

Using Machine Learning for Industry 5.0 Efficiency Prediction Based on Security and Proposing Models to Enhance Efficiency

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Abstract—Machine learning, with its huge untapped potential, is being researched all over the world to develop truly intelligent systems. Its applications are not enclosed in just one domain but in almost everything, from prediction models, recommender systems, and anomaly detection to automation and teaching a computer how to fly a helicopter. In this research, Multivariate Linear regression of supervised machine learning is studied to predict the efficiency of Industry 5.0, however, the efficiency of the model would be dependent on many factors and components such as security protocols and models, Industrial IoT - performance, connectivity, reachability, availability and many more. These factors and components would be categorized as the features of the algorithm which would be assigned weight 'w' and bias 'b'. To improve the efficiency of the model, these components could be changed and updated in order to enhance the overall model. Previous research papers discussed the integration of "hot" technologies like 5G, Blockchain, AI, and IIoT in the industry 5.0 model, but this research is presented as their future work as it proposes to determine the efficiency of the model based on the features provided so that ultimate and optimal model could be determined. Later it proposes security and IIoT models that could improve the overall Industry 5.0. Quorum blockchain is proposed by the research in order to implement the ultimate security in the Industry 5.0.

Keywords— Artificial Intelligence, Machine Learning, Supervised Machine learning, Multivariate Linear Regression, IIoT, Blockchain, 5G, Quorum

I. INTRODUCTION

Artificial Intelligence is considered the future of humankind and truly it is. Artificial Intelligence is not

just about making intelligent models but is also used for data science, to learn from the data and provide valuable insights which are eventually beneficial for the human race. Artificial Intelligence is a broad term for amateurs to understand the meaning it has. In theory, it is categorized into 3 parts – Artificial Intelligence, Machine learning, and Deep learning. Machine learning and Deep learning are also referred to as the subsets of Artificial Intelligence. The research dives into machine learning to implement its algorithms that are based on regression problems [4].

Machine learning can be further categorized into 'n' subsets due to its wide application and implementation, however, for general understanding, it could be categorized into 2 parts - Supervised machine learning and Unsupervised Machine learning. This research is focused on Supervised Machine learning and so it will be the covered topic of the research. The data is labelled in the supervised machine learning which is used to train the model along with some features, then the model is used to predict the output for new data. Supervised learning is also a huge domain itself and so is further categorized into 2 parts – Regression and Classification. The research could use both but it is focused on finding the efficiency, which is not a category so classification is ruled out. Regression plays a very important role in day to day life from house price prediction to temperature prediction. This study proposes to use the regression algorithm of supervised learning to predict the efficiency of the industry 5.0 model which would be a real number ranging either in percentage

or general. Figure 1 describes the category distribution of the Artificial Intelligence and its subparts until regression and classification. It was necessary in order to make the audience understand the vastness of machine learning and on which subset this research is focused [9].

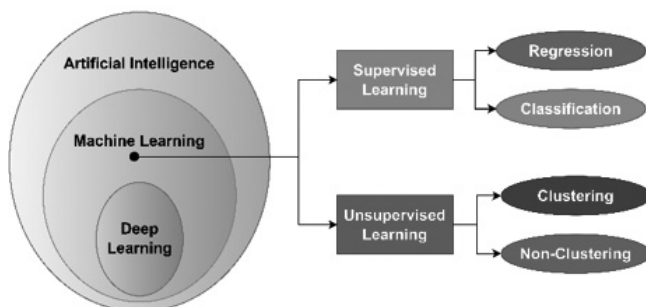


Fig. 1: The Subsets of Artificial Intelligence

Security is one of the major aspects of any model, let it be a basic computer device, website, or Industrial IoT model. No model is complete if security is not implemented. In this digital age where networking devices are more prone to get hacked, it is mandatory to implement security protocols to ensure the safety of the data and privacy of the users. Sometimes not only hacking is the only case to worry about, but we must also ensure that the model is not prone to domestic corruption. Blockchain technology is one of the most popular to implement strong, chained, and encrypted data which ensures the ultimate security of the model [1].

IIoT, also called as Industrial Internet of things, is a subset of IoT which primarily focuses on Industrial applications and is hence perfect to be implemented in industry 5.0. Industrial IoT ensures faster, reachable, better, and stronger connections between machines and takes machine-to-machine communication to a different futuristic level. Advanced IIoT is one of the most important components to move from industry 4.0 to industry 5.0. In Industry 5.0 [8], the working process is automated and it is basically a perfect environment for machine and human interaction with both of them working together [7]. Therefore, implementation of the IIoT in Industry 5.0 is supported by the research along with the introduction of the 5G network. It is crucial to understand that IIoT requires a strong network in order to work optimally [11]. It will not be able to perform well if the network lacks strength, availability, and speed, so in order to ensure the optimal working of the IIoT, the research proposes the implementation of a 5G network to ensure and provide strength, availability, and speed [5].

The Model may have various components for security, working, and other processes but improper arrangement or proportion of these components may not produce good enough efficiency for the Industry 5.0 model and so we will implement multivariate linear regression to predict the efficiency of the model and try various arrangements of components to understand which would be best for our

model. In further sections, we will implement multivariate linear regression theoretically and understand how it would predict the efficiency of the model.

II RELATED WORK

Most of the research work are based on Integration of various technologies in the Industry to move from industry 4.0 to industry 5.0. So this study is somewhat unique and is future work of its previous papers.

S. K. Jagatheesaperumal, et al, research discussed efficiency, techniques and application of industry 4.0 when the big data and AI are implemented together. The research did not focus on other important factors like security, network, etc. Our study implements Artificial Intelligence along with other important components like blockchain for security, 5G, and IIoT.

Z. Rahman, et al, Study proposes the AI-enabled industry 4.0 model and the security threats it would face. The research was focused on AI and industry 4.0. Our research presents the subset of AI, which is more efficient and focuses on the future industry 5.0. Both the studies aimed at dealing with the security threats however the approaches were different as our study proposes the blockchain model.

H. Yamaguchi, et al, study proposes the machine learning integration with wireless sensor network to improve their efficiency. This study proposes various algorithms in order to achieve distributed machine learning. Our study implemented the linear regression to predict the efficiency of the overall model whereas author's study covered the Machine learning implementation on the Wireless sensor network.

The author of the research is inspired by Andrew NG, one of the biggest researcher in the field of Artificial intelligence and so his concepts of linear regression is studied by the author and implemented as a research to improve the industry 5.0 and show case the power of AI.

III. PROPOSED METHODOLOGY

Multivariate Linear regression is one of the most powerful regression algorithm. The name 'Multivariate' means dealing with multiple variables or features. Since it has multiple feature, we need to understand that the learning function 'f' would become complex than the univariate linear regression, thus resulting in higher time complexity. Let us theoretically perform the multivariate linear regression to predict the efficiency of industry 5.0 [10].

A. Understanding Problem Statement

It is crucial to understand the problem statement well in order to make our algorithm work well. If we do not understand what we want the algorithm to predict than we will not be able to pick important features or discard unimportant features. Overall, the problems needs to be understood clearly in order to perform correct prediction using correct set of features. Many of the times amateur data scientist makes these mistakes where they underestimate

the importance to spend some time to understand what the problem actually is! The research understand the research problem well, the problem statement is that - Previous research papers discussed about the integration of technologies like Blockchain, AI, 5G, IIoT in the Industry 5.0 but they do not discuss which arrangement or components actually yields greater efficiency. So Multivariate linear regression is proposed to predict the model efficiency for different components.

B. Gathering Data and its Pre-processing

One of the most important and crucial task for this research is to gather data for learning. Gathering data and labelling it is a time taking task which requires domain knowledge and resource mining techniques. After the data is collected, it needs to be cleaned. The empty field needs to be dealt with, formatting of the data and removing unnecessary redundancy. After this phase is done, only then we can move to the next step.

In the study, data would come from previous industries like 3, 4 with implementation of variety of components and then labelling of 'y' efficiency as output. Moreover, the research proposes that the majority of the data should be collected from dummy models of Industry 5.0 which would update the algorithm and ensure that predictions are more accurate. Let the number of training example be 'm'.

Implementation in Python and installing required packages

Python is favourite language of the data scientist and machine learning engineers because of its advanced features and huge developer community. R is one of the competent language for data science but this research proposes the Python language for the algorithm implementation because of its versatile nature, speed, strength, huge developer community, variety of packages, easy to use and many more features.

Even in the Python, there are various IDE (Integrated Development Environment) or platform for python code execution. The study proposes the 'Jupyter Notebook' because it provides line by line execution of the code, which somewhere helps to deal with errors better and the fact that it has huge developer community and popularity. The Notebook can be used through "Anaconda" IDE or through VS Code.

After choosing Programming language and IDE, it is time to list down the important packages that are must for the research. There are many packages offered by the Python language which are built just for data science. Some of them are - NumPy which is used for advanced computation, Matplotlib which helps to plot the graphs and many more like Pandas, openCV, Scikit learn. Etc.

D. Playing with Data

One of the most important and underrated concept to play with your data which encourages to understand the

data you will work with. It is very important to know the data we have and use the following techniques to get a better understanding of the data

- Load your data
- Dimension of your data and matrices
- View your data
- Data visualization

E. Understanding and Choosing Features

Feature selection is the deciding factor for the prediction of the algorithm and so it must be done carefully. Let us select and discuss some of the important feature. Let feature be represented by 'x_{ji}'. One feature could be the security itself, the protocol of security followed, rating of the security protocol, strength of the security protocol, etc. Another feature could be derived from the IIoT which would have sub components like different types of devices, their range of communication, communication speed and power. Same way we can derive and choose various features that might affect the model. Let feature be denoted by 'n'. It is to be noted that in order to ensure proper functioning of the algorithm the number of feature should not be more than the number of training examples i.e.

$$\text{Proper working of Algorithm} \leftrightarrow m > n \quad (1)$$

The figure 2 shows a matrix of number of training example m and features n given by output y.

No. of Training example	Features					Output
	x_1^1	x_2^1	x_3^1	x_n^1	y^1
	x_1^2	x_2^2	x_3^2	x_n^2	y^2

	x_1^m	x_2^m	x_3^m	x_n^m	y^m

Fig. 2: Matrix of m and n

E. Weight and Bias

Weights are associated with a feature and so they determine the influence of the feature on the final output. Bias is like harmless objects which are added to the equation to ensure smooth execution. Let the weight of a feature j be 'w_j' and bias be denoted by 'b' [13].

G. The Learning Function

The learning function, denoted as fw, b(x(i)), takes features, weights and bias and predicts output. Learning function are later used to determine the cost of error and the algorithm is corrected to give least possible error.

$$f_{w,b}(x^{(i)}) = w_j * x_j^i + b \quad (2)$$

H. Cost Function

The cost function returns the cost error which comes from subtracting the predicted value and the actual value. The squared error means is implemented to ensure the smooth prediction of the algorithm. The cost function is

later used to adjust the parameters w and b to get better results which is done using gradient descent.

The Cost function is denoted by $J(w,b)$ computed as-

$$J(w,b) = \frac{1}{2m} \sum_{i=0}^{m-1} (f_{(w,b)}(x^{(i)}) - y^{(i)})^2 \quad (3)$$

I. Gradient Descent

After computing the cost function, the gradient descent will be implemented which will try to remove the cost error with each of its iterations and ensure that the cost function reaches the global minima. The gradient descent function will take w , b , x , y , and α (α) as parameters. Alpha determines the step taken for the descent, the bigger the alpha, the bigger the step. It is recommended to have a smaller alpha so that it can reach global minima easily although it may be computationally expensive sometimes. There are many methods for the descents but gradient descent is one of the best so the study proposes the gradient descent to reach the global minima and decrease the cost error. At last, the testing of the model needs to be performed and in case there are some errors, following these steps again would solve it, or changing the values of the parameters would help as well.

J. Prediction

The final step is to use the model and predict the efficiency. In this phase, the actual prediction will take place, and based on the output we would do changes if necessary. Now in this phase, we will pass the features of the model to be predicted like security protocols, IIoT features, and Intelligence of the system as parameters, and then after successful execution of the algorithm, it will return us the overall efficiency of the model.

K. Feature Analysis and Models to Enhance Efficiency

As we have the algorithm ready, now we will pass various arrangements and features to find out which would give the best efficiency. We could change the security protocols and IIoT features which would affect the efficiency of the system [12]. We could try various Blockchain protocols like Quorum, Corda, Hyperledger, Ethereum, etc. Then we could change the network to see which network would give the best result like 2G, 3G, 4G or 5G. By doing this feature analysis, we can determine features that are actually useful for the industry and would give it the best efficiency.

I. Quorum Blockchain

The model could encounter a wide range of security issues in various types and domains. Blockchain technology can solve these problems. Blockchain technology is a distributed ledger that is hash-based, decentralised, and monitors the provenance of digital assets. Blockchain technology is extremely helpful in sectors dealing with large payments, cyber-security, and healthcare since the data on it cannot be altered either by design or by anyone once it has been created [2].

Because the system is decentralised and transparent, everyone with permission can access it and track changes to the data in real time, eliminating any risk of corruption. The idea behind blockchain is to store data in blocks that are linked together in a chain so that one node is connected to the others and cannot be changed. In figure 3, the basic structure of the Blockchain is shown to make the audience understand terms like chaining [3].

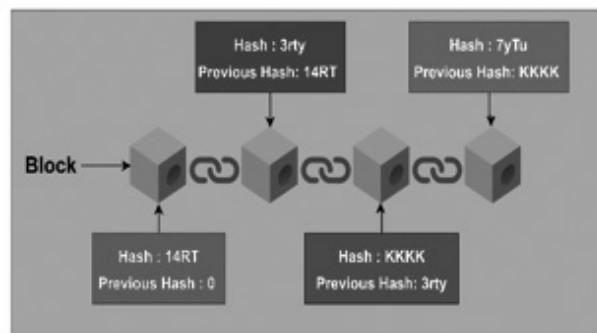


Fig. 3: Structure of Blockchain

The “Quorum” blockchain platform is proposed by the research because it is well renowned for its capacity to eradicate data manipulation in many types of transactions. Data that would continuously flow from linked devices in the sector is not secure and is therefore vulnerable to manipulation or theft. The research suggests using the Quorum platform for blockchain deployment to prevent these situations and secure the system’s ultimate security.

Quorum would be ideal for the model suggested by the research as it is an extension of the Ethereum blockchain that focuses on enhancing blockchain technology. Although the first generation of Blockchain provides scalability, peer-to-peer networks, interoperability, transparency, and other advantages, it is far from perfect, and we thus need a superior blockchain for future industries like Quorum. Quorum’s characteristics include performance that is faster than Bitcoin’s, administration of permissions, enhanced anonymity, management of assets, etc. Refer figure 4 to understand the architecture of the Quorum blockchain where the nodal structure is also shown with its sub-components.

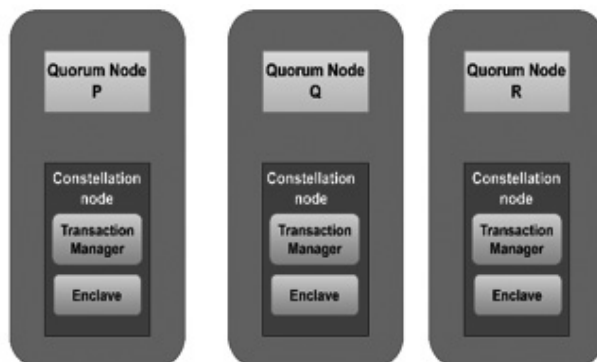


Fig. 4: Architecture of Quorum

IV. RESULT AND DISCUSSION

Making intelligent models is just one application of artificial intelligence, but it is also utilized in data science to get knowledge from the data and offer important insights that will ultimately benefit humanity. Machine learning and Deep learning are also referred to as the subsets of Artificial Intelligence. Due to its extensive use and implementation, machine learning can be further divided into ‘n’ subsets, however, for purposes of common understanding, it can be divided into two categories: supervised and unsupervised machine learning. Supervised Machine Learning was the research’s main emphasis and subject of discussion.

In the current digital era, where networking devices are more likely to be compromised, security mechanisms must be put in place to safeguard the privacy of users and the security of their data. Sometimes domestic corruption is a concern as well, so we need to make sure the model is not just vulnerable to hacking. One of the most widely used methods for implementing secure, chained, and encrypted data is blockchain technology, which guarantees the model’s complete security.

The research supports the deployment of the IIoT in Industry 5.0 as well as the launch of the 5G network. It is crucial to realize that for IIoT to operate at its best, a robust network is necessary. The research suggests the adoption of a 5G network to assure and provide strength, availability, and speed in order to ensure the optimal functioning of the IIoT. If the network is not strong, available, or fast, it will not be able to operate well [6].

The theoretical working of the Multivariate Linear regression is presented which predicts the efficiency of the model based on its features. The result of the research is achieved by the successful development and testing of the algorithm. The analysis part is implemented that is to use the algorithm and features of various industry 5.0 models to determine the features that produce the most efficient model of Industry 5.0.

For the implementation of the Algorithm, Python and Jupyter Notebook are used along with several packages like NumPy, Matplotlib, etc. For the security of the model, Blockchain is proposed as it would give the highest efficiency. There are various blockchain protocols so the paper encourages the audience to find out the efficiency of the model using various blockchain protocols and determine the best protocol for industry 5.0. As for this research, the Quorum blockchain is proposed because Quorum’s features include performance that is faster than bitcoin’s, administration of permissions, enhanced privacy, management of assets, and many more. Quorum would be ideal for the model suggested by the research as it is an extension of the Ethereum blockchain that focuses on enhancing blockchain technology. Although the first generation of Blockchain provides scalability, peer-to-peer networks, interoperability, transparency, and other

advantages, it is far from perfect, and we thus need a superior blockchain for future industries like Quorum.

The IIoT is also proposed along with the installation of 5G network to fulfil the demand of strong and fast network. Using various components as features and applying them to the algorithm, we can predict the components for Industry 5.0 that are useful and important in order to make the model efficient.

V. CONCLUSION

Research on machine learning is being done all around the world to create genuinely intelligent systems because of its enormous untapped potential. Its applications cover practically every field, including automation, teaching a computer to fly a helicopter, anomaly detection, recommender systems, prediction models, and recommender systems. In order to predict the effectiveness of Industry 5.0, multivariate linear regression of supervised machine learning is studied in this study; however, the model’s effectiveness would depend on a variety of factors and components, including security protocols and models, Industrial IoT performance, connectivity, reachability, availability, and many more. These variables and elements would be grouped as algorithmic characteristics and given the letters “w” and “b” for weight and “b” for bias. These elements could be updated and changed to enhance the model as a whole and increase model efficiency. Regression is one of the most powerful machine learning algorithms that is used to perform prediction analysis. However, this research is presented as their future work as it proposes to determine the efficiency of the model based on the features provided so that the ultimate and optimal model could be determined. Earlier research papers discussed the integration of “hot” technologies like 5G, Blockchain, AI, and IIoT in the industry 5.0 model. Quorum blockchain is the second-generation blockchain that is enhanced and more advanced. It is proposed by the research for the implementation of security in Industry 5.0. Along with that, the study also supports the integration of IIoT that could enhance Industry 5.0 as a whole.

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