ISSN(Online) : 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering
An ISO 3297: 2007 Certified Organization Vol.5, Special Issue 5, June 2017
8th One Day National Conference on Innovation and Research in Information Technology (IRIT- 2017)
Organized by
Departments of ISE, CSE & MCA, New Horizon College of Engineering, Bengaluru, Karnataka 560103, India

Swarm Intelligence in Strategy Games

Ashika A[1], Blessy Thomas[1], A Rafega Beham[2]
Student, Dept. of ISE, New Horizon College of Engineering, Bangalore, Karnataka, India
Student, Dept. of ISE, New Horizon College of Engineering, Bangalore, Karnataka, India
Senior Assistant Professor, Dept. of ISE, New Horizon College of Engineering, Bangalore, Karnataka, India

ABSTRACT: Artificial intelligence is a vast dynamic field, growing every day and Swarm Intelligence is a drop of that huge ocean. In this paper, we discuss about what Artificial Intelligence andSwarm intelligence means and their usage in games. It discusses about the different types of games and also explains the algorithms used by Swarm intelligence in Strategy games, which maybe real time or turn based.

KEYWORDS: Artificial Intelligence; Swarm intelligence; Turn Based Strategy Game; Real time Strategy game

I. ARTIFICIAL INTELLIGENCE (AI)

According to the father of artificial intelligence, John Mc Carthy, Artificial Intelligence is “The science and Engineering of making intelligent machines, especially intelligent computer programs”.
Artificial Intelligence is the study of making machine think intelligently to solve real world problems. A Computer cannot think as a human does. Artificial Intelligence concept is usedto bridge the gap between the natural thought process and machine. It is concerned with analyzing human thinking, decision making, problem solving and learning activities to solve computational mathematical problems [5].
The most important concepts of Artificial Intelligence are intelligence, thinking humanly, deep learning, knowledge representation and touring test approach.
Artificial Intelligence can be used to solve complex analysis problems. It is used in optical character recognition, face recognition, designing devices, developing strategy games etc.Some of these studies are “Nature Based” theories which reflect natural intelligence such as Swarm Intelligence.

II. SWARM INTELLIGENCE (SI)

Swarm is a loosely structured collection of interacting agents. Animals swarm to migrate, to forage and to defend against predators. Swarm intelligence is the decentralized self-organized approach, where multiple agents work together as sub units to achieve an ultimate goal. It can also be defined as a probabilistic technique for solving computational problems which can be used to get optimal solution [18]. SI has evolved by drawing inspiration from collective behavior of social insect colonies; it is impressive as there is no central unit controlling or assigning tasks to groups.
Agents in Swarm Intelligence follow simple rules; interact locally with each other and environment. Swarm Intelligence is very adaptive to its environment. Some of the natural examples of Swarm Intelligence are Ant colonies, bird flocks, behavior of Wasps, swarm of bees, fish schooling etc.
There are several general principles of Swarm Intelligence: Proximity Principle, Quality Principle, Principle of Diverse Response and Principle of Stability and Adaptability [16]. Swarm intelligence can be applied in routing in

ISSN(Online) : 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering
An ISO 3297: 2007 Certified Organization Vol.5, Special Issue 5, June 2017
8th One Day National Conference on Innovation and Research in Information Technology (IRIT- 2017)
Organized by
Departments of ISE, CSE & MCA, New Horizon College of Engineering, Bengaluru, Karnataka 560103, India

telecommunication networks, robotics, staff scheduling, strategy games, process optimization, crowd simulation and ant based routing.
The most common Swarm Intelligence algorithms are Particle Swarm Optimization, Ant Colony Optimization, and Artificial Bee-colony Optimization.

III. ADVANTAGES OF SWARM INTELLIGENCE

Swarm system is very adaptive to the changing environment. It can adjust to predetermined stimuli as well as new stimuli that change beyond narrow range. Swarm Intelligence evolves. Only a collective system can adapt over time from one environment to other i.e., the intelligence spreads from one being to the entire population. Swarm intelligence is boundless.
In swarm system positive feedback can help in increasing the order by extending structures beyond the bounds of its initial state. Swarm is also flexibles as it spontaneously responds to all the kinds of disturbance and challenges. Agents can be easily added or removed without disturbing the structure. A swarm does not consist of central controlling unit. Every group has an equal or deserved priority in this method. Agent systems in Swarm intelligence are simple in design i.e., they are robust. Tasks will be completed even if some agents fail, as reliance on each agent in Swarm intelligence is very less. Swarm intelligence can overcome or tackle simple failures easily. And changes propagate very fast in Swarm intelligence network
.

IV. GAME

A game is nothing but a sport played according to definite rules. Games can be classified based on genre of the situation. One of the most favored genre is the video game. There are different types of video games such as, action games, puzzle games, adventure games, MMO (Massively multiplayer online) games, strategy games.
Strategy is the highest level of decisions taken to achieve the objectives. Mathematically, a strategy consists of finite set N (Number of players) for each player $i \in N$, anon-empty set A_i (set of strategies available to player i) exists whereby $A=\pi_i A_i$. In general,astrategy game consists of a set of players and each player has a non-empty set of actions and each player has preference relation over the set of action profiles.
In strategy games, player's ability to command influences

- Resource management: The player's knowledge is required to decide how to spend, save and produce the resources.
- Spontaneous decision-making: Player's spontaneous response is required to face a battle or an uncertain or unaware condition.
- Planning: Deciding the number of troops, type of troops in battle games is required for planning of future circumstances.
- Spatial and Temporal Reasoning: Player requires knowing and understanding the nature of the environment and performing accordingly with the available resources to avoid damage.
- Understanding the opponent: It is required for a player to predict the behavior of the opponent and tackle him [17].

These are the most common challenges faced by players.

ISSN(Online) : 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering
An ISO 3297: 2007 Certified Organization Vol.5, Special Issue 5, June 2017
8th One Day National Conference on Innovation and Research in Information Technology (IRIT- 2017)
Organized by
Departments of ISE, CSE & MCA, New Horizon College of Engineering, Bengaluru, Karnataka 560103, India

V. TYPES OF STRATEGY GAMES

There are two most popular strategy games:

1. Turn based strategy game
2. Real time strategy game

1. TURN BASED STRATEGY GAME (TBS):

As the name suggests, here the game flow is partitioned into well-defined visible parts called turns. Turn based strategy game is a pure strategy game which has increased thinking time available. There is no requirement of immediate reflexes. It deals entirely on decision making to obtain optimal solution i.e., to give the best move and does not focus on time. Speed and accuracy are not important factors here as it is in Real Time Strategy games. Time available for planning is the distinctive point between real time strategy game and turn based strategy. Turn based strategy game limits the unpredictability of path finding algorithms. Here the maps are tiled which simplifies pathing. In Turn Based Strategy games it is required to develop an opponent which is an intelligent agent. The AI player must have the same capability as that of human player. A Turn Based Strategy game is more strategic, complex and requires a lot of thought process. A Turn Based Strategy game also faces same challenges as that of Real Time Strategy game in opponent learning, spatial and temporal reasoning, planning etc. A Turn Based Strategy game is mainly concerned with plan adaptation technique and ontological information relating objects in the game environment. In a Turn Based Strategy game more knowledge is required to make a move. There are different types of Turn Based Strategy games such as board games (Ex: Chess, Go), indie games (Ex: Free Civ), open source games (Ex: Games by super Cell), browser based games i.e., desktop games.

A classic Turn Based Strategy game according to majority is civilization series. Another example of Turn Based Strategy game would be Sword Fight. Poker is also one of Turn Based Strategy Game.

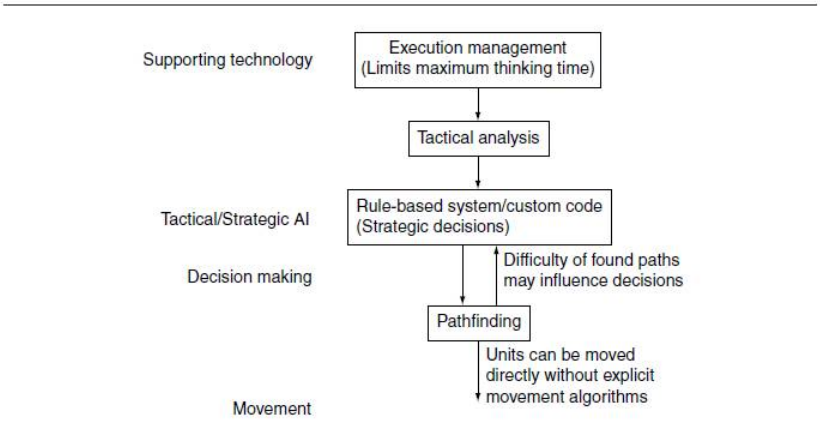

Fig: Artificial Intelligence architecture for Turn Based Strategy Game [4].

SI ALGORITHM FOR TURN BASED STRATEGY GAME

The below mentioned algorithms can be used to implement Swarm Intelligence in a Turn Based Strategy Game. There are two phases in Swarm intelligence which are represented in two different algorithms.

- Selfish phase
- Negotiation phase

ISSN(Online) : 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering
An ISO 3297: 2007 Certified Organization Vol.5, Special Issue 5, June 2017
8th One Day National Conference on Innovation and Research in Information Technology (IRIT- 2017)
Organized by
Departments of ISE, CSE & MCA, New Horizon College of Engineering, Bengaluru, Karnataka 560103, India

Selfish phase: In this phase, the algorithm will find which task would be the best to be performed and all the sub units of that particular unit would consider that particular task as their Selfish intent.

Negotiation phase: In this phase, there are two sub functions,

- Recognition
- Validation

They are run in succession.

In the recognition phase, the units will reconsider their selfish intents and decide if their intention is the best or that followed by the group.

In the validation phase, all the units when reconsidered their selfish intents to that of the groups then its intention is validated.

These two phases are run in succession, and together they allow the swarm to reach a consensus. A consensus is met when there are no units reconsidering, and the end state is valid for all units. While there are any units reconsidering, the cycle continues.

Time complexity for Selfish phase is O(N).

In Negotiation phase- time complexity for Recognition is O(N X N) and Validation is O(N).

Therefore the time complexity for Turn Based Strategy Game = O(N)+O(NXN)+O(N)

$=O(2N+N^2) \approx O(N^2)$

[17].

2. REAL TIME STRATEGY GAME(RTS):

A Real Time Strategy game is sub-genre of strategy game which mainly focuses on resource allocation and management. It is important to manage resources in this type of game, as they are nonrenewable and are scattered throughout the map. Real Time Strategy game is very challenging, as the player has to deal in parallel with the objectives such as base construction, improve level and technology, battle against enemies etc., therefore player has to have very quick reflexes. It is largely played due to its distributive and multi objective behavior. In a typical Real Time Strategy game, a player has control over parts of map that is visible or has been acquired. The screen for a Real Time Strategy game is been divided into parts of the map that is visible and an interface for issuing commands. Complex User Interface is required to design Real Time Strategy game, some of which are derived from the desktop interface like click, drag and drop, scroll. Here the player has an isometric perception of the virtual world. Most of the Artificial Intelligence development work focuses on developing intelligent agents to play against humans.

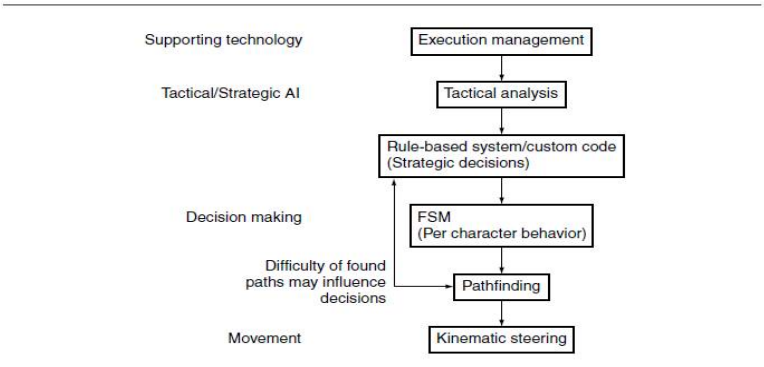

Fig: Artificial Intelligence architecture for Real Time Strategy Game [4].

ISSN(Online) : 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

An ISO 3297: 2007 Certified Organization Vol.5, Special Issue 5, June 2017

8th One Day National Conference on Innovation and Research in Information Technology (IRIT- 2017)

Organized by

Departments of ISE, CSE & MCA, New Horizon College of Engineering, Bengaluru, Karnataka 560103, India

SWARM INTELLIGENCEALGORITHM IN REAL TIME STRATEGY GAME

Swarm Intelligence is also used in Real Time Strategy games. The most used algorithm for task allocation is Swarm GAP algorithm. Self-organization refers to the process which new patterns or structures arise in the system from the interaction of their numerous elements, without interventions of external directing influences. Nature often rely on self-organization [1].

Let $s_j \in [0,1]$ be the stimulus associated with task $j \in J$ and $\theta_{ij} \in [0,1]$ be the response threshold of individual (agent) i to task j. The tendency, or probability, of individual i to engage in task j is given by $T_{ij} \in [0,1]$, calculated using Eq. 1.

$$T_{ij} = \frac{s^2_j}{s^2_j + \theta^2_{ij}} \quad (1)$$

In swarms, due to polymorphism, individuals maybe more able to perform certain kinds of tasks. This characteristic is captured in Eq. 2, which determines the response threshold of individual i to task j according to its capability ($k_{ij} \in [0,1]$) to perform task j.

$$\theta_{ij} = 1 - k_{ij} \quad (2)$$

The goal of Swarm-GAP, is to allow agents to individually decide which task they will engage in a simple and efficient way, minimizing computational effort and communication between agents. With Swarm-GAP, agents communicate via a token based protocol [13].

VI. USE OF ARTIFICIAL INTELLIGENCE AND SWARM INTELLIGENCE IN GAMES

Artificial Intelligence can play a supportive as well as opposition role. Artificial Intelligence in computer games deal with behavior and decision making process of the player. Artificial Intelligence has to analyze, learn and also be at the level of player, so that the player should not feel bored of getting defeated or always winning. A game should always seem challenging to the player.

A perfect Artificial Intelligence must always adapt itself to game changes, player learning curve and current ability. Player must always feel that it is a different opponent each time. An Artificial Intelligence player is composition of multiple techniques, ideas and choices. An AI player is nothing but a subset of goal driven agents. Decision taken during unpredictable situations by the Artificial Intelligence can be used for implementation in the real world as in case of defense.

The most common of uses of swarm intelligence in games are for path finding, organizing schedule tasks and learning. It can also be used for decision making process.

Strategy games are great test beds for Artificial Intelligence [13].

VII. CONCLUSION

As discussed above, Artificial Intelligence in games can help us improve the quality of the game. We can determine the uncertainties that may occur considering a situation. It will enhance the thinking capability of a player. It also trains soldiers to a battle, in decision making perspective. Artificial Intelligence can be improved by implementing an algorithm in the game.

ISSN(Online) : 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

An ISO 3297: 2007 Certified Organization Vol.5, Special Issue 5, June 2017

8th One Day National Conference on Innovation and Research in Information Technology (IRIT- 2017)

Organized by

Departments of ISE, CSE & MCA, New Horizon College of Engineering, Bengaluru, Karnataka 560103, India

REFERENCES

1. Felipe S. Bo□o1, Paulo Roberto Ferreira Jr.1,2, Ana L. C. Bazzan1, A Comparison of Algorithms for Task Allocation in RoboCup Rescue
2. Paulo R. Ferreira Jr., Felipe S. Boffo and Ana L. C. Bazzan , A Swarm Based Approximated Algorithm to the Extended Generalized Assignment Problem (E-GAP)
3. Renato L. de Freitas Cunha Luiz Chaimowicz , An Artificial Intelligence system to help the player of Real-Time Strategy games
4. Ian Millington and John Funge, Artificial intelligence for games, Second Edition
5. Stuart J. Russell and Peter Norvig, Artificial Intelligence-A Modern Approach
6. Stuart J. Russell and Peter Norvig, Artificial Intelligence, A Modern Approach, Third Edition
7. Patrick Henry Winston, Artificial Intelligence, Third Edition
8. Shuo Xiong and Hiroyuki Iida, Attractiveness of Real Time Strategy Games
9. Ben G. Weber, Michael Mateas, Arnav Jhala,Building Human-Level AI for Real-Time Strategy Games
10. Aleksandar Micić, Davíð Arnarsson, Vignir Jónsson,Developing Game AI for the real□time strategygames STARCRAFT, Research Report, spring 2011
11. Paulo R. Ferreira Jr.1 and Ana L. C. Bazzan, Distributed Task Scheduling through a Swarm Intelligence Approach
12. Gilles Schtickzelle, Dynamic Task Allocation in a Turn-based Strategy Game, Academic year 2011-2012
13. Anderson R. Tavares, Hector Azp´urua, Luiz Chaimowicz., Evolving swarm intelligence for task allocation in a real time strategy game
14. Antonio S´anchez-Ruiz, Stephen Lee-Urban, H´ector Mu˜noz-Avila, Bel´en D´ıaz-Agudoy, Pedro Gonz´alez-Calero, Game AI for a Turn-based Strategy Game with Plan Adaptation andOntology-based retrieval
15. Genetic and Evolutionary Computation Conference 2008
16. Yichen Hu, Swarm intelligence
17. Auguste Antoine Cunha,Swarm Intelligence in Strategy Games
18. Deepa and Dr. A. Senthilkumar, Swarm intelligence from natural to artificial systems: ant colony optimization
19. Melvin Winstrøm-Møller , Niels Thykier , Turn-based Game Engine and AI, August 31, 2010
20. Ian Watson, Damir Azhar, Ya Chuyang, Wei Pan & Gary Chen, Optimization in Strategy Games: Using Genetic Algorithms to Optimize City Development in FreeCiv