PROJECT SYNOPSIS

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<tr><td>DEPARTMENT</td><td colspan="4">Computer Science and Engineering.</td></tr>
<tr><td>TITLE OF THE PROJECT</td><td colspan="4">Breaking the Carbon Curve: Advanced Forecasting of Global CO2 Emissions Using CNN-GRU.</td></tr>
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<tr><td rowspan="4">STUDENT NAMES/ USN/ PHONE/ MAIL ID</td><td>Lohish Vinayak Yadav K</td><td>Pranav Arya S</td><td>Pranav J S</td><td>Prudhvi Raj R</td></tr>
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<tr><td>PROJECT TIMELINE (Tentative Start date-End Date)</td><td colspan="4">August 2024 to December 2024.</td></tr>
<tr><td>PROJECT GUIDE</td><td colspan="4">Prof. Annapoorna B.R , Assistant Professor.</td></tr>
<tr><td></td><td colspan="4"></td></tr>
<tr><td>PROJECT - DOMAIN</td><td colspan="4">Data Science .</td></tr>
<tr><td>INTRODUCTION</td><td colspan="4">The rise in carbon dioxide (CO2) emissions is a pressing global issue, driving climate change and affecting everything from weather patterns to the health of our planet's ecosystems. Accurately predicting these emissions is critical for shaping the policies that can help us mitigate the impacts of climate change. However, traditional forecasting methods often struggle to keep up with the complex and ever-changing nature of emission patterns, which are influenced by factors like economic growth, energy usage, and government policies. To tackle this challenge, we need to turn to more advanced tools that can offer better accuracy and deeper insights.

In this project, we're exploring a new approach to forecasting CO2 emissions by using a hybrid model that combines Convolutional Neural Networks (CNNs) with Gated Recurrent Units (GRUs). CNNs are great at picking out important features from large sets of data, while GRUs excel at making sense of time-based sequences, like the trends in emissions over the years. Together, they form a powerful duo that we believe can provide more accurate predictions than traditional models like ARIMA or even some of the more commonly used deep learning models like LSTMs.

Our goal is to not only predict future CO2 emissions with greater accuracy but also to provide valuable insights that can inform global climate policies. By understanding where emissions are headed, policymakers can make smarter decisions that help steer us toward a more sustainable future. This project is our contribution to the fight against climate change, using cutting-edge technology to make a real difference.</td></tr>
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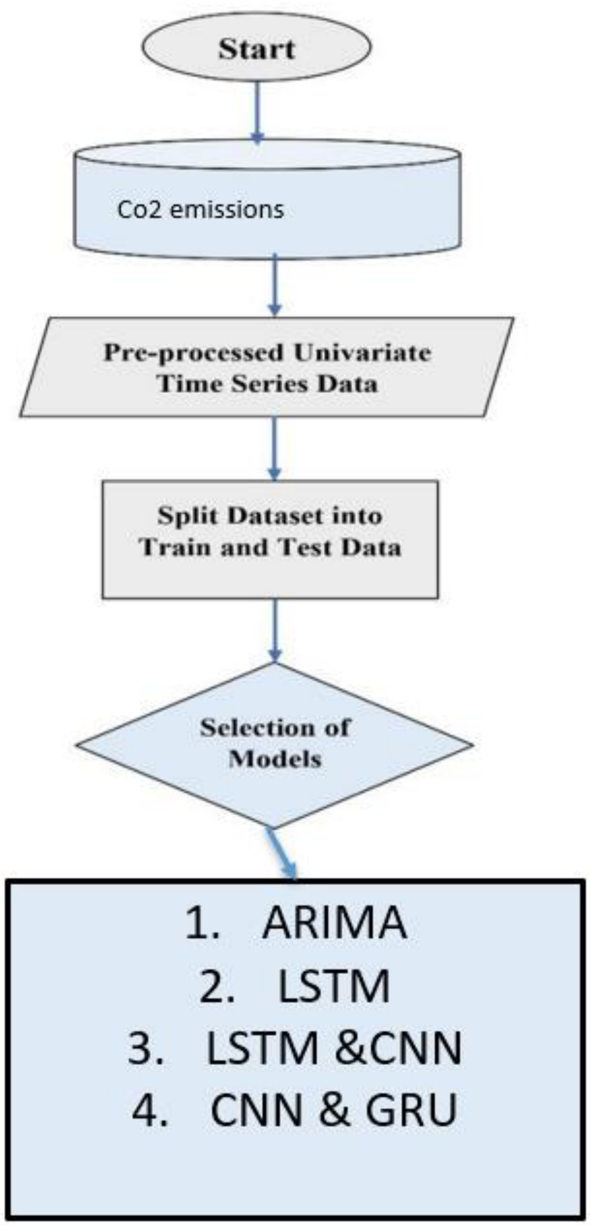
APPLICATION/S	1. Shaping Climate Policies: Our model can help governments craft smarter climate policies by predicting future CO2 emissions and helping them set achievable goals for reducing those emissions. 2. Guiding Urban Development: City planners can use our forecasts to make better decisions about where to build, how to manage traffic, and where to create green spaces, all aimed at reducing the city's carbon footprint. 3. Supporting Corporate Sustainability: Companies looking to cut their carbon emissions can rely on our model to predict how different strategies might impact their CO2 output, helping them stay on track with their sustainability goals. 4. Informing Energy Choices: Energy providers can use our forecasts to see how various energy sources—like coal, natural gas, or renewables—will affect future emissions, guiding them toward cleaner energy investments. 5. Raising Public Awareness: Environmental organizations can leverage our data to create compelling stories and visuals that make the case for urgent action on climate change, helping to engage and inform the public.
SHORT LITERATURE SURVEY	**<u>"A comparative analysis to forecast carbon dioxide emissions"</u>** **Literature Survey:** The paper provides a comprehensive overview of existing methodologies and models used in time-series forecasting, especially in the context of CO2 emissions. It discusses traditional models such as ARIMA and compares them with more advanced neural network-based approaches like LSTMs, GRUs, and CNNs. The survey highlights the strengths of each method, such as the interpretability of ARIMA and the capability of LSTMs to capture long-term dependencies. **Lacuna:** Despite the advancements in time-series forecasting models, the paper identifies a gap in the integration of explainability within hybrid models. While many models achieve high accuracy but it cannot be used in real world. The research gap lies in developing a novel hybrid model that not only combines the strengths of existing models but also incorporates explainability features to make the predictions more transparent and actionable for stakeholders. This lacuna forms the basis for proposing a new model in the research. **<u>"Machine learning-based Time Series Models for Effective CO2 Emission prediction in India"</u>** **Literature Survey:** The paper reviews a range of models used for CO2 emission forecasting, including traditional statistical models like ARIMA, SARIMAX, and Holt-Winter, as well as machine learning models such as

	Linear Regression and Random Forest, and deep learning models like LSTM. It highlights the strengths and weaknesses of these models, particularly in the context of their application to time-series data in India. The paper notes that while statistical models are effective for certain types of data patterns, machine learning and deep learning models can better handle complex non-linear relationships, leading to more accurate predictions. **Lacuna:** Despite the comprehensive comparison and application of various models, the paper identifies a key gap in not incorporating external factors such as population growth, technological advancements, and shifts to renewable energy sources into the forecasting models. These factors can significantly influence CO_2 emissions, and their absence could limit the accuracy of long-term predictions. The paper suggests that future research should explore the integration of these external variables to develop more robust and realistic forecasting models that can better inform policy decisions and environmental strategies.
CHALLENGES IN THE CURRENT WORK	One of the primary challenges in our current work lies in the inherent complexity of accurately modeling CO_2 emissions across different countries. Emissions are influenced by a wide range of factors, including economic activities, energy consumption patterns, policy changes, and even unexpected events like natural disasters or pandemics. Capturing these diverse influences in a predictive model is difficult, particularly when working with time-series data that may have gaps, inconsistencies, or noise. Additionally, while the CNN-GRU hybrid model offers promising capabilities, fine-tuning the model to balance accuracy and computational efficiency presents another layer of complexity. Ensuring that the model generalizes well across different regions and timeframes without overfitting to specific patterns is a critical hurdle that must be carefully managed.
PROJECT PROBLEM STATEMENT	Predicting CO_2 emissions is tough because so many factors—like economic changes, energy use, and new policies—are constantly shifting. Current models often struggle to keep up, leading to forecasts that aren't always accurate. This makes it harder to take meaningful climate action. What we need are smarter forecasting methods that can cut through the complexity and give us reliable insights to better tackle climate change.
OBJECTIVES OF THE PROJECT	• Develop a Hybrid Model: Create and refine a hybrid CNN-GRU model to enhance the accuracy of CO_2 emissions forecasting. • Improve Forecasting Precision: Achieve more reliable predictions of future CO_2 emissions compared to existing models. • Analyze Emission Trends: Utilize time-series data to identify and understand trends and patterns in CO_2 emissions across different countries.

	• Support Climate Policy: Provide actionable insights to help inform and guide effective climate policies and strategies. • Benchmark Performance: Compare the performance of the CNN-GRU model with traditional forecasting methods like ARIMA and LSTM.
PROPOSED SOLUTION	The project aims to develop a novel model for forecasting CO2 emissions using a time-series dataset from 01-01-2019 to 31-05-2023. After preprocessing and exploratory data analysis, the project will compare traditional models like ARIMA and LSTM with hybrid architectures like LSTM-CNN and CNN-GRU. The goal is to create a more accurate forecasting model while integrating explainability techniques to provide insights into emissions trends. 

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<tr><td rowspan="4">PLATFORM THAT WILL BE USED FOR IMPLEMENTATION</td><td>HW:
1.Computing Resources: High-performance computer or server with sufficient RAM and GPU capabilities for training deep learning models.
Storage: Adequate storage for handling large datasets and model files.

2.Programming Language:
Python: For implementing the machine learning models, data processing, and analysis.</td></tr>
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<tr><td>Front End/Back End Tools:

1.Front End:
• Visualization Libraries: Matplotlib, Seaborn, Plotly for creating charts and visualizations of the results.

2.Back End:
• Data Processing Libraries: Pandas, NumPy for data manipulation.
• Machine Learning Frameworks: TensorFlow, Keras, or PyTorch for building and training the CNN-GRU model.</td></tr>
<tr><td>Other Details :

1.Version Control: Git for managing code versions and collaboration.

2.Documentation: Tools like Jupyter Notebooks or Markdown for documenting the process and findings.</td></tr>
<tr><td>Demonstration Details</td><td>To demonstrate the project, we will create an interactive web application featuring:

• Dashboard: Displays CO2 emissions forecasts and trends with dynamic charts and graphs.
• Data Visualization: Interactive graphs showing historical data and future predictions.
• Policy Insights: Provides recommendations based on forecast results.

UI Details:
• Homepage: Overview and navigation.
• Forecasting Page: Input parameters and forecast results.
• Trend Analysis Page: Historical data visualization.</td></tr>
<tr><td>ARE THERE ANY STANDARD DATASETS AVAILABLE</td><td>Yes

https://www.kaggle.com/datasets/saloni1712/co2-emissions</td></tr>
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PROJECT RISKS (IF ANY)	• Data Quality Issues: Incomplete or inconsistent data could affect model accuracy. • Model Performance: The CNN-GRU model might not outperform traditional models as expected. • Computational Limitations: High resource demands for training and running models. • Scalability Challenges: Difficulty in adapting the model to different regions or larger datasets. • Implementation Delays: Possible delays in developing or integrating the application due to unforeseen technical challenges.
REFERENCES	[1] M. O. Faruque, M. A. J. Rabby, M. A. Hossain, M. R. Islam, M. M. U. Rashid, and S. M. Muyeen, "A comparative analysis to forecast carbon dioxide emissions," Energy Reports, vol. 8, pp. 1430-1443, June 2022. [2] S. K. Singh and S. Kumari, "Machine learning-based time series models for effective CO2 emission prediction in India," Research Square, Feb. 2022. [3] H. Bhatt, M. Davawala, T. Joshi, M. Shah, and A. Unnarkat, "Forecasting and mitigation of global environmental carbon dioxide emission using machine learning techniques," Cleaner Engineering and Technology, vol. 10, Jan. 2023, Art. no. 100454. [4] S. Sah, B. Surendiran, R. Dhanalakshmi, S. N. Mohanty, F. Alenezi, and K. Polat, "Forecasting COVID-19 pandemic using Prophet, ARIMA, and hybrid stacked LSTM-GRU models in India," *Computational Intelligence and Neuroscience*, vol. 2022, May 2022, Art. no. 1234567. [5] A. P. Wibawa, A. B. P. Utama, H. Elmunsyah, U. Pujianto, F. A. Dwiyanto, and L. Hernandez, "Time-series analysis with smoothed convolutional neural network," *Journal of Big Data*, vol. 9, no. 44, Apr. 2022. [6] X. Wei and Y. Xu, "Research on carbon emission prediction and economic policy based on TCN-LSTM combined with attention mechanism," Frontiers in Environmental Science, vol. 11, Oct. 2023, Art. no. 1098671 [7] A. Hamdan, A. Al-Salaymeh, I. M. AlHamad, S. Ikemba, and D. R. E. Ewim, "Predicting future global temperature and greenhouse gas emissions via LSTM model," *Sustainable Energy Research*, vol. 10, no. 21, Mar. 2023. [8] S. M. Malakouti, "Utilizing time series data from 1961 to 2019 recorded around the world and machine learning to create a global temperature change prediction model," *Journal of Environmental Management*, vol. 325, Feb. 2023, Art. no. 116719.