type of servo motor is usually involve in an application that require high motion controlled and high speed. It is used in an industry for pick and place for a wide variety of product transfer application. That said, depending the situation at hand that does not require high precision a less precise servo motor is good enough to be implemented.

On the other hand, the servo motor can be controlled in many ways. A research paper proposed by Hao (2012), states, a complex system can be simplified by applying the fuzzy logic to control the servo motor.

For better result, the grey theory was used in order to overcome the disadvantages of the traditional method of computing the torque technique and at the same time, it has similar simple control structure to the PID controller (Rong, Rou & Li, 2001).

c) GSM (Global System for Mobile)

GSM (Global System for Mobile Communication), is a standard developed by the company known as the European Telecommunications Standards Institute (ETSI) to describe the protocols for second generation (2G) digital cellular networks used by mobile phones.

The GSM standard was developed as a replacement for first generation (1G) analog cellular networks and originally described a digital, circuit-switched network optimized for full duplex voice telephony. This was expanded over time to include data communications, first by circuit –switched transport, then packet data transport via GPRS (General Packet Radio Services) and EDGE (Enhanced Data rates for GSM Evolution or EGPRS).

In the paper written by C. D. Oancea (2011), GSM is able to operate in several frequencies. Based on its on its own SIM (Subscriber Identity Module), the known band it can operate are 900MHz, 1800MHz and 2100MHz. This will provide the user and identity in the network with having a unique telephone number for each of them. C.D. Oancea (2011) also states that in order to produce a communication between hand phones and computer, a GSM/GPRS modem is needed. Plus, the communication goes both ways.

In an application that are opposite with the previous mentioned, a paper written by Rozita, Salah Addin, Kok and Mok (2013), the handphones is used to control the home appliance through SMS by going through the GSM.

A signal will need to travel in order to reach its destination. Kazemi, Mosayebi, Etemadi, Boloursaz and Behnia (2012) has written in their research that the data transmission in GSM happen in many channel that are available and it can be compute by using a certain technique or method. Such methods are "Parameter mapping" and "Codebook Optimazation". A paper written by Guifen & Guli (2010) has supported that usage of GSM to for wireless communication especially for cellular phones as it has a lot of advantages and conveniences.

d) Central Processing Unit

In all devices, they must have a unit that will be able to receive all the input, compute all the things need to be calculated such as distance and manipulate the other unit to produce outputs. This usually will be done by a central processing unit (CPU), or also known as the brain for the devices. Without it, the input will not be put into use; the output cannot be control and so on as there is no communication between these units. The microprocessor or microcontroller took the role as the CPU for the devices.

In recent years, for making prototype devices, the microcontroller knows as Arduino is used most of the time. As stated by Masimo (2011), Arduino is a user friendly device with open source software. As it is an open source programe, user all over the world are able to share their knowledge. Furthermore, according to Vicky, Fifki, Ary and Diotra (2013), the Arduino Uno is a microcontroller board based on the ATmega328 which has 16 digital input/output pins, 6 analog inputs and a lot more of other features.

With Arduino, doing the coding for the software is quite simple as it is based on C++ language. Plus it is also cheaper compared to the other available microcontroller. These facts are supported by the research by Luiz, OSvaldo, Marli, Paulo, Leonardo and Fatima (2013).

The practical usage or Arduino as a microcontroller a widely used in many fields such as for lab kits for starters, school competition to nurture future researchers and going up, for robotic configuration. The usage describe previously are written by John & Ioannis (2010), Radhika, Shoba, Terry & Maryam (2013) and also Luiz et al (2013).

For this project, the Arduino is used to program the servo motor. A paper written by Francisco & Vignaud (2013) shows that the Arduino can also be used to control a brushed DC motor all together with the motor driver.

e) Temperature sensor

As implied by its name, it is sensor that measures temperature. For this paper, the temperature here will focus to measuring the temperature in water, such as ponds, lake or ocean. For most cases, this type of temperature is used to monitor the water condition for aquatic life.

In paper written by Chen, Zhong and Cai (2011) has stated that, in moving an ornamental fish, a fish that are sensitive to temperature changes, a temperate sensor is used to monitor the heat from the water as other devices is used to control or cool the water for fish transfer. Fig. 2.10 shows their program flow-chart.

In another, research by Min, Ji and Daoliang (2012), they have state that, in case of a sea cucumber, its growth rate and development are heavily depended on the temperature of the water. From this alone, the factor of water temperature must not be neglected as it can affect the aquatic life.

III. System Design

In this chapter, the project description will be elaborated as well as the design and component selection and justification will be presented. The components for this project will be discussed into two separate categories which are mechanical and electronics.

a) Mechanical Structure

The automatic fish feeder has been designed as such as shown in appendix B.

The material that is required is very simple where the device is mostly constructed by using plastic. This is because the body of the device needs to be highly stable to hold all the electronics components. There are many types of materials can be used to make a robot body, for example, wood, metals, glass and other suitable materials. Each of these components has their own advantages and disadvantages and they normally been selected based on the type of projects. In this project, plastic is selected due to its light weighted and is cheap as shown in the Fig.3.1.

As for the rod used as the limit switch, plastic is preferred to be used as the material. The opening for the feeder is at the bottom of the device.

The below image shows the event when the lead is close and open. As seen, the feed is put inside the storage and it will fall down by gravitational force when the lid is open.

b) Electronics Components

Arduino is an open source physical computing microcontroller board. This device is just needed to connect to the computer with a USB cable to begin uploading the necessary coding. Both of Arduino UNO and MEGA2560 features are shown in the Table 3.2.

Microcontroller	ATmega328	ATmega2560
Operating Voltage	5V	5V
Input Voltage (recommended)	7-12V	7-12V
Input Voltage (limits)	6-20V	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)	54 (of which 14 provide PWM output
Analog Input Pins	6	6
DC Current per I/O pin	40mA	40mA
DC Current for 3.3V Pin	50mA	50mA
Flash Memory	32 KB (ATmega328) of which 0.5KB used by boot loader	256 KB of which 8 KB used by boot loader
SRAM	2 KB (ATmega328)	8 KB
EEPROM	1 KB (ATmega328)	4 KB
Clock Speed	16 MHz	16 MHz
Price	RM 72.00	RM 168.00

Arduino was selected to be the microcontroller since it is a new component and its features are simpler and complex coding also can be done in such a way that easy to understand. Furthermore, this microcontroller has its own a USB connection, a power jack, an ICSP header and a reset button. Between the two, Arduino Mega is selected due to the high number of digital I/O pins as this project may require more than 16 I/O pins.

i. *Servo Motor*

Different than normal motor, the servo circuitry is built right inside the motor unit and has a positional shaft, which usually is fitted with a gear (as shown below as shown Fig 3.2.). The motor is controlled with an electric signal which controls the shaft movement.

Inside the servo is a simple set-up: a small DC motor, potentiometer and a control circuit. As the motor rotates, the potentiometer's resistance changes, thus the control circuit can precisely regulate how much movement there is and in also which direction to turn.

This is possible due to the motor is attached by gears to the control wheel.

When the shaft of the motor is at the desired position, power supplied to the motor is stopped. If not, the motor is turned in the appropriate direction. The desired position is sent via electrical pulses through the signal wire. The motor's speed is proportional to the difference between its actual position and desired position. So if the motor is near the desired position, it will turn slowly, otherwise it will turn fast. This is called proportional control. This means the motor will only run as hard as necessary to accomplish the task at hand.

Servos are controlled by delivering an electrical pulse of pulse width modulation (PWM) or variable width, through the control wire. There is a minimum pulse, a maximum pulse and a repetition rate. Most servo motors can usually only turn 90 degrees in either direction for a total of 180 degree movement. The motor's neutral position is defined as the position where the servo has the same amount of potential rotation in the both the clockwise or counter-clockwise direction. The PWM sent to the motor determines position of the shaft, and based on the duration of the pulse sent via the control wire; the rotor will turn to the desired position. The servo motor expects to see pulse every 20ms and the length of the pulse will determine how far the motor turns. For example, a 1.5ms pulse will make the motor turn to the 90-degree position. Shorter than 1.5ms moves it to 0 degrees and any longer than 1.5ms will turn the servo to 180 degrees as diagramed below:

When these servos are commanded to move, they will move to the position and hold that position. If

an external force pushes against the servo while the servo is holding a position, the servo will resist from moving out of that position. The maximum amount of force the servo can exert is called the torque rating of the servo. Servos will not hold their position forever though; the position pulse must be repeated to instruct the servo to stay in position.

As describe previously. The position of the servo motor can be controlled by user input using a microcontroller. Below are the movements that are set to move at 45° with 45° increment with the limit at 180° and also the servo motor that is used for this project.

The TG9e is known as a cheap but reliable servo motor. The motor has the same performance as other servo with a 0.10 sec travel time and up to 1.5kg in torque and an ultra-narrow dead bandwidth.

Table 3.2 : Turnigy TG9e Specification

Dimension:	23x12.2x29mm
Torque:	1.5kg/cm (4.8v)
Operating speed:	0.10sec/60 degree 0.09sec/60 degree (6.0V)
Operating voltage:	4.8V
Temperature range:	0-55C
Dead band-width:	7us
Lead Length:	260mm

ii. *GSM*

There are many types of GSM that can be used. Below is another table that shows some of the said items that are considered.

Table 3.3 : Comparison between GSM modules

Sensors	Features
SIM900 GSM/GPRS shield	Size: 7.14 x 6.60 x 0.16 cm Price: RM 220.00 Product Features: • IO ports-RXD, TXD, Free USB to TTL for PC, supports 12000bps-115200bps, Supports AT commands GSM 07.07, 07.05, SIMCOM AT Extended commands • Antenna – SMA connector, comes with GSM 900M/1800M small antenna • Power ports-DC 5V 2A 2.1 mm, BAT/GND connector for external mobile phone battery • SIM Slot – Support 1.8V/3V SIM card • working frequency – EGSM 900 MHz/DCS 1800 Mhz – Auto Dual Band • Size of PCB 59mm*43mm • with ESD Protection • With On/Off button and Power LED indicator • Signal LED Indicator
Mini SIM900A GSM SMS GPRS Module	Size: 0.59 x 0.43 x 0.16 cm Price: RM 150.00 Product Feature • IO ports-RXD, TXD, Free USB to TTL for PC, supports 12000bps-115200bps, Supports AT commands GSM 07.07, 07.05, SIMCOM AT Extended commands • Antenna – SMA connector, comes with GSM 900M/1800M small antenna • Power ports-DC 5V 2A 2.1 mm, BAT/GND connector for external mobile phone battery • SIM Slot – Support 1.8V/3V SIM card • working frequency – EGSM 900 MHz/DCS 1800 Mhz – Auto Dual Band • Size of PCB 59mm*43mm • with ESD Protection • With On/Off button and Power LED indicator • Signal LED Indicator

Based on the previous comparison, the Mini SIM900A GSM SMS GPRS Module is chosen. First factor is due to its lower cost. Plus, the objective for this project is to deliver a SMS when the warning sensor is triggered. At the same time it will also be used to deliver SMS when the temperature is too high.

Matrix keypad is widely use in our daily life. Often, matrix keypad is available in 3x4 or 4x4. In general, matrix keypad is a good substitution to normal push button. This is due to the matrix keypad offers more input to the microcontroller with lesser I/O pins required as compared to buttons. Considering system that needs 16 inputs, this keypad will only requires 8 I/O pins with keypad instead of 16 I/O pins. So I can actually use the extra 8 pins for other functions.

The matrix keypads work by based on Table 3.3 mapping.

Table 3.5 : Mapping of buttons with rows and columns

	Col 0	Col 1	Col 2	Col 3
Row 0	1	2	3	A
Row 1	4	5	6	B
Row 2	7	8	9	C
Row 3	*	0	#	D

A 4x4 matrix keypads consist of 4 rows and 4 columns. On paper, the keypad looks roughly like this:

From the Fig. 3.7, there is a switch connected to each row and column. So, these combinations of rows and columns make up the 16 inputs of a normal pushbutton.

Normally, for a regular pushbutton, the entire switches are open or not connected. Then when I pressed either one of the buttons, the switch will become closed or connected. As a result, between the row and column, connection exists.

Relating with the project microcontroller, I connect the first 4 pins to the column as the INPUT. Meanwhile the other 4 pins are connected to the row as the OUTPUT. The input meant that is the input to the microcontroller while output is the output from the microcontroller. Note that the input to the microcontroller has to connect to pull high resistor, or the internal pull up from Arduino itself can be used.

Here is how it works, the microcontroller send LOW to each row one at a time and check whether there is a LOW signal detected on the column. If there is no button pressed, the microcontroller will scan for the next row and read for LOW signal. Since the column is pull HIGH internally, so no button pressed would return 1 to the microcontroller. When you pressed one of the buttons, now the row and column are connected. The 0 from row would make the column return a 0 to microcontroller.

With the row and column, I can know which button I am pressing.

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The resons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

Table 3.5 : Pin Description

Pin No	Function	Name
1.	Ground (OV)	Ground
2.	Supply voltage; 5V (4.7V-5.3V)	Vcc
3.	Contrast adjustment; through a variable resistor	VEE
4.	Selects command register when low; and data register when high	Register Select
5.	Low to write to the register; High to read from the register	Read/write
6.	Sends data to data pins when a high to low pulse is given	Enable
7.	8-bit data pins	DB0
8.		DB1
9.		DB2
10.		DB3
11.		DB4
12.		DB5
13.		DB6
14.		DB7
15.	Backlight Vcc (5V)	Led+
16.	Backlight Ground (OV)	Led-

iii. *Sensor (Limit Switch)*

For the warning system, in order to select a correct sensor available in the market, thus I have chosen a component that will act similar to an analog sensor that is the limit switch. A list of features and prices of various types of switch that can be used are considered as shown in the Table 3.1 below.

For this project, after considering all the available switches with their practical uses, plus balancing with their cost, the KW11-3Z limit switch is chosen. Compared to the rest of the switches, although each of them has their own unique uses, however, optimizing the cost while achieving the similar result, the rest of them is omitted. Plus the chosen switches are available easily acquired.

Based on the Fig 3.13, when the feed is full, the rod will not touch the limit switch. However, when the feed level reach a low level, the rod at the outer side will trigger the limit switch which in turn will give a signal or input to the microcontroller.

The limit switch, KW-11-3Z Micro Switches specifications are shown at the table below.

Table 3.7 : Pin Description

Color:	Silver + Black
Material	PA66 material
Voltage:	AC 250V
Current:	5A

iv. *Temperature Sensor*

From the many temperature sensors, I chose the sensor that is waterproof as I will put it in the water for temperature measurement. Below, table 3.8 is the specification of the chosen sensor.

This sensor is a simple 1-wire interface. The DS18B20 provides 9 to 12-bit (configurable) temperature readings over a 1-Wire interface, so that only one wire (and ground) needs to be connected from a central microprocessor.

c) Bills of Materials and Costing

The actual budget of this project is RM 500.00 for the whole complete project. In this FYP 1, some of the component was already acquired from previous project, some are yet to be purchased and the estimated total cost is RM 391.00. The components were selected based on careful research from previous articles and suitable to be used for this project. Do note that this price is only for core components. The miscellaneous items are not included yet. The bills of materials used in this project are shown Appendix B.

V. Conclusion & Future Plan

a) Conclusion

To create an automatic fish feeder device is not an easy task. Plus, adding the sensor for environment monitoring that is the water temperature is new to me. It requires a lot of research and reading. I also have to consider balancing the optimum cost with it practical usage as, in terms of marketing, no customer will want to buy an overpriced product. This will be a challenge to us, because with my limited knowledge, I do not know all the cheapest component that are available in the market that fulfill the requirement and achieved the desirable result.

I already did some literature review to get the idea on the component used to make this device. I also already have my design and also the initial idea on how everything will be put together. I already select the possible components to be used and Insya Allah in the next semester, the project will continue with the creation of the devices.

b) Future Plan

For the next semester, I will work on how to program the Arduino using Arduino IDE, how to code the servo motor at desired interval and desired opening angle, how to use the GMS900 and interface it with the Arduino, how to use the display connected to the keypad, how to connect temperature sensor with its coding and also how to create the overall algorithm. I will also need to prepare for trouble shooting as combining all the coding into one big program will usually cause a lot of error. At the same time, I also need to make sure the device is stable and somewhat robust.

References Références Referencias

1. Ahmed M.A., Haidar, Chellali B., M. Zahir (2013). Software Interfacing of Servo Motor with Microcontroller. J. Electrical Systems 9-1 (2013): 84-99
2. B.C Mohapatra, Bikash S., K.K. Sharma and D. Majhi. (2009). Development and Testing of Demand Feeder for Carp Feeding in Outdoor Culture System. Agricultural Engineering International : the CIGR Ejournal. Manuscript No 1352. Vol. XI
3. Chen S., Zhong K, Cai Y.L. (2011). The Design and Application of the Water Temperature Control System for Large Aquaculture Pond. Measuring Technology and Mechatronics Automation (ICMTMA), 2011 Third International Conference on Measuring Technology and Mechatronics Automation, Volume: 3 Publication Year: 2011, Page(s): 737_739
4. C.L. Ku, Y.K. Tan, S.K. Panda (2006). High – Precision Position Control of Linear Permanent Magnet BLDG Servo Motor for Pick and Place Application. Pg2191-2924
5. Constantin D. O. (2011). GSM Infrastructure Used for Data. Transmission The 7th international symposium on advanced topics in electrical engineering

6. Francisco A.A., Vignaud G.A. (2013). Using open-source platform for trajectory control of DC motors, IEEE
7. Guifen G., Guili P. (2010). The Survey of GSM Wireless Communication System International Conference on computer and Information Application (ICCIA 2010). Pp121-124
8. Hao Y. (2012). DSP-BASED Fuzzy Logic Servo Motor Control. International Conference on Control Engineering and Communication Technology.
9. John S., Ioannis K. (2010). Lab Kits Using the Arduino Prototyping Platform. 40th ASEE/IEEE Frontiers in Education Conference
10. Liuz A.J., Osvaldo T. N., Maril F. H., Paulo S. M., Leonardo L. R., F'atima A. G. (2013). A Low- Cost and Simple Arduino- Based. Educational Robotics Kit Cyber Journals: Multidisciplinary Journals in Science and Technology. Journal of Selected Areas in Robotics and Control (JSRC), December Edition, 2013, Volume 3, Issue 12.
11. Min S., Daoliang L. (2012) Water Temperature Prediction in Sea Cucumber Aquaculture Ponds by RBF Neural Network model. 2012 International Conference on Systems and Informatics (ICSAI 2012). Pp1154-1159
12. M. Z. H. Noor, A.K. Hussian, M. F. Saaid, M. S. A. Ali, M. Zolkapli (2012). The Design and Development of Automatic Fish Feeder System Using PIC Microcontroller Control and System. Graduate Research Colloquium (ICSGRC 2012), IEEE
13. M. V. G. Aziz, Rifki W., Ary S. P., Diotra H. (2013). HASH MD5 Function Implementation at 8 –bit Microcontroller. Joint International Conference on Rural Information & Communication Technology and Electric-Vehicle Technology (rICT & ICev-T). IEEE
14. M. F. Shaari, M. E. I. Zulkefly, M. S. Wahab, F. Esa (2011). Aerial Fish Feeding System. International Conference on Mechatronics and Automation, IEEE
15. Rong J.W., Rou Y. D., Li J.C. (2001). Grey Feedback Linearization Speed Control for Induction Servo Motor Drive. IECON'01:The 27th Annual Conference of the IEEE Industrial Electronics Society
16. R. Kazemi, R. Mosayebi, S.M. Etemadi, M. Boloursaz and F. Behnia (2012). A lower Capacity Bound of Secure End Data Transmission via GSM Network 6th International Symposium on Telecommunications (IST'2012), pp1015-1020
17. Rozita T., Salah A. A., Kok W. C., Mok V. H. (2013). Smart GSM Based Home Automation System Conference on Systems, Process & Control (ICSPC2013), IEEE, pp306-309
18. Radhika G, Shoba K., Terry S., and Maryam K. (2013). A Competition-Based Approach for Undergraduate Mechatronics Education Using the Arduino Platform
19. S. J. Yeoh, F. S. Taip, J. Endan, R. A. Talib and M.k. S. Mazlina (2009). Development of Automatic Feeding Machine for Aquaculture Industry. Pertanika J. Sci. & Technol. 18 (1): 105-110 (2010)
20. Stanley J. B., James D. I. (2006). Aquaculture Feed Buoy Control-Part 1: System, IEEE
21. Shih A. L., Chung W. W., Yi H. C., China H. L., Min H. Y., Yi C. L., Ming H. H., Ching C. W. (2012). Servo motor Controller design for robotic Manipulator. International Symposium on Intelligent Signal Processing and Communication Systems (ISPACS 2012), IEEE

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Simulating the Bird's Leg as a Double Inverted Pendulum

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Simulating the Bird's Leg as a Double Inverted Pendulum

Ramdhun Vyas [α] & Jianbin Xue [σ]

Abstract- The double inverted pendulum is a system which is non-linear, unstable with fast reaction. Stabilising a double inverted pendulum means the pendulum is not oscillating and moving and there is no force on it. In this paper the leg of a birdist modelled as a double inverted pendulum and the nattempt to control it. The Linear Quadratic Regulator is used to control the system. Modelling of then onlinear dynamic equations is obtained with the help of Euler-Lagrange equation and linearization is done using the Jacobian matrix. Simulations are done with the help of Matlab which shows that the bird's leg can be stabilise if they are double inverted pendulums. Future use of the results is to be used for the design of a landing gear based on the principles of a bird's leg.

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I. Introduction

An inverted pendulum is a system whereby the centre of mass of the pendulum is located above the point of pivot of the pendulum [1]. It is often described as a typical fast speed system, with many variables, nonlinear and entirely unstable. The inverted pendulum system is one the most difficult systems while being at the same time a standard problem in the field of control systems due to it being really unstable [2]. A proper force balance must be maintained in order for the system to be kept stable, which eventually lead to the need of a proper control theory [3].

The required force balance is achieved, either by a specific torque applied at the point of pivot; horizontally moving the pivot point in the feedback system; changing the speed at which the mass mounted of the pendulum parallel to the axis of pivot rotates, producing a net torque on the pendulum or by oscillation of the pivotal point vertically. There are so far two kinds of inverted pendulum that have been studied extensively: the simple inverted pendulum and the double inverted pendulum. Other orders of the inverted are deemed really unstable and therefore more difficult to study. There is a wide range of applications of the inverted pendulum. It serves as an excellent model idea for the automatic landing system and stabilisation for aircrafts in turbulent air-flow, stabilization of the cabin in a ship and so on [4]. The process of stabilizing an inverted pendulum is a non-linear one which is unstable with one input signal and several output signals.

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II. Literature Review on the Double Inverted Pendulum

A double inverted pendulum is a combination of the inverted pendulum and the double pendulum. The double inverted pendulum is said to be a multivariate nonlinear system which has fast reaction as well as being an unstable one. This eventually results in the formation complex equations when finding a stabilized position. Stabilization of a double inverted pendulum system is not only a problem which is challenging but also a valuable way in showing the power of the control method.

Since the double inverted pendulum system has strong nonlinearity and inherent instability, sometimes the mathematical model of the object near upright position of the pendulum has to be made linear by the inconsistent structure control system [5]. Control of a double inverted pendulum is a quite a challenge due to it being nonlinear. It is sometimes used as a tool to test linear and nonlinear laws [6] [7]. There are two main problems which are concentrated when working on pendulum control: the control design of the pendulum swing up and stabilising of the inverted pendulums.

Much research has been done on the control of the double inverted pendulum by using different techniques such the fuzzy control systems, control strategies such as the PID controller, neural network and gravity compensator. Experiments using the fuzzy control theory, which contains fuzzy interference, have shown that is difficult to design a fuzzy controller for the double inverted pendulum. Fuzzy control theory was used by Qing-Rui Li et. al. [8] to stabilise the double inverted pendulum. The results show that the controller had great precision, with rapid convergence speed and greater precision. It was concluded that the control results can be extended for controlling multiple order of inverted pendulum and a proven way to control other unstable system has been obtained.

Alexander Bogdanov[9] studied and compared many algorithms for the ideal control of a double inverted pendulum on a cart (DIPC). He tested many different methods. The results of the simulations showed that the state-dependent Riccati equation (SDRE) had a better performance than other methods he used. Linearization technique to balance a double inverted pendulum on a cart was attempted by Mandar R.

Nalvadeet. al [10]. The Jacobian method was used to obtain the linearization form with the proper cost function and modelling was done with the help of Euler-Lagrangian equation. The simulation results were obtained by MATLAB which showed that the linearization technique is good for stabilisation around an equilibrium point.

In nature many living things follow the concept of the inverted pendulum such as humans and animals when standing on their feet. They need a proper force balance for stabilisation when carrying specific activities so that they don't fall. A bird is an animal of nature. As it is known the bird's leg consists of four parts[11]; femur, tibia and fibula, tarsus and finally the claw. It is said to be underactuated. The main focus of this paper are the the femur, tibia and fibula and the tarsus. They are among the important structures in a bird's leg which help it to carry out its activities. The aim of this paper is to model the leg of a bird as a double inverted pendulum and thentry to stabilise it using LQR control method.

III. Structure of the Bird's Leg and the Relationship with the Inverted Pendulum

a) Structure of the bird's leg

Fig. 1 below shows the skeletal structure of a bird, with the femur, tibia and fibula, tarsus and the claw.

They are all connected with each other by joints, with the femurin the end connected to the ilium, which is a part of the skeletal structure of the bird as shown.

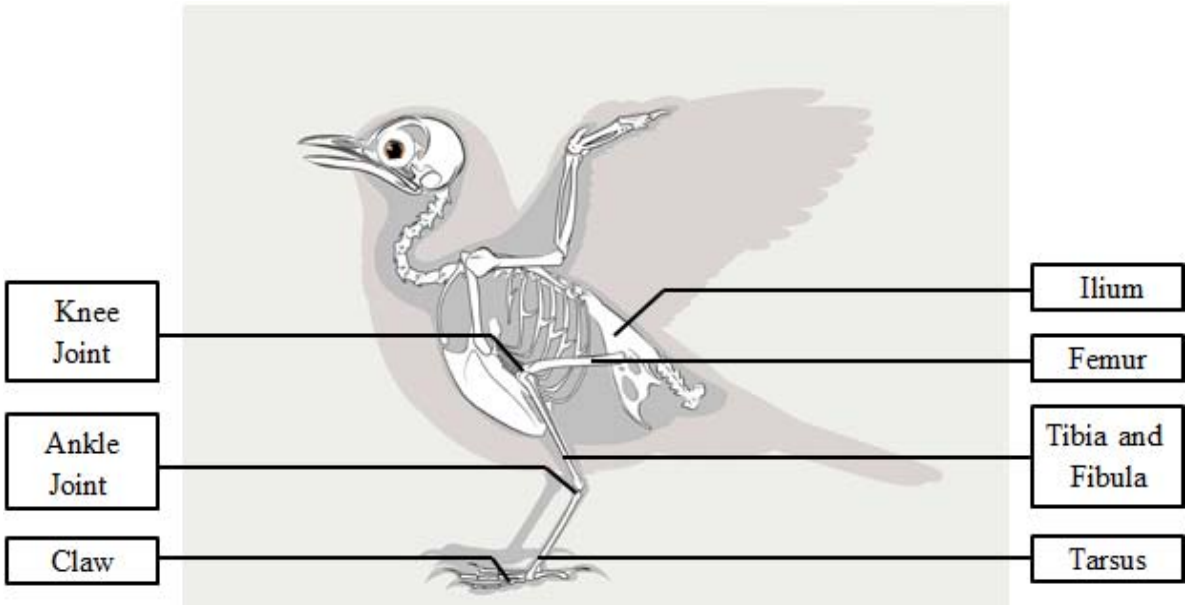

Fig. 1 : Skeletal structure of a bird

When a bird stands on its legs, its knees are flexed at the same time putting the knee joints near the centre of gravity and the feet are positioned approximately under the centre of gravity and the tail acts as a counter-balance. All these actions lead to stabilize the balance of the body when the bird is standing. The tail also acts as a means of balancing when the bird walks/hops on the ground or perches. Birds like woodpeckers have stiffened tail feathers, which they use as a prop, helping them in perching and climbing on vertical tree trunks.

b) The relationship between the bird's leg and the inverted pendulum

A close look at the leg of the bird, it can be seen that its shape resembles to that of an inverted pendulum, with the body of the bird on the top and the foot the ground. The bird changes the angle of the ankle and knee joints to balance it self with the help of ligaments behind the ankle and knee joints which help them to flex within the required angle when perching, standing or hopping, thus forming an imaginary system of an inverted pendulum. Inverted pendulums are among the basics for body balance such as the human leg and in this case, of a bird's leg. In Fig. 2 below, the relationship of the bird's leg to the inverted has been shown, with a schematic diagram to simplify representation of the bird body and its leg.

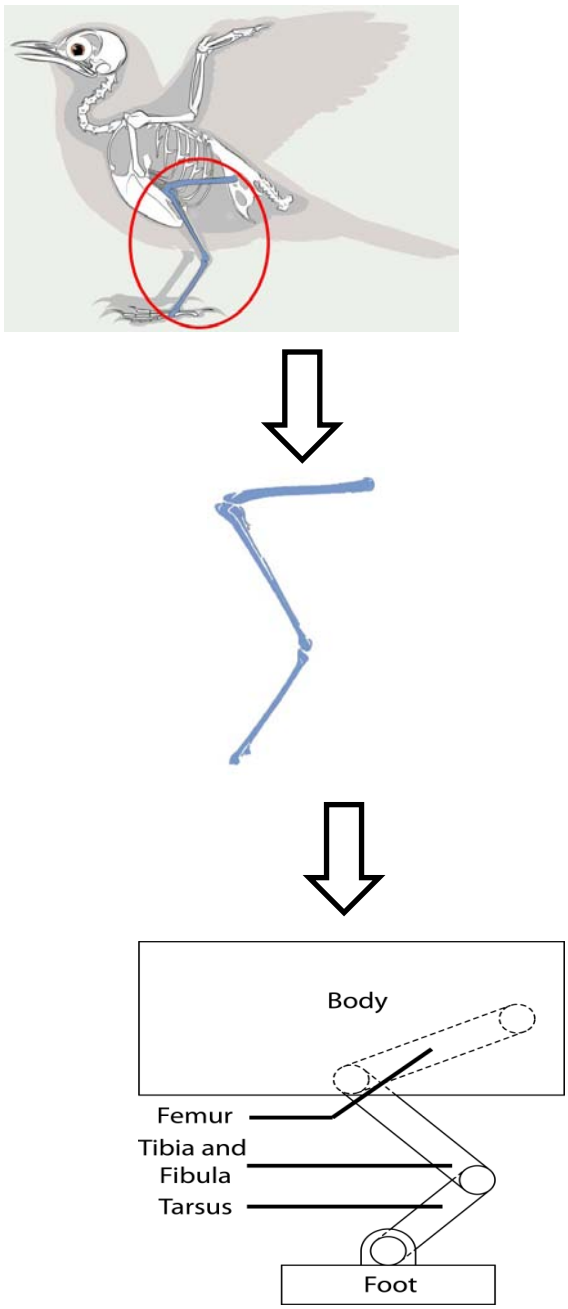

Fig. 2 : Schematic diagram of bird's leg

IV. Modelling the Bird's Leg as a Double Inverted Pendulum

a) The bird's leg as a double inverted pendulum

The bird's leg is geometrically a three order inverted pendulum, also known as the triple inverted pendulum. But a triple inverted pendulum is practically really unstable. In practice, some of the triple inverted pendulum parameters may not be known precisely, which has a big impact on the system dynamics [12]. By ignoring the femur which is usually inside the body of the bird, the inverted pendulum can be considered as double inverted one. Fig. 3 below shows the bird in schematic diagrams as it would be if considered as a double inverted pendulum from the triple inverted pendulum. The claw has been represented as the "Foot" of the bird in the diagrams due to its complex shape and the body of the bird is represented as "Body".

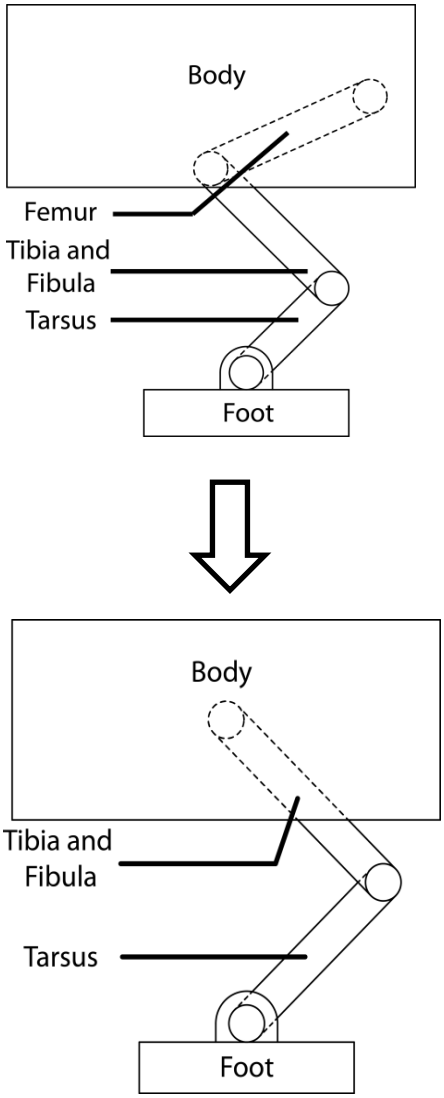

Fig. 3 : Bird's leg from triple inverted pendulum to double inverted pendulum

b) Modelling

As being a living thing, the bird legs follow certain the rules of which cannot be mimicked here. Fig. 4 below shows a schematic representation of the bird's leg as a double inverted pendulum where the mass *M* represents the body of the bird, the rods of length L_1 and $L_2$and massesm_1 and m_2 respectivelyrepresent the tibia and fibula and tarsus and finally the base which is fixed, represents the foot of the bird. The rod sare attached to a pivot in the base which are allowed free rotation within certain degrees; $\theta_1$andθ_2.

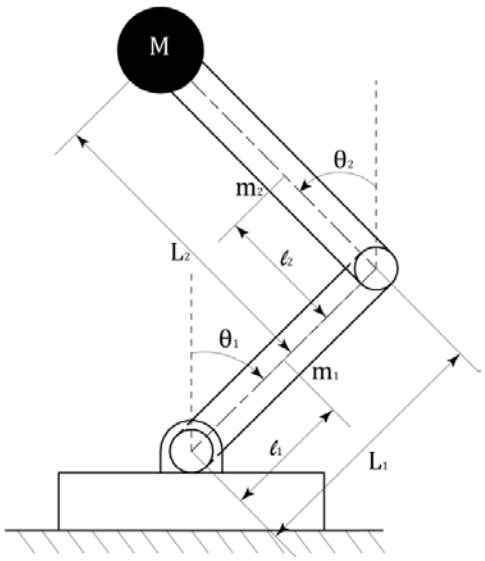

Fig. 4 : Bird's leg as a double inverted pendulum

The double inverted is restricted to linear motion and with the base connected to a fixed place. The movement of the mass *M*, to and thro, causes the system to be unstable. If the mass is tilted to the right, the pendulum moves to the right and vice-versa. The equations of motion of inverted pendulums depend on the constraints that are placed on the movement of the pendulum.

They can be derived using the Lagrange's equations:

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{\theta}}\right) - \frac{\partial L}{\partial \theta} = Q \tag{1}$$

Where L = T − U is the Lagrangian; T and U are the total kinetic energy and potential energy respectively. $Q$is a vector of the generalized forces or moments that is acting in the direction of the generalized coordinates θ and is not taken into consideration in forming the equations of kinetic energy and potential energy and is usually considered as Q = 0 for a stabilized system.

Derivation of the total kinetic energy and potential energy:

Total Kinetic Energy,

T = Kinetic Energy of rod$_1$+ Kinetic Energy of rod$_2$+ Kinetic Energy of Mass

$$= \frac{1}{2}m_1 v_{rod\,1}^2 + \frac{1}{2}I_1\dot{\theta}_{rod\,1}^2 + \frac{1}{2}m_2 v_{rod\,2}^2 + \frac{1}{2}I_2\dot{\theta}_{rod\,2}^2 + \frac{1}{2}Mv^2 \tag{2}$$

where$v$ is the speed at the time $\theta(t)$and *I* is the moment of inertia of the rods

Kinetic energy of rod$_1$:

$$= \frac{1}{2}m_1 v_{rod\,1}^2 + \frac{1}{2}I_1\dot{\theta}_{rod\,1}^2$$

$$= \tfrac{1}{2}m_1(\dot{x}_1^2 + \dot{y}_1^2) + \tfrac{1}{2}I_1\dot{\theta}_1^2$$

$$= \frac{1}{2}m_1\ell_1^2\left[\left(\frac{d}{dt}(\sin\theta)\right)^2 + \left(\frac{d}{dt}(\cos\theta)\right)^2\right] + \frac{1}{2}I_1\dot{\theta}_1^2$$

$$= \frac{1}{2}m_1\ell_1^2\dot{\theta}_1^2 + \frac{1}{2}I_1\dot{\theta}_1^2$$

Kinetic energy of rod_2 :

$$= \frac{1}{2} m_2 v_{rod\,2}^2 + \frac{1}{2} I_2 \dot{\theta}_{rod\,2}^2$$

$$= \frac{1}{2} m_2 (\dot{x}_2^2 + \dot{y}_2^2) + \frac{1}{2} I_2 \dot{\theta}_2^2$$

$$= \frac{1}{2} m_2 \left[\left(\frac{d}{dt} (L_1 \sin\theta_1 + \ell_2 \sin\theta_2) \right)^2 + \left(\frac{d}{dt} (L_1 \cos\theta_1 + \ell_2 \cos\theta_2) \right)^2 \right] + \frac{1}{2} I_2 \dot{\theta}_2^2$$

$$= \frac{1}{2} m_2 \left[(L_1 \dot{\theta}_1 \cos\theta_1 + \ell_2 \dot{\theta}_2 \cos\theta_2)^2 + (-L_1 \dot{\theta}_1 \sin\theta_1 - \ell_2 \dot{\theta}_2 \sin\theta_2)^2 \right] + \frac{1}{2} I_2 \dot{\theta}_2^2$$

$$= \frac{1}{2} m_2 \left[L_1^2 \dot{\theta}_1^2 + 2 L_1 \ell_2 \dot{\theta}_1 \dot{\theta}_2 \cos(\theta_1 - \theta_2) + \ell_2^2 \dot{\theta}_2^2 \right] + \frac{1}{2} I_2 \dot{\theta}_2^2$$

Kinetic energy of Mass :

$$= \frac{1}{2} M v_{Mass}^2$$

$$= \frac{1}{2} M \left[L_1^2 \dot{\theta}_1^2 + 2 L_1 L_2 \dot{\theta}_1 \dot{\theta}_2 \cos(\theta_1 - \theta_2) + L_2^2 \dot{\theta}_2^2 \right]$$

Total kinetic energy,T:

$$= \frac{1}{2} m_1 \ell_1^2 \dot{\theta}_1^2 + \frac{1}{2} I_1 \dot{\theta}_1^2 + \frac{1}{2} m_2 \left[L_1^2 \dot{\theta}_1^2 + 2 L_1 \ell_2 \dot{\theta}_1 \dot{\theta}_2 \cos(\theta_1 - \theta_2) + \ell_2^2 \dot{\theta}_2^2 \right] + \frac{1}{2} I_2 \dot{\theta}_2^2 + \frac{1}{2} M \left[L_1^2 \dot{\theta}_1^2 + 2 L_1 L_2 \dot{\theta}_1 \dot{\theta}_2 \cos(\theta_1 - \theta_2) + L_2^2 \dot{\theta}_2^2 \right] \quad (3)$$

Total Potential Energy,

U = Potential Energy of rod_1 + Potential Energy of rod_2 + Potential Energy of Mass

$$= m_1 g h_{\text{rod}\,1} + m_2 g h_{\text{rod}\,2} + M g h_{\text{Mass}} \quad (4)$$

Potential energy of rod_1 :

$$= m_1 g h_{\text{rod}\,1}$$

$$= m_1 g (\ell_1 \cos\theta_1)$$

Potential energy of rod_2 :

$$= m_2 g h_{\text{rod}\,2}$$

$$= m_2 g (L_1 \cos\theta_1 + \ell_2 \cos\theta_2)$$

Potential energy of Mass :

$$= M g h_{\text{Mass}}$$

$$= M g (L_1 \cos\theta_1 + L_2 \cos\theta_2)$$

Total Potential energy,U:

$$= m_1 g (\ell_1 \cos\theta_1) + m_1 g (L_1 \cos\theta_1 + \ell_2 \cos\theta_2) + M g (L_1 \cos\theta_1 + L_2 \cos\theta_2) \quad (5)$$

The Lagrange equation is given by:

$$L = T - U$$

$$= \frac{1}{2}m_1\ell_1^2\dot{\theta}_1^2 + \frac{1}{2}I_1\dot{\theta}_1^2 + \frac{1}{2}m_2\left[L_1^2\dot{\theta}_1^2 + 2L_1\ell_2\dot{\theta}_1\dot{\theta}_2\cos(\theta_1-\theta_2) + \ell_2^2\dot{\theta}_2^2\right]$$

$$+\frac{1}{2}M\left[L_1^2\dot{\theta}_1^2 + 2L_1L_2\dot{\theta}_1\dot{\theta}_2\cos(\theta_1-\theta_2) + L_2^2\dot{\theta}_2^2\right] + \frac{1}{2}I_2\dot{\theta}_2^2 - m_1g(\ell_1\cos\theta_1) - m_2g(L_1\cos\theta_1 + \ell_2\cos\theta_2)$$
$$+ Mg(L_1\cos\theta_1 + L_2\cos\theta_2) \quad (6)$$

And therefore the equations of motion are:

$$\frac{d}{dt}\left(\frac{\partial L}{\partial\dot{\theta}_1}\right) - \frac{\partial L}{\partial\theta_1} = 0$$

$$\frac{d}{dt}\left(\frac{\partial L}{\partial\dot{\theta}_2}\right) - \frac{\partial L}{\partial\theta_2} = 0$$

Substituting L in these equations and simplifying leads to the equations that illustrate the motion of the inverted pendulum:

$$\frac{d}{dt}\left(\frac{\partial L}{\partial\dot{\theta}_1}\right) - \frac{\partial L}{\partial\theta_1} = 0$$

$$\frac{d}{dt}\left[\left(m_1\ell_1^2 + I_1 + m_2L_1^2 + ML_1^2\right)\dot{\theta}_1 + m_2L_1\ell_2\dot{\theta}_2\cos(\theta_1-\theta_2) + ML_1L_2\dot{\theta}_2\cos(\theta_1-\theta_2)\right]$$
$$-(m_1\ell_1 + m_2L_1 + ML_1)g\sin\theta = 0$$

$$\left(m_1\ell_1^2 + I_1 + m_2L_1^2 + ML_1^2\right)\ddot{\theta}_1 + m_2L_1\ell_2\ddot{\theta}_2\cos(\theta_1-\theta_2) + m_2L_1\ell_2\dot{\theta}_2^2\sin(\theta_1-\theta_2)$$

$$+ML_1L_2\ddot{\theta}_2\cos(\theta_1-\theta_2) + ML_1L_2\dot{\theta}_2^2\sin(\theta_1-\theta_2) - (m_1\ell_1 + m_2L_1 + ML_1)g\sin\theta_1 = 0$$

$$\frac{d}{dt}\left(\frac{\partial L}{\partial\dot{\theta}_2}\right) - \frac{\partial L}{\partial\theta_2} = 0$$

$$\frac{d}{dt}\left[\left(m_2\ell_2^2 + I_2 + ML_2^2\right)\dot{\theta}_2 + m_2L_1\ell_2\dot{\theta}_1\cos(\theta_1-\theta_2) + ML_1L_2\dot{\theta}_1\cos(\theta_1-\theta_2)\right]$$
$$-(m_2\ell_2 + ML_2)g\sin\theta_2 = 0$$

$$\left(m_2\ell_2^2 + I_2 + ML_2^2\right)\ddot{\theta}_2 + m_2L_1\ell_2\ddot{\theta}_1\cos(\theta_1-\theta_2) - m_2L_1\ell_2\dot{\theta}_1^2\sin(\theta_1-\theta_2)$$

$$+ML_1L_2\ddot{\theta}_1\cos(\theta_1-\theta_2) + ML_1L_2\dot{\theta}_1^2\sin(\theta_1-\theta_2) - (m_2\ell_2 + ML_2)g\sin\theta_2 = 0$$

Therefore the equations are:

$$\left(m_1\ell_1^2 + I_1 + m_2L_1^2 + ML_1^2\right)\ddot{\theta}_1 + m_2L_1\ell_2\ddot{\theta}_2\cos(\theta_1-\theta_2) + m_2L_1\ell_2\dot{\theta}_2^2\sin(\theta_1-\theta_2)$$
$$+ML_1L_2\ddot{\theta}_2\cos(\theta_1-\theta_2) + ML_1L_2\dot{\theta}_2^2\sin(\theta_1-\theta_2) - (m_1\ell_1 + m_2L_1 + ML_1)g\sin\theta_1 = 0 \quad (7)$$

$$\left(m_2\ell_2^2 + I_2 + ML_2^2\right)\ddot{\theta}_2 + m_2L_1\ell_2\ddot{\theta}_1\cos(\theta_1-\theta_2) - m_2L_1\ell_2\dot{\theta}_1^2\sin(\theta_1-\theta_2)$$
$$+ML_1L_2\ddot{\theta}_1\cos(\theta_1-\theta_2) + ML_1L_2\dot{\theta}_1^2\sin(\theta_1-\theta_2) - (m_2\ell_2 + ML_2)g\sin\theta_2 = 0 \quad (8)$$

The equations of motion of Lagrange can be rewritten to a compact matrix form [9]:

$$\boldsymbol{D}(\theta)\ddot{\theta} + \boldsymbol{C}(\theta,\dot{\theta})\dot{\theta} + \boldsymbol{G}(\theta) = \boldsymbol{H}u \quad (9)$$

Where

$$\boldsymbol{D}(\theta) = \begin{pmatrix} d_1 & d_2\cos(\theta_1-\theta_2) \\ d_2\cos(\theta_1-\theta_2) & d_4 \end{pmatrix} \quad (10)$$

$$\boldsymbol{C}(\theta,\dot{\theta}) = \begin{pmatrix} 0 & -d_2 \sin(\theta_1 - \theta_2)\theta_2 \\ -d_2 \sin(\theta_1 - \theta_2)\dot{\theta}_1 & 0 \end{pmatrix} \tag{11}$$

$$\boldsymbol{G}(\theta) = \begin{pmatrix} -f_1 \sin\theta_1 \\ -f_2 \sin\theta_2 \end{pmatrix} \tag{12}$$

$$\boldsymbol{H} = (1\ 0\ )^T \tag{13}$$

Assumption: The centers of mass of each pendulums and the mass, M, are at the geometrical center of each component. Therefore $2\ell_i = L_i$ and$I_i = m_i L_i^2/12$. Then for the element of$\boldsymbol{D}(\theta)$,$\boldsymbol{C}(\theta,\dot{\theta})$, $\boldsymbol{G}(\theta)$ become:

$$d_1 = m_1\ell_1^2 + I_1 + m_2L_1^2 + ML_1^2$$
$$d_2 = m_2L_1\ell_2 + ML_1L_2$$
$$d_3 = m_2L_1\ell_2 + ML_1L_2$$
$$d_4 = m_2\ell_2^2 + I_2 + ML_2^2$$
$$f_1 = (m_1\ell_1 + m_2L_1 + ML_1)g$$
$$f_2 = (\ m_2\ell_2 + ML_2)g$$

V. Control Design

a) Linearization

It can be seen clearly by the system's equation that the model belongs to a nonlinear system. Normal differential equations can be created by the conversion of the system into state space model format. When a control law is designed, Lagrange equations of motion (9) are reformatted. To be able to carry this out, a state vector is introduced which is as follows.

$$x = \begin{pmatrix} \theta & \dot{\theta} \end{pmatrix}^T$$

To be able to apply the LQR technique on the system, linearization is important. Therefore the nonlinear model of the system turns into:

$$\ddot{\theta} = -D^{-1}C\dot{\theta} - D^{-1}G + D^{-1}Hu \tag{14}$$

After putting the variables of the system matrices in the above generalisation and their derivatives, the system equation is as follows:

$$\dot{x} = \begin{pmatrix} 0 & I \\ 0 & -D^{-1}C \end{pmatrix} x + \begin{pmatrix} 0 \\ -D^{-1}C \end{pmatrix} + \begin{pmatrix} 0 \\ D^{-1}H \end{pmatrix} u \tag{15}$$

Where I and 0 are identity and zero matrices respectively.
The system equation can be rewritten as:

$$\dot{x} = f(x) + g(x)u \tag{16}$$

Where

$$f(x) = \begin{pmatrix} 0 & I \\ 0 & -D^{-1}C \end{pmatrix} x + \begin{pmatrix} 0 \\ -D^{-1}C \end{pmatrix} \tag{17}$$

$$g(x) = \begin{pmatrix} 0 \\ D^{-1}H \end{pmatrix} \tag{18}$$

b) Linear Quadratic Regulator Controller

The Jacobian matrix is used to do an approximated linearization of the above system equation to reduce the nonlinear system equation to a standard linear system one in the form:

$$\dot{x} = Ax + Bu \tag{19}$$

Where

$$A = \frac{\partial f(x)}{\partial x} = \begin{pmatrix} 0 & I \\ -D(\theta)^{-1}\frac{\partial G(\theta)}{\partial \theta} & 0 \end{pmatrix} \tag{20}$$

$$B = \frac{\partial g(x)}{\partial x} = \begin{pmatrix} 0 \\ D(\theta)^{-1}H \end{pmatrix} \quad (21)$$

The cost function is given by:

$$J = \int_0^\infty (x^t Qx + u^t Ru)\, dt \quad (22)$$

Where Q is a positive semi-definite matrix and R is a positive definite matrix as well as constant. The control value u is called the optimal control which is:

$$u(t) = -R^{-1}B^T P(t)x(t) = -Kx(t) \quad (23)$$

Where $P(t)$ is the solution of the standard Riccati equation and K is the linear optimal feedback matrix. The Riccati equation is as follows:

$$PA + A^T - PBR^{-1}P + Q = 0 \quad (24)$$

VI. Experiment Andresults

Table 1 : The data of a bird's leg

Symbol	Parameter	Value	Unit
M	Mass of bird's body	0.912	kg
m_1	Mass of tarsus	2.556×10^{-3}	kg
m_2	Mass of tibia and fibula	3.444×10^{-3}	kg
L_1	Length of tarsus	0.07378	m
L_2	Length of tibia and fibula	0.09942	m
I_1	Moment inertia of L_1	1.159×10^{-6}	kgm^2
I_2	Moment inertia of L_2	2.837×10^{-6}	kgm^2
G	Acceleration of gravity	9.81	ms^{-2}

Table 1 shows the data of a leg of a bird [13] and $\theta_1 = 42.71°$ and $\theta_2 = -17.62°$are the angles of L_1 and L_2 respectively. $L_2$is negative because it is moving in the opposite direction to L_1 which is to the left.

Using equation (20) and (21), the matrices of A and B can be obtained:

$$A = \begin{pmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 46.5299 & 0 & 0 \\ 0 & 76.9990 & 0 & 0 \end{pmatrix}$$

$$B = \begin{pmatrix} 0 \\ 0 \\ 265.3683 \\ -97.5428 \end{pmatrix}$$

a) Simulation of the double inverted pendulum

When LQR method is used, the selection of weighting matrices *Q* and *R*are important have an effect on the optimal control whereby if they are not selected properly the actual system performance requirements will not be met. They are called the priority matrices. *Q* and *R* are usually obtained through simulation of trial. According to [14] where *Q* changes most of the times compared to *R* which is fixed at most times.

Using Matlab the values are input into the formula for LQR where *K*=lqr[*A*,*B*,*Q*,*R*], where *A*, *B*, *Q* and *R* are matrices from calculations.

VII. Results

Using Matlab command, the calculations results;K= [-1.0000 -60.1690 -1.2099 -6.2206]. The following step response graph was obtain for

$$Q = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix} \text{and } R = 1$$

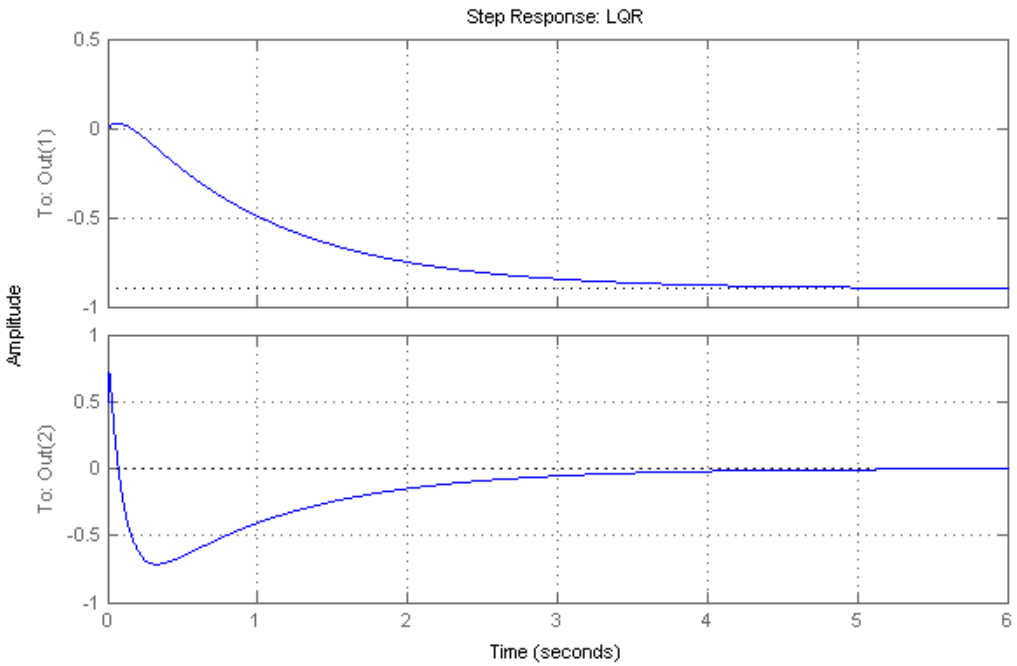

Fig. 5 : Step response 1 of the system

It can be seen from the results in Fig. 5, the pendulum at first is really unstable from 0s as it started to move, causing the overshoot. Then it started to find the stability as it can been described by the graph as it starts to flatten. It can also be seen that the settling time and rise time are large.

To minimize the rise time and the settling time, many other simulations can be done using different values of *Q* and *R*.

$$Q = \begin{pmatrix} 0.0025 & 0 & 0 & 0 \\ 0 & 0.0025 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix} \text{ and } R = 1$$

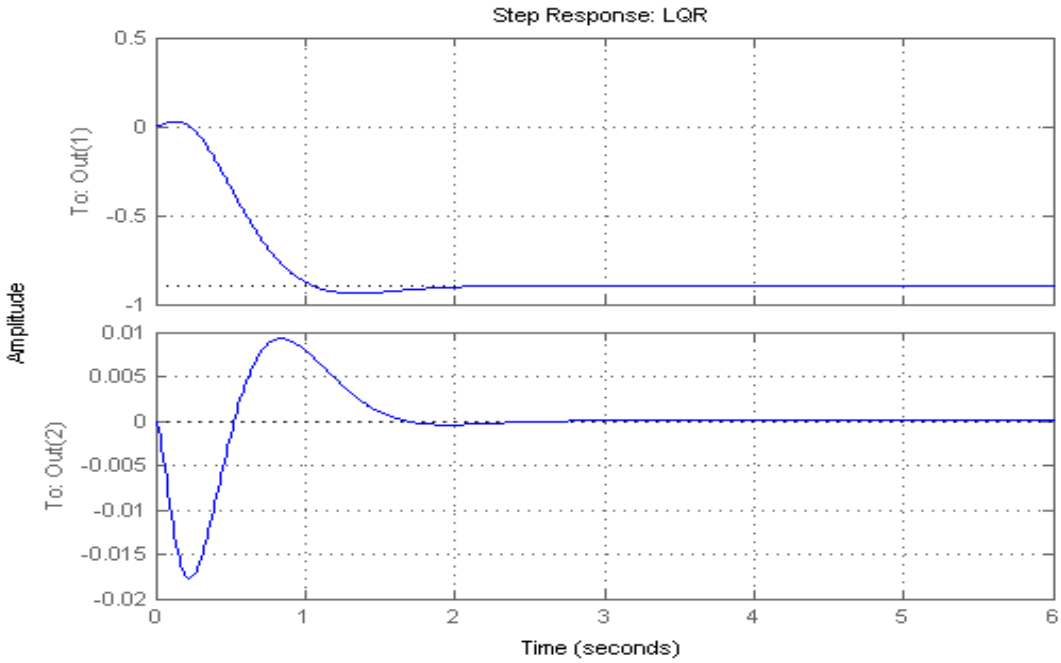

Fig. 6 : Step response 2 of the system

The graph above shows another simulation with different values of *Q* and *R*. It can be seen that the rising time and settling time are lower than that of the first simulation with K= [-0.0500 -2.8929 -0.0287 -0.3157].

VIII. Conclusion

The above results show that a double inverted pendulum can be stabilised using the LQR method. Different values of the priority matrices *Q* and *R*, gives different results, with smaller rising and settling time. Therefore it can be deduced that the stability of the double inverted pendulum is directly related to the priority matrices, *Q* and *R*.

There are other better ways which can be used to determine the stability of the double inverted pendulum more accurately than the LQR, such the Neural Network and state-dependent Riccati equation (SDRE). They can be used independently or in combination with the LQR method to have precise data. The aim of this paper was to design an LQR based controller to show how the leg of a bird can stabilised if considered as a double inverted, which was met with success.

IX. Discussion

As state before, a bird is a living thing; therefore in real it may not really follow the modelling. A bird has two legs, with 2 tibias and fibula and 2 tarsi. In order to maintain a stable body, both legs works together to achieve the required stability. In real when a bird perches, the tarsus moves with more visible change via the angle θ_1 whereas the angleθ_2, of the tibia and fibula, has very little change almost negligible where it can be said that the tibia and fibula is static. The changes in the angles allow the body to maintain stability while perching, standing or hopping.

While the angle of the tarsus and the fibula and tibia plays an important role to maintain stability in a bird, there are other factors that come into play. The size of bird's body is one such factor. In this modelling, the body of the bird was considered as a static mass *M* above the pendulum. But in real, the body of the bird moves, within certain angles and directions such that if the pendulum goes to the left, it goes to the rightand vice-versa to help maintain balance, while shifting its centre of mass at the same time.

The equations for the modelling have been described and formulated as that of a double inverted pendulum where the femur was excluded. If the femur is taken into consideration, this leads the system of the leg to be a triple inverted pendulum, which is even more unstable than the double inverted pendulum. For the bird's leg, considering a triple inverted pendulum can be quite complicated due to the high instability of the triple inverted pendulum. The high instability means more complicated and longer equations are needed to be resolved in order to find a better control. This is mostly done through a computerised system.

With promising results on the double inverted pendulum, the control of stability theorem can be useful in the balancing of UAVs where the UAV is fitted with landing devices resembling the bird's leg. They UAV will represent the bird's body while the landing devices will represent the legs of the bird. The control will help the UAV to maintain its stability, for e.g., when it is perching on a cable wire or a branch or while it is on a flat surface after landing. This can be useful for the UAV in situations where it flies to places where people cannot go and lands for collection of data.

In addition to perching, the UAV can use the photovoltaic effect to recharge its batteries. In order to perch-and stare, the UAV will be able to land on numerous types of different surfaces. Birds' feet show a specific and interesting behaviour which makes them adaptable to most surfaces. The future aim is to design a landing device that can help the UAV to perform the perch-and-stare manoeuvre and at the same time be able to take-off and land normally, just a bird would do.

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We present our sincere gratitude to those friends for providing us their support and advices while writing this paper.

Conflict of Interest

I, Ramdhun Vyas, together with my supervisor Jianbin Xue, hereby states that this manuscript has not been published elsewhere, everything written in this manuscript is our own research work and we have no conflicts of interest to disclose. I hope this manuscript is appropriate for journal and meets the proper standards.

References Références Referencias

1. Khalil Sultan and Ashab Mirza. Inverted pendulum: analysis, design and implementation. Visionaries Document; 2003.
2. Rubi J, Rubio A, Avello A. Swing-up control problem for a self-erecting double inverted pendulum [J]. *IEEE Proceedings-Control Theory and Applications*, 2002, 149(2): 169-175.
3. K.J. Åström and K. Furuta. Swinging up a pendulum by energy control.Automatica 2000; 36; 287-295.
4. Navin John Mathew, K. Koteswara Rao and N. Sivakumaran. Swing Up and Stabilization Control of a Rotary Inverted Pendulum. Preprints of the 10th IFAC International Symposium on Dynamics and Control of Process Systems, Mumbai, India, 2013.
5. Pan Y., Furuta K. VSS controller design for discrete-time systems. Proceedings of IECON'93, vol. 3, 1993. pp. 1950-5.

6. Brockett, R.W., Li, H. A light weight rotary double pendulum: maximizing the domain of attraction [C]. In Proceedings of the 42nd IEEE Conference on Decision and Control, Maui, Hawaii, December (2003).
7. Furuta, K., Okutani, T., Sone, H. Computer control of a double inverted pendulum. Computer and Electrical Engineering, 5, pp 67-84 (1978).
8. Qing-Rui Li, Wen-hua Tao, et. al. Stabilization Control of Double Inverted Pendulum System [C]. The 3rd International Conference on Innovative Computing Information and Control, Dalian Liaoning, China, 2008.
9. Bogdanov Alexander, 2004, "Optimal Control of a Double Inverted Pendulum on a Cart", Technical Report CSE-04-006.
10. Mandar R. Nalavade, Mangesh J. Bhagat and Vinay V. Patil. Balancing Double Inverted Pendulum on a Cart by Linearization Technique [J]. International Journal of Recent Technology and Engineering. Vol.3, No.1, 2014.
11. N. S. Proctor and P. J. Lynch. Manual of Ornithology: Avian Structure and Function [M]. Ann Arbor, Michigan: Edwards Brothers, Inc., 1993.
12. Da-Wei Gu, Mihail M. Konstantinov and Petko H. Petkov, "Robust Control Design with MATLAB®", M.J Grimble and M.A Johnson, eds, Springer-Verlag London, pp. 291- 295, 2005.
13. Daniel J. Field, Colton Lynner, Christian Brown and Simon A. F. Darroch. Skeletal Correlates for Body Mass Estimation in Modern and Fossil Flying Birds. PloS One, vol. 8, issue 11, 2013.
14. Sandeep Kumar Yadav, Sachin Sharma and Mr. Narinder Singh. Optimal Control of Double Inverted Pendulum Using LQR.

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Controlling Silicon and Soot Content in the Crank Case Oil to Improve Performance of Diesel Engine

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Keywords: diesel engine, lubricant analysis, silicon, generator set.

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I. Introduction

Emission requirements of diesel engines was analyzed by Geehan [1] based on the soot content levels in engine crank case oil will increase significantly due to retarded timing to lower NOx. This study made in Cummins M11 engine. Results proved that soot level 9% in the crank case oils to extend filter life, maintain oil pumpability. Geehan [2] also studied about effect of soot on piston deposits and crank case oils. The root cause of entry of soot in crank case oils analyzed in this study. Also how the soot initiates the wear and tear on moving parts analyzed. Geehan [3] extended his research on the reasons for increased soot levels in crank case oil. The main reasons found in his study were: lower oil consumption reduces the soluble organic fraction (SOF) in the exhaust. It also lowers the fresh oil added to the crank case and therefore increases the soot in oil; high top-ring pistons lower the transient emissions by reducing the crevice volumes between the top ring, piston top and line wall were analyzed in this study.

Engine life and performance is mainly depending on the lubrication types and quality of lubrication used. The life span of lubricant usage that is change of lubricant period is fixed as per the manufacturers design and recommendations. Even though on due course of work, the formation of micro elements is unavoidable and will contaminate the engine crank case oil, leading to premature failures [4]. In the prevailing situation, the life span and quality of lubricants will be determined by the presence of micro elements of oil. In turn, this micro constituent in the contaminated oil determines the condition of equipments and the same time, some of the micro elements badly affects the life and quality of lubricants and accelerates the wear and tear of engine. So far no studies were made on Silicon content in the crankcase oil. In this present work, a detailed investigation was made on the silicon contents of the crank case oil. Hence, the relation between the silicon and soot content and the other micro constituents in the sample oil affecting the condition of the equipment is analyzed. Finally a technique is suggested to control the silicon and soot content to improve the life of the engine.

II. Micro Element Analysis

Table 1 : Micro constituents

Micro constituents identified from oil analysis	Received from components
Copper	Determines the condition of bearings and bushes.
Iron	Determines the condition of rubbing materials of iron components.
Chromium	Determines the journal bearings and push rod materials, caps, etc.
Lead	Determines the bearings materials and various joints condition.
Aluminum	Determines the condition of casting and alloy materials used in the components.
Silicon	Determines the condition of seals, joints, iron components, rubber bushes, etc.
Soot	Is the burnt materials of fuels and crank case oils

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The micro elements can be identified from the sample oil analysis, periodically drawn from the sump (engine oil crank case).The presence of such micro constituents in oil determines the condition of corresponding components of equipment. The Table 1 shows the microelement constituents identified in the oil and the components from where the microelement is received. The other constituents of oil like water, soot, oxidants, Nitrates, Sulphur products and Total Base Number also can be determined from the sample oil analysis, which affects the quality and life of lubricants.

Table 2 : Specifications of the engines under study

Engine Number	Engine specifications and Model	Remarks
1	Brand new 12 Cylinder V-Type CATERPILLAR Engines of 5AG 2301 – 3412 DITA model – coupled with 500 KVA	Dust proof parallel operation with engine number 2. Turbocharged after cooled.
2	Brand new 12 Cylinder V-Type CATERPILLAR Engines of 5AG 2301 – 3412 DITA model – coupled with 500 KVA	Dust proof parallel operation with engine number 1. Turbocharged after cooled.
3	3406 C DITA Cat Engine with CAT DEO 15W40 oil	Turbo charged after cooled
4	3306 B DITA Cat Engine with CAT DEO 15W40 oil	Turbo charged after cooled

The analysis procedure can be divided into two parts, the data acquisition and data interpretation undertaken after each sample analysis. Engine crank case oil samples drawn periodically just prior to the engine oils service period and the sample oil is analyzed to find out the quantity of such active micro elements.

Two new 12 cylinder V type Cater pillar Engines used for test sample analysis for this purposes. The above said engines are used in parallel operation according to the load demand and the sample oil drawn at the same time from both the engines. This study on machines started from 0 hour meter readings, i.e., brand new machines. The first sample collected at 226 hrs from engine 1 and 220 hrs from engine 2 just prior to the first crank case oil service. Refer to the silicon values in the tables 3 and 4. The second sample collected at 465 and 467 operating hours just prior to the second crank case oil service. The same way, third samples collected from the engines at the hour meter readings of 717 in engine 1 and 716 in engine 2 respectively. Air filter cleaning carried out in every 50 hrs of operation. On comparing the values of Silicon contents with Soot contents in (refer to Tables 3 & 4) with other micro elements like Fe (iron) in each sample periods, it drastically is varied in between 250hrs and 500 hrs of operation. Also from the tables 3 and 4 it is shown that silicon & soot are the combined elements inducing wear and tear of iron (Fe) and other metallic particles. In engine 1 initially at 220 hour sample more soot materials found, it is due to excess oil entry through initial commissioning stage and in the latter stages it is stabilized between 20 to 25 ppm.

Table 3 : Microelement Constituents of Engine 1

HMR	Cu	Fe	Cr	Pb	Al	Si	W	F	St	Oxi	Nit	Sul	TBN
226	2	4	1	2	1	2	N	N	38	0	0	13	PASS
465	3	11	1	2	1	11	N	N	20	0	0	12	PASS
717	3	8	1	2	1	7	N	N	20	0	0	12	PASS

reading
HMR – Hour meter
Fe – Iron
Cr – Chromium
Cu – Copper
Al – Aluminum
Si – Silicon
Pb – Lead
F – Fuel
St – Soot
W – Water
Nit – Nitrates
Sul – Sulphur products
Oxi – Oxidants
TBN – Total Base Number.

Table 4 : Microelement Constituents of Engine 2

HMR	Cu	Fe	Cr	Pb	Al	Si	W	F	St	Oxi	Nit	Sul	TBN
220	4	15	1	2	2	5	N	N	74	0	0	12	PASS
467	3	12	1	2	1	12	N	N	20	0	0	12	PASS
716	3	7	1	2	1	7	N	N	18	0	0	12	PASS

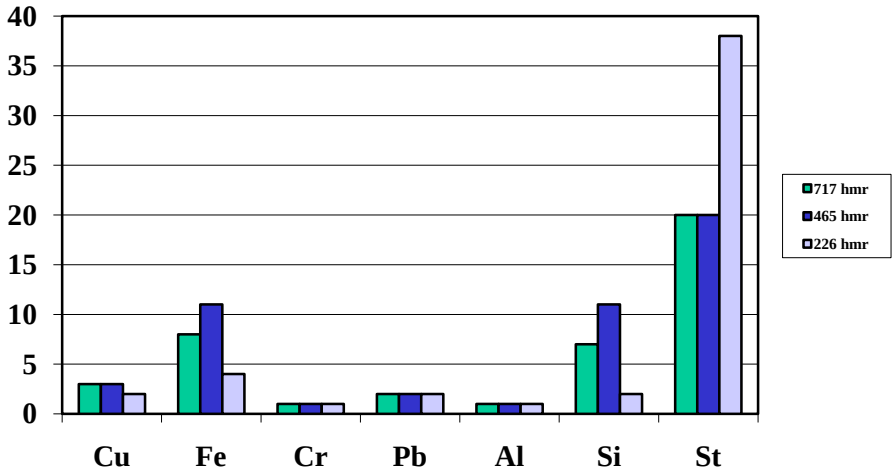

Fig. 1 : Amount of microelements in the oil at various hours of Engine 1

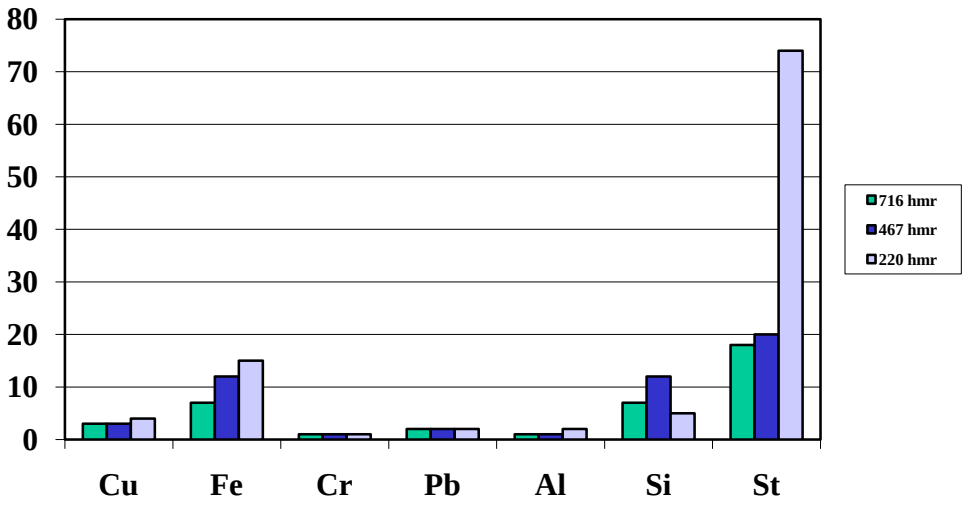

Fig. 2 : Amount of microelements in the oil at various hours of Engine 2

The same procedure is followed for the 3rd and 4th Engines at different irregular intervals but after long run. The third engine's oil sample is considered for study even though when it was failed to run after 7174 hours of running. This study on machines 3 and 4 started from 1957 hour meter and 0 hour meter readings respectively, i.e., two old machines operated under variable load and dusty environments. The first sample collected at 1957 hrs from engine 3 and 274 hrs from engine 4 just prior to the crank case oil service. The second sample is collected at 1873 and 2610 operating hours-just prior to the crank case oil service. The same way, third samples collected from the engines at the hour meter readings of 2203 in engine 3 and 5145 in engine 4. Air filter cleaning is carried out in every 50 hrs of operation.

The iron (Fe) content is on the higher side when ever the silicon and soot contents are on the higher side (refer to Tables 5 and 6). Therefore, it is evident that Silicon and Soot are the combined elements inducing more iron (Fe) content. The Silicon and soot are the micro elements in engine oil contamination inducing the wear and tear of the machine. In engine 3 at 1957 hour, more soot and silicon materials found. As a corrective measure, a new engine air filter is fitted after cleaning the breathing system of the engine. This drastically reduce the silicon and soot content at 2203 and 2266 hours respectively. Note that the silicon and soot contents are reduced to the normal operating level.

In engine number 4, no measure is taken for air filter and breathing system hence the soot content is increased from 170 to 192 and silicon content is increased from 39 to 245. Note that the soot content is in the higher side even at 1873 hours and the silicon content is suddenly increased from 39 to 245 when operated from 5145 hours to 7174 hours at which the engine failed to run. In this engine it is proved that gradual increase in soot and Silicon contents encouraged the wear and tear of engine components till the engine fails to run.

Table 5 : Microelement Constituents of Engine 3

HMR	Cu	Fe	Cr	Pb	Al	Si	W	F	St	Oxi	Nit	Sul	TBN
1873	2	4	1	2	1	5	N	N	38	0	0	13	PASS
1957	2	10	1	3	1	12	N	N	56	0	0	13	PASS
2203	1	4	1	2	1	3	N	N	36	0	0	13	PASS
2266	1	4	1	1	2	10	N	N	34	0	0	13	PASS

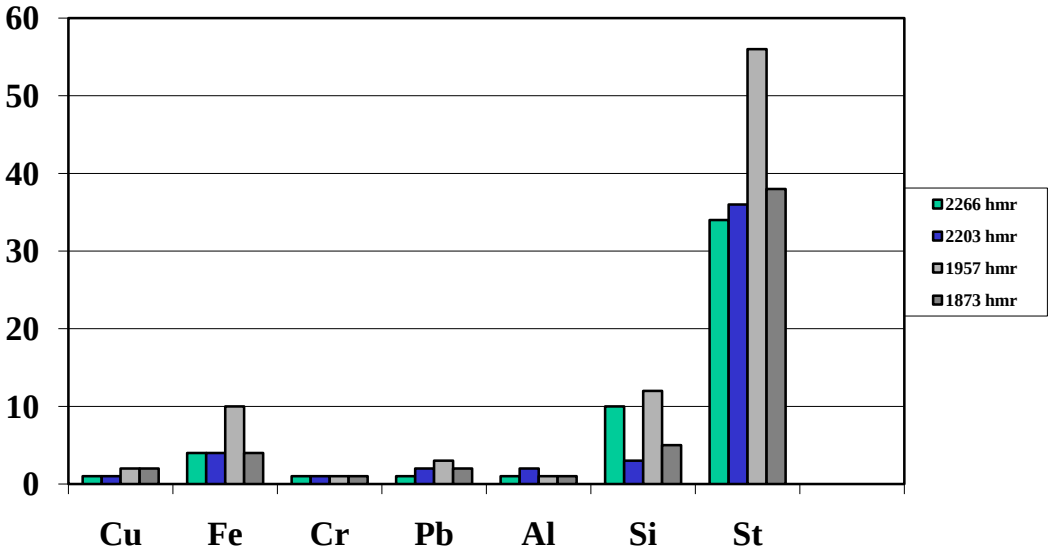

Fig. 3 : Amount of microelements in the oil at various hours of Engine 3

Table 6 : Microelement Constituents of Engine 4

HMR	Cu	Fe	Cr	Pb	Al	Si	W	F	St	Oxi	Nit	Sul	TBN
274	90	82	2	7	4	39	N	N	170	0	0	17	PASS
2610	11	120	3	3	7	36	N	N	132	0	0	14	PASS
5145	19	108	2	7	11	39	N	N	184	0	0	24	PASS
7174	56	472	22	81	49	245	N	N	192	0	0	18	PASS

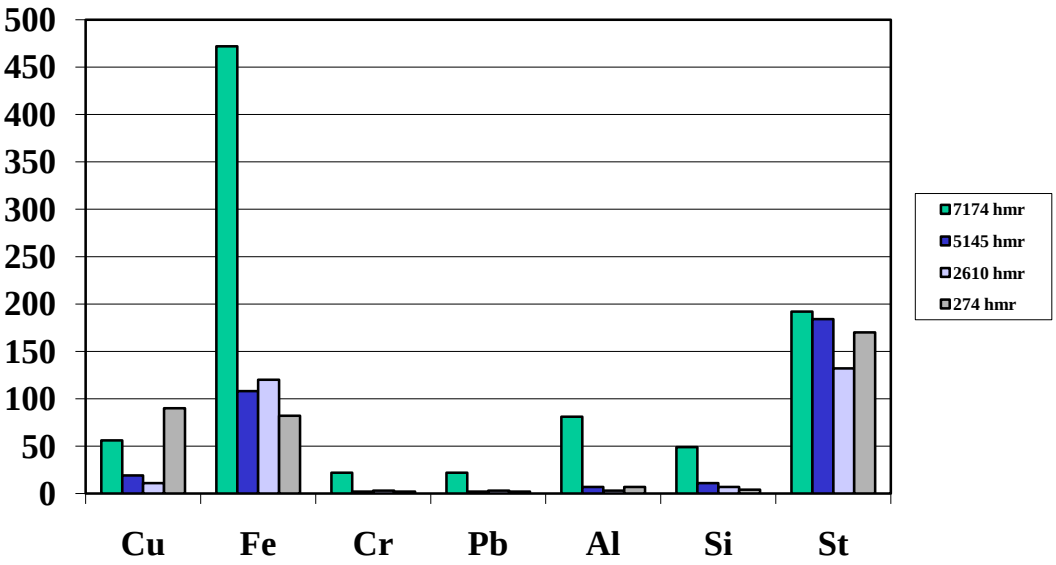

Figure 3 : Amount of microelements in the oil at various hours of Engine 3

The main entry of silicon into the engine crank case oil is from Air filters, engine breathing systems and seal joint materials. It is evident from the tables 3 and 4 that there is considerable reduction in silicon contents in the crank case oil due to new air filters and breather case filters changed at 465 and 467 hours respectively. The soot can be controlled by giving the additional filtering system in diesel tank or with good quality of

diesel fuel or by improving the fuel firing system. Note that due to dusty working environment, engines 4 and 5 showed increased the soot contents beyond normal.

III. Conclusion

From the oil analysis it is shown that the Silicon (Si) and Soot (St) are the main micro constituents which accelerate the wear and tear of engine parts. This wear and tear increase the content of Iron (Fe) in the engine crank case oil. Silicon and soot are the elements which contaminate oil easily, passing through crank case oil (lubricants) to turbo chargers, piston rings & liners, main bearings and push rod cups, various costlier components and accelerates the wear and tear, which, leading to premature failure of engine components. Hence it is shown that, controlling both Silicon and Soot will improve the life and quality of crank case oil, and increase in life of other components of the engine in an appreciable level.

References Références Referencias

1. James A Mc Geehan, B.J. Fontana, 1999, "The pivotal role of crankcase oil in Preventing life in low emission diesel engines." *SAE 1999-01*-1525*, May 1999*.
2. James A. Mc. Geehan, A. Rutherford, 1980, "Effect of Soot on piston Deposits and crankcase oils-Infrared spectrometric technique for analyzing the soot," *SAE* 801368*, Oct 1980.*
3. James A.Mc. Geehan, W. Alexander, 1991, "Clean Diesel Exhaust but Sooty Engines, the importance of the crankcase oils" *SAE 912342 , Oct 1991*.
4. Brinckman FE, Blair WR.1979, Speciation of metals in used oils: Recent progress and environmental Implications of molecular lead compounds in used crankcase oils, 1979, National Bureau of Standards.

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The Institute will be entitled to following benefits:

The IBOARS can initially review research papers of their institute and recommend them to publish with respective journal of Global Journals. It can also review the papers of other institutions after obtaining our consent. The second review will be done by peer reviewer of Global Journals Incorporation (USA) The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.

The author fees of such paper may be waived off up to 40%.

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The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

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After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

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Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

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The Author can submit the paper either online or offline. The authors should prefer online submission.Online Submission: There are three ways to submit your paper:

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1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

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25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

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Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
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This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
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Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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