Malaysian Journal of Consumer and Family Economics (MAJCAFE) Vol 31 (2023)
https://www.majcafe.com : eISSN : 2948-4189

The Prediction Model of Human Household Behavior of the Refuse Management System with Artificial Neural Network

Rohana Sham[1], Nor Aziyatul Izni[2]*, Nor Asiah Mahmood[3], Nur Ilyana Ismarau Tajuddin[4]

[1]School of Business, Asia Pacific University of Technology and Innovation, 57000 Kuala Lumpur, Malaysia
[2]Centre of Foundation Studies, Universiti Teknologi MARA, Cawangan Selangor, Kampus Dengkil, 43800 Dengkil, Selangor, Malaysia
[3]College of Business Administration, Prince Sultan University, 66833 Riyadh, Saudi Arabia
[4]Pusat Tamhidi, Universiti Sains Islam Malaysia, 71800 Nilai, Negeri Sembilan, Malaysia
**Corresponding author email: naizni@uitm.edu.my*
DOI: https://doi.org/10.60016/majcafe.v31.08

Abstract

Efficient management of household trash is essential to maintaining a sustainable society and a good environment. Low community engagement in environmental cleanup has led to dozens of unused refuse management apps. Today's refuse management system lacks a secure identification protocol for identifying users, especially those who have signed up for the app. Predicting and understanding human household behavior is needed, and it remains a complex challenge. Therefore, this study aims to predict human household behavior in the refuse management system using artificial neural networks (ANN). The work involved in developing the prediction model included data collection, data pre-processing, neural network model development, and performance validation. There are 505 participants, urban residents in Kuala Lumpur obtained for this study. ANN with one hidden layer is developed in MATLAB. The results show that the accuracy of the developed model is 83%. It indicates that ANN performed well in predicting household behavior in the refuse management system.

Keywords: artificial neural networks, refuse management system, household behavior, blockchain, prediction

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

1.0 Introduction

Major environmental issues in Malaysia are linked to waste management due to low community involvement in environmental cleanup. Lack of participation among urban residents, especially in managing their household waste, worsens the issues. It is agreed that engaging the community to reduce pollution is a global issue (Borhan & Ahmed, 2012). Over the last two decades, extreme efforts have been made to support market-based instruments and environmental performance measurements by including everyone in the discussion of environmental challenges. One proposed tool for managing pollution is the Internet of Things (IoT) (Kshetri, 2017). As the goal of this research is to encourage community engagement in environmental cleanup, a way to secure information on participants is essential to ensure their participation. Thus, a blockchain system was proposed. Blockchain is a well-known method of securing IoT and user data (Vikaliana et al., 2020). However, challenges remain in integrating this technology with IoT, particularly in measuring the behavior of urbanites who use the system (Reyna et al., 2018).

The pressure on urban residents to engage in the system increases as pollution in urban areas increases daily. Thus, managing their behavior is crucial to measuring the blockchain system's success among them. As the process of urbanization creates pressure on the environment, current studies on the environment are focusing more on human behavior toward cleaning up their surroundings. This is because most of the community desires a high standard of living (Uli et al., 2011). However, the unseen pollution chemicals make them oblivious to the dangers surrounding them. According to Almalawi et al. (2022), the IoT has been used as a trend to monitor pollution in urban areas. Many of us are unaware of atmospheric chemicals that damage human health and the health of other living organisms. Thus, IoT can help the community understand the environment and its issues. A recent study by Sham et al. (2020) looks at a new model of a population-free climate using blockchain technology to improve the high pollution issues among urban residents. At the same time, their study focuses on raising community awareness of pollution. This paper fills the gaps by examining the prediction model of urban residents' use of the refuse management system using a blockchain model. However, achieving the desired prediction accuracy is difficult because cities are dynamic systems of organized complexity with numerous independent variables that all affect each other (Bonaiuto et al., 1999).

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

1.1 Blockchain as a Tool

Sham et al. (2020) have proposed a blockchain model for refuse management for a household in an urban area to create trust among urban residents. However, the research needs to study the prediction model of human behavior toward the blockchain system. A detailed study on the previous blockchain only discusses the definition and application of the blockchain concept. Most studies agree that all blockchain transactions are recorded chronologically to monitor digital currency trading without central control (Joshi et al., 2018). They also decided that every computer in the network is called a node, and every node receives built-in duplicate information of all network transactions; type styles are automatically downloaded. Recently, blockchain technology was used to develop an automated access-control protocol to safeguard each transaction (Agbo et al., 2019). Thus, blockchain can provide security and privacy in peer-to-peer networks. A detailed elaboration by Li et al. (2017) on the essential criteria of blockchain is the crypto that they have to use in blockchain, including Ethereum, bitcoin, and Monero. To ensure the security of each transaction, all blockchain transactions are recorded in chronological order to monitor digital currency trading without central control (Joshi et al., 2018). In a blockchain system, every computer in the network is called a node, and every node receives built-in duplicate information of all network transactions; type styles are automatically downloaded. Recently, blockchain technology developed an automated access-control protocol (Agbo et al., 2019).

1.2 Lack of Transparency in Current Transaction

One of the significant findings in current online transactions is the fear of being hacked. This is because passwords can be easily obtained without computational power if they are irresponsibly written down or through simple observation. The problem worsens as some users reuse passwords across platforms, increasing the risk of hacking (Bélanger et al., 2017). Additionally, customers who subscribe to several online app services will be compelled to replicate and store login data across multiple servers by being required to keep their passwords for authentication on each server. These repeated data exchange procedures could result in widespread abuse of the authentication process. These vulnerabilities have caused the app's users to suffer from data breaches, identity theft, and, to some extent,

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

financial loss. To overcome this, many service providers try to provide multiple levels of security and questions to protect users. Finally, more muscular walls are being built for more robust encryption, resulting in a more complex procedure for the system. Users can easily see the authentication process, which verifies the entity's identity when accessing protected resources. It immediately affects how they perceive trust. An alternate solution is needed to address these issues because of the outdated, disjointed, and ineffective nature of the personal data ecosystem as it currently exists. Apart from that, most passwords are stored centrally, making attacks easier. Avoiding centralized authentication makes blockchain more secure. This is true for digital certificates and centrally stored public or private encryption keys. However, this needs to be communicated to society to increase its potential usage of the blockchain system, as biometrics and multi-factor authentication are safer than passwords.

In addition to that, the users also need to be aware of the replacement of their centralized authentication with blockchain technology to prevent security breaches in a typical online transaction. Blockchain was built on the idea that decentralized systems are more secure (Hong et al., 2018). This approach is hackproof since it uses multiple shared copies of publicly available information over a chain of blocks where data is copied at a predefined frequency. Even when identical data is present on another server in the chain, losing one server will not affect the data. To alter a person's biometric data in a biometric authentication scenario, a hacker would need to change every block in the blockchain (O'Gorman, 2003), which is impossible because new blocks are created every minute, seemingly out of thin air.

1.3 Lack of Public Engagement in Clean the Environment

Chin et al. (2019) say communities know about pollution and the environment. He reported that fewer want to stop air or other pollution individually. Although most participants agreed on the importance of environmental protection and reducing air pollution, none were willing to clean the environment daily due to their high job commitment. This led to more critical environmental pollution, especially in urban areas. It is widely acknowledged that education plays a vital role in engaging and involving the public in environmental cleaning.

The government has issued policies and regulations for the country to follow. However, individuals and communities do not care

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

about the environment due to a lack of knowledge and involvement. According to Khatibi et al. (2021), there is a link between knowledge and engagement in environmental awareness. A policy is not enough and is impossible to achieve if the community lacks the ability to maintain a clean environment. Thus, engagement and knowledge should be provided to the community through programs related to the pristine environment and its impact on future generations. This will help the community be more engaged and aware of what to do next. According to Nahar et al. (2022), the community needs to understand the causes and effects of environmental pollution on their surroundings. Most important is the willingness of urban residents to engage in cleaning activities despite their busy lives.

Another issue contributing to low societal engagement in system usage is information leakage on the standard platform. This led to a situation where high-passive mobile apps exist, but the adoption of blockchain still needs to grow. Furthermore, data leaks have fueled distrust in these apps, resulting in lower usage among urban households. Most app users would have had to provide their identity by entering their login information for online and cloud services. This has generated a massive amount of user data, most of which could leak and reduce the potential usage of blockchain technology in cleaning up the environment among urban residents.

1.4 Security Issues in Blockchain

Aside from information leakage, another critical factor preventing urban households from using the system is blockchain security issues (Garcia, 2018). Being online exposes IoT devices to threats, and security and privacy issues can arise due to the heterogeneous, dynamic, and sometimes undefined devices found in IoT. This makes it hard to solve current security issues in any application (Ouaddah, 2019).

In light of these challenges, blockchain-based systems' analysis, understanding, and definition must be approached cautiously. Each IoT domain has its own set of quirks that must be considered to maximize privacy and security. Experience can be gained from those who have ventured into this field, such as Schöner et al. (2017), who conducted an in-depth analysis to produce concrete specifications that meet security and privacy requirements to gauge urban resident participation. While the project only focuses on achieving a pollution-free environment, the previous study also drew upon ideas and

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

experiences regarding the use of blockchain and its benefits to the community (Kewell et al., 2017). Previous research has also shown that blockchain can help smart cities in various ways, including environmental stewardship (Sun et al., 2016). However, no definite prediction model can explain the model's usage, even though blockchain has been argued to increase trust (Wolfond, 2017; Kshetri & Voas, 2018). The question is whether this trust will result in community engagement and activation that will reduce pollution. Trust is essential to community engagement (Wolfond, 2017; Habibi et al., 2014). Blockchain security is based on a distributed source of truth. However, the research must study how to predict human behavior toward the blockchain system. A detailed study on the previous blockchain only discusses the definition and application of the blockchain concept. This paper fills the gaps by examining the prediction model of human household behavior of the refuse management system using artificial neural networks (ANN).

The remainder of this paper is organized as follows. Section 2 provides a brief overview of related work in the blockchain in the supply chain and current refuse management workflow and household engagement. Section 3 describes the methodology and implementation details of the proposed prediction of human household behavior via an Artificial Neural Network. Section 4 discusses the results and analysis of the study. Finally, Section 6 concludes the paper by summarizing the contributions, highlighting the key findings, and outlining future works of this research domain.

2.0 Literature Review

A blockchain can be used in many ways to create a trusted network for all stakeholders. Miraz & Ali (2018) found that blockchain has the following applications, as shown in Figure 1 and Figure 2. Figure 1 and Figure 2 depict a possible blockchain transaction. What makes a blockchain unique is that the technology has many non-monetary uses. This includes supply chain, healthcare, location proofing, and cloud storage. Two features were highlighted for a successful blockchain platform. The transaction's contract comes first, typically initiated by the participant using a digital ledger. Second was the block itself, where a data pool was gathered, accurately timestamped, and recorded.

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

Figure 1 : Example of Blockchain Application by Miraz & Ali (2018)

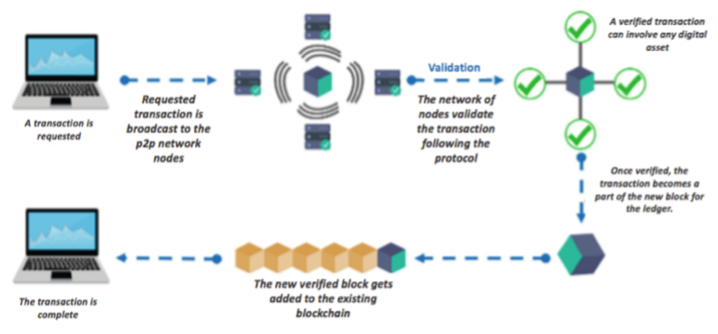


Figure 2: Blockchain Technology Transaction by Miraz & Ali (2018)

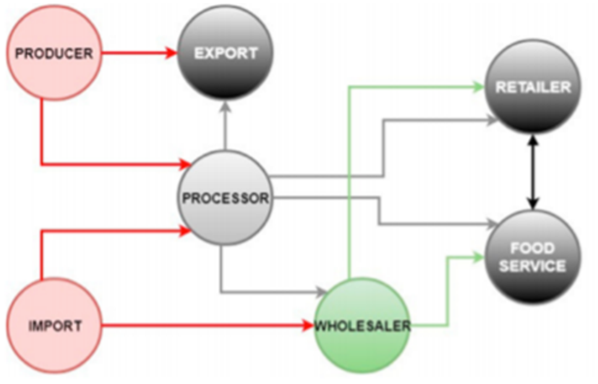
A blockchain-based refuse management system should have been mentioned in any analysis of blockchain applications among urban residents in Malaysia. This paper fills the gaps left by the need for more discussion on the prediction model for blockchain usage among urban household residents. Thus, to better understand blockchains and human applications, the following sections discuss

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

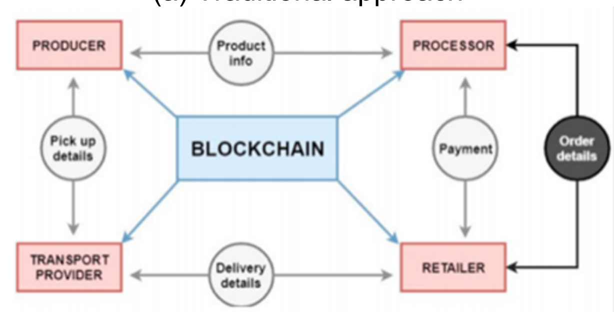
their potential applications in general, apart from environmental cleaning.

2.1 Blockchain in Supply Chain

Although blockchain could be applied in many ways, one is through the supply chain. With the Internet of Things (IoT), centralized organizations will require tools to track the locations of goods, increasing transaction transparency (Francisco & Swanson, 2018; Helo & Hao, 2018; Korpela et al., 2017). Blockchain is needed in this context, as asynchronous information and isolated data can reduce supplier trust. Low-quality and counterfeit products would affect the supply chain. As a result, information fraud and supply chain stress may increase or reduce trust among users (Abeyratne & Monfared, 2016; Tian, 2016). According to Casado-Vara et al. (2018), blockchain in multiagent systems can solve linear supply chain issues by decentralizing supply chains with user-entered transactions. However, users must first trust the system, as shown in Figures 3(a) and 3(b).



(a) Traditional approach



(b) Blockchain approach

Figure 3 : Comparison of the Supply Chain with A Traditional Approach and with Blockchain

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

It is agreed that blockchain would allow supply chain members to enter all processes, and users with direct connections would be able to read the blocks, increasing network security and privacy. Other users can access blocks to investigate the origins of transactions or items. To increase data trustworthiness, blockchain can verify data integrity, reduce duplicate data, and reconcile data (Helo & Hao, 2018). Figure 4 depicts how blockchain can improve supply chain management by increasing transparency, accuracy, and efficiency. If potential users are well-informed about the capabilities of the blockchain system, it is expected that user adoption will be high.

Figure 4 : Blockchain in the Supply Chain (Mire, 2018)

2.2 Current Refuse Management Workflow and Household Engagement

All trash collectors are part of an ecosystem that will affect urban residents. Users who use the system will need to access these ecosystems using private keys. Any entity, person, or asset (bin) in refuse management has a unique digital identity credential (public key number or hash code). These credentials can be used for a global identity verification exchange without revealing real identities. This creates a unique relationship that links society to a global ecosystem. Refuse management with blockchain technology can use the ecosystem model to develop applications that connect all stakeholders in a chain or node. This model allows for autonomous business, social, governmental, and other activities (see Figure 5). These ecosystems consist of the following:

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

- Actors, including apps, users, vendors, and municipal councils (who create and use these applications to track the movement of the refused item).
- Manages all user roles (public, vendor, and municipal), application access rights, and user participation.
- Can operate on their own or connect to another ecosystem if needed.
- The wallet or identity owner can create it.

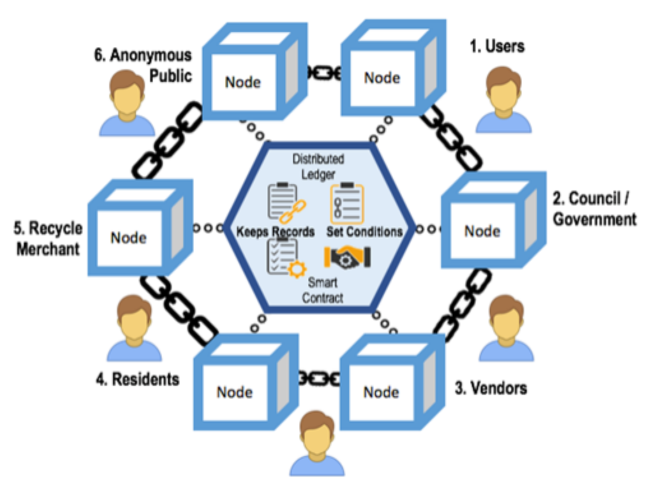


Figure 5 : Refuse Management Ecosystem (Sham et al., 2020)

By default, an ecosystem founder has complete control over all applications, user roles, permissions, ecosystem parameters, etc. However, other ecosystem members can take control (on the blockchain). The ecosystem's founder defines how to accept new members. Although the system can be autonomous, the ecosystem's founder and members create rules to control its operations. Intelligent laws are used for waste management. Before absorbing a new member into the total refusal system or work, the intelligent law system establishes rules for modifying access rights and other regulations. Only today, there has been a need for more discussion on the prediction model for human behavior when using the tools as a cleaning model. Thus, a unique methodology was carried out to examine the prediction model.

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

3.0 Methodology

The study's approach was broken down into different stages. Specifically, the authentication of users who are prepared to engage will be the focus of the first phase of the research, which will examine the current security challenges brought on by the inadequacies of blockchain technologies in a refuse management system. This phase starts with a detailed analysis of the various authentication techniques and frameworks suggested for online services. Additionally, this stage outlines the advantages and disadvantages of multiple authentication methods and the taxonomy of the cutting-edge cloud service authentication utilized for standard app development. This is consistent with the approach taken by Qiang et al. (2019), who did a thorough study to ensure the suggested technology's maximum effectiveness and application.

Further research is then done on the security issues associated with the Internet of Things (IoT) and online app authentication (Joshi et al., 2018; Khan & Salah, 2018). After that, data collection and analysis take place. An overview of the previously described inquiry and analysis to formulate the investigation's problem complete this phase.

Based on issues found in the literature, this phase focuses on identifying the blockchain method's shortcomings in a trash management system (Reyna et al., 2018). This phase starts with a thorough analysis of why the blockchain mechanism still needs to improve with application appropriateness. The flow diagram of a user's interactions with a service provider's smart contract, introduced to the blockchain system via the active apps, is then presented. The final design will then cover the user of the transaction that can be made in a refuse management system using the smart contract on the blockchain network. This phase ends with a framework and architecture for the proposed mechanism to develop high-security authentication among users. This involvement with the technical and coding reporting for the blockchain mechanism is proposed. Han & Ma (2019) used this approach to present a new derivation scheme utilizing blockchain through simulation results to confirm performance improvement.

This stage focuses on the fundamental problems with the blockchain-based trash management method. The mechanism will be carried out by looking into the current issues with the blockchain. After identifying the problems, the suggested technique is tested by executing the smart contract to produce measurements. It is followed

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

by a system evaluation in terms of several performance metrics, such as CPU usage, memory usage, block creation time, consensus time, and first confirmation time, to complement earlier work done by Novo (2018). Data dependability, integrity, and confidentiality will be closely monitored. We will closely monitor the process to look for information leaks, typically when a blockchain system does not secure IoT data. The issues and difficulties mentioned by Panarello et al. (2018) will be considered as formal security proof used to evaluate each activity during this phase.

The research's documentation and a model for how blockchain could be included in the garbage management system to involve the neighborhood for better environmental cleaning are the main goals of the final phase. To activate an ecologically friendly garbage management system employing a blockchain method, proper testing and validation are needed. Thus, using blockchain technology, a prediction model based on a machine learning approach is implemented to predict how human household behavior would affect the efficiency of the refuse management system. The artificial neural network (ANN) technique has been used to predict the actual performance of human household behavior. ANN can be defined as a computing system that simulates neuron systems and is used for pattern recognition and optimization.

The work involved in developing the prediction model included data collection, data pre-processing, neural network model development, and performance validation. The targeted population for this study is urban residents in Malaysia living in the metropolitan area of Kuala Lumpur. Data from 505 participants was obtained for this study. The survey was conducted using an online platform via a WhatsApp group in a residential area and only included those who reached 18. Table 1 below shows the survey collected and the corresponding descriptive statistics for the mean score analysis to predict household behavior. The variable with the highest score is the second, with a score of 3.07, indicating that most households separate household waste at home. It was good behavior. Meanwhile, the opinion of the participants that human behavior would affect efficient refuse management obtained a 4.44 score, where people believe that the efficiency of the refuse management system depends on household behavior. The ANN topology will use these collected parameters as input and target to develop the prediction model.

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

Table 1 : Score Analysis for the Input and Output Variables

No.	Variables	Mean	Standard Deviation
Input Variable			
1	I like to recycle waste.	2.86	1.68
2	I usually separate my household waste at home.	3.07	1.63
3	I regularly recycle certain parts of my household waste by putting them inside the recycling bin.	2.84	1.71
4	Separation of household waste is not a waste of time.	2.62	1.72
5	For me, waste separation at home is beneficial.	2.76	1.74
Output Variable			
1	Human behavior would affect the efficient refuse management system	4.44	0.99

Pre-processing the samples will ensure that the input and target datasets lie within the same range of values and are trustworthy, which is necessary for an efficient training process. A dependable dataset is crucial because it can affect the generated model's accuracy and performance. A dataset may also impact the learning process of the model during training. This study applied two types of data pre-processing methods—data selection and data inspection—to obtain a clean dataset.

ANN has been used for the model development process to develop a model that can predict potential household behavior regarding the effectiveness of the refuse management system. Figure 6 depicts the structure of the model. ANN with one hidden layer is developed in MATLAB. The input layer is the initial layer where data enters the ANN, followed by one hidden layer, and the output layer is the last layer where output data is produced.

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

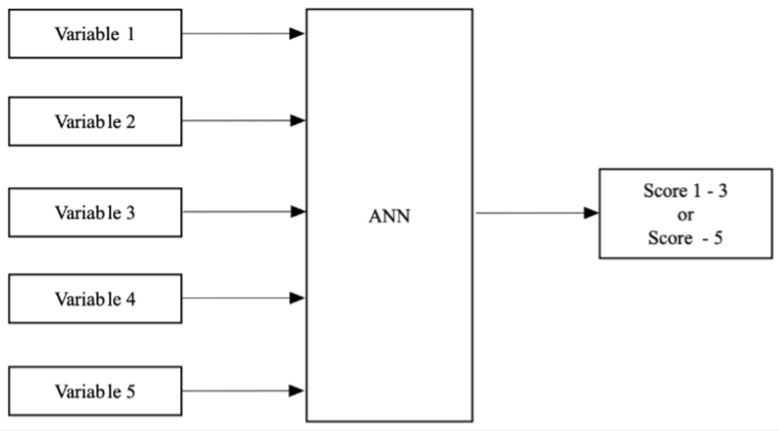


Figure 6 : ANN Structure for Household Behavior Prediction Model

The acquired data was split into training and testing data to develop the prediction model. Four hundred and six data points were used for training data to build a model, and 99 data points were used for testing data to determine the effectiveness of the constructed model. The data were divided into three groups during the training phase: 70% of the data were used to train and build the network; 15% of the data were used to validate the network created by the training data set; and the remaining 15% of the data were used to confirm the developed network's capacity for prediction.

4.0 Findings

The confusion matrix, receiver operating characteristics (ROC), cross-entropy performance, and error histogram plot were taken into account when evaluating a model's performance in the training state or during the model development process. The confusion matrix's mapping is shown in Figure 7. The network output displays more correct responses in the green regions, which is deemed an accurate model. As indicated by the red regions, there were fewer incorrect responses. The region of interest, situated in the lower right corner of the confusion matrix, serves as a representation of the overall accuracy of the model that has been constructed. This accuracy is explicitly reported to be 83%. The aforementioned statement indicates that the model exhibited a commendable level of accuracy, accurately classifying 83% of the instances it encountered throughout the evaluation process.

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

The utilization of a confusion matrix proves to be an invaluable instrument in the assessment of a model's efficacy, be it during the training phase or throughout the entirety of the model creation process. The aforementioned feature offers a visual depiction of the model's effectiveness in accurately classifying various categories or labels. In the given context, it can be observed that Figure 7 effectively portrays the mapping of the confusion matrix. The regions colored in green signify the presence of accurate responses, thereby indicating the model's precise classification of instances into their respective categories.

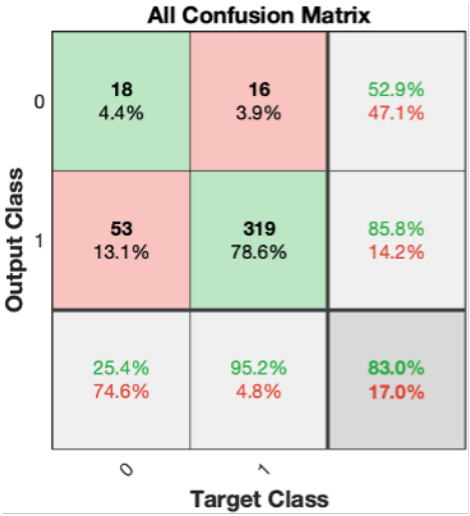


Figure 7 : Confusion Matrix

Figure 8 shows the receiver operating characteristics (ROC), a plot of the actual positive rate (sensitivity) versus the false positive rate. The plot demonstrates that the model is a reliable test for the training phase. As a result, it is consistent with the performance mapping in the confusion matrix.

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

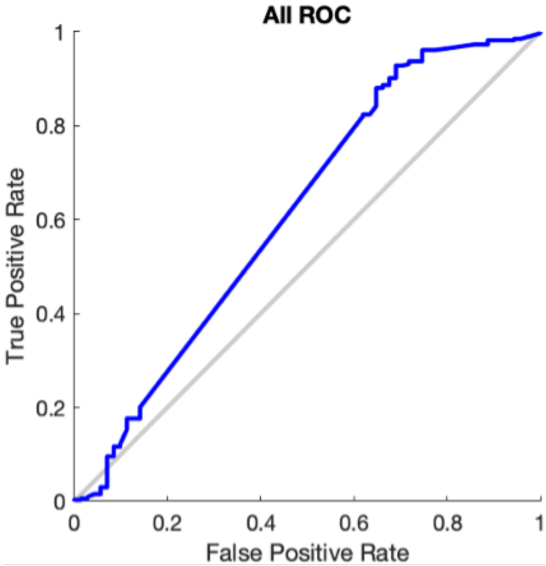


Figure 8 : Receiver Operating Characteristic (ROC)

Figure 9 depicts the cross-entropy finding. Cross-entropy is a loss function to optimize the classification model, and the best cross-entropy performance for this model is 0.21312. The quality of the generated model improves with lower cross-entropy values. According to the model mentioned above, most training data is successfully distinguished during the training process. It indicates that ANN performed well in predicting household behavior in the refuse management system.

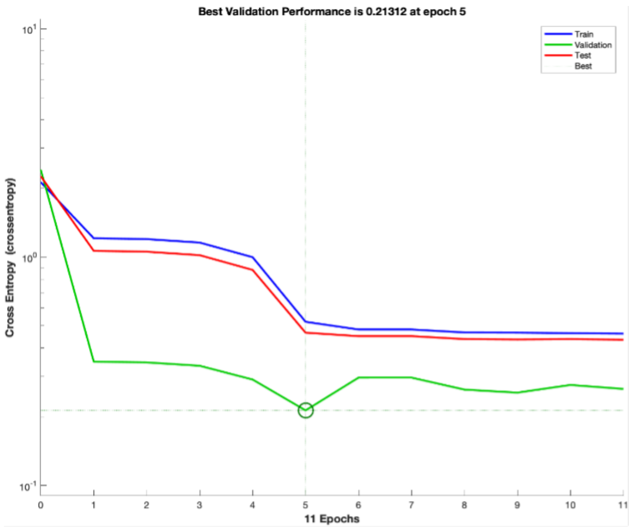


Figure 9 : Cross-Entropy to Optimize the Classification Model

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

The study posits the utilization of ANN to predict human household behavior within refuse management systems, predicated upon survey data. The study showcases the efficacy of ANN classification, as evidenced by its commendable performance in achieving an accuracy rate of 83% when applied to survey data. This research aids the theoretical understanding of human behavior concerning waste management. It explores the subtleties of why people choose specific options for waste management, recycling, and related activities. This understanding can be applied to other areas of behavioral science. This research fills the knowledge gap between behavioral economics, artificial intelligence, and environmental science. Predictive analytics is a developing subject with applications outside waste management, and the creation of predictive models employing ANNs contributes to the theoretical underpinnings of this field.

Municipalities and waste management businesses can optimize their operations by predicting home behavior, resulting in more effective waste collection, lower costs, and a cleaner environment. The study's findings' ramifications are significant for academics and professionals working in the related fields. By using ANN to correctly predict human behavior, a strong foundation is created for the prospective use of this technology to improve the effectiveness of waste management systems. This phenomenon can lead to improved waste management techniques, more effective resource use, and eventually, a higher level of sustainability.

To augment the efficacy of artificial neural networks (ANN) in prognosticating human household behavior, prospective avenues of investigation may be pursued to incorporate supplementary variables or inputs. An exemplary illustration can be found in the examination of the ramifications of technology, social structure, and religion on household behavior, which has the potential to yield invaluable insights. By considering these various factors, scholars can acquire a more comprehensive and nuanced comprehension of the fundamental determinants that shape human behavior within refuse management systems.

This entire study clarifies how powerful ANN is for predicting and understanding human behavior in waste management. The hypothesis broadens the possibilities for further research and development within this field, thereby improving the effectiveness and expertise of waste management approaches.

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

5.0 Conclusion and Recommendations

In this study, the prediction of human household behavior using ANN has been proposed. This study investigates how household behavior in refuse management systems can be identified using ANN based on survey information. This study has shown that classification results with ANN present a good performance for predicting human behavior with 83% accuracy when using survey data. The findings of this study can help other researchers lay the foundation for using ANN to predict human household behavior toward the efficiency of the refuse management system. Future directions in analyzing the performance of ANN may consider more variables (inputs), such as analysis of technology, social structure, and religion. In summary, creating an ANN-based prediction model of human household behavior in refuse management advances the theoretical understanding of human behavior and complex system modeling and provides real-world solutions to increase waste management effectiveness, lower costs, and support environmental sustainability. Research that has an impact in diverse disciplines consistently combines theory and practice.

Acknowledgments

Highly appreciation also to the research team from Asia Pacific Universiti, Universiti Teknologi MARA, Cawangan Selangor, Kampus dengkil, Prince Sultan University, Saudia Arabia, and Universiti Sains Islam Malaysia for their commitment throughout this study.

References

Abeyratne, S. A. & Monfared, R. P. (2016). Blockchain Ready Manufacturing Supply Chain Using Distributed Ledger. *International Journal of Research in Engineering and Technology*, 5(9), 1–10.

Agbo, C. C., Mahmoud, Q. H. & Eklund, J. M. (2019). Blockchain Technology in Healthcare: A Systematic Review. *Healthcare*, 7(2), 1–30.

Almalawi, A., Alsolami, F., Khan, A.I. et al. (2022). An IoT-based system for magnify air pollution monitoring and prognosis using hybrid artificial intelligence technique. *Environmental Research*, 206, 112576.

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

Bélanger, F., Collignon, S., Enget, K. & Negangard, E. (2017). Determinants of early conformance with information security policies. *Information and Management*, 54(7), 887–901.

Bonaiuto, M., Aiello, A., Perugini, M., Bonnes, M., & Ercolani, A. P. (1999). Multidimensional perception of residential environment quality and neighbourhood attachment in the urban environment. *Journal of Environmental Psychology*, 19(4), 331–352.

Borhan, H. & Ahmed, E.M. (2012). Green Environment: Assessment of Income and Water Pollution in Malaysia. *Procedia - Social and Behavioral Sciences*, 42, 66–174.

Casado-Vara, R., Prieto, J., De La Prieta, F. & Corchado, J. M. (2018). How blockchain improves the supply chain: Case study alimentary supply chain. *Procedia Computer Science*, 134, 393–398.

Chin, Y. S. J., De Pretto, L., Thuppil, V. & Ashfold, M. J. (2019). Public awareness and support for environmental protection—A focus on air pollution in peninsular Malaysia. *PLoS ONE*, 14(3), e0212206.

Francisco. K. & Swanson, D. (2018). The Supply Chain Has No Clothes: Technology Adoption of Blockchain for Supply Chain Transparency. *Logistics*, 2(1), 2.

Garcia, P. (2018). Biometrics on the blockchain. *Biometric Technology Today*, 2018(5), 5–7.

Habibi, M.R., Laroche, M. & Richard, M.O. (2014). The roles of brand community and community engagement in building brand trust on social media. *Computers in Human Behavior*, 37, 152–161.

Han, L. & Ma, M. (2019). Blockchain-based mobility management for 5G. *Future Generation Computer System*, 110, 638–646.

Helo, P. & Hao, Y. (2018). Blockchains in operations and supply chains – a review and reference implementation. Proceedings of International Conference on Computers and Industrial Engineering, 242–251.

Hong, S., Park, S., Park, L. W., Jeon, M. & Chang, H. (2018). An analysis of security systems for electronic information for establishing secure Internet of things environments: Focusing on research trends in the security field in South Korea. *Future Generation Computer Systems*, 82, 769–782.

Joshi, A. P., Han, M., & Wang, Y. (2018). A survey on security and privacy issues of blockchain technology. *Mathematical Foundations of Computing*, 1(2), 121–147.

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

Kewell, B., Adams, R. & Parry, G. (2017). Blockchain for good? *Strategic Change,* 26(5), 429–437.

Khan, M. A., & Salah, K. (2018). IoT security: Review, blockchain solutions, and open challenges. *Future Generation Computer System*, 82, 395–411.

Khatibi, F. S., Dedekorkut-Howes, A., Howes, M. & Torabi, E. (2021). Can public awareness, knowledge, and engagement improve climate change adaptation policies? *Discover Sustainability*, 2(18), 1–24.

Korpela, K., Hallikas, J. & Dahlberg, T. (2017). Digital Supply Chain Transformation toward Blockchain Integration. Proceedings of the 50th Hawaii International Conference on System Sciences, 4182–4191.

Kshetri, N. (2017). Blockchain's roles in strengthening cybersecurity and protecting privacy. *Telecommunications Policy*, 41(10), 1027–1038.

Kshetri, N. & Voas, J. (2018). Blockchain-enabled e-voting. *IEEE Software*, 35(4), 95-99.

Li, X., Jiang, P., Chen, T., Luo, X. & Wen, Q. (2017). A survey on the security of blockchain systems. *Future Generation Computer Systems*, 107, 841–853.

Miraz, H. & Ali, M. (2018). Blockchain Enable Enhance IoT Ecosystem Security. International Conference on Emerging Technologies in Computing, 1–9

Mire, S. (2018). Blockchain in Supply Chain Management: 13 Possible Use Cases. DMCA Report.

Nahar, N., Hossain, Z., & Mahiuddin, S. (2022). Assessment of the environmental perceptions, attitudes, and awareness of city dwellers regarding sustainable urban environmental management: a case study of Dhaka, Bangladesh. *Environment, Development and Sustainability, 1*–29.

Novo, O. (2018). Scalable Access Management in IoT using Blockchain: a Performance Evaluation. *IEEE Internet of Things Journal*, 6(3), 4694-4701.

O'Gorman, L. (2003). Comparing passwords, tokens, and biometrics for user authentication. Proceedings of the IEEE, 91(12), 2021–2040.

Ouaddah, A. (2019). Chapter Eight - A blockchain-based access control framework for the security and privacy of IoT with strong anonymity unlinkability and intractability guarantees. *Advances in Computers*, 115, 211–258.

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

Panarello, A., Tapas, N., Merlino, G., Longo, F., & Puliafito, A. (2018). Blockchain and IoT integration: A systematic survey. *Sensors*, 18(8), 2575.

Qiang, Q., Nurgaliev, I., Muzammal, M., Jensen, C.S & Fan, J. (2019). On Spatio-temporal blockchain query processing. *Future Generation Computer System*, 98, 208–218.

Reyna, A., Martín, C., Chen, J., Soler, E., & Díaz, M. (2018). On blockchain and its integration with IoT. Challenges and opportunities. *Future Generation Computer Systems*, 18, 173–190.

Sana, M., Karim, A., Safdar, Z., Safdar, K., Ahmed, E. & Imran, M. (2019). Securing IoTs in Distributed Blockchain: Analysis, Requirements, and Open Issues. *Future Generation Computer System*, 100, 325–343.

Schöner, M. M., Kourouklis, D., Sandner, P., Gonzalez, E. & Förster, J. (2017). Chapter Eight - A blockchain-based access control framework for the security and privacy of IoT with strong anonymity unlikability and intractability guarantees. Blockchain technology in the pharmaceutical industry, Frankfurt, Germany: Frankfurt School Blockchain Center.

Sham, R., Hussin, A. A. A., Abdamia, N., Musa, O., & Rasi, R.Z. (2020). Block Chain Technology Application in A Refuse Management System. 2nd International Conference on Computer and Information Sciences (ICCIS) 2020, 9257713.

Sun, J., Yan, J. & Zhang, K.Z. (2016). Blockchain-based sharing services: What blockchain technology can contribute to smart cities. *Financial Innovation*, 2(1), 26.

Tian, F. (2016). An agri-food supply chain traceability system for China based on RFID & blockchain technology. 13th International Conference on Service Systems and Service Management (ICSSSM), 1–6.

Uli, J., Tiraieyari, N., Mahmood, N. A., Othman, J., Samah, B. A., Hassan, M. S.H. & Ali, N. A. (2011). Factors Explaining the Variation of Quality of Life Among Employees In The Malaysian Public Sector. *Australian Journal of Basic and Applied Sciences*, 5(12), 3255–3263.

Vikaliana, R., Rasi, R. Z. R. M., Pujawan, I. N., & Sham, R. (2020). The Application of Blockchain Technology In Agribusiness Supply Chain Management In Indonesia. *Solid State Technology*, 63(6), 16522–16533.

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/

Wolfond, G. (2017). A blockchain ecosystem for digital identity: improving service delivery in Canada's public and private sectors. *Technology Innovation Management Review*, 7(10), 35–40.

Copyright © 2018 Malaysian Consumer and Family Economics Association (MACFEA).
This is an open access article under the CC BY-SA
https://creativecommons.org/licenses/by-sa/4.0/