Cryptocurrency analysis: Benefits, dangers and price prediction using neural networks

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Abstract: *In this paper we will discuss a hot topic of our decade, cryptocurrency. Firstly, we will assess how currency is defined and works and why the current state of money is not suited to guarantee a safe and stable trajectory in the future. Moreover, we will present the benefits of cryptocurrency in contrast with common forms of currency, along with the dangers that may arise. Lastly, we will construct an artificial neural network model to predict the price trajectory of the most prominent cryptocurrencies up until now, Bitcoin and Ether.*

Keywords: *Cryptocurrency, Bitcoin, Ethereum, price prediction, neural networks, analysis*

1. Introduction

What is the purpose of money? By definition, money exists to act as a medium of exchange between two quantities, material or non-physical that hold approximately similar value. For example, one can pay 20 euros in exchange for a book, a material object, or one can pay 100 euros in exchange for a one year gym membership, which is a non-material quantity but holds proportional value according to its demand. In this sense, money represents value but what determines how much value the medium holds? Money has by nature a very tight relationship with the one responsible distributing and regulating it. As for euro in our case, the one responsible is the European Central Bank. Therefore, money always holds value, as long as the governments that regulate it, keep it legal as the default medium of exchange. This is why paper money such as euro, dollar etc. is called "currency" or "fiat money". In further detail, the word currency in Greek is translated as νόμισμα, stemming from the word νόμος (greek for: law). As such, the medium of exchange – paper money – holds value, as long as the law allows it. However, the above statement arises many insufficiencies

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regarding fiat money. Firstly, money behaves like a product, as per the supply-and-demand rule. That means when supply is increasing, the price will drop, whereas when supply is decreasing and demand is growing, the price will rise. Consequently, since the distributor has the power to produce or stop producing cash, he also has the power to regulate the price and the value money holds. Every fiat currency on the planet as of right now, is centralized. This means that every fiat currency has one single distributor that can create or destroy value. For example, the European Central Bank for euro and the American Federal Reserve for dollar. When only one organization has that much power over such a widely used medium of exchange, dangers can surface. For example the government could snatch public money from bank accounts without straight permission. Or the government could mass produce seriously vast amounts of money, thus dropping the currency's value to critical levels. This is the reason that when we want to talk about real money, we usually refer to precious materials such as gold, silver and diamond. Precious materials like them, have financially interesting properties. They are divisible, meaning they can be broken down into smaller portions for trading purposes. They are physically durable, which makes them resilient to change due to physical force. They also hold consintent value that hasn't reduced essentially in the past millenium. Lastly they have natural value by themselves. This means that their quantity is by nature limited, therefore they cannot be produced or disintegrate thus losing their value.

2. Birth of cryptocurrency

As the time passes, fiat money shifted from its physical form – paper – to a digitalized form (e.g. PayPal, Skrill etc). Albeit that change of form, the state of currency still remains centralized. This happens mainly because in electronic form, users would perfom concurrent transactions (double-spending) or duplicate their account balance into multiple accounts. This is why digitalized money remain until now centralized, in other words, a single organization or digital service must exist to keep track of the transactions and account balances, so that the client cannot fool the system. This way, noone can make or claim changes in their account, if it doesn't agree with the service's own ledger status. In 1989 the very first form of purely digital currency was created, DigiCash. DigiCash offered anonymous, untraceable transactions by using public and private key cryptography. However, in 1998 after placing its trust to the wrong investors, DigiCash went bankrupt and soon disappeared [1]. The next best thing after DigiCash was Paypal [2]. Founded in 1998 and gone public in 2002, Paypal allowed electronic transactions between banks and users, but it was nothing else but a new form of cash flow, far from what cryptocurrency is all about. Nevertheless, trials of making digital currency like DigiCash possible were abandoned and Paypal remained as the star of the scene for many years. Until 2008 when the mortgage economic crisis took place. That

was a pivotal event in global economic history, because it shook people's trust in fiat currency. When people realized that the value in fiat money like euro and dollar can be manipulated or altered significantly, everyone tried to claim back their value of years of hard work and deprivation. Some even went and withdrew their whole savings from banks, others lost everything [3]. Trust in fiat currency was under siege.

3. Cryptocurrency and why it works

Then 2009 came and a person under the alias of Satoshi Nakamoto introduced blockchain, and consequently Bitcoin [4]. Blockchain is a publicly distributed ledger maintained by millions of peer-to-peer network users worldwide, called miners. Blockchain is essentially a list of transaction records, called blocks, connected together using cryptography. Each block contains the transaction data, a hash of the prior block and a timestamp when the transaction took place. Hash or cryptographic hash function (CHF) is nothing more than a mathematical algorithm that takes up information of any size and converts them into a specific-size key. Bitcoin specifically uses the SHA-256 CHF. The unique advantage of hashing is that it is impossible for someone to take the key and reverse-engineer it back to the original information string. That makes each hash unique and unfeasible to be recreated. Moreover, since blocks are so tightly connected together, it is impossible for a malicious user to alter the blockchain or inject new blocks of transactions inside the blockchain. So what makes cryptocurrency a solid alternative or perhaps a fiercesome competitor, compared to fiat currency?

4. Pros and cons of cryptocurrency

Cryptocurrency has three major advantages when compared to fiat money. The first one and probably the novelty of the last decades in money management and distribution, is that cryptocurrency is decentralized. Contrary to fiat currency that is distributed and controlled by a single organization as we discussed before, cryptocurrency's ledger of transactions is public. Everyone having access to a peer-to-peer network and a high-performing computer, is able to log on to that ledger and actually keep track of it himself. In all honesty, you actually get paid 12.5 bitcoins – an amount reduced by half every few years [5] – just by sacrificing some of your computer's inner workload (proof-of-work system) and electricity power to keep track of the ledger and add a new block to the blockchain. Another advantage of cryptocurrency is that it constitutes a limited resource. There is no central authority to mass produce or slow down the production of bitcoins. Bitcoins are not created, they are only distributed between people. The only creating process taking place is the one mentioned above, where users get rewarded a handful amount of bitcoins for keeping track of the ledger. This is why it's called mining. In the same way you can mine a new speck of gold or any other precious metal from earth,

same process happens with bitcoin. However, since the amount mined reduces by half every few years, mathematically speaking, the amount of bitcoins mined some day in the future, will stop forever. It is actually computed that when the mining stops, there will be a total of 21 million bitcoins mined worldwide [5]. It is a small number if one takes into account the amount of tens and tens of trillions of fiat money circulating the market and also the possibility that authorities like the Federal Reserve can mass produce any amount of it in any time they wish to. This is why bitcoin and cryptocurrency in general is more akin to real money like gold, rather than fiat money like euro. Finally the last upside that cryptocurrency provides is anonymity and here is why. Fundamentally the whole concept of cryptocurrency is based on two things, the blockchain and the private key. Earlier we discussed how records of blockchain are kept by millions of users around the world and because of each block in the blockchain is connected via hashing to the previous and the next block, blockchain cannot be injected with malicious code or get hacked. But what is the private key and why it is so important? The private key is essentially the identity of the cryptocoin owner. It is a random number generated between 1 and 2^{97} , making it impossible to be guessed by any computer software. Whenever a transaction takes place, the private key is converted via a complex mathematical function into the public key. The public key is nothing more than an address which tells the blockchain where the cryptocoins should be sent to. After the cryptocoins are sent to the address the public key specifies, the coins are available to the owner via his private key. Without it, the user cannot have access to his cryptocoins at all. Private key acts like a personal bankbook while the public key acts like a bank account number. We should say here that public keys cannot be reverse-engineered back into their original private keys. So even if a hacker gets hold of your public key, he cannot gain access to your account. This is why cryptocurrency is fully anonymous. Private and public keys have no connection to your real-world name or social security number etc. Noone can tell how many cryptocoins you own or what transactions you've made, except from yourself. However, it would be wise to mention that the rise of interest in cryptocurrency comes with unpleasant side-effects. The yearly energy consumption for mining Bitcoins is estimated to be around 110 TWh [6]. To put this into perspective, Greece, a country of ten million people, consumes annually around 50 TWh [7]. This is indeed a sad statistic that comes to show us that cryptocurrency brings harmful effects to an already deteriorated and compromised environment.

5. Effects on economy

Even if we try to ignore cryptocurrency's clear and notable advantages as opposed to fiat currency, one can question what effect will cryptocurrency have on the global economy if it will actually be adopted by governments and people as a means of exchange. First of all, since cryptocurrency is a limited resource like gold, one can

expect that its price will stay consistent long-term with a slight tendency to rise. That means that according to the supply-and-demand principle, when currency maintains a stable upward trajectory, the price of commonly used goods and services usually goes down. In other words, cryptocurrency has a deflationary effect on the market, making commonly bought items and services cheaper to consumers. Another effect of cryptocurrency is that online and digital transactions will be sufficiently more secure than today's internet transactions. Cases of fraud or hacking will decrease to a bare minimum since any cryptocurrency transaction is end-to-end encrypted, so that the sender and the recipient of the transaction remain anonymous. Moreover, cryptocoins can be stored off-line in USB drives – called cold storage wallets – making it impossible for anyone to withdraw or steal money from your account. Lastly, a huge effect takes part on declaring cryptocurrency as a legal means of exchange, specifically in countries with destroyed and heavily damaged economies. People living in countries like Somalia or Venezuela [8], where the economic crash is so substantial that fiat money is actually worthless, they can greatly benefit from storing their value in cryptocoins. Cryptocurrency is a far more functional and trusted value storage than their governments' chosen means of exchange, because it preserves its value steadily.

6. Bitcoin & Ethereum

As of the time this paper is written, the most prevalent cryptocurrency on the market right now is Bitcoin, with its current exchange value to be that 1 Bitcoin equals to approximately 25,000 euros. Since its creation in 2009, Bitcoin received a major boost in 2016 where its price reached around 730 euros, mainly due to Greece's and Britain's possibility of leaving the European Union in 2015 and 2016 respectively [9]. These statistics show that when trust in fiat currency is shaken, people look for more robust and resistant vessels of value, like gold or in our case cryptocurrency. Ethereum or Ether is the second most popular cryptocurrency right now. It was created in 2013 by Vitalik Buterin and launched publicly in 2015 [10]. The reason why Ether gained so much popularity compared with other Bitcoin alternatives, is that Ethereum is an open-source blockchain platform through which users and organizations can deploy their own decentralized interactable applications while also create smart contracts and exchange nonfungible tokens (NFTs).

7. Price prediction

In this paper, we are going to use deep learning algorithms and data science techniques to construct a time-series model for predicting future cryptocurrency prices. The model will be written in Python (v. 3.9.2) and we are going to use four kinds of datasets taken directly from:

https://www.investing.com/crypto/bitcoin/historical-data

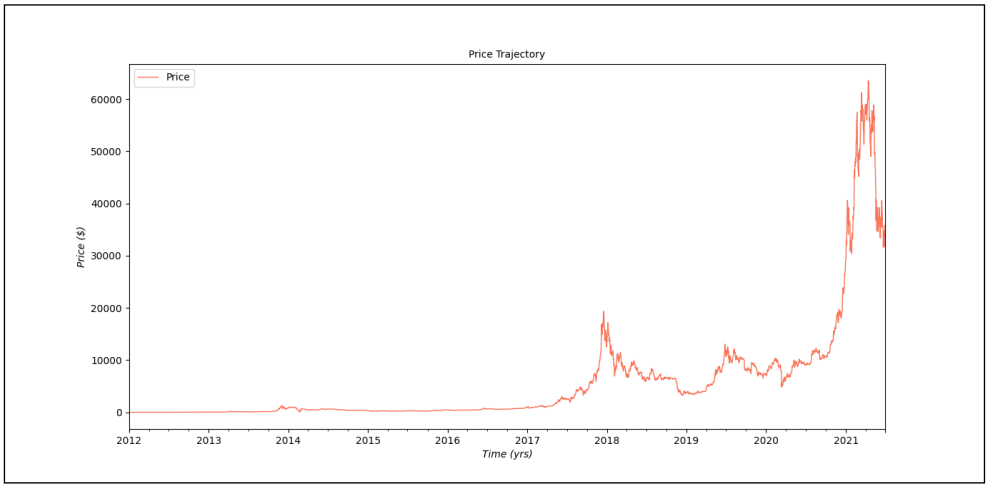
https://www.investing.com/crypto/ethereum/historical-data

The four datasets are:

- Bitcoin prices ranging from Jan-01-2012 to Jul-1-2021 Dataset [1]
- Bitcoin prices ranging from Jul-1-2021 to Jul-20-2021 Dataset [2]
- Ethereum prices ranging from Mar-10-2016 to Jul-1-2021 Dataset [3]
- Ethereum prices ranging from Jul-1-2021 to Jul-20-2021 Dataset [4]

First, we are going to analyze Bitcoin prices. Let's take a look at the data (Dataset [1]).

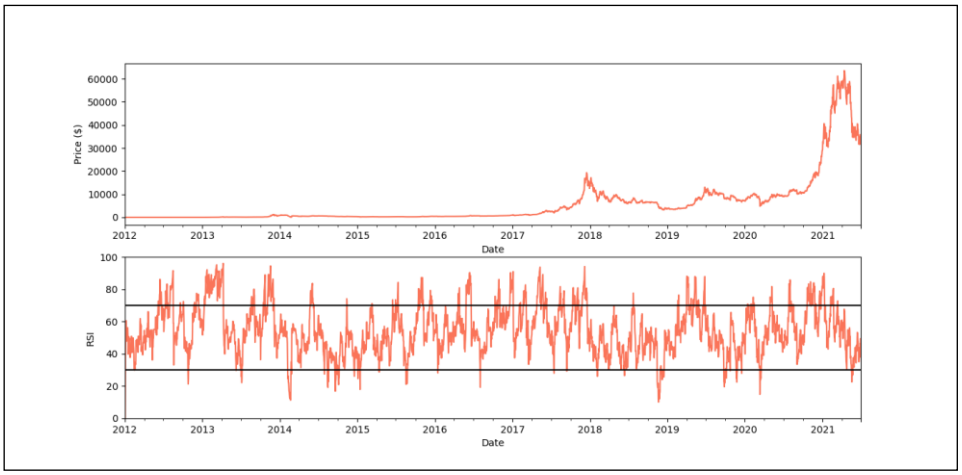
Figure 1.1: Bitcoin price trajectory from 2012-01-01 to 2021-07-01



We can see that Bitcoin started rising fairly smoothly, reaching around 20,000 $ in late 2017. Then the curve takes a fall, having its own rhythm of ups and downs until 2021 where the curve literally skyrockets to prices beyond 50,000 $, reaching a record price of 63,000 $ in April 2021 and then falling back to prices between 40,000 and 30,000 $ respectively. This ambivalent nature of Bitcoin's price curve is not abnormal, if one takes into account that Bitcoin's increasing trajectory in 2017 was overthrown partly by US Securities & Exchange Commission's decision to disapprove a Bitcoin exchange-trusted fund, and partly by financial tycoons, such as J.P Morgan CEO Jamie Dimon and the once richest man in the world Warren Buffett, despising vigorously Bitcoin's rise and cryptocurrency in general [11] . Moreover in 2017 a software change proposal to reduce

transactions' time by altering block size, split the Bitcoin community in half, causing the altcoin Bitcoin Cash (BCH) genesis [12] . As for the sudden rise in 2021, let's keep in mind the heavy toll worldwide economy took from the COVID-19 pandemic and the US elections in November 3, 2020 causing a turmoil in politics regarding COVID-19 vaccine, refugees and war outbreaks in the Middle East and the Mediterranean [13]. As we mentioned earlier, every hit in worldwide fiat currency, directs more and more people to cryptocurrency. Another interesting graph we create is the Relative Strength Index (RSI) compared to Bitcoin's price trajectory. RSI is an indicator used in technical analysis to measure the magnitude of recent price changes. An RSI above 70 means that an asset is overbought or overvalued, while an RSI below 30 indicates that an asset is oversold or undervalued.

Figure 1.2: Bitcoin price trajectory compared to its Relative Strength Index



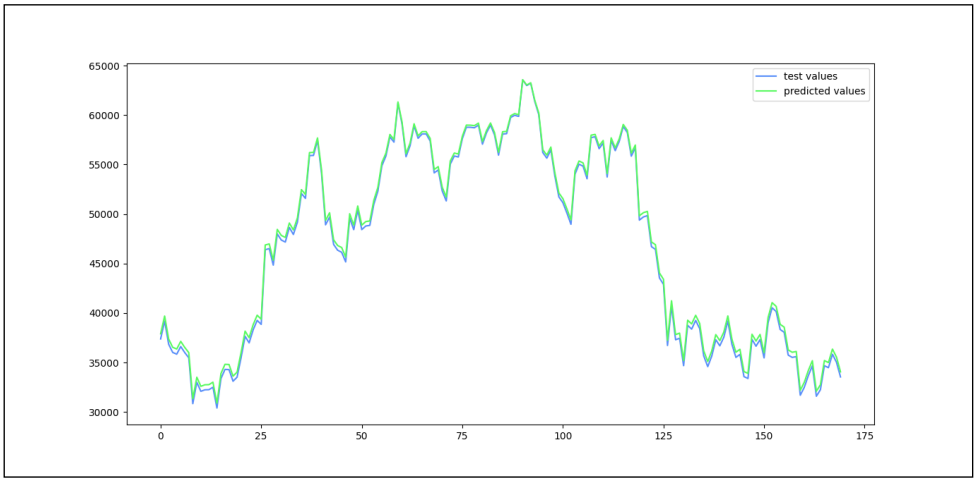
Indeed we can infer from the graph that the time periods of 2012 – 2013, 2015 – 2017, 2019 and late 2020, Bitcoin was considered overvalued. Again, this is not unusual since 2012 – 2013 indicates a time when cryptocurrency was making its first appearance on the market and everyone was speculative of it. 2015 – 2017 also marks the period when Greece and UK aimed to leave the European Union, while 2019 matches the spike Bitcoin price had, nearly tripling its price in June that year. Finally the period of late 2020 marks the time Bitcoin really took off for reasons discussed in the previous graph. As for Bitcoin considered undervalued, there are very few instances, mainly in early 2014 and late 2018. Now that we know how Bitcoin's price flunctuated through the years, it's time to put our machine learning model into action. Our model of choice will be a Long-Short-

TermMemory (LSTM) model. LSTMs are a unique type of reccurent artificial neuron networks (RNNs) allowing previously learned information input to persist and to influence the future ones. That is the reason LSTMs are preferred alot in time-series analysis, because time-series data from a previous event, heavily correlate with future events. After splitting our data into two sets – training and test sets – and scaling them properly in the range of 0 to 1, to avoid our model being overthrown by the value height difference, we train the model in the following way:

```
model = Sequential()
model.add(LSTM(units=100,activation='sigmoid',input_shape=(X_t rain.shape[0] , X_train.shape[1])))
model.add(Dense(units=1))
model.compile(loss='mse', optimizer='adam')
model.fit(X_train, y_train, epochs=50, verbose=1, batch_size=5)
```

After the model is trained, we compare our model's predictions with data unseen by the model itself (test set) and we evaluate how accurately the model can perform a prediction on those data.

Figure 1.3: Unseen price data (test) in relation with predictions made by the model

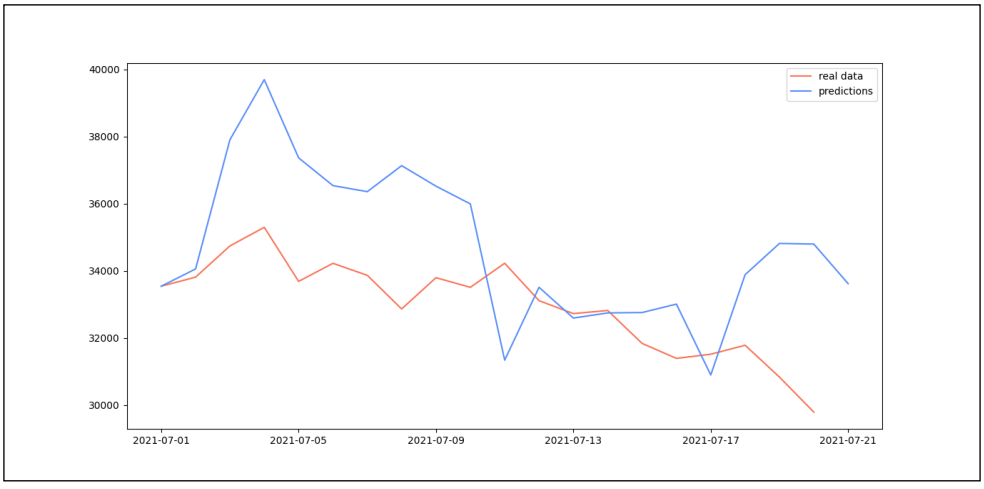


As we can see the predicted values match very closely the test set. This means that our model's accuracy is very high. Next, we are going to make predictions and try to design

the trajectory the price is going to take in the following 20 days after July 1, 2021. After that, we are going to take real-world data (Dataset [2]) from July 1, 2021 through July 20, 2021 and compare with our model's predictions. Unfortunately, real-world prices beyond July 20 cannot be obtained at the time this paper is written.

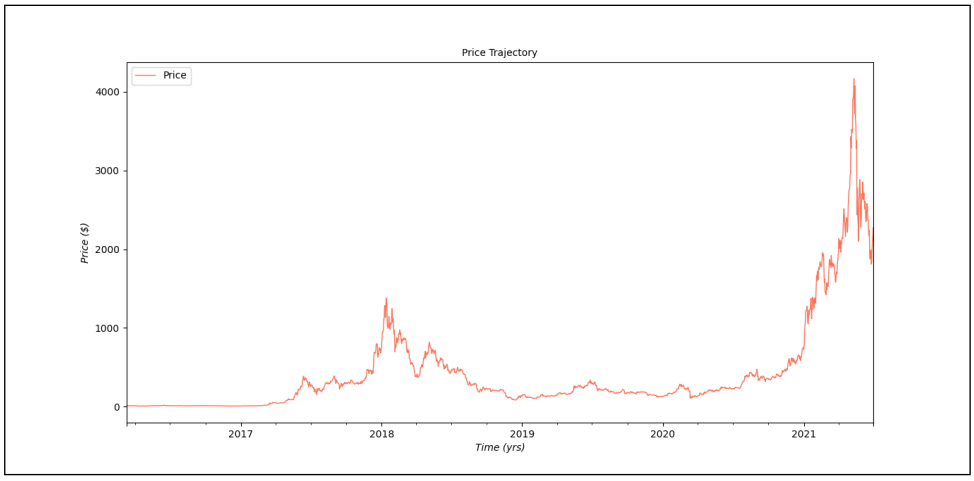
Figure 1.4: Predictions made by the model from 2021-07-01 to 2021-07-21

Figure 1.5: Real-world data compared with model's predictions from 2021-07-01 to 2021-07-21



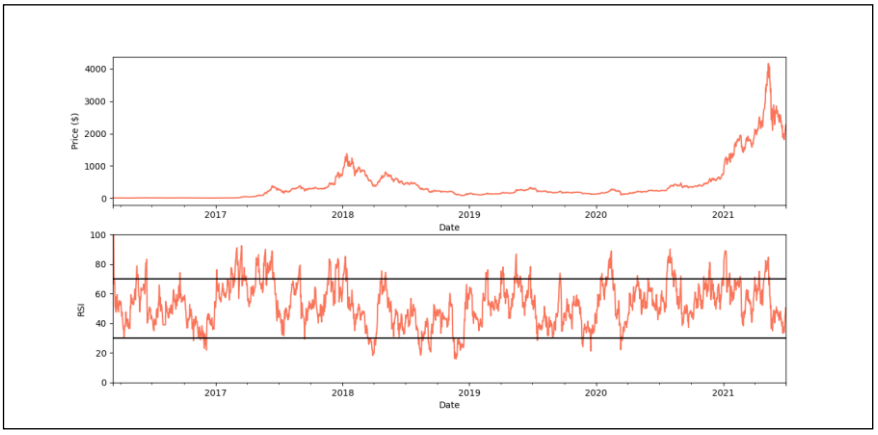
The predicted curve has the same slope as the real data. However in the time period between 2021-07-03 and 2021-07-10 the price difference between real and predicted values reaches around 4,000 $. In the same way, from 2021-07-18 to 2021-07-20 price difference reaches from 3,000 to 5,000 $. Even though the predictions follow the same trajectory as the real data, the model often overestimates the price change. We have to keep in mind that cryptocurrencies are extremely volatile assets, making them way more difficult to predict, compared with other more stable and time independent assets such as gold. After Bitcoin, we are going to apply the same model as we did before, to Ether. Our data source now is Dataset [3] :

Figure 2.1: Ethereum price trajectory from 2016-03-10 to 2021-07-01



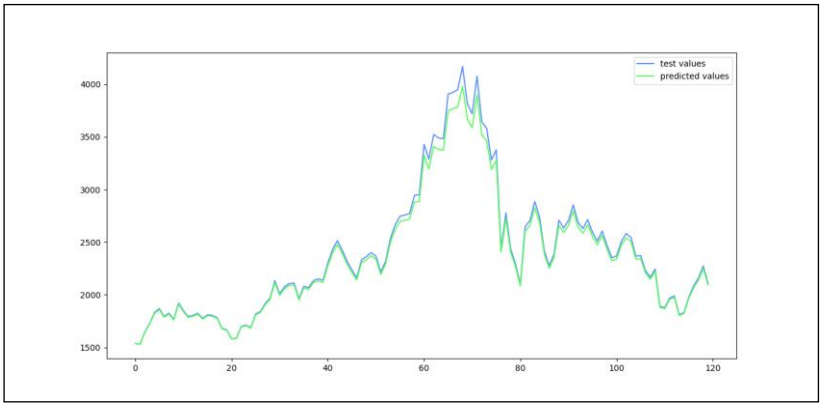
Ethereum's reached prices over 1,400 $ in January 2018 following big companies' statements like Microsoft, to use Ethereum's platform for developping their own applications [14]. Also NFTs' popularity grew considerably in 2018, with their production reaching vast proportions. This led many people to trade and exchange their Bitcoins for Ether, in the thought that Ethereum offered many exciting technological outlets and innovations, compared to Bitcoin. Last thing we notice is the peak Ether got in April 2021 when the world's most expensive NFT was sold for more than 69 million dollars, spiking the coin's price to over 2,700 $ [15] . Next graph we output is the Relative Strength Index of Ether through the time period 2016- 03-10 to 2021-07-01.

Figure 2.2: Ether price trajectory compared to its Relative Strength Index



The suprising thing about this graph is that even before its first price spike in 2018, Ether was considered heavily overvalued from early 2016 to late 2017. Keep in mind that even then, investing in Bitcoin was considered a gamble by many, making investing in Ether seem like a very risky choice. Now that we analyzed Ether's price from 2016 to mid 2021, we train the exact same deep learning model as in Bitcoin's case above. First let's evaluate if the predictions made by the model match Ether's test data.

Figure 2.3: Unseen price data (test) in relation with predictions made by the model



As we can see, the model makes very close predictions over the unseen data. Now we will have our model generate predictions for the next 20 days after July 1, 2021. We are going to compare these predictions with real-world data taken from Dataset [4].

Figure 2.4: Predictions made by the model from 2021-07-01 to 2021-07-21

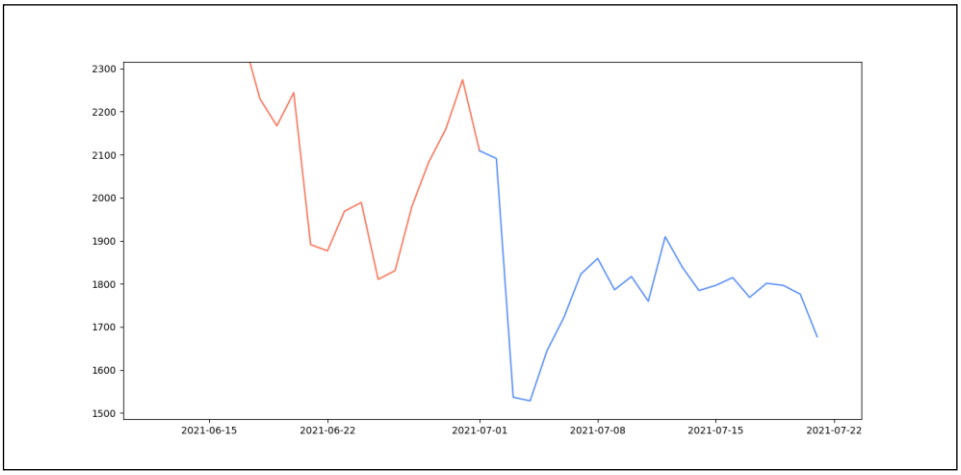
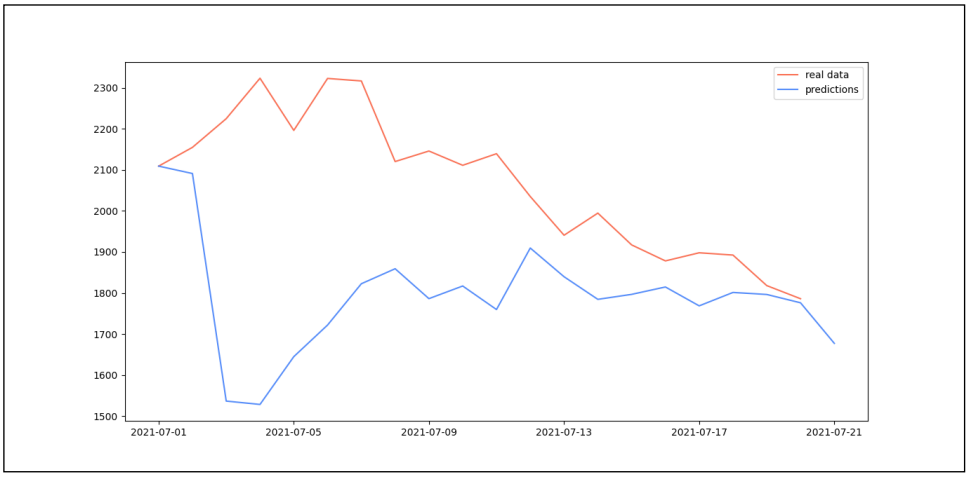


Figure 2.5: Real-world data compared with model's predictions from 2021-07-01 to 2021-07-21



In the period 2021-07-03 to 2021-07-07 predictions are way off conscerning the real data curve. However from 2021-07-07 and onwards, the prediction curve has a slope similar to the real data, indicating that our model predicted wisely the direction the price

would take. In that chunk of data the price difference between the curves starts from 300 $ and decreases consistently.

8. Summary

Initially, currency was defined and the mechanisms that makes cryptocurrency viable longterm and essential in today's centralized economic system. Later we discussed cryptocurrency's effects, ranging from world politics to economic growth, personal privacy issues and environmental matters. Two cryptocurrencies were introduced, Bitcoin and Ether. A simple LSTM neural network model was constructed. Price trajectories for both currencies were analyzed and predictions were made for the aforementioned cryptocurrencies.

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