Mechanical Design For Nonholonomic Car-Like Mobile Platform.

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Abstract- **This paper describes the first phase in development of the non-holonomic Car-Like Mobile Platform (CLMP). Within this context, we are interested in mechanical design and fabricate a small mobile platform, car-type steering. This mobile platform will be expecting to be use as a platform for various motions like car. This project will be the turning point for the future car toward generating autonomous vehicle. Generally, car-like mobile platform are made from mimic the real automobile. The position and velocity control of such a platform is extremely difficult. Fathomer, such modified platform is not suitable for rough use. We present an alternative design and fabricate to improve it. The main part of this project was we achieving that motion which will use such a device that can control every movement and turning accurately. We found that steeper motor were perform with more accurate. Every degree of motor rotation can easily made by giving pulse. The entire projects were presenting mechanical part for design and development CLMP.**

Keywords: **Non-holonomic , Mobile platform, steering, Fabricate Mechanical part.**

I. Introduction

Know a day's in the world, the air pollution create by car is drastically increase. To solve this problem, many researches have proposed to design and fabricate an electric car similar in design to normal car [1]. However a security problem was often occurring in the transport industry. There is no alternative way to solve this matter. There is also suggestion to enforce public use the public transportation. Still it does not make any progress. The really vivid way to solve it is using autonomous vehicle which everything is navigated without human assist. A lot of research has been start on this area. Hopefully, it will become reality one day.

A CLMP is an autonomous vehicle that automatically capable of movement in a given environment. CLMP is constructs of mechanical part to create the environment of the real car. A car-type steering system is what we built in the mobile platform. It has been found that this type controlling is not as maneuverable as coaxially steered mobile platform. Examples of car-type steering platform are MBR-01 and Postur-I.

Maneuverability of this platform ware improved when these robots were put through a basic obstacle course. There had to complete the course in the minimum amount of time whilst being controlled by the user, and avoiding the obstacles placed in the paths. Researchers typically consider car-type steered platform not as good as coaxially steered robots. However, it gives improvement in outdoor navigation for applications such as people transportation or on autonomous intelligent vehicle. An excellent overview concerning different types of these robots can be found in [2].

Designing a mobile platform that mimics the ability and capacity of a real car is becoming more and more of a necessity amongst researchers. Potentially, these kinds of platforms can be applied in many situations. However, applications for autonomous intelligent vehicles are becoming more apparent. Such platforms can use drive systems for either standard DC motors or steppers motors depending on the type of control required. In most cases, accurate position control is required. Hence stepper motors appear to be a common choice. The main advantage of stepper motors is that they can achieve accurate position control without the requirement for position feedback. In other words, they can run "open-loop", which significantly reduces the cost of a position control system.

In this paper, the mechanical design and fabrication of CLMP is presented in detail. In this work, we are only interested in the design and fabricate of the parts. Design consideration should include position and velocity control. Loading should also be a design parameter.

II. Research And Design

A. Design Car-Like Mobile Platform

There are two separate parts in developing a car. First was design the car computer simulation software and test. Then fabricated the chassis according to the data obtain by the software. Design always plays an important role in developing a new product. In case of design a car we were following some steps such research and development accordance with analysis, statistical, computer simulation and forth. There are

two major considerations in creating our CLMP. The consideration was design and fabrication the chassis and the non-holonomic motion planning. This important so that the research finding might afford related to autonomous for the real car [3].

Highlight in design and development for the mechanical part in the chassis is list below:

- Find the suitable material.
- Parts in the mobile platform were designed and fabricated with take all technical precaution.
- Find the dimension that similar to the real car.
- Each mechanical part in the chassis needs to be measure their weight. To ping point the center mass mobile platform.
- Find the right arrangement and location for front and rear wheels so that went the base steer it mimic the real car.
- Finally, discuss about the steer, which need continues curvature angel went turning. This is similar to the Non-holonomic motion concept which employed to the real car.

III METERIAL CAPBABILITY DETERMINATION

Catia is amazing software with offer analysis and simulate result with applying force to our design. It is the method where the capability of selecting material can easily determine before make it into real. This software also was showing the entire characteristic about the material in fact [4].

A software test was conducted to choose the right material that carry load up to six kilos. This material will be use to design our chassis. The Fig. 2, was showing the yield strength that need for base plate. According to the design concept, acceptable design formulated as below:

$\sigma design \leq 0.4Sy$ (1)
$\sigma design$ - Maximum stress
Sy - Yield Strength

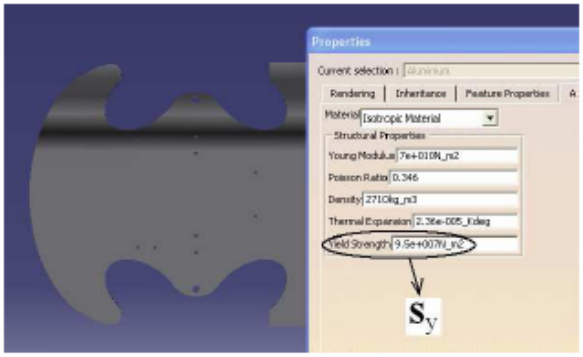


Fig. 2. Simulatio of yield strength.

Above Fig. 2, was showing the yield strength of aluminum for front base plate from Catia Software and the result as below:
$Sy = 9.5 \times 10^7 N/m^2$

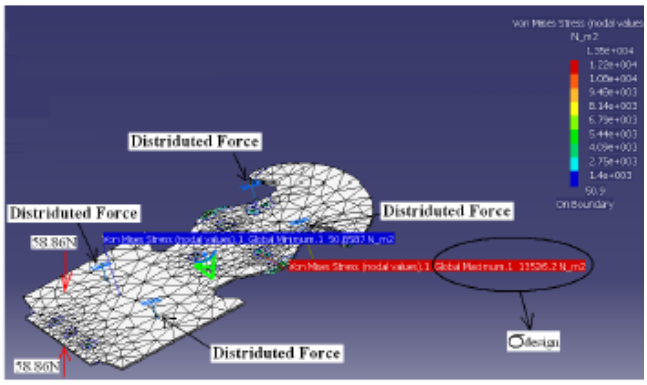


Fig. 3. Base plate simulate the impact of force.

Fig. 3 shows the design stress after applying force of equivalent to six kilo on the base plate. The result for gives the minimum stress need for design base plate is:

$\sigma design = 13526.2 N/m^2$

Aluminum plate found to be higher that estimated value which is as following:

$13\,526.2 N/m^2 \leq 38\,000k N/m^2$

From selected material we start our design and construct part following the drawing that made in Catia Software. Fig. 4 shows the complete models design for our CLMP that drawn. Hence, the models ready to be put into practice for chassis design and development.

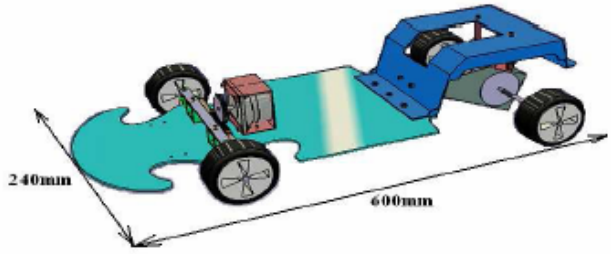


Fig. 3. The complete models design for our CLMP

IV CHASSIS DESIGN AND DEVELOPMENT

Our first design parameter which will affect the hardware design of our drive system is the chassis. The aim is to build and design a chassis for a CLMP. The chassis of this platform is built from aluminum plates. The plate bends into two compartments. The front compartment holds the steering control for the front wheel. The mobile platform uses a rack and pinion gear in the steering assembly. The rack is attached directly to one of the two joint levers. The complete assembly is a combination of a toothed gear circle pinion which has *40* teeth and a rack of equal teeth size. We can then estimate the maximum front wheels curvature angle ϕ which equal to *40°*. Fig. 4 shows the determination of gear angle rotation θ, for maximum horizontal displacement X_c. From the experiment, it was found that for X_c is equal to 8mm, θ is equal to *22.5°*. This angle is transmitted using two steering joint levers to the front wheels that are attached to both end sides of the joint. Fig. 5 shows the assembly of the front wheel steering control.

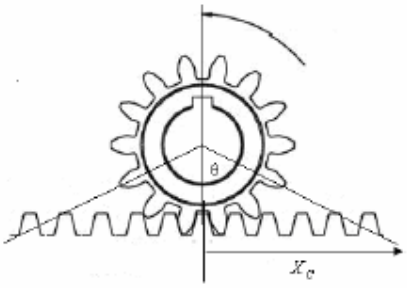


Figure 3.1: Maximum curvature angle for X_c equal to *8mm*

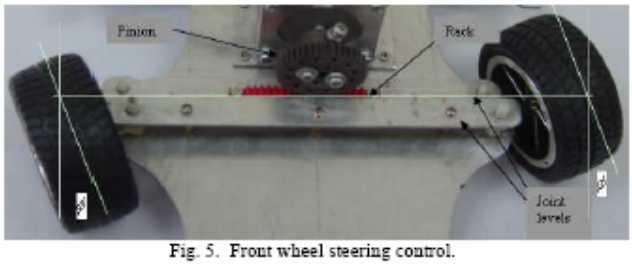


Fig. 5. Front wheel steering control.

The middle of the chassis is a space where the control circuitries of the platform are held. The back of the chassis holds the motion actuator and the compartment for the battery. Motion actuators with a single center axle for the rear wheels are shown in Fig. 3.3. This makes our CLMP more ideal to a rear wheel drive vehicle. The shape in the front of the chassis was adjusted a couple of times in order to fit the steering wheels. The complete chassis assembly was adjusted to ensure that the center of mass of the platform is at the center of the chassis. The body of the mobile platform is rectangular with the length of 60cm, width 24cm and height 12cm. This shape and size was chosen by considering the standard ratio of commercial vehicles. Fig. 6 shows the complete mobile platform chassis that we fabricated.

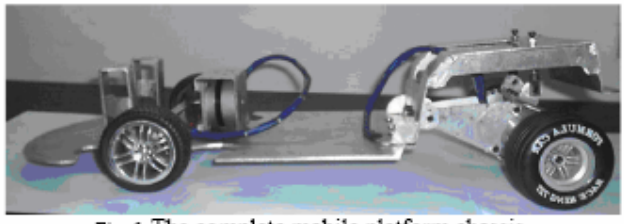


Fig. 6. The complete mobile platform chassis.

V. ACUATOR SELACTION

Since we know the radius r, of the wheels (45mm) for our mobile platform, we can calculate the holding torque T that required:

$$T = Fr \qquad (1)$$

T = Torque,
F = Force,
r = Radius

For $F = 400g$ and $r = 45mm$

$$T = Fr$$
$$T = 0.4 \times 9.81 \times 45 \times 0.001$$
$$T = 0.1766$$

The results of our experiment are tabulated in Table I.

TABLE I
Loading vs. Torque.

Total Car Weight (gram)	Force Required (gram)	Torque Required (Nm)
2100	400	0.1766
3100	550	0.2428
4100	750	0.3311
5100	1150	0.4077
6100	1200	0.5013
7100	1400	0.6018

By estimating the total weight of the fabricated car to be around six kilos, we needed to get a motor, which could provide at least 0.43Nm of starting torque. Moreover the mobile platform don't yet stack with any item, we decide to choose about 0.50Nm holding torque actuator for the rear wheels. A single center axle was chosen for the real wheels actuator.

A similar experiment was also conducted for the front wheels we found out it need about 0.25Nm of holding torque. Front wheels were drive by motor with 0.26Nm holding torque.

VI IDEA FOR CAR TURNING AND MOVING UNIT

Fig. 7, was showing the idea for car turning portion. We were grape the idea from refereeing a RC car. The components were place as above pictures. Once the motor revolve, motor shaft will rotate and the rotation will transmit to spur gear. The transmitted gear will move the attached rack in linear motion. The attached bar with rack will move too and it causes the whole wheel system will move together. We limited the gear system because the accuracy is a big concern in our project. Therefore, direction of motor rotation will play importance role in turning left or right side [5] [6].

Left turning – Clockwise (motor)
Right turning – Counter Clockwise (motor)

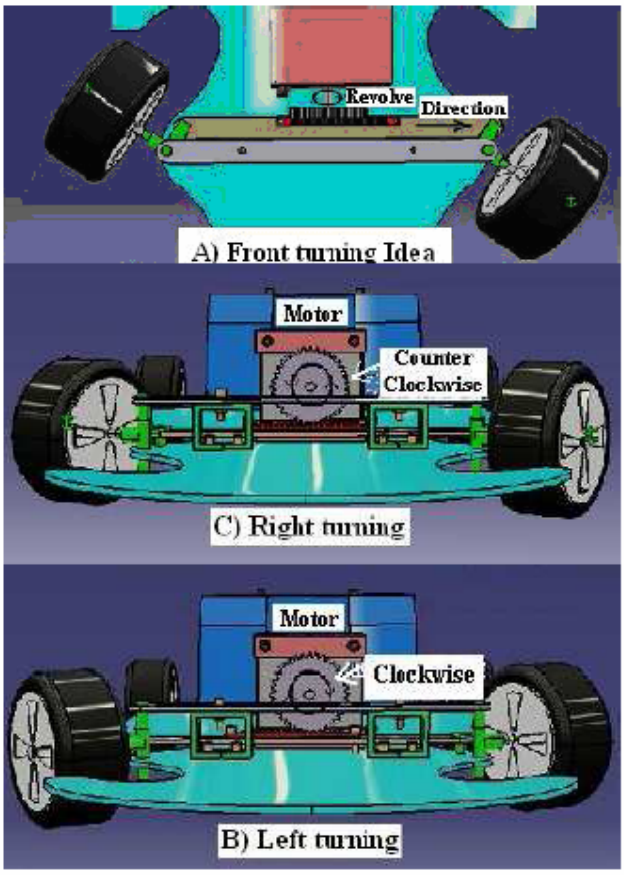


Fig. 7. Front turning idea and front turning unit

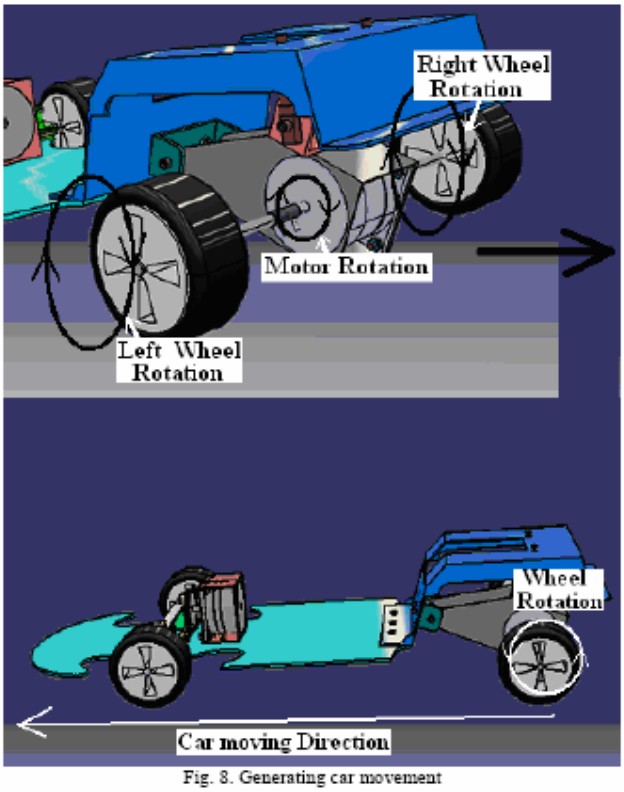


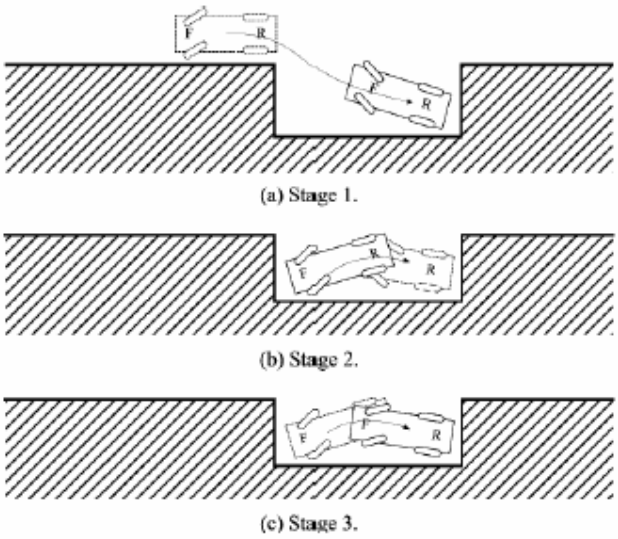
Fig. 8. Generating car movement

The idea for car movement for our project was show in above Fig. 8. This is a common idea for move a car by placing motor at the backside. The both wheels attached to the motor by shaft. The wheels turn due to the motor rotation. Therefore, the whole car moves accordance to the motor rotation. This simple application was implementing in our project. Below Fig. 9, shows the full complete invention of our CLMP.

Fig. 9. The full complete invention of our CLMP

VII. Non-Holonomic Motion Planning

Non-holonomic motion planning deals with path planning for mobile paltform systems that are subject to either non-holonomic constraints or non-integrable conservation laws. A non-holonomic constraint, such as a rolling contact constraint in the instance of parallel-parking, is a constraint on the velocity of the system which can not be integrated into position constraints. Fig. 10 shows the example parallel-parking. Similarly, a non-integrable conservation law, such as angular momentum conservation in the case of a falling cat, is a physical law that constraints the velocities of the system [7].



(a) Stage 1.

(b) Stage 2.

(c) Stage 3.

Fig. 10 (a), (b) and (c). The stage for backward parallel-parking.

Summary

The design builds using engineering software (Catia V5). Every idea was plan carefully and we was simulate using software before fabricate. Each design has tested and analyzed before implementation. By carefully select each component and part we finally assembled together and ready for put on testing. The main idea is to gather bunch data from this mobile platform that can lead us for the real applications on autonomous electric car.

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