OPTIMIZED LOCATION IDENTIFICATION FOR ELECTRIC VEHICLE CHARGING STATIONS BASED ON FUZZY C-MEANS CLUSTERING AND QGIS

Dharshni Prabha P
Department of Electrical and Electronics Engineering
Paavai Engineering College
Namakkal, Tamilndau. India.

Dr.Jagatheesan K
Associate Professor
Department of Electrical and Electronics Engineering, Paavai Engineering College,
Namakkal, Tamilndau. India.

ABSTRACT

Electric vehicles (EVs) will be the next technological leap for urban mobility however the market penetration rate depends on several factors, including the major hurdle of limited EV charging stations. Equity is also an important factor – ensuring EV charging stations are widespread and available for all segments of the population. This paper outlines an innovative methodology to systematically determine the locations of EV charging stations while considering equity and efficiency to maximize accessibility and usage. The methodology has two levels. First, solving what is known as the Set Covering Location Problem (SCLP) by determining a threshold so that the distance (or travel time) between the consumer and the EV charging station will be less than or equal to a given value.

This is a policy-based decision and provides a framework to ensure EV charging stations are ubiquitous and equitable. Second is solving the Maximum Covering Location Problem (MCLP) by considering a series of evaluation criteria to satisfy the demand of the early adopters. Following evaluation of the SCLP and MCLP, selected locations are aggregated by partitions to develop larger scale hubs. These hubs will not only include EV charging stations but will also function as connection points that integrate different modes of transportation. and policy supports in recent years, which leads to a larger demand of charging stations. Strategies about how to find the optimal location for charging facilities are urgently needed in order to further assist This paper describes application of GIS using Trans CAD software by combining SCLP and MCLP approaches to address both equity and efficiency.

Keywords—electric vehicle, location, optimization, gis, charging stations, threshold

I. INTRODUCTION

The electric vehicle (EV) market has grown rapidly in recent years, though at varying rates in different countries. While there are some certainties about the reliability of the EV technology, challenges remain. The main barriers to adoption include the cost of purchasing and operating an electric vehicle, as well as reasonable access to EV charging stations (EVCS). This paper addresses the latter concern by developing a multicriteria, GIS-based decision-making approach for determining EVCS locations with the objective to minimize “range anxiety” while considering the potential demand and working towards equitable placement for EV chargers. Range anxiety refers to the stress an EV driver may have about potentially running out of power before reaching the desired destination and is considered a major hurdle in mass adoption of EVs. Moreover, the current locations of EVCS do not consider equity factors. This paper proposes a method to satisfy both concerns in determining the locations of EVCS

II. LITERATURE REVIEW

A. LITERATURE REVIEW

Zhang, Q., Li, H., Zhu, L., [1] Campana, P. E., Lu, H., Wallin, F., & Sun, Q. (2018). Factors influencing the economics of public charging infrastructures for EV–A review. Renewable and Sustainable Energy Reviews, 94, 500-509

Davidov, S., & Pantos,[2] M. (2017). Planning of electric vehicle infrastructure based on charging station reliability and quality of service. Energy, 118, 1156-1167

S. Bayram, S. Bayhan(2020)[3] Location analysis of electric vehicle charging stations for maximum capacity and coverage, in: 020 IEEE 14th International Conference on Compatibility, Power Electronics and Power Engineering, CPE-POWERENG, 2020,

C.W. Hsu, K. Fingerman [4] , Public electric vehicle charger access disparities across race and income in California , Transp. Policy 100 (2021) 59–67

J. Asamer, M. Reinthaler[5] M. Ruthmair, M. Straub, J. Puchinger Optimizing charging station locations for urban taxi providers Transp Res Pt. A-Policy Pract, 85 (2016), pp. 233-246

L. Bitencourt, T.P. Abud, B.H. Dias [6], B.S. Borba, R.S. Maciel, J. Quirós-Tortós

Optimal location of EV charging stations in a neighborhood considering a multi-objective approach Elec Power Syst Res, 199 (2021), p. 107391

H. Mehrjerdi, R. [7] Hemmati Electric vehicle charging station with multilevel charging infrastructure and hybrid solar-battery-diesel generation incorporating comfort of drivers J Energy Storage, 26 (2019), p. 100924

J. Li, X. Sun, Q. Liu, W. Zheng, H [8] Liu, J.A. Stankovic, Planning electric vehicle charging stations based on user charging behavior, in: 2018 IEEE/ACM Third International Conference on Internet-of-Things Design and Implementation.

C. Karolemeas, S. Tsigdinos, P.G. Tzouras, [9]A. Nikitas, E. Bakogiannis, Determining Electric Vehicle Charging Station Location Suitability: a Qualitative Study of Greek Stakeholders Employing Thematic Analysis and Analytical Hierarchy Process, 2021. URL, https://www.mdpi.com/2071-1050/13/4/2298. Retrieved in November 2021.

I. Frade, A. Ribeiro, A.G. Gonçalves, A.P. Antunes,[10]Optimal location of charging stations for electric vehicles in a neighborhood in Lisbon, Portugal, Transport. Res. Rec.J. Transport. Res. Board 2252 (2252) (2011).

.

III. OBJECTIVE OF THE PROJECT

The main aim of this project is to achieve the optimized location identification which can be used for the charging the electric vehicles. It also optimizes and involves the queuing theory to study the movement of people, objects or information through a line with QGIS.

IV. EXISTING SYSTEM

A. *EXISTING SYSTEM OF STATION*

Charging infrastructure, as the energy provider of electric vehicles, is critical to the development of an electric vehicle system. The availability of efficient, convenient and economic EVCSs could enhance the willingness to buy of consumers and promote the development of the sector. Low availability of charging infrastructure could hinder EV adoption, which could then in turn reduce incentives to invest in charging infrastructure development. EVCS siting is the preliminary stage of EVCS construction.

B. *METHODOLOGY*

- In this, GIS analysis is used as a powerful tool to integrate economic, social and technical variables with the geographic information. In this paper, the study district could be split into certain amounts of grids using GIS to identify the distribution of charging demand based on the land-use classification. In addition, some decision support system models are frequently used, and the most commonly used one is the linear/nonlinear programming model either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as “3.5-inch disk drive”.

- In this study, Mixed Integer Linear Programming (MILP) is adopted to obtain the optimal location and size of charging stations, with the objective of maximizing the overall profits and five important constraints. GIS is also chosen to process some important parameters related to geographical information in the MILP model, such as traffic flow and charging possibilities.

C. *THE OBJECTIVE FUNCTION*

To achieve better returns of investment on the charging stations, an objective function of maximizing the total profits of all the new stations is adopted in the MILP model. Parking lot is a reasonable and convenient location to install chargers owing to its accessibility, so the alternative locations of charging station in this model are defined as the parking lots in the study area. The decision variables in this model are the locations of the charging stations; the number of fast or slow chargers needed to be installed in each station; and the charging demands met by each station. The profits of deploying the new stations are the revenues of charging EVs subtracted by the costs of building and maintaining the station

D. *FRAMEWORK MODEL*

- Defines the attributes that help to choose the optimum places in detail. Fourth section handles our proposed GIS-based Fuzzy approach for EVCS site selection while the fifth section examines a case study for Ankara. Last section summarizes the study and gives directions for future research.

E. *EXAMPLE SIMULATION*

- First, we simplify the Ireland land area into a rectangle with a length of 350 km and a width of 200 km. Then we fragment it into small squares and there are charging needs at every intersection point. We establish a coordinate system with the lower left corner of the rectangle as the origin. However, not every point is equivalent, considering Ireland has five main cities as transportation hubs.

F. *SENSITIVITY ANALYSIS*

- The test is done via simulation. We do sensitivity analysis on the charging vehicle flow. When the charging vehicle flow increases by 5%, the total construction cost of the charging station will increase by 8%. When the charging vehicle flow decreases by 5%, the total construction cost of the charging station will decrease by 4%.

V. PROPOSED SYSTEM

The global electric vehicle market has been experiencing significant growth in recent years. This is driven by increasing environmental concerns, government incentives, and advancements in EV technology. As more people switch to EVs, the demand for charging infrastructure grows. Hence, finding optimal charging station locations ensure that EV users have easy access to charging facilities. The proposed method involves Queuing theory to study the movement of people, objects, or information through a line with QGIS.The Queuing theory is used to identify the arrival patterns of vehicle for better identification of optimal locations.

A. *SITE SELECTION*

A Evaluation criteria are very important to the optimal EVCS siting. It is important to establish an evaluation index system to comprehensively reflect the inherent characteristics of EVCS siting However, the electric-vehicle industry is still in the early stages of management and technological exploration, so there is no consistent list of criteria for EVCS site selection in China. Since electric vehicles are a sustainable way of energy development, the evaluation index system for optimal EVCS siting is built from the perspective of extended sustainability.

B. *PARAMATERS CONSIDERED*

- Substation load
- Road accessibility
- Road visibility
- Land availability
- Population or heads

C. *OPTIMISED SITE SELECTION*

The internal factors that can injected through impact on which the soil and vegetations at which the service capacity, absorption of the power capacity. The location of which they can optimized location for charging stations the power grid at which the total identification of location on which they are optimized.electric vehicles are transport vehicles that use one or more electric motors or traction motors for propulsion. An EV may be powered through a collector system by electricity from off-vehicle sources, or may be self-contained with a battery or generator to convert fuel to electricity. In some countries, the cost of petroleum products forces people to use public transportation or to walk. The cost of charging an electric car costs less than the cost of a full tank. EVs can potentially emit substantially lower CO_2 emissions than internal combustion engine vehicles

D. ALGORITHM OF PROPOSED WORK

I .INPUTS

a) Read the substations involved

b) Initialize the load parameters for substations

c) Identify the locations for establishing charging station between the destinations

d) Input the parameters land availability and population

e) Input parameters are depends on the 5 parameters

f) Road accessibility

g) Substation Load

h) Road visibility

i) Land availability

j) Population

II. PROCESS

k) Map the substation with QGIS

l) Map the locations identified for charging station in QGIS

*m)*Identify the parameters road accessibility, road availability from QGIS

III. CLUSTERING TECHNIQUE

n) Apply Fuzzy C Means clustering technique to identify the clusters which satisfy the parameters for optimal charging station location.

IV.OUTPUT

o) Output the Optimal charging station location.

E. EFFECT OF PEAK DEMAND ON POWER UTILITY GRID.

- Current in power lines increases at peak load time
- Losses in the transformer and transmission line increases
- Voltage drop in the transmission line increases
- Total network voltage drops in peak hour
- Power factor decreases
- Finally, it results in high active power demand on generating stations

F. EFFECT OF EV

- Most of the electric vehicles connected to home chargers during evening and night
- Electric vehicles connected to the grid for charging during peak hours worsen the situation
- Power utility grid suffers to meet the demand

G. ALGORITHM

- FCM has its own meritorious place in the field of image segmentation and pattern recognition. The FCM algorithm partitions every image pixel into a collection of the fuzzy clusters by minimizing the weighted sum of squared error objective function.
- The Objective function of FCM is Fuzzy partitioning is done iteratively updating the membership function Uij and cluster centers Ci optimizing the objective function. The membership function is updated by The cluster centers are updated using

The basic FCM algorithm is as follows ,

- ❖ Input the number of clusters c, the fuzzifier m, and the distance function
- ❖ Initialize the cluster centers ci0 (i = 1; 2; : : : ; c).
- ❖ Calculate Uij(j = 1; 2; : : : ; n; i = 1; 2; : : : ; c)
- ❖ Update ci (i = 1; 2; : : : ; c)
- ❖ If ,then go to step 6 else go to step 3
- ❖ Output the results.
- ❖ of the electric vehicles connected to home chargers during evening and night

VI. SOFTWARE DESCRIPTION

A. MAT LAB SOFTWARE DESCRIPTION

MATLAB, a high-performance language for technical computing, integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. It is a prototyping environment, focusing on the ease of development with language flexibility, interactive debugging, and other conveniences lacking in performance-oriented languages like C and FORTRAN. While Mat lab may not be as fast as C, there are ways to bring it closer. We want to spend less time total developing, debugging, running, and obtaining results. It is an interactive system whose basic data element is an array that does not require dimensioning. It allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar with no interactive language such as C or FORTRAN.

The name MATLAB stands for matrix laboratory. MATLAB was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects. Today, MATLAB engines incorporate the LAPACK and BLAS libraries, embedding state of the art in software for matrix computation.

B. WORKING OF MATLAB

Tool boxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular problems. You can add toolboxes for signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many other areas.

C. The Language

The MATLAB language is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows "programming in the small" to rapidly create quick programs you do not intend to reuse. You can also do "programming in the large" to create complex application programs intended for reuse.

D. Graphics

MATLAB has extensive facilities for displaying vectors and matrices as graphs and annotating and printing these graphs. It includes high-level functions for two-dimensional and three-dimensional data visualization, image processing, animation, and presentation graphics. It also includes low-level functions that allow you to fully customize the appearance of graphics and build complete graphical user interfaces on your MATLAB applications.

E. EXTERNAL INTERFACES

The external interfaces library allows you to write C and Fortran programs that interact with MATLAB. It includes facilities for calling routines from MATLAB (dynamic linking), MATLAB as a computational engine, and reading and writing MAT files.

F. MULTITHREADED COMPUTATION

Mat lab 7.4 (R2007a) introduced multithreaded computation for multi-core and multiprocessor computers. Multithreaded computation accelerates some per-element functions when applied to large arrays (for example, ^, sin, esp.) and certain linear algebra functions in the BLAS library. To enable it, select File! Preferences! General! Multithreading and select Enable multithreaded computation." Further control over parallel computation is possible with the Parallel Computing Toolbox

G. DESKTOP TOOLS AND DEVELOPMENT ENVIRONMENT

This part of MATLAB is the set of tools and facilities that help you use and become more productive with MATLAB functions and files. Many of these tools are graphical user interfaces. It includes the MATLAB desktop and Command Window, an editor and debugger, a code analyzer, browsers for viewing help, the workspace and files, and other tools.

H. SIMULINKS

A block diagram environment for multi-domain simulation and Model-Based Design. It supports system-level design, simulation, automatic code generation, and continuous testing and verification of embedded systems. Simulink provides a graphical editor, customizable block libraries, and solvers for modelling and simulating dynamic systems.
It is integrated with MATLAB, enabling you to incorporate MATLAB algorithms into models and export simulation results to MATLAB for further analysis. To model a system and then simulate the dynamic behavior of that system.The basic techniques you use to create the simple model in this tutorial are the same techniques for more complex models. To create this simple model, you need four Simulink blocks. Blocks are the model elements that define the mathematics of a system and provide input signals.

I. MODELLING

To model algorithms and physical systems using block diagrams. You can model linear and nonlinear systems, factoring in real-world phenomena like friction, gear slippage, and hard stops. A comprehensive library of predefined blocks helps you to build models. You add blocks from the library to your model using the Simulink Editor. In the editor, connect blocks by way of signal lines to establish mathematical relationships between system components. You can also refine the model appearance and add masks to customize how users interact with the model. You can design your models to be hierarchical by organizing groups of blocks into subsystems. This approach enables you to build discrete components that reflect your real-life system and simulate the interaction of those components.

J. BLOCK LIBRARIES

Blocks are the main elements you use to build Simulink the Library Browser models to browse and search the block libraries. When you find the block, you want to use, add it to your model.

K. SIMULATION

On the can interactively simulate your system and view the results on scopes and graphical displays. For the simulation of continuous, discrete, and mixed-signal systems, you can choose from a range of fixed-step and variable-step solvers. Solvers are integration algorithms that compute system dynamics over time.
The integration of Simulink and MATLAB enables you to run unattended batch simulations of your Simulink models using MATLAB commands. This tutorial shows how to simulate a dynamic system model using Simulink® software and then use the results to improve the model. After you prepare the model for simulation, you can use an interface to input measured system data and set room temperature.

L. PERFORMANCE

A high-performance Simulink model compiles and simulates quickly. Simulink provides techniques that you can use to speed up the model simulation. As a first step to improving simulation performance, use Performance Advisor. Performance Advisor checks for conditions that might be slowing down your simulations. The tool can automatically change your model to address these conditions, or you can review and apply suggested changes manually. Performance Advisor can check your model for conditions and settings that can slow down simulation speed. It can recommend modelling optimizations, implement them automatically, and run simulations in accelerator mode for you.

M. COMPONENT-BASED MODELING

The component-based modelling and modular design. You can segment your model into design components and then model, simulate, and verify each component independently. You can save individual components as subsystems in a library or as separate models. Team members can then work on those components in parallel. Use Simulink Projects to organize large modelling projects by finding required files, managing and sharing files and settings, and using source control.A component is a piece of your design, a unit-level item, or a subassembly that you can work on without needing the higher-level parts of the model. Componentization involves organizing your model into components. Componentization provides many benefits for organizations that develop large Simulink models that consist of many functional pieces.

N. MODELLING OF SIMULINKS

These componentization techniques support a wide range of modelling requirements for models that vary in size and complexity. Most large models use a combination of componentization techniques. Simulink provides tools to convert from subsystems to model referencing. Because of the differences between subsystems and model referencing, switching from subsystems to model referencing can involve several.

O. MODELING GUIDELINES

These modelling guidelines help you develop models and generate code using Model-Based Design with Math works products. Applying these guidelines can improve the consistency, clarity, and readability of your models. The guidelines also help you identify model settings, blocks, and block parameters that affect simulation behavior or code generation. The high-integrity guidelines and corresponding Model Advisor checks are summarized in the table. For the guidelines that do not have Model Advisor checks, it is impossible to automate the checking of the guideline. Guidelines without a corresponding.

P. BLOCK CREATION

With the built-in modelling functionality provided by Simulink, you can create custom blocks and add them to the Simulink Library Browser. You can create a custom block from a MATLAB function MATLAB Function blocks enable you to use the MATLAB language to define custom functionality, and these blocks are a good starting point.

- You have an existing MATLAB function that models the custom functionality.
- You find it easier to model custom functionality using a MATLAB function than using a Simulink block diagram.
- The custom functionality does not include continuous or discrete dynamic states such as masking a subsystem of other blocks or incorporating C, C++.

VII. RESULT AND DISCUSSIONS

A. RESULT

The result of the applied procedure determines the ranking of EV charging stations by their level of priority with lower numbers representing higher priorities. The ranks are the outcome of the evaluation criteria and their weights follow the ubiquitous hexagon grids as a strategy to consider equity. Therefore, on one hand, different segments of demand and walkability factors have influenced the ranks and on the other hand, the procedure is framed based on hexagons which will result in widespread locations of EV chargers in an equitable manner. Hence, the ranks are meant to be used for prioritizing the EVCS depending on other constraints, such as budget, to initially build a group of the high ranked locations.

It is important to note that the main objective of this paper is to contribute a robust methodology which considers both efficiency and equity. Selection of the evaluation criteria can vary and expand depending on the goals in different cities, while availability of data is also imperative. The distance between hexagon centers could also change so dense areas have shorter distance and therefore more charging locations, and the spacing can be longer for the hexagons in low density areas. The next step applies a partitioning procedure to group the cells and assign a focal point to be utilized as a mobility hub equipped with a higher number of EV chargers.

Mobility hubs provide connectivity between different modes of transportation including walking, biking, transit, and shared mobility. They also include amenities and sustainable features. The grouping of the hexagon cells to determine the major hubs is based on balancing the partitions according to the number of residents, resulting in each partition covering approximately the same number of residents.

The same demand and walkability criteria used for EVCS locations are also imperative for mobility hubs because these hubs should service high population and employment areas; they should also support and integrate other modes of transportation. Additionally, use of walkability as a criterion is important for locating mobility hubs. Higher walkability will not only result in a higher level of use of non-motorized transportation, but also increase public transit ridership because at least two legs of any transit trip are by walk.

Decision makers using this study can define the number of groups and accordingly develop the partitions for the hubs. The previous step determines the locations of EV charging stations and prioritizes them based on given attributes.

B. CONCLUSION

This paper presented a methodology, using an innovative systematic approach, to determine the locations of EV charging stations at the planning stage. The implication of the process described in this paper, for planners, will provide a tool that can be used as a guideline, enabling planning in a more prudent and efficient manner.

The methodology applied is applicable at the policy level by applying the first step to solve the Set Covering Location Problem (SCLP) which will enable decision makers to locate an EV charging station within certain time or distance. The same step can be evolved to what is known as Maximum Covering Location Problem (MCLP) which not only considers the time or distance threshold to locate each station, but also considers the potential demand and accordingly, the methodology ranks each station for its maximum efficiency. Moreover, the approach applied in this study can be improved by estimating the size of each station and the number of chargers.

C. ANALYSIS OF FUTURE SCOPES

Transportation efficiency is usually measured by calculating the fuel decrease in the tank; but we assume the fuel will always be there. But if we don't take protective actions we will not be able to calculate the fuel in tanks. Although there are many alternative transportation opportunities that are more environmentally and efficient, many countries including Turkey depend on private automobiles. This situation comes up with more dependence on petroleum products.

FUTURE SCOPE

The algorithms to access the suitable charging station can be worked on Choice of location can be also be made including parameters such as no of EV passing through, type of charging required, duration of charging required, type of vehicle and so on Ensemble classification can be used when large parameters are considered .To view output download QGIS 3.8.1 and run csv.

REFERENCES

[1] Zhang, Q., Li, H., Zhu, L., Campana, P. E., Lu, H., Wallin, F., & Sun,Q. (2018). Factors influencing the economics of public charging infrastructures for EV–A review. Renewable and Sustainable Energy Reviews, 94, 500-509.

[2] Davidov, S., & Pantoš, M. (2017). Planning of electric vehicle infrastructure based on charging station reliability and quality of service. Energy, 118, 1156-1167

[3] S. Bayram, S. Bayhan(2020) Location analysis of electric vehicle charging stations for maximum capacity and coverage, in: 020 IEEE 14th International Conference on Compatibility, Power Electronics and Power Engineering, CPE-POWERENG, 2020,

[4] C.W. Hsu, K. Fingerman, Public electric vehicle charger access disparities across race and income in California, Transp. Policy 100 (2021) 59–67

[5] J. Asamer, M. Reinthaler, M. Ruthmair, M. Straub, J. Puchinger Optimizing charging station locations for urban taxi providers Transp Res Pt. A-Policy Pract, 85 (2016), pp. 233-246

[6] L. Bitencourt, T.P. Abud, B.H. Dias, B.S. Borba, R.S. Maciel, J. Quirós-TortósOptimal location of EV charging stations in a neighborhood considering a multi-objective approach Elec Power Syst Res, 199 (2021), p. 107391

[7]. H. Mehrjerdi, R. Hemmati Electric vehicle charging station with multilevel charging infrastructure and hybrid solar-battery-diesel generation incorporating comfort of drivers J Energy Storage, 26 (2019), p. 100924

[8] J. Li, X. Sun, Q. Liu, W. Zheng, H. Liu, J.A. Stankovic, Planning electric vehicle charging stations based on user charging behavior, in: 2018 IEEE/ACM Third International Conference on Internet-of-Things Design and Implementation (IoTDI), 2018, pp. 225-236