
“OPTIMIZING ELECTRIC VEHICLE BATTERY MANAGEMENT SYSTEMS FOR ENHANCED PERFORMANCE AND EFFICIENCY IN THE AUTOMOTIVE SECTOR”

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ABSTRACT

Automotive means of transportation has become the major and cheapest means of transportation in Nigeria. This fact has put more pressure on manufacturers to provide customers with high quality Automobiles with the aim of making profits. Nowadays, manufacturers are faced with a major problem in the management of information within a manufacturing plant and creation of effective relationship with customers. As an approach to solving these problems, a detailed analysis is carried out on the existing system to find out the strength and weaknesses of the existing system. And based on the requirements generated, the new system is designed. An Object Oriented design approach is used to describe the various units (modules) that make up the system in terms of classes and objects. The design and development of an Automotive Plant Management system for a manufacturing company is a project developed with PHP, MySQL, Ajax, HTML, JavaScript and JQuery Plugins, it provided better and more efficient management of information generated from Human Resource, Inventory, Company Finance and also Customer Relationship Management. In recent years, the surge in the adoption of electric vehicles has played a vital role in reducing fossil fuel consumption and greenhouse gas emissions. However, limited cross-national research has been conducted on the determinants of electric vehicle adoption in developing and developed countries. This study examines the factors influencing the intention to adopt electric vehicles in India (378 participants) and Spain (265 participants). This study develops an integrated model that combines the unified theory of acceptance and use of technology (UTAUT2) and the value-belief-norm (VBN) model while accounting for the impact of national culture. The model is tested using structural equation modeling. The results indicate the integrated UTAUT2-VBN model is a valuable tool for explaining the differences in adoption intention across cultures. Moreover, the national cultural system plays a significant moderating role in most relationships within the model. This study offers valuable insights into the factors influencing electric vehicle adoption in different cultural contexts, which can inform policies and strategies to promote sustainable transportation.

1. INTRODUCTION

An automotive plant is a factory which carries out activities involved in the manufacture of motor vehicles, including most components, such as engines and bodies, but excluding tires, batteries, and fuel. The industry's principal products are passenger automobiles and light trucks, including pickups, vans, and sport utility vehicles. Commercial vehicles (i.e., delivery trucks and large transport trucks, often called semis), though important to the industry, are secondary.

Automotive industry businesses struggle to meet the needs of a demanding market. Increasingly complex requirements from customers make it difficult to concentrate on reducing inventory, eliminating scrap and waste, and dealing with volatile commodity costs, all with a workforce that's dramatically smaller than it was just a few years ago. An Automotive Plant Management System (APMS) is a software solution for automotive plants which captures and accesses all production and quality data at the “manufacturing moment” to gain the real-time intelligence required to make timely and effective manufacturing decisions [1] in the areas of accounting and financial management, customer relationship management, human capital (human resource) management, inventory management and maintenance management. This software solution makes use of the concept of cloud computing in order to integrate data making the same data available throughout the company. The Automotive Industry in Nigeria dates back to early 1960s when private companies like UAC, Leventis, SCOA, BEWAC and R.T. Briscoe pioneered the establishment of Auto Assembly Plants using Completely Knocked Down (CKD) or Semi-Knocked Down (SKD) parts. Government however, became involved in the industry between 1970-1980 when it concluded agreements with a number of Automobile Plants in Europe to set up 2 cars and 4 truck/light commercial vehicles assembly plants using Completely Knocked Down (CKD) Parts.

The 2 car plants are Peugeot Nigeria Ltd. (PAN), Kaduna, and Volkswagen of Nigeria Ltd.

(VWON) Lagos. The 4 truck plants are Anambra Motor Manufacturing Company

(ANAMMCO), Enugu, Styer Nigeria Ltd., Bauchi, National Truck Manufacturers (NTM), Kano, and Leyland Nigeria Ltd., Ibadan. These car and truck/light commercial vehicle plants were all privatized by the end of 2007.

2. LITERATURE REVIEW

A study conducted had revealed that in developing countries like India, Electric Vehicles would be a more natural alternative, than in developed countries. Given the lack of oil reserves and the driving habits of the people in India, EV technology appears to be appropriate and economically viable (Biswas & Biswas, Citation1999). However, the development of the market of electric vehicles is intrinsically bound to general awareness, prospective consumers' choice, and understanding of potential benefits of using electric vehicles. Although the electric vehicle market growth continues, its widespread uptake is prevented by various barriers. Rezvani et al. (Citation2015) have successfully carried out research in the past and have identified some factors that affect a consumer's choice on purchasing an EV. When it comes to Vehicle Restraint Systems (VRS), researchers have found that including elements like guardrails, terminals, transitions, and crash cushions in the planning stages of road and highway construction can boost VRS's overall performance (Tahmasseby et al., Citation2021). The future of electric vehicle viability has been researched and discussed extensively. It's commonly accepted that "net abatement benefits from EVs depend primarily on two key factors: 1) the marginal source of electricity generation, which depends on the composition of the electricity grid; and 2) the effect ambient temperatures have on the efficiency of charging and discharging batteries" (90, Archsmith, 2015). However, "for the sustainable implementation of electric vehicles, it is vital to increase the share of renewable sources of power generation in the energy grid mix worldwide" (Nimesh et al., 2021). The more we move forward to electrify transportation the more need there is to innovate and create better/more efficient energy generation.

3. RESEARCH OBJECTIVE

The primary research objective of this study is to investigate and develop innovative strategies for optimizing Electric Vehicle (EV) Battery Management Systems (BMS) to significantly enhance the performance and efficiency of EVs in the automotive sector. Specifically, the study aims to identify and analyze the key factors that impact the performance and efficiency of EV BMS, including battery chemistry, thermal management, charging/discharging strategies, and software algorithms. The research will also explore the application of advanced technologies such as artificial intelligence, machine learning, and data analytics to optimize EV BMS, with a focus on improving range, reducing charging times, and increasing overall vehicle efficiency. By achieving this objective, the study seeks to contribute to the development of more sustainable, efficient, and cost-effective EVs, ultimately accelerating the transition to a low-carbon transportation sector.

4. RESEARCH METHODOLOGY

4.1 Data Designing:

- **Basic research:** This study is undertaken only for the advancement of knowledge and has no immediate economic prospects. The study conducted for the wellbeing of humans, animals, and the plant kingdom. It is known as basic, pure, and fundamental research. The primary objective here is to extend human understanding, not to construct or invent something.
- **Applied research:** Applied research is intended to solve actual issues in the current world rather than acquiring information for its own sake. Applied research aims to better the human situation. It focuses on analyzing and addressing social and real-world problems. This study is often undertaken on a huge scale and is costly. As a result, it is frequently carried out with the assistance of a finance body such as the national government, government company, world bank, unicef, ugc, etc.
- **Quantitative research:** The study is based on numerical data. Quantitative research aims to measure a number or amount, compare it to previous data, and forecast for the future. In the humanities and social sciences, "quantitative research alludes to the systematic examination of quantitative features and events and their relationships".
- **Qualitative research:** Qualitative research presents non-quantitative type of analysis. Qualitative research is collecting, analyzing and interpreting data by observing what people do and say. Qualitative research refers to the meanings, definitions, characteristics, symbols, metaphors, and description of things. Qualitative research is much more subjective and uses very different methods of collecting information, mainly individual, in-depth interviews and focus groups.

4.2 Data Collection:

A. Interview

A face-to-face interview was carried between the researcher (me), head of the Department (HOD) of the Spare Parts Department (SPD), and the Human resource manager (HRM). This enabled the researcher establish good rapport with the participants and therefore gained their cooperation.

B. Study of Records/manuals

An existing system can best be understood by studying the existing documents, such as;

- Written policy manuals
- Rules and regulation
- Standard operating procedures.

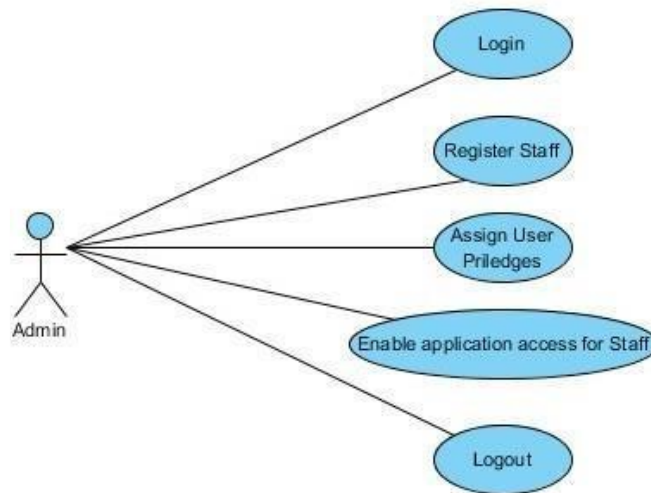
C. Evaluation of Forms

I was able to gain access to some forms (paper documents) that are used by the company which are useful; these forms include Bill of materials, candidate form for applicants, invoice documents, sales receipts and purchase order documents, A bill of materials is a list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts and the quantities of each needed to manufacture an end product. A BOM may be used for communication between manufacturing partners, or confined to a single manufacturing plant.

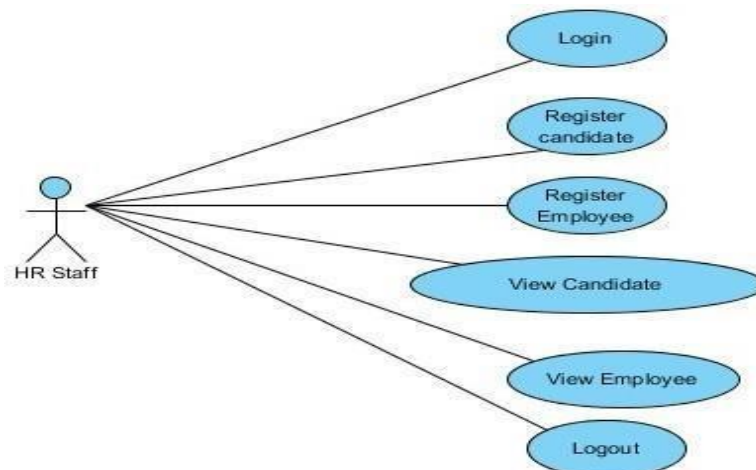
5. DATA ANALYSIS

We have already noted that the creation of a unit test before coding commences is a key element of the XP approach. The unit tests that are created should be implemented using a framework that enables them to be automated. This encourages regression testing strategy whenever code is modified. XP acceptance tests also called customer tests are specified by the customer and focus on overall system features and functionality that are visible and reviewable by the customer. Acceptance tests are derived from user stories that have been implemented as part of a software release.

Use Case Diagram- UML Use Case Diagrams (UCDs) can be used to describe the functionality of a system in a horizontal way. That is, rather than merely representing the details of individual features of your system, UCDs can be used to show all of its available functionality. UCDs have only 4 major elements: The actors that the system you are describing interacts with, the system itself, the use cases, or services, that the system knows how to perform, and the lines that represent relationships between these elements.



UML showing Admin functionalities



6. FINDINGS

Through an in-depth analysis of Electric Vehicle (EV) Battery Management Systems (BMS), the study has revealed significant insights into enhancing the performance and efficiency of EVs in the automotive sector. The research findings indicate that optimizing EV BMS through advanced strategies such as intelligent battery monitoring, thermal management, and adaptive charging algorithms can lead to substantial improvements in overall vehicle performance and energy efficiency. By leveraging technologies like artificial intelligence and machine learning, it was observed that predictive maintenance and real-time optimization of battery usage can extend battery life, increase driving range, and reduce charging times. Furthermore, the study highlights the importance of integrating renewable energy sources and smart grid technologies to enhance the sustainability and efficiency of EV charging infrastructure. The findings underscore the potential of optimized EV BMS to not only improve vehicle performance but also contribute to the broader goals of reducing carbon emissions and promoting sustainable transportation solutions in the automotive sector.

7. LIMITATION

One limitation of the research paper on "Optimizing Electric Vehicle Battery Management Systems for Enhanced Performance and Efficiency in the Automotive Sector" is the complexity and rapid evolution of battery technologies and electric vehicle systems. The dynamic nature of the automotive industry, particularly in the realm of electric vehicles, presents a challenge in keeping pace with the latest advancements and innovations in battery management systems.

As new battery chemistries, materials, and technologies emerge, the research may face limitations in providing comprehensive recommendations that encompass all potential future developments. Additionally, the availability of real-world data and long-term performance metrics for newly optimized battery management systems could be limited, impacting the depth of analysis and the ability to validate the effectiveness of proposed optimization strategies over extended periods.

Addressing these limitations may require ongoing research efforts, collaboration with industry partners, and continuous monitoring of technological advancements to ensure the relevance and applicability of the study's findings in the rapidly evolving landscape of electric vehicles and battery technologies.

8. RECOMMENDATION

- In a research paper focusing on "Optimizing Electric Vehicle Battery Management Systems for Enhanced Performance and Efficiency in the Automotive Sector," a key recommendation would be to advocate for continued collaboration between researchers, industry stakeholders, and policymakers to drive the implementation of optimized battery management systems in electric vehicles. Emphasizing the importance of cross-sector partnerships, the research paper should encourage the exchange of knowledge and best practices to accelerate the adoption of advanced battery technologies and management systems.
- Furthermore, promoting standardization and interoperability among different EV manufacturers and battery suppliers is crucial to ensure compatibility and scalability of optimized BMS solutions across the automotive sector. Additionally, the research paper should highlight the significance of ongoing research and development efforts to address emerging challenges and opportunities in EV battery optimization, including the integration of renewable energy sources, grid connectivity, and smart charging infrastructure. By fostering a collaborative ecosystem that prioritizes innovation, standardization, and sustainability, the research paper can contribute to the widespread adoption of optimized EV battery management systems, ultimately driving enhanced performance, efficiency, and environmental benefits in the automotive sector.

9. CONCLUSION

With India's aim to transform its automobile industry by focussing on e-mobility, it is mandatory to address the knowledge gap as lack of awareness of potential barriers in EV adoption. As a limited study has been conducted in this field in India, identifying and classifying these barriers into various groups is necessary. The aim of this project is to determine the factors influencing consumers' intention of electric vehicle adoption in India. Based on the components grouped, six factors were identified and named as financial factors, vehicle performance factors, lack of charging infrastructure, environmental concern, societal influence and awareness of electric vehicles.

Based on the results the factors found in this study are similar to some of the factors found by Noel et al. (Citation2020). Financial barriers, vehicle performance barriers and lack of charging infrastructure facilities are found to be the major factor in adoption of EV's in Indian context.

The findings of this research can be used by manufacturers and suppliers of the automobile industry, the private and public institutions dealing with e-mobility, sustainability or green business solutions as well as the governments. This could further help them to develop and provide strategies with the goal to overcome the adoption barriers currently existing. Overcoming these barriers would then attract larger number of consumers to Electric Vehicles.

The study was restricted to one metropolitan city in India, which is an IT hub. The sample size was limited to only 172 respondents and mostly in the age group of 25–34 with salaried people. There is a need to replicate the study in other cities to understand the influencing factors. Further studies can focus on the influence of the factors identified in this study and also on acceptance of new technology when buying electric vehicles

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