Algomy: Predicting ALGO Price

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Abstract

This Paper introduces Algomy, a machine learning software that predicts the price of ALGO, the Algorand cryptocurrency. First, this Paper discusses the Algorand blockchain from a tokenomics perspective. Second, it discusses the background behind Algomy, including analysis of information theory and software implementation. Finally, this Paper describes the machine learning techniques applied and the results from Algomy, which predict the future price trajectory of ALGO.

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Introduction

Alchemy is a process by which materials are converted to gold.[2] Interestingly ALGO, the Algorand cryptocurrency, has returned profits at a much higher rate than gold,[3] with ALGO outperforming gold by ~443.77% over the past year alone.[4] Along with these great gains, the volatility of digital assets remains turbulent. As such, this Paper introduces a new technology for navigating uncertain asset pricing in decentralized finance (DeFi). Thus, similar to the way in which alchemy is a process for converting any object to gold,[5] Algomy is a process for converting digital asset trades to profit by predicting the price and optimizing purchase time.

With high risk comes high reward, but risk also scares off many investors. Volatility in the price of ALGO is powerful enough that investors may gain as much as 114.28% or lose as much as 47.22% of their investment in a single week.[6] This creates uncertainty for investors, as well as risks for the cryptocurrency market because sudden swings can have detrimental impacts for decentralized economic ecosystems. One major cause for the historically broad volatilities is erratic asset speculation.

Market speculators and large index holders often induce artificial trading activity. One of the principal problems with investing in cryptocurrencies is speculative asset allocation. However, not all investments in cryptocurrency are speculative. In fact, tactical investments may be based on meticulous mathematical mechanics that near determinism. Algomy is designed as a solution to the speculation problem for ALGO. By predicting the future price of the digital asset, Algomy allows investors to reach an informed and non-speculative decision about the asset's current and future value.

This Paper introduces Algomy, a machine learning algorithm that predicts the price of ALGO. First, it introduces Algorand and delves into traditional financial concepts, such as volatility, that apply to the cryptocurrency market as a whole. Second, it discusses the theoretical background behind Algomy, including the information theory foundations and the technologies chosen to implement them. Finally, this paper describes the data, modelling techniques, and results from Algomy which predict the future price trajectory of ALGO.

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[2] Marcos Martinon-Torres, University College London, The Archaeology of Alchemy and Chemistry in the Early Modern World: An Afterthought Archaeology International 15 (December 2012), DOI:10.5334/ai.1508. *See also* Keyser, Paul T. Alchemy in the Ancient World: From Science to Magic. Illinois Classical Studies 15(2): 353-372, 358 (1990). (In the ancient world, alchemy was a practice of natural philosophy. People were attracted to the potential of turning ordinary objects to gold because it promised limitless riches.)

[3] Gold has an estimated net value annual value of -7.56% measured on October 1, 2021 at 12:36 PM (PT).

[4] Algorand price measured on October 1, 2021 at 12:27 PM (PT), yielding annual return of ~436.21%.

[5] Alchemy is an ancient and mythical process by which materials are converted to gold. *See* Marcos Martinon-Torres, University College London, The Archaeology of Alchemy and Chemistry in the Early Modern World: An Afterthought Archaeology International 15 (December 2012), DOI:10.5334/ai.1508. *See also* Keyser, Paul T. Alchemy in the Ancient World: From Science to Magic. Illinois Classical Studies 15(2): 353-372, 358 (1990). (In the ancient world, alchemy was a practice of natural philosophy. People were attracted to the potential of turning ordinary objects to gold because it promised limitless riches.)

[6] For example, on April 17, 2021, at 1:30PM, ALGO was trading on Coinbase at $1.80 and on April 22, 2021 at 7:00PM ALGO was trading at $0.95. Additionally, on September 11, 2021, at 11:00AM ALGO was trading at $1.19 and on September 12, 2021 at 5:00PM ALGO was trading at $2.55.

I. Algorand

Blockchains are decentralized databases, which are maintained by global computer networks. The design of a blockchain network consists of a series of computers called nodes, which are connected via the Internet and maintain a record of transactions called a ledger.[7] According to scholar, Primavera De Filippi, "blockchain technology constitutes a new infrastructure for the storage of data and the management of software applications, decreasing the need for centralized middlemen."[8] As an active architecture, a blockchain is a distributed ledger which records transactions between parties across the Internet.[9]

There are several problems with the legacy blockchains, such as Bitcoin. Most notably, proof-of-work blockchains lack both efficiency and scalability due to their reliance on computing power. Algorand evolved to solve problems in the legacy blockchains and has captured a last-mover advantage in the market. The relationship between Bitcoin and Algorand is analogous to that of direct and alternating current technologies for electrical power generation. Thomas Edison invented the light bulb with a direct current,[10] but the direct current model was not scalable to supply power across the country and was instead very limited by a radius relative to a power station. By contrast, Nikola Tesla invented an electric generator with an alternating current, which was able to scale by sending electricity a greater distance and to more people.[11]

Like Edison's direct current, Bitcoin was a seminal innovation in the 21st Century, but it is not accessible because the computing power necessary to access the network is too high. Moreover, transactions on the Bitcoin Network are inefficient, preventing it from scaling to widespread use. By contrast, Algorand is accessible, scalable, and has captured the technical edge through a decentralized consensus mechanism and proof-of-stake technology. Algorand's scalable technology will allow it to power financial systems for generations to come, similar to the way in which Tesla's alternating current powers the world today, more than a century later.

Algorand is a proof-of-stake blockchain, which improves security and power efficiency across blockchain networks by eliminating miners and validating transactions proportional to ownership.[12] In other words, proof-of-stake blockchains are better than proof-of-work blockchains by an order-of-magnitude measured according to computing costs, energy expenses,

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[7] David Mills et al., Distributed Ledger Technology in Payments, Clearing, and Settlement 10, Fed. Reserve Bd. Fin. & Econ. Discussion Series, Working Paper No. 95 (2016). *See also* Elona Marku, et al., General Purpose Technology: The Blockchain Domain (2019). *See also* Ekaterina Gonina, A Framework for Productive, Efficient and Portable Parallel Computing A dissertation submitted in partial satisfaction of the requirements for the degree of Doctor of Philosophy (2013). *See also* Elona Marku, et al., General Purpose Technology: The Blockchain Domain (2019).

[8] PRIMAVERA DE FILIPPI, AARON WRIGHT, BLOCKCHAIN AND THE LAW 33 (2018).

[9] The Internet has two fundamental layers, the Transmission Control Protocol (TCP), which manages packet assembly, and the Internet Protocol (IP) which passes packets from one computer to another. Blockchain networks rely on TCP and IP to operate and can be viewed as application protocols, sitting on top of the transport layer.

[10] U.S. Patent No. 219,628 to Edison, Electric-Light (September 16, 1879).

[11] U.S. Patent No. 381,69, to Tesla, Electro Magnetic Motor (May 1, 1888).

[12] Yossi Gilad, et al., Algorand: Scaling Byzantine Agreements for Cryptocurrencies, 53 (2017). *See also* Emily Wells, et al., Blockchain Benefits and Risks, The Military Engineer, 62 (2018). ("Blockchain technologies are being considered as solutions to various cybersecurity and information technology threats and challenges.")

and predictable profit.[13] In fact, Algorand is the most technically advanced and sophisticated blockchain technology, utilizing advanced post-quantum cryptographic mechanisms and zero-knowledge proofs (ZKPs) for everyday transactions across its peer-to-peer network.

A. Transactions

The peer-to-peer network developed to solve the double spending problem, where the same digital token is spent more than once.[14] In essence, a peer-to-peer network is a network structure in which all members have equal opportunity and obligations toward one another.[15] By maintaining a record of all transactions, the peer-to-peer network ensures all transactions are validated based on upon the record of previous transactions. On Algorand, transactions are data structures encoding the transfer of value between participants in a system using ZKPs.[16]

A key innovation for the Algorand blockchain is that transaction fees are *de minimis*, < $0.01 per transaction. The low transaction fees are possible because Algorand uses a proof-of-stake mechanism to validate blocks instead of a proof-of-work. The proof-of-stake mechanism incorporates the timestamp signature used in proof-of-work blockchains,[17] but relies on ZKPs instead of hashing to validate transaction. As such, Algorand's pure proof-of-stake model gives it a significant advantage over traditional proof-of-work blockchains and corresponding cryptocurrencies.

B. Cryptocurrency

Cryptocurrencies are digital currency tokens, created with blockchain technologies. In the Bitcoin White Paper, Satoshi Nakamoto defines an electronic coin as "a chain of digital signatures."[18] In short, cryptocurrencies may be defined as a collection of concepts and technologies forming the basis for a digital economy. Cryptocurrencies, perhaps now more than ever, are as important as financial instruments as they are for their traditional purpose in facilitating digital asset transfers.

[13] For example, one important technical problem Algorand solves specifically is the majority override attack, a cryptographic hack which results from a competitive computing advantage in mining.
[14] Satoshi Nakamoto, Bitcoin: A Peer-to-Peer Electronic Cash System 8 (2008).
[15] Satoshi Nakamoto, Bitcoin: A Peer-to-Peer Electronic Cash System 1 (2008).
[16] Fabrice Benhamouda, et al., Efficient Zero-Knowledge Proofs for Commitments from Learning with Errors over Rings, ESORICS (2015).
[17] Tal Rabin, A Simplified Approach to Threshold and Proactive RSA, 90, Annual International Cryptology Conference (1998). ("Proactive signature schemes use threshold signature schemes as the basis but drastically reduce the assumption concerning failures.") *See also* Scott J. Shackelford, Steve Myers, Block-by-Block: Leveraging the Power of Blockchain Technology to Build Trust and Promote Cyber Peace, 19 Yale J. L. & Tech. 334, 351 (2017). *See also* Tal Rabin, Verifiable Secret Sharing and Multiparty Protocols with Honest Majority (1989).
[18] Satoshi Nakamoto, Bitcoin: A Peer-to-Peer Electronic Cash System 2 (2008).

Figure 1

Figure 1 graphs the price of ALGO from September 18, 2019, to September 18, 2021. ALGO is unique in that, the currency rewards holders with approximately 6.00% APY returns, which may be received every time an account engages in an ALGO transaction.[19]

According to some, at its core, money is a good assuming the role of an accepted medium of exchange.[20] As cryptocurrencies have become more mainstream, they have taken a life of their own, and now make up a significant proportion of both the digital economy and traditional financial investments. According to recent research, over 13.00% of Americans invested in cryptocurrencies over the past fiscal year, compared to 24.00% in the stock market.[21] As of September 2021, the cryptocurrency market exceeds $2.0 trillion, with ALGO specifically at a market capitalization of approximately $12.0 billion.[22]

Cryptocurrency transactions are chiefly facilitated with smart contracts on the Algorand blockchain. A smart contract is a computer program which automatically executes, transferring cryptocurrency. According to the revered cryptographer, Fabrice Benhamouda, "[n]early all blockchain architectures support the notion of smart contracts, namely a programmable application logic that is invoked for every transaction."[23] Computationally, Algorand smart contracts are programs that are logically executed on a blockchain without a central oversight.[24]

[19] Jing Chen, Silvio Micali, Algorand 67 (2017), arXiv:1607.01341.
[20] SAIFEDEAN AMMOUS, THE BITCOIN STANDARD 1 (2018).
[21] NORC, More Than One in Ten Americans Surveyed Invest in Cryptocurrencies, University of Chicago (2021).
[22] Measured on October 4, 12:21PM PT at $12,155,576,279.00.
[23] Fabrice Benhamouda, et al., Supporting Private Data on Hyperledger Fabric with Secure Multiparty Computation, IBM Journal of Research and Development (April 2019), DOI: 10.1147/JRD.2019.2913621.
[24] Massimo Bartoletti, A formal model of Algorand smart contracts, 1 (2021), https://arxiv.org/abs/2009.12140v3. ("Smart contracts are agreements between two or more parties that are automatically enforced without trusted intermediaries.")

There are robust regulatory restraints relating to cryptocurrency evolving, including securities regulation, taxation considerations, and criminal activity and uses. Indeed, the United States Federal Reserve states compliance with the Bank Secrecy Act and anti-money-laundering requirements as two of its chief concerns relating to blockchain regulation.[25] Still, many institutionalized investment firms are refraining from offering digital asset services to customers, claiming there is still relatively minimal regulatory guidance causing high volatility.[26]

C. Volatility

Volatility is a measure of statistical change in value. Investing in cryptocurrencies and other digital assets often comes with high risk due to the high volatility present in the underlying markets.[27] As such, investors wishing to allocate capital to digital assets such as cryptocurrencies and NFTs are often limited to high-risk trades. This may cause significant financial loss for individual investors because of inefficient trading, a lack of reliable information, expensive fees, and a lack of security. Thus, DeFi is full of uncertainty for investors[28] because there are large risks due to the potential for the cryptocurrency market to suddenly swing in a way that may have detrimental impacts for new investors.

There have been multiple suggested reasons for the volatility present in the market for digital assets, ranging from a lack of fiscal regulation to market speculators and whales implementing pump and dump market manipulation schemes. All the while, the average investor has no access to the monetary and computing resources possessed by most investment funds and index holders. As such, individuals trading in digital assets often suffer from innate volatility issues that plague the blockchain community. They have no chance of competing with investment funds or market speculators, as they lack the ability to form monetary pools, which provide advantages resulting from economies of scale such as security and reduced risk. All of this contributes to a significant power disparity between institutionalized funds and the average investor.

The dominance of large holders in the digital asset market contributes to a culture of hierarchical control, which typically leads to allocations and funds controlled by a small team of institutional decision makers. This framework stifles innovation and development, as well as the personal autonomy of network participants. Meanwhile, individual investors are lacking a secure storage source for digital assets that is protected from volatility. This problem leaves small investors without a stable way to store digital assets and be guaranteed marginal returns over time.

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[25] David Mills et al., Distributed Ledger Technology in Payments, Clearing, and Settlement Fed. Reserve Bd. Fin. & Econ. Discussion Series, Working Paper No. 95, 30 (2016). *See also* Veronica Root, The Compliance Process, 94 IND. L.J. 203, 214 (2019), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3151893. *See also* Veronica Root, More Meaningful Ethics, U. CHI. L. REV. Online, 9 (2019), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3474344.
[26] Jamie Dimon, Letter to Shareholders, J.P. Morgan Chase, 43 (2020).
[27] With high risk comes high reward for many, while other investors may suffer substantial financial loss.
[28] Olesya Grishchenko, et al., Measuring Inflation Anchoring and Uncertainty: US and Euro Area Comparison, Federal Reserve Board, Finance and Economics Discussion Series 2017-102, 8 (2017). *See also* S. Muzzioli, H. Reynaerts, American option pricing with imprecise risk-neutral probabilities, International Journal of Approximate Reasoning, 49, 140-147, 141 (2008).

II. Autonomy

Autonomy refers to machines which may operate without human intervention or command to achieve goals. In other words, autonomy is a process by which tasks or behaviors are mechanized. This Part integrates autonomy for DeFi applications on Algorand, specifically to forecast the future price of Algo. Key facets of automation for financial forecasting include reverse engineering, data science, and deep learning.

A. Reverse Engineering

Individual investors in digital asset markets suffer from a lack of autonomy and efficiency regarding their investment decisions. Thus, a democratized autonomous process combats and alleviate this issue. An autonomous process refers to an algorithm that can guarantee both efficiency and effectiveness over a long period of time. When applied to traditional computational problems, autonomous processes typically develop through reverse engineering existing architectures.

Reverse engineering is a process by which inventions are deconstructed to fundamental principles and reimagined anew.[29] Start from the principle that all inventions or ideas can be reverse engineered, and improved spawning new patentable creations.[30] Now, consider the optimal investment machine, one which can accurately predict the price of assets in the future. Indeed, the key reason risk exists for investors is because the future price of assets is, at least in part, uncertain.

To predict the future price of assets, it is necessary to reverse engineer a machine which accurately forecasts financial data. It is easy to imagine such a predictive machine, including its inputs and outputs, but building the system is much more complex. As such, reverse engineering is both a technical and computational skill, requiring the marriage of minds of inventors and computer scientists. These skills create a flexible leverage which exploits the attenuating bonds between logical syntax and linguistic semantics to generate a valuable and formalized result.

Reverse engineering is an efficient recreation of a method or operation through fundamental analysis. In relation to investments, an autonomous process can be created by reverse engineering the processes large index funds use to make decisions. This autonomous algorithm may be open source, in part or in whole, thus helping to democratize investments in the digital asset sector.[31] More specifically, reverse engineering allows information technology that was once secluded to have an impact in a variety of sectors, allowing for new inventions that build and expand upon previous processes. To advance this initiative, data is the most necessary asset.

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[29] Jeanne C. Fromer, *Machines as the New Oompa-Loompas: Trade Secrecy, the Cloud, Machine Learning, and Automation*, N.Y.U. L.R., 706, 717 (2019), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3359746.
[30] 35 U.S.C. § 101 (2021).
[31] Saule T. Omarova, The People's Ledger: How to Democratize Money and Finance the Economy, Cornell Legal Studies Research Paper No. 20-45, Vanderbilt Law Review (2021). *See also* Saule T. Omarova, New Tech v. New Deal: Fintech As A Systemic Phenomenon, 36 Yale Journal on Regulation 735 (2019).

B. Data Science

Data science is a systemic approach toward information theory. The process by which data is analyzed to create value for industrial application, data science drives innovation and efficiency for business intelligence. Both centralized financial institutions and DeFi applications run on data, which are the foundational units for blockchain technology. Indeed, blockchain is above all else, an information technology facilitating data transfer across a public ledger.

Most of the time spent developing data science applications is focused during the preprocessing stage. During this initial phase, machine learning[32] researchers gather, organize, and aggregate data for statistical analysis with neural networks.[33] The types of data neural networks process vary. For example, in the context of Algomy, the data gathered includes a variety of public data from the Internet about cryptocurrencies.

One important aspect of Algomy was creating a way to clean data for processing. Data cleaning refers to the process by which data are synthesized and structured to reduce error and generate reliable results. To facilitate cleaning in an efficient manner, much of the Algomy software includes automated techniques for cleaning data to generate a preprocessed database.

The goal for a particular application or system largely defines the data's organizational structure. In other words, the problem's definition guides the way in which data are obtained and preprocessed. For example, in Algomy, which is being developed predictive purposes, the data may be labeled with positive and negative instances of an occurrence to support a supervised learning model. Supervised learning refers to a machine learning model which uses structured and labeled to data to make predictions or generalizations about future data instances.

C. Deep Learning

Deep learning is a type of machine learning concerned with acquiring knowledge from large amounts of data. Rina Dechter first introduced the term deep learning in the year 1986.[34] But, the technology's technical roots date back to the middle of the twentieth century.[35] The deep learning process is inspired by the neurological structures found in the human brain.[36] Each neuron in the brain is connected to other neurons through synapses. Similarly, artificial neurons

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[32] Emily Berman, *A Government of Laws and Not of Machines*, 98 B.U. L. REV. 1277, 1278 (2018), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3098995. (Machine learning is a strand of artificial intelligence that sits at the intersection of computer science, statistics, and mathematics, and it is changing the world.)

[33] Fang Liu, Assessment of Bayesian Expected Power via Bayesian Bootstrap 14 (2017), https://arxiv.org/abs/1705.04366. ("The bootstrap-based procedures will appeal to non-Bayesian practitioners given their analytical and computational simplicity and easiness in implementation.")

[34] Rina Dechter, Learning While Searching in Constraint-Satisfaction Problems, AAAI-86 Proceedings (1986). Rina Dechter is a professor of computer science at University of California, Irvine.

[35] Frank Rosenblatt, The Perceptron: A Perceiving and Recognizing Automation, Cornell Aeronautical Laboratory, Report No. 85-460-1 (1957). In 1957, Frank Rosenblatt published an algorithm that automatically learned the optimal weight coefficients for an artificial neuron – the perceptron. Rosenblatt's perceptron is still the foundation for most artificial neurons today. *See also* C.E. Shannon, *A Mathematical Theory of Communication*, Bell Systems Technical Journal 8 (1948).

[36] Both artificial and biological neurons receive input from various sources and map input information to a single output value.

model the strength of synapses with mathematical coefficients. Indeed, neural information transfer in the biological brain inspires the way in which modern deep neural networks operate.[37]

Importantly, learning is a process by which matter rearranges to improve its ability to compute a desired function. In deep learning, the idea is to learn patterns in information, deriving knowledge from data with minimum human contribution.[38] The most common deep learning model is the deep neural network (DNN), which is an organized structure of interconnected neurons. The network's interconnected neurons are modeled with weight coefficients, which are adjusted through a learning process until a model is optimized for performance. Typically, matrix multiplication and partial derivative calculations are the mathematical core for learning algorithms. Importantly, neural networks are universal function approximators, meaning they can approximate any function with desired accuracy.[39]

Every neural network has an input layer and an output layer. And the depth of the model is defined by the number of hidden layers between the input and output layer. For example, a DNN contains many hidden layers between the input and output layer. The number of hidden layers may vary and is dependent on the particular model. Each layer of hidden neurons acts as a feature extractor by providing analysis of slightly more complicated features.[40] But for machines to learn, there must be a way in which matter evolves itself to improve performance.[41]

Backpropagation is a training algorithm for updating the weights in a neural network, improving accuracy over time. In other words, backpropagation is how neural networks learn.[42] Generally, a backpropagation algorithm has three steps: (1) an instance enters the network, flowing forward until the network generates a prediction; (2) the network's error for the prediction is calculated by comparison to the correct output; and (3) the error is propagated back through the network, updating the weights. Technically, backpropagation's central task is training the deep learning program.[43] The algorithm iterates through the network toward a set of weights producing a

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[37] Ava P. Soleimany, et. al., Evidential Deep Learning for Guided Molecular Property Prediction and Discovery, ACS Cent. Sci. 2021, 7, 1356−1367 (2021).

[38] As such, the internet is the driving force behind deep learning strategies because the internet enables humanity to organize and aggregate massive amounts of information. In fact, every day humans create roughly five exabytes of data, as much as civilization created from the dawn of time until the year 1999. For reference, one exabyte is one quintillion, or 10^{18} data bytes.

[39] Since all information can be represented as numbers, the neural network's ability to generalize to new information is a critical component for deep learning.

[40] The layers in a neural network are represented as a matrix, a rectangular array of numbers, symbols, or expressions, arranged in rows and columns. The mathematics for a forward pass —input to output— in a neural network is matrix multiplication.

[41] In other words, the machine must have a method of interacting with its environment that recursively self improves.

[42] Paul John Werbos, THE ROOTS OF BACKPROPAGATION FROM ORDERED DERIVATIVES TO NEURAL NETWORKS AND POLITICAL FORECASTING (1994). In the 1970s and 1980s, researchers developed backpropagation as a way to train neural networks. Paul John Werbos is considered the first person to explore backpropagation through neural networks. By applying a temporal element to the learning process, Werbos showed neural networks iteratively learn through time.

[43] Maria Schuld, et al., Prediction by linear regression on a quantum computer, 1 (2016), https://arxiv.org/abs/1601.07823v2. ("The central problem of machine learning is pattern recognition, in which a machine is supposed to infer from a set of training data how to map new inputs of the same type to corresponding outputs.")

desirable result. After consistent iteration, the network converges, capturing a pattern and allowing the network to generalize about new instances, rather than merely memorizing training data.

Algomy combines blockchain data, a new type of deep neural network, and a backpropagation algorithm to learn to accurately predict the future price of ALGO. The Algomy framework specifically leverages deep learning with a model that improves in predicting the price of Algo over time. This allows Algomy to maintain a competitive advantage over traditional timing strategies, such as dollar cost averaging,[44] for making investments. Furthermore, due to its decentralized framework, Algomy manages to bring the power of deep learning and neural networks to the Internet with a new DeFi protocol.

III. Algomy

Algomy is an autonomous data processor and machine learning algorithm using neural networks to predict the future prices of digital assets. In its initial iteration, Algomy predicts the price of the Algorand native asset, ALGO, Bitcoin (BTC), Ethereum (ETH), and Cardano (ADA).[45] Bitcoin and Ethereum, were included because of their market prevalence as the two largest blockchains.[46] Cardano was included because like Algorand, it also operates on a proof-of-stake blockchain and has seen rapid growth over the past fiscal year.

Algomy relies on open and transparent blockchain data to derive meaningful insights and economic analysis regarding the blockchain tokenomics. A unique feature for blockchain technologies is blockchains are most commonly open source software.[47] The open source movement also provides transparency for the Network. In traditional investments, such as stocks or currencies, the data is masked by corporations and governments. However, on the Algorand Network, most of the information about the Network is available to everyone with access to the Internet. Open innovation on the public ledger is spawning a global and borderless economy.

A. Data

Algomy automatically aggregates data about digital assets from Yahoo Finance, generating an updated set every time it is trained. This eliminates the manual collection of data, thus making

[44] Dollar cost averaging strives to minimize volatility impacts on investments over time through an interval strategy.
[45] The Algomy model was built for interoperability across Algorand, Bitcoin, Ethereum, and Cardano.
[46] Measured by market capitalization.
[47] For example, much of Algorand's software is open sourced under the MIT License. *See* The MIT License, Open Source Initiative (2021). The reason blockchains are designed to be open source is because the technology is intended to decentralize economic transactions. Then, the open source license grants a license to use the technology, while limiting liability for the copyright holder. *See* Typically, the code is protected under copyright law, which includes certain functional elements for the technology. *See* 17 U.S.C. §102. Here, the software code for Algomy may be made open source under the Apache License. Apache License, Version 2.0 (January 2004), http://www.apache.org/licenses/. ("2. Grant of Copyright License. Subject to the terms and conditions of this License, each Contributor hereby grants to You a perpetual, worldwide, non-exclusive, no-charge, royalty-free, irrevocable copyright license to reproduce, prepare Derivative Works of, publicly display, publicly perform, sublicense, and distribute the Work and such Derivative Works in Source or Object form.")

Algomy more computationally efficient. The data is aggregated into a matrix, which makes it ideal for iterating over. Algomy analyzed each cryptocurrency over a 2-year period, starting at Algorand's inception in September 2019 to the present day. Overtime, this data model will be expanded to directly leverage data on the blockchain.

The data was cleaned using a reverse sampling algorithm that automatically replaced not a number (NaN) values with an average of the previous *n* values, where *n* is an arbitrary number than can be selected by the creator. We specifically chose 2 for *n*, meaning that the reverse-sampling algorithm replaced null values with the average of the previous 2 values.

(1) $$d = \begin{cases} b_0 & b_1 & b_2 & b_3 \\ s_0 & s_1 & s_2 & s_3 \\ c_0 & c_1 & c_2 & c_3 \end{cases}$$

(2) $$d = [b_n \oplus s_n \oplus c_n]$$

(3) $$b_n \oplus s_n \oplus c_n = [v_0 \quad \cdots \quad v_{11}]$$

Equation (1), Equation (2), and Equation (3) define the variable allocations for the initial dataset.

(4) $$if \begin{cases} error\ in\ b_n \oplus c_n \oplus s_n \\ replace\ b_n \oplus c_n \oplus s_n \end{cases}$$

(5) $$if \begin{cases} 10 > v_n \in b_n \oplus c_n \oplus s_n \\ v_n = +v_1 \end{cases}$$

Equation (4) and Equation (5) define data cleaning mechanics, which were automated with the Algomy software.

The data are divided into two datasets – the training set and the test set – such that 80.00% of the data are in the training set and 20.00% are in the test set. Each individual data set was first cleaned using an iterative algorithm: for every *k* rows that were blank due to market close times, or holidays, a reverse sampling methodology was used, manipulating the data for *k* – *n*, where n represents the number of days until the last valid market date.[48] This back-sampling generated a robust net dataset that was made up of 12 individual datasets.

B. Methods

For processing, a backpropagation-based neural net was applied, where the weights are updated to reflect predictions and assumptions. To illustrate, consider a simple model where the price of an asset goes by *n*. If the neural network predicted a number *m* with a current weight of *w*, it will then update its weight *w* based on the net error between *n* and *m*. This iterative process allows for continuous improvement in the net accuracy of the neural network, leading to model that

[48] Olga Russakovsky, et al., Best of both worlds: human-machine collaboration for object annotation (2015). (Introducing a model that integrates multiple computer vision models with multiple sources of human input in a Markov Decision Process.)

continuously improves over time. Each price relationship is analyzed using this method, thus creating a model that not only relies on the historical price of ALGO, but may also takes into account the price history of related digital assets, securities, and fiat currencies.

To facilitate the learning process,[49] Algomy utilizes recurrent neural networks (RNNs). An RNN is a neural network tailored for sequential series of information in which the output contributes to its own input.[50] Another way, RNNs are well suited for processing time series data, such as data from daily market metrics.[51] The term recurrent refers to the way in which the network processes information with a dependency on preceding calculations, acting as an artificial memory mechanism.[52] The memory mechanism is inspired by a biological counterpart in the human brain.[53]

As such, RNNs work by strengthening the relationships between certain nodes in the network through a recurrent feed-forward model. Equation (6), Equation (7), and Equation (8) are various models for RNNs.

(6) $$[x_l \quad x_p \quad x_a] \otimes \begin{bmatrix} x_l \\ x_p \\ x_a \end{bmatrix} \oplus \begin{bmatrix} x_l \\ x_p \\ x_a \end{bmatrix} \otimes [x_l \quad x_p \quad x_a]$$

(7) $$[x_l \quad x_p \quad x_a] \oplus \begin{bmatrix} x_l \\ x_p \\ x_a \end{bmatrix} \oplus \begin{bmatrix} x_l \\ x_p \\ x_a \end{bmatrix} \oplus [x_l \quad x_p \quad x_a]$$

(8) $$[x_l \quad x_p \quad x_a] \otimes \begin{bmatrix} x_l \\ x_p \\ x_a \end{bmatrix} \otimes \begin{bmatrix} x_l \\ x_p \\ x_a \end{bmatrix} \otimes [x_l \quad x_p \quad x_a]$$

In general, RNNs are appropriate for problems where specific prior nodes influence later nodes in the network because RNNs process sequences of data one element at a time. The Algomy RNN is novel in that it utilizes a deep convolutional model, rather than a traditional single layer model, to predict the price of ALGO.

The task of updating the network's weights, representing synapses, is solved with brute force. While, the overall technique is called back propagation, which takes in a window size and computes error. Specifically, the network's weights are updated based on the error over each epoch, or iteration, over the dataset. Error is measured using a loss function.

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[49] Michelle Guo, Neural Graph Matching Networks for Fewshot 3D Action Recognition, Stanford University, ECCV (2018).
[50] EUGENE CHARNIAK, INTRODUCTION TO DEEP LEARNING 82 (2018).
[51] Serena Yung, et al., Every Moment Counts: Dense Detailed Labeling of Actions in Complex Videos (2017), https://arxiv.org/abs/1507.05738. *See also* Serena Yeung, et al., End-to-end Learning of Action Detection from Frame Glimpses in Videos (2016).
[52] Layla El Asri, Frames: A Corpus for Adding Memory to Goal Oriented Dialogue Systems (2017), https://arxiv.org/abs/1704.00057.
[53] MOHEB COSTANDI, NEUROPLASTICITY 55 (2016). (In the brain, memories are formed by the strengthening of synaptic connections.)

$$\hat{y} = y_{n+1} \tag{9}$$

$$e^* = \min_e e(y - \hat{y}) \tag{10}$$

Equation (9) defines the relationship for measuring the true value compared to the next predicted value in the time series. Equation (10) is an optimization algorithm for minimizing the difference between the actual and predicted values.

Algomy also makes predictions regarding the volatility of ALGO. This is done by applying statistical methods to the predictions of the closing prices. Specifically, the standard deviation for *k* days was calculated, where *k* represents the total number of days in the period. Then, the volatility was calculated by calculating the average difference between consecutive periods. This methodology was applied both to historical data and predictive data, thereby allowing users to compare the volatility for past data with future data to make decisions at optimal times. A general form of these algorithms was implemented using the TensorFlow machine learning library, [54] which is written in the Python programming language.[55]

Algomy also provides statistical analysis for ALGO, specifically focusing on market indicators such as relative strength index (RSI) and stochastic oscillators. At the end of each training and prediction period, Algomy gives the user a recommendation of future price based on these statistics. This extra data allows the user or investor to make a more meticulous decision. Thus, Algomy is a multi-faceted prediction machine and generates both intelligent and traditional asset analysis.

C. Results

The initial results for Algomy were derived after training and correctly predicted a rise in price for ALGO. Figure 2 illustrates Algomy's initial predictions.

[54] GitHub, TensorFlow (2021), https://github.com/tensorflow.
[55] Guido van Rossum, An Introduction to Python (2001).

Figure 2

The output focused on predicting the closing price for the next month. This particular result shows that the price of ALGO will move upward toward $2.00 in the month of October, eventually moving above it. The results were generated through a prediction function that applied the model generated during training to an attached array with future dates. For this specific iteration, the range was 30 days in advance, although this can be manually adjusted in construction of the time series generator that drives the model.[56]

The results are also supported by sound business logic.[57] As liquidity providers enter the Algorand blockchain, such as TinyMan,[58] it is likely the value of the Algorand Network will grow rapidly. In fact, the Algorand Network will begin to capture much of the value created in Algorand Standard Assets, such as Choice Coin. Liquidity pools create a pricing mechanism to facilitate on-chain trades between assets, which adds value to the Network as a whole, facilitating growth. Thus, the Algo asset should have consistent growth over the next month due to continuous development and the release of new assets.

Algomy also applied its prediction model to forecast volatility for ALGO. The majority inflection points are present when the model predicted a large volatile change in the price of ALGO based on its backpropagation model. Figure 3 represents a logarithmic return for the past

[56] This result confirms many of the current trends based on market movement and traditional investment analysis.
[57] Consider the Ethereum blockchain cryptocurrency, ETH is worth $354.2 billion. Still the Ethereum blockchain is home to more than 4,000 additional assets valued at more than $330.00 billion. In fact, there 48 tokens on Ethereum, in addition to ETH, with a market capitalization in excess of $1.0 billion.
[58] TinyMan is an open source liquidity pool software which will be deployed on the Algorand blockchain in the year 2021.

price volatility of ALGO. Figure 4 represents a logarithmic return for the future price volatility of ALGO.

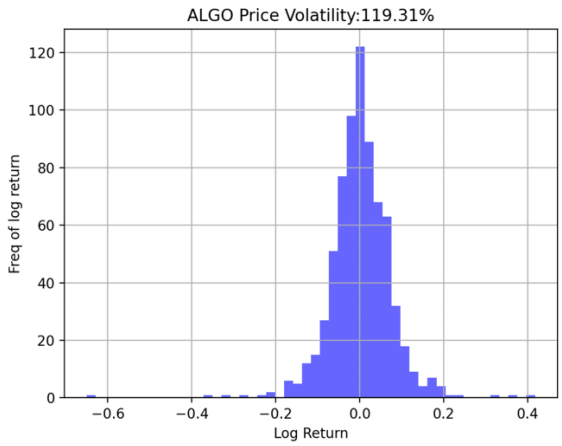

Figure 3

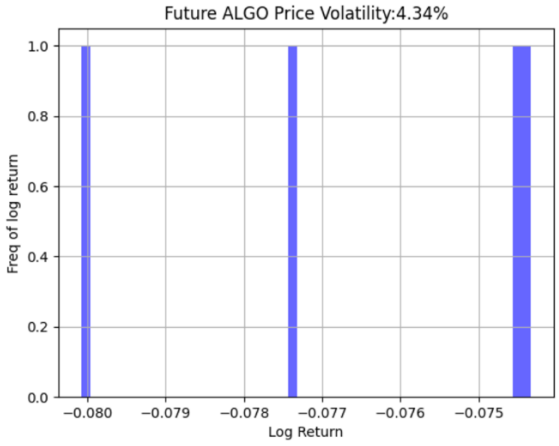

Figure 4

The low volatility found for Algo is based on current market trends and is consistent with the predictions made earlier. The model is generalizable and can be used to predict the volatility of other digital assets such as Bitcoin and Ethereum. A model such as this will be invaluable to the DeFi industry, as it will create a more scalable, efficient, and transparent market.

Conclusion

When most people make investments in digital assets, they often do so with limited information about the asset. As a result, many revert to speculation or randomized processes, such as dollar-cost-averaging, to time investments. But the value of digital assets is not random as some suggest. Rather, the value of digital assets reflects the underlying value deliberately created and captured by a computer network. In the case of ALGO, value is created and captured by a global network of the world's most talented cryptographers, technologists, and entrepreneurs. As such, with a data driven approach to financial analysis, the value is predictable with precision using Algomy.

This Paper reviewed the current state of both the digital asset market and machine learning applications, before introducing Algomy a new technology for predicting the price of ALGO. Part I provided an overview of financial investments in the digital asset sector. Part II analyzed the potential of both machine learning and deep learning in financial market analysis. Finally, Part III presented Algomy as a solution to the speculation problem.

In sum, the Algorand blockchain is facilitating a new financial system.[59] Deep learning technologies are heralded for their ability to stabilize financial markets.[60] At the confluence of Algorand and deep learning, financial forecasting is fostering innovation and inspiring the next generation global economy. Running on cryptographic protocols, ALGO is decentralized, secure, and open to all.[61] The goal for Algomy moving forward is to facilitate the marriage of these technologies to create a more efficient, advanced, and decentralized economy.

[59] S. Micali, et al., A fair protocol for signing contracts, IEEE Transactions on Information Theory (Volume: 36, Issue: 1, Jan. 1990). See also Fabrice Benhamouda and Huijia Lin., Multiparty Reusable Non-Interactive Secure Computation., In TCC 2020 (to appear), https://eprint.iacr.org/2020/221.
[60] Gary Gensler and Lily Bailey Learning and Financial Stability, SSRN 3723132, at 32 (November 1, 2020).
[61] Michel Abdalla, Fabrice Benhamouda, Markulf Kohlweiss and Hendrik Waldner. Decentralizing Inner-Product Functional Encryption. In PKC 2019. https://eprint.iacr.org/2019/020. *See also* Fabrice Benhamouda, et al., Supporting Private Data on Hyperledger Fabric with Secure Multiparty Computation, IBM Journal of Research and Development (April 2019), DOI: 10.1147/JRD.2019.2913621.