The Use of Artificial Intelligence in the Bank Card Industry

Jusuf Qarkaxhija[1]

Ersan Hamdiu[2]

Laurik Helshani[3]

Shkëlqim Miftari[4]

AAB College,
Faculty of Computer Sciences,
Kosovo

Received: 05 July 2025 / Accepted: 30 August 2025 / Published: 25 September 2025

Doi: 10.56345/ijrdv12n2s103

Abstract

The integration of artificial intelligence (AI) in the bank card industry is revolutionizing traditional banking practices, enhancing security, and improving customer experience. AI-driven technologies, such as machine learning and natural language processing, are deployed to detect and prevent fraudulent activities, analyze transaction patterns, and provide personalized financial services. Advanced algorithms continuously monitor and evaluate transactions in real-time, identifying suspicious activities and reducing the risk of fraud. AI also enables the automation of customer support through chatbots and virtual assistants, offering immediate and accurate responses to customer inquiries.Moreover, AI-powered analytics provide banks with insights into customer behavior, enabling targeted marketing and customized product offerings. By leveraging AI, banks can offer tailored financial products and services that meet the specific needs and preferences of individual customers. This level of personalization enhances customer satisfaction and fosters loyalty, as customers feel more valued and understood. The adoption of AI in the bank card industry not only increases operational efficiency but also enhances customer trust by ensuring secure and seamless transactions. AI-driven solutions can detect unusual spending patterns and flag potentially fraudulent transactions, providing an additional layer of security for customers. As AI technology continues to evolve, its role in the banking sector is expected to expand, further transforming the landscape of financial services.Furthermore, AI can aid in regulatory compliance by automatically detecting and reporting suspicious activities in line with anti-money laundering (AML) regulations. The continuous advancements in AI technology offer the potential for even greater innovations, making the bank card industry more efficient, secure, and customer-centric.

Keywords: *AI, Banks, Bank Card Industry, etc*

1. Introduction

One of the fundamental pillars of the modern financial system, facilitating fast, secure, and efficient transactions for both individual consumers and businesses, is the bank card industry [1]. The rapid advancement of technology - particularly in the field of artificial intelligence - has played a pivotal role in the evolution of bank cards, transforming them from simple plastic instruments into smart cards that support digital payments [2].

Major global payment networks such as Visa [3], Mastercard, American Express, and Discover serve a central

function in this industry by providing the infrastructure required for transaction processing on a global scale [4]. Concurrently, banks and financial institutions act as card issuers, managing both the security and service frameworks associated with these cards, while striving to remain aligned with ongoing technological advancements - especially those driven by artificial intelligence.

The integration of artificial intelligence (AI) into the bank card industry has significantly enhanced security measures, operational efficiency, and service personalization. AI algorithms are capable of analyzing complex patterns of user behavior, enabling the real-time detection and prevention of financial fraud. This capability substantially mitigates the risk of financial loss for both institutions and clients [5]. Moreover, AI is increasingly employed in streamlining the transaction approval process, developing virtual customer service assistants, and delivering personalized financial management recommendations. Through such innovations, AI is contributing to the development of a more secure, intelligent, and adaptive payment ecosystem [6].

2. Methodology

In this paper, artificial intelligence is applied to the Luhn algorithm, which is used to verify whether a given number corresponds to a valid bank card. This algorithm operates through the application of modulo functions in mathematical operations [7]. The modulo function is a mathematical method for dividing one number by another and determining the remainder. In the context of this study, the relevant divisor is the integer 10.

When a card number is subjected to this algorithm to verify its validity, the modulo function is applied [8]. If the card number has been damaged or altered, AI is employed to identify the correct missing digit. In cases where two or more digits are missing, AI generates all possible combinations that satisfy the constraints of the algorithm.

To better understand the operation of the modulo function, particularly modulo 10, the following examples illustrate how the remainder is derived when a number is divided by 10:

18 mod 10 = 8

When 18 is divided by 10, the quotient is 1 and the remainder is 8.

14 mod 10 = 4

When 14 is divided by 10, the quotient is 1 and the remainder is 4.

12 mod 10 = 2

When 12 is divided by 10, the quotient is 1 and the remainder is 2.

These examples illustrate the fundamental operation behind the Luhn algorithm, which serves as a basis for card number validation and is further enhanced through the application of artificial intelligence.

3. The Use of Bank Card Numbers

All digits of a bank card number [9] follow a well-defined mathematical algorithm; they are not assigned randomly. This mathematical algorithm was developed by IBM scientist Hans Peter Luhn and is widely known as the Luhn algorithm [10]. How does this algorithm work? Below, we present an example of a bank card number to illustrate the process.

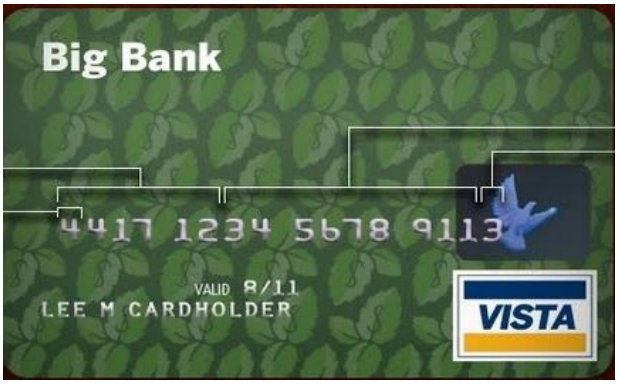

Figure 1: Bank Card

From the Figure 1, we observe that the digits of this bank card number are 4417 1234 5678 9113. The first digit of a card number indicates the industry to which the card belongs. Specifically: if the first digit is 1 or 2, the card is associated with the aviation industry; if the first digit is 3, it corresponds to the travel and entertainment industry; if the first digit is 4 or 5, the card falls under the banking and financial services industry; a first digit of 6 indicates that the card is used in the retail and banking sectors; the digit 7 is associated with the petroleum industry; the digits 8 and 9 are linked to the telecommunications sector and national data assignment, respectively.

This classification, embedded in the card number structure, enables rapid identification of the issuing sector and serves as an integral part of card validation and categorization.

The first six digits of a bank card number serve to identify the institution that issued the card. The following digits - from the seventh up to and including the penultimate digit - represent the account number of the cardholder (many cards use exactly nine digits for this purpose). The final digit (the 16th digit) is used to verify the validity of the card through the application of the Luhn algorithm.

The verification process is carried out by multiplying every second digit of the bank card number by 2. An example is provided below to illustrate this process:

(4 * 2) + 4 + (1*2) + 7 + (1 * 2) + 2 + (3 * 2) + 4 + (5 * 2) + 6 + (7 * 2) + 8 + (9 * 2) + 1 + (1 * 2) + 3 = 8 + 4 + 2 + 7 + 2 + 2 + 6 + 4 + 1 + 0 + 6 + 1 + 4 + 8 + 1 + 8 + 1 + 2 + 3 = 70 (1)

(If, during the multiplication process, the result is a two - digit number or greater (i.e., 10 or higher), the digits of that number are summed together. For example: 7 * 2 = 14 = 1 + 4 = 5, or 5 * 2 = 10 = 1 + 0 = 1 and so on).

If, after performing all the calculations, the resulting sum is divisible by 10 (i.e., a multiple of 10), then we can be sure that the bank card is valid (i.e., 70 : 10 = 7). If the sum is not divisible by 10, the card is considered invalid.

Here's how we can proceed with the Luhn algorithm step-by-step for the provided card number 1505 0300 0025 9836. We perform the same procedure as below, as in the previous case:

(1 * 2) + 5 + (0 * 2) + 5 + (0 * 2) + 3 + (0 * 2) + 0 + (0 * 2) + 0 + (2 * 2) + 5 + (9 * 2) + 8 + (3 * 2) + 6 = 2 + 5 + 0 + 5 + 0 + 3 + 0 + 0 + 0 + 0 + 4 + 5 + 1 + 8 + 8 + 6 + 6 = 53 (2)

From the result obtained above, we observe that the card number is not valid, as the sum we obtained (53) is not divisible by 10 (i.e., 53 : 10 = 5.3).

4. The Application of AI in the Luhn Algorithm

First, we can say that Artificial Intelligence (AI) is the ability of computers and sophisticated systems to perform tasks that usually require human intelligence. AI uses algorithms and large amounts of data to improve performance over time [11]. It has numerous applications in every area of life, and one of them is in the bank card industry. Artificial Intelligence (AI) can transform the bank card industry in several ways, such as fraud prevention, process automation, risk management, etc.

How can we apply AI in the case of the previous bank card?

If in the above bank card number, which was: 4417 1234 5678 9113, instead of the last digit 3, we put the number 4, meaning: 4417 1234 5678 9114, then the result from applying the algorithm would be:

(4 * 2) + 4 + (1 * 2) + 7 + (1 * 2) + 2 + (3 * 2) + 4 + (5 * 2) + 6 + (7 * 2) + 8 + (9 * 2) + 1 + (1 * 2) + 4 = 8 + 4 + 2 + 7 + 2 + 2 + 6 + 4 + 1 + 0 + 6 + 1 + 4 + 8 + 1 + 8 + 1 + 2 + 4 = 71 (3)

Using AI, it is possible to identify which digit may be incorrect by testing all possible variations [12]. The AI simulates every potential change for each digit in the number (from 0 to 9) and applies the Luhn algorithm to each substitution [13].

Example of possible substitutions for the last digit (4):

We replace 4 with each digit from 0 to 9 and calculate the total sum:

If 4 become 0, the sum = 67 (not valid).

If 4 become 1, the sum = 68 (not valid).

If 4 become 2, the sum = 69 (not valid).

If 4 become 3, the sum = 70 (valuable) (3')

AI confirms that the last digit should be 3.

There are also other cases where AI can be applied to bank card numbers. One such case involves a card with the digits: 4417 1234 567X 9113, where we observe that one digit in the card number is entirely unknown or completely missing [14]. In this case, we are presented with the following situation:

4417 1234 567X 9113

(4 * 2) + 4 + (1 * 2) + 7 + (1 * 2) + 2 + (3 * 2) + 4 + (5 * 2) + 6 + (7 * 2) + X + (9 * 2) + 1 + (1 * 2) + 3 = 8 + 4 + 2 + 7 + 2 + 2

+ 6 + 4 + 1 + 0 + 6 + 1 + 4 + X + 1 + 8 + 1 + 2 + 3 = 62 + X (4)

The sum = 62 + X

For the card number to be valid, the sum 62 + X must be divisible by 10. This gives us the solution:

X = 8 (4')

If there are two unknown digits in a bank card number and we need to identify them to ensure the number is valid according to the Luhn algorithm, the process becomes slightly more complex. AI can play a significant role in reducing the number of possible combinations and solving the problem more efficiently [15]. Here is a concrete example:

4417 123X 56Y8 9113

(4 * 2) + 4 + (1 * 2) + 7 + (1 * 2) + 2 + (3 * 2) + X + (5 * 2) + 6 + (Y * 2) + 8 + (9 * 2) + 1 + (1 * 2) +3= 8 + 4 + 2 + 7 + 2 + 2 + 6 + X + 1 + 0 + 6 + Y * 2 + 8 + 1 + 8 +1 + 2 +3=61+X+2*Y (5)

How to find combinations for X and Y?

The possible combinations for X and Y that satisfy the required condition are:

61 + X + 2*Y = 70

X + 2*Y = 9

Since X and Y are digits (0–9), only the following combinations are valid:

X = 1, Y = 4 (5')

X = 3, Y = 3

X = 5, Y = 2

X = 7, Y = 1

X = 9, Y = 0

The question arises, why it cannot be in this case:

61 + X + 2*Y = 80, or

X + 2*Y = 19 (6)

This cannot happen due to certain impossible combinations that are not allowed by the modulo function applied in the Luhn algorithm. For example, if X were 1 and Y were 9, according to the modulo function, we would have the following situation:

X + 2*Y = 1 + 2 * 9 = 1 + 18 = 1 + 1 + 8 = 10

61 + X + 2*Y = 61 + 10 = 71

5. Results

From the mathematical equation (1), where the modulo function is applied in the Luhn algorithm to the bank card number, we see that it is indeed a valid bank card, as the result obtained is divisible by 10. On the other hand, from the mathematical equation (2), we observe that it is not a bank card, as the result obtained is not divisible by 10. These equations, as such, do not require the application of any form of AI for their verification to determine whether they are bank cards or not.

In the case of equation (3), we can observe the application of AI in the card, because an incorrectly placed number (placing the digit 4 instead of the digit 3) results in the fact that the card is not a bank card. Below equation (3), the possible solutions are proposed, and the correct solution is the number 4, which we see in equation (3'). From equation (4), we see that the number of the bank card is completely unknown, and in this case, artificial intelligence is immediately applied and provides the possible solution, 8, which we see in equation (4').

As for equation (5), where we see that two numbers are unknown, all the possible solutions proposed by artificial intelligence are presented in equation (5') at the end. Regarding equation (6), under no circumstances and in no combination of the Luhn algorithm and artificial intelligence, can it be a valid bank card.

6. Conclusions

The bank card industry is a central component of the ongoing digital transformation within the global financial infrastructure. With billions of transactions processed daily, the assurance of security and data integrity is critical. The implementation of the Luhn algorithm - a checksum formula used to validate identification numbers - alongside the integration of artificial intelligence techniques, exemplifies the effective application of algorithmic design and intelligent systems in enhancing transactional reliability and fraud detection within financial technologies [16].

The Luhn algorithm, which operates through a simple numerical calculation, has for decades served to verify the

basic integrity of bank card numbers. However, it is no longer sufficient to address the modern challenges posed by cyber fraud, human error, and corrupted data.

It is precisely at this point that artificial intelligence emerges as a vital complement. AI enhances the functionality of the Luhn algorithm by enabling the verification and correction of card numbers, even in cases where certain digits may be missing. Leveraging its capacity for large-scale data analysis, pattern recognition, and predictive modeling, artificial intelligence can detect irregularities and anomalies in user behavior, flag potential fraud attempts, and maintain real-time transactional security.

One of the greatest advantages of artificial intelligence is its ability to continuously learn from the data it processes - an aspect known as machine learning [17]. Through this capability, AI can construct models of normal user behavior and instantly detect deviations or anomalies. This makes it a powerful tool not only for ensuring security but also for enhancing the personalization of customer services.

Nevertheless, every technology introduces its own set of challenges. The use of artificial intelligence must be accompanied by robust measures for the protection of personal data, transparency in algorithmic processes, and an ethical balance between technological efficiency and the respect for user rights [18]. However, these concerns represent a broader discourse that extends beyond the scope of technical security and into higher-level ethical and regulatory discussions.

In conclusion, it can be stated with confidence that the Luhn algorithm and artificial intelligence are not, and cannot be, standalone components within the bank card industry [19]. Rather, they function as inseparable collaborative partners in the construction of a secure, efficient, and reliable system. While the Luhn algorithm provides the foundational layer of validation, artificial intelligence elevates this foundation to a new level of sophistication and security.

Ultimately, the future of bank cards is closely intertwined with the ongoing advancement of technology as a whole [20]. As artificial intelligence continues to evolve, financial systems around the world become increasingly robust and intelligent [21]. In this context, the convergence of both traditional and advanced mathematics with modern technological innovations represents a necessary step toward building a secure and sustainable digital economy for all.

References

Artificial Intelligence in Banking. (2022). How AI is transforming the financial sector. Retrieved from [https://verisave.com/how-ai-is-impacting-credit-cards/#:~:text=Detecting%20Fraudulent%20Transactions,proactively%20identify%20and%20block%20fraud.]

Binns, R. (2018). Adapting to artificial intelligence: Ethical considerations in data protection and user rights. Journal of Ethics in Technology, 9(2), 45-58. https://doi.org/10.1016/j.jeth.2018.03.004

Bishop, C. M. (2006). Pattern recognition and machine learning. Springer

Chen, Y., & Wang, L. (2020). Artificial intelligence for fraud detection: Integrating machine learning with traditional validation algorithms. Journal of Financial Technologies, 14(3), 142-158. https://doi.org/10.1016/j.jfintech.2020.03.007

Chen, Y., & Zhang, L. (2019). Enhancing error detection in financial systems with artificial intelligence: A machine learning approach to the Luhn algorithm. Journal of Computational Finance, 12(4), 220-234. https://doi.org/10.1109/jcf.2019.00756

Davenport, T. (2021). Artificial intelligence in the digital economy: The future of payments. Journal of Digital Finance, 12(3), 220-233.

Géron, A. (2019). Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems (2nd ed.). O'Reilly Media.

Hoffman. (2024). What is a credit card. Retrieved from [https://www.bankrate.com/credit-cards/advice/what-is-a-credit-card/]

Luhn, H. P. (1954). Computer for verifying numbers. IBM Journal of Research and Development, 2(2), 159–165.

Patel, S., & Roy, A. (2020). Artificial intelligence in financial applications: Error detection and correction using machine learning algorithms. Journal of Artificial Intelligence in Finance, 8(3), 134-146. https://doi.org/10.1016/j.jaif.2020.01.005

Rosen, K. H. (2012). Discrete mathematics and its applications (7th ed.). McGraw-Hill.

Russell, S., & Norvig, P. (2021). Artificial intelligence: A modern approach (4th ed.). Pearson.

Saxena, E., Alfarano, A., Wenger, E., & Lauter, K. (2024). Teaching Transformers Modular Arithmetic at Scale. arXiv. https://arxiv.org/abs/2410.03569

Smith, A., & Zhao, M. (2018). The application of Luhn's algorithm in financial technologies: From theory to practice. Journal of Computational Finance, 12(2), 34-45. https://doi.org/10.1016/j.jcf.2018.02.009

Smith, J., & Johnson, P. (2020). Artificial intelligence in banking: Fraud detection and prevention. Journal of Financial Technology, 15(3), 45–60.

Smith, J., & Johnson, R. (2018). Algorithms for financial security: The role of checksum formulas in card number validation. Financial Technology Press.

Smith, J., & Kumar, R. (2020). AI-driven systems in financial security: Enhancing the reliability of card transactions. International Journal of Computer Science in Finance, 14(3), 220-235. https://doi.org/10.1016/j.jcsf.2020.05.004

Visa. (2020). Visa payments and the future of digital finance. Retrieved from [https://usa.visa.com/pay-with-visa/cards/visa-credit-cards.html]

Zhang, X., & Li, J. (2021). Optimizing problem-solving efficiency with artificial intelligence: Reducing computational complexity through machine learning. Journal of Artificial Intelligence and Computational Optimization, 15(2), 101-113. https://doi.org/10.1016/j.jaco .2021.01.009

Zhang, Y., & Lee, J. (2022). Artificial intelligence in modern financial systems: Building secure and adaptive payment ecosystems. Springer.

Zhang, Y., & Wang, X. (2020). Modular arithmetic in neural networks: A new approach to data encryption. Journal of Artificial Intelligence Research, 67, 123-145.