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APPLIED RESEARCH

Research on Bargaining Algorithm of Unmanned Vending Machine Based on Game Strategy

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ABSTRACT Traditional unmanned vending machines currently do not have the function of bargaining, and cannot provide consumers with personalized bargaining intelligent services. Based on the psychological benefits of users being more inclined to buy discounted goods, the study aims to introduce the bargaining function to unmanned vending machines. Use bargaining to stimulate paid conversions of purchases. This is similar to a business scheme that uses discounts on goods or issues coupons to stimulate customers to pay. This study makes up for the gap in the bargaining function of unmanned vending machines, which is of great significance. Based on the game strategy, this study establishes a set of algorithmic models for unmanned vending machine bargaining. The algorithmic model applies five different sub-algorithms. When the unmanned vending machine bargains with the customer, the algorithm model only randomly selects one of the sub-algorithm models within a fixed period of time. Next, the selected sub-algorithm performs the commodity bargaining game operation and outputs the game result. Therefore, the algorithm is applied to unmanned vending machines, adding personalized bargaining functions. It meets the bargaining expectations and purchase needs of different customers. In a limited space, the article focuses on the implementation of mathematical principles of unmanned vending machine bargaining algorithm based on game strategy. The study describes the interaction between the two sides of the game. In this study, simulation experiments are carried out to verify the accuracy of the algorithm model by analyzing a series of parameters.

INDEX TERMS Bargaining, game strategy, retail drones.

I. INTRODUCTION

In 1962, a revolution in distribution emerged, mainly in the form of vending machines [1], [2], [3], [4] Gradually spreading throughout the world by the 20th century, unmanned vending machines offer better cost advantages and immediacy value. Among all the research areas related to vending machines, [5], [6] global research on their key technologies has focused on the following 3 areas:

(1) Research on the way of implementing sales actions within the system;

(2) Research on the implementation mode of fund settlement and statistical management of sales information;

(3) The research of power consumption saving mode.

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We propose an intelligent algorithm for unmanned vending machine bargaining based on game strategy, which can ensure that the buyer and seller converge to the same constant after several bargaining stages one by one; the unmanned vending system integrating this algorithm can be extended to the application field of unmanned vending engineering, relying on the digital system and using real-time data flow to achieve refined management [7], [8], [9] using intelligent machines to reduce the False detection brought by human beings, and the unmanned vending machine can break the situation of unmanned vending machine with a single function by adding the bargaining function at the same time in addition to the unmanned payment function.

The bargaining algorithm of unmanned vending machine based on game strategy has five sets of mathematical models, and the buyers randomly select one bargaining algorithm mathematical model to play the bargaining game when they buy different bargaining results. When a buyer buys a product, he or she chooses whether to bargain for it, and if he or she chooses to bargain, the buyer randomly selects a model to play the bargaining game and outputs the price result, asks the buyer whether he or she accepts the bargained price of the product, and if the buyer accepts the price to buy, the transaction is successful; if the buyer does not accept the bargained price of the product, the algorithm determines whether the bargaining process can continue. If the buyer does not accept the bargained price, the algorithm determines whether the bargaining can continue, and if it can continue, it goes to the next bargaining iteration, and if it cannot continue, it outputs a failed transaction.

From the perspective of game theory, [10], [11], [12] bargaining is a non-zero-sum game, in which it is implied that there may be some common interests among the participants to achieve ''win-win'' or ''multi-win'' for the game participants [13] The bargaining game proposed in this paper is essentially a positive-sum game in a non-zero-sum game, because for both buyers and sellers, the interests of both parties are increased, the sellers can earn profits from the sale of books, but the size of the profits is changed, and the buyers can save some money on the purchase of commodities after the bargaining game. The transaction process of bargaining plays an important role in economic consumption and can significantly promote consumer transactions to reach, based on the game strategy bargaining algorithm applied to unmanned vending machine,which is business value [14]

II. COMPARISON OF BARGAINING PRINCIPLES

In 1950, the American mathematician John Forbes Nash Jr. proposed the Nash Equilibrium, [15], [16], [17] which is widely used in Economics, Computer Science, Evolutionary Biology, Accounting, Policy, Military theory and Artificial Intelligence [18], [19], [20], [21] Bargaining theory was a major early contribution of Thomas Schelling, whose paper ''An essay on bargaining'' was first published in the American Economic Review in 1956. In 1972, Starr studied bargaining with a limited number of rounds, forming a game in which both parties alternate offers until the end of the game (Game Theory, GT). In 1982, Mark Rubinstein simulated the basic, infinite full-information bargaining process using a full-information dynamic game approach, and established a full-information turn-based bargaining model called Rubenstein Bargain Model, [22] which is a zero-sum game that extends the game from finite to infinite levels. In 2016, Weiqun Tao proposed a Bilateral Adaptive Anticipation Model for ''bargaining'' from an economic perspective, and used the binary constant coefficient linear difference equation system of this model to reveal the formation path of ''Nash bargaining'' and theoretically ensure the final deal of bargaining.

Land Bank of Taiwan applied for a patent for a foreign exchange bargaining system including a bargaining device and a first electronic device [23] The foreign exchange bargaining system shown in Fig. 1. The foreign exchange negotiation system includes a bargaining device and a first electronic device. The bargaining device generates a first bargaining value based on bargaining information. The bargaining information includes a bargaining rate and a bargaining amount. The first electronic device communicates with the bargaining device and sends a second bargain value and a first transaction amount to the bargaining device. When the first bargain value is the same as the second bargain value, the bargaining device determines whether the first bargain value amount is less than or equal to the transaction amount threshold, and the bargaining device conducts the transaction based on the bargaining rate and the first bargain value amount.

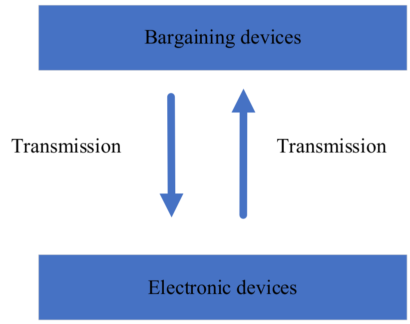

FIGURE 1. Foreign exchange bargaining system.

Beijing Jingdong Century Trading Co., Ltd. applied for a patent for an online bargaining system in online shopping. [24] The bargaining system for online shopping is shown in Fig. 2. The acquisition user information module obtains the user's membership level, attention to the product, browsing time, repeated browsing times, historical shopping records and other information, and obtains the user's information through the software program that accesses the corresponding database. The bargain request receiving module is used to receive the user's bargain request. The data information includes the name, number, expected price reduction, target price and other information of the product requested by the user for negotiation. The negotiation method determines that the maximum accepted price reduction range of the merchant is greater than or equal to the expected price reduction range of the user's request. The negotiation result generation module generates negotiation results based on user information and negotiation requests, and generates different levels of purchase intentions according to user information, so as to generate lower negotiation results for users with higher purchase intentions. The bargaining result sending module sends the bargaining result to the user end by the communication link.

Contrast analysis shows that the bargaining principle remains only in the methodological theory and is not extended to the engineering field [25], [26] The infinite bargaining game mentioned in economics is not possible for real consumer transactions where consumers have that long to make infinite bargains. The above bargaining algorithm is single and functionally incomplete. The bargaining algorithm based

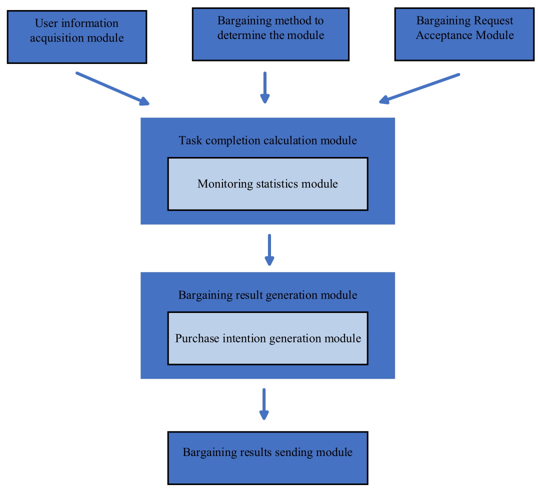

FIGURE 2. **The bargaining system for online shopping.**

on game strategy is implemented using 5 parts of basic mathematical principles. The advantage of the algorithm is that it is more functional and novel, and the unmanned vending machine bargaining algorithm provides a more convenient and efficient method and system for completing bargaining; consumers converge on the same constant result by alternately proposing their own price solutions, after a finite number of iterations of the bargaining game, until the end of the successful offer for both sides of the transaction.

III. METHODS

Why does the unmanned vending machine bargaining algorithm based on game strategy set up five different sub-algorithms? On the one hand, the bargaining game process is realized, and multiple different commodity price values are output to multiple different customers. Meet different customers to meet their bargaining expectations. At the same time, the algorithm realizes the diversity of bargaining games. Why does the bargaining process between the vending machine and the customer only randomly select one of the sub-algorithm models? On the other hand, the algorithm realizes that after the game operation between the unmanned vending machine and a customer, the bargaining game process converges and outputs a unified commodity transaction price.

A. THE STRATEGY AND INTERACTION PROCESS OF BOTH SIDES OF THE BARGAINING GAME

The strategies and interaction processes of the bargaining parties are shown in Fig. 3.

(1)Strategies for unmanned machine sales: Based on practical applications, the game algorithm applies 5 different sub-algorithms and can provide 5 different game strategies. Implement the bargaining function to output multiple different commodity bargaining values.

(2)Customer's strategy: The customer bargains with the vending machine. Then decide whether to buy based on the price of the product.

(3) Interactive process: The strategies and interaction processes of the bargaining parties are shown in Figure 3. The customer makes a bargaining decision to the unmanned vending machine. Unmanned vending machines combined with artificial intelligence algorithms identify customer needs. Then, according to the instructions, the bargaining algorithm selects sub-algorithms to conduct bargaining games. After the end of the game process, the bargaining result is sent to the customer's terminal through the unmanned vending machine. The user makes a purchase decision, determines whether to accept the price to purchase the goods, and feeds back the customer's decision-making results to the unmanned vending machine.

B. MATHEMATICAL PRINCIPLE OF BARGAINING ALGORITHM

1) SUBALGORITHM 1

The study assumes that the selling price of a commodity is presented in the form of a range, the lowest price that the merchant accepts for sale is A, and the highest price that the merchant accepts for sale is B, then the commodity is presented in the form of a range of $[A,B]$ in the bottom algorithm of the unmanned vending machine [27] Therefore, the algorithm assumes that the merchant sells the commodity price range: $[A,B]$.

Both A and B are rounded to get A' and B' respectively, so that M represents the difference between the absolute value of the highest sale price rounded up and the rounded lowest selling price A', and B', as in (1).

$$\text{Then, } M = |B' - A'|; \tag{1}$$

M is divided into equal shares in units of 1. Factor n indicates the proportion of 1 of them, as in (2). m represents the percentage of copies remaining, as in (3).

$$\text{Then, } n = 1/M; \tag{2}$$

$$m = (1 - n); \tag{3}$$

In the M interval, let the merchant who sells the goods get the share of the money as G_i, and its value as in (4).

$$G_i = [(1 - n)/(1 - \mathrm{n}^2)] \times M = [1/(1 + n)] \times M; \tag{4}$$

After the iteration of bargaining, the unmanned vending machine is set to sell the goods at the transaction price of H_1, and the mathematical definition principle formula of the unmanned vending machine bargaining algorithm based on the game strategy is obtained, as in (5).

$$H_1 = A + G_i; \tag{5}$$

where H_1 represents the transaction price of the sale of the commodity at the end of the bargaining game. A is the lowest price at which the merchant accepts the sale, and $G_i$is the share of money received by the merchant who sells the commodity within the M range.

In this study, the value of $H_1$is rounded to determine whether the bargaining game algorithm meets the iteration

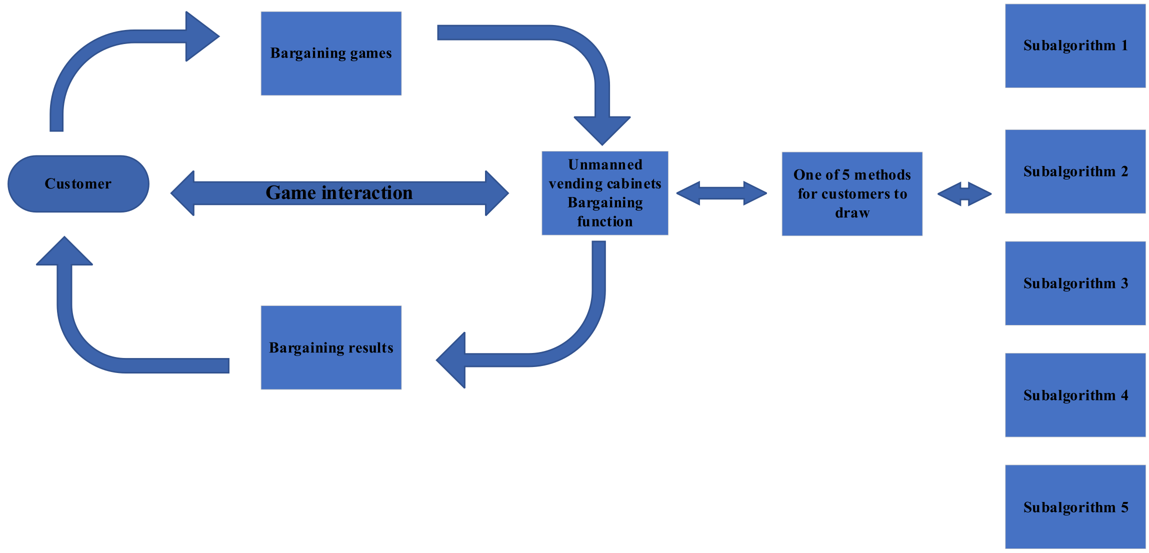

FIGURE 3. The strategy and interaction process of the two sides of the bargaining game.

of the game algorithm. When (H_1-A) $\leq$ 1, bargaining is automatically stopped.

2) SUBALGORITHM 2

The study assumes that the sale price of a commodity is presented in the form of a range. The lowest price at which a merchant accepts a sale is A, and the highest price at which a merchant accepts a sale is B. Then the product is presented in the form of an interval of [A, B] at the bottom of the unmanned vending machine.

Therefore, the algorithm assumes that the merchant sells the commodity price range: [A, B].

Both A and B are rounded to get A' and B' respectively, so that M represents the difference between the absolute value of the highest sale price rounded up and the rounded lowest selling price A' and B', as in (6).

$$\text{Then, } M = |B' - A'|; \tag{6}$$

M is divided into equal parts in units of 1. factor n represents the proportion of 1 of them, as in (7). m represents the proportion of remaining copies, as in (8).

$$\text{Then, } n = 1/M; \tag{7}$$
$$m = (1 - n); \tag{8}$$

In the M range, let the buyer who buys the goods get a share of the money as G_j, as in (9).

$$G_j = [(1 - m)/(1 - m \cdot n)] \times M \times m; \tag{9}$$

After a bargaining iteration, set up an unmanned vending machine to sell goods at the transaction price of H_2. Unmanned vending machine bargaining algorithm based on game strategy, mathematical definition principle formula, as in (10).

$$H_2 = A + G_j; \tag{10}$$

where H_2 represents the transaction price of the commodity for the second bargaining game algorithm, and G_j is the share of money received by the buyer of the absolute value of the difference interval M selling the commodity.

The values of H_2 is rounded to determine whether the bargaining game algorithm meets the iteration of the game algorithm. When (H_2-A) $\leq$ 1, bargaining is automatically stopped. k (k = 1,2,3…natural positive integer) indicates that the first iteration of the bargaining game algorithm was made.

3) SUBALGORITHM 3

This study assumes that the selling price of a commodity is presented in the form of a range, the lowest price that the merchant accepts for sale is A, and the highest price that the merchant accepts for sale is B. Then, the commodity is presented in the form of a range of [A, B] in the bottom algorithm of the unmanned vending machine.

Therefore, the algorithm assumes that the merchant sells the commodity price range: [A,B].

After n iterations of the bargaining game, the final unmanned vending machine sells the goods at the transaction price of H_3. Unmanned vending machine bargaining algorithm based on game strategy, mathematical definition principle formula, as in (11).

$$\textit{Then, } H_3 = B - k; \tag{11}$$

where H_3 represents the price at which the item is sold in the third bargaining game algorithm, B is the highest price at which the merchant accepts the item for sale, and k (k = 1, 2, 3 ……natural positive integer) is the number of iterations of the bargaining game algorithm.

The experiment rounds the value of H_3 to the nearest whole number and rounds up A to get A'. The value of $H_3$is compared with the value of A'. When $H_3 > A'$, continue the

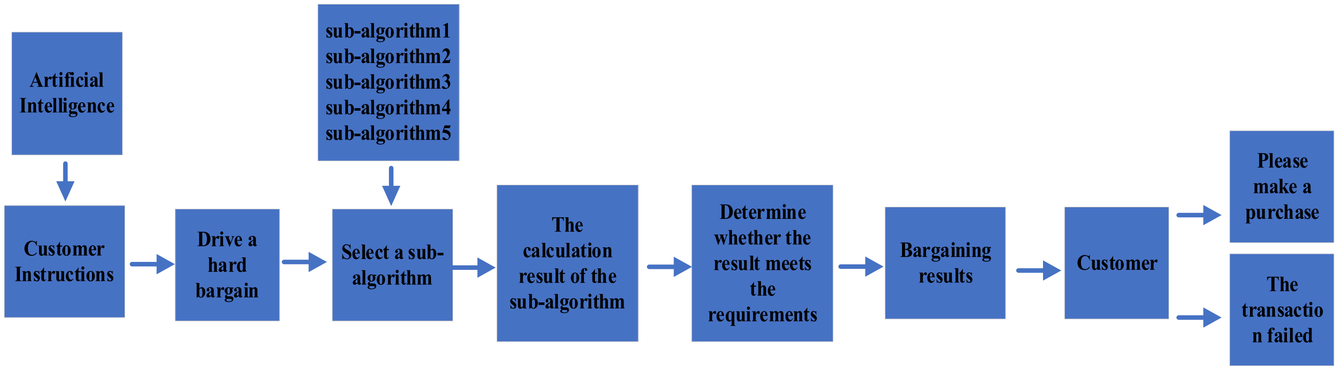

FIGURE 4. Game bargaining algorithm implementation strategy.

next round of bargaining game iteration process, $H_3 \leq A'$ automatically stop bargaining.

4) SUBALGORITHM 4

The study assumes that the sale price of a commodity is presented in the form of a range. The lowest price at which a merchant accepts a sale is A, and the highest price at which a merchant accepts a sale is B. Then, the goods are presented in the form of an interval of $[A,B]$ at the bottom algorithm of the unmanned vending machine. k (k = 1,2,3...natural positive integer) indicates that the first iteration of the bargaining game algorithm was made.

This algorithm assumes that the merchant sells the product price range: $[A,B]$.

Suppose that after n iterations of the bargaining game, the unmanned vending machine finally sells the commodity at the transaction price of H_4. Unmanned vending machine bargaining algorithm based on game strategy, mathematical definition principle formula, as in (12).

$$Then,\ H_4 = B - 2k; \tag{12}$$

Where H_4 represents the price at which the item is sold in the third bargaining game algorithm, B is the highest price at which the merchant accepts the item for sale, and k (k = 1, 2, 3 ......natural positive integer) is the number of iterations of the bargaining game algorithm.

In this experiment, the H_4 value is rounded and A is rounded to get A'. The value of H_4 is compared to the value of A'. When $H_4 > A$' continues the next round of bargaining game iteration process, $H_4 \leq A'$ automatically stops bargaining.

5) SUBALGORITHM 5

The study assumes that the sale price of a commodity is presented in the form of a range. The lowest price at which a merchant accepts a sale is A, and the highest price at which a merchant accepts a sale is B. Then, the goods are presented in the form of an interval of $[A,B]$ at the bottom algorithm of the unmanned vending machine. k (k = 1,2,3...natural positive integer) indicates that the first iteration of the bargaining game algorithm was made.

This algorithm assumes that the merchant sells the product price range: $[A,B]$.

Suppose that after n iterations of the bargaining game, the unmanned vending machine finally sells the commodity at the transaction price of H_5. Unmanned vending machine bargaining algorithm based on game strategy, mathematical definition principle formula, as in (13).

$$Then,\ H_5 = B - 2k - 1; \tag{13}$$

where H_5 represents the price at which the item is sold in the third bargaining game algorithm, B is the highest price at which the merchant accepts the item for sale, and k (k = 1, 2, 3 ......natural positive integer) is the number of iterations of the bargaining game algorithm.

The experiment rounds the value of H_5 to the nearest whole number and rounds up A to get A'. The value of $H_5$is compared with the value of A'. When $H_5 > A'$, continue the next round of bargaining game iteration process, $H_5 \leq A'$ automatically stop bargaining.

C. BARGAINING ALGORITHM IMPLEMENTATION STRATEGY

The implementation strategy of the Bo bargaining algorithm is shown in Fig. 4.

Step 1: Unmanned vending machines combined with artificial intelligence algorithms to recognize the instructions selected by customers.

Step 2: The bargaining game algorithm determines whether the customer chooses to bargain.

Step 3: Select the sub-algorithm and complete the bargaining decision-making process based on the calculation results of the known data. The bargaining game interaction process consists of five different sub-algorithms. The key step is to select one of the five different sub-algorithms in order to calculate the result.

Step 4: Determine whether the result meets the requirements.

Step 5: Determine whether the customer accepts the negotiation result. If the customer accepts, the algorithm outputs the instruction "Please make the purchase", and if the customer does not accept, the algorithm outputs the instruction "transaction failed".

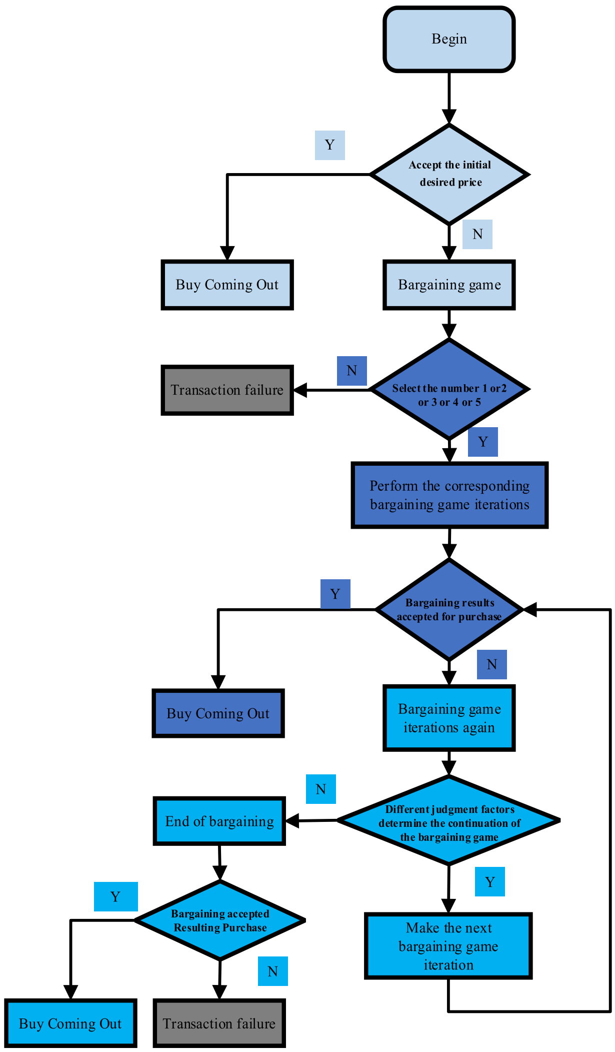

FIGURE 5. Flowchart of the bargaining function.

D. THE BASIC OPERATION PROCESS OF THE SIMULATED BARGAINING FUNCTION SYSTEM

The unmanned retail machine introduces the bargaining function, and the functional process of the research game algorithm is determined according to the game results. A flowchart of the bargaining function program, as shown in Fig. 5. The algorithm determines whether the customer accepts the initially desired price conditions and, if so, buys the goods at a higher price. If the buyer does not accept, a bargaining game is played.

Step 1: The unmanned vending machine bargaining algorithm based on game strategy executes the judgment instruction of ''whether the customer accepts the initial expected price conditions''. If the customer accepts, the algorithm outputs the instruction ''Buy goods at H_i price'' at the user terminal. If the customer chooses to bargain, the algorithm performs a ''bargain game'' instruction.

Step 2: The algorithm executes the instruction of ''customer selects the sub-algorithm of the bargaining game'' and completes the selection of one of the five sub-algorithms for bargaining.

Step 3: After selecting the sub-algorithm, the algorithm performs the first iteration of the bargaining game. The algorithm calculates the bargaining result of goods based on the mathematical principle equation of the sub-algorithm. The algorithm then executes the output ''bargain commodity price'' instruction.

Step 4: The algorithm executes the judgment instruction of ''whether the customer accepts the negotiation result''. If the customer accepts, the algorithm outputs the instruction ''Buy goods at H_i price'' at the user terminal. At the same time, the algorithm executes the instruction that outputs ''trade successful''.

Step 5: If the customer does not accept the price of the negotiated result, the algorithm executes the conditional instruction of ''determining whether the next bargaining game iteration is satisfied''. According to the mathematical factors of different bargaining game strategies, the algorithm determines whether the conditions for re-iteration of bargaining games are met. If the bargaining game iteration can continue, then the algorithm proceeds to the next bargaining game iteration. If the bargaining game iteration cannot continue, the algorithm executes the ''stop bargaining'' instruction, and the bargaining game is over.

Step 6: The algorithm determines the conditional instructions of ''whether the customer accepts the negotiation result''. If the customer accepts and buys at the H_i price, the algorithm executes the instruction that outputs ''purchase successful''. If the customer does not make a purchase, the algorithm executes the instruction that outputs ''transaction failed''. There are various monitoring equipment inside the machine. Accurately monitor the number of times consumers pick up goods and pieces, so as to achieve correct deductions.

Where the value of H_i represents the result of the bargain. Based on different game bargaining mathematical principles, different bargaining values are obtained.

E. THE EQUILIBRIUM PROBLEM OF THE GAME

Game equilibrium is an important concept in game theory, which describes the state in which all parties choose strategies in a multi-party game, and the parties to the game achieve their own maximum utility, and the actual utility and satisfaction of each party are different [28], [29], [30] To further observe the equilibrium of the game, we examine the steady-state solution of the decision for each user group. The game aims to describe how users rationally decide to react to ongoing bargaining. The unmanned vending machine bargaining algorithm based on game strategy realizes different end customers to achieve their own bargaining expectations on the one hand. On the other hand, according to the psychology of customers who want to bargain for discounted goods, the form of bargaining is used to stimulate users to pay. The sale of unmanned vending machine goods has increased, increasing the profit income of merchants. Customers and merchants bargain to achieve what they think is the maximum utility. The game algorithm in this study satisfies the game equilibrium condition.

F. THE ISSUE OF BARGAINING FAIRNESS

The rise of internet shopping, dynamic pricing, and personalized pricing is a new phenomenon. Advances in data collection and computing technology have made it possible. Algorithmic pricing can differentiate prices based on individual consumer information over time and personal dynamics. The result of personalized pricing is that the same product is sold at different prices to groups with different levels of consumption. Some people believe that price personalization is an unfair form of discrimination. Although these methods are legal, their morality needs to be examined, as they often raise ethical questions and sometimes even anger [31], [32] The introduction of bargaining algorithms in unmanned vending machines will also lead to the result of different consumers buying the same product at different prices, and this involves fairness issues, and the following analyzes the issue of bargaining fairness from a commercial perspective [33]

If the temperature is above 20 ° C, the price of Coca-Cola will rise, As early as 1999, Douglas Ivester the CEO of Coca-Cola discussed the potential introduction of temperature-sensitive vending machines that adjusts the price according to the outside temperature. Amazon's ''Go'' store or the Chinese BingoBox track movements and facial expressions of their customers and can make personalized offerings in the shop. The mentioned algorithmic pricing is a computer-aided real-time pricing mechanism based on data analysis that automatically generates dynamic and customer-specific actual prices. Without being informed, the Company estimates the willingness to pay from different consumers to different consumers based on the customer information in the database. Therefore, it may be perceived as unethical by consumers and the public. [34]

Discounting merchandise or issuing coupons to increase customer purchase rates is considered an effective framework strategy, a business tool that successfully masks the ethical discrimination of personalized pricing. Merchants issue targeted coupons to different consumer groups, which also raises the question of whether it is fair for different consumers to buy the same product at different prices. But it's hard to spot public outcry over volume discounts, coupon discounts, student discounts, car price negotiations, and many other events.

Is it fair to charge different prices for the same product? Price fairness depends in part on consumers evaluating a given price and the price of competitors to determine whether a price is acceptable. When customers see the product of the unmanned vending machine, the first reaction is that the product is more expensive than the discount store. The customer refuses to buy the product of the unmanned vending machine. However, through the psychological benefits of customers more inclined to buy discounted promotional goods, if the unmanned vending machine introduces a bargaining function, the form of bargaining is used to stimulate the user's paid conversion of purchased goods. The proper application of the algorithm may benefit both businesses and consumers, with merchants increasing sales and customers saving some of their expenses. Bargaining algorithms are valuable business methods for different consumers to buy the same product at different prices, rather than a neutral decision-making tool. Most importantly, bargaining is carried out on the premise that the customer already knows. The bargaining algorithm does not belong to price discrimination based on big data analysis of customer information, but is a promotion similar to coupons. In short, the discussion of the morality of algorithms is still limited and currently more morally reasonable [31]

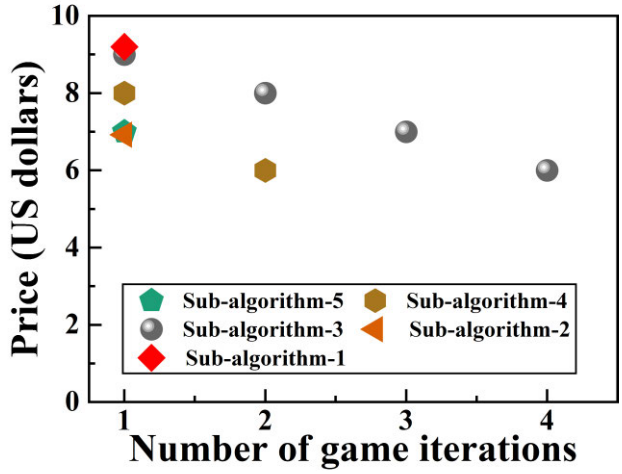

FIGURE 6. Algorithm simulation verification results.

IV. DISCUSSION OF THE RESULTS

The study conducts a series of experiments, analyzing the parameters of the experiment. Study the accuracy of mathematical models of algorithms. The purpose is to study the unmanned vending machine bargaining algorithm based on game strategy to realize the bargaining function.

A. THE BASIC OPERATION PROCESS OF THE SIMULATED BARGAINING FUNCTION SYSTEM

We solve the mathematical model using MATLAB for our comparative analysis. In this study, the algorithm code is compiled in order to verify the accuracy of the calculation results of the five-part sub-algorithm. The verification scheme combines the actual case of merchants selling books with the unmanned vending machine bargaining algorithm based on game strategy to illustrate the accuracy of the algorithm principle. In this practical case, a merchant sells a book for a maximum price of $10 and a merchant sells the book for a minimum price of $6. Then the book is sold in the range of [6] and [10] dollars in unmanned vending machines.

In order to study the accuracy of the mathematical model of the algorithm, a series of parameter analyses were carried out on the case. The results of the five-seed algorithm bargaining

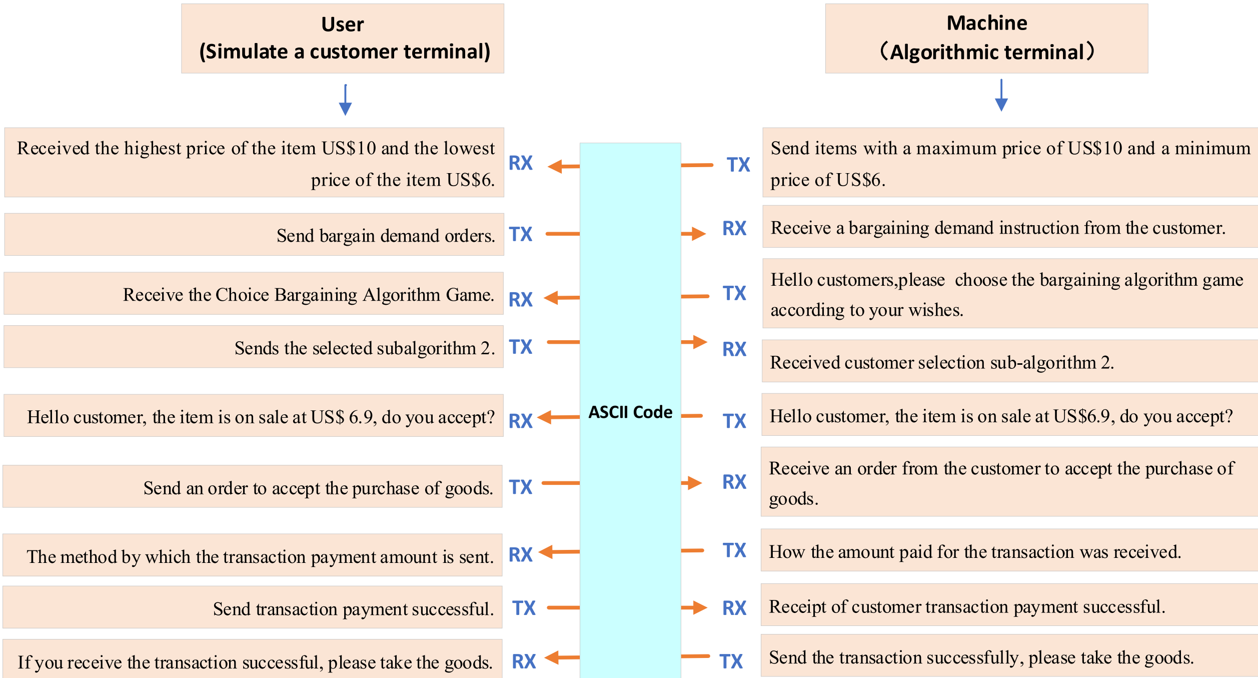

FIGURE 7. Verification scheme of serial port command information interaction.

TABLE 1. Verification of each sub-algorithm.

Experimental verification	Number of game iterations (Unit times)	The transaction price of the commodity (US dollars)
Sub-algorithm-1	1	9.2(US dollars)
Sub-algorithm-2	1	6.9(US dollars)
Sub-algorithm-3	4	6(US dollars)
Sub-algorithm-4	2	6(US dollars)
Sub-algorithm-5	1	7(US dollars)

game are shown in Table 1. In this practical case, sub-algorithm 3 has the most iterations, and the final transaction price is 6 US dollars after 4 bargaining games. At the same time, the transaction price of sub-algorithm 3 goods decreases the most than the original selling price of the goods, which is the most beneficial to customers. Sub-algorithm 1 conducts 1 bargaining process, and the final transaction price is 9.2 US dollars. Sub-algorithm 1 is the least decrease in the transaction price of the commodity compared to the original selling price of the commodity, which is the most beneficial to the merchant.

The algorithm simulation verification results are shown in Fig. 6, which shows that the five bargaining results all meet the price of the goods sold by the merchant. After computational verification, the results of the five bargaining algorithms all satisfy the mathematical principle equation of the sub-algorithm, which indicates that the algorithm is calculated correctly. At the same time, the number of iterations of each sub-algorithm is also correct, thus proving that the mathematical principle of the algorithm is accurate. At the same time, it can be seen from Table 1 that the algorithm can output the negotiation results of different amounts. It can be proved that the same product can output the negotiation results that meet the bargaining expectations of different end customers through the calculation of the algorithm.

B. BARGAIN FOR THE FEASIBILITY OF ALGORITHMIC INTERACTION

The study designed a validation protocol for the experiment. The scheme is shown in Fig. 7, by verifying the information exchange instructions between the two parties. The left module of Figure 7 is the user port, and the right side of Fig. 7 is the machine port. In addition, the interaction between the two parties needs to be converted with ASCII Code. The scheme in Fig. 7 is to simulate the bargaining interaction function of the algorithm. Then use the serial debugging assistant to verify whether the information interaction is correct. By judging whether the interaction results of the serial port debugging assistant are the same as the results of the designed experimental scheme, the feasibility of the algorithm function is verified.

The experiment solve the algorithm model using MATLAB and Serial port debugging assistant for our comparative analysis. The MATLAB window of the bargain game algorithm results is shown in Fig. 8. All five bargaining outcomes satisfy the selling price set by the merchant. Thus, it is proved that the bargaining algorithm functions correctly. At the same time, we use the serial port debugging assistant to simulate the information interaction process between customers and unmanned vending machines. The results of the information exchange between the two parties are shown in Fig. 9.

```
>> test01
Commodity maximum price: 10  Commodity lowest price: 6
Verification 1 Commodity final transaction price:  9.2
Verification 2 Commodity final transaction price:  6.9231
Verification 3 Product iterations: 4   Commodity final transaction price:  6
Verification 4 Product iterations: 2   Commodity final transaction price:  6
Verification 5 Product iterations: 1   Commodity final transaction price:  7
```

FIGURE 8. Bargaining game algorithm results of MATLAB window.

```
>> test01
Commodity maximum price: 10  Commodity lowest price: 6

TX: The highest price of the item is US$10, and the lowest price of the item is US$6.
RX: Received a bargaining order from the customer.
RX: Received customer selection sub-algorithm 2.
TX: Hello customer, the item is sold at US$ 6.9, do you accept?
RX: Receive an instruction from the customer to accept the purchase of goods.
TX: How the transaction pays the amount.
RX: Received payment from customer transaction successful.
TX: The transaction is successful, please take the item.
fx >>
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FIGURE 9. The interface of serial port assistant for information interaction.

In Fig. 9, the information interaction between the two parties realizes the serial port instruction information interaction scheme designed by us in Fig. 7. The information interaction between the serial port assistant is correct. Therefore the feasibility of the bargaining algorithm interaction function can be proved.

V. CONCLUSION

In a limited space, this study focuses on the mathematical implementation of unmanned vending machine bargaining algorithm based on game strategy. The unmanned vending machine introduces this research algorithm, which can complete the addition of personalized bargaining function. In the current research field related to vending machines, the research on its key technologies lacks the application of bargaining function. It cannot provide consumers with a humanized bargaining intelligence service. Importantly, reasonable and efficient algorithmic pricing is now considered a key business driver. Unmanned retail stores with bargaining functions are necessary and rational, and their value is irreplaceable. This study makes up for the gap in the bargaining function of unmanned vending machines, and combines artificial intelligence to lead automatic vending into a new stage of ''intelligent bargaining'', which is of great practical significance in the field of unmanned vending machines.

(1) This study establishes the mathematical principle equation of the bargaining algorithm, and the model applies five sub-algorithm mathematical principles. On the one hand, the algorithm realizes that after the game operation between the unmanned vending machine and a customer, the bargaining game process converges and outputs a unified commodity transaction price. On the other hand, the bargaining game process is realized, and multiple different commodity price values are output to multiple different customers. Meet different customers to meet their bargaining expectations.

(2) The study describes fairness issues regarding customers buying the same item at different prices. Game decisions are designed to describe how users make rational decisions after comparison. Bargaining algorithms are not price discrimination based on big data analysis of customer information. The algorithm is that consumers evaluate a given price and the price of competitors under the premise that the customer knows, so as to determine whether the price is acceptable.

(3) The study describes the interaction between the two sides of the game, using game theory to capture the decision-making process and the interaction between different individuals. Study of strategic interaction behavior according to game theory.

(4) In this study, the mathematical principle formula and the game solution of the algorithm are verified by simulation. The simulation results show that the proposed scheme is effective.

(5) By introducing the algorithm in this study, the unmanned vending machine can realize intelligent and personalized bargaining functions.

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