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## Multi variant range Maximization Model for Improved Performance of Electric Systems using Genetic algorithm

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### Abstract:

*The driving range provided by any electric vehicle is the most concern now days. The problem of range maximization in electric system has been approached with various methods in literature. However, they suffer to achieve higher range due to the factor that they consider only limited parameters. To handle this issue, an efficient Multi variant range maximization model with genetic algorithm (MRMM-GA) is presented in this article. The model use the road map of the area where the vehicle is moving and finds the routes available. With the routes and traffic data available, the method generates number of combinatory routes possible. With the routes produced, the method applies genetic algorithm to measure the fitness value for the possible routes. At each population, the method measure the Multi variant range support (MVRS) for the routes and population. Based on the value of MVRS, the method performs route selection towards maximizing the range of the vehicle. The proposed method improves the performance of electric system and range maximization.*

### Index Terms:

*Range Maximization, MRMM-GA, Genetic Algorithm, MVRS*

**Introduction:**

The modern society has great impact from the electric vehicles as the cost of fuel being used by the commercial and personal vehicles are getting increased. The fuel market is the most dominant one which decides the economy of the country and the most countries import the fuels from abroad and they spend huge amount in buying the crude oil which increases the economy of the foreign country and the home country loose their economy due to this conditions. This has been considered by the finance ministry of the country and decides to reduce the fuel consumption by neglecting the introduction of LPG vehicles. As an alternate for them, they have decided to use the electric vehicles in the place of LPG vehicles. But it has lot of risks and many factors must be analyzed before using the EV on the road.

The EV manufacturers publish the vehicle with the span of specific K kilometers. The user can drive the vehicle for the above mentioned distance but in reality, the span mentioned would not be perfect and the user has the risk of standing at the middle without any drive support. This must be considered as important factor and the road support must be provided in terms of route selection. There are number of drive span maximization algorithms available which consider the traffic conditions alone on the road to perform route selection. But in reality, various factors like traffic, distance, number of routes and junctions available must be considered. By choosing the constraints towards route selection, the performance of

the vehicle in terms of span can be improved.

The performance of EV is depending on the span it provides without any trouble and how the vehicle supports on various traffic and road conditions. For example, even the vehicle provides specific span, if the road conditions is poor then it absorbs maximum energy and leads to the reduction of span. So, it is necessary to consider various factors apart from traffic, routes and so on. Apart from data mining techniques, the machine learning techniques can be used around the problem which is capable of handling missing data. In terms of route discovery, the Genetic algorithm can be used in finding the routes available and measure the support of vehicle towards range maximization.

By considering the various factors of vehicle and the road map, an efficient Multi variant range maximization model with genetic algorithm (MRMM-GA) is presented in this article. The model uses the road map of the area where the vehicle is moving and finds the routes available. With the routes and traffic data available, the method generates number of combinatory routes possible. With the routes produced, the method applies genetic algorithm to measure the fitness value for the possible routes. At each population, the method measure the Multi variant range support (MVRS) for the routes and population. Based on the value of MVRS, the method performs route selection towards maximizing the range of the vehicle. The proposed model would increase the span of the vehicle and improves the quality drive.

The complete working of the model has been sketched in this section.

### **Related works:**

There exist number of approaches around the problem of drive span maximization and this section briefs some of the methods around the problem.

An intelligent energy management system is presented in [1], to support flexible operation of grid connected solar powered electric vehicle (EV), which uses the constraints like PV availability, grid loading and EV charging load data. The model monitors the availability of photovoltaic systems in the road and the grid systems available to manage the energy of vehicle.

A disturbance observer (DOB)-based model predictive voltage control (MPVC) is presented in [2] to support electric vehicle. The model predict the voltage possible voltage at various time stamp to perform regulation and voltage control.

A particle swarm optimization (PSO) based control law generation model is presented in [3], which generates maximum voltage from photovoltaic generator (GPV) and applies PSO to regulate the supply to the vehicle. The PSO has been used to identify the most suitable charging point and the route for the vehicle to perform navigation.

A multi battery block module (MBM) topology is presented in [4], to support electric vehicles which uses multi-battery block module and photovoltaic (PV) panel into an asymmetrical half-bridge (AHB) converter, to supply a multilevel bus voltage for the SRM drive. The method monitor the storage capacity of batteries

available to provide power support in maximizing the span of vehicle. A tracking absorption strategy is presented in [5], which adjust the charging process of electric vehicle through electric vehicle aggregator (EVA) and uses soft actor-critic (SAC) algorithm in scheduling the process.

A electric-drive-reconstructed onboard charger (EDROC) is presented in [6], which has six phase machine drive and power traction inverter to leverage the charging process. The on board charger helps to maximize the span but still it is up to the capacity of the batteries of the vehicle.

An synchronous MPPT over DPP topology is presented in [7], to facilitate more targeted decoupling and reduce the difficulty and complexity of decoupling. The MPPT support the performance maximization of span. A long short-term memory (LSTM) recurrent neural network (RNN) based model is presented in [8], to schedule charging and discharging of number of EVs in the model. The LSTM model helps to maximize the performance of vehicles and use of RNN support the growth of vehicles in span maximization.

A three stage voltage allocation and distribution model is presented in [9], to support electric two wheelers in charging station. The three stage model support the navigation of vehicles in maximizing the span with selective charging stations.

A power grid voltage stability analysis framework is presented in [10], which analyze power generation and load demand with Monte Carlo simulation. The method consider the demand of various consumers and the ability of power plants in

power generation to maintain the stability of power grids in power supply.

The driving data of Toyota prius car has been demonstrated and analyzed in [11]. An optimal scheduling model is presented in [12], which handles the distribution mobile energy storage systems. A hierarchical coordination framework is presented in [13], to manage domestic load using photovoltaic (PV) units, battery-energy-storage-systems (BESs) and electric vehicles (EVs).

**Multi variant range Maximization Model with Genetic Algorithm (MRMM-GA):**

The proposed Multi variant range maximization model with genetic algorithm (MRMM-GA) model use the road map of the area where the vehicle is moving and

finds the routes available. With the routes and traffic data available, the method generates number of combinatory routes possible. With the routes produced, the method applies genetic algorithm to measure the fitness value for the possible routes. At each population, the method measure the Multi variant range support (MVRS) for the routes and population. Based on the value of MVRS, the method performs route selection towards maximizing the range of the vehicle.

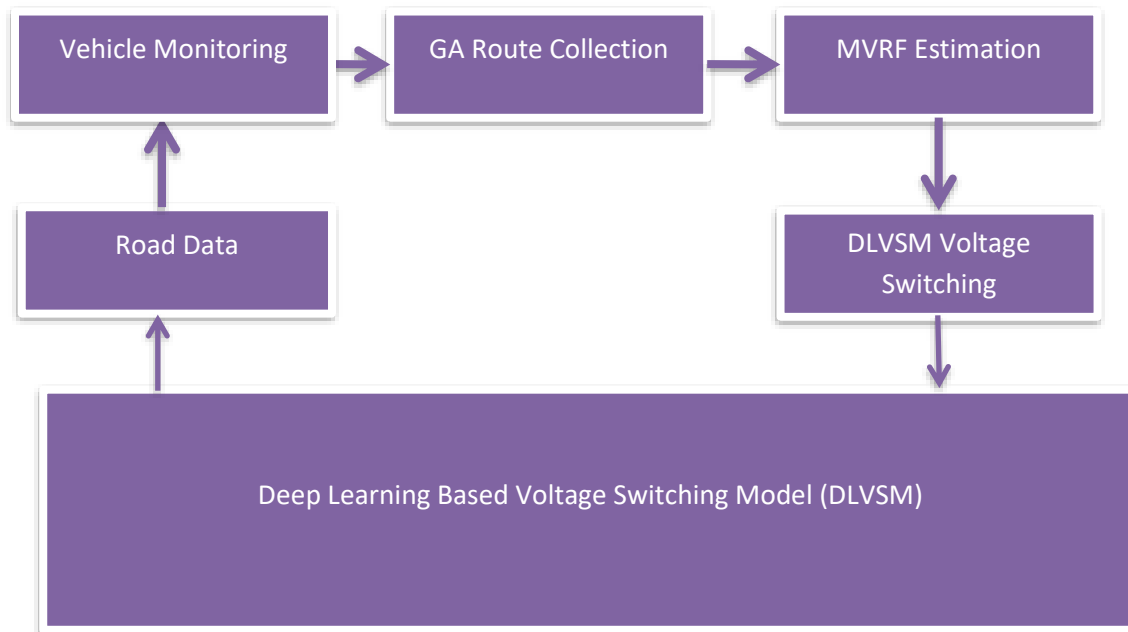


Figure 1: Block Diagram of Proposed MRMM-GA model

The working diagram of proposed MRMM-GA has been presented in Figure 1 and the functions of the model have been sketched in this section.

**Vehicle Monitoring:**

The proposed method monitors the vehicle for its state at all the fraction of its

travel time. The method monitors the vehicle for its residual energy, speed, traffic on road. Such data being fetched has been converted into feature vector. Such feature vector generated has been used towards estimating MVRS (Multi Variant Road Support) for the route considered. The value

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of MVRS has been used towards route selection and drive span maximization.

Algorithm:

Given: Road Taxonomy RT, Vehicle V

Obtain: Feature Vector Fv.

Start

    Read RT and V.

    While true

        Vehicle Speed Vs =  
Speed  $\in V$

        Vehicle Energy VE =  
Energy  $\in V$

        Vehicle Destination Vd =  
Destination  $\in V$

        Route Set Rs = GA Route  
Collection (RT, Vd, Vs, VE)

        Route R = Perform MRMM-  
GA Drive Span Maximization.

        Divert EV on route selected.

    End

Stop

The vehicle monitoring function fetches the vehicle data and performs GA route collection. Further, the method performs MRMM-GA drive span maximization.

GA Route Collection:

The genetic algorithm has been used in several scientific problems and the same can be used in span maximization of electric vehicles. To perform this, the proposed approach uses the genetic algorithm towards collecting the routes available. With the features of the vehicle, the method identifies the set of routes according to the taxonomy. With the initial routes, the method applies genetic algorithm towards detecting uncovered routes. The method produces number of mutations till there is repeat of

routes. Such routes identified are used to perform span maximization.

Algorithm:

Given: Road Taxonomy RT, Feature vector Fv

Obtain: Route set Rs.

Start

    Read RT and Fv.

    Route set Rs =  
size(RT)

$\sum RT(i).Destination == Fv.vd \ \&\& \ RT(i) \in Fv.location$   
     $i = 1$

    For each route R

        For each diversion d

            Generate Mutation M.

            Add mutation to route

    set RS =  $\sum (Routes \in Rs) \cup M$

    End

    End

Stop

The genetic algorithm based path collection function discovers the set of routes and add the routes to the route set to support span maximization.

Multi Variant Range Support Estimation (MVRS):

The multi variant range support is the measure which represents the efficacy of the routes towards span maximization. It has been measured based on the vehicle residual energy, speed, traffic in the route, number of diversions in the route and so on. According to the above mentioned features, the method estimates the value of MVRS. Estimated MVRS value has been used to perform drive span maximization.

Algorithm:

Given: Route R, Feature Vector Fv

Obtain: MVRS

Start

    Read R and Fv.

Compute no of diversion  $N_d = \sum \text{diversions} \in R$

Compute Traffic  $Tr = \text{Traffic} \in R$

Compute  $MVRS = \frac{Tr}{N_d} \times \frac{Fv.Speed}{Fv.Energy}$

Stop

The MVRS estimation algorithm computes the value of MVRS according to the traffic conditions and features of the vehicle to support span maximization problem.

MRMM-GA Drive Span Maximization:

The proposed MRMM-GA drive span maximization algorithm discovers the hidden routes by applying the genetic algorithm. For each route identified, the method computes the value of MVRS and based on that a single route has been selected to perform navigation.

Algorithm:

Given: Route Set  $R_s$

Obtain: Null

Start

Read route set  $R_s$ .

For each route  $R$

    Compute  $MVRS = MVRS$

Estimation.

End

$$\text{Route } R = \underset{i=1}{\text{Max}}(R_s(i).MVRS)$$

Perform navigation with the selected route  $R$ .

Stop

The proposed algorithm performs route selection according to the MVRS measure computed to support vehicle navigation and span maximization.

**Results and Discussion:**

The proposed Multi variant range maximization model with genetic algorithm (MRMM-GA) has been implemented with Simulink. The performance of the model has been evaluated under various parameters and presented in this section.

Parameter	Value
Tool Used	Simulink
No of Roads	100
Time	10 minutes

Table 1: Experimental Details

The experimental details used towards performance analysis are presented in table 1.

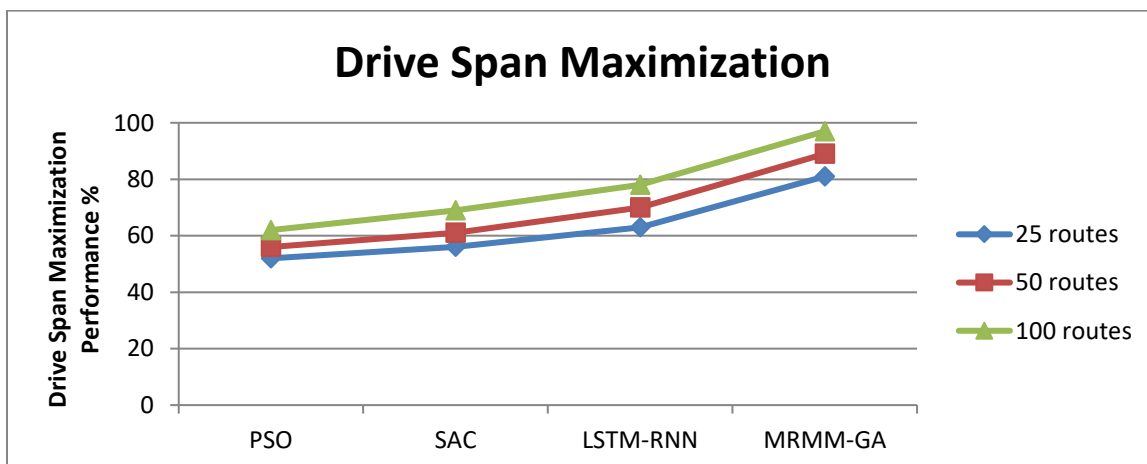


Figure 2: Drive Span Maximization Performance

The performance of method in drive span maximization is measured and presented in Figure 2. The MRMM-GA model introduces higher performance than others. The performance of span

maximization is measured according to the number of routes available. In each case, the proposed MRMM-GA model has produced higher span performance than others.

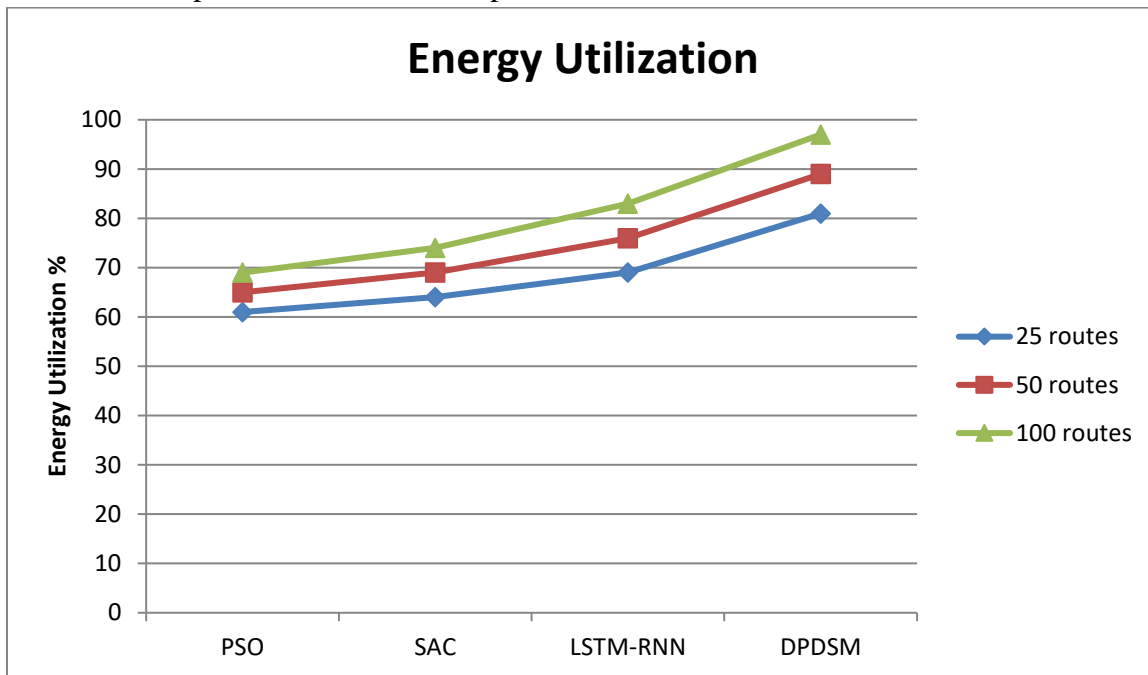


Figure 2: Energy Utilization Performance

The performance of methods in energy utilization is measured and presented in Figure 3. The proposed MRMM-GA method produces higher energy utilization performance than others. The performance of energy utilization is measured for various methods at different number of routes in the network. In all the cases, the proposed method DPDSM has produced higher performance than other methods.

#### Summary:

This paper presented a Multi variant range maximization model with genetic algorithm (MRMM-GA) model use the road map of the area where the vehicle is moving and finds the routes available. With the routes and traffic data available, the method generates number of combinatory routes

possible. With the routes produced, the method applies genetic algorithm to measure the fitness value for the possible routes. At each population, the method measure the Multi variant range support (MVRS) for the routes and population. Based on the value of MVRS, the method performs route selection towards maximizing the range of the vehicle. The proposed method improves the performance of drive span maximization and energy utilization.

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