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Visual Analysis of Temporal Data Associated with Cryptocurrencies

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Abstract. Cryptocurrencies have emerged as a novel and dynamic asset class in the financial landscape, attracting significant attention from investors and researchers alike. As the popularity and diversity of cryptocurrencies continue to grow, there is an increasing need to analyze and understand the temporal dynamics and patterns within their data. Therefore, the treatment of such data involves the application of a wide range of tools for analysis and exploration, including different visualization techniques. In this paper, we present CryptoVisualizer, an integral visual analysis tool for temporal data associated with cryptocurrencies. Our proposal integrates different visualization methods and interactions to empower users in exploring and understanding temporal patterns, trends, and relationships in cryptocurrency markets.

Keywords: Visualization. Temporal Data Visualization. Cryptocurrencies. Visual Data Analysis.

1. Introduction

Visualization of temporal data refers to the process of using visual representations to explore and understand data that varies over time. It involves examining patterns, trends, and relationships within the temporal data to gain insights and extract meaningful information. In various academic disciplines understanding temporal patterns and trends is essential for making informed decisions and extracting significant insights. By using visualizations, researchers can examine and compare data at different time scales, facilitating the interpretation and analysis of information [1,2].

The visualization of temporal data also contributes to effectively communicating scientific findings. Temporal visualizations can help illustrate significant changes, demonstrate the evolution of variables over time, and identify trends and patterns that occur over time. The visualization of temporal data has emerged as a crucial area of research and development in recent years, driven by the increasing availability of time-series data across various domains [3]. Several traditional visualization techniques have been applied to this kind of data,

(like line charts, bar charts, and heat maps, among others) and dedicated techniques have been presented [4,5,6]. In this context, Andrienko and Andrienko [7] proposed a taxonomy of tasks for time-oriented data aimed intended to help researchers and practitioners in understanding the diverse challenges and objectives of working with temporal data.

Cryptocurrencies have garnered significant attention from investors and technology experts in the field of economics. Analyzing the behavior of cryptocurrencies is of interest in the fields of economics and technology due to their impact on technological innovation, financial volatility and risk, new economic models, and their influence on economic policies. Understanding how they function and how they affect economic and financial systems is fundamental to harnessing their benefits and addressing the challenges associated with this new form of value exchange. In this context, the visual analysis of financial data has become a relevant research and development field [8]. Cryptocurrency visualization encompasses a variety of methods [9,10,8,11]. However, to the best of our knowledge, no visual analysis tools that integrate several visualization techniques and allow the integral analysis of different currencies are available in the literature.

In this context, we present *CryptoVisualizer*, a cryptocurrency visualization tool specifically focused on 4 cryptocurrencies of interest: Bitcoin (BTC), Ethereum (ETH), Cardano (ADA), and Dogecoin (DOGE).

In the next section, we define the questions that will serve as the basis for defining the *CryptoVisualizer*'s requirements. In section 3, we describe our proposal, detailing the characteristics of the data, the designed dashboards, and the supported interactions. In section 3.2, the results are presented, explaining how the developed tool addresses the questions defined in section 2. Finally, in section 4 a discussion is outlined, and in section 5 we elaborate on the conclusions and future work.

2. Requirements

After conducting a thorough analysis of the state of the art and basing on Andrienko and Andrienko's taxonomy of tasks for time-oriented data [7], we defined a set of questions that we considered essential to be answered by our tool. These questions formed the basis for the requirements of *CryptoVisualizer*.

1. **Q1:** In general terms, has the trend of the considered cryptocurrencies been constant, bullish, or bearish?
2. **Q2:** During a specific period of time, does the behavior of a cryptocurrency exhibit any relationship with other cryptocurrencies?
3. **Q3:** Is it possible to detect trends in the transaction volume for the different cryptocurrencies? Is there a relationship between the volume trends of different currencies?
4. **Q4:** Is it possible to detect periods of time during which the currencies remain stable or exhibit an upward or downward trend?

3. CryptoVisualizer

In this project we combined 4 datasets downloaded from the *Yahoo! Finance* repository [12] containing information related to the prices and transaction volumes of BTC, ETH, ADA, and DOGE between 2014 and 2023.

3.1 Availability and Design

CryptoVisualizer is a coordinated multi-view data visualization tool developed with Tableau [13] freely accessible from any browser[1]. The user interface was designed as a combination of two dashboards: the *PDash* (Prices Dashboard, see figure 1), and the *VDash* (Volumes Dashboard, see figure 2). Navigation to the *VDash* is facilitated by a dedicated button situated within the *PDash*.

The *PDash* integrates several views. Figure 1B shows two line charts representing the price trends of the closing price for the four cryptocurrencies from their inception to the present day. The difference between the two charts is the scale chosen to represent the Y-axis (the chart on the left uses a logarithmic scale, and the chart on the right uses a linear scale). An area chart represents the price growth of each cryptocurrency (see figure 1 C) Additionally, the *PDash* includes a *difference view*, a custom-designed view that allows analyzing losses and gains by representing the difference between the closing price and the opening price of each cryptocurrency over time (see figure 1D top). In the graph below, the difference in closing price compared to its value from the previous day is shown, also aiming to identify bullish or bearish price trends (see figure 1D button). The size of the rectangles encodes the magnitude of the difference, and the color indicates whether the difference is positive or negative. This dashboard also contains a filtering and selection panel (see figure 1A), that enables user interaction with the price charts and provides access to the *VDash* through a navigation button.

The *VDash* represents the average number of transactions conducted in different years, the relationship between volume and closing price, the relationship between the days of the week and the transaction volume, etc. It contains a filtering and selection panel similar to the *PDash* (see figure 2A). Figure 2B illustrates the *average volume graph*, which represents the average transaction volume per currency and per time unit using square marks, where the size and color are associated with the recorded average transaction volume. A line graph (see figure 2C) represents the variation of transaction volume over time for each currency. The *VDash* also contains a custom-designed area graph inspired by the Theme River technique [14], where the price of each currency is represented above and the transaction volume is represented below a horizontal axis (see figure 2D). Additionally, four bar charts (one for each currency) represent the transaction volume related to the days of the week (see figure 2E). Finally, a

custom-designed view (see figure 2F) represents the transaction volume of each cryptocurrency over time. Each rectangle represents the transaction volume in a specific time unit. Its size is associated with the transaction volume, and its color represents the cryptocurrency.

CryptoVisualizer offers a rich set of interactions that allow users to explore the data, such as single and multiple cryptocurrency selection, time range selection, and filtering by transaction volume range, among others.

[1] https://tinyurl.com/CryptoVisualizer (Spanish version)

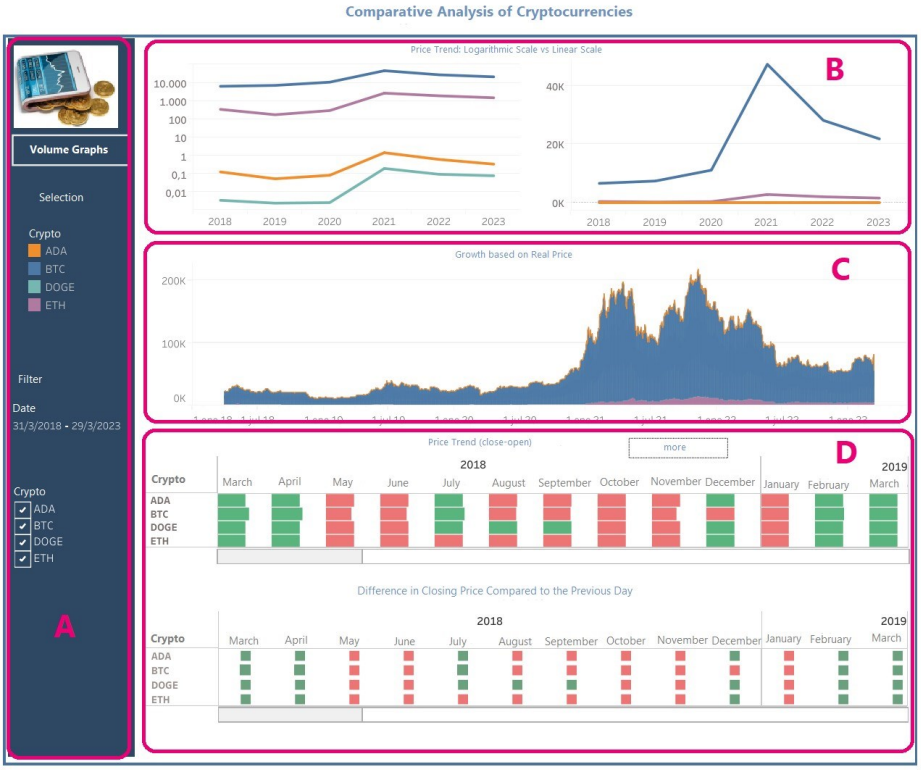

Fig.1. The Prices Dashboard (*PDash*)

3.2 Results

For price trend analysis **(Q1)**, line and area charts corresponding to the *PDash* were used (figure 3A). This view displays the behavior of the closing price of the four cryptocurrencies simultaneously, where, in general terms, from 2020 onwards, overall bullish growth is observed. However, for a more detailed analysis, filtering has been applied for each cryptocurrency (see figures 3B-E for BTC, ETH, ADA, and DOGE respectively).

For behavioral patterns detection **(Q2)**, the *difference view* in the *PDash* was used. Figure 4 illustrates an example where the same average annual behavior of the four cryptocurrencies can be observed in 2017, 2018, 2020, 2021, and 2022.

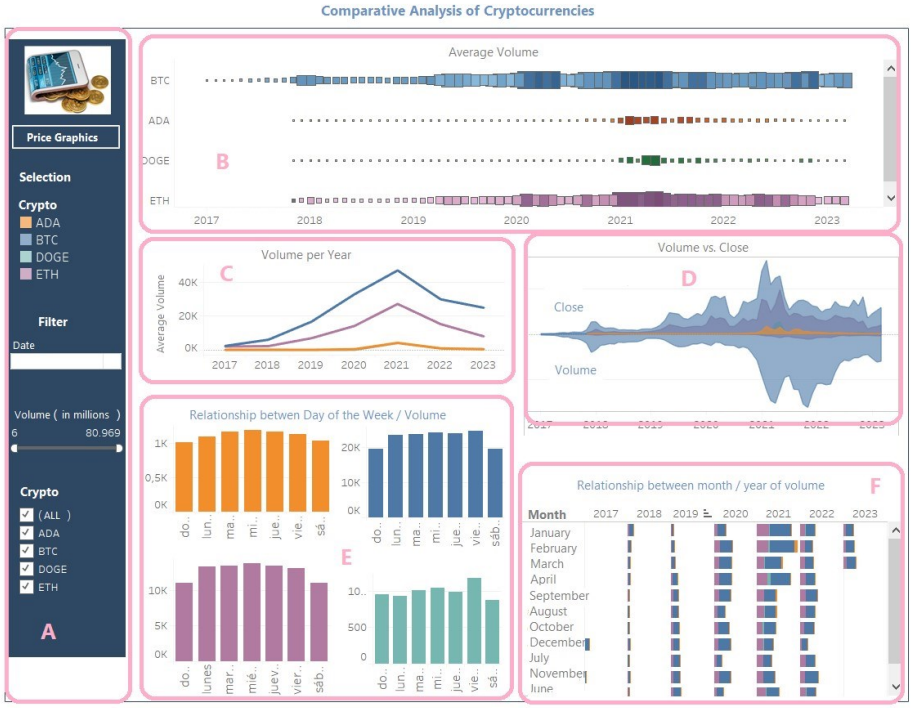

Fig.2. Volumes Dashboard (*VDash*)

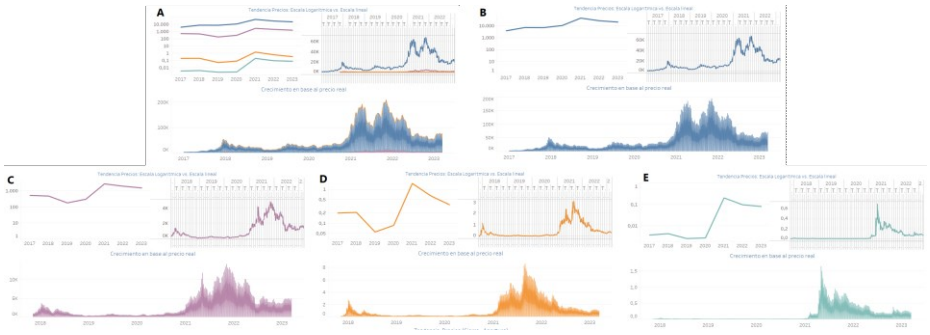

Fig.3. Trends of the four cryptocurrencies using line and area charts for the closing price. View (A) displays the trends of all cryptocurrencies together, while views (B), (C), (D), and (E) show the behavior of BTC, ETH, ADA, and DOGE respectively by utilizing filters in the *PDash*

Fig.4. Behavioural pattern detected in the *difference view* in the *PDash*. Periods of gains are highlighted in green, and losses are marked in red.

Fig.5. Line chart in the *VDash*. In **A** it can be observed that the growth rate of BTC's transaction volume is significantly higher than the rest of the cryptocurrencies, with all of them reaching their peak in volume in the year 2021. Applying quarterly temporal granularity, in **B**, the trend of BTC (blue) and ETH (purple) is analyzed.

For transaction volume trends detection **(Q3)**, the *VDash* was used. Figure 5A shows that from 2016, the transaction volume of BTC and ETH begins to grow significantly until the year 2021. In that year, all four cryptocurrencies reach their peak in transaction volume growth. However, after this peak, there is a period of considerable declines in the transaction volume for all four cryptocurrencies, while still maintaining an overall bullish trend. In the same chart, it is also evident that BTC has the highest transaction volume, followed by ETH, both of which are significantly higher than the other two cryptocurrencies. When changing the temporal granularity of the line chart, the transaction volume of BTC and ETH can be observed to be quite unstable, as shown in figure 5B. On the other hand, in figure 6A, it can be observed that the same pattern repeats for BTC during the second quarter of 2020 and the first and second quarters of 2021. This pattern shows a significant rise and then a steep decline in the average transaction volume. A very similar pattern can be seen in ETH during the second quarter of 2021, as shown in figure 6B. One of the reasons for these spikes could have been caused by the announcement from Elon Musk, the CEO of electric vehicle company Tesla, stating that his company would no longer accept BTC as payment due to the significant environmental cost of mining the cryptocurrency [15]. This not only affected BTC but also other cryptocurrencies. Another event that may have impacted the value of BTC during the same period was the restrictions imposed by China on cryptocurrencies [16].

To detect periods during which the currencies remain stable or exhibit an upward or downward trend **(Q4)** we use the *PDash*. Figure 7 shows in green the quarters (Q4 of 2017 and Q4 of 2020) in which bullish behaviors occurred, while in red, it displays the time periods (Q4 of 2018, Q4 of 2019, and Q2 of 2022) that presented more representative bearish behaviors considering the 4 cryptocurrencies. One of the factors that could have affected this behavior in May 2022 is the so-called *crypto winter* [17], which is associated with difficult moments in the global economy, where large capitals prefer to seek refuge in safer investments, causing a significant decline in the value of cryptocurrencies.

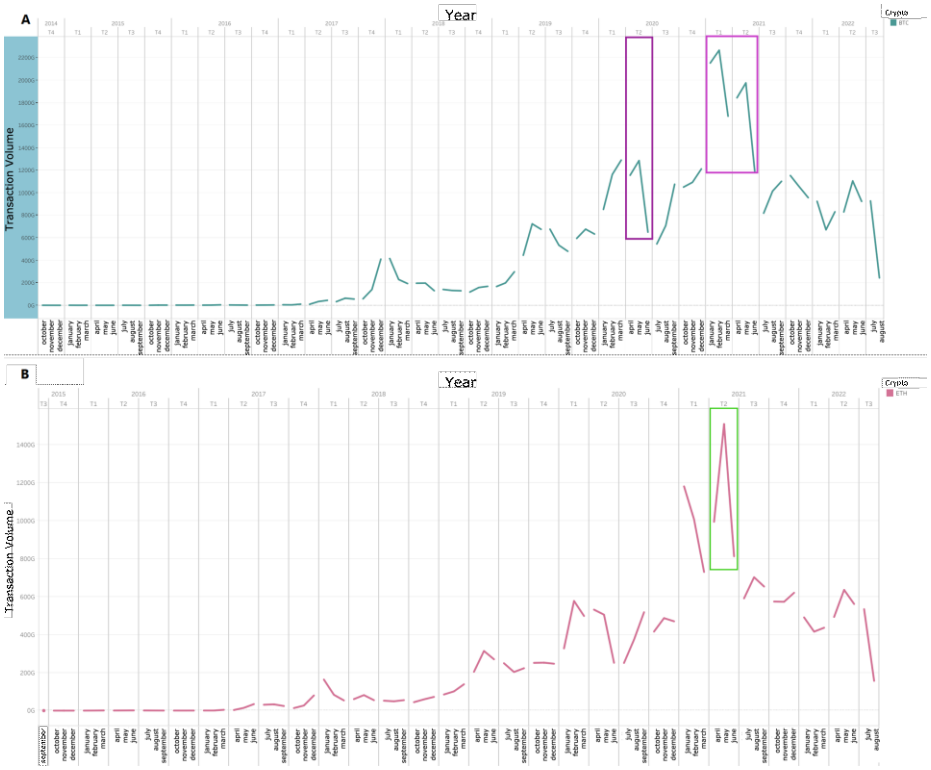

Fig.6. Line chart in the *VDash*. In **A**, purple rectangles highlight a behavioral pattern characterized by 3 periods of sharp declines for BTC volumes. **B** shows a strong increase in ETH's volume followed by a significant decline during the second quarter of 2021 with monthly granularity.

4. Discussion

The proposed solution and its exploration not only allowed us to answer our initial questions but also gave rise to new inquiries, such as: How volatile are the cryptocurrencies? **(Q5)**, Is there any daily seasonality regarding the transaction volume of cryptocurrencies? **(Q6)**, Is there any relationship between the closing price of each cryptocurrency and its transaction volume? **(Q7)**, among others.

When referring to volatility **(Q5)**, we are talking about the frequency and intensity of price changes of a stock or asset in a specific time range. This value is typically influenced by real events but also by speculation. Figure 8 displays ADA, DOGE, and ETH with very little variation; however, the blue highlighted area associated with BTC stands out with very abrupt changes, indicating high volatility in its price. This allows the user to understand the risks involved in investing in this currency, while also showing the behavior of other currencies that have remained more stable since their

inception. In this way, the intention is to provide the user with a general overview and enable them to make the best decision when investing in any cryptocurrency.

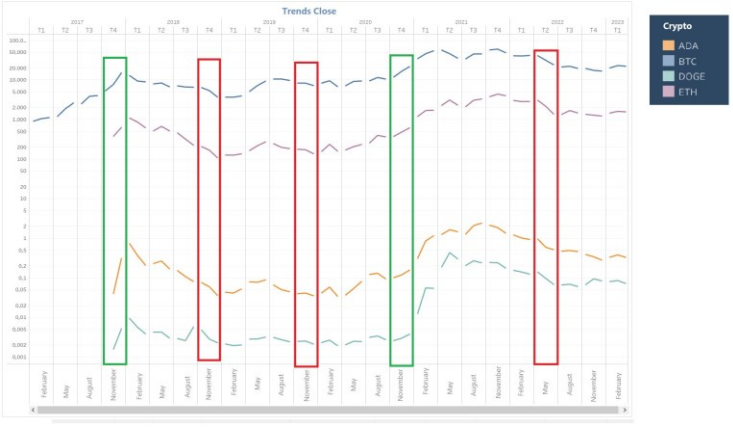

Fig.7. Line graph in the *PDash*. Periods of significant bullish behaviors (green rectangles) and bearish behaviors (red rectangles) considering the 4 cryptocurrencies.

Fig.8. *PDash*. High volatility of BTC compared to other cryptocurrencies.

Regarding **Q6**, a similar question is posed in [18], seeking to answer whether there is a "Monday effect" or "January effect" in financial markets. These are phenomena in which certain days of the week or months of the year have significantly higher or lower values compared to other periods. Figure 9A shows 4 bar charts, each corresponding to one of the cryptocurrencies. In each chart, it can be observed that Saturdays and Sundays are the days with the lowest number of transactions, while, for example, for

BTC (blue bars) and DOGE (bluish-green bars), Friday is the day with the highest number of transactions.

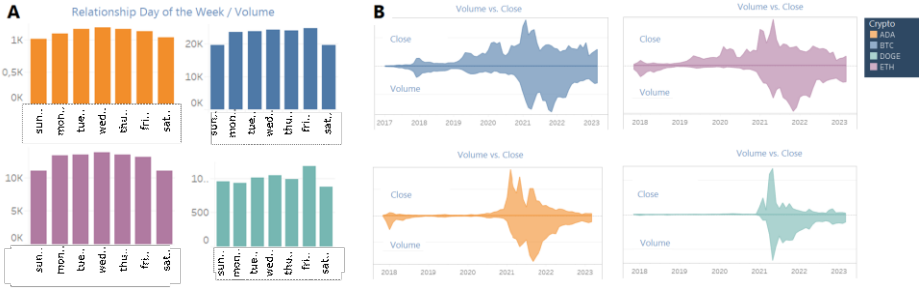

Fig.9. Volumen Dashboard. **B** Bar graph showing the relation between the day of the week and transaction volume. **B** Theme River showing the relation between price and transaction volume.

Regarding the relation between price and volume **(Q7)**, intuitively and based on the analysis of the presented dashboards, it is expected that both variables are related. If we observe figure 9B, we can conclude that, in general terms, the increase or decrease in the closing price of a cryptocurrency impacts its transaction volume. The graph shows that the peaks of both variables occur in very similar periods. Similarly, the periods of decline are well-marked.

5. Conclusions and Future Work

This paper presents a visualization tool for analyzing financial data of cryptocurrencies. The review of existing literature revealed that there are numerous visualization techniques associated with financial markets and cryptocurrencies in particular. However, to the best of our knowledge, there were no visualization tools that integrate multiple comparisons between more than one cryptocurrency in a single dashboard. In this context, we focused on the design and implementation of a visual analysis tool that allows the user to explore the trends and relations between different cryptocurrencies and answer important questions for the application domain. Future work includes collaboration with domain experts, implementing *CryptoVisualizer* in a lower-level language, and automating pattern detection with intelligent interactions.

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