
Bachelor thesis in the Computer Science and Media degree programme

Tactical Game AI with shared Knowledge based on Influence Maps

submitted by

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Abstract

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Chapter 1

Introduction

1.1 Motivation

During his studies, Mr Akdogan always wondered how the game AI shares its knowledge. Because if the artificial intelligence (AI) always knows everything, it would not be beneficial for the player and you want to give the player a good experience. While looking for a topic for his bachelor thesis, he came across a game developers conference (GDC) video from [Brewer and Graham, 2020] that talks about the representation of information and also about influence maps for the AI. This raised the question of how much influence shared knowledge (SK) has among AI as opposed to agents not sharing their knowledge with each other.

1.2 Scientific question

How big is the difference between the AI agents when they share their influence map or each agent uses its own influence map?

1.3 Structure of the Thesis

Chapter 2

Related work

In [Champandard, 2021] article discussed how influence map (IM) works in general. As well as the important part of giving an agent or squad a memory of the current influence range on the map.

Chapter 3

Theoretical background

3.1 Influence Map

All information is taken from the book AI for Games unless otherwise cited in this chapter [Mellington, 2020].

An IM is used to record the current balance of Military Influence at each position in a level. Many factors can affect military influence, such as the proximity of a unit, the proximity of a base, the length of time a unit has been last seen, the terrain, the current weather, the strength of a unit. Many factors have only a small influence. Based on how the abstract image is drawn across the map or level of influence, more marginal information can be communicated to the AI and tactical decisions can be made.

3.1.1 Simple Influence

The influence of a unit in an area consists of how much its influence is weighted. Assuming it is a Real Time Strategy game and there is a foot soldier unit and a tank. Normally, a tank has more lives, more damage and a longer range than a simple foot soldier. This means that a larger Influence value is taken and injected into the IM at the unit's position. If you take the strength of a unit, it decreases with increasing distance. So the further away you are from the unit, the less influence it has. A linear drop-off model can be used for this. A doubling of the distance results in a halving impact:

$$I_d = \frac{I_0}{1 + d} \quad (3.1)$$

I_d is the influence at a given distance. d is the distance from the unit to the point and I_0 is the influence at the distance value 0 to the unit. It would also be possible to use a more sloping initial drop off, with a greater range of influence:

$$I_d = \frac{I_0}{\sqrt{1 + d}} \quad (3.2)$$

It is also possible to use an equation that first flattens out and then falls sharply:

$$I_d = \frac{I_0}{(1 + d)^2} \quad (3.3)$$

3.1.2 Calculating the Influence

For the IM, a large calculation is needed for each unit on the map for each possible position. The execution time would be $O(nm)$ and the memory is $O(m)$. m represent the number of possible positions in the game and n the number of units. With a linear drop-off curve, the influence is covered with a threshold value. In this way, small values are not unnecessarily stacked on top of each other in a larger range:

$$r = \frac{I_0}{I_t - 1} \quad (3.4)$$

Where I_t is the threshold value for the influence. Thus, the influence of each unit is only applied to the places that are within the given radius. This limits the calculation time to $O(nr)$ for the time and to $O(m)$ for the memory. r is the number of locations that are within the given radius.

3.1.3 Dealing with unknowns

Here, only the influence of units that can be seen in their radius is calculated for the unit. Thus, an aspect called fog-of-war (FOW) is built in. This is important for investigating whether the SK of units makes a difference. In this way, units also have a maximum distance they can see and can only build a personal IM based on the friendly or enemy units they can see and incorporate this into their decisions. This can lead to problems for the AI decision making, because it does not have the same memory as humans have and cannot map the context. Therefore, it is important to give the AI some kind of memory. This can be mapped well with IM so that the AI can manage well in the FOW. It will also be very interesting to see if it makes a significant difference between the Shared and Unshared Knowledge Teams.

3.1.4 Influence Map Setup

All information in this section is quoted from the article [Champanand, 2021]. Otherwise they are cited as such.

For the IM, a 2-dimensional grid is stretched over the map and divided into a grid system. Then, all areas that cannot be walked on, such as walls or similar, are excluded from the calculation and ignored. This enables the unknown and the FOW. Because with this, the influence does not proper through obstacles but around them. After that, the cells that have the shortest distance to each agent are injected with their influence in the 2 dimensional grid. This means

that these cells are always set to the influence value of the unit regardless of anything else. After setting the values of each agent in the IM, a blur algorithm is applied as explained in the chapter 3.2. The choice of which blur method is best suited for each game depends heavily on the game designer. For example, depending on whether there are many walls on the level or more open vials, it can be decided whether to use one of the distance-based blur algorithms described in Chapter 3.1.1 or a blur algorithm from Chapter 3.2. The important thing is to only apply this to cells that are accessible. Thus, the influence must propargize around walls and no distorted image is transmitted. The value from the blur algorithm is then multiplied by the decay to implement a decay of the influence on the range.

$$I_{xy} = b_{xy} * D \quad (3.5)$$

I_{xy} is the influence at the point x and y in the grid. This is equal to the blurred value b_{xy} at the point x and y from the algorithm multiplied by the decay value D .

- **Momentum** With momentum the influence is linearly interpolated from the cell. In this way the memory of the IM is suggested.

$$I_{xy} = I_{xy} TODO \quad (3.6)$$

- **Decay** Decay is for the decay of the influence value within an IM so a kind of fading memory is built up and the influence continues to decrease depending on how far it is from its point of origin.
- **Update Frequency** This parameter describes how often the influence is updated.

3.2 Blur

For the calculation of the influence on maps with narrow corridors and small areas a blur algorithm is used [Champandard, 2021]. This suggests that the algorithm is not affected by obstacles. Thus the influence flows around the corners. In this work, a boxblur algorithm was applied. But it would work just as well with a Gaussian blur. This is open to the individual preferences of how the influence should spread. For this work, the boxblur algorithm was chosen because it provides a more uniform distribution in all directions of influence.

0.000	0.000	0.000	0.000	0.000
0.000	1.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000
0.000	0.000	-1.000	0.000	0.000

Table 3.1: Boxblur influence example grid - Iteration 0. The inflow of two units was injected into a completely new IM. The cell with the value 1.000 is from the own team and the cell with the value -1.000 from the opposing team.

The Box Blur is a spatial domain linear filter. It takes a pixel (or in our case a cell) from the grid and takes itself and its surrounding pixels and calculates the average as the new value. A 3 by 3 box blur (radius 1) can also be described as a matrix:

$$K = \frac{1}{9} \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix} \quad (3.7)$$

K is the average value of pixel and its surrounding values.[Handwiki, 2021]

0.250	0.200	0.200	0.030	0.008
0.240	1.000	0.160	0.006	0.007
0.210	0.180	0.150	0.040	0.002
0.060	-0.040	-0.070	-0.100	-0.010
0.005	-0.170	-1.000	-0.200	-0.078

Table 3.2: Boxblur influence example grid - Iteration 1. After the first iteration, from top left to bottom right, the cell was placed the 3 by 3 matrix. So that the center of the matrix lies on the cell and then calculated the mean value.

0.420	0.370	0.290	0.080	0.025
0.400	1.000	0.250	0.009	0.027
0.300	0.250	0.140	0.030	-0.007
0.068	-0.057	-0.130	-0.15	-0.069
-0.039	-0.221	-1.000	-0.271	-0.142

Table 3.3: Boxblur influence example grid - Iteration 2

Through this box blur, the influence is gradually expanded with 1.000 and -1.000 and then stagnates after a certain iteration. The Celle with 1.000 means that there is an allied unit that places its influence there and -1.000 means that there is an enemy unit.

3.3 Waypoints

Waypoints are positions distributed around the game world. With waypoints, the AI can use this for its pathfinder in order to progress in the game world. Tactical waypoints require more data describing these points in order to make a correct decision about which waypoint to use [Mellington, 2020].

Chapter 4

Experimental setup

The experiment consists of a map on which two teams compete against each other. This will be similar to the game mode "Conquest" from Battlefield 1 [bat, 2016]. In Conquest, there are a certain number of places that a team tries to capture. At the beginning, each place is still uncaptured. When a team has taken a place, it always gets points added to their points account at certain time intervals. The team that has reached a certain number of points first after a certain time has won. One side will consist of a squad of five agents, the other side of five squads of one agent each. A squad always knows where its agents are and whether a unit sees a friendly or enemy agent and can thus build up an IM. When a team has won, information about the match is saved for later evaluation and the next match starts. This allows you to run this several thousand times so that the result is not falsified.

4.1 Game mode adjustments

Since in the game mode Conquest of Battlefield [bat, 2016] the current state of the capturable locations is always queried with a certain tick rate, this can lead to inaccurate values. Therefore the time a place is in possession of a team is counted to avoid the sampling problem.

4.2 Assumption

The side with the squad and its five agents has a slightly higher win rate than the side with the 5 squads with one agent each. This is because it has more information to decide, for example, which of the points to attack first or which point may have no enemy units.

4.3 Rules of the game

The goal of a match is to have captured capturable locations for the longest time. There are 3 capturable locations distributed for the agents. A location can be captured if there is no agent from the opposing team with an own agent at the location. In this case, the location's affiliation changes immediately. After the location is captured, the time is accumulated on the team's points account. The match ends after a total duration of 300 seconds. During the match, the agents shoot at the opposing team then. Each agent has 100 health points and each shot that hits takes away 50 health points. If an agent dies, it will be instantiated again after 5 seconds. On a random location on the map that does not count as a capturable point but more about that in chapter 4.3.2.

4.3.1 Playing field construction

Two different types of maps are used. An open map where an agent can more easily discover own team members or enemy units and a closed map with many corridors to not promote the unknown as explained in chapter 3.1.3. The unknown is the FOW that the agent cannot see on the map.

4.3.1.1 Open map structure

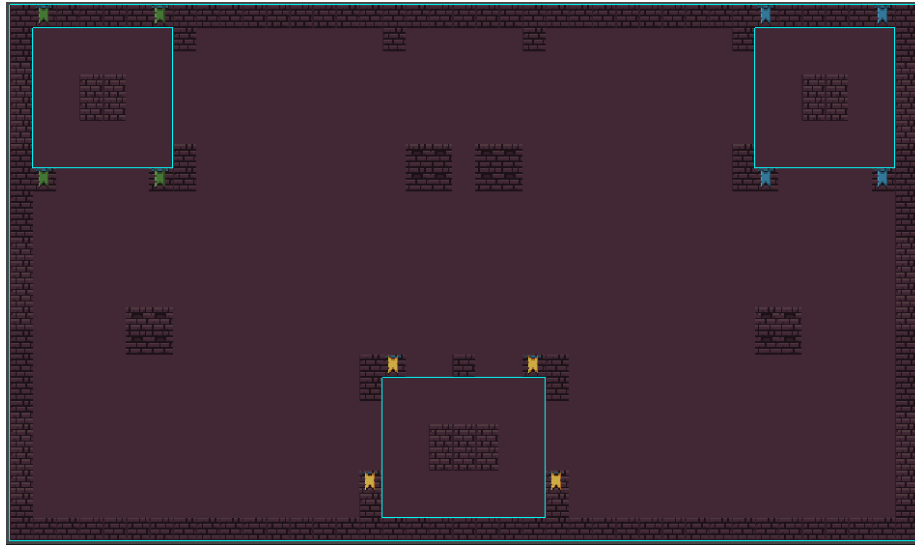


Figure 4.1: An open map with three capturable points marked with a cyan rectangle.

4.3.1.2 Closed map Structure

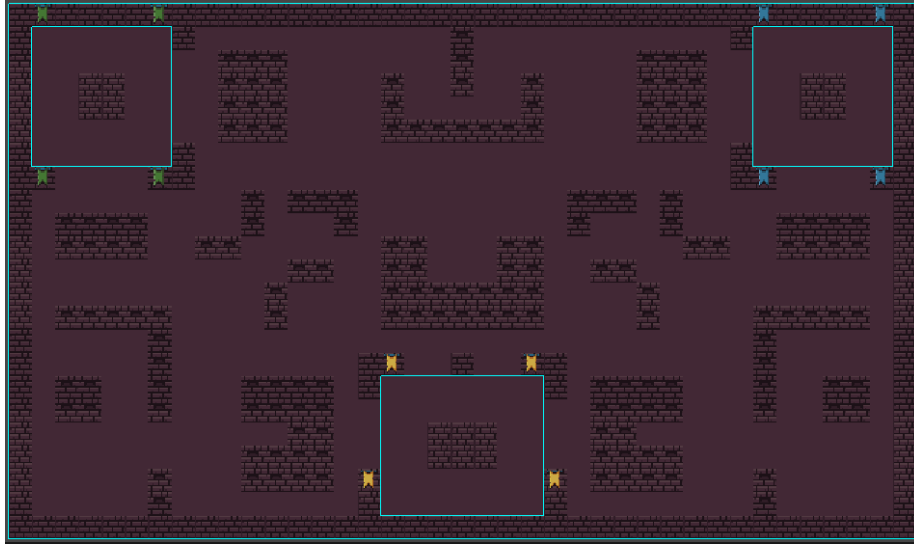


Figure 4.2: A closed map with three capturable points marked with a cyan rectangle. Here are many angles and small corridors distributed on the map and it was careful not to have too many open spaces so that the influence must propargieren more around the corners and that the agents are not very line of sight to own team members or opponents.

4.3.2 Randomness factor

Chapter 5

Results

5.1 Open map

5.1.1 Shared vs Unshared

5.1.2 Unshared vs Shared

5.1.3 Shared vs Shared

5.1.4 Unshared vs Unshared

5.2 Closed map

5.2.1 Shared vs Unshared

5.2.2 Unshared vs Shared

5.2.3 Shared vs Shared

5.2.4 Unshared vs Unshared

Chapter 6

Discussion

Chapter 7

Conclusion

Chapter 8

Lists

List of Acronyms

IM	influence map
FOW	fog-of-war
AI	artificial intelligence
GDC	game developers conference
SK	shared knowledge

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