BUSINESS GAMES POWERED BY ARTIFICIAL INTELLIGENCE IN EDUCATION

Josef Pavlicek, Vaclav Svec, Ivana Ticha, Petr Hanzlik

pavlicek@pef.czu.cz

Department of Software Engineering,
Czech university of Life Sciences

ABSTRACT

The business games are a useful tool for the education of management. These games can be helpful in training of decision making and strategic planning. Each game can be understood as a simulation of real business conditions in the strategic management area. These business conditions must be effectively solved by the manager. This exercise helps student gain skills, which can be applied to the real problems in the future. The quality of the simulation closely correlates with the skills student gains. In general, the more realistic the game simulation is, the more realistic decision making must be applied by the participant. Defining the mechanisms for recording games, learning and adaptation of the intelligent computer system is the goal of the team. At the Czech University of Life Sciences we will have the "Athena" named artificial intelligence with the ability to simulate human beings behaviour during playing managerial games. To describe, how to adapt the artificial intelligence based system into the business games is main goal of this paper.

KEYWORDS

Business game, game strategy, game interface, artificial intelligence, training set, adaptation, intelligent agent, E-Learning

INTRODUCTION

The ability to adapt to the business environment, to choose and follow an appropriate strategy, to critically assess the market situation, to minimize loss or maximize profit - every graduate of management courses should possess the ability to handle. Jarošová (2005) defines two main approaches which she calls experiential and academic (based on the theoretical knowledge.)

By Jarošová (2005), we can understand the academic approach to learning as a process of acquiring the highly formalized objective scientific knowledge, the capability development process of critical review, and skills to apply knowledge in practice. Experiential approach is represented by the experiential learning. According to Kolb (1984: 37) we can understand the experimental learning as 'process whereby knowledge is created through the transformation of experience'. Managerial simulation games (in general Business Games) can serve as an effective supporting tool in acquiring the essential managerial skills. According to Wawer et al (2010) the individual games can be perceived as scenarios describing possible market situations, which are very likely to be encountered in the real world. Managerial games offer an entertaining way to hone these crucial skills in a virtual environment, thus without impacts on the real world. It can be assumed the more realistic the game conditions are, the more realistic the decision making procedure must be applied.

The game must be played up until the end, in order to evaluate the full impact of strategies

implemented. To assess these, the steps each player took should be carefully recorded. The rules of the game also must be followed; otherwise the game can yield unwanted conclusions. The time-consuming characteristics of the vast majority of these games also mean the possibility to record the current state of the game and continue later could be highly beneficial. All these conditions can be realized with basic software. The key determinant of each game success is, however the set of quality opponents, which is not always available. The authors combine the modern technology and possibilities of artificial intelligence to realistically imitate the behaviour of a human game adversary. By the term "Artificial intelligence" we understand the machine which is able to think similar to human beings (Russell and Norvig, 2009). This artificial intelligence is based on the perceptron neural networks technology with backpropagation learning algorithm (Tettamanzi and Tomassini, 2001). The illusion of playing against a human being should be as credible as possible. The software will also enable a game of human players only, serving just as a virtual game board and rule maintainer. Each time a player makes a turn; our solution represents it in the form of turn-vectors, which are stored, and consequently used for training the artificial intelligence. By connecting the gathered data with qualitative survey at the end of the game, we can get a complex understanding of the strategies used. This can be used in directing further education efforts to address the areas of managerial skill responsible for a wrong strategy choice and eventual loss. We develop the students' knowledge by a controlled polling and at the same time, we can modify the game parameters in a way, which can help them in so needed managerial skills.
Defining the mechanisms for recording games, learning and adaptation of the intelligent computer system is the goal of the team. At the Czech University of Life Sciences we will have "Athena" named artificial intelligence, with the ability to simulate human beings behaviour during playing managerial games. To describe, how to adapt the artificial intelligence based system (sometimes called as intelligent agent) into the business games is the main goal of this paper.

Materials and Methods

In the introduction, the general issues associated with ability to simulate human beings behaviour during business games strategy developing has been discuses. Via disused problems we decided to formalized business games general rules and join them with the artificial intelligence based solution.
We suppose, for each business game exist some general rules. According to them the players optimize the strategy utilized. We suppose business games are in general created around following ideas:

- Gather resources
- Develop an industry
- Ensure continual growth (develop strategic units – population, houses, factories etc.)
- Limit competitors (block resources, conquer a competing unit)

Unfortunately, the state space of conventional managerial games is usually quite limited. When keeping the game in a purely deterministic way, the players can soon get an understanding of the game principles and employ a collection of "hard coded" strategies that work only in the limited game domain. Therefore, the practical relationship with the real world scenarios would be negligible. To overcome this issue, the authors include various elements of chance in their games (rolling a dice, picking a random card, etc.). Certain games also incorporate the elements of bluffing and bidding. This makes the

outcomes less predictable and the illusion of the game taking place in the real world much stronger.

The deterministic software utilizes for such tactics only pseudo-random algorithmic mechanisms. Human players are usually capable to learn how such functions work after several iterations. The intelligent system in comparison, imitates the behaviour of human beings, and acts in a nondeterministic way. Moreover, the game intelligence adjusts its settings based on the varying initializing conditions. It is thus close to impossible for a player to learn anything more than basic game rules. The system behaviour is much closer to the human being behaviour and the illusion of playing against a real player is more realistic. We decided to use Power Grid game (Friese, 2004) as practical example of business games. This game can be played by students or volunteers. Thanks to recording players´ decisions during the game, we received data describing player's strategy. This data is used as training set for our artificial intelligence.

Power Grid game short description

Power Grid game is a classical business board game for 2 – 6 players, developed by Friese (2004). In the case of the Power Grid game, the players aim to supply the given count of cities with electricity. The rules govern the possibilities of purchasing, storing, consuming, and renewing the scarce resources, and limit the possibilities of purchasing new power plants. Similar set of rules also limit the construction of wiring network among cities.

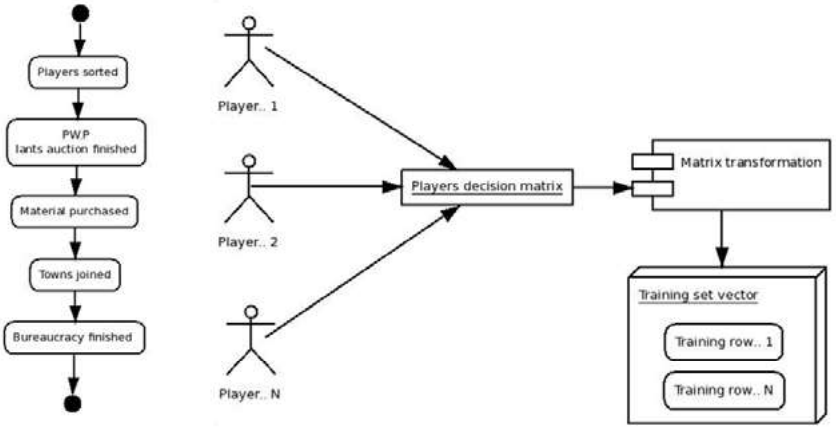

Fig. 1: Power Grid game State Chart and Players decision matrix transformation

The Power Grid game can be elementary described as a three epoch based game. Each epoch is typical by a different offer of power plants and resources (materials). During the first epoch, only the resource consuming (coal, oil etc.) power plants exist. During next two epochs are new power plants developed. The player can buy new power plants as solar based and resources consuming power plant can be rejected. Prices and number of power plants and resources available are changing. To win the game, each player thus must find the optimal balance between the expenditures for resources and revenues from the supplied cities.

Each epoch has five laps as described by Fig. 1 (left). During these laps the players can interact and make the business. Firstly players define playing order, next they start Power

Plants auction, next start buy resources, next start join towns and finally they gained money (Fig. 1, left side).
Each game epoch is stored as the matrix of players' decisions. Data into this matrix can be stored directly by player using prepared form (it consumes energy and time) or automatically. The players' decision matrix must be transformed into game strategy vector as described Fig. 1. Set of these vectors can be used as a training set for the artificial intelligence (Fig. 1, right side).

Game strategy use for Artificial intelligence

Following Thompson (2010) we can propose that the game strategy is the key point of the whole solution. It evolves dynamically. The implemented strategies differ according to the resources and the power stations available. While in the classical game scenario, students get the understanding of the available types of power plants, and structure of the game world, the intelligent software solution flexibly generates these values. The "technological development" of the power plants can also have varying pace, be slower or faster, depending on the required situation. Therefore, students are forced to abandon trivial strategies, and modify their plan gradually. When the intelligent agent acts in a human-like way, it can choose the optimal strategy depending on the game round and development. In that case, students would have an ideal educational tool at hand. The aim of this project is to create an artificial solution that will not be differentiable from a human being in a game play.
While in one epoch, it can be beneficial to save money and invest them after several game rounds; in other epochs can such a strategy lead to the loss of important power plants and inevitable defeat. From the game strategy point of view, it may be important to save money and focus on purchasing the power plants, which in turn enables the player to store plenty of resources and thus sell out the game market. This can force the opponents to restructure the portfolio of the power plants owned. Another possible strategy relies on early purchase of the short and thus cheap wiring between cities, without actually supplying them with energy. Such investment into infrastructure means a financial disadvantage for the game adversaries in the later stages of the game. By Becker (2011) we suppose the player can also rely on the 'eager finish', when the last turn means a complete consumption of resources, which would normally affect players' performance in further rounds, but is irrelevant because of the actual victory. This idea is relevant for "Power Plants" game too. Each of these strategies and their combinations lead to various scenarios of bidding and bluffing during the power plant purchasing stage. Such intentional manipulation of game adversaries introduces a real world situation for the students, where the decision making is dependent on the environment (Nemerow, 1996), where the available information influences our reasoning.
We understand that possible ways of addressing these situations are countless, and each of them represents a feasible study variant, and thus a beneficial educational game. We now stand upon a verge of a complex issue – designing a software solution capable of replacing a human player.
Let's go to focus onto very specific part of the game: Power plant auction (Fig. 2). This game lap is typical for "clever" human decision. Each player must calculate with a lot of unknown variables. "How will change my adversary's strategy, if I try to buy a better power plant?", "Start auction?", "How much money can I spend?", "Can I bluff and manipulate with them to by Power plant, which I really don't want?"

Thanks to this example it is visible that for realistic behavior the system must use something more than the randomness Fig: 2.

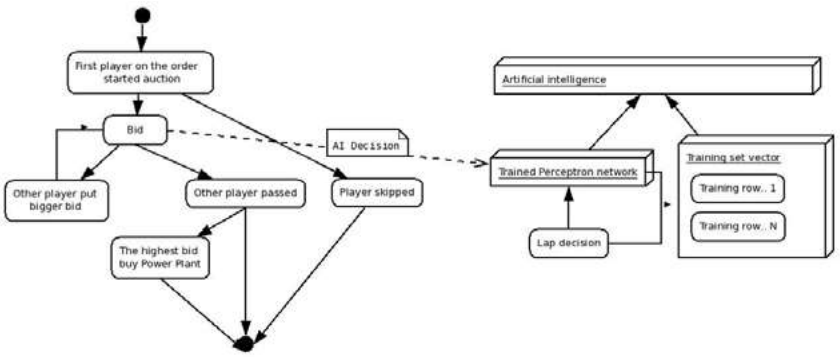

Fig. 2: Artificial intelligence decision mechanism implemented for the auction

Figure 2 shows the Artificial intelligence decision mechanism implemented into the Power plant auction. The system makes decision via internal strategy. This strategy should be de facto optimal solution for game.

Results and Discussion

The previously described methods of artificial intelligence adaptation for business games purpose have real results. These results we can split into four parts, which we call business game architecture. These parts are designed at the CULS:

- Game application interface
- Game message server
- Game intelligence
- Game client (Graphical interface)

Game application Interface

This is standardized by the SOA architecture. The Enterprise Application coded in the Java Enterprise edition runs on the GlassFish 4.0 application server. It distributes the WSDL description of the interface. The desktop application coded by the CULS team connects through this interface. Thanks to the open standard, the web application or mobile application can be easily designed as well, which is another benefit of the proposed solution. When a request for a different game or a better GUI arises, it can be realized without limiting the actual game service.

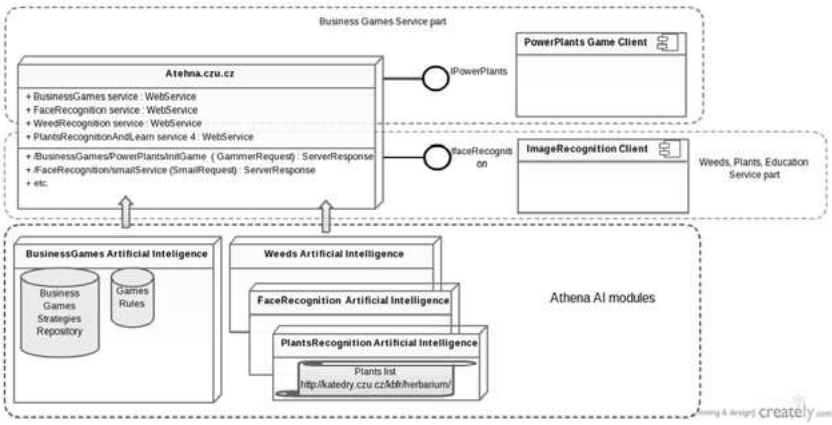

Fig. 3: Business Games Service is a small part of the multi-purpose AI project on the CULS. This paper talks about the Business Games Service placed on top of the picture.

Game message server

The message server is in fact a simple timer-driven application. From the moment of its launch on the application server, it awaits the connection requests from players. When the game GUI is launched and connected to the server, the server assigns each player a unique identifier and generates a game board setting. The game board is set up at the beginning of each game and remains unchanged until the end of the on-going game epoch. The server also ensures the basic game rules and settings, including:

- Amount and distribution of resources.
- Generation of power stations and random set up of their properties:
  - The power plant generation follows the price rule. The "technologically worst" and hence cheapest are the power stations burning the fossil fuels.
  - Power plants operating on two different commodities (excluding wind) are always available for purchase.
  - The wind power stations require no additional resources for their operation. This type or power plants cannot store resources.
- Game plan set up, and placing a player at a random location on the game board.
- Dynamic game board refreshing

The random generation of the game board and player's starting location can naturally put a certain player into disadvantageous starting position. This is also desirable from the educational point of view, because in such situation a different set of strategies must be applied. After creating the game world, the solution consequently prompts individual players to make their turns. It ensures the game is played according to the rules, manages the consumption of resources, their availability and prices on the market. It also updates the list of available power stations, and governs the auctions.

Without seeing the actual game adversary, we cannot perceive the facial expressions of our opponents. This naturally highly reduces the space for bluffing, which is currently one of the key disadvantages of such computer game. Our research team considered scanning the facial expression of the individual players. This however goes against the idea of replacing the game adversary with the artificial intelligence. Naturally up to the point when a computer would be capable of efficiently imitating human mimics. This

possibility is however on the theoretical level only.
The decision each player makes must be stored in the form of a vector, also called the vector of solution, to the solution database (Fig. 3). The winning strategy is consequently presented to the intelligent agent, which uses it for learning (Fig. 3). Such empirically gathered data are valuable, because the player can retrospectively follow the strategy utilized in game, and find out the important breakthroughs in the game. This function is priceless from the educational point of view.

Game Intelligence

The game intelligence is formed by the perceptron neural network with one hidden layer, which adapts itself based on the gathered learning sets from winning strategies. The aim of this research is to make the network capable of replacing a human player, and become fully independent. From the technical point of view, this is a standard artificial intelligence task. Porter (1990), Mitchell et al (2000), Baker, Gedajlovic and Lubatkin (2005) and many other authors describe various strategies companies utilize. Based on these findings a classical optimization algorithm can be designed, but the complex nature of the game mechanisms makes such a solution inappropriate. The behaviour of artificial neural network is highly unpredictable, because of the ability to predict as well as make mistakes. The student should thus feel like playing against a human adversary. This is the main goal of the entire research project, which is yet in its opening phase. We have however found out the machine can learn, which is a crucial determinant of future success.

Game Client

The Figure 4 shows user interface design of the game client. This client is the "java desktop" based application. We developed it for experimental gaming. The player can play game with other players. During the game are current data stored into Business Games Strategy storage (Fig 3.). These data are used as teaching vector for our Athena Artificial Intelligence server shown by Figure 3.

Fig. 4: Power plant game client

The Game Client is only experimental tool, which helps to record players decisions. We developed it by our team and we can change it according to our needs.

Discussion

Becker (2011) has described the impact of business games as a tool of experiential learning. In comparison with their approach, we do not rely on the predesigned set of game strategies, but instead propose a solution capable of learning from the recorded games. By adapting the methods of artificial intelligence, the solution can evolve together with the players and thus better support their professional development similar to Wawer et al (2010), Wolfe (2000) or Hawtrey (2007). This way the game keeps its dynamic character, which is difficult to predict, and players thus must gradually work on their strategy. The future stages of the project are to gain big number of game strategies. According to these strategies we suppose to improve our intelligent agent adaptation (to play better and be cleverer than current agent). Beside of that we can quantify benefits from playing business games by conducting a survey among the students of the management courses. This game can be available as an e-learning tool for future managers.

Conclusion

The business games based on the artificial intelligence solution can be used in the education of students of management courses. The nondeterministic character of the game generated using such an agent can further approximate the real market situation, and thus support the players in acquiring the important managerial skills and insights into the practical work of managers. The authors have introduced software capable of eliminating the key disadvantages of the algorithmic game system, including the game adversary intelligence problem.

This solution can be used as an E-learning tool which helps the student to gain managerial skills. Students can apply these skills to the real problems in the future. The quality of simulation will be improved by our team according to our growing knowledge. Thanks to open architecture and Web Services based technology, the solution open for other teams is presented. We suppose to develop a community of contributors. Thanks to the community contribution, we can improve the quality of simulation, quality and availability of the game client (for tables and mobiles for example) and other game aspects. The Power Grid solution can be presented during the ERIE conference time for the audience.

References

Baker, T., Gedajlovic, E. and Lubatkin, M. (2005) 'A framework for comparing entrepreneurship processes across nations', *Journal of International Business Studies*, vol. 36, pp. 492–504. http://dx.doi.org/10.1057/palgrave.jibs.8400153

Becker, R. (2011) *Interactive Games for Business Training*, Becker Multimedia, Inc.

Friese, F. (2004) *Power Grid*, Game manual. USA: Rio Grande Games.

Hawtrey, K. (2007) 'Using Experiential Learning Techniques', *Journal of Economic Education*, vol. 38, no. 2, pp. 143-152. http://dx.doi.org/10.3200/JECE.38.2.143-152

Jarošová, E. (2005) *Trénink sociálních a manažerských dovedností: metodický průvodce*, Praha: Management Press.

Kolb, D.A. (1984) *Experiential learning: experience as the source of learning and development*, New Jersey: Prentice Hall.

Mitchell, R.K., Smith B., Seawright, K.W. and Morse, E.A. (2000) 'Cross-cultural cognitions and the venture creation decision', *Academy of Management Journal*, vol. 43, no. 5, pp. 974–993. http://dx.doi.org/10.2307/1556422

Nemerow, L.G. (1996) 'Do classroom games improve motivation and learning?', *Teaching and Change*, vol. 3, no. 4, pp. 356–366.

Porter, M.E. (1990) *The Competitive Advantage of Nations*, The Free Press: New York.
Russell, S. and Norvig, P. (2009) *Artificial Intelligence: A Modern Approach,* Prentice Hall: New Jersey.
Tettamanzi, A. and Tomassini, M. (2001) *Soft Computing: Integrating Evolutionary, Neural, and Fuzzy Systems*, Springer: Berlin.
Thompson, A. (2010) *The Business Strategy Game*, computer software: GLO-BUS Software, Inc.
Wawer, M., Milosz, M., Muryjas, P. and Rzemieniak, M. (2010) 'Business Simulation Games in Forming of Students' Entrepreneurship', *International Journal of Euro-Mediterranean Studies*, vol. 3, no.1, pp. 49-71.
Wolfe, J. (2000) *The Global Business Game: A Simulation in Strategic Management and International Business*, Boston: South-Western college Publishing.