Enhancing art with information: the case of blockchain art

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Throughout history, art and value have always been intertwined concepts, and many actors within and beyond the art world have studied the dynamics underpinning this association. But is there an objective, standardized means to determine this relationship and, perhaps, inform it? In other words, can we actually measure the value of art? Of course, there is no univocal answer to such a question. Some might say this problem simply cannot be solved, as it involves too many variables; others might argue it *should not* be solved, for to reveal the secret behind the alchemy at issue might deprive art of its mystery. Actually, this question would demand us to discuss the very definition of both art and value themselves in the first place, if we had the ambition to address it properly. In any case, however we look at the matter, it will appear that knowledge and research are crucial to our understanding of arts and culture and their value. When considering the crypto art genre, whether we wish to determine the relevance and meaning of a piece or its monetary price, the influence of background data and mined information on these aspects is undeniable.

CCS Concepts: • **Applied computing** → **Media arts**; • **Information systems** → **Digital libraries and archives**.

Additional Key Words and Phrases: blockchain, crypto art, art metrics, art experts

1 INTRODUCTION

Blockchain technologies, while commonly associated with cryptocurrencies, are rapidly expanding in the arts and creative industries [18]. Blockchain is already used in the arts to record provenance [13], to create fractional equity [19], and to guarantee digital scarcity [1, 2, 15]. In particular, a form of blockchain-enabled innovation is *crypto art*, sometimes called blockchain art [10]. Crypto art is a rising art movement in this cypher space that associates digital artworks with unique and provably rare tokens that exist on the blockchain (Figure 1). These codes are the equivalent of the artist's signature. The real potential of the emerging crypto art current is to give a digital image the dignity of a true work of art, made unique, eternal and collectible through blockchain technology. There are already several notable examples of art using blockchain technology including the following:

- in fall 2018, Artory was the first company to list a major auction sale on a blockchain when it became the registrar of the Ebsworth Collection, sold at Christie's New York for 318M\$;

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- in September 2018, the company Maecenas bought Andy Warhol's *14 Electric Chairs* and divided it up into shares sold as so-called ART tokens. The company raised 1.7M$ for 31.5% of the artwork at a valuation of 5.6M$;
- Robert Alice's Block 21 has been the first non-fungible token sold at Christie's in October 2020. Starting from an estimate fork of 12,000$ - 18,000$, the artwork realized a price of 131,250$.

As a significant by-product, crypto art is generating increasing amounts of openly available structured and unstructured data, and this is probably the main feature that sets it apart from traditional art. Indeed, all trades in crypto art are immutably recorded on a public blockchain, typically Ethereum, and this data is immediately available for analysis. On the contrary, in traditional art this information is typically secreted or available only for a (significant) fee. Besides open data, another facet of crypto art that distinguishes it from its traditional counterpart is velocity. In crypto art something can happen at every instant: an artist forges a new piece or accepts a bid made from a collector, a collector makes a bid for an artwork or directly buys it, two artists or collectors exchange the corresponding non-fungible tokens. It turns out that the crypto art system is a real-time stream of events, more akin to financial trading than traditional art [9]. Figure 2 illustrates the fast increase of participating users that are active on crypto art gallery SuperRare.

Our thesis in this work is simple but powerful:

Information can greatly increase the value of art.

In other words, art alone without any accompanying information loses part of its potential. This is for sure true for both traditional and blockchain art; however, in this article, we analyze the case of crypto art enhanced with information. We distinguish between two radically different kinds of information that can be mined from art:

- *art mined information*: this is the assessment given by art experts. It is intrinsic, subjective, deep, time-consuming and expensive;
- *data mined information*: this is the information mined by data scientists using historical valued bids and sales, on primary and secondary market, associated with the artwork. It is extrinsic, collective, superficial, fast, and low-cost.

While art mined information corresponds to the classical judgment given by few field experts, data mined information is the judgment given by the collectivity (of collectors, in this case).

Interestingly, the dichotomy between expert and collective evaluation is not peculiar to art, but it is also present elsewhere, like, for instance, in academic research evaluation. In this context, the expert judgment is well-known as peer review, the evaluation of scholar publications given by peer experts working in the same field of the publication. The collective evaluation refers to the use of bibliometric indicators defined on the bibliographic citations accrued by the publication, for instance Pagerank-based indicators [7]. An accepted practice in academic research evaluation is the so called *Informed Peer Review*: the assessment of a bibliometric unit (a scholar or a publication) by peer experts who have also access to bibliometric indicators on the unit to evaluate. Hence, both subjective and collective evaluation are taken into account with this model of informed review. Another comparison is with fundamental analysis (akin to art mined information) and technical analysis (similar to data mined information), the major schools of thought when it comes to approaching the markets. Fundamental analysis is a method of evaluating securities by attempting to measure the intrinsic value of a stock. Earnings, expenses, assets, and liabilities are all important characteristics to fundamental analysis. Technical analysis differs from fundamental analysis in that the stock's price and volume are the only inputs. The core assumption is that all known fundamentals are factored into the price, thus there is no need to pay close attention to them [14]. In fact, often both methods are combined for researching and forecasting future trends in stock prices.

Inspired by the informed peer review method to assess academic research, we propose an *Informed Art Review* (IAR, for short) model in which the art expert is informed by data mined information in order to review art. The *art mined information* considered by this model relates to the intrinsic qualities of artworks and their context. It
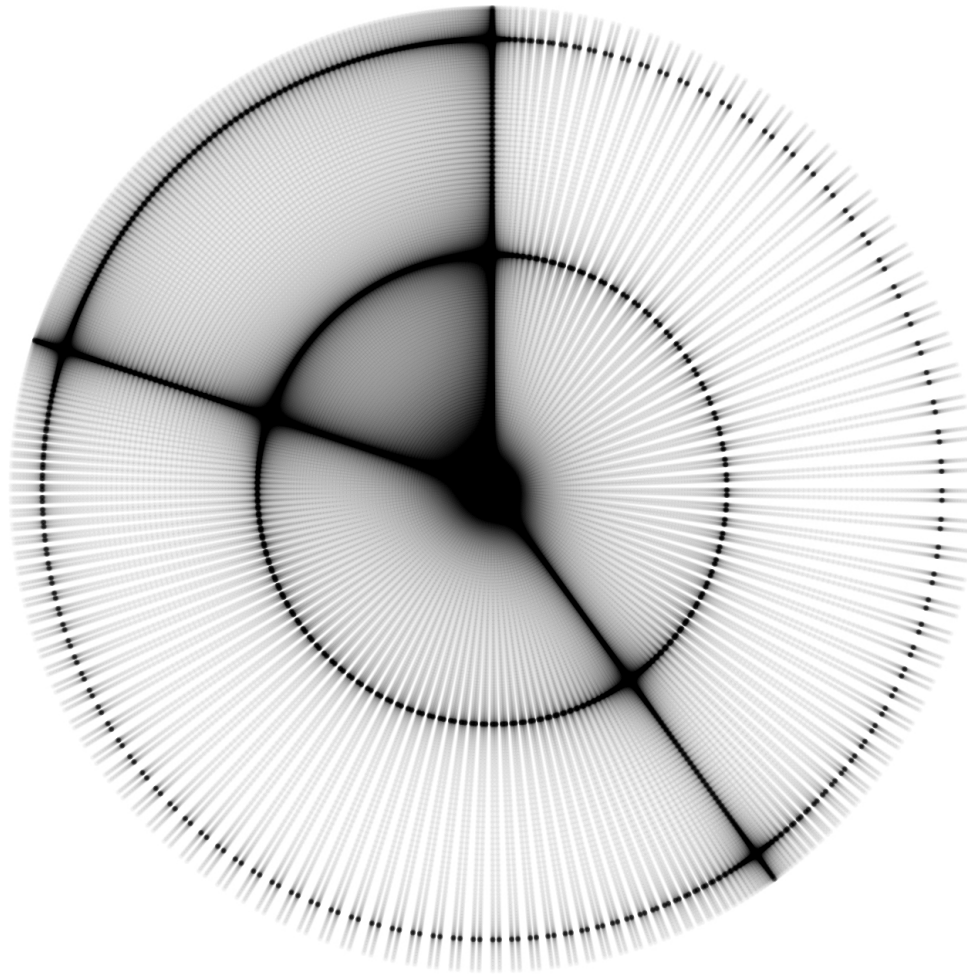
Fig. 1. Generative snail, hex6c. SuperRare, 2020.

addresses and, ultimately, informs the artworks' cultural value through an act of interpretation that transcends the very qualities analysed, often resulting in an increase in the works' price as well. In blockchain art, this specific information results from the sensible observations of experts capable of posing themselves at the intersection of art and technology and, most importantly, effectively share their findings. Besides having an art background, such experts must be well acquainted with the challenges and novelties of the context where they operate and where
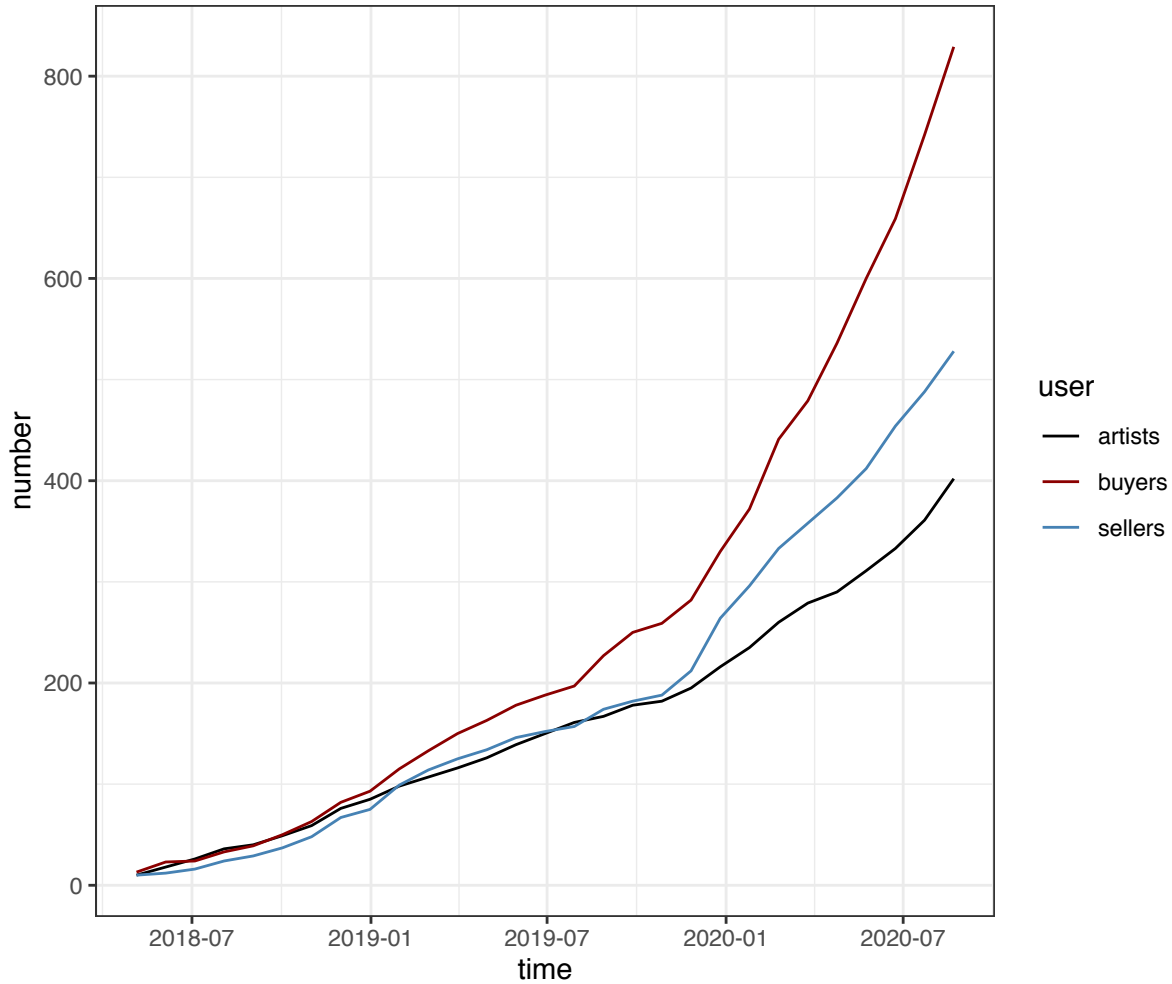
Fig. 2. Cumulative number of unique users (artists, buyers and sellers) per month on gallery SuperRare since its beginning.

the artworks they study are presented and traded, if not directly created. In particular, art experts must face the facets of volume, velocity, variety and strong ties to currency of blockchain art (more below). Thanks to their analysis, a selection of blockchain artworks is made more accessible to the general public, raising awareness and engagement also among those whose interest in art might not be strictly economic. In other words, art experts enhance visibility, foster common recognition and debate in the arts field; in blockchain art, they magnify the impact of certain works on generic viewers and introduce them to this new genre, favoring their cultural return. Left alone the case of financial speculations, cultural significance and reputation are key to arts' economic return too.

As for the *data mined information* of the considered model, we assume a general setting in which artworks are created by artists and displayed in a digital gallery. Artists can set a price for the displayed artworks. Collectors can directly buy the artwork at the set price or make an offer (a bid) for an artwork. Artists can accept the highest

bid for a listed artwork. When sold, the artwork remains tradable on the secondary market of the gallery. In our view, the first-class citizen in art is the artwork, the creativity product of artists that collectors long avidly. Hence, we will mainly focus on artworks, and indirectly on artists and collectors. We define a novel method to rate an artwork on a digital gallery and, for the sake of the assessment, we view artists and collectors as bags of artworks: the artist is associated with the set of created artworks, the collector with the set of collected artworks.

The paper is organized as follows. In Sections 2 and 3 we delve into the art and data mined components of our framework. The limitations of our model are outlined in Section 4. Finally, Section 5 discusses some use cases of the informed art review model.

2 ART MINED INFORMATION

Information can be mined starting from an artwork's inherent qualities, always considered by art experts in relation to the context in which such work is created, presented and traded. Art mined information is more associated to the cultural value of a work rather than to its price, although they somewhat feed into each other. In the traditional art market, monetary value derives primarily from the reputation of the artist who made it, while reputation, in turn, is related to the artist's personal network and access to prestigious institutions [6]. Therefore, rather than an artist's craftsmanship or a work's visual qualities, key factors in determining a work's price are its recognition and visibility. In a similar way, cultural value is tied to information and accessibility as well. In fact, especially regarding cultural heritage conservation, accessibility is integral to an asset's value and is defined primarily by the ability of such asset to convey information to the widest range of people. Therefore, effective communication of information is critical to the definition of value of artistic goods, certainly contributing to the multifaceted system of positive characteristics generally perceived as worth.

This information associated with art derives from an act of interpretation: by drawing from the intrinsic qualities of the artworks at stake, carefully considering their historic significance, the relationship with the time-space context in which they are created and mediating between personal and collective resonances, art experts can produce and share meaningful material that relates to and, ultimately, informs the works' cultural relevance. Among the professionals involved in the artistic field, we will focus on art curators as they hold both an active and impartial role producing art-related content, creating the concrete chance for such art to be accessible first-hand to the public and dealing primarily with the cultural value of art rather than its price [5, 11]. Curators can function as *interpretive philosophers* [17], if not as artists themselves, shading new light on the works they analyse and informing their fruition. In fact, if recognition and visibility are key factors in determining both monetary and cultural value, curated exhibitions are an ideal means to increase the exhibited art's potential. In the traditional art scene, exhibiting art entails expensive and time-consuming activities mainly related to logistics and catalog production. While some activities remain the same, the context in which an exhibition can be developed and shared presents radical changes when it comes to blockchain art.

Blockchain art, or crypto art [10], identifies digitized or digitally native artworks, typically short animations, whose scarcity and provenance are intrinsically proven by their univocal association with tokens, namely, NFTs (Non-Fungible Tokens), secured on the Ethereum blockchain. The context in which such art is showed, shared, discussed and traded – if not directly created (see dada.nyc) – presents significant novelties in relation to curatorial action and discourse. Crypto art galleries, such as SuperRare, KnownOrigin, AsyncArt and MakersPlace, are increasingly concerned with the organization of events and exhibitions that transcend their web page, creating suitable venues for their collection's display in virtual reality worlds such as Cryptovoxels and Decentraland, hosting talks and guided tours and fostering dialogue. In such spaces, exhibition designs and buildings do not necessarily mimic real-world scenarios, given the new possibilities the metaverse provides in terms of artworks arrangement, scale customization, and freedom to shape and navigate the space. Moreover, these events are free of charge and usually open to anyone with an internet connection (Cryptovoxels) and digital wallet (Decentraland).

Thus, in the digital space, accessibility might present technology- or awareness-related barriers, while in real life the audience might experience more stringent economic and temporal issues instead. However, alongside real-time accessibility, blockchain art presents new challenges as well.

As the crypto art market keeps growing, some of the top crypto art galleries had to face overwhelming numbers of artists trying to submit their art to them. Free access and unrestrained production might still work within a small community, where the limited number of actors involved assures a certain degree of manageability and control against forgery. Now most galleries present guidelines against overproduction and copyright infringement while issuing market reports and spotlight articles on certain art pieces, creators or collections. Whether in a curated or free-access model, it is apparent that the *volume* of crypto art is one of its main characteristics. While some raise concerns regarding the possible consequences of an inflated digital art market, others are advocates of abundance as a means for artists to improve while not necessarily damaging their demand [4]. Yet, in a society overwhelmed by visual stimuli and messages per se, the number of works continuously issued challenges the viewer's attention, possibly resulting in a partial, if not poor, appreciation of them and hence posing an issue of visibility. Within the Informed Art Review frame we propose, accompanying artworks with art mined information would help a properly contextualized consideration of such works and their intrinsic qualities, prompting subjective interpretations and debate.

Strikingly enough, the great volume of crypto artworks produced and tokenized became a challenge for blockchain-based platforms in just over two years, as most of them were launched in Spring 2018. This highlights crypto art's *velocity*, which again might represent an issue for the proper fruition of art in terms of both visibility and recognition. Even the communication related to blockchain artworks, sales and auctions is rapid, with the risk of obliterating "old" information within seconds from its publication. The crypto community typically shares art views and news via Twitter, privileging fast, incisive communication over dense texts. While there are noticeable exceptions, as some artists and collectors autonomously provide insights into their own practice, still they might be somewhat biased by personal interest or unable to reach as wide a public as curators could. Moreover, thanks to their experience in mediating between the work and the audience, curators can be more effective considering that most people are not necessarily acquainted with the matter at hand.

As an agile ecosystem of written and visual information, the crypto community offers a wonderful primal broth where reciprocal contaminations of ideas, techniques and even styles can happen. In fact, besides its hard-to-process volume and speed, crypto artworks are characterized by extreme *variety*. On a technological level, most recent works seem to show an increase in complexity. The platforms themselves currently support heavier, bigger files, and from still images, crypto art soon started privileging short animations and videos with sound and even 3D objects. As for techniques and practices, some crypto artworks proceed from tangible works, sometimes enhanced through augmented reality, some have been directly 3D-modelled, sculpted in virtual reality, or even generated by leveraging neural networks or glitch accidents. Interactive works are on the rise, possibly foreseeing the convergence between the worlds of blockchain art and gaming, and some platforms allow to create, own and inform crypto art collectively. Regarding authorship and reciprocal endorsement, crypto art is an extremely collaborative genre, so much so that earlier this year platforms such as SuperRare and KnownOrigin implemented mechanisms of fractioned reward for collective works following the community's demands. Even neural networks are increasingly involved in the creative process, possibly prefiguring a new definition of co-authorship between human and machine. The wide array of influences informing blockchain art's subject matter span from art history masterpieces (such as Leonardo da Vinci's) or currents (conceptual or generative art) to the milestones of the history of Ethereum blockchain – despite it beginning just over five years ago – to current issues like Black Lives Matter (BLM). If compared to non-tokenized contemporary art, a stronger taste for (blockchain) technology can be sensed: coming from a rather circumscribed community, crypto art is memetic and highly self-referential too [3].

According to curator and AI specialist Luba Elliott, *"aside from an integrated knowledge of art history, an informed critique of the field of digital art may now require intimate familiarity with emerging technical features, an anthropological perspective on the social implications of these tools, and even an astute awareness of the global political situation"* [12]. We argue that when considering blockchain art, its volume, velocity and variety – akin to big data – are crucial characteristics to be taken into account alongside its integral connection to currency. As we saw, crypto art is a (non-fungible) token, this meaning that on the blockchain, in most cases, an artwork is made of the same immaterial *substance* money is made of. An example of the correlation between non-fungible tokens and currency tokens can be found in Rarible, an NFT marketplace still allowing unrestrained access and total freedom to tokenize works. Interestingly, the platform's reputation was not that of a quality-driven one, and it was excluded from the art discourse until its recent implementation of economic rewards (the token RARI) for those owning and trading non-fungible tokens. When their social currency quotation raised, this injection of liquidity managed to raise interest in the platform too, with some affirmed crypto artists starting trading through it shortly after. To counterbalance this case, the relation between crypto art and currency might find in dada.nyc a virtuous example. This platform currently advocates for the adoption of a shared-economy model, where extrinsic rewards are substituted by intrinsic motivation, favoring collective benefits over private, somewhat speculative ones [16].

Still, economic interests seem to be a significant drive in the context of blockchain art, with artists and collectors representing the main actors in the space. Besides personal expression and art appreciation, these actors are tied to money too. Artists in particular cannot escape the dynamics of visibility and while some are experienced self-promoters, others might be less effective communicators and remain overlooked. As a matter of fact, the true issue of the crypto community is the lack of general public, intended as people with no economic return in experiencing art, who follow its evolution for no reason other than cultural enrichment and personal growth. Perhaps, given our generalized *onlife* condition, which is, the indissoluble blend of online and offline experiences that constitute our daily existence, crypto art might soon speak more directly to the contemporary audience, and especially to the youngest, digitally native generations. The coronavirus pandemic has only accelerated an already existing tendency to digitize our reality and social activities, included artistic fruition and trade. While it does not solve the problem of generalized appreciation, art mined information would certainly help the transition of a more traditional art public towards the crypto realms.

To integrate a more accessible way to read the art for such audience might have been the reason why digital artists and platforms are now on the hunt for curators and art experts to support building a narrative around the artworks. To curate is to bridge a gap between crypto art and artists and the general public, while providing greater accessibility to the subject of art and technology as an enjoyable and memorable experience. Considered crypto art's volume, velocity, variety and strong ties to currency, curators contribute in temporarily suspending the flux of production and fruition/monetisation of art; through sharing art mined information, they help give each art piece the proper space for it to breathe, engage with the viewers and, ultimately, prove its relevance in terms of cultural value. Interestingly enough, we could recently witness a swift increase of the initial artworks' market price and artists' quotations which, in some cases, occurred on the back of a curatorial insight. When a curator or art expert invests time in studying and sharing information on a certain art genre, artist series or single work, the assets tend to get noticed, often being perceived as a valuable form of investment as well.

Although curatorial views might seem at odds with the crypto community decentralized spirit, art mined information helps create a context for art to be enjoyed and understood by the audience, which is paramount for meaningful engagement with the arts and culture, often prompting both an economic and cultural reward. Our intellectual freedom is founded on owning and increasing our personal culture, and art and science lay at its core. While science tries to solve questions, art is all the more meaningful when it helps raising new ones, stimulating curiosity, dialogue and the thriving of human creativity. Which is in itself *invaluable*.

3 DATA MINED INFORMATION

Information can be also mined from historical data on trades of an artwork, if available. We assume a general setting in which artworks are created by artists while collectors can directly buy the artwork at the set price or make an offer (a bid) for it. Sold artworks remain tradable on the secondary market. As said above, the focus of our rating system is on artworks; different units like artists, collectors, and even entire galleries are collections of artworks and can be assessed in terms of the artworks they contain. In this setting, there are two major signals of market success for an artwork:

- the *bid history*, composed of all bid prices and bidders;
- the *sale history*, made by all sale prices on primary and secondary market.

Specifically, we used the following metrics to assess the bid and sale history of an artwork:

- *sell volume* (α): the sum of all sale prices on primary and secondary market made by the artwork;
- *bid volume* (β): the sum of the *largest* bid prices received by the artwork from each bidder;
- *number of bids* (γ): the *total* number of bids received by the artwork;
- *number of bidders* (δ): the number of *different* bidders that have bid for the artwork.

For example, suppose the bid and sale history of an artwork is as follows:

(1) bid of 1 from A;
(2) bid of 2 from B;
(3) bid of 3 from A;
(4) bid of 4 from B;
(5) bid of 5 from C;
(6) sale for 5 to C;
(7) bid of 6 from A;
(8) sale for 6 to A.

Here, collector A is willing to pay 6 (their largest bid) for the artwork, collector B would pay 4, and collector C would spend 5. Hence, the sum of largest bids on the artwork is $\beta = 6 + 4 + 5 = 15$ and represents a sort of *open interest* for the piece. The total number of bids is $\gamma = 6$ and the number of different bidders is $\delta = 3$ (A, B and C). The sum of all sales is $\alpha = 5 + 6 = 11$.

We thus define an *artwork rating ρ* for an artwork t as a weighted average of the above four metrics after normalization:

$$\rho(t) = \frac{1}{3} \cdot \frac{\alpha(t)}{\max(\alpha)} + \frac{1}{3} \cdot \frac{\beta(t)}{\max(\beta)} + \frac{1}{6} \cdot \frac{\gamma(t)}{\max(\gamma)} + \frac{1}{6} \cdot \frac{\delta(t)}{\max(\delta)}$$

Given a collection of artworks S, we further define the *cumulative rating σ* of S as:

$$\sigma = \sum_{t \in S} \rho(t)$$

and the *average rating μ* of S as:

$$\mu = \frac{\sigma}{|S|}$$

where $|S|$ is the number of elements of S. Notice that σ depends on the size of the collection S while μ is size-independent.

An important caveat is how to assess the actual price of sales and bids. Since digital artworks are mainly traded in crypto currencies (mainly Ether, the coin of Ethereum blockchain), and these coins are not stable (they

show large variance of the historical prices), we decided to use the price expressed in fiat money (dollars) at the exchange rate of the time of the bid or sale.

3.1 Application

We applied our method to the entire collection of SuperRare crypto art gallery. As of today (24th October, 2020), artists created more than 15,000 digital artworks on SuperRare, with more than 3M$ earned by artists on the primary market and almost 1M$ earned by collectors on the secondary market.

We first computed the artwork rating ρ for all artworks of the collection. Then we assessed artists by the artworks they created. Here, we have two choices. We can assess an artist using the cumulative rating of all artworks tokenized by the artist. This choice, however, favors the most productive artists. Since tokenization is (almost) free when you are a white-listed artist on a gallery, we did not opt for this choice. The second possibility is to assess an artist using the mean of the ratings of all artworks they created. However, different artists create at different rates (there are artists that tokenize a new piece each day and others that mint one new artwork every month) and, moreover, they have different histories (some have long been active in the space while others just landed there). It turns out that the collections of artworks created by the artists are very heterogeneous in size. It is not statistically sound to compare means over samples of sizes that differ largely. Hence, we adopted a *top-n-min-k approach*. Given numbers k and n with $k \geq n \geq 1$:

(1) we select only artists that created at least k pieces;
(2) for them we select the best n artworks according to the artwork rating ρ;
(3) finally, we rate an artist using the mean rating of the n selected artworks.

A high value for n favors artists with a long activity history; on the other hand, a small value for n is inclusive with respect to artists with a short activity history, including emerging ones. We assessed collectors with the same method, considering the collection of artworks they acquired. We set $n = k = 20$ for artists and $n = k = 50$ for collectors. The website ARTRA displays the ratings and rankings for artworks, artists and collectors.

4 LIMITATIONS

We have proposed a blended model for a review of art based on information mined from art by human agents (curators) on top of information mined from market data by automatic agents (algorithms). We are aware that the proposed Informed Art Review model has a number of potential limitations, including the following:

- reviews of curators might be biased because of the (inescapable) limited knowledge of humans; this limitation is particularity relevant in view of the variety of crypto art in terms of different styles and cutting-edge technologies used to create artworks;
- the work of human curators does not scale to large numbers of artworks (as opposed to that of automatic agents); the limit of art that a human curator can review in a unit of time is soon reached, in particular considering the increasing volume and velocity of crypto art;
- also the information mined by algorithms might be influenced (and biased) by the possibly limited knowledge of collectors that cast the bids and sales on marketplaces;
- finally, the artwork rating method we proposed might penalize young artworks missing a long sale history or those artworks that are acquired and then stored in art vaults by collectors with strong hands, and hence never re-sold on the secondary market.

In the following we expand on the last limitation. An important facet of an artwork is the artist that created it. One might consider assessing each artist using the very same rating of the artworks he or she created and then feed the rating method for an artwork with this additional parameter. However, this creates the following feedback loop: the artwork score depends on its creator's score, which in turn depends on the scores of the artworks he or she created. Besides this technical problem, the inclusion of an artist's score in the rating for

an artwork has pros and cons. For instance, suppose a foresighted collector scouts and acquires for a few cents the artworks of an emerging artist who eventually becomes a blue chip. If the collector has strong hands and holds the collected artworks, the sale (and possibly bid) history of the collected artworks is limited, and hence these artworks do not increase their value in terms of these metrics. This issue is mitigated if we include the rating of the artist in the assessment of the artwork, computed in some meaningful exogenous way. Indeed, as the artist climbs the ranks, their artworks do too. On the other hand, notice that both the bid and sale history already contain, indirectly, the artist facet. An artwork created by a blue-chip artist will reasonably receive more and higher bids and will be sold for higher prices and maybe more times. Hence, including the artist in the assessment of the artwork has the risk of overloading the artist factor and reducing the game competition to the usual suspects. Indeed, our experiments confirm this strong bias.

5 DISCUSSION

Franceschet [8] investigated the overlap of prestige and success in art by inviting a group of art experts and artists to select a small number of artworks that they deemed valuable. They had to choose among the works on display in the crypto art gallery SuperRare. Their selection was then matched with indicators of market success for such works. The research found that prestigious artworks selected by art experts and artists are also successful in the gallery marketplace, revealing an interesting link between prestige and success, despite the early stage of the movement. This academic work inspired the Art for Space online exhibition on the Museum of Contemporary Digital Art (MoCDA). The artworks in this exhibition are a collection of the top ten works selected from the categories of success (handpicked by collectors) and prestige (chosen by curators).

In the Art for Space exhibition both art and data mined information is present. However, in this case, the outcome of the review of curators and the information mined from the market data are only juxtaposed. On the other hand, we foresee a number of use cases in which the careful assessment of art and market are integrated in a synergistic way according to the Informed Art Review model we propose in this contribution:

- a gallery wishes to acquire a piece of art for its collection and is looking for a fair estimation of the artwork;
- an auction house needs an estimation of a piece of art in view of an incoming auction;
- a collector wants to insure their art collection or make a will: in both cases they need a rating of the collection;
- an investor wants to diversify investments in the field of art and hopes to identify a set of art pieces with potential optimal return on investment (ROI);
- an artist longs for an assessment of an artwork they created in order to fix the reserve price for an incoming auction;
- a notable collector or an important artist yearn for a scrupulous evaluation of their art collection in order to mint a new crypto currency backed by their collection[1].

6 ACKNOWLEDGMENTS

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