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DEEP REINFORCEMENT LEARNING BASED MULTIPREDICTOR ENSEMBLE DECISION FRAMEWORK FOR REGIONAL GDP PREDICTION

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ABSTRACT - Gross Domestic Product (GDP) is a good way to show how the economy is growing and how resources are being used in different areas. It's not enough to just look at a single factor when trying to figure out a region's GDP; you also need to look at factors like schooling, business, jobs, population, and more. It is important for both economics and government to be able to predict regional GDP because it tells us a lot about the economic health and growth of areas. We suggest using a Deep Reinforcement Learning-based multi-predictor ensemble decision system in this project to make area GDP forecasts more accurate and reliable. To train the GDP Prediction, we can use the Gated Recurrent Unit (GRU), the Temporal Convolutional Network (TCN), the Voting Classifier, the XGBooster, and the Deep Belief Network (DBN). These models can predict the data. In a multipredictior ensemble decision structure, a vote algorithm comes to a decision by putting together results from different predictors. The Deep Q-Network (DQN) method quickly checks how well these neural networks change to different GDP datasets so that an ensemble model can be made that gives correct results.

Keywords:-*Deep Reinforcement Learning, GRU, TCN, Voting Classifier, GDP Prediction.*

1. INTRODUCTION

Gross Domestic Product (GDP), which is usually calculated every three months or once a year, is an important economic number that shows how much all the goods and services made in a country were worth in money during a certain time frame. The GDP is a very important measure of a country's economic health and success. GDP is an important tool for economists, investors, decision-makers, and researchers because it helps them make smart choices about economic policies, investments, and business strategies. It also makes it easier to compare how economies are doing in different countries and gives researchers a way to study and predict the economy. It is important to remember that the GDP is not perfect and is not fully responsible for things like equal income, protecting the environment, and maintaining a high standard of living. Because of this, other measures are often added to it to get a better picture of the economic and social health of a country as a whole.

You can figure out the size and growth rate of an economy by getting an idea of its GDP. GDP can be found by adding up investment, production, and income. The GDP can then be changed to account for population and costs to get more accurate results. The foreign balance of trade, investments, growth in private stocks, paid-in building costs, and the total amount spent by both individuals and the government all count toward a country's GDP. Exports increase value whereas imports decrease it. The trade balance between nations is crucial. The GDP of a country

tends to rise when its people sell more goods and services to other countries than its own people buy from other countries. GDP, which is found by dividing GDP by a country's population, is often used to measure how well off and how well off the people who live there are.

The main goal of the study is to predict the GDP of different areas. Regional GDP projections can help with many things, such as economic planning, allocating resources, and making policy. Predictions of the regional GDP that are right can help people make decisions at both the regional and national levels.The project's goal is to create a system with a lot of predictions. It tries to combine the prediction power of several data sources or models instead of relying on a single model or forecast to figure out regional GDP.By mixing the strengths of different models, this ensemble method is often used to make predictions more accurate.

Effective regional GDP forecasting in economic operation and development may anticipate macroeconomic trends and contribute to healthy macroeconomic growth, as well as ecologically sustainable urban development. The government may forecast and anticipate market economy development to make growth plans and local economy-friendly actions [1]. Technology that can predict GDP can help change the future of sustainable growth in an area.It is the main sign of national economic accounts and a key way to measure the state and amount of growth of an economy.

It will be the key to the next level of social progress if it is used to change the way social resources are planned and distributed while keeping the economy's growth safe and sustainable. Estimating the area GDP can help local governments make better economic and science choices. A lot of experts agree that the standard GDP only looks at the growth of the economy's overall amount and doesn't take into account how natural resources and society affect the economy [2].By mixing the strengths of different models, this ensemble method is often used to make predictions more accurate. The ensemble decision framework may greatly enhance the model's ability to make predictions by mixing different parts in a smart way. Nonlinear modeling, data analysis, and feature extraction may produce this.

2. LITERATURE SURVEY

The literature looked at includes a range of different ways to model and predict the economy, with a focus on China's regional GDP and the bigger picture of economic and environmental change. Li et al. (2022) suggest a three-step feature selection and deep learning method for predicting regional GDP. They show that it works well at catching complex trends in China's economic setting [1]. Li et al. (2022) published another paper that uses deep reinforcement learning to create a multipredictor ensemble decision framework. This makes it even better at predicting regional GDP [2].

Ming et al. (2019) [3] show that fractional calculus can be used in models of Chinese economic growth. Zhou et al. (2021) look into the threshold effect of economic growth on energy usage in wealthy countries. This shows how complexly economic and energy factors interact [4]. In his 2021 paper, Pirgmaier looks at the importance of value theory for ecological economics, focusing on how important it is for understanding how economic actions affect the

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environment [5]. D'amato and Korhonen (2021) suggest a long-term plan for sustainability that includes the bioeconomy, the cycle economy, and the green economy [6].

The research by Wu et al. (2019) looks at how economic downturns affect the use of materials in 157 different countries. Their findings show how economic downturns affect the use of resources [7]. Borio et al. (2020) say that the financial cycle is a key tool for predicting recessions [8]. Cohen et al. (2019) and Myszczyszyn et al. (2021) look into how emissions are no longer linked to GDP in China and how economic growth, energy use, and carbon dioxide emissions are connected in V4 countries [9, 10]. As a whole, this literature gives us a full picture of the different approaches and points of view that help us understand how economies work, how they can last, and how they affect the environment.

3. ALGORITHMS

In this project we can used algorithms like Xgboost - Voting Classifier (SVC + RF + DT) - MLP - Based on Elastic Net (ELM) - SVM - TCN - GRU - LSTM - CNN + LSTM - (DQN-TCN-GRU)

XGBoost – Extreme Gradient Boosting:

XGBoost is a well-known and useful open-source version of the gradient boosted trees method. An open source machine learning tool called XGBoost is famous for being able to solve supervised learning problems like classification and regression issues. Using gradient boosting methods, it builds a group of decision trees. Then, it puts these decision trees together to make a good prediction model. Combining the predictions of a group of simpler, weaker models is what gradient boosting does to get a good guess at a goal variable.

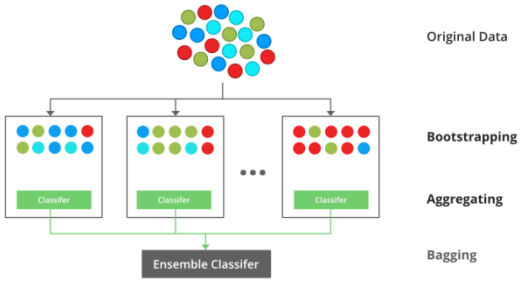

Fig 1 :Xgboost

Voting Classifier (SVC + RF + DT)

A Voting Classifier is a type of machine learning ensemble model that takes the results from several base classifiers and puts them all together to make a single estimate. Classification and regression are both things that it can be used for. We want to make a Voting Classifier that takes the results from three different classifiers and puts them all

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together. These are the Support Vector Classifier (SVC), the Random Forest (RF), and the Decision Tree (DT). This group method usually leads to more accurate predictions than putting each algorithm to work on its own. The Voting Classifier can often lower the risk of overfitting and boost generalization, which leads to better results all around. Voting classifiers are machine learning predictors that train several base models or estimators and generate predictions depending on their results. The factors for aggregation can be used to make a decision about each estimate result.

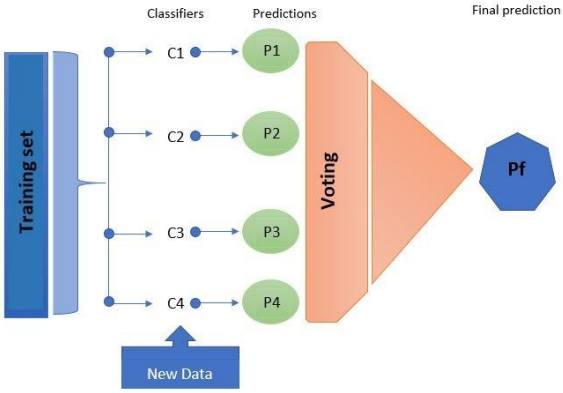

Fig 2 : Voting Classifier

MLP:

MLPs, like ABNs, are Artificial Neural Networks used for regression and classification. This neural network is termed a feedforward neural network because data only travels from input to output. There are no loops or return links.MLPs can be used for many things, like figuring out what a picture is, understanding natural language, predicting time series, and more.

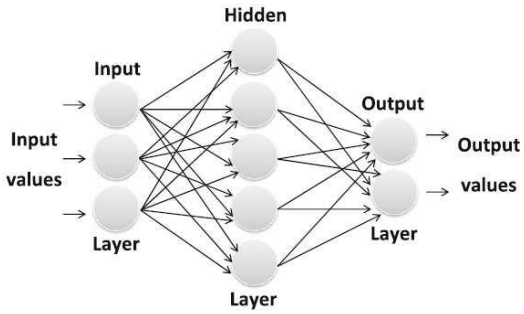

Fig 3: MLP

Based on Elastic Net (ELM) :

Based on Elastic Net—The elastic net method selects variables and makes them more regular at the same time. It is used for regression tasks, especially when working with big datasets that have traits that might be linked. By allowing limiting data in the model's coefficients, Elastic Net can do feature selection and stop overfitting. When the

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dimensional data is bigger than the number of samples used, the elastic net method works best. The elastic net technique's main jobs are to group factors and choose which ones to use.

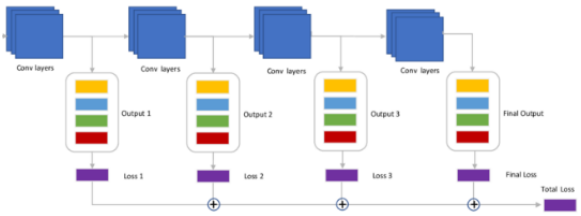

Fig 4: ELM

SVM:

Support Vector Machine (SVM) is a type of guided machine learning that can do both regression and classification. Even though we talk about regression problems, they work best for sorting. Most of the time, it works best for binary classification tasks, but it can also be used for regression and multi-class classification. SVMs are famous for being able to find the best hyperplane in a high-dimensional feature space to separate data points into different groups.

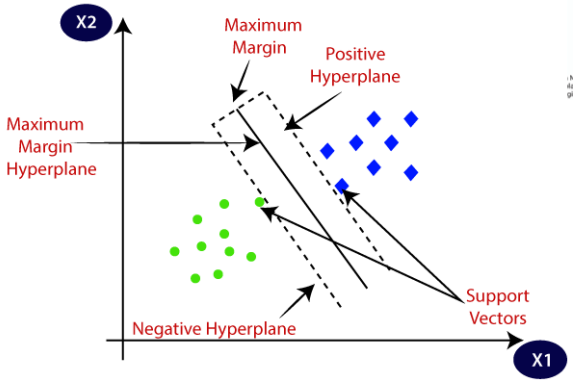

Fig 5: SVM

GRU:

The Gated Recurrent Unit (GRU) is a type of Recurrent Neural Network (RNN) design that was created to fix some problems with traditional RNNs, such as the loss of gradients and long-term dependence. People often use GRUs, which are a type of Long Short-Term Memory (LSTM) network, for sequential data tasks like natural language processing, speech recognition, and time series forecasts. GRUs use less computing power than LSTM networks and can find long-range relationships in linear data.

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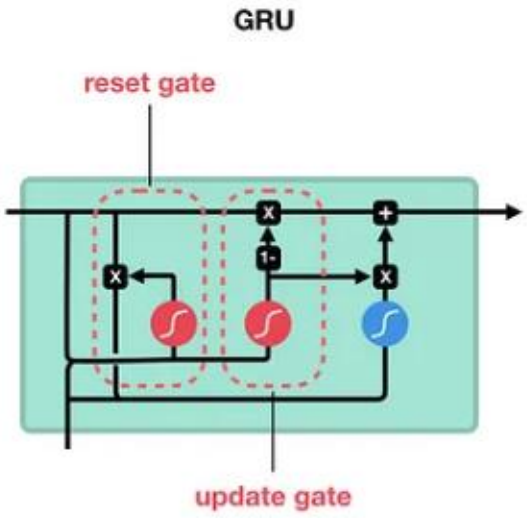

Fig 6: GRU

LSTM:

In the area of deep learning, Long Short-Term Memory networks, or LSTMs, are used. This is a type of Recurrent Neural Networks (RNNs) that might be able to learn long-term connections, especially when predicting sequences.

CNN + LSTM:

Long Short-Term Memory (LSTM) and Convolution Neural Network (CNN) layers work together in a model to guess sequences and pull out traits from incoming data.

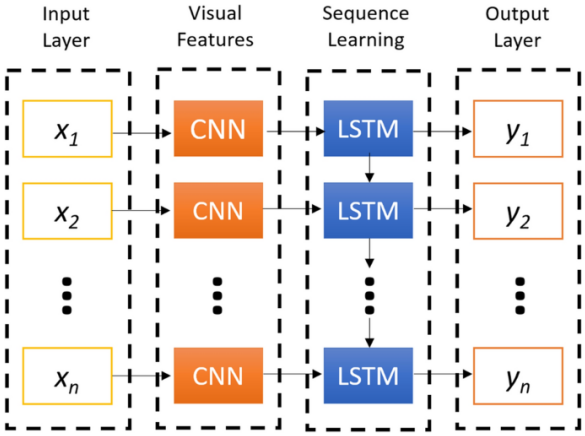

Fig 7: CNN + LSTM

4. SYSTEM ARCHITECTURE

System Architecture summarizes the project. Database, features, fundamental models, Q-Learning ensemble technique, and assessment modules comprise the system architecture. These modules forecast GDP.

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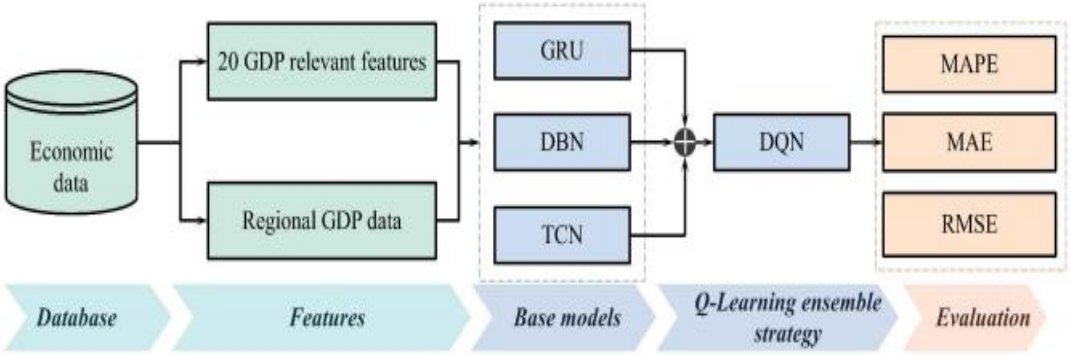

Fig 8: System Architecture

5. COMPARISON TABLE

Table.1: A summary of Image Deblurring Aided by Low-Resolution Events

S. No	Title	Author/Reference	Method/Algorithm implemented	Advantage	Disadvantage
1	A Novel Multi-Factor Three-Step Feature Selection andDeep Learning Framework for Regional GDP Prediction:Evidence from China	LiQingwen, YanGuangxi, and YuChengming [1]	The proposed framework involves three steps: (1) Feature Crossing uses an algorithm to extract key information from original datasets. (2) BorutaRF and Q-learning analyze deep correlations to select high-quality features. (3) TCN utilizes selected features to build a robust GDP prediction model, achieving over	1. The three-step framework significantly improves TCN's prediction accuracy by over 10%, providing more reliable forecasts for regional GDP in developing areas. 2. Compared to 14 benchmark models, the proposed	1. The feature-crossing algorithm and deep learning model may introduce computational complexity, potentially requiring substantial resources for implementation and training on large datasets. 2. The effectiveness of BorutaRF and Q-learning algorithms may vary across

			10% accuracy improvement and outperforming 14 benchmarks with MAPE values consistently below 5%.	system demonstrates superior forecasting capabilities, outperforming competitors and achieving lower MAPE values consistently below 5%.	datasets, making the system sensitive to data characteristics and potentially impacting generalizability.
2	A New Multipredictor Ensemble Decision Framework Based on Deep Reinforcement Learning for Regional GDP Prediction	Li Qingwen, Yu Chengming, and Yan Guangxi [2]	The proposed method employs GRU, TCN, and DBN as predictors for regional GDP forecasting. Deep reinforcement learning, specifically the DQN algorithm, analyzes the adaptability of these predictors to diverse GDP datasets, optimizing ensemble weight coefficients for improved prediction performance exceeding 10% over individual	1. The ensemble framework leverages diverse predictors and deep reinforcement learning, achieving superior GDP prediction accuracy surpassing benchmark models. 2. DQN algorithm dynamically adjusts ensemble weights, optimizing	1. The integration of multiple predictors and the DQN algorithm may introduce complexity in implementation and model interpretation. 2. Deep reinforcement learning training may require significant computational resources and time, potentially limiting real-time applicability.

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			predictors.	model performance and consistently outperforming benchmark models with lower MAPE values.	
3	The Application of Fractional Calculus in Chinese Economic Growth Models	H. Ming, J. Wang, and M. Fečkan [3]	We utilized Caputo-type fractional order calculus to model Chinese GDP growth in R software. Comparative analysis with integer order models was conducted, prioritizing variables through the BIC criterion. Results indicate that the Caputo fractional approach provides enhanced accuracy in predicting GDP values (2012–2016).	1. Caputo fractional calculus improves GDP modeling accuracy, offering more reliable predictions compared to traditional integer order models. 2. The BIC criterion assists in identifying crucial variables, refining the model's explanatory power and interpretability.	1. Implementing Caputo fractional calculus may require a steep learning curve, hindering widespread adoption and understanding. 2. The fractional calculus approach may demand more computational resources, potentially posing challenges in resource-constrained environments.
4	Threshold Effect of Economic Growth on Energy Intensity—	J. Zhou, Z. Ma, T. Wei, and C. Li [4]	The study employed a threshold regression model	1. The threshold regression model	1. Oversimplification may not capture the complexity of

	Evidence from 21 Developed Countries		on panel data from 21 developed countries (1996–2015) to analyze the impact of economic growth on energy intensity. Key factors were considered, such as energy mix, urbanization, industrial structure, and technological progress, revealing varying effects based on development stages and thresholds.	optimizes energy intensity reduction by considering key factors and development stages. 2. The system provides tailored advice for well-developed economies, emphasizing cleaner energy, urbanization, tertiary industries, and advanced technologies.	economic and energy dynamics, leading to potential inaccuracies. 2. Limited to 1996–2015, the system may not account for evolving trends and unforeseen changes in energy dynamics.

6. SUMMARY

This project creates a multi-predictor ensemble decision system based on Deep Reinforcement Learning so that accurate and reliable regional GDP predictions can be made. The system uses models like GRU, TCN, Voting Classifier, and XGBooster, and a Deep Q-Network method to make it better at adapting to different GDP datasets. The ensemble method, which uses a vote algorithm to combine the strengths of each indicator, makes accurate predictions about area GDP. This new way of using deep reinforcement learning shows that predictions are more accurate, which is useful for economic planning and government.

7. CONCLUSION

Gross Domestic Product (GDP) is a key measure of the health of a country's or region's economy and the long-term growth of society. Technology that predicts GDP helps the regional government study and make decisions about economic policy. Deep reinforcement learning is used in this project to come up with a Multi predictor Ensemble Decision Framework for predicting GDP. To train the GDP forecast, there are three models: GRU (Gated Recurrent Units), TCN (Temporal Convolutional Network), Voting Classifier, XG Booster, and DBN (Deep Belief Networks).

These models can predict the data. In a multipredictor ensemble decision system, a voting algorithm makes a choice by putting together results from a number of different predictors. Unlike regular RNN and shallow neural network frameworks, these three neural networks are better at analyzing the original features of GDP and making accurate predictions thanks to the way they are built. The DQN (Deep Q-Network) method quickly checks how well these three neural networks change to different GDP datasets so that an ensemble model can be made that gives correct results. The DQN algorithm gave us the final data for predicting GDP. There are several GDP datasets that can be used by the DBN, TCN, Voting Classifier, XG Booster, and GRU to make accurate predictions. Features of the industrial organization, past GDP data, and schooling all have a big effect on how well GDP predictions work. In the end, the project does better when the ensemble multi-predictor regional GDP forecast system based on deep reinforcement learning is used.

8. FUTURE SCOPE

In the coming years, it will be very important to make regional economic growth plans that use GDP predictions and policies that are specific to each area. These tactics will be very important for good governance because they will help governments control the economy on a large scale based on correct GDP predictions. This method that looks to the future makes it easier to make strategic decisions, which gives officials the power to make the best use of resources, promote long-term growth, and deal with new problems that come up in regional economies. By making sure that policies are in line with what they think will happen in the future, governments can make the economy more stable and help areas grow. This keeps growth goals in line with how the economy is changing.

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