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Application of AI Agents in Enhancing Financial Education Games: A Case Study

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Abstract: ***This article explores the application of AI Agents in financial education games. We demonstrate how AI Agents can enhance the generation of events and investor profiles in these games, thereby changing their dynamics. The study provides insights into the potential of AI in improving financial education. The insertion of Artificial Intelligence (AI) components in educational games, and more specifically financial games, has been a trend in recent years. Mainly in the production of games, with the generation of narratives, generation and selection of scenarios and audio, generation and selection of events that occur throughout the game, and generation of player profiles. In this Article we show an application of AI Agents in the generation of events in a financial education game and investor profile in an investment education game. The article also discusses how the insertion of these agents changes the dynamics of the game.***

Keywords: Games · Financial Education · Investment · AI Agents

1. Introduction

The use of games as tools to support Financial Education has become a growing approach to promote critical analysis in consumer society. In parallel, according to Portal G1 (2019), a study by S&P Rating Services pointed out that Brazil ranks 74th in a global ranking that measures the level of financial education of 144 countries, ranking lower than poorer countries such as Madagascar, Togo and Zimbabwe. To improve this scenario, the National Strategy for Financial Education (ENEF) was established, aiming to promote conscious and autonomous financial decision-making, improve the efficiency of the financial system and strengthen citizenship (Forte, 2021), in addition, to the inclusion of Financial Education in the Common National Curricular Base (BNCC, 2018). Such governmental decisions highlight the urgency in the elaboration of learning objects that help Brazil advance in the international scenario in the educational and business areas. On the other hand, the insertion of AI Agents, in educational games, and more specifically, financial games are a trend in recent years, (Torrens, 2021). Mainly, seeking to raise the quality of player experience. Many games apply AI, mainly in the development of non-player characters (NPCs) that can act as allies, with specialized skills to interact with the player, guiding actions or transferring some kind of knowledge.

This paper presents the results of the development of two games (Finance and Investment) with the insertion of AI Agents aimed at building financial thinking during High School. While Finance deals with the trajectory of a young man traveling through the Amazon to teach conscious consumption, Investment is based on a brokerage house in which clients are guided by the player in deciding the best investment to reach personal goals. Investment introduces the player to income calculations, thus becoming tools for teaching financial applications.

2. Materials and Methods

This section describes the concepts, methods and elements that comprise the development of this work.

Educational Games

Educational games are designed with the purpose of teaching players specific knowledge or skills. These games aim to engage players in an interactive and fun way, offering an alternative to more traditional games. Educational games can cover a wide range of subjects, including math, science, language, history, and more. By playing these games, students can gain new knowledge and skills while enjoying the gaming experience (Oliveira et al., 2018).

Finance

Finance is an educational game with a linear storyline with choices that involve Financial Education in everyday life, based on a plot that tells the story of the character Cauê and his friends. Together, they have, as a goal, to travel through the interior of the Amazon, without incurring debts. This goal is used to guide the player to start planning future expenses, referring to what he will need to buy during the game. Through situations experienced by the characters and minigames, each phase introduces knowledge about finances (planning, fixed expenses, variable expenses, among others). Little by little, the player learns how to use his money consciously.

Figure 1 shows a sequence of moments in the game. Finance stands out for the use of visual elements characteristic of the Amazon region, with mention to the traditional festivals of each city in the Amazon, as well as the insertion of characters from Brazilian folklore. There are also minigames related to Environmental Education, encouraging the preservation of the fauna and flora and showing the cultural richness of Amazon.

Figure 1: Different moments in the Finance educational game

Investment

Investment, on the other hand, approaches and teaches the player about the world of investments. The game's story begins with a broker named Luísa who starts a small business with the help of her mentor. In her day-to-day life, she has to serve clients and help them choose and manage investments. Each client has a goal, and depending on his or her personal preferences, the player must choose the most suitable investment and indicate the time needed to reach the desired amount. If the time is too short, the player will inevitably learn that in this scenario no investment is suitable.

Each phase introduces a type of investment. By the end, the player will know the particularities of investments in savings, LCI (Real Estate Letter of Credit), LCA (Agribusiness Letter of Credit), CDB (Bank Deposit Certificate) and Treasury Direct Securities.

In Figure 2, it is possible to see an elderly client walking towards Luisa. Based on their dialog, the appropriate investment is chosen and the broker's reputation will increase or decrease depending on the customer's satisfaction with the financial application. During the game, problems will eventually arise, that is, expenses not initially foreseen. If Luisa has taken this into account, the chances of success will increase.

Figure 2: Main environment of the educational game Investment

Smart Agents

An agent is any entity that: perceives its environment through sensors (e.g., cameras, microphone, keyboard, file or DB contents) - acts on the environment through actuators (e.g., claw of a robot, video, speaker, printer, writing to files) (Russel, 2003). In Artificial Intelligence, an intelligent agent is an autonomous entity that can observe an environment through sensors and act on it, through actuators. To make its decisions it can act reactively, perform reasoning by symbolic algorithms, seeking to achieve goals (in the "rational" sense defined in economics).

Machine Learning

Figure 3 shows a schematic representation of a Machine Learning (ML), which consists of a knowledge base and a learning algorithm. The data is structured into attributes and, in the case of Supervised Learning, a class for each set of attributes (Géron, 2017; Jiang, 2021). A part of the base is used to train the learning algorithm, while another part is used to test and evaluate the performance of ML. The more data used to train the ML, the better its performance or hit rate in the classification process. Because most of the data attributes are binary, the paper proposes a Machine Learning model composed of three learning algorithms: Linear Regression, Logistic Regression and Decision Tree. The Composite Model is shown in Figure 4 where each ML makes its classification and the resulting classification is the mode of the partial classifications or the classification of the ML with the highest score if the mode is not found. In this work we use ML for generating the profiles of new customers in the game.

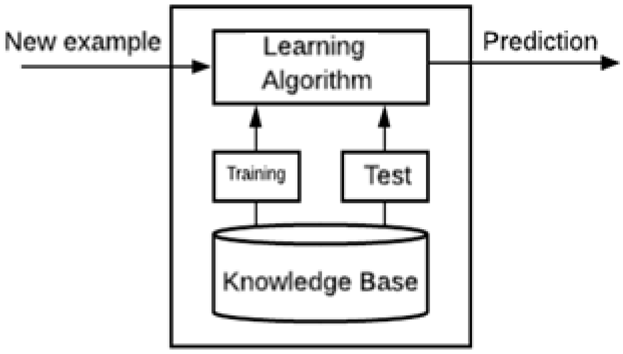

Figure 3: Schematic representation of an ML that is composed of a knowledge base with a set of data for training and another set for testing, and a learning algorithm

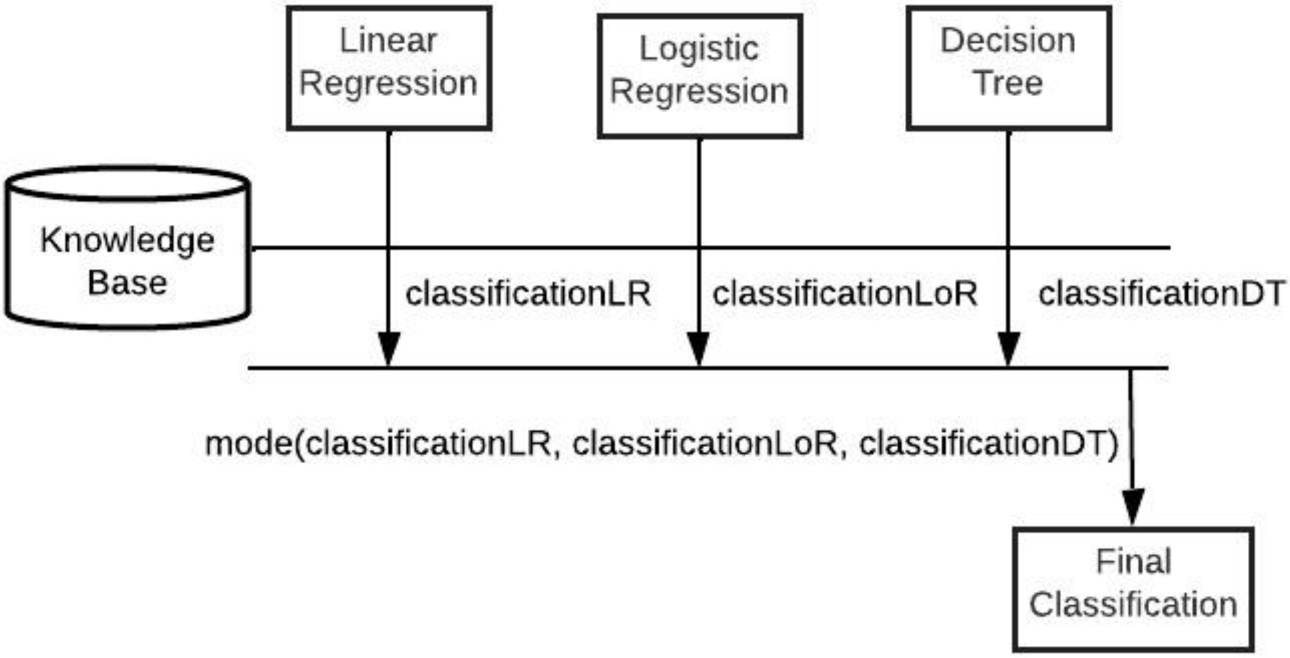

Figure 4: ML model proposed for ML. The model uses 03 ML (Linear Regression, Logistic Regression and Decision Tree), to obtain the classification of the investor profile for each ML and select the classification by mode or the one with the highest score

Fuzzy System

Fuzzy set theory, or simply Fuzzy, is a mathematical approach to dealing with uncertainty and imprecision in decision-making problems. The theory was proposed by Lotfi Zadeh in 1965 as an alternative to traditional Boolean logic systems that require variables to be precise and binary. The main application of fuzzy sets theory is in control and decision making systems, where uncertainty and imprecision are common. Fuzzy systems can handle these situations and provide accurate and effective answers. Figure 5 shows a representation of a Fuzzy System, which comprises an input that receives a quantitative value from the real world, converts it into a linguistic variable (Fuzzification), evaluates the degree of pertinence in the Fuzzification curves, applying a set of rules (Inference) and converts the linguistic variable resulting from the inference into a quantitative value (Defuzzification), for classification. In this work we use the Fuzzy System to generate new events in the game.

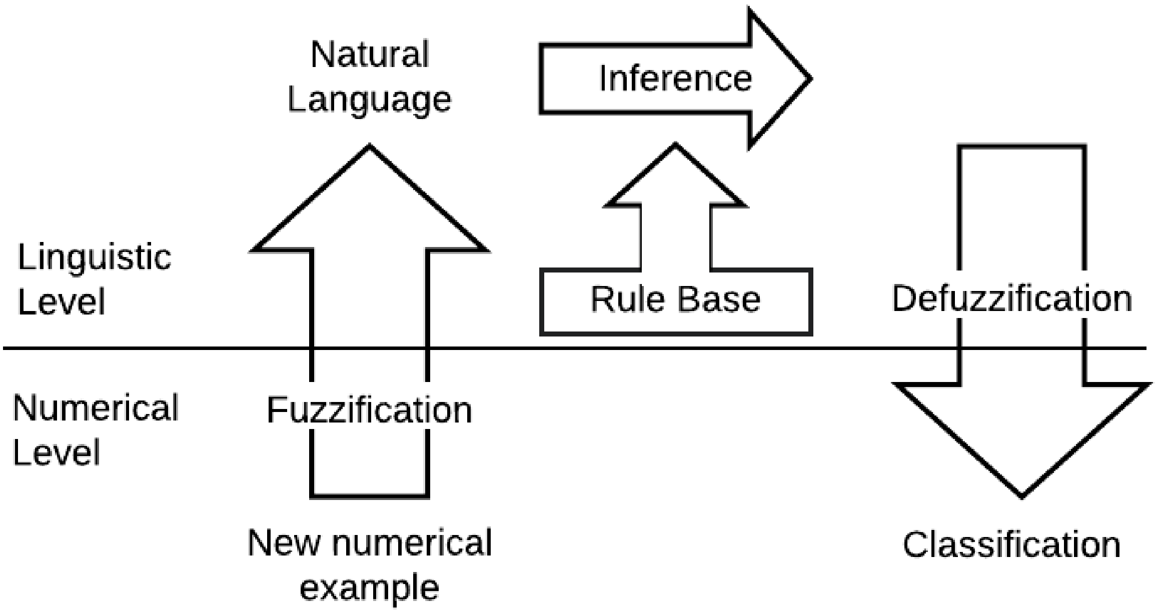

Figure 5: Fuzzy System: receives a quantitative value from the real world, converts it into a linguistic variable (Fuzzification), evaluates the degree of pertinence in the Fuzzification curves, applying a set of rules, (Inference) and converts the linguistic variable resulting from inference into a quantitative value (Defuzzification), for classification

Artificial Neural Networks (ANN)

Artificial neural networks are massive and parallel information processing systems formed by the interconnection of simple processing units, called artificial neurons (Russel, 2003), as illustrated in Figure 6. Artificial neurons receive this denomination because they originated from a mathematical model of a natural neuron. The motivation behind this alternative computational processing paradigm is the possibility of devising effective solutions to problems that are difficult to deal with based on conventional computing. Using a given set of examples, ANNs can generalize the knowledge assimilated to an unknown data set. They are also able to extract non-explicit characteristics from a set of information's provided as examples (El-Shahat, 2018).

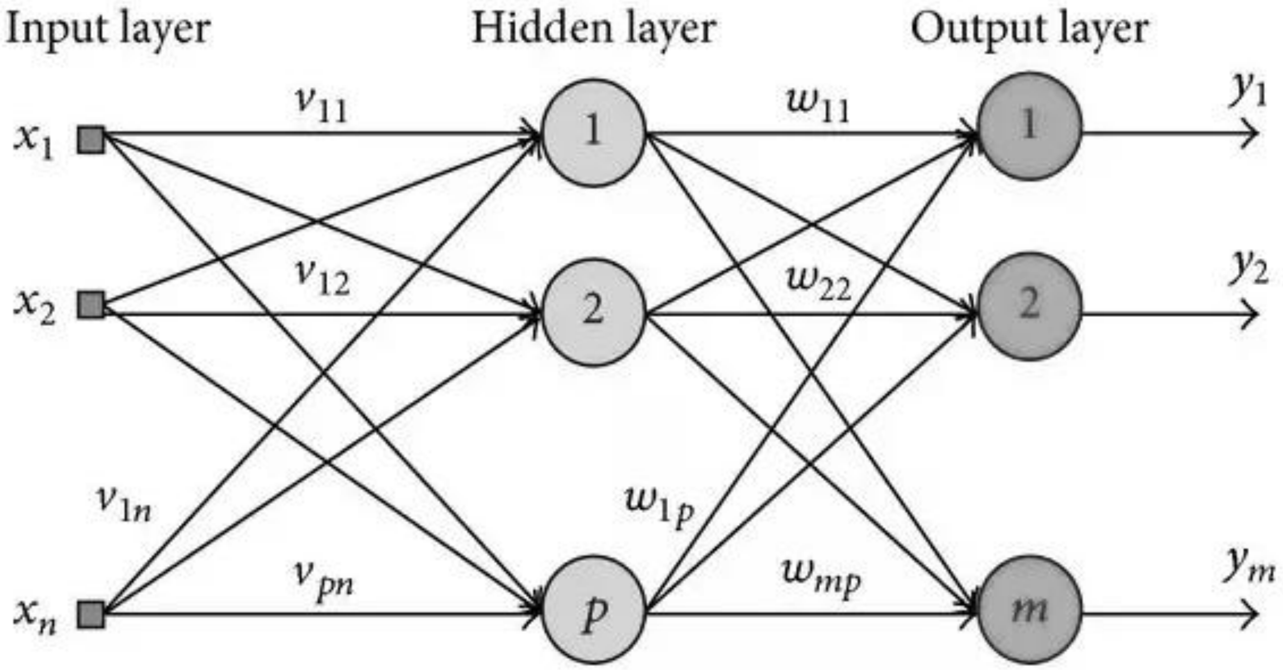

Figure 6: Artificial Neural Networks: Model composed of layers of interconnected artificial neurons. Each artificial neuron receives inputs, performs a calculation that produces an output that is transmitted to other neurons in the network

Automata

Automata are abstract mathematical models that describe the behavior of dynamic systems, such as machines and processes. They consist of a finite set of states, an input or set of inputs, and a transition function that maps each state to another state or set of states. Automata are widely used in computer science, electrical engineering, control systems, linguistics, and other areas to model systems that operate in discrete time. There are several types of automata, such as deterministic finite automata (DFA), non-deterministic finite automata (NFA), stack automata, Turing automata, and others. Each type has its own properties and limitations. Automata are essential to the theory of computation, as they are the basis for building formal languages, grammars and compilers. They are also used in artificial intelligence to model decision making and machine learning. Figure 7 shows an automaton modeling a situation where the player is low on money and a new event will be generated from this state.

In this automaton we see how naturally one can map the automaton to the Fuzzy System, with linguistic variables such as "incident", "debt", and "credit".

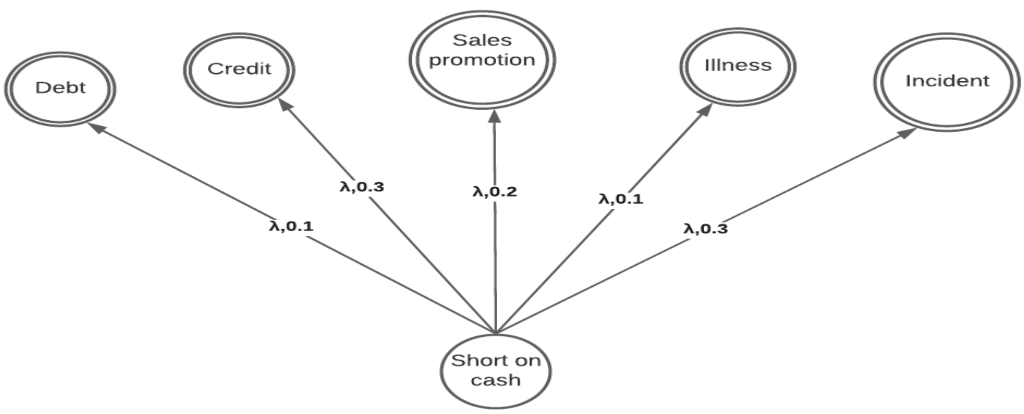

Figure 7: Automaton modeling an event generation situation, where the player in the low money state can transition to any of the events marked as the final state

Methodology for inserting AI Agents in games

Following the practices of Design Thinking, in both games we tried to formulate a natural storytelling. That is, with interactive elements that brought dynamism to the story, making it more engaging and authentic.

Intelligent models can contribute in this regard, as they are not based on explicitly stated logical rules. Rather, they learn from the database and simulate varied aspects (Chollet, 2021).

Insertion in the Finance Game

In Finance, AI is used to generate random events in order to add an extra difficulty to the game, as well as to encourage replayability, since the experience is different with each attempt. From the player's mood and money statuses are established probabilistic weights that feed a fuzzy system. It is through this that the event class (debt, credit, promotion, etc) is chosen. Figure 8 shows the insertion of the Fuzzy System for generating events in the Finance game.

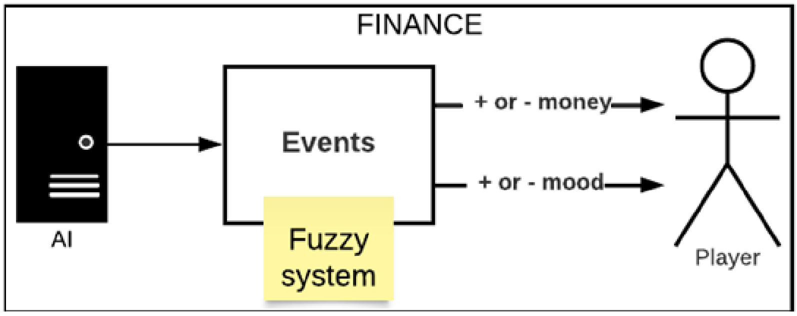

Figure 8: Inserting the Fuzzy System into the Finance game for event generation

4.2 Insertion in the Investment Game

In Investment, AI is used with the intention of generating clients with different profiles, so that, besides the player needing to think about the ideal type of investment for the client, he also needs to worry about the unpredictability of events and their decisions according to the client's profile. To make this possible, from the customer's characteristics, events and decisions are generated by the AI to meet the customer's profile. The generation of events, as in Finance, is done by the Fuzzy system, and the decisions regarding the events are made from a manually generated dataset with examples of clients (knowledge base) with decisions generated by the Machine Learning model (refer Subsection 2.1). In addition to generating the customer's events and decisions, the rates of return for each month for each type of customer investment are also generated from ANN, considering actual data that was previously collected and used to make the prediction. Figure 9 shows the insertion of the Fuzzy System for generating events, Machine Learning for decision making based on the customer's profile and ANN for rate prediction for investment choice.

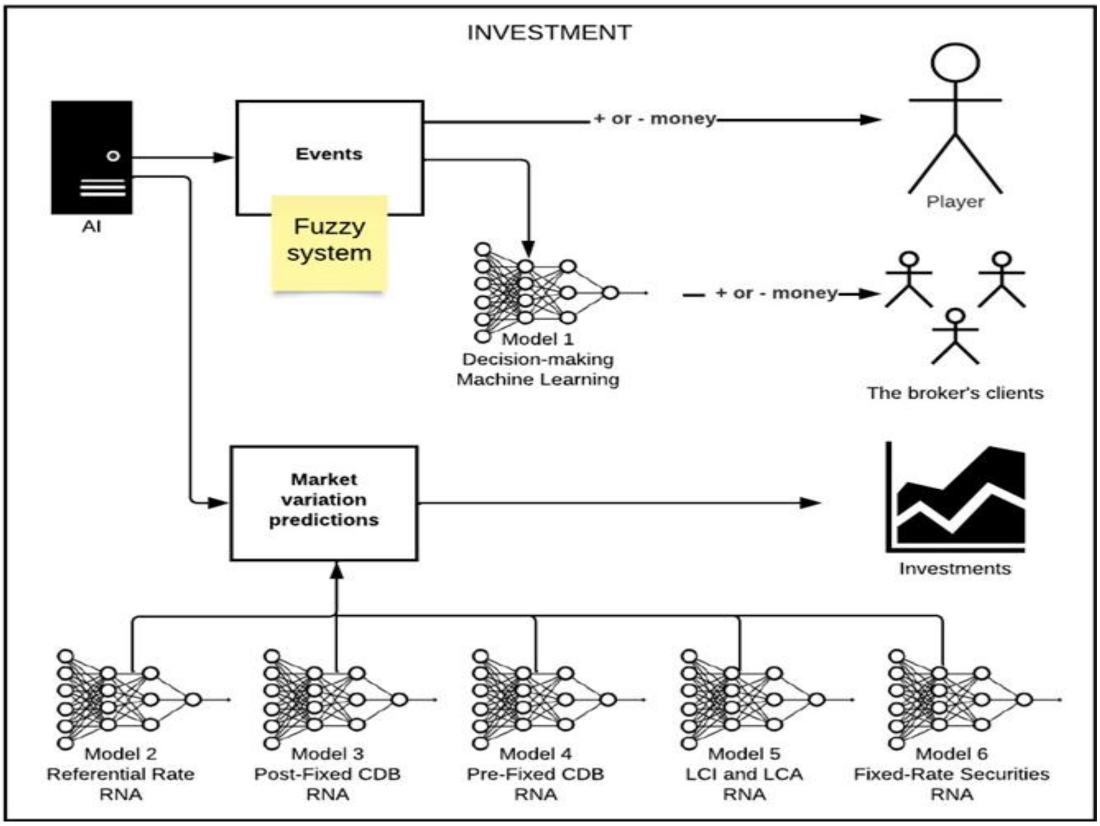

Figure 9: Insertion of the Fuzzy System Machine Learning and RNA into the Investment game

3. Results

For the Finance game a fuzzy system was developed that chooses an event at predetermined times in the game, thus activating the event screen. In this system a 30 second timer was implemented that limits the amount of time the player must choose the event. Depending on the player's choice, the amount of T-Coin (game currency) and mood are subtracted or added to the player. Figure 10 shows a moment in which the player is presented with a new event. In this case, the event is to purchase a hygiene item (deodorant) and the player has decided to buy it for 20 T-Coins.

For the Investment game, since there are many clients, it would be unfeasible for the player to make the decision for each one. So, a decision model was created (Model 1 shown in Figure 9) which follows the behavior presented in Figure 4. To evaluate its performance, the database was divided in the following manner: 90% for training and 10% for testing. The analysis on the test set resulted in an accuracy of 73.47% and precision of 87.83%, proving the viability of using Machine Learning to simulate customer decisions.

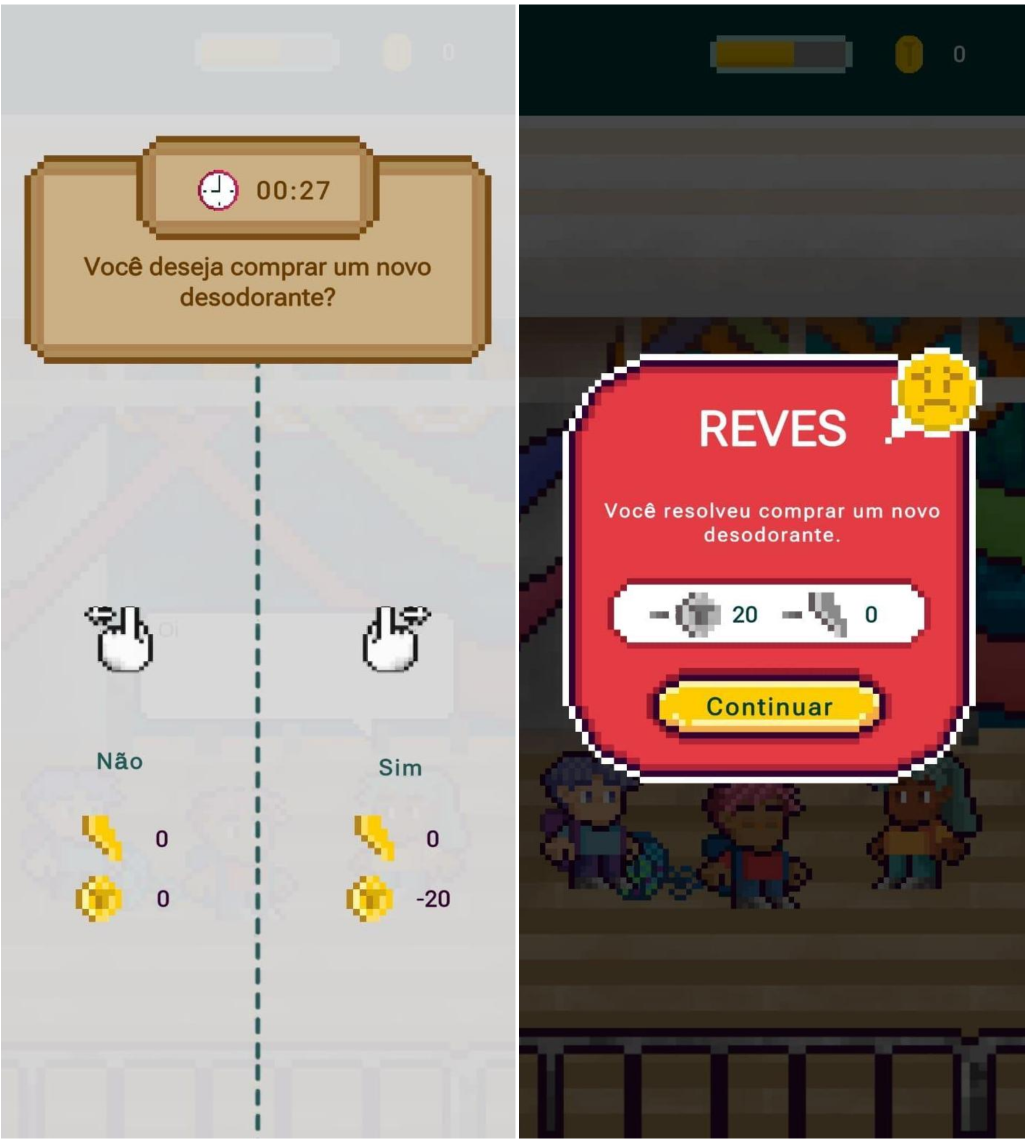

Figure 10: Event with decision in the Finance game

Figure 11 shows the dashboard with the events that were generated for a client of the Investment game and a graph with the monthly profitability of the chosen financial application, calculated from the base and the profitability rates generated by the AI.

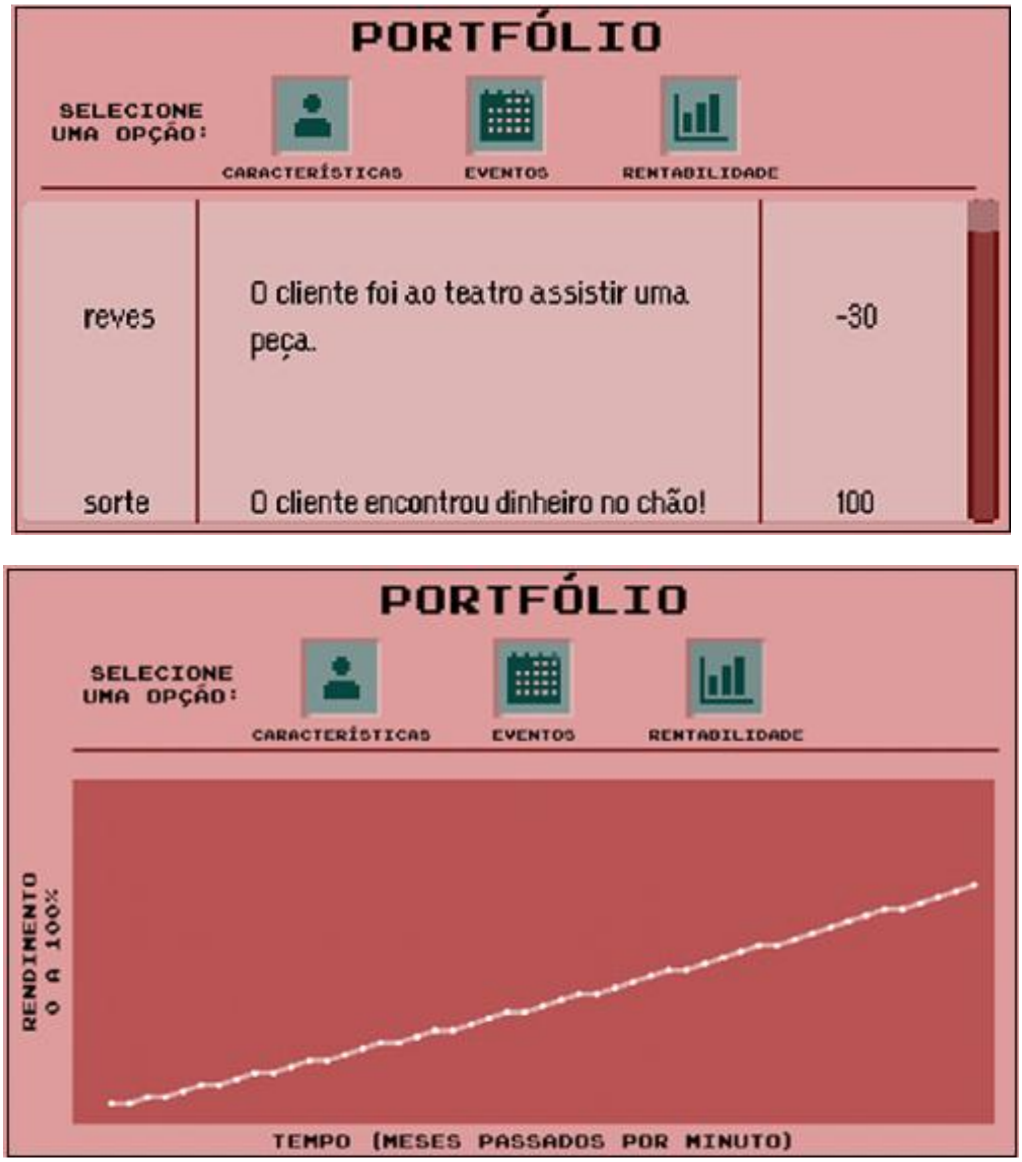

Figure 11: Dashboard showing the client's portfolio with event listing and investment yield rate, both generated by the AI

As the Investment game is temporal, i.e., time influences gameplay, neural networks were used to predict time series (variation rates of investments). The data was divided according to a holdout type cross validation in which 80% of the values were used for neural network training (corresponding to the profitability values from 01/2000 to approximately 01/2018) and 20% for training, with the remaining data continuing until the year 2023.

In order to verify if the prediction occurred as desired, graphs were made comparing the actual data with the data that was predicted using AI, for example in Figure 12, in addition to accuracy tests and other accuracy metrics.

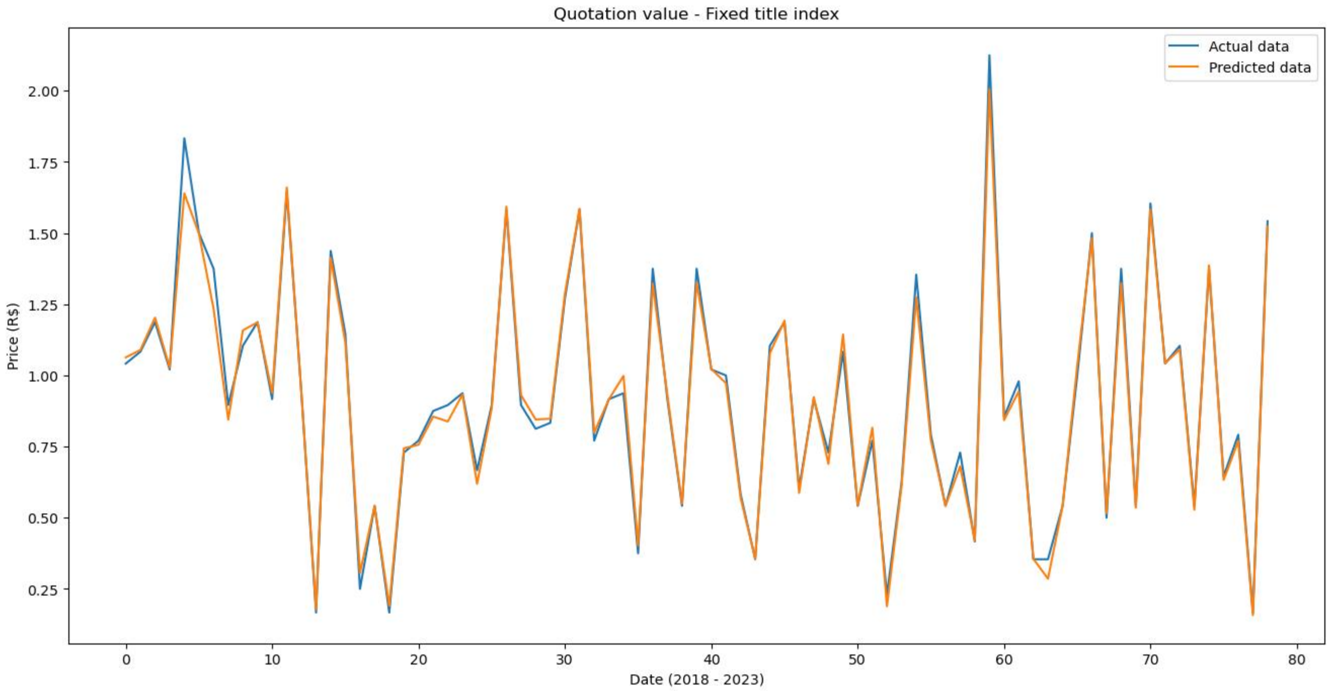

Figure 12: Example of one of the graphs referring to the quotation indexes, demonstrating the results obtained by making the comparison with the actual values and those predicted through machine learning

4. Discussions

The results show that the insertion of the AI agents added a sense of unpredictability to the games, which makes them more fun. In this paper, we are concerned only with the insertion of AI Agents into the games. A possible improvement would be to implement events with consequences for previous event choices. We can also further explore the fuzzy characteristic of the fuzzy system, further increasing the unpredictability of the game by varying the intersections between the fuzzy sets.

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Statements & Declaration

Competing Interests

*Financial interests: a*ll authors are fellows of the project, including Dra. Silvia Freitas the Coordinator, Dr. Ernande Melo and Dr. Raimundo Oliviera, Researchers, PhD student in Computing Jean Lima and scholarship students Natanael Figueira, Giovanna Teodoro, Helder Schramm and Vinicius Barros, fellows.

Author Contributions

All authors contributed to the development of this work. Coordination was carried out by Dra Silvia Freitas, design, organization and guidance by Dr. Ernande Melo and Dr. Raimundo Correa, development by Dr, Ernande Melo and graduate students Giovanna Teodoro, Natanael Figueira, Helder Schramm and Vinicius Barros, revision by doctoral student Jean Lima.

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