A Review of Artificial Intelligence in Serious Game for Public Health

Abdul Rafiq¹, Tuty Asmawaty Abdul Kadir², Siti Normaziah Ihsan³

¹,²,³ Soft Computing and Intelligent System Research Group (SPINT)
Faculty of Computer Systems and Software Engineering,
Universiti Malaysia Pahang, Kuantan, Pahang, Malaysia

Email: MCP18005@student.ump.edu.my

Abstract. Serious games used in public health for purposes including training, learning, prediction, coaching, diagnostic, rehabilitation and supporting. However, the serious game focuses mainly on user experience and graphical application, but less attention on applying artificial intelligence (AI). By enhancing artificial intelligence, it will have the capability to solve issues, especially in the field of public health. This article discussed a review of the use of artificial intelligence in a serious game for public health. The main idea of this paper is to gather all the related articles and create a trend analysis of the use of Artificial Intelligence (AI) in a serious game for public health. The related articles were applied to Artificial intelligence (AI) in the area of decision-making. The final section discussed the new trend and the future of Artificial intelligence using current AI techniques.

1. Background

Early in the 21st century, a video games market has become stabilized and increasingly popular. Video game concepts are being applied in various studies, one of the subjects in the area known as a serious game. Over the last decades, the technologies and applications have evolved significantly, but the trend of a serious game has remained maintained. In 1970, Clark Abt has invented a new term “Serious Game” in his book Serious Game [1]. Serious Game has the main purpose instead of entertainment and fun [2]. The main purpose of a serious game can be trained or teach and to be fun. It’s been proved that serious game can be used as educational tools. Serious games span a broad range of areas of expertise such as military, health, marketing, education, politics, government, religious and art games. According to Maslow’s hierarchy of need, health is one of requirement basic need in life [4]. By focusing on public health, a serious game can be designed to deliver the message and educate people about awareness health. The advantages of serious games are as a teaching tool by improving cognitive, affective, and psychomotor knowledge and skills acquisition [5]. The main idea of this paper is to gather all the related articles and create a trend analysis of the use of Artificial Intelligence (AI) task in a serious game for public health. The related articles discussed and analyze Artificial intelligence (AI) technique the area of decision-making and future meta-heuristic algorithms in a serious game. Moreover, a serious game has the potential to improve a player’s making a decision in the real world. It can be improved by using Artificial Intelligence (AI) techniques in the game. Artificial Intelligence (AI) in a game is about making a computer game capable to execute the task. AI model splits into three sections of AI tasks: movement, decision-making, and strategy.
The paper separated into particular sections. Firstly, a complete method to collect and analyze data from the literature review. Then, a discussion and conclusion about the AI task used in a serious game for public health. Finally, the section ends with a new future of Artificial Intelligence (AI) metaheuristic in a serious game.

2. Method

More specifically, this section will discuss the process of data gathering, data analysis and create a trend analysis of the use of artificial intelligence in a serious game for public health. The scope of this review will be limited between 2010 and 2018. This section will discuss the process of data gathered and classify within the following categories. Databases: The data from this review paper collected using the search engine provided by the Website. IEEE, Google Scholar, ScienceDirect contains a great journal, articles, and book online. The authors collected data from database focused on related articles such as a serious game for public health, computer science, AI task, Decision making, Movement, Strategy, and metaheuristic algorithms. Search by terms: The authors searched the articles by using a combined of the terms and words “Awareness”, “Game”, “Serious Game”, “AI for games”, “Public”, “Health”, “Artificial Intelligence (AI)”, “Decision Making”, “Goal-Oriented Behavior”, “Decision Tree”, “State Machine”, “Fuzzy Logic”, “Movement”, “Kinematic Movement Algorithms”, “Steering Behavior”, “Strategy”, “Waypoint Tactics”, “Tactical Pathfinding”, “Meta-Heuristic Algorithms”, “Particle Swarm Optimization (PSO)”, “Ant Colony Optimization (ACO)”, “Monte Carlo Tree Search (MCTS)”, and “Neural Network”. A Selection of Paper: The authors selected the articles by reading the abstracts of the paper. From the abstract, the authors defined the data include specific Game Title, Game Objective, AI Technique, AI Purpose, Platform, Issue and Future Research. 20 out of more than 40 are relevant articles and met the criteria to achieve this objective of the paper.

The 20 papers have been selected based on the criteria. The information from the papers was taking out and classify within the following categories. Author and Year: The first author’s name and year of publication of the article. Game Title: the name of a serious game project. Serious Game Purpose: serious game purpose in public health such as training, coaching, rehabilitation, diagnostics, and prediction. AI Technique: Artificial intelligence (AI) for a game in the area of decision making, such as decision tree, fuzzy logic, state machine, and goal-oriented behavior. AI Technique: Artificial intelligence (AI) for the game in the area of decision making, such as decision tree, fuzzy logic, state machine, and goal-oriented behavior. Platform: This category refers to where a game was specific play in an electronic device such as PC, Mobile/Tablet, Virtual Reality, Augmented Reality, Mixed Reality, and others

3. AI Task

There are three main requirements Artificial Intelligence in Game, which are decision-making, movement, and strategy. Decision-making refers to the character what to do next. Movement refers to character able to move anywhere. Strategy refers to group strategic required to coordinate a team. The paper focuses on reviewing an AI task for decision-making. Initially, all AI tasks being considered in the review. Unfortunately, due to very limited and unfound resources related to movement and strategy in public health, so they were excluded from this review. Decision-making is one of the most popular Artificial Intelligence (AI) task used in serious games. These techniques and algorithms compiled by the system based on information from the logical and rational decision-making process. Decision-making refers to the character what to do next. Usually, each character possesses a range of various behaviors, they could choose to perform such as walking, running, swimming, attacking, holding, patrolling, exploring and so on. The decision-making system needs to work out based on character behavior. The chosen behavior executed using movement AI and animation technology. The following
subsections present information about the serious game in public game classified by specific AI techniques within the field of decision-making.

### 3.1 Decision Tree

The objective of the decision tree is to create a prediction model based on a set of decision rules. These sections categorized most related publications using this technique applied to the serious game in the field of public health. Eight articles described research that applied decision tree. Refer to Table 1 for a complete list of articles in this section.

| Year | Author | Game Title          | SG Purpose | AI technique | Platform |
|------|--------|---------------------|------------|--------------|----------|
| 2010 | Alberto [6] | Training          | Training   | Decision Tree | PC       |
| 2010 | Jing Qin [7] | Orthopedic-Surgery | Learning   | Decision Tree | PC       |
| 2010 | RCosta [8] | -                 | Rehabilitation | Decision Tree | VR       |
| 2011 | Aarij [9] | The Project CLES | Diagnostic | Decision Tree | PC       |
| 2011 | Fabio [10] | Supermarket Game | Diagnostic | Decision Tree | PC       |
| 2014 | Maite [11] | -                 | Diagnostic | Decision Tree | Mobile   |
| 2018 | Benjamin [12] | The Cure     | Prediction | Decision Tree | Website  |
| 2018 | Kim C. M. [13] | -             | Diagnostic | Decision tree | -       |

Based on Table 1, the related articles were selected and categorized according to the following features.

- **Serious Game Purpose** – Regarding their serious game purpose, selected articles were classified as follows; 4 papers under the category of diagnostic [9], [10], [11], [13]. One paper under training [6], learning [7], rehabilitation [8], and prediction [12].
- **Platform** – Out of the 8 included articles, 4 were designed for PC [6], [7], [9], [10], while the remaining 1 was for Virtual Reality [8] and one for Website [13].

### 3.2 Fuzzy Logic

Fuzzy logic is a set of mathematical techniques designed to cope with gray areas. Condition and decisions have been true or false. Eight articles employed fuzzy logic. The most related article publications using this fuzzy logic technique applied to the serious game in the field of public health. Refer to Table 2 for a complete list of articles in this section.
Table 2. Fuzzy logic in a serious game for public health

| Year | Author       | Game Title     | SG Purpose     | AI technique | Platform |
|------|--------------|----------------|----------------|--------------|----------|
| 2010 | Yundong [14] | -              | -              | Fuzzy Logic  | PC       |
| 2012 | Voravika [15]| LISSA          | Teaching       | Fuzzy Logic  | PC       |
| 2018 | Twinkle [16] | -              | Prediction     | Fuzzy logic  | Mobile   |
| 2011 | Frederick [17]| -              | Training       | Fuzzy Logic  | PC       |
| 2012 | Odessa [18]  | -              | Teaching       | Fuzzy Logic  | PC       |
| 2012 | Fernando [19]| ARVET          | Supporting     | Fuzzy logic  | VR       |
| 2012 | Michele [20] | -              | Rehabilitation | Fuzzy Logic  | -        |
| 2014 | Ali [21]     | Cup and Plate  | Rehabilitation | Fuzzy Logic  | -        |

Based on Table 2, the related articles were selected and categorized according to the following features.

- **Serious Game Purpose** – the purpose of a serious game in this section were balanced: with two out of seven were rehabilitation [20], [21] and teaching [15], [18]. The remaining articles were belonged to prediction [16], teaching [15], [18] and supporting [19].
- **Platform** – The majority of this section was developed for PC [14], [15], [17], [18] while 1 was for virtual reality [19] and 1 were specifically developed for mobile phone [16].

### 3.3 State Machine

In a state machine, each character occupies one state. States connected together by transitions. Each transition leads from one state to another, the target state, and each has a set of associated conditions.

Three articles employed state machine. The most relevant article's publication using this state machine technique applied to the serious game in the field of public health. Refer to Table 1 for a complete list of articles in this section.

Table 3. State Machine in serious game for public health

| Year | Author      | Game Title     | SG Purpose     | AI technique      | Platform      |
|------|-------------|----------------|----------------|-------------------|--------------|
| 2012 | Agnieszka [22]| Master your Fear | Rehabilitation | State Machine    | PC           |
| 2011 | Loreto [23] | GEQ            | Rehabilitation | State Machine    | Mixed reality|
| 2013 | Chek T. [24]| sPEAK-MAN      | Rehabilitation | State Machine    | PC           |

Based on Table 3, the related articles were selected and categorized according to the following features.

- **Serious Game Purpose** – Table 3 show, all three papers under the category of rehabilitation [22], [23], [24]
- Platform – Out of the 3 included articles, 2 were designed for PC while the remaining 1 was for Mixed Reality.

3.4 Goal Oriented Behaviour

Goal-oriented behaviour is a blanket term that covers any technique taking into goals. Goal oriented behaviour consists of a set of goals and a set of actions. A character may have one or more goals. Only one article was related to goal-oriented behaviour in a serious game for health. Refer to Table 4 for a complete list of articles in this section.

| Year | Author | Game Title | SG Purpose | AI technique | Platform |
|------|--------|------------|-------------|--------------|----------|
| 2010 | Genaro [25] | - | Coaching | Goal oriented behaviour | PC |

Based on Table 4, the related articles were selected and categorized according to the following features.
- Serious Game Purpose – only one article related to the serious game in public health using goal-oriented behavior. The purpose of a serious game in this section is coaching [25].
- Platform – Out of the 1 included articles, 1 was designed for PC [25].

4. Result in Decision Making

This section presents the result and conclusion in the use of decision-making technique in the serious game for the public health field.

| AI Technique | Number (N) | Rehabilitation | Diagnostic | Prediction | Teaching | Training | Other |
|--------------|------------|----------------|------------|------------|----------|----------|-------|
| Decision Tree | 8          | 1              | 4          | 1          | 0        | 1        | 1     |
| Fuzzy Logic State machine Goal Oriented Behavior | 8          | 3              | 0          | 1          | 2        | 1        | 1     |
| State machine Goal Oriented Behavior | 3          | 3              | 0          | 0          | 0        | 0        | 0     |
| Goal Oriented Behavior | 1          | 0              | 0          | 0          | 0        | 0        | 1     |
| Total | 20         | 7              | 4          | 2          | 2        | 2        | 3     |

Table 5 displays the number of publications according to the serious game purpose and decision-making technique. Based on table 5, rehabilitation and diagnostic are the categories with the highest number of labeled articles, with 35% and 20%. Most of the decision tree used for a diagnostic purpose in public health. Several AI Technique: decision tree and fuzzy logic balanced used for the serious game purpose in teaching, training, and prediction. The remaining segment is another coaching, learning and supporting. The number of publications shows that decision tree and fuzzy logic are the most popular...
technique used in the purpose of a serious game in public health. The lowest AI technique used in the serious game for public health is goal-oriented behavior.

| AI Technique          | N | PC | Virtual Reality | Mobile | Website | Other |
|-----------------------|---|----|-----------------|--------|---------|-------|
| Decision Tree         | 8 | 5  | 1               | 1      | 1       | 0     |
| Fuzzy Logic           | 6 | 4  | 1               | 1      | 0       | 0     |
| State machine         | 3 | 2  | 0               | 0      | 0       | 1     |
| Goal Oriented Behavior| 1 | 1  | 0               | 0      | 0       | 0     |
| Total                 | 18| 12 | 2               | 2      | 1       | 1     |
| Percentage %          | 100|66.7| 11              | 11     | 5.6     | 5.6   |

Table 6 displays the number of publications according to the platform used in the serious game and decision-making technique in the field of public health. The majority of reviewed articles, 66.7% was developed for Personal Computer (PC). The second highest developed in the serious game was 11% virtual reality and 11% mobile. The remaining was a website and other. The paper concluded that the trend of a platform in public health was designed for PC. Another finding in the review, most of the game is a casual and puzzle genre. Many genre games can be a serious game for public health. Additionally, movement and strategy might be suitable for the Role Playing Game (RPG) genre.

5. Implications

Current trends of AI research in public health focusing on a decision-making task. However, the exploration of other AI tasks such as movement and strategy is important as interesting games especially for RPG genre requires movement and strategy. The next future or trend for Artificial intelligence (AI) for a serious game is Metaheuristic algorithms. There are many algorithms uses in metaheuristic algorithms such as Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), Hill Climbing algorithms and so on. The future of trend can be implemented on other AI task which is movement and strategy in a serious game for public health.

6. Conclusion

The review of articles has a few limitations. It was limited by the search in a database. The number of publications used artificial intelligent task such as movement and strategy for a serious game in the field of public health was limited. So, the trend of artificial intelligence (AI) tasks only use decision-making techniques. The articles give an overview of the trends and limitations over the last decade (2010 – 2018). The new era of serious game is very close to the entertainment video game, and they can use to increase attention to the target audience by using artificial intelligence. The next future trends of artificial intelligence are metaheuristic algorithms in serious game.
Acknowledgements

The authors would like to thank University Malaysia Pahang (UMP). This work is supported by University Malaysia Pahang (UMP) and funded by Ministry Education Malaysia under FRGS Grant FRGS/1/2016/ICT01/UMP/02/2.

References

[1] P. Wilkinson, “A Brief History of Serious Games,” pp. 17–41, 2016.
[2] T. Marsh and T. Marsh, “Serious games continuum : Between games for purpose and experiential environments for purpose Serious games continuum : Between games for purpose and experiential environments for purpose,” Entertain. Comput., vol. 2, no. 2, pp. 61–68, 2017.
[3] J. Ecalle, “Serious games as new educational tools : how effective are they ? A meta-analysis of recent studies,” no. June, 2013.
[4] N. Jerome, “Application of the Maslow ’ s hierarchy of need theory ; impacts and implications on organizational culture , human resource and employee ’ s performance,” vol. 2, no. 3, pp. 39–45, 2009.
[5] S. Bigdeli and D. Kaufman, “Digital games in health professions education : Advantages , disadvantages , and game engagement factors ,” vol. 2017, 2017.
[6] A. C. Vidani and L. Chittaro, “Using a Task Modeling Formalism in the Design of Serious Games for Emergency Medical Procedures,” 2009 Conf. Games Virtual Worlds Serious Appl., pp. 95–102, 2009.
[7] F. Article, “Learning Blood Management in Orthopedic Surgery through ,” pp. 45–57, 2010.
[8] R. M. E. M. Costa, D. S. Souza, and I. Mendonça, “Exploring intelligent agents for controlling user navigation in 3D games for cognitive stimulation ,” pp. 1–6, 2010.
[9] A. M. Hussaan et al. , “Helping Children with Cognitive Disabilities through Serious Games : Project CLES ,” pp. 10–11, 2011.
[10] A. P. Z. Bastos, L. C. V Andrade, K. Revoredo, and P. Mattos, “Assessment of ADHD through a Computer Game : An Experiment with a Sample of Students ,” 2011.
[11] M. Frutos-pascual, “Adaptive Tele-Therapies Based on Serious Games for Health for People with Time-Management and Organisational Problems : Preliminary Results ,” pp. 749–772, 2014.
[12] B. M. Good et al. , “The Cure : Making a game of gene selection for breast cancer survival prediction ,” pp. 1–9, 2013.
[13] K. C. M. Bul et al. , “RESEARCH ARTICLE A serious game for children with Attention Deficit Hyperactivity Disorder : Who benefits the most ? ,” pp. 1–18, 2018.
[14] F. Article, “Creating an Immersive Game World with Evolutionary Fuzzy ,” no. April, 2010.
[15] V. Wattanasoonthorn, “LISSA : A Serious Game to learn Cardiopulmonary Resuscitation .”
[16] T. Rambha, M. Dhodi, S. D. State, V. Patel, D. R. Kalbande, and S. Patel, “Design of an Intelligent system for Autism ,” 2018.
[17] F. Imbeault, B. Bouchard, and A. Bouzouane, “Serious Games in Cognitive Training for Alzheimer ’ s Patients ,” 2011 IEEE 1st Int. Conf. Serious Games Appl. Heal. , pp. 1–8.
[18] O. J. Petit, T. Raby, F. Ravaut, and M. Rothan-tondeur, “Nurse Education Today Developing the Serious Games potential in nursing education ,” YNEDT , vol. 33, no. 12, pp. 1569–1575, 2013.
[19] F. M. De Oliveira, R. S. Lanzillotti, R. M. E. Moreira, P. C. Computacionais, and R. Gonçalves, “ARVET AND SAPTEPT : A Virtual Environment and a System supported by Fuzzy Logic in Virtual Reality Exposure Therapy for PTSD patients ,” pp. 103–107, 2012.
[20] M. Pirovano, R. Mainetti, G. Baud-bovy, P. L. Lanzi, and N. A. Borghese, “Self-Adaptive Games for Rehabilitation at Home ,” 2012 IEEE Conf. Comput. Intell. Games , pp. 179–186, 2012.
[21] A. Karime, M. Eid, J. Mohamad, and A. El Saddik, “A Fuzzy-Based Adaptive Rehabilitation
Framework for Home-Based Wrist Training,” vol. 63, no. 1, pp. 135–144, 2014.

[22] A. Szczesna, J. Grudzinski, T. Grudzinski, R. Mikuszewski, and A. Debowski, “The Psychology Serious Game Prototype for Preschool Children,” 2011.

[23] D. L. Ines, “Mixed Reality Serious Games : The Therapist Perspective,” no. v, 2011.

[24] C. T. Tan and S. Ferguson, “sPeAK-MAN : Towards popular gameplay for speech therapy Categories and Subject Descriptors,” no. March 2016, 2013.

[25] G. Rebolledo-mendez, S. De Freitas, A. Rosa, and G. Gaona, “A Model of Motivation Based on Empathy for AI-Driven Avatars in Virtual Worlds,” 2009.