Original or Fake? How to Understand the Digital Artworks' Value in the Blockchain

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Abstract. The recent Blockchain technology for recording and storing data opened a cultural scenario which prefigures unexplored frontiers. It is precisely in this frontier territory that a revolution in the digital art sector has come to life, represented by the introduction and dissemination of non-fungible tokens (NFTs) as certificates of ownership/authorship of a digital work. NFTs redefine the concepts of artwork ownership/authorship, authenticity and value. Supported by the Blockchain structure, which is in fact permanent and unchangeable, these certificates are inviolable, unassailable and indestructible, offering a type of guarantee never experienced before. As any new technologies, there are challenges that users face: 1) avoiding fraud (i.e. digital artworks that are not original, but mere copies of the original) 2) estimating the real value of a NFT connected to a digital artwork. The paper proposes a predictive tool, NFT price Oracle, as a solution for the Blockchain users that want to be sure they are purchasing an authentic digital artwork and wish to understand the value of the artwork (and thus how much to pay for the NFT associated with the artwork) in the Blockchain.

Keywords: Non-fungible token · Digital artwork · Blockchain · Oracle prices · History of production · History of effects

1 Introduction

In recent years, the digital art market has been considerably growing thanks to the combination of the Blockchain technology and non-fungible tokens [1]. A Blockchain is a distributed and decentralized ledger that contains connected blocks of transactions and it guarantees tamper-proof storage of approved transactions [2,3]. A NFT is a representation of a unique digital asset that cannot be equally swapped or traded for another NFT of the same type. NFTs are stored on a Blockchain and are used to represent the ownership/authorship of unique items [4,5]. NFTs attracted billions of dollars in investment. Christie's, the British auction house founded in 1766 by James Christie [6], auctioned an NFT associated with a digital work by the digital artist Mike Winkelmann (Beeple) for 69 million of dollars.

The paper aims to answer the following questions:

– RQ1 can the Blockchain technology with NFTs prevent the forgery of an artwork?;
– RQ2 can the Blockchain help the user to have a more correct estimate of the value of the artwork itself?

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– RQ3 If not, how could a more correct estimate of NFT prices be given?

To answer the first question, the paper argues that the Blockchain can serve to trace the "history of production" of an artwork [7,8], because it provides an incorruptible proof of ownership/authorship, meaning that an original artwork and their owners/authors can always be identified via the Blockchain, even when an image or video is widely copied.

To answer the second question, the paper argues that the data contained in the Blockchain are not sufficient to determine the real value of a digital artwork, as the value of a digital artwork is not reducible to the set of Blockchain's identifying properties, such as the number of transactions and the price at which it is traded. Rather, the digital artworks' value is a function of its "history of effects" [9], i.e. the net of valuable interactions that the original artwork spread within and outside the Blockchain in its lifespan. Blockchain users might face difficulties in evaluating the real value of an artwork (and its fakes), just based on the Blockchain history of transactions. They might also search data from the outside to understand the digital artworks' value in the Blockchain. The paper proposes a predictive tool, NFT price Oracle, as a solution for the Blockchain users that wish to understand the value of the artwork (and thus how much to pay for the NFT associated with the artwork) in the Blockchain. NFT price Oracle is designed to give a correct estimation of an artwork, providing the Blockchain users with the fairest price to pay for the NFT, based on both the artwork's history of production and its history of effects. In particular, the NFT price Oracle needs to be decentralized, to better guarantee that faked digital artworks are not paid as if they were original.

2 Technical Components

This section provides the readers with a brief introduction on the technology used to handle the digital artwork on the Blockchain: smart contracts, NFT and the software Oracle.

2.1 Blockchain

The Blockchain is an ordered sequence of blocks containing the records of valid transactions as approved by a consensus algorithms shared between a set of computational nodes in a peer-to-peer network. It is a shared ledger where, to keep unchangeable the block sequence and the temporal order of recorded transactions, each block includes a cryptographic hash depending on the information recorded on the previous block. Each block is also identified by progressive number named "height" [10]. Once a block is created and added to the Blockchain, the transactions in the block cannot be changed or deleted. This is to ensure the integrity of the transactions and to prevent the double-spending problem [11].

2.2 Smart Contract

A smart contract is a digitally signed, computable agreement between two or more parties. A virtual third party, a software agent, can execute and enforce (at least some of) the terms of such agreements. In the context of the Blockchain, where it truly takes its sense, a smart-contract is an event-driven program, with states, that runs on a replicated, shared ledger and which can take custody over assets on that ledger. Smart contracts on the Blockchain, created by computer programmers, are entirely digital and written using programming code languages. This code defines the rules and consequences in the same way that a traditional legal document would, stating the obligations, benefits and penalties, which may be due to either party in various different circumstances. The code is automatically executed by a distributed ledger system, in a non-repudiable and unbreakable way [12], diversely from traditional contracts. Smart contract code has some unique characteristics:

– Deterministic: Since a smart contract code is executed on multiple distributed nodes simultaneously, it needs to be deterministic i.e. given an input; all nodes should produce the same output. That implies the smart contract code should not have any randomness; it should be independent of time (within a small time window because the code might get executed a slightly different time in each of the nodes); and it should be possible to execute the code multiple times.
– Immutable: smart contract code is immutable. This means that once deployed, it cannot be changed. This of course is beneficial from the trust perspective but it also raises some challenges (e.g. how to fix a code bug) and implies that smart contract code requires additional due diligence/governance.
– Verifiable: Once deployed, smart contract code gets a unique address. Before using the smart contract, interested parties can and should view or verify the code.

2.3 NFT

"A non-fungible token (NFT) is a unit of data stored on a digital ledger, called a Blockchain, that certifies a digital asset to be unique and therefore not interchangeable" [13]. Indeed, anyone can obtain copies of the digital items (NFTs) on the Blockchain, but they are tracked so as to provide proof of ownership/authorship [14]. An NFT is like a certificate of authenticity for an object, real or virtual. The unique digital file is stored on a Blockchain network, with any changes in ownership verified by a worldwide network [13]. That means that the chain of custody is permanently marked in the file itself, and it is impossible to swap in a fake. The NFT file on the Blockchain does not contain the actual digital piece of art, music, video clip, etc., rather it is like a contract stipulating that "Mr A owes Mrs B a digital file of X".

As the name suggests, NFTs are characterized by their non-fungible nature. In economic terms, fungibility is the ability of an asset to be exchanged with other individual assets of the same type for the purpose of transacting value. Correspondingly, fungible assets in the same denomination imply the same value and include, for example, gold, a specific security or currency in FIAT/crypto. Conversely, this means, that NFTs are, by definition, not interchangeable, irreplaceable and unique.

While in the "real world" there is always a unique original work, such as the painting the artist created with her own hands, in the digital world there has so far been no equivalent in the sense of an "original digital artwork". The non-manipulative nature of NFTs enables both real and digital art objects to have original ownership/authorship.

For artists, this is a way to fight plagiarism as well as earn money by their work. NFTs also allow collectors to value digital art in a similar way to physical art, creating thus new opportunities for digital artists.

The main characteristics of the NFT are: 1) Indestructible - The technology that drives NFTs enhances these assets with the property of being immutable. All the metadata which are stored via smart contracts in the Blockchain cannot be replicated, removed or destroyed, thus granting ownership rights of the NFT, to the wallet or peer that possess it. 2) Verifiable - The process of authentication is also provided by the underlying features of the Blockchain technology. This allows a traceability within the ledger, as all the transactions are historically registered and stored within the blocks of data. This property allows any NFT attached to an artwork to be traced back to the original creator, eliminating the need of a third-party authentication method.

2.4 Oracle

In the Blockchain terminology, Oracle may have different meanings. An Oracle can be a program which provides the smart contracts with reliable data collected from outside the Blockchain. Oracles are also software systems which analyze some data and make some prediction on that basis [15].

In this paper, the term Oracle assumes a specific meaning related to the activity of predicting NFTs' prices. Thus an NFT Oracle analyses both Blockchain data and external data to predict the best price to pay for an NFT. The Oracle's predictions may be important for companies and users because of economic implications. It is thus crucial for them that Oracles' predictions are as reliable as possible.

3 Method

Existing Oracles rely only on blockchain data to provide the "history of effects" that determines the value of NFTs. This is done through the transaction history which provides information on the changes in ownership and the values at which the NFT was traded. However, the history of the effects of an artwork is not recorded on the blockchain.

The model presented in this study is based on the implementation of an Oracle that provides users with both the transaction history (see Sect. 4) which are stored in the blockchain and the history of the effects of the artwork itself in the world (see Sect. 5). Such an Oracle would also be centered on real world data and not just on blockchain data like in the existing Oracles. The real world data are very important for users to value an artwork and make a decision on the NFTs to purchase. For example, providing users with data about the history of the effects of an artwork can help them in the decision-making process by looking for more information related to the NFT they are buying or changing their view and preventing them from buying what they were buying. Indeed, additional information from the real world can have an impact on forming or revising their beliefs.

4 History of Production

There always have been cases of vendors trying to pass off other artists' work as their own. Recently, one of the most sensational facts is the "Fake Bansky NFT" sold through the artist's website for 336 thousand of dollars [16]. The scam was done in the following way: Bansky's official website was forged so that to include a link to an NFT auction with a artwork called "Great Redistribution of the Climate Change Disaster", which was a perfect copy of the original, even though associated with another artist. If the buyer had checked the address associated with the token on the Blockchain, he would have discovered that the work was only a copy of the original artwork. However, checking the belonging of an artwork to its original author through the Blockchain may not be an easy task for a user, who might instead be prone to buy the forgery as it were.

An Oracle centered on the user should try to minimize this possibility by checking real world data. For example, before writing data on the blockchain the oracles should check different sources to establish with a high probability that a piece of art is authentic or not. A possible solution to this problem is to base the model not on a unique source of data, but on more than one source. It would be possible to hack a site as it was for the fake-Bansky, but it is very unfeasible that the same user would hack different sources to make the fake-Bansky as real.

5 History of Effects

As we would like to argue, there is an alternative, user-centered way to help the Blockchain users not only to identify the ownership/authorship of the artwork, but also its value. In our view, this alternative is provided by the gadamerian notion of "history of effects". In his well-known book, Truth and Method [17], Hans-Georg Gadamer deals with the problem of understanding as a fundamental mode of human existence. In his perspective, the value of each human work is provided not very much by the work itself but rather by the (different) human interpretations and uses of the work itself. Indeed, a single artwork makes sense within an "hermeneutic circle", i.e. it acquires a value only on the whole background of interpretations that are provided by human beings. In the case of an artwork, the history of effects is not an appendix, or an addition to the understanding of a work, but rather the foundations for understanding its value. However, the set of interpretations of the artwork is potentially unlimited, while human beings are limited as well as their understanding, which is historically rooted in their world and times. As a consequence, everyone deals with historically and culturally determined conceptual structures which pre-determine and influence the artwork's understanding. Thus, everyone (the artwork's creator included) has a structural limited access to an artwork's "history of effects". It is therefore "require[d] an inquiry into "history of effects" every time a work of art or an aspect of the tradition is led out of the twilight region between tradition and history so that it can be seen clearly and openly in terms of its own meaning" [18].

In our view, in the case of digital artworks, the human inquiry into the "history of production" of an artwork can be helped via technology, and specifically the Blockchain technology above mentioned. In this case, however, the artwork's history of effects is not just related to real-world chain of uses and/or interpretations, as it can also be related to the history of the Blockchain itself. Thus, a double (both real-world and Blockchain) history of effects needs to be considered to estimate the value of the digital artwork. Indeed, in the Blockchain, NFTs have no objective intrinsic value, as they rely on a collective consensus to establish their value. It is the collective demand from the users, based on their understanding and use of the collectible that shapes value. Without a community aiming to collect a digital artwork, the digital artwork itself is not worth collecting. It is the collective acceptance of an artist's digital artwork that creates demand for the artwork, making originals worth millions of dollars.

The NFT price Oracle proposed in this paper thus considers the overall digital artwork's history of effects (at the time t the user starts her inquiry via NFT price Oracle) to predict its value, i.e. to provide the user with the fairest estimate of the digital artwork's value. As mentioned above, the value of an NFT comes not only from intrinsic factors accessible from the Blockchain, such as the proof of ownership/authorship provided by its "history of production", but also from extrinsic factors that are not directly accessible from the Blockchain, such as:

- Scarcity: Many NFTs represent digital objects that are unique or limited. For instance, only 10k CryptoPunks were released. Of those, only 24 are "apes". And among the apes, just one ape wears a fedora [19].
- Effects on entertainment industry. For example, some NFTs are more than just collectibles, since they can be used in games, like virtual lands, spells, or characters. This feature of NFTs gives them an added value, which accrues over time depending on the popularity of the underlying project. As the community of the project grows, many of them might be willing to pay more for a particular NFT [20].
- Art exhibition events. Recently, some art exhibition has shown NFTs in holographic form [21].
- Tangibility. Some NFTs are tied to real-world objects, which gives them value in terms of tangibility supported by the immutability of ownership/authorship. Collectables linked to NFTs can accumulate value over time as the number of items in circulation decreases.
- Transaction cost. Every trade of NFT has a transaction cost that impacts on possible earnings. Part of the transaction cost is due to Blockchain properties, part by the smart contract attached to the NFT.

Some elements that allow us to reconstruct part of the "history of effects" are in the Blockchain. The data that can be taken from the Blockchain are: the transaction number of a specific work of art, and the prices at which it is traded. Details on how these data are calculated from the Oracle can be found in the next section.

5.1 From a Data-Centered Model (TWPA) to a User-Centered Model (UCP)

The data-centered models are actually used by the Oracles to provide the users with proof of authenticity for a specific artwork and sometimes its value, based on the artwork's trades history (if it is present in the Blockchain). The aim of this research is to use also other data coming from the "external world", to provide the users with a more accurate estimate of the NFT value. To this aim, the model proposed in this paper collect and analyze both Blockchain data and external world data, shifting to a user-oriented perspective.

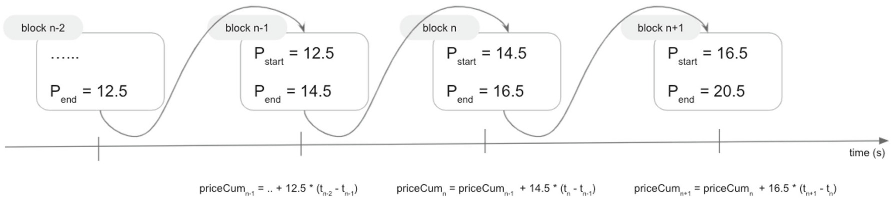

Fig. 1. NFT cumulative price on blockchain. The initial price of an NFT in the next block is equal to the final price of the same NFT in the previous block

In respect to Blockchain data, we based the user-oriented NFT price Oracle on the TWAP model. In finance, time-weighted average price (TWAP) is the average price of a tradable financial asset over a specified period of time, and it is used to determine if an asset is overvalued or undervalued. If the order price is below the TWAP, it is considered undervalued, while if it is more than the TWAP, it is considered overvalued. We based the NFT price Oracle on the TWAP model, because this formula is used for stock trend predictions [22]. Formula 1 formally denotes the TWAP. Figure 1 represent the NFT cumulative price on Blockchain.

$$TWAP = \frac{priceCumulative_n - priceCumulative_{n-1}}{timestamp_n - timestamp_{n-1}} \tag{1}$$

Unlike the stock markets, it is not possible to directly apply the formula 1, because the NFT market is illiquid, there are few trades. NFTs are generally less frequently traded: this represents a problem for an Oracle, in the process of observing and retrieving price data. Therefore, we decided to design the NFT price Oracle to consider similar sales. Similar sales are defined as the prices at which similar collectibles have been sold. Similar sales are commonly used in determining real estate prices as well.

In respect to real-world data, these data plus the metadata contained in a NFT allow to define similar collectible class. The average price of collectibles defined in a specific collectible class has thus been used as a parameter for any other collectible being in a similar collectible class. In this paper, similarity is based not only on design elements and history of production in the Blockchain, but also on a similar history of effects in the data from the outside [23,24]. Example of data from the outside are the number of the author's followers, the number of the artwork's downloads, the number of art exhibition events expected in the next month related to the object linked to the NFT and the number of tickets sold to these events. These data are not available in the blockchain but are indeed available in the external world.

The TWAP formula could be applied only on NFT that are very frequently traded. We do not usually have such scenarios, because most NFTs are illiquid and they cannot be exchanged as easily as traditional investments, like stocks and bonds. To apply the TWAP formula to NFTs, we need to group NFTs that are similar. To this aim a cluster analysis might be performed. Each NFT consists of some metadata that can be used to evaluate the similarity of the artwork. To calculate the similarity between different NFTs, the model needs to analyze all the feature data for those NFTs. Some of these features could be the address associated with the NFT creator, the number of art exhibition events expected in the next month related to the object linked to the NFT and the number of tickets sold to these events. Then, a cluster analysis could then group a set of NFTs in such a way that NFTs in the same group (a cluster) are more similar to each other than to those in other groups or clusters. The cluster analysis can be achieved by algorithms that significantly differ in their results.

We analyzed the time series of some extrinsic data to establish if they can be used to predict the NFTs' prices. Table 1 shows the results of the pair-wise Granger causality test performed for NFT price versus the extrinsic variables. The results show how the data series of different extrinsic variables, such as the number of downloads and the number of art exhibitions of a particular NFT within a specific time interval (one day), do Granger-cause the NFT price variation. The $p < 0.05$ means that the null hypothesis is rejected, suggesting that the effect of the lagged values (i.e., values coming from an earlier point in time) of the other variables on the NFT price variable is statistically significant.

Table 1. Granger causality test results

Null hypothesis	F-statistics	Prob.	Decision
The NFTs price does not Granger-cause the number of downloads	4.213	0.0231*	Reject
The number of downloads does not Granger-cause NFTs price	2.172	0.0381*	Reject
The NFTs price does not Granger-cause the number of search requests	2.733	0.0297*	Reject
the number of search requests does not Granger-cause the NFTs price	1.322	0.0131*	Reject
The NFTs price does not Granger-cause the number of art exhibition	2.329	0.3821	Accepted
The number of art exhibition does not Granger-cause the NFTs price	1.426	0.4835*	Reject
The NFTs price does not Granger-cause the number of author's followers	1.223	0.0878	Accepted
The number of author's followers does not Granger-cause ot the NFTs proce	1.432	0.0733	Accepted
The NFTs price does not Granger-cause the value of the USD/Ether pair	2.423	0.4818	Accepted
The value of the USD/Ether pair does not Granger-cause the NFTs price	1.143	0.0416*	Reject

6 Threats to Validity

As to the internal validity of the study, it might be claimed that the model proposed in this study considers only few factors to estimate the NFT value. Indeed, the value of a specific NFT is due to a variety of causes. All collectible markets are affected by a variable completely separate from the collectible itself, alias the general trend in economy. Better economy generally means people's more willingness to spend on collectibles of all kinds. The Blockchain is unaware of a possible economic crisis. The Oracle could be made "aware" of economic crisis, but in this study this possibility is not considered.

Another factor to be considered is the crypto macro. Generally when crypto is performing well against fiat measurement, demand for NFTs are high. If the crypto markets were to crash, the demand for NFTs would be negatively affected. In any case, NFTs sold in crypto denomination will appear to keep gaining value in fiat terms, as crypto appreciates in price and lose value in the inverse case. We used the time-weighted average price to estimate the NFT value, but other models could be used and should be tested to check which one performs at best.

7 Conclusion

The market for NFTs has recently grown, with more than five billions of dollars spent in the first half of the year 2021. Despite the recent surge in popularity, the NFT (non-fungible token) space is still in its infancy [25] and the users need specific tools to understand the authenticity and the value of what they buy in the Blockchain, especially in the case of digital artwork. Experts say that buyers should be aware of illiquidity and fraud in this new market, because any user can try to take advantage of this business by offering digital works that do not belong to the author.

We argued that the current NFT Oracles based on a data-driven model are able to guarantee the digital artwork's ownership, simply by analyzing its history of production via the data stored on the Blockchain, but they cannot estimate neither the artwork's authorship nor the artwork value which rather depends on its "history of effects". We discussed and proposed a user-centered solution based on digital artworks' "history of effects" accessible from both the Blockchain and the real world, to provide the users with an accurate, fair and plausible estimate of the artwork.

The solution proposed in this paper needs to be further refined, as the NFT price Oracle is a first step to help the NFT investors' comprehension of the digital artworks' value, by collecting and analyzing information on different NFT projects.

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