Global Journal of Arts Humanity and Social Sciences
ISSN: 2583-2034

GSAR PUBLISHERS
GLOBAL SCIENTIFIC AND ACADEMIC RESEARCH

OPEN ACCESS
Global Journal of Arts Humanity and Social Sciences
ISSN: 2583-2034
Abbreviated key title: Glob.J.Arts.Humanit.Soc.Sci
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link: https://gsarpublishers.com/journal-gjahss-home/

Volume - 4 | Issue - 12 | Dec 2024 | Total pages 1040-1044 | DOI: 10.5281/zenodo.14413059

Using Artificial Intelligence to Reduce Carbon Emissions from the Saudi Commercial Fleet

By

Akram Elentably

King Abdul-Aziz University Maritime Studies College Supply chain and maritime business

Article History
Received: 01- 12- 2024
Accepted: 07- 12- 2024
Published: 10- 12- 2024

Corresponding author
Akram Elentably

Abstract

The Saudi commercial fleet contributes significantly to the nation's carbon footprint. This paper explores the potential of Artificial Intelligence (AI) to optimize fleet operations and reduce associated emissions. We delve into various AI applications, including predictive maintenance, optimized routing, and intelligent speed control, highlighting their efficacy in minimizing fuel consumption and maximizing operational efficiency. The paper also discusses challenges and opportunities associated with AI implementation in the Saudi context, considering the specific requirements of the local fleet and infrastructure. Ultimately, integrating AI into fleet management systems offers a promising pathway towards achieving sustainability goals and reducing the environmental impact of commercial transport in Saudi Arabia.

Keywords: Artificial Intelligence, Carbon Emissions, Saudi Arabia, Commercial Fleet, Predictive Maintenance, Optimized Routing, Fuel Efficiency, Sustainability.

1. Introduction

The transportation sector, especially commercial fleets, is a major contributor to global greenhouse gas emissions. Saudi Arabia, with its extensive commercial fleet supporting a wide range of industries, faces a significant challenge in mitigating these emissions and achieving its sustainability objectives. This paper investigates the potential of Artificial Intelligence (AI) to optimize fleet operations and reduce carbon footprints. By leveraging AI-powered technologies, including predictive analytics, route optimization, and smart vehicle management, Saudi Arabia's commercial fleet can achieve substantial reductions in fuel consumption and emissions, ultimately leading to environmental and economic benefits. This study will delve into the development of a mathematical model utilizing AI to demonstrate how it can contribute to a cleaner and more sustainable transportation future in Saudi Arabia, supported by a thorough review of the relevant background and existing literature.

The transportation sector, including maritime shipping, is a major contributor to global greenhouse gas emissions. Saudi Arabia, with its extensive coastline and flourishing maritime trade, faces the challenge of reducing its commercial fleet's carbon footprint. While various initiatives are in place to achieve sustainability goals, the integration of artificial intelligence (AI) presents a promising avenue for achieving significant emissions reductions.

2. Background

[1] The transportation sector, globally and in Saudi Arabia, has a substantial environmental impact due to its dependence on fossil fuels. [2] Commercial fleets, including trucks, buses, and delivery vehicles, play a crucial role in supporting economic activities, but their high fuel consumption contributes significantly to carbon emissions. [3] The Saudi government has recognized the need to reduce carbon emissions and has implemented various initiatives to promote sustainability, including investments in renewable energy and fuel efficiency programs. [4] However, the potential of AI in optimizing fleet operations and driving emission reductions remains largely untapped. [5] This gap provides an opportunity to explore AI-driven solutions that can streamline fleet operations, leading to environmental and economic benefits.

The global transportation sector, including Saudi Arabia, significantly impacts the environment due to its reliance on fossil

Copyright © 2024 The Author(s): This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY-NC 4.0).

fuels. Commercial fleets, such as trucks, buses, and delivery vehicles, are vital to economic activity but contribute substantially to carbon emissions through high fuel consumption. While the Saudi government acknowledges the need to reduce these emissions and has initiated various sustainability efforts, including investments in renewables and fuel efficiency, the potential of Artificial Intelligence (AI) in optimizing fleet operations and mitigating emissions remains largely unrealized. This untapped potential presents a valuable opportunity to develop AI-driven solutions that streamline fleet operations, yielding both environmental and economic gains.

[1] The transportation sector, specifically road transportation, plays a vital role in the Saudi Arabian economy, contributing significantly to the movement of goods and people. However, this sector also accounts for a substantial portion of the country's carbon emissions, posing a major environmental challenge. [2] The Saudi government has recognized the need to transition towards a greener economy and has set ambitious targets for reducing carbon emissions. [3] The commercial fleet, comprising trucks, buses, and other commercial vehicles, is a major contributor to these emissions. [4] The increasing demand for transportation services and the growth of e-commerce further exacerbate the issue. [5] Consequently, there is an urgent need to implement innovative solutions to optimize the operations of the Saudi commercial fleet and minimize its environmental footprint.

3. Literature Review

[6] Several studies have explored the role of AI in optimizing transportation systems and reducing emissions. [7] For instance, route optimization algorithms powered by machine learning can significantly reduce fuel consumption and travel time by identifying the most efficient paths for vehicles. [8] Predictive maintenance models based on AI can minimize downtime and optimize maintenance schedules, further contributing to fuel efficiency. [9] Furthermore, AI-powered systems can analyze traffic patterns and weather conditions in real-time, enabling proactive adjustments to fleet operations and minimizing delays that contribute to increased emissions. [10] The integration of AI with connected vehicle technologies can enhance situational awareness and enable more efficient fleet management.

[6] Existing literature has explored the application of AI in various aspects of transportation, including route optimization, traffic management, and predictive maintenance. [7] Several studies have demonstrated the effectiveness of AI algorithms in reducing fuel consumption and emissions in commercial vehicles. [8] For example, machine learning models can be trained on historical data to predict optimal driving speeds and anticipate traffic conditions, enabling drivers to adjust their driving styles for improved fuel efficiency. [9] AI-powered route optimization systems can identify the shortest and most efficient routes, reducing the overall distance traveled and consequently minimizing fuel consumption and emissions. [10] Furthermore, AI can be instrumental in predictive maintenance, enabling proactive identification of potential vehicle malfunctions and scheduling timely repairs, thereby preventing breakdowns and reducing fuel wastage.

4. The Need for Sustainable Fleet Management

The transportation sector, particularly commercial fleets, plays a crucial role in the Saudi economy, moving goods and people across the vast nation. However, this activity comes at a substantial environmental cost, with emissions from commercial vehicles contributing significantly to the country's carbon footprint [1]. Addressing this challenge is vital for achieving Saudi Arabia's Vision 2030 goals, which emphasize environmental sustainability and economic diversification [2]. Reducing carbon emissions from the commercial fleet is paramount to mitigating climate change and fostering a more sustainable future.

5. Explanation of Artificial Intelligence

Artificial Intelligence (AI) is a branch of computer science that aims to develop intelligent agents that can perform tasks typically requiring human intelligence [3]. AI encompasses a wide range of techniques, including machine learning, deep learning, natural language processing, and computer vision. Machine learning, a core component of AI, involves training algorithms on large datasets to identify patterns and make predictions [4]. AI systems can learn from experience, adapt to new information, and improve their performance over time. This ability makes AI particularly valuable in dynamic environments like fleet management, where numerous variables influence operational efficiency and emissions.

6. AI Applications for Reducing Fleet Emissions

Several AI-driven solutions can be implemented to optimize fleet operations and minimize carbon emissions. One promising application is **predictive maintenance**, which uses machine learning to analyze data from vehicle sensors and predict potential failures [5]. By anticipating maintenance needs, fleets can reduce downtime, minimize fuel waste associated with inefficient vehicles, and prevent unexpected breakdowns that contribute to increased emissions.

7. Optimized Routing and Dispatching

Another crucial application of AI is **optimized routing and dispatching**. AI-powered algorithms can analyze real-time traffic conditions, road closures, and other factors to generate the most efficient delivery routes [6]. By minimizing travel distances and optimizing delivery schedules, fleets can reduce fuel consumption and overall emissions. This technology is especially beneficial for large fleets operating in complex urban environments or across vast geographical regions, as seen in the Saudi context.

8. Intelligent Speed Control and Driver Behavior Analysis

AI can also help optimize driver behavior and promote fuel efficiency. **Intelligent speed control systems** leverage AI algorithms to monitor and adjust vehicle speed based on road

Copyright © 2024 The Author(s): This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY-NC 4.0).

conditions and traffic patterns [7]. Furthermore, AI can be used to analyze driver performance, identifying habits that contribute to higher fuel consumption, like harsh braking and acceleration [8]. Feedback mechanisms and driver training programs based on AI-generated insights can lead to significant improvements in fuel efficiency and emission reduction.

9. Challenges and Opportunities in the Saudi Context

Implementing AI solutions for fleet management in Saudi Arabia presents both challenges and opportunities. The integration of AI technologies requires significant investment in infrastructure, including data connectivity and robust sensor networks across the fleet [9]. Data privacy and security are also crucial considerations, particularly concerning sensitive operational and driver data [10]. However, the Saudi government's commitment to technological innovation and the growing availability of cloud computing resources can facilitate the implementation of AI solutions.

10. Understanding Artificial Intelligence

Artificial intelligence (AI) encompasses the development of computer systems capable of performing tasks that typically require human intelligence. These tasks include learning, problem-solving, decision-making, and pattern recognition. AI algorithms are trained on large datasets, enabling them to identify trends, make predictions, and optimize processes.

AI relies on several core techniques, including:

- **Machine Learning:** This involves training algorithms on vast quantities of data to enable them to learn patterns and make predictions without explicit programming.
- **Deep Learning:** A subset of machine learning utilizing artificial neural networks with multiple layers to extract complex features from data.
- **Natural Language Processing (NLP):** Enables computers to understand and interpret human language, facilitating communication and data analysis.
- **Computer Vision:** Allows AI systems to "see" and interpret images and videos, useful for tasks like object detection and anomaly identification.

11. AI Applications for Reducing Carbon Emissions

AI can be deployed across various facets of the Saudi commercial fleet to drive emissions reductions:

11.1 Route Optimization:

AI algorithms can analyze historical data, weather patterns, and ocean currents to optimize vessel routes. By identifying the most fuel-efficient pathways, AI can minimize fuel consumption and reduce emissions. This optimization can be further enhanced by considering factors like port congestion and vessel traffic density.

11.2 Predictive Maintenance:

AI-powered predictive maintenance systems can analyze sensor data from vessels to predict potential equipment failures. This allows for timely repairs and prevents unexpected breakdowns that can lead to increased fuel consumption and emissions. By minimizing downtime and optimizing maintenance schedules, AI can contribute to significant efficiency gains.

11.3 Fuel Efficiency:

AI can optimize vessel speed and engine performance to maximize fuel efficiency. By analyzing real-time data on weather conditions, cargo weight, and other factors, AI can suggest optimal operating parameters that minimize fuel consumption. Furthermore, AI can be integrated with engine control systems to automate adjustments and ensure optimal operation.

11.4 Vessel Optimization:

AI can play a role in the design and construction of future vessels by optimizing hull shape and propulsion systems for enhanced fuel efficiency. AI-powered simulations can evaluate different design configurations to identify the most environmentally friendly options.

12. Challenges and Opportunities in the Saudi Context

Implementing these AI solutions in the Saudi context presents unique challenges and opportunities:

- **Data Availability and Quality:** The success of AI hinges on access to high-quality data from various sources. Integrating data from different systems and ensuring data standardization will be crucial.
- **Infrastructure Development:** Developing the required infrastructure, including cloud computing capabilities and high-speed internet connectivity, will be essential for supporting AI applications.
- **Skills and Expertise:** Developing a local workforce with the necessary skills in AI and data science will be critical for the long-term success of these initiatives.
- **Collaboration and Partnerships:** Collaboration between governmental agencies, research institutions, and industry players will be crucial for fostering innovation and driving adoption of AI technologies.

13. Construction of a Mathematical Model using Artificial Intelligence

We propose a mathematical model based on AI to optimize fuel consumption and subsequently reduce carbon emissions in the Saudi commercial fleet. The model integrates various AI techniques such as machine learning and optimization algorithms to achieve this goal.

Step 1: Data Collection and Preprocessing

The first step involves gathering relevant data from the commercial fleet, including:

- **Vehicle data:** Vehicle type, fuel efficiency, engine specifications, maintenance history.

Copyright © 2024 The Author(s): This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY-NC 4.0).

- **Operational data:** Trip details (origin, destination, route, duration), driver behavior (speed, acceleration, braking), traffic conditions, weather data.
- **Environmental data:** Ambient temperature, road surface conditions.

This data will be preprocessed to handle missing values, outliers, and inconsistencies, ensuring data quality for subsequent AI model development.

Step 2: Feature Engineering
Relevant features that influence fuel consumption will be engineered from the collected data. These features could include:

- **Trip distance**
- **Average speed**
- **Number of stops**
- **Idle time**
- **Acceleration and braking patterns**
- **Road gradient**
- **Traffic density**
- **Weather conditions**

These features will serve as inputs for the AI model.

Step 3: Model Development – Machine Learning Regression
We will use a machine learning regression model to predict fuel consumption based on the engineered features. A common choice for this task is a **Support Vector Regression (SVR)** model. The SVR model utilizes a kernel function (e.g., radial basis function) to map the input features to a higher-dimensional space where it finds the optimal hyperplane that best fits the data.

14. Mathematical Equation (SVR):

$$y = w^T\varphi(x) + b$$

Where:

- **y:** Predicted fuel consumption
- **w:** Weight vector
- **φ(x):** Kernel function that maps input features (x) to a higher-dimensional space
- **b:** Bias term

14.1. Example (SVR):
Imagine we have a dataset with features like trip distance (x1) and average speed (x2), and we want to predict fuel consumption (y). After training the SVR model, we obtain the following parameters: w1 = 0.5, w2 = 0.2, b = 1.

For a trip with x1 = 100 km and x2 = 60 km/h:

$$y = (0.5 * \varphi(100)) + (0.2 * \varphi(60)) + 1$$

Assuming the kernel function outputs φ(100) = 2 and φ(60) = 1.5:

$$y = (0.5 * 2) + (0.2 * 1.5) + 1 = 1 + 0.3 + 1 = 2.3 \text{ liters}$$

Therefore, the SVR model predicts a fuel consumption of 2.3 liters for this trip.

Step 4: Optimization – Genetic Algorithm
Once the fuel consumption prediction model is trained, we deploy a genetic algorithm (GA) to optimize the fleet's operations for minimizing fuel consumption. GA is a metaheuristic optimization technique inspired by natural selection. It iteratively improves a population of solutions (representing fleet operations) by applying genetic operators like selection, crossover, and mutation.

14.2 Mathematical Equation (Fitness Function):

Fitness(Solution) = 1 / TotalFuelConsumption(Solution)

Where:

- **Fitness(Solution):** Fitness value of a particular solution (e.g., a specific route or scheduling plan).
- **TotalFuelConsumption(Solution):** Total fuel consumed by the fleet following the given solution.

14.3 Example (Fitness Function):
Consider two potential routes for a delivery:

Route 1: Total fuel consumption = 20 liters **Route 2:** Total fuel consumption = 15 liters

Fitness(Route 1) = 1/20 = 0.05 Fitness(Route 2) = 1/15 = 0.067
In this example, Route 2 has a higher fitness value, indicating it is a more desirable solution as it leads to lower fuel consumption.

Step 5: Implementation and Evaluation
The optimized solutions from the GA are implemented into the fleet management system. This involves updating routing plans, driver instructions, and maintenance schedules. The model's performance is continuously evaluated by comparing predicted fuel consumption with actual consumption. The model is retrained periodically with new data to ensure its accuracy and adaptability.

14.4 Mathematical Equation (Carbon Emission Calculation):

CO_2 Emissions (kg) = Fuel Consumption (liters) * CO_2 Emission Factor (kg CO_2/liter)

Where:

- **CO_2 Emissions:** Total carbon dioxide emissions.
- **Fuel Consumption:** Total fuel consumed (obtained from the AI model).
- **CO_2 Emission Factor:** Specific to the fuel type (e.g., diesel).

14.5 Example (Carbon Emission Calculation):
Assume the fuel consumption for a particular trip is 50 liters and the CO_2 emission factor for diesel is 2.65 kg CO_2/liter.
CO_2 Emissions = 50 liters * 2.65 kg CO_2/liter = 132.5 kg CO_2
Therefore, this trip would generate 132.5 kg of CO_2 emissions.

Conclusion

The Saudi commercial fleet presents a major opportunity for leveraging AI to achieve substantial reductions in carbon emissions. By implementing AI-powered solutions for route optimization, predictive maintenance, fuel efficiency, and vessel optimization, Saudi Arabia can significantly minimize its

Copyright © 2024 The Author(s): This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY-NC 4.0).

environmental impact while improving operational efficiency and achieving economic benefits. Addressing the challenges related to data availability, infrastructure development, and skills development will be key to realizing the full potential of AI in promoting a sustainable maritime sector. The application of AI presents a compelling solution to reduce carbon emissions from the Saudi commercial fleet. AI-powered tools can optimize fleet operations through predictive maintenance, efficient routing, and improved driver behavior, leading to substantial reductions in fuel consumption and emissions. While challenges related to infrastructure and data security need to be addressed, the potential benefits of AI in achieving sustainability goals are significant. Further research and development are needed to refine AI algorithms, address specific challenges in the Saudi context, and facilitate the widespread adoption of these technologies within the commercial fleet sector.

References

1. Saudi Aramco World, "Saudi Arabia's Energy Future," Saudi Aramco, 2021.
2. Saudi Vision 2030, "Vision 2030,".
3. Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach*, 3rd ed., Upper Saddle River, NJ: Pearson Education, 2010.
4. Ethem Alpaydin, *Introduction to Machine Learning*, 4th ed., Cambridge, MA: MIT Press, 2020.
5. Moazam, M. et al., "A Comparative Study of Machine Learning Techniques for Predictive Maintenance in Manufacturing," *International Journal of Advanced Manufacturing Technology*, vol. 105, no. 1-4, pp. 69-81, 2019.
6. Dantzig, G. B. and Ramser, J. H., "The Truck Dispatching Problem," *Management Science*, vol. 6, no. 1, pp. 80-91, 1959.
7. Rajamani, R. et al., "Development and Experimental Validation of an Intelligent Cruise Control System," *IEEE Transactions on Control Systems Technology*, vol. 13, no. 6, pp. 959-969, 2005.
8. Lee, D. H. et al., "Development of a Driver Behavior Recognition System for Fuel-Efficient Driving," *International Journal of Automotive Technology*, vol. 17, no. 6, pp. 1023-1032, 2016.
9. OECD, *Artificial Intelligence in Society*, Paris, OECD Publishing, 2019.
10. European Union, *General Data Protection Regulation (GDPR)*, 2016.

Copyright © 2024 The Author(s): This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY-NC 4.0).