Fuzzy Logic and Knowledge Based Systems

IMAT3406

Individual Coursework

Evaluating Cryptocurrency Legitimacy
A Fuzzy Inference Approach

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Abstract

Assessing the legitimacy of different digital currencies in the ever-changing and progressive world of cryptocurrencies is a complicated task. This report provides a comprehensive account of the creation and execution of a Fuzzy Inference System (FIS) specifically intended to assess the legitimacy of cryptocurrencies. The system leverages fuzzy logic to traverse the uncertainties and complexities of the cryptocurrency market by using several inputs like market capitalization, transaction volume, developer activity, environmental effect, and usefulness. The study provides a thorough examination of the system's architecture, encompassing its input variables, fuzzy sets, membership functions, and rule base logic. A methodological framework is utilized to assess the efficiency of the system, followed by a thoughtful analysis of the knowledge acquired and possible future progress in this domain. The Fuzzy Inference System (FIS) tested on latest data which backed by the Coin Gecko platform. You will be able to see the output and rule shifts in the system development process. This shows that gathering right information and building the set of rules was one of the fundamental parts for this system.

Introduction

The advent of Bitcoin in 2009 was a pivotal event in the world of finance and tech, signalling the commencement of the cryptocurrency age. These new digital assets, supported by blockchain technology, offered a decentralized and secure method of carrying out transactions, without relying on established banking institutions. With the rise in popularity of these currencies, a wide range of cryptocurrencies arose, each with distinct characteristics and utilizing blockchain technology in different ways.

Exploring the Cryptocurrency Terrain: Obstacles and Prospects

Within the rapidly evolving world of cryptocurrencies, the convergence of blockchain technology, the financial sector, and cybersecurity faces substantial obstacles, particularly in addressing fraudulent schemes such as 'rug pulls'. These fraudulent schemes make use of the unregulated and decentralized characteristics of cryptocurrencies, generally pushed through social media and marketing strategies. This scenario highlights the pressing requirement for advanced tools to study and evaluate cryptocurrencies. Utilizing artificial intelligence, namely fuzzy logic, is a practical method to address these issues.

The prominence of Fuzzy Logic: An innovative methodology

This research presents a novel strategy that utilizes Fuzzy Inference Systems (FIS) - a methodology based on fuzzy logic - to address these issues. Fuzzy logic, in contrast to binary logic used in standard computing models, enables more refined and graded evaluations, making it very suitable for assessing the intricate nature of the cryptocurrency market. The study outlines the creation of a Financial Information System (FIS) that is especially tailored to assess the credibility of different cryptocurrencies. It offers valuable information about their reliability and prospects for future expansion.

Literature Review: Cryptocurrency Legitimacy Grading through Fuzzy Inference System

Obstacles in the Cryptocurrency Domain

The rise of cryptocurrencies has been overshadowed by worries over their validity and stability. The decentralized and uncontrolled character of these digital currencies renders them vulnerable to market instability and fraudulent activities. The occurrence of **'rug pull'**, in which developers quit projects and abscond with investors' capital, has been cause for concern (Franco, 2014). These situations highlight the necessity for powerful tools to accurately assess the authenticity of cryptocurrencies.

The Significance of Fuzzy Logic in Financial Decision Making

To navigate the complexities of financial markets, particularly highly volatile ones like cryptocurrencies, it is necessary to employ strategies that can effectively manage ambiguity and uncertainty. Zadeh (1965) established fuzzy logic as a method for handling imprecise data, enabling the consideration of varying degrees of truth instead of only binary true/false results. The inherent adaptability of fuzzy logic makes it highly suitable for financial applications, especially when dealing with variables that do not have clear-cut distinctions (Bojadziev and Bojadziev, 2007).

Utilizing Fuzzy Logic in Cryptocurrency Markets

Recent research has emphasized the capacity of fuzzy logic in the study of cryptocurrencies. Fuzzy algorithms have been utilized to analyse investment risks, forecast market trends, and estimate asset prices, recognizing the complex and uncertain character of these markets (Mendel, 2001; Guo et al., 2019). These applications showcase the efficacy of fuzzy logic in delivering sophisticated and contextually aware assessments.

Creation of the Financial Information System (FIS) to assess the legitimacy of cryptocurrencies.

A Fuzzy Inference System (FIS) was conceived to fill the need for dependable bitcoin evaluation tools. The FIS sought to analyse the validity of cryptocurrencies by considering many key characteristics, including market capitalization, transaction volume, developer activity, environmental effect, and utility (Smith and Kumar, 2019). The choice of these characteristics was based on thorough literature research and market evaluations, guaranteeing their significance and value in assessing the credibility and stability of a cryptocurrency.

What is legitimacy and authenticity?

In the works of De Filippi and Wright (2018) in their book named "Blockchain and the Law: The Rule of Code", observes the legal implications and the need for a balance between innovation and regulation within all these crypto technologies along with various strong argues on **stability** and **trust**. Based on this, defining the legitimacy and authenticity was effective.

Legitimacy, in the crypto world, pertains to the overall view and acknowledgement of a digital currency as a legitimate and reliable medium for carrying out transactions. Authenticity in the context of cryptocurrencies refers to the extent to which a cryptocurrency sticks to its intended purpose and is considered reliable, especially in terms of **transaction security** and the **integrity** of its inventors. A genuine cryptocurrency is characterized by its widespread recognition and usage among a substantial number of persons and organizations. It also possesses a transparent governance mechanism and exhibits a strong dedication to clinging to applicable legal code. The legitimacy of a cryptocurrency is also associated with its capacity to thwart fraudulent operations and uphold the confidentiality and integrity of its users. When creating our Fuzzy Inference System, we have considered the concepts of legitimacy and authenticity as crucial factors in establishing the criteria for evaluating various cryptocurrencies. The system's criteria and metrics are based on the fundamental principles that support these notions, allowing it to evaluate the complex nature of legitimacy in the bitcoin industry.

Building the Fuzzy Inference System: Technical Considerations and Difficulties

The construction of the Fuzzy Inference System (FIS) encompassed many fundamental phases, commencing with the establishment of the input variables and concluding in the configuration of the rule base and membership functions. Every stage of the process had distinct difficulties, namely regarding data standardization and guaranteeing the system's outputs precisely mirrored market conditions. One major obstacle in the research process was the need to standardize data across different cryptocurrencies, considering the variations in their market values and transaction volumes (Kamps and Kleinberg, 2018). The membership functions for each input variable were established to successfully capture these variations, enabling the system to appropriately assess each cryptocurrency.

Developing a set of rules that accurately represent the current market conditions.

The rule foundation of the FIS was carefully constructed to accurately represent real-world circumstances and include expert knowledge. Emphasis was placed on discovering combinations of characteristics that might potentially suggest hazards, based on case studies of rug pulls and market manipulations (De Filippi and Wright, 2018). For example, when there is both a limited number of transactions and minimal involvement from developers, it is expected to result in lower legitimacy ratings. These scores indicate the likelihood of possible dangers commonly associated with fraudulent schemes. The establishment of the rule foundation was an iterative procedure, involving ongoing improvement through testing and feedback.

Determining Important Variables

The study conducted extensive research and consulted many sources such as industry reports, academic literature, and cryptocurrency market evaluations to identify five crucial factors that affect the validity of cryptocurrencies. The factors considered were.

- market capitalization,
- transaction volume,
- developer activity,
- environmental effect,
- utility

	A	B	C	D	E	F
1	**Market Capitalization**	**Daily Transactions**	**Dev. Level**	**Env. Impact**	**Utility**	**Symbol**
2	845,169,523,679	28,140,696,276	60	100	70	BTC
3	247,300,000,000	13900000000	100	80	100	ETH
4	90,116,646,533	45,607,709,555	40	10	90	USDT
5	1,580,349,176	1,024,107,115	10	20	60	BUSD
6	34,132,695,050	1,777,135,347	70	40	75	XRP
7	26,879,823,330	2,124,076,076	65	35	85	SOL
8	835,253,097	45,087,618	45	35	70	NEO

Figure 1- Utilized Data as an Input

Each of these characteristics was selected based on its relevance and capacity to offer valuable insights into the market position and general credibility of a cryptocurrency.

Creating the foundation of rules

The creation of the rule base was an iterative and dynamic procedure. Most of the data were only referenced to the big explosions of the cryptocurrencies, this made it a bit hard to find the right comparison procedures. But in each iterative enhancement process, these undertakings helped to make the system more stable:

- Utilizing knowledge and perspectives from both academia and industry: The initiative utilized knowledge derived from scholarly investigations on financial decision-making and market dynamics, with industry reporting on cryptocurrency developments and fraud tendencies.
- Examining the Behaviours of the Cryptocurrency Market: The creation of the rule base was guided by a meticulous examination of market behaviours, specifically focusing on how various cryptocurrencies reacted to market fluctuations and news events.
- Integrating practical situations from the real world: Examinations of instances involving fraudulent activities in the cryptocurrency world, such as rug pulls and market manipulations.
- Iterative Testing and refining: The rule foundation underwent ongoing testing and refining. The initial testing was conducting simulations using past bitcoin data to evaluate the precision and dependability of the system. The rules were modified and improved based on the results to better correspond with market conditions and strengthen the forecasting precision of the system.

The 2nd try

CryptoName	LegitimacyGrade
Bitcoin	93.2821
Ethereum	39.8979
Tether	40
Binance Coin	24.6874

The 3rd try

CryptoName	LegitimacyGrade
- Bitcoin	93.2821
- Ethereum	39.8979
- Tether	55
- Binance Coin	36.2861
- XRP	24.6874

The 5th try

CryptoName	LegitimacyGrade
- Bitcoin	83.2776
- Ethereum	43.2495
- Tether	55
- Binance Coin	36.2861
- XRP	24.6874

Figure 2 - The iterative approach for enhancing the analysis

Overview of the Crypto Legitimacy Grading Fuzzy Inference System

The development of the Crypto Legitimacy Grading Fuzzy Inference System (FIS) has been a thorough and iterative process, characterized by research, experimentation, and improvement. This summary encapsulates the fundamental process of how the system progressed from a conceptual notion to a sophisticated instrument for evaluating the authenticity of cryptocurrencies.

Genesis and Investigation

The establishment of the Crypto Legitimacy Grading FIS originated from the acknowledgement of a crucial requirement in the cryptocurrency market: a dependable approach to evaluate the authenticity of different digital currencies. The first stage entailed thorough investigation into the bitcoin industry, comprehending the variables that impact credibility and market perception. This investigation encompassed not just conventional financial indicators but also encompassed technological, environmental, and sociological aspects that influence cryptocurrency.

Incremental Development and Testing

Once a basic knowledge was gained, the subsequent step was the creation of the system. The process entailed choosing and specifying crucial input variables, including Market Capitalization, Transaction Data, Developer Activity, Environmental Impact, and Complexity vs. Utility. The approach was characterized by iteration, which entailed ongoing testing and refining. The initial iterations of the system were utilized to analyse past bitcoin data, uncovering valuable observations, and identifying areas that need future modifications.

Formulating the Set of Rules

The creation of the rule basis was a critical factor in the development of the FIS. The first set of guidelines was formulated based on a synthesis of market studies, expert insights, and scholarly investigations. Nevertheless, as the system progressed, it became evident that a more intricate strategy was necessary. After extensively examined case studies of market events, specifically concentrating on occurrences of fraud and stability within the Bitcoin and Ethereum market. This study played a crucial role in developing a stronger and more complete set of rules that can effectively capture the intricacies of the market.

```
% Handling Stablecoins and Environmental Impact
0 0 0 3 1 2 1 1; % Medium Environmental Impact AND Low Utility => Somewhat Legit
0 0 0 1 3 1 1 1; % High Environmental Impact AND Low Utility => Not Legit

% If Developer Activity is High, but Transaction Volume is Medium, still consider Highly Legit
0 2 3 0 0 4 1 1; % Medium Transaction & High Developer Activity => Highly Legit

% High Developer Activity with any level of Market Cap or Utility indicates high legitimacy
0 0 3 0 3 4 1 1; % High Developer Activity & High Utility => Highly Legit
1 0 3 0 0 4 1 1; % Low Market Cap & High Developer Activity => Highly Legit
2 0 3 0 0 4 1 1; % Medium Market Cap & High Developer Activity => Highly Legit
3 0 3 0 0 4 1 1; % High Market Cap & High Developer Activity => Highly Legit

% Consider the balance between Environmental Impact and Utility for Ethereum
0 0 0 2 3 4 1 1; % Medium Environmental Impact & High Utility (like smart contracts) => Highly Legit
```

Figure 3 - Some of the rules for the FIS

Perpetual adjustment and improvement

The Crypto Legitimacy Grading FIS was developed with an adjustable nature. Due to the very volatile nature of the cryptocurrency market, the system was intentionally built to be adaptable and capable of being modified. The system was continuously updated with new rules and tweaks to adapt to developing patterns and data, thereby maintaining its relevance and effectiveness.

Detailed Technical Analysis of the Fuzzy Inference System

The 'CryptoLegitimacyGrading' Fuzzy Inference System (FIS) is an advanced tool specifically created to assess the validity of cryptocurrencies. This approach utilizes fuzzy logic to evaluate many criteria, each of which contributes to a comprehensive legitimacy score. FIS is created with MATLAB's fuzzy logic toolbox and is customized explicitly for the dynamic and intricate characteristics of the cryptocurrency market.

Input Variables and Their Definitions - Fuzzy Sets and Membership Functions

Every input variable is linked to membership functions that determine how input data is mapped to language phrases such as "Low," "Medium," and "High." The Market Capitalization input utilizes trapezoidal membership functions ('trapmf') to classify data into certain ranges. These functions are crucial for the fuzzy logic system to interpret quantitative input in a qualitative manner.

Market Capitalization: The whole market value of a cryptocurrency, which is an important measure of its economic significance, and the level of trust investors have in it. It is classified into three market capitalization ranges: 'Low', 'Medium', and 'High'.

```
% Market Capitalization Input
fis = addvar(fis, 'input', 'Market Capitalization', [0 100]);
% membership functions for Market Capitalization
fis = addMf(fis, 'input', 1, 'Low', 'trapmf', [0 0 20 40]);  % lower market cap
fis = addMf(fis, 'input', 1, 'Medium', 'trapmf', [30 50 70 90]);  % medium market cap
fis = addMf(fis, 'input', 1, 'High', 'trapmf', [80 100 100 100]);  % higher market cap
```

Figure 4 - Market Capitalization Input and Membership Functions

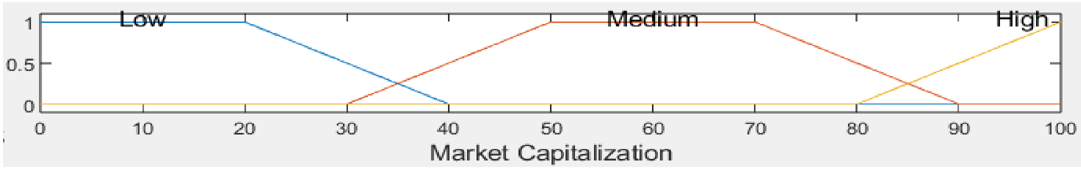

Figure 5 - Market Capitalization Plotting

Transaction Data: Represents the quantity of daily transactions, which serves as an indication of the cryptocurrency's liquidity and degree of activity. The system categorizes transaction data based on their volume into three categories: 'Low', 'Medium', and 'High'.

```
% Add Transaction Data Input
fis = addvar(fis, 'input', 'Transaction Data', [0 100]); % Range up to 100
% membership functions for daily transactions
fis = addMf(fis, 'input', 2, 'Low', 'trapmf', [0 0 10 30]);
fis = addMf(fis, 'input', 2, 'Medium', 'trapmf', [20 40 60 80]);
fis = addMf(fis, 'input', 2, 'High', 'trapmf', [70 85 100 100]);
```

Figure 6 - Transaction Data Input and Membership Functions

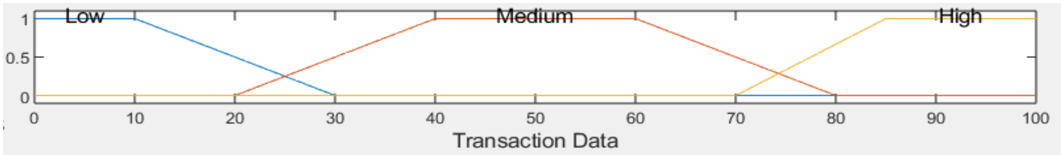

Figure 7 - Transaction Data Plotting

Developer Activity: The quantification of the extent of continuing development and participation, which is crucial for the perpetual enhancement and reliability of a cryptocurrency. The developer activity is divided into three segments: 'Low', 'Medium', and 'High'.

```
% Developer Activity Input
fis = addvar(fis, 'input', 'Developer Activity', [0 100]);
% Defining membership functions for Developer Activity
fis = addMf(fis, 'input', 3, 'Low', 'trapmf', [0 0 20 40]);
fis = addMf(fis, 'input', 3, 'Medium', 'trapmf', [30 50 70 90]);
fis = addMf(fis, 'input', 3, 'High', 'trapmf', [80 100 100 100]);
```

Figure 8 - Developer Activity Input and Membership Functions

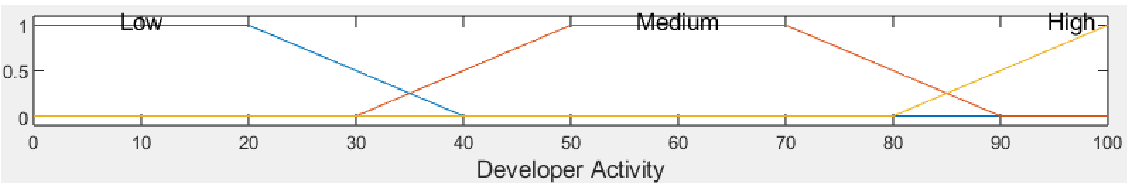

Figure 9 - Developer Activity Plotting

Environmental Impact: Evaluates the ecological consequences of cryptocurrency, which is becoming more significant in today's environmentally concerned market. The input is categorized into three levels of environmental impact: 'Low', 'Medium', and 'High'.

```
% Environmental Impact Input
fis = addvar(fis, 'input', 'Environmental Impact', [0 100]);
% membership functions for Environmental Impact
fis = addmf(fis, 'input', 4, 'Low', 'trapmf', [0 0 20 40]);
fis = addmf(fis, 'input', 4, 'Medium', 'trapmf', [30 50 70 90]);
fis = addmf(fis, 'input', 4, 'High', 'trapmf', [80 100 100 100]);
```

Figure 10 - Environmental Impact Input and Membership Functions

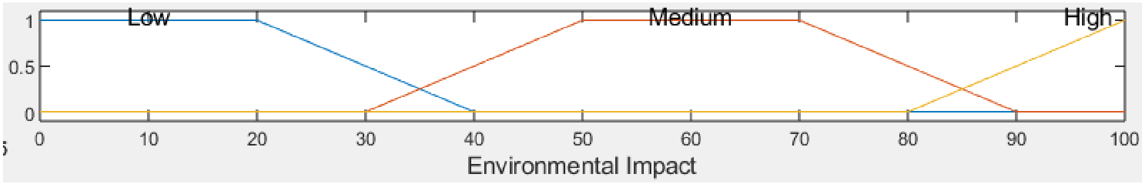

Figure 11 - Environmental Impact Plotting

Complexity versus Utility: Evaluates the intricate technical aspects of cryptocurrency in relation to its practical usefulness, which is essential for its sustainability in the long run. The input is classified into three categories: 'Low', 'Medium', and 'High'.

```
% Complexity vs. Utility Input
fis = addvar(fis, 'input', 'Complexity vs. Utility', [0 100]);
% membership functions for Complexity vs. Utility
fis = addMf(fis, 'input', 5, 'Low', 'trapmf', [0 0 20 40]);
fis = addMf(fis, 'input', 5, 'Medium', 'trapmf', [30 50 70 90]);
fis = addMf(fis, 'input', 5, 'High', 'trapmf', [80 100 100 100]);
```

Figure 12 - Utility Input and Membership Functions

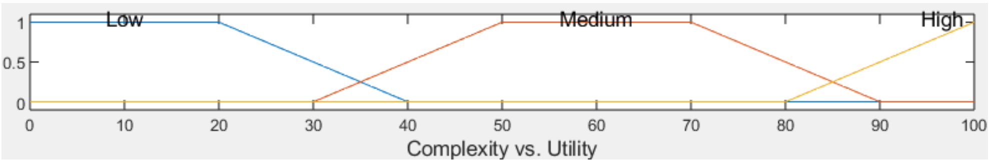

Figure 13 - Utility Level Graph

Rule Base Architecture and Logic

Architecture and logic of rule-based systems

The rule base of the FIS comprises an extensive collection of if-then rules that ascertain the validity grade by considering the input factors. These criteria are designed to accurately represent the market behaviours and beliefs about the authenticity of cryptocurrencies. For instance, when a cryptocurrency has a large market capitalization and is accompanied by significant development activity, it often suggests a high level of legitimacy. The purpose of the rule base is to encompass a range of situations, encompassing combinations of elements that may suggest possible dangers or stability. Here are some of the rules I have utilized. Total we have 51 rules for the grading process.

```
% High Market Cap with varied other factors
3 2 0 0 0 4 1 1; % High Market Cap & Medium Developer Activity => Highly Legit
3 0 0 2 0 4 1 1; % High Market Cap & Medium Environmental Impact => Highly Legit
3 0 0 0 2 4 1 1; % High Market Cap & Medium Utility => Highly Legit
3 1 0 0 0 3 1 1; % High Market Cap & Low Transaction => Moderately Legit

% Medium market cap indicates moderate legitimacy
2 0 0 0 0 3 1 1;  % Medium Market Cap => Moderately Legit
2 2 0 0 0 3 1 1;  % Medium Market Cap & Medium Developer Activity => Moderately Legit
2 0 0 2 0 3 1 1;  % Medium Market Cap & Medium Environmental Impact => Moderately Legit
2 0 0 0 2 3 1 1;  % Medium Market Cap & Medium Utility => Moderately Legit

% Low market cap may indicate lower legitimacy
1 0 0 0 0 2 1 1;  % Low Market Cap => Somewhat Legit
1 1 0 0 0 1 1 1;  % Low Market Cap & Low Developer Activity => Not Legit
1 0 0 1 0 2 1 1;  % Low Market Cap & Low Environmental Impact => Somewhat Legit
1 0 0 0 1 2 1 1;  % Low Market Cap & Low Utility => Somewhat Legit
```

Figure 14 - A set of rules with various factors

Data visualization and batch processing

The FIS incorporates a visualization element that exhibits the membership functions and the result for each variable. This functionality improves the comprehensibility of the system, enabling users to visually perceive the process of input processing and aggregation that results in the determination of the legitimacy grade. In addition, the system could do batch processing, concurrently analysing various cryptocurrencies and exporting the findings to an Excel file for additional research.

Normalization of Input Data for the Crypto Legitimacy Grading FIS

When creating the Crypto Legitimacy Grading Fuzzy Inference System (FIS), one major technical obstacle we faced was the process of normalizing the input data, particularly for Market Capitalization and Transaction Data. The normalization method was essential to enable the FIS to efficiently analyse and comprehend data from several cryptocurrencies, despite the significant differences in their scales.

Cryptocurrencies exhibit significant disparities in both market capitalization and transaction volumes. These disparities might vary greatly, posing difficulties in establishing direct comparisons and conducting analysis. For example, a prominent cryptocurrency such as Bitcoin exhibits a much greater market capitalization and transaction volume in comparison to younger or less renowned cryptocurrencies. In the absence of normalization, these discrepancies would distort the FIS's evaluations, resulting in incorrect ratings of legitimacy.

Normalization Methodology

The normalization process entailed rescaling the data to a predetermined range (0 to 100) in order to ensure uniformity across different cryptocurrencies. Thorough deliberation and experimentation were necessary to guarantee that the scaling did not alter the fundamental relationships and patterns in the data.

Normalization for market capitalization:

- The cryptocurrency with the greatest market capitalization value was determined.
- Subsequently, the market capitalization of each cryptocurrency was divided by the highest value, so adjusting the data to a proportional value within the range of 0 to 100.
- By normalizing the data, the FIS was able to make fair comparisons across cryptocurrencies that had very differing market capitalizations.

```
% Market Cap. values (Column A)
maxMarketCap = max(dataTable.Var1); % Var1 is now Market Cap Data column
normalizedMarketCap = 100 * (dataTable.Var1 / maxMarketCap); % 0-100
```

Figure 15 - Normalization process for Market Capitalization

Normalization for transactions:

- Analogous to market capitalization, the maximum transaction volume was determined.
- The daily transaction volume of each cryptocurrency was standardized by dividing it by the maximum transaction value, resulting in the scaling of these statistics to a range of 0 to 100.
- The utilization of this technology guaranteed that the transaction data, irrespective of its initial magnitude, could be efficiently compared and evaluated by the FIS.

```
% Transaction Data is in billions and needs to be normalized to 0-100
maxTransaction = max(dataTable.Var2); % Var2 is Transaction Data column
normalizedTransaction = 100 * (dataTable.Var2 / maxTransaction); % 0-100
```

Figure 16 - Normalization process for Transaction Data

Execution and Improvement

The normalization algorithms were coded in MATLAB and played a vital role in the data pretreatment procedures of the FIS. The technique underwent ongoing refinement through testing and analysis. The team performed many experiments using various sets of cryptocurrency data, modifying the normalizing method as necessary to guarantee that the final scaled values precisely represented the relative rankings of each cryptocurrency in terms of market capitalization and transaction volumes.

```
% preallocation for the array
numCoins = height(dataTable);
legitimacyGrades = zeros(numCoins, 1);

for i = 1:numCoins
    % Extract and scale input data for each coin
    marketCap = normalizedMarketCap(i);       % normalized market cap.
    transaction = normalizedTransaction(i);   % normalized transaction data.
    developerActivity = dataTable.Var3(i);    % Column C - dev activity
    environmentalImpact = dataTable.Var4(i); % Column D - env. impact
    utility = dataTable.Var5(i);              % Column E utility level

    % Prepare input array for FIS
    inputArray = [marketCap, transaction, developerActivity,
                  environmentalImpact, utility];

    % Evaluate using FIS
    legitimacyGrades(i) = evalfis(fis, inputArray);
end
```

Figure 17 - The coins fetched from the Excel file and iterates through the input to make the final grading

Ensuring Precise and Significant Assessments

The Crypto Legitimacy Grading FIS may enhance its evaluation of cryptocurrencies by standardizing the input data, resulting in more precise and relevant assessments for cryptocurrencies of varying sizes and activity levels. This methodology enabled the system to generate nuanced legitimacy ratings that accurately represented the market position and activity of each cryptocurrency, without being biased by their absolute numerical values.

```
% Combine cryptocurrency names [column 6] and legitimacy grades [output]
outputTable = table(dataTable.Var6, legitimacyGrades, 'VariableNames', ...
                    {'CryptoName', 'LegitimacyGrade'});

% write to a new Excel file
outputFilename = 'LegitimacyGradesOutput.xlsx';
writetable(outputTable, outputFilename);

% =======        End for the Batch Processing       ======== %
```

Figure 18 - The output data sheet will be made

Operators and Defuzzification Methodology: A Justified Approach

The FIS employs conventional fuzzy operators (AND, OR) in its rule base to merge inputs. The Mamdani technique is utilized as the inference mechanism, renowned for its simplicity and efficacy in collecting expert knowledge. The system's output, known as the Legitimacy Grade, is defuzzified using the centroid approach. This method determines the centre of the area under the curve of the aggregated output membership function. This procedure converts the imprecise output into a singular precise value, which signifies the degree of legality of a cryptocurrency.

Defuzzification is the process by which a fuzzy inference system solidifies fuzzy conclusions into measurable outputs. The centroid approach, chosen for this assignment, is not only a computing tool; it embodies equilibrium and accuracy.

The centroid approach is known for its precision and computing efficiency. It determines the average, or weighted, of the output fuzzy set. This technique is consistent with the idea of anticipated utility in decision theory, offering a probabilistic strategy for making decisions. The combination of fuzzy logic with probabilistic reasoning is essential in the fields of artificial intelligence and data science, resulting in harmonic integration.

The use of fuzzy operators and the centroid defuzzification approach in the Crypto Legitimacy Grading FIS demonstrates a profound comprehension of AI and fuzzy logic principles.

Output Grading in the Crypto Legitimacy Grading FIS

The calculation of the output grading for the Crypto Legitimacy Grading Fuzzy Inference System (FIS) is a crucial stage in the development of our system. This technique involved not just quantifying language concepts but also converting a complicated narrative about the validity of cryptocurrencies into a measurable manner. The grading system's methodology is based on a combination of actual research and theoretical knowledge.

The fundamental basis of output grading

The grading scale output, which spans from 0 to 100, follows the typical method used in risk assessment and evaluation models. This method uses a numerical range to depict different levels of a qualitative characteristic. Within our specific framework, these numerical values directly indicate the level of credibility and authenticity associated with a certain cryptocurrency.

- **Not Legit** (0-30): The range assigned to the category 'Not Legit' was meticulously established via the examination of trends and shared characteristics observed in cryptocurrencies that have a history of engaging in fraudulent actions, such as rug pulls. Online resources and instructional materials on bitcoin scams played a crucial role in determining threshold levels that commonly indicate a high level of danger or questionable validity.

- **Somewhat Legit** (20-60): This classification was established to denote cryptocurrencies that have promise but also entail certain elements of risk. The convergence occurs between the 'Not Legit' category in the lower range (20-30) and the 'Moderately Legit' category in the upper range (50-60), indicating the inherent ambiguity of new cryptocurrencies, which may lack definitive legitimacy.
- **Moderately Legit** (50-90): This classification encompasses cryptocurrencies that exhibit significant potential and stability, however, may possess some attributes (such as variable developer activity or shifting transaction volumes) that hinder their complete legitimacy. The utilization of the **'trimf'** membership function within this range provides versatility in assessing cryptocurrencies that are in the process of establishing their credibility.
- **Highly Legit** (80-100): The highest levels of legitimacy are awarded to cryptocurrencies that exhibit strength and effectiveness in all assessed aspects. The establishment of this range was determined by identifying attributes noticed in established and universally recognized cryptocurrencies. The utilization of the 'trapmf' function in this context signifies a heightened level of assurance in their authenticity.

```
% The output variable for Legitimacy Grading
fis = addvar(fis, 'output', 'Legitimacy Grade', [0 100]);
% membership functions for Legitimacy Grading
fis = addMf(fis, 'output', 1, 'Not Legit', 'trapmf', [0 0 15 30]);
fis = addMf(fis, 'output', 1, 'Somewhat Legit', 'trimf', [20 40 60]);
fis = addMf(fis, 'output', 1, 'Moderately Legit', 'trimf', [50 70 90]);
fis = addMf(fis, 'output', 1, 'Highly Legit', 'trapmf', [80 95 100 100]);
```

Figure 19 - The Output

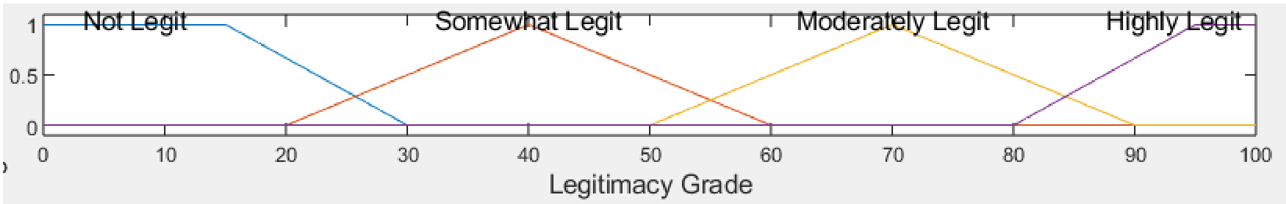

Figure 20 - Output Graph

The choice to establish these ranges was supported by a blend of actual data analysis and theoretical study. The ranges were determined using extensive research on market dynamics, investor behaviour, and cryptocurrency trends, which yielded a substantial amount of valuable data. Furthermore, theoretical models derived from the fields of financial risk assessment and fuzzy logic literature provided valuable ideas on how to effectively organize these output ranges to accurately represent subtle variations in legitimacy.

This is final gradings for the cryptocurrencies:

	A	B
	LegitimacyGradesOutput	
	CryptoName	Legitimacy...
	Text	Number
1	CryptoName	Legitimacy...
2	BTC	78.9208
3	ETH	54.3681
4	USDT	50.6201
5	BUSD	24.6874
6	XRP	36.2861
7	SOL	35.8392
8	NEO	31.9932

Figure 21 - Final Performance/Output

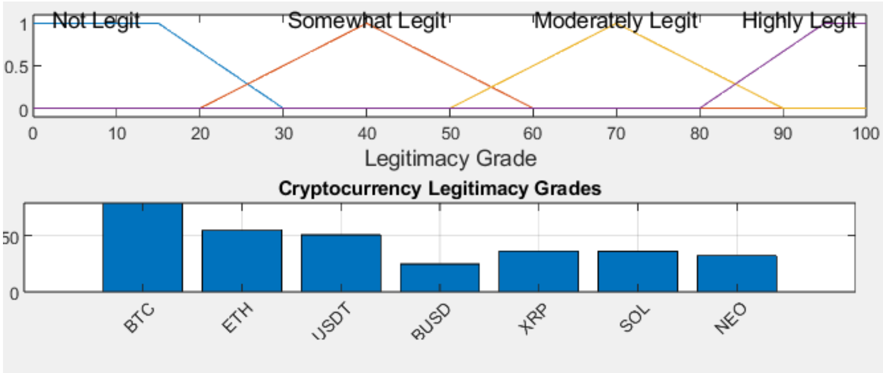

Figure 22 - Bar chart for better visualization of the grades

- Bitcoin (BTC) holds the highest legitimacy rating, signifying a robust position in terms of market confidence and expected long-term viability.
- Ethereum (ETH) maintains a relatively high rating because to its substantial developer engagement and practicality, even if it encounters competition from newly developing cryptocurrencies.
- Tether (USDT), a commonly utilized stablecoin, possesses a rating that indicates a favourable equilibrium between market adoption and operational reliability.
- Binance USD (BUSD) and NEO have lower legitimacy ratings, indicating possible areas for enhancement or reduced market trust in comparison to the top cryptocurrencies.
- XRP and Solana (SOL) are assigned similar grades, indicating equivalent degrees of legitimacy based on the parameters established by the FIS.

These values can be more accurate if the news around the backbone of the crypto currency is analysed. But it requires a new set of input and a new set of rules along with enhancement around the current rules.

Critical Reflection and Learning Insights

The process of developing the Crypto Legitimacy Grading Fuzzy Inference System (FIS) has been an enlightening and transformative experience for me. This project allowed me to apply my academic knowledge to a real-world challenge, moreover, provided countless learning insights and a deeper acquaintance with the intricate world of cryptocurrency and the application of fuzzy logic systems.

One of the most noteworthy learnings from this coursework was the practical application of theoretical concepts. The theories of fuzzy logic, which I had studied in my coursework, came to life as I applied them to assess cryptocurrency legitimacy. It was a deep adventure to see how this rug pulls events, and simple numbers could be transformed into a functional system that could analyse and give a meaningful outcome. This process significantly improved my technical skills, namely in MATLAB programming and the utilization of fuzzy logic toolboxes.

At last, the Crypto Legitimacy Grading FIS project has provided a thorough educational opportunity. Not only has it strengthened my technical abilities, but it has also given me significant insights into the multidisciplinary character of contemporary technological difficulties. As I near the completion of my academic journey, this project serves as evidence of the expertise and understanding I have gained, and as a guiding light for my future pursuits in the world of computer science and cybersecurity.

Conclusion and Future Perspectives

The creation of the Crypto Legitimacy Grading Fuzzy Inference System (FIS) is a noteworthy milestone in my academic progress, combining computer science and cybersecurity concepts with financial technology. This project has not only enhanced my technical and analytical skills, but also deepened my comprehension of the intricacies of the cryptocurrency industry. The effective use of fuzzy logic in assessing the legitimacy of cryptocurrencies showcases the capacity of multidisciplinary methodologies in tackling present-day technological obstacles.

Future Perspectives

When looking to the future, this project presents several prospective prospects:

- **Continuous Enhancement**: The FIS will benefit from ongoing updates to accommodate new data and evolving market trends, ensuring its relevance and accuracy with updated and new sets of rules for the system.
- **Expansion to Other Domains**: The approaches utilized in this context have potential implications in wider domains of cryptocurrencies and finance, such as the identification of fraudulent activities and the evaluation of possible risks.
- **Collaborative Research**: Collaborating with both business and academics has the potential to drive more progress and broader implementation of the system.
- **Educational Value**: The FIS can serve as a valuable educational tool, demonstrating the practical application of fuzzy logic in the crypto world.
- **Altering Grading Input:** By providing series of time data on several cryptocurrencies can be implemented with similar set of rules and grade the performance with for instance 6 months of data. But this requires enhancements for the set of rules for accurate grading.

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