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TÉLÉMATIQUE

AN ALGORITHM TO ESTIMATE RANGE OF ELECTRICAL VEHICLE

UN ALGORITMO PARA ESTIMAR LA AUTONOMÍA DEL VEHÍCULO ELÉCTRICO

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Abstract

Electric vehicle are becoming popular due to fuel crises. The world is promoting use of electric vehicles and battery operated vehicles. The use of renewable energy resources in generating electric energy are also playing vital role in this promotion. The vehicle designer are using static and dynamic equation in design of electric vehicles. Various competitions are getting organized throughout the world in designing high performance electric vehicles. The automobile sector and companies are transforming their share of fuel engine vehicles into the electric battery operated vehicles. Most of the vehicle designed are giving good performance at little higher cost to the customer. The battery technology is improving and hence enhancing the range of vehicles. The movement of use of electrical vehicle will strengthen as more people are getting involved in the design and use of electric vehicle. The main objective of this proposed system is to provide the in-detail knowledge about estimate design parameters of the Electric vehicle.

Keywords- Electric vehicle; power; resistance; Python; estimation

Resumen

Los vehículos eléctricos se están volviendo populares debido a la crisis del combustible. el mundo está promoviendo el uso de este tipo de vehículos. El

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objetivo principal de este sistema propuesto es proporcionar el conocimiento detallado sobre los parámetros de diseño estimados del vehículo eléctrico. El diseñador de vehículos utiliza ecuaciones estáticas y dinámicas en el diseño de vehículos eléctricos. Se están organizando varios concursos en todo el mundo en el diseño de vehículos eléctricos de alto rendimiento. El sector del automóvil y las empresas están transformando su cuota de vehículos con motor de combustible en vehículos eléctricos a batería. La mayoría de los vehículos diseñados ofrecen un buen rendimiento a un costo un poco más alto para el cliente. La tecnología de las baterías está mejorando y, por lo tanto, ampliando la gama de vehículos. El movimiento de uso de vehículos eléctricos se fortalecerá a medida que más personas se involucren en el diseño y uso de vehículos eléctricos.

Palabras clave: Vehículo eléctrico; fuerza; resistencia; Pitón; Estimacion

INTRODUCTION

The Electric vehicle (EV) isvehicle with electric propulsion. Direct current battery power is an energy source. This is used to run the drive train. However, the drive motors have different characteristics such as method of operation, rating, size, torque, speed and working principle. Motor selection is influenced by speed, weight& type of vehicle .To obtain expected performance from electrical vehicle design parameters must be accurately selected. The mechanical and electrical parameters are highly influencing the overall performance. Proposed system provides guidelines for motor selection parameters & range of vehicle with ref to battery power & tractive efforts.
Tractive efforts (Fte) is defined as the tractive force of a vehicle exerts on a surface or the amount of tractive force is parallel to the direction of motor.

$$Fte = Frr + Fg + Fad + Fla + FAA \quad -------- (1)$$

Rolling resistance (Frr) is the resistive force of vehicle which opposes the rolling of the wheels. It is calculated by the given formula:

$$Frr = urr \times mxg \times cosx \quad ----------- (2)$$

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urr is coefficient of rolling resistance car tire on concrete 0.013, rolled gravels 0.02, tar road 0.025Aerodynamic drag (Fad) is one of the main obstacles to accelerate a solid body when it moves in the air.

$$Fad = \left(\frac{1}{2}\right) \times p \times CdxAX(V + Vair)^2 ----------(3)$$

p is density of air (kg / m^3) = 1.204 at 20deg, Cd is aerodynamic drag coefficient typical value is 0.3, bus = 0.6 motorcycle =0.6 to 0.7 ,stream line = 0.15 to 0.2. V is forward velocity of vehicle .A is front area of vehicle. V Air is velocity of air in opposite direction. Gradient force is pressure gradient force (Fg) is a force per unit mass (i.e., an acceleration).

$$Fg = mgsinx ------------(4)$$

Fg is Gradient force .m is mass of vehicle. g is Acceleration due to gravity 9.8 kg m /s2 , x is Slope angle of road.

Linear Acceleration force is defined as the uniform acceleration caused by a moving body in a straight line.

$$Fla = \frac{mdv}{dt} ------------(5)$$

Angular Acceleration is the time rate of change of the angular velocity.

$$FAA = \frac{\frac{J}{(r2)xdv}}{dt} = \frac{T}{r} ----------(6))$$

Torque required to spin rotating parts J/r is inertia r is radius of gear v is speed of rotation. J is rotational mass.

Power is related to rating of electric component.

$$Power = Force \times Speed\ (F \times V = FxS/t)\ -----(7)$$

Energy is related to battery storage

$$Energy = Power \times Time = p \times t = p \times \left(\frac{S}{V}\right) --------(8)$$

Speed is the distance covered by vehicle.

$$Speed = E \times \frac{V}{P} -------(9)$$

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Aerodynamic drag power is given by:
$$Pad = Fad \times V - - - - - - - - - (10)$$

Equation used in vehicle population system is:
$$Power\ =\ Fte\ X\ V - - - - - - - - - - (11)$$

Radius of wheel = r meters. Velocity of vehicle = V m/s. Wheel torque = Tw. Wheel Angular velocity= Ww. Motor torque is Tm. Motor Angular velocity is Wm. Gear ratio is G.

Efficiency is Ng. Tw = Fte X r ,Ww = V/r,Tm = Tw/(G X Ng), Wm = Ww X G J is Inertia.

LITERATURE REVIEW

The virtual prototyping of electric vehicles has been the subject of numerous recent research studies. The journal article by Santucci (2016), which compares the most popular models with the effects of electric vehicles on the environment, the economy, and the power grid, provides a basic review of electric vehicles. In the thorough article, the topic of the effects of electric vehicles is covered, and the in-depth analysis suggested therein pertains to vehicles of category L. The Guiggiani textbook [2014] on vehicle dynamics is a great resource for the study of vehicle performance. Journal papers are another source of helpful.

Yongjie Lu [2015] and colleagues used multi body dynamics to create a virtual prototype model of a heavy duty truck (DFL1250A9). Shock absorbers and leaf springs' geometric structural parameters and nonlinear properties were properly specified. By contrasting the test results, the dynamic model was proven to be accurate. The research shows that the testing results and the virtual prototype car model were extremely similar, suggesting that increasing running speed may be harmful.

K. Chinnaraj [2008], among others, have decided to optimise the chassis frame assembly weight of a big vehicle utilised for long-distance cargo hauling. Experimental measurements and reports on the component's dynamic stress-strain response as a result of braking and cornering motions were made. The numerical simulation used to represent the dynamic behaviour of the frame rail assembly during cornering and braking used a quasi-static technique, which breaks down the dynamic manoeuvres into a number of tiny processes with static equilibrium. The quasi-static numerical simulations were run using the for-profit finite

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element tool ANSYS and the findings were compared with those from the experiments.
The 4.5 Ton truck chassis against road roughness and excitations has been researched by Teo Han Fui et al. Road roughness-induced vibration and excitation by vibrating components installed on the chassis were investigated. By examining stress distribution and displacements, chassis reactions were investigated. The positions where components like engine and suspension systems should be mounted are determined by mode shape results.
Using Ansys software, N.V. Dhandapani et al. [2012] studied the effects of different stress distributions using finite element methods. They installed gussets in the failure location to better understand the field failure of the 100-ton dumper. After modification, the chassis structure underwent linear static analysis to confirm its safety, which was successful.
M. Faizal et al [2019] used Higher beginning costs are a significant barrier to EV adoption. Public charging infrastructure is also concerned about high initial costs and low turnover. Even with acceleration, the energy storage technologies are still not economically viable.
A. O. Mulani et al [2017] suggested FPGA based implementation of DWT alongwith AES based watermarking. A. O. Mulani et al [2022] proposed realistic reusable low-cost non-invasive glucose monitoring system is developed using 802.11a Wi-Fi module. A. O. Mulani et al [2019] designed AES algorithm using Xilinx SysGen, implemented on Nexys4 and simulated using Simulink. Mandwale A. J. [2015] discussed different kind of implementation of Viterbi decoder along with their performance. P. R. Kulkarni [2015] suggested an algorithm which combines the information of low frequency DWT coefficients and the watermark image.
Godse A. P. et al [2009] text book on Embedded Systems give detailed view of Microcontrollers and real time systems. H. S. Deshpande et al [2015] suggested area optimized implementation of AES algorithm. A. O. Mulani [2019] discussed High-Speed area-efficient implementation of AES algorithm on reconfigurable platform. A. Kamble et al [2022] proposed Google Assistant based Device control. Boxey A. et al [2022] suggested Face recognition using Raspberry Pi. V. B. Utpat et al [2022] discussed the machine vision approach to form a quality grading analysis system. J. P. Patale et al [2023] presented the detailed survey on Estimation of Electric vehicles. S. Takale [2022] suggested DWT-PCA based watermarking. A Mandwale et al [2014] proposed implementation of convolutional encoder. B. Gadade [2022] suggested automatic system for car health monitoring. Y.

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Maske et al [2023] developed a Biobot system to assist Covid patient and caretakers.

METHODOLOGY

This invention is related to design of electric vehicle system. It takes vehicle and battery specification. It estimates the tractive forces on vehicle, range of vehicle and proposes the motor selection parameters.

a. System Design:

Architecture of proposed system is as represented in the figure below. The HTML, CSS framework is used for the implementation of the system. The programs are compiled using VS works for python. Web is ported and tested using GIT HUB registration. The algorithm is implemented using Python as programming language.
The design of proposed system contains following blocks

1. Front End GUI
2. Algorithm and Equation Database

As shown in figure 1, the graphical user interface is developed in the HTML, CSS framework. The system function are used for implementation of GUI components. Energy balance equation is used for estimation of range of vehicle and motor parameters. These parameters are estimated using static model of vehicle.

Figure 1 Architecture of proposed system

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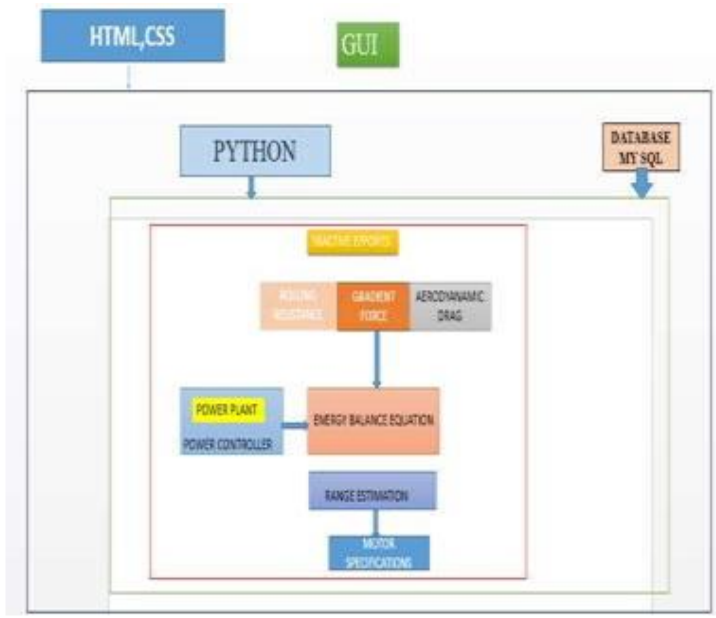
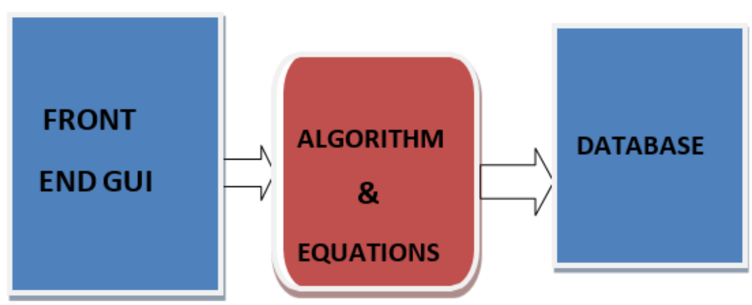


b. **Proposed block Diagram:**

The proposed system includes the front end graphical user interface and database with middle ware interconnection.

Figure 2. Block diagram of proposed system



The front end system interact with designer and reads parameter from user. The algorithm developed uses database and input parameters to estimate motor requirement and range of vehicle.

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c. **Front end GUI:**

Proposed system is interactive and helps designer in design of electrical vehicle through this developed GUI. The system display various parameters related to vehicle design. This include parameters related to tractive forces, vehicle type and load. For range estimation it also reads the battery bank details from user.

d. **Algorithm and Equation:**

Various equation have been used to estimate vehicle parameters. These equations will be developed in python. This program will interact with front end GUI and database at backend.

e. **Database:**

MYSQL database will be used to store the parameters to be estimated. The fixed parameters or tables are stored in the backed. The queries will be developed to write and read data from the database. As well as the result of case studies will be stored in the database.

PARAMETERS USED

Various parameters used for implementation .The propulsion unit of the vehicle delivers the force necessary to move the vehicle forward. This force of the propulsion unit helps the vehicle to overcome the resisting forces due to gravity, air and tire resistance.
Acceleration of vehicle depends on-

- The power delivered by the propulsion unit
- The road conditions
- The aerodynamics of the vehicle
- The composite mass of the vehicle
- Forces acting on a vehicle

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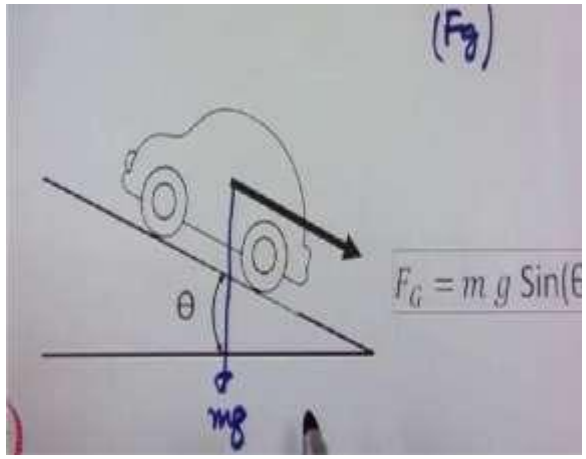

Figure 3 Acceleration of vehicle

I. Resistances offered to a vehicle

- Resistance
- Air Resistance (Aerodynamic Drag Resistance) (Ra)
- Rolling Resistance (Rr)
- Gradient Resistance (Uphill Resistance) (Rg)

Total Resistance = Air Resistance + Rolling Resistance + Grade Resistance

Above formula is used to calculate various force acting on vehicle like aerodynamic drag, tractive efforts.

II. Aerodynamic Resistance (Ra):

Composed of Turbulent air flow around vehicle body (85%) Friction of air over vehicle body (12%), Vehicle component resistance, from radiators and air vents (3%).

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Figure 4 Aerodynamic Resistance

III. Rolling Resistance Rr:

Figure 5 Rolling resistance

Composed primarily by:

- Resistance from tire deformation (90%)
- Tire penetration and surface compression (4%)
- Tire slippage and air circulation around wheel

IV. ANGLE OF BANKING RELEVANCE

Banking of road: For safety of a vehicle moving along a curved road at high speed, the road surface is kept inclined to horizontal so that outer edge of road is at higher level than inner edge.

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Angle of banking (θ): The angle made by a banked road surface with horizontal is called as the angle of banking. The angle through which the outer edge of the roads are raised is called the angle of banking. The angle of banking is given by,
θ=tan−1 (rgv2) where m is the mass, v is the velocity and r is the radius

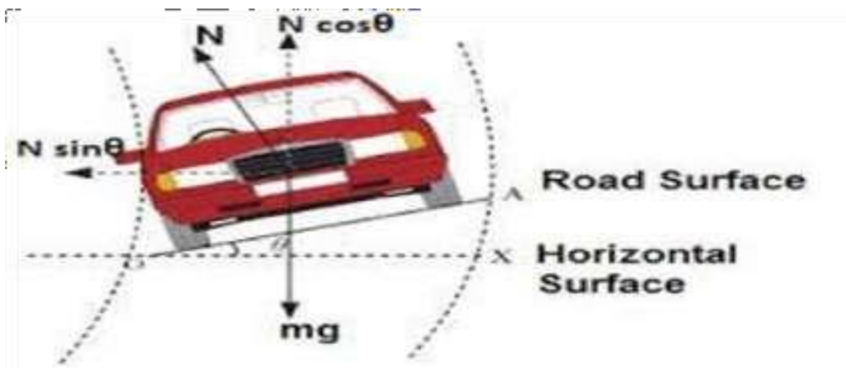

Figure 6 Angle of Banking

FLOWCHART

Figure 7 shows flowchart of Python algorithm.

RESULTS AND DISCUSSIONS

Result shows battery estimation parameters. That is battery bank voltage, bankcurrent, battery bank wattage.
Tractive force calculation view: this is actual view of our portal about estimation of parameters result and view design.
Effect of road slope banking angle on the tractive efforts
The vehicle range is function of slope angle of road. As the slope increase the tractive efforts required are increasing for drive the vehicle. This will increase the total work done for shifting vehicle for same distance. As battery power is same vehicle range decreases with increase in slope angle of road.
A Graphical representation of python algorithm to estimate range of electrical vehicle due to change angel of banking is data static result using graph plots and chart. The representation of effective understanding and comparing the data.

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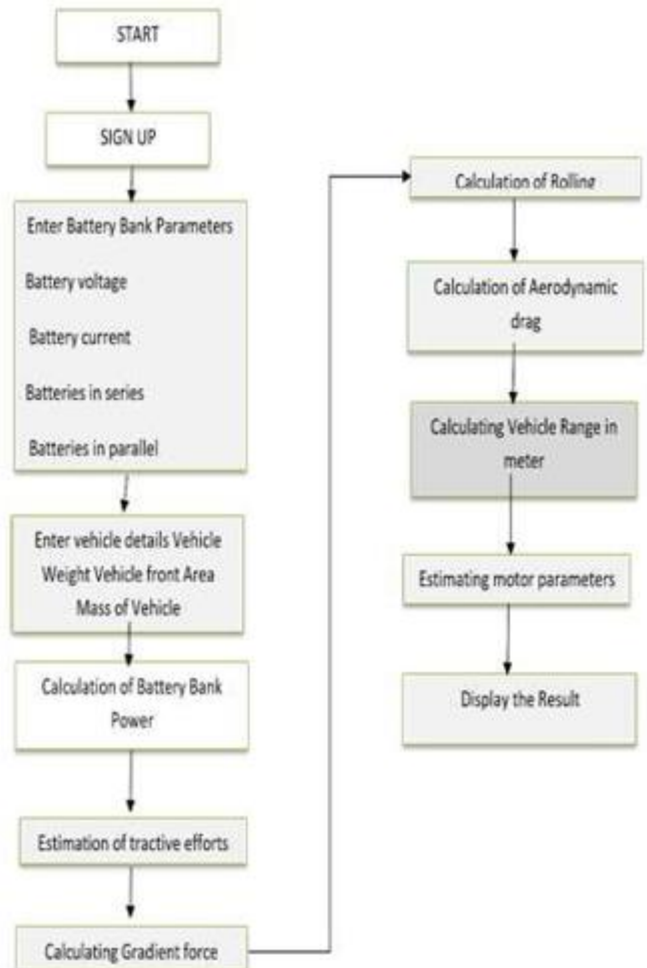

Figure 7 Flowchart of Python algorithm

As displayed in table 1, road slope is increased by 1 degree step and corresponding vehicle range is estimated. As slope angle increases the tractive efforts increases.

As shown in figure 6, slope angle of road changes the tractive efforts of vehicle increases. The graph is linear and shows increase in the tractive efforts with increase in the slope angle of road. Tractive efforts are directly proportional to the road slope angle and shows linear is w.r.t. to slope angle.

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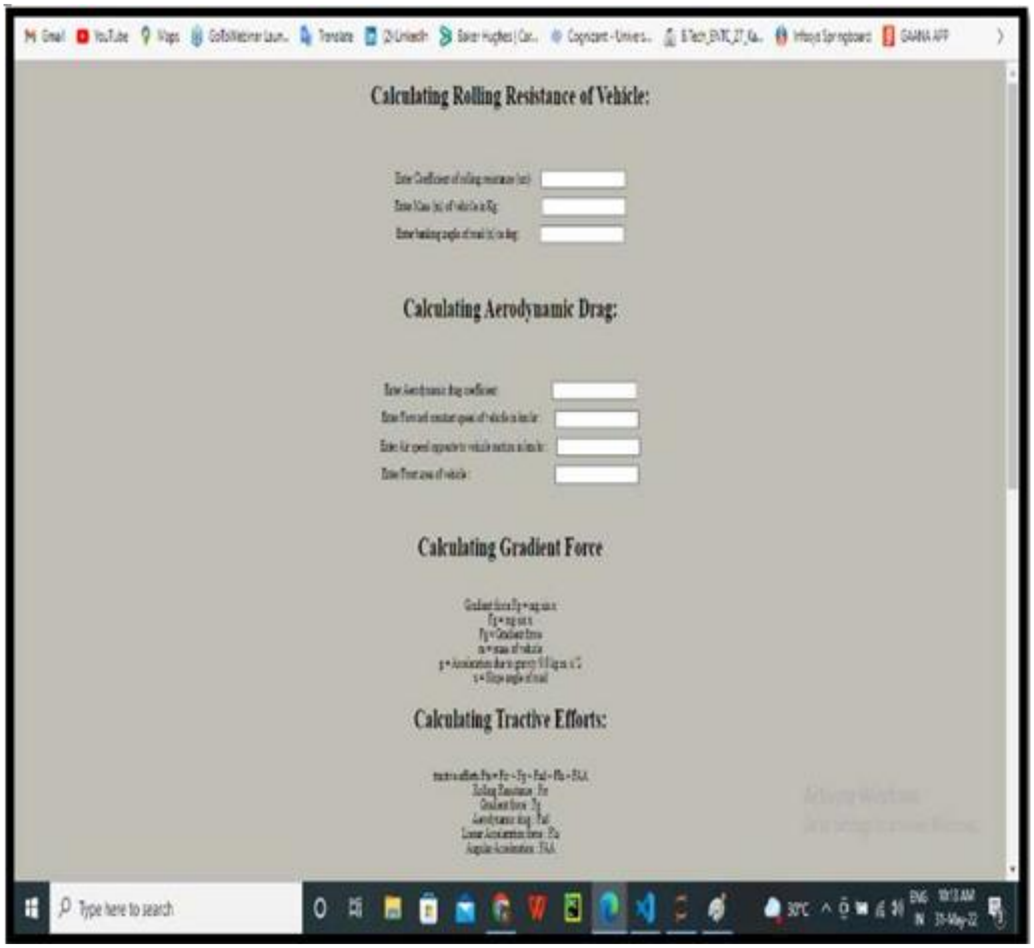

Figure 8- Calculations

Table 1- Effect of slop angle on tractive efforts

Road slope Banking Angle in Degree	Tractive Efforts in N
0	97.17
1	111.27
2	128.36
3	145.43
4	162.47
5	179.49
6	196.47

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Figure 9- Plot of Banking angle vs. tractive efforts electrical vehicle

As shown in figure 9, slope angle of road changes the tractive efforts of vehicle increases. The graph is linear and shows increase in the tractive efforts with increase in the slope angle of road.
Tractive efforts are directly proportional to the road slope angle and shows linear is w.r.t. to slope angle.

Table 2 Graphical representation: Road slope Angle VS Distance

Banking Angle in Degree	Distance in km
0	73.39
1	62.11
2	53.84
3	47.11
4	42.54
5	38.50
6	35.17

Table 2 lists the road slope angle verses the vehicle range in kilo meters. It shoes that the vehicle range decrease as road slope angle increases. The vehicle range exponentially decreases as increases in the road slope angle. As banking angle changes

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various force value like gradient force, aerodynamic drag Changes. Tractive effort is a calculation of all forces
i.e. it changes with banking angle. Vehicle range is inversely proportional to the slope angle of vehicle.

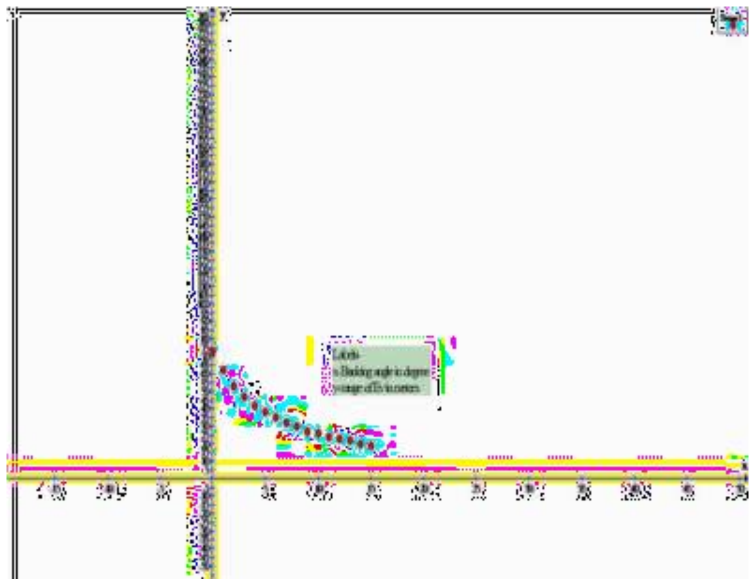
Figure 10- slope angle vs. Range of EV range

i. Effect of vehicle mass on the tractive efforts
In this experiment the vehicle mass is varied and its effect on the vehicle rage is observed. Mass of vehicle is increased with 100kg steps and its effect on tractive efforts for constant road slope is observed.

Table 3 -Effect of vehicle mass on the tractive efforts

Mass of vehicle	Tractive Efforts
100	270
200	375
300	477
400	580
500	682

As mass of vehicle changes various force value like gradient force, aerodynamic drag Changes. Tractive effort is a sum of all forces. Variation in the tractive efforts is function mass. It increase linearly

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as shown in figure 4.4 with increase in the mass. Mass is directly proportional tractive efforts.

ii. Effect of vehicle mass on the vehicle range

The experiment is carried out estimate the effect of vehicle mass on the vehicle range. The mass varies with increment of 100 kg

Figure 11- Mass of vehicle VS Tractive Efforts

Table 4 Effect of vehicle mass on the vehicle range

Mass of vehicle	Distance in km
100	73
200	62
300	53
400	47
500	42

Figure 12 Mass of Vehicle Vs. vehicle range (Distance in Km)

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As mass of vehicle influences various force value like gradient force, aerodynamic drag Changes. Tractive effort is a function of all forces i.e. it changes with mass of vehicle. Mass of vehicle is inversely proportional to vehicle range. The vehicle range exponentially decreases as increase in the mass of vehicle.

CONCLUSIONS

The vehicle range is function of mass and road banking angle. For fixed value of battery power plant, the vehicle range decreases as road slop angle increases. As well as the vehicle range decrease exponentially with increase in vehicle mass. The main objective of this proposed system is to provide the in-detail knowledge about estimate design parameters of the Electric vehicle. The first and foremost advantage of this system is support to vehicle design team in calculation of parameters along with the detail specification of each and every term of the vehicle in one segment.

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