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A Review of Artificial Intelligence in Serious Game for Public Health

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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.

Table 1. Decision Tree in serious game for public health

Year	Author	Game Title	SG Purpose	AI technique	Platform
2010	Alberto [6]	-	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.

Table 4. Goal Oriented Behaviour in serious game for public health

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.

Table 5. Result for Serious game purpose

AI Technique	Number (N)	Rehabilitation	Diagnostic	Prediction	Teaching	Training	Other
Decision Tree	8	1	4	1	0	1	1
Fuzzy Logic State machine	8	3	0	1	2	1	1
Goal Oriented Behavior	3	3	0	0	0	0	0
	1	0	0	0	0	0	1
Total	20	7	4	2	2	2	3
Percentage %	100	35	20	10	10	10	15

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.

Table 6. Result for the platform

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.

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