FairMLancer: Dynamic Resource Allocation and Fairness Optimization in Decentralized Systems for Machine Learning Freelancing

Abstract— **The emergence of decentralized systems backed by blockchain technology has transformed a variety of sectors, including machine learning freelancing. "FairMLancer" is a decentralized Ethereum-based platform for machine learning freelancing. It handles dynamic resource allocation and fairness optimization in tabular data projects. Freelancers may be assigned to tasks, and the platform assesses models using IPFS test datasets. Notably, FairMLancer uses co-operative game theory and the IPF method to distribute fair remuneration based on RMSE results. The top three models are chosen to maximize customer outcomes. This study presents a unique method for fair compensation in decentralized systems, which is enhanced using a tabular GAN model to produce synthetic data for training datasets. FairMLancer's mission is to promote equity and transparency in the machine learning freelancing industry or the gig economy.**

Keywords— Blockchain, Smart Contracts, Decentralization, Gig economy, GAN, Game Theory

I. Introduction

Gig economy has given people new opportunities to work independently and openly, but it has also created issues with employment insecurity and appropriate remuneration. Platform owners, who have great influence over job allocation and payment, routinely mistreat and treat gig workers unjustly, according to. Furthermore, the algorithms utilized on these platforms to assign employment and compensate individuals are often opaque. As a result, freelancers have lost faith in these platforms [1].

There are number of centralized platforms that facilitates freelances and buyers in this economy. The centralized platforms are managed by a single company, which oversees all platform activities. Furthermore, all users are reliant on a central server, to which they send queries, and the server responds with the data requested [2]. Centralized freelance platforms are the most popular among freelancers and clients. According to an International Labor Organization report, although freelancing platforms serve as intermediaries between freelancers and clients, providing the infrastructure for both to overcome trust issues and work together with as little conflict as possible [3], they have been ineffective due to the following factors,

- Non-autonomy at work
- Refusal of payment
- Bias Ratings
- Mismatching
- High fees
- Dispute resolution limited awareness
- Not fully decentralized

The environment of machine learning freelancing has changed dramatically in recent years, due to the introduction of decentralized networks backed by blockchain technology. These decentralized platforms have created new opportunities and difficulties for customers looking for data-driven solutions as well as freelancers providing their skills in the sector. However, as the decentralized machine learning freelancing ecosystem expands, providing equal compensation and dynamic resource allocation for participating freelancers becomes an increasingly important challenge [4]. Decentralized systems have the potential to eliminate conventional middlemen, lowering transaction costs and increasing transparency. However, the equitable allocation of resources and incentives in such systems remains a hard problem,[5] particularly in the context of complicated machine learning tasks such as tabular data processing.
The use of Generative Adversarial Networks (GANs) for data synthesis in the context of decentralized freelancing platforms is one area of study need. While GANs have been used for image synthesis, there has been little research into their application for tabular data synthesis. GANs may be used for tabular data synthesis, according to one research by [6] although their efficiency varies depending on the kind of data and the quality of the input dataset. This suggests that more study on the use of GANs for tabular data synthesis in the context of decentralized freelance marketplaces is needed.

To solve these shortcomings, we present "FairMLancer," an Ethereum-based decentralized platform meant to address these important concerns. The concepts of openness, justice, and efficiency underpin FairMLancer. FairMLancer allows clients to submit machine learning projects focusing on tabular data analysis, with tasks ranging from predictive modeling to data categorization. Freelancers who want to lend their knowledge can independently claim projects that match their abilities and interests. FairMLancer, in particular, use a tabular GAN model to produce synthetic data for training datasets, hence improving project privacy and dataset quality.

II. Terminologies

A. Blockhain

A blockchain is an immutable digital ledger that is spread over a network of computers. Each transaction is saved in a block, which is connected together in a chain to provide transparency, security, and decentralization.

B. *Smart contracts*

Smart contracts are self-executing contracts that are programmed with predetermined rules and circumstances. They automatically implement and enforce contract obligations when certain criteria are satisfied, eliminating the need for middlemen.

C. *Ethereum*

Ethereum is a decentralized, open source blockchain technology that allows smart contracts to be created and executed. It is well-known for its adaptability and extensive use in the development of decentralized apps (DApps).

D. *Solidity*

Solidity is a high-level programming language that was created exclusively for creating smart contracts on the Ethereum network. It enables developers to specify the logic and behavior of Ethereum blockchain smart contracts.

E. *Tab-GAN*

Tab-GAN is a generative adversarial network which was designed specifically for augmenting/synthesizing tabular datasets with less noise.

F. *Gas Price*

The cost of processing resources necessary to complete a transaction or conduct an operation on the Ethereum blockchain is referred to as the gas price. Users define the amount of gas they are ready to spend in order to get miners to include their transactions in a block.

G. *Meta-mask*

Metamask is a popular bitcoin wallet and blockchain application gateway. It enables users to maintain their Ethereum accounts, connect with DApps, and keep private keys securely.

III. Literature review

A. *Blockhain Technology in the gig economy*

Decentralized systems have caused a paradigm change in several industries, including freelancing. Decentralized systems have the ability to improve transactional efficiency, lower costs, and promote transparency [7]. Because of their disruptive potential, these platforms have piqued the interest of both scholars and practitioners. Centralized freelance platforms are frequently chastised for a lack of openness and trustworthiness, which can result in unfavorable encounters for both clients and freelancers. According to [8], traditional freelance platforms frequently struggle with gaining consumer trust since there is no guarantee that clients' data will be handled safely or that the work will be of high quality. This can lead to a lack of confidence in the platform, resulting in lower user engagement and significant revenue loss. Furthermore, payment issues and job accessibility are common issues for freelancers using centralized platforms [9].

B. *Issue of Privacy and Data Security*

One of the major challenges that centralized freelancing platforms confront is a lack of privacy and data protection, which can result in a loss of trust and faith in the platform between both clients and freelancers [9]. Centralized platforms retain sensitive client data on their servers, such as payment information, work product, and communication logs, establishing a single point of failure for possible security breaches. Because freelancers must submit their resumes, work samples, and contact details to the platform's servers, they risk having their personal and professional information compromised [10].

According to studies, privacy and data security are top concerns for both customers and freelancers in the gig economy. According to a HoneyBook poll, 50% of freelancers' main worry while utilizing freelancing platforms is data privacy and security. Similarly, 62% of clients on freelancing platforms are concerned regarding the security of their data, according to an Upwork poll.

C. *Fair Compensation and Resource Allocation*

Achieving equitable pay and resource distribution in decentralized systems has emerged as a popular study and conversation issue [11]. Ensuring that participants are fairly compensated for their services is a complicated task, and novel ways are necessary to adequately address this concern. Cooperative game theory has gained popularity as a theoretical paradigm for equitable resource allocation [12]. This technique considers the collaborative features of resource allocation, in which participants work together to ensure a fair distribution of resources. Cooperative game theory, which has been applied in a variety of disciplines, including decentralized systems, provides a mathematical framework for examining fairness. The Iterative Proportional Fitting (IPF) method is one technique suggested for equitable resource distribution based on cooperative game theory [13]. IPF is an iterative method that aims to discover a resource allocation that meets stated fairness requirements. It has applications ranging from economics to resource allocation on decentralized networks.

D. *GANs for Tabular Data synthesis*

Tabular data analysis and the use of Generative Adversarial Networks (GANs) for data augmentation have become essential components of machine learning initiatives [14]. Tabular data, defined as structured information organized in rows and columns, brings new difficulties and opportunities in a variety of disciplines.

Machine learning initiatives that range from predictive modeling to data categorization usually entail the study of tabular data. Tabular data's organized design makes it particularly well-suited for jobs in which understanding the connections between distinct variables is critical. Tabular data analysis has found uses in finance, healthcare, and a variety of other fields [15].

Insaf Ashrapov[16] Demonstrated that GANs have the potential to improve the quality of tabular datasets. Their research shows how GANs might help with data shortages by producing realistic synthetic samples. This approach improves the resilience and generalizability of machine learning models trained on tabular data.

The addition of a tabular GAN model for data augmentation is a big improvement in the context of FairMLancer. It not only enhances training data quality, but it also adds to project privacy by decreasing the requirement for direct access to sensitive client data.

E. IPF Algorithm

The IPF method employed in this project is intended to provide equitable reward distribution across freelancers based on their performance as determined by their RMSE score. This method relies on game theory, which is a mathematical framework used to simulate strategic decision-making [17], game theory is currently used to study and construct incentive structures that encourage cooperation and justice in a variety of domains, including political science, economics, and computer science.

The use of game theory into the IPF algorithm is intended to promote fairness among freelancers by motivating them to perform well. The system is programmed to allocate weights to each freelancer depending on their inverse RMSE score, which is a performance metric. The overall weight is then used to calculate each freelancer's reward, with the top three performers earning the largest payouts.

F. Average Ensemble method

The average ensemble method is a machine learning methodology that combines the results of numerous models to increase prediction accuracy. It works by taking the average of each model's forecasts to arrive at a final prediction. This method has been proven to improve prediction accuracy in a variety of domains, including picture classification, audio recognition, and natural language processing[18].

In this is case, this method has been used for selecting the best three models based on the root mean square error (RMSE) values and using the average ensemble method to arrive at a final prediction.

G. Related work

P. Deshmukh conducted a study that suggests a decentralized freelancing platform based on blockchain technology and smart contracts [19]. The platform is intended to overcome the shortcomings of existing freelance platforms in terms of openness, privacy, and remuneration. The authors recommend adopting Ethereum as a blockchain platform and IPFS for big dataset storage. The platform enables transparent payment by utilizing smart contracts, which automatically release cash to the freelancer upon assignment completion. The software also protects freelancers' privacy by allowing them to utilize pseudonyms and encrypting the client's data. To assure the quality of work, the platform has a reputation system in which clients may grade freelancers based on their performance, which is then made public for prospective clients to see. Furthermore, the platform offers dispute resolution mechanisms via smart contracts to ensure fairness in the event of disagreements between the client and the freelancer.

M. Gandhi et al.'s work "A Decentralized Marketplace for Freelancers" offers a decentralized freelancing platform where clients may employ freelancers without the need of intermediaries. Blockchain technology is used by the platform to facilitate safe and transparent transactions between customers and freelancers. The authors recommend using smart contracts to automate the recruiting process and guarantee freelancers are paid fairly. The system features a reputation system to assist clients in selecting the correct freelancers and ensuring job quality[20].

IV. IMPLEMENTATION

In the following section, we go through the implementation specifics of the proposed DApp "FairMLancer," which is intended to address the issues of decentralized machine learning freelancing. FairMLancer is developed on top of the Ethereum public blockchain, employing its features to secure the freelancing ecosystem's transparency, security, and efficiency.

A. Etherum blockchain as foundation

FairMLancer is based on the Ethereum blockchain, a very stable and well-established platform known for its great support for creating decentralized apps (DApps). Ethereum provides a set of fundamental functions that form the foundation of FairMLancer's decentralized ecosystem.

FairMLancer's operations are built around Ethereum's signature feature, the capacity to execute smart contracts. Smart contracts, which consist of self-executing code with preset rules, have largely replaced traditional middlemen in the freelancing arena. These contracts play an important role in automating essential procedures including project management, pay distribution, and dispute settlement. FairMLancer supports the trustless execution of these activities by employing Ethereum's smart contract technology.

Ether (ETH), Ethereum's native cryptocurrency, serves as the primary mode of payment on FairMLancer to facilitate transactions and interactions. Users pay transaction fees in ETH to execute smart contracts, submit projects, and engage in other platform activities. This cryptocurrency provides the secure and transparent execution of financial transactions, which contributes to the operational transparency of FairMLancer.

FairMLancer has been easily integrated into the **Sepolia** Test Network, an Ethereum test net, during the development and testing phases. This connection enables developers to experiment with smart contracts, do rigorous testing without putting actual ETH at risk, and validate the operation of the DApp before releasing it to the Ethereum main net, therefore increasing the platform's stability.

The usage of **ThirdWeb** as the smart contract deployment platform simplifies the implementation of smart contracts on the Ethereum blockchain. This option streamlines the deployment process and ensures that

FairMLancer's code is safely and effectively incorporated into the Ethereum network.

Critical data inside FairMLancer is securely maintained on the Ethereum blockchain, including client project details, IPFS Content Identifiers (CIDs) of datasets, and RMSE scores of machine learning models. This storage method ensures data openness, immutability, and integrity, allowing users to confidently access and verify vital information.

B. Smart contracts for project management

The primary component of the system of FairMLancer's project management system is smart contracts, which introduce a novel approach to project coordination and automation. These contracts, meticulously designed in the Solidity programming language, will be deployed on the ThirdWeb platform. They are an important part of the FairMLancer ecosystem, helping to streamline and secure the administration of customers, freelancers, dataset Content Identifiers (CIDs), model predictions, and payments.

To bring FairMLancer's concept to reality, the team used Solidity, a specialized programming language designed for constructing smart contracts on the Ethereum blockchain. The syntax, features, and compatibility of Solidity with Ethereum's Virtual Machine make it an excellent choice for creating safe, trust less, and efficient contracts. FairMLancer's smart contracts support a wide range of CRUD (Create, Read, Update, Delete) activities, allowing for the rapid administration of essential entities on the platform.

Smart contracts handle the management of clients, freelancers, dataset CIDs, model predictions and payouts. These contracts manage the complex process of distributing project payments, ensuring that freelancers are compensated fairly based on project completion and model success.

One of the key benefits of smart contracts is their inherent security and dependability. These contracts function in a secure environment, faithfully carrying out pre-defined norms and conditions. Smart contracts reduce the chance for conflicts and inspire confidence in the FairMLancer community by eliminating the need for middlemen, promoting an atmosphere of trust and reliability.

C. Tabular GAN Model for Data Augmentation

FairMLancer uses an innovative Tabular Generative Adversarial Network (GAN) model in order to improve the quality and amount of training data. This complex model is at the heart of our approach to overcoming the obstacles caused by unequal data distribution in machine learning applications. The study of **Insaf Ashrapov**, whose work on Tabular GANs for managing unequal data distributions has been a guiding influence in the creation of our augmentation method, inspired our initiative. Ashrapov's study sheds light on the creation and implementation of GAN models designed exclusively for tabular data. We have utilized the power of GANs to overcome the issues given by uneven data distributions within the freelancing ecosystem by embracing and applying the ideas stated in Ashrapov's study.

It is vital to highlight that our Tabular GAN model is just used to supplement the training dataset. This strategic approach is consistent with our unrelenting dedication to protecting customer data privacy. While the training dataset is enhanced to improve its quality and quantity, the test dataset is left unchanged and secret. This strategy ensures that sensitive customer data is never exposed or compromised, ensuring the highest data privacy and security requirements.

FairMLancer's commitment to ethics and openness extends to machine learning model assessment. The platform ensures the realism and authenticity of model evaluation by using a genuine test dataset that stays unaltered during data augmentation. This guarantees that machine learning model accuracy evaluations are based in real-world settings, giving clients with trustworthy insights into model performance.

D. Equations

An Iterative Proportional Fitting (IPF) algorithm has been designed and implemented in Solidity to achieve equal incentive distribution and weighting in the FairMLancer platform. This method seeks to properly distribute payments among freelancers based on their performance indicators, using the inverse of their RMSE scores as weights.

The core formula guiding the IPF algorithm is expressed as follows:

$$\boldsymbol{P[i] = \frac{3(tp)^2}{[\,\sum_{i=1}\ (RMSE[i])^{-1}\ ]^{-2}}} \tag{1}$$

In this formula:

- P[i] represents the payout for freelancer i
- totalPayout is the total amount of payout available.
- RMSE[i] represents the Root Mean Square Error score for freelancer

Algorithm steps:

1. **Initialization:**

• Create a weights array with the same length as. number of freelancers.

• Set the overall payment amount (totalPayouttotalPayout).

• Create a variable for the total weight.

2. **Weight Calculation:**

• Iterate through the selection of freelancers.

• Calculate each freelancer's weight as the inverse of their RMSE score.

• Add the weights together to get the total weight.

3. **Payout Calculation:**

•Create an array to hold the computed payments.

•Create a variable for the total salary of the top three freelancers.

•Iterate over the top three freelancers (according to their weights).

•Calculate each freelancer's salary based on their weight and the overall pay.

•Update the total payout of the top 3 freelancers.

4. Average Payout Determination:

•Determine the average compensation among the top three freelancers.

5. Weight Adjustment:

•Iterate on the top three freelancers.

•Update the weights by multiplying the payments by 3 and dividing by the average payout.

6. Iterations:

•Set an epsilon threshold and the maximum number of iterations.

•Create an iteration counter and an epsilon value.

•Start a loop that runs until epsilon reaches 0 or the maximum number of iterations is reached.

•During each iteration:

  •Calculate the entire weight again.

  •Reset epsilon to zero.

  •Iterate through the selection of freelancers.

  •Calculate each freelancer's new weight based on their existing weight, total payment, and total weight.

  •Calculate the absolute difference between the new and prior weights to update epsilon.

  •Update each freelancer's weight.

7. Payout Finalization:

•Recalculate the rewards using the new weights and total payoff.

•Transfer the computed compensation to the addresses of each freelancer.

•Ensure that Ether is successfully sent to each freelancer, raising an exception if any transfer fails.

8. Return Payouts:

•Return an array containing the computed payments.

The IPF algorithm systematically and iteratively allocates rewards to freelancers based on their performance, striving for fairness and proportionality in reward distribution through the dynamic adjustment of weights derived from the inverse of RMSE scores.

V. Result and Discussion

Performance Testing: The focus will be the IPF algorithm which is implemented in solidity. As a proxy of performance author has decided to obtain gas cost of 10 test cases that utilize the algorithm. The execution time won't be taken into consideration because the idea of time in a blockchain differs from that of traditional systems, thus using timestamps or execution time to gauge performance is unreliable. Block timestamps are determined by the clocks of miners and nodes, which can be distorted, and block execution durations vary according to the complexity of the transactions in the block.

Hence use gas cost as a proxy for performance instead of execution time is the better method for testing. Gas is an Ethereum unit of account that measures the quantity of computing labor necessary to complete a transaction. It is a more trustworthy performance statistic since it represents the real cost of completing the transaction on the network. The author has utilized the remix IDE for the testing.

Test case ID	RMSE scores (Input)	Total Payout in WEI (Input)	Gas cost
1	[2,3,4]	1000000000000000000	77357
2	[2,6,9]	12400000000000000000	82684
3	[1,3,7]	500000000000000000	70657
4	[11,6,1]	25000000000000000000	70657
5	[1,1,1]	10000000000000000	77357
6	[9,3,5]	3500000000000000000	77357
7	[4,6,2]	2200000000000000000	82684
8	[10,13,12]	9000000000000000000	77357
9	[2,4,6]	250000000000000000	77357
10	[1,5,9]	6000000000000000000	70657
Total Gas Cost			**764 124**

Table 1: Gas Cost

The average gas cost = 764 124 / 10

= **76412 WEI / 10^{18}**

= **<u>0.000000000000076412 ETH</u>**

According to the findings of the performance testing, the algorithm's average gas cost is around 0.000000000000076412 ETH. This implies that the algorithm is efficient in terms of gas utilization, which is a crucial consideration in the construction of smart contracts on the Ethereum blockchain. As a result, the algorithm may be regarded optimized for gas consumption, which can add to the general cost-effectiveness of the smart contract that uses this algorithm.

VI. Conclusion and Future Work

The project aim was successfully achieved through design, development, and evaluation of the decentralized freelance platform that addresses the trust, privacy, and fairness challenges of centralized platforms. The platform enables organizations to hire third-party developers for integrating AI and big data requirements while ensuring transparency and trust between parties. The thorough exploration of the study domain and technological body, along with the construction of components and performance evaluation, have confirmed the viability of the selected hypothesis.

By analyzing the test results of the prototype, it has been identified that many improvements must be done in order to achieve the proposed functionalities. The main improvement will be altering this algorithm while the smart contract execution time gets optimized. This can be achieved with a machine learning algorithm in solidity. Currently there are no integrations to the IPFS file system. That can be utilized for storing data files such as ML models while saving the integrity of the network. The integration to the chain-link can be more secured using Oauth authentication methods. The usage of meta mask and ganache can be utilized to check for truncations and payments that has been filed over the network. This will greatly improve the transparency of the network.

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