Human-Like AI in Real-Time Strategy Games

Duncan John Bunting
School of Arts, Media and Computer Games
University of Abertay Dundee
DUNDEE, DD1 1HG, UK

ABSTRACT

Context

Artificial Intelligence (AI) in video games has been ignored for a long time in the rapid advancement in technology and game development; however, in recent years the topic of AI has resurfaced and is now a large talking point in the games industry and outside it. A large area of research currently being investigated for video games is the implementation of a more human-like AI to provide a better player experience.

Aim

To research and develop a more human-like AI through the use of AI techniques: Simple Rule-Based System, Rule-Based Fuzzy Logic, Artificial Neural Network and finally an exploration and possible development of the theorised Neuro-Fuzzy AI and analysis the decision making process and impact on player experience.

Method

Development of a real-time strategy environment followed by implementation of a simple rule-based system; afterwhich, a rule-based fuzzy logic system will be implemented and then an artificial neural network - it is hard to judge complexity and time required for such a project, but if time allows an investigation and possible implementation of a hybrid neuro-fuzzy system will be the final part of this project.

Results

A critical analysis of the AIs' performances will be conducted, evaluating the decisions taken and why they were taken while also analysing the overall performance against the other AI and human players. Human players will be surveyed via questionnaire and face-to-face talks on how they believe the AI performed, if the AI made believable actions and how this affected their experience overall.

Conclusion

This project will hopefully provide a greater insight into AI decision making and how to make artificial intelligence more human-like in an attempt to further the development of more believable artificial intelligence. In addition vital research may be gathered on the possibility of using a neuro-fuzzy technique to perform decision making in games.

Keywords

Artificial Intelligence, Human-Like AI, Real-Time Strategy, Fuzzy Logic, Artificial Neural Network, Neuro-Fuzzy.

1. INTRODUCTION

Artificial Intelligence in terms of games is often considerably different to what an academic would consider to be AI, while academics is very process oriented, games AI is mostly results oriented while goal for academics is to solve the algorithm and how the problem is solved, games AI are concerned with appearance and the gameplay an AI produces, neither side is "correct" but each with their own goals and motivations.

"In my experience this is a fundamental misunderstanding that academic AI folk often have about game AI: it doesn't matter what is controlling the characters, as long as it looks right.". (Millington 2006, p.376)

Since the beginning of computer gaming AI in games has not had a need to be robust and often not even remotely considered intelligent so long as it serves its purpose and while hardware rapidly improves AI has been considered, for the most part, left behind in terms of improvements: "The current AI performance in commercial RTS games is poor." (Buro 2004). This has left very basic AI being implemented into very complex games with powerful hardware when there is plentiful room for improvement. For a large part in games, AI follows a sometimes predictable rule-set that players can often figure out after a few attempts and then exploit while the AI can do nothing but follow the predefined rules given to it, if the player goes outside these rules the AI is left clueless and is revealed to be unintelligent.

"Until the industry figures out how to create AI that can learn from the player as it goes along, we have to be content with difficulty levels that are set by the players themselves". (Scott 2003, p.399)

This is a challenge all modern games should address but its true advantages have yet to be exploited and its disadvantages have yet to be properly discovered and investigated. While some games have attempted to make an AI that can learn it has not yet been widely accepted and while games with an AI that can learn have been developed, such as Hello Neighbor (2017) and Galactic Civilizations III (2015) the area of realism is sometimes overlooked, an AI can learn and adapt but this can often lead to AI's being un-human-like and undefeatable as humans have flaws while computers are considered not to make mistakes. Although exploration and development into AI that learns is not new, the room for improvement is great. If games were to spend more time improving their AI an adaptive AI could potentially make each play-through of a game unique all depending

on the player's actions. As mentioned, in addition to adaptability, an AIs behaviour and why it does certain things can be greatly improved with exploration into implementing 'emotions' into the AI to assist in controlling the outcome of an event based on how that particular AI feels about the situation and about the player.

2. RESEARCH QUESTION

Which AI Technique is more effective at simulating a human-player's actions in a Real-Time Strategy game, and how does having an AI with emotion and other human-like qualities affect the player experience?

3. LITERATURE REVIEW

AI in Games

While AI has been left behind in the rapid advancement of games and technology, the desire for a human-like AI grows stronger. Brad Wardell, CEO and founder to Stardock (1991), creators of Galactic Civilizations III (2015) states that:

"The first problem, Wardell explained, is that good AI doesn't really sell games. Gamers may value good AI, but it's not the determining factor in whether people buy a title… It's no longer enough to tell the player, "The shopkeeper looks frightened", as players want to see that the shopkeeper *is* frightened". (Hruska, 2015).

A genre that can have improvements in their AI without this need is strategy games. Series such as Total War (2000) and Civilization (1991) show a clear improvement with every generation. Both games implemented a version of human-like opinions or emotions towards others, in Total War: ROME II (2014) if a player rapidly expands their territory they are labelled around the world as "Expansionists" making other players more weary.

Singleplayer VS Multiplayer

Multiplayer adds a whole new layer to any game, and this is especially true in strategy games where human strategy tactics are almost limitless. In the Civilization games series (1991), mind-games between players is at its height; although not truly their friend, alliances form if they benefit both parties and can shatter when either player decide; however, in almost any online strategy game developers face the same complaint: games last too long. From the pure amount of power required to process a turn to the simple fact that humans take longer to decide what to do than computers. "I choose to play at *my* pace, on *my* terms, the cast of the game does not huff and grumble" (Walker 2011).

Real-Time Strategy Games

Commonly a Real-Time Strategy (RTS) involves players having one or many bases, units that spawn from these bases with the goal to take out other players. RTS games have always been a touchy area when it comes to AI, from the release of Dune II (1992) pushing RTS into mainstream gaming to Stellaris (2016), it is hard to predict how good players can be at a game performed in real-time as you must also consider those that cannot perform as much actions per minute as an expert player.

Fuzzy Logic

The best explanation of fuzzy logic is by its inventor Lotfi Zadeh in his original paper on fuzzy set theory: "Fuzzy Logic is a means of presenting problems to computers in a way akin to the way humans solve them … the essence of fuzzy logic is that everything is a matter of degree" (Zadeh 1965). Fuzzy logic can be used to control non-player-characters and give their actions a more realistic meaning rather than yes or no, an AI will be able to properly evaluate the amount of yes and the amount of no before taking action.

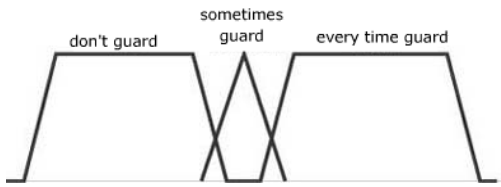


Figure 1 – *Output Fuzzy Sets* (Ertürk 2009)

Figure 1 (Ertürk 2009) presents a common fuzzy set for a simple fuzzy logic problem. For rule-based systems the more variables added the more unmanageable the calculation can become, this is where fuzzy logic becomes effective with the outputs of attack, flee or something else and the inputs of ammo, health, etc. Figure 2 (Bourg and Seemann 2004a, p.204) shows the end result of a fuzzy calculation.

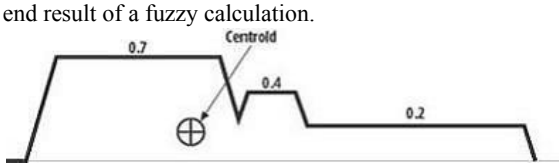


Figure 2 – *Fuzzy Output* (Bourg and Seemann 2004a, p.204)

Neural Networks

Neural Networks are considered to be the closest we are to the architecture of how humans think, the understanding so far is that a neuron takes a great number of inputs and uses them to calculate an output which is represented by pulses, this output is carried to other neurons which can be repeated thousands of times until a decision is made. Figure 3 (Buckland 2002, p.242) shows a simplified neural network. This model of how humans think has assisted game programmers in creating AIs with critical advantages over other AI techniques. "This is a rather intriguing possibility and is a very popular subject in the game AI community at this time." (Bourg and Seemann 2004b)

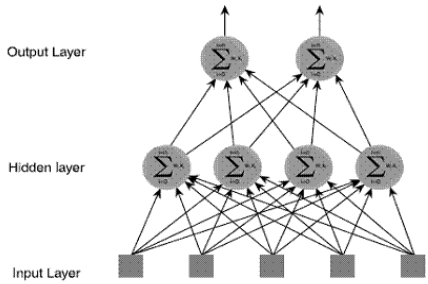


Figure 3 – *Structure of a neural network* (Buckland 2002, p.242)

Hybrid AI

Hybrid intelligent systems take a combination of AI techniques and deploys them in parallel. “The use of intelligent hybrid systems is growing rapidly with successful applications in many areas...” (Fullér 2001, p.8) The hybrid intelligent system of interest is the combination of neural networks and fuzzy logic, named Neuro-Fuzzy System.

“While fuzzy logic provides an inferences mechanism under cognitive uncertainty, computational neural networks offer exciting advantages ... To enable a system to deal with cognitive uncertainties in a manner more like humans, one may incorporate the concept of fuzzy logic into the neural networks.” (Fullér 1995, p.207).

In addition to working together on tasks the possibility of using each technique for a specific area of the AI where they are most effective, for example, fuzzy logic for short term decision making and neural networks for long term decision making. Although no known game has tried this approach Umut Riza Ertürk believes, “the result for fuzzy logic seems to fit like a glove [for] the given problem.” (Ertürk 2009) and although no concrete calculations or experiments have been conducted Umut believes “conceptual ANN distributed system can be a new approach for solving the problems of ANNs in RTS games.” (Ertürk 2009) in relation to long term decision making.

3. METHODOLOGY

Practical

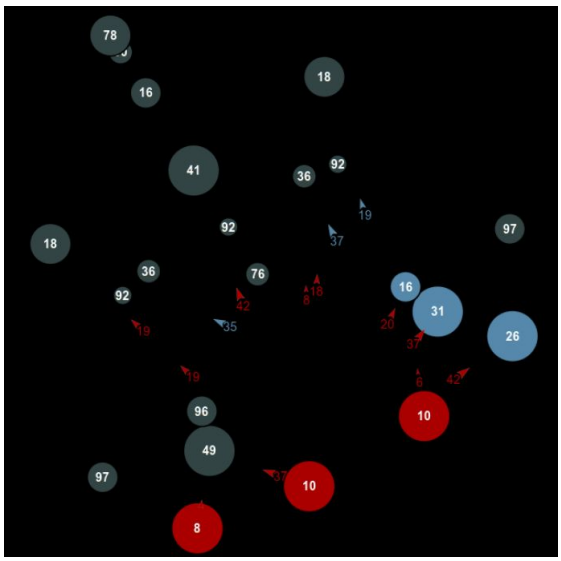


Figure 4 – *Screenshot of Google’s Planet Wars* (Melis 2011)

In Fall of 2010 Google (1998) hosted an AI challenge “Planet Wars”, where on an open map representing the universe there are planets, as shown in Figure 4 (Melis 2011). Each planet has a different number of units in it that increase over time, players may own planets by attacking it with more units than are defending and claiming the planet for themselves, several AIs play against each other by first starting at their home planet and taking over surrounding neutral planets and then must use unit management and other strategies to take other AI planets and eventually own all planets in the game to win. This is a simple game idea based on Galcon (2008) since the release of Galcon many games have been created with slight adaptions on how you play, games like Little Stars for Little Wars 2 (2012), shown in Figure 5 (MKG 2012), where they implemented multiple planet upgrade types (Defensive, Aggressive, Normal) to Auralux (2011) which visually shows each unit who also orbit the planet until ordered to move, as shown in Figure 6 (McNeill 2011).

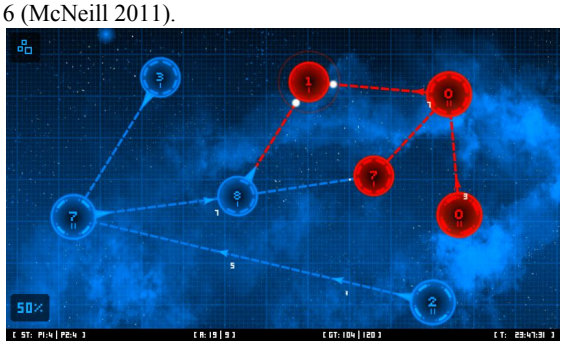


Figure 5 – *Screenshot of Little Stars for Little Wars 2* (MKG 2012)

This game design is simple to play but also challenging for players and AI alike as they will have many factors to consider before committing to any actions - this type of design also allows easy management of development time, features in the game can be added independently and do not rely on other areas of the game aside from the very base game idea of planets containing units that can be sent to attack other planets. Although this would be an effective play-test ground to test various AI including hybrid AI, the desire to make actions more human like require a few new variables to be considered, incorporating opinions and emotions towards other players within the game based on actions that happen within the game; this will be the direction taken to explore and implement a more believable human-like AI..

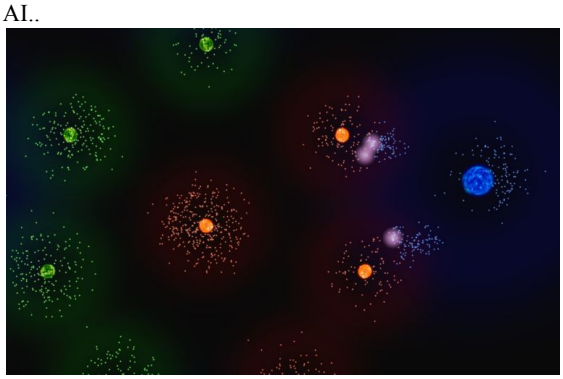


Figure 6 – *Screenshot of Auralux* (McNeill 2011)

After developing the base game with everything needed to implement an AI; the first goal would be to develop a simple rule-based AI, followed by a rule-based fuzzy-logic AI and then depending on time limitations either exploration and development into other fuzzy logic techniques or an artificial neural network - the preferred option would be the development of an artificial neural network. Finally, if time allows the end goal would be to merge the research gathered while creating a neural network and fuzzy logic system to explore and develop the creation of neuro-fuzzy hybrid AI following on from Umut Riza Ertürk’s research (2009) into the subject.

Evaluation

Critical analysis of how each AI behave will be performed to determine if it can be considered human-like and if it plays the game well. Extensive data will be outputted and saved by the game to track each AIs behaviour, precisely why they made particular decisions and their performance gameplay wise. Additionally human-players will pit themselves against these AIs in a series of games against each type to evaluate if the player experience gained anything from having such an AI in the game. Human testing will for the most part be face-to-face so proper evaluation of decisions being made can be recorded. No human players should require previous RTS or other gaming experience and data from participants will be recorded via questionnaires.

This project will follow the timescale and schedule shown in Appendix A.

Risk Assessment

Plenty of room and maneuverability for the tasks needing to be completed has been assigned as well as a logical order that allows me to expand on research as time limits allow. In addition to this, the base game required is fairly simple, any extra features (especially those that enhance gameplay only, ie: graphics, units that orbit planets, fog of war) can be easily removed without greatly effecting the desired simulation. The only major risk is the development of multiple AI techniques and not being able to complete the hybrid AI; it has, however, been stated that this has never been successfully implemented in research or in practical application in commercially available games. At this time it is hard to judge the complexity and time requirements of the project; however, the topic should make an outstanding honours project no matter which outcome, even if the tentative objectives are not completed, as vital research and understanding into a mostly unexplored area of games will be gained regardless if the hybrid AI is developed or not.

4. SUMMARY

This project will explore what may be an unexplored possibility of hybrid AI in RTS games while also addressing the very popular topic of having a more human-like AI in games. Not only could this project bring insight into the use of hybrid AI in game development but also the practical use, advantages and disadvantages of having an artificial intelligence that can act more human. As previously stated AI is also a field of games that has been left behind in the rapid advancement of hardware and technology, the room for improvement is greater than ever before. Hopefully the project can inspire the use of unexplored techniques via hybrid AI with games and spark talks of improving the overall quality of artificial intelligence across the games industry as demand grows for better AI.

5. REFERENCES

Auralux. 2011. [computer game]. Android. War Drum Studios.

Bourg D.M., Seemann,G. 2004. *AI for Game Developers*. 1st ed. O'Reilly Media

Bourg, D.M., Seemann, G. 2004. *Four Cool Ways to Use Neural Networks in Games*. Available from: http://www.onlamp.com/pub/a/onlamp/2004/09/30/AIforGameDev.html [Accessed 03 November 2016]

Buckland, M., LaMothe, A. 2002. *AI Techniques for Game Programming*. 1st ed. Premier Press.

Buro, M. 2004. *Call for AI Research in RTS Games*. Available from: https://skatgame.net/mburo/ps/RTS-AAAI04.pdf [Accessed 03 November 2016]

Civilization. 1991. [computer game series]. PC. Firaxis Games.

Civilization V. 2010. [computer game]. PC. MicroProse, Activision, Firaxis Games.

Dune II. 1992. [computer game]. MS-DOS. Westwood Studios.

Ertürk, U.R. 2009. *Short Term Decision Making with Fuzzy Logic And Long Term Decision Making with Neural Networks In Real-Time Strategy Games*. Available from: http://www.hevi.info/tag/artificial-intelligence-in-real-time-strategy-games/ [Accessed 03 November 2016]

Fullér, R. 2001. *Neuro-Fuzzy Methods*. Available from: http://uni-obuda.hu/users/fuller.robert/dam.pdf [Accessed 03 November 2016]

Fullér, R. 1995. *Neural Fuzzy Systems*. Available from: http://uni-obuda.hu/users/fuller.robert/ln1.pdf [Accessed 03 November 2016]

Galactic Civilizations III. 2015. [computer game]. PC. Stardock.

Hello Neighbour. 2017. [computer game]. PC. Dynamic Pixels.

Hruska, J. 2015. *Why AI still sucks in video games - and how DirectX 12 could change it for the better*. Available from: https://www.extremetech.com/gaming/219358-why-ai-still-sucks-in-video-games-and-how-directx-12-could-change-it-for-the-better [Accessed 03 November 2016]

Little Stars for Little Wars 2. 2012. [computer game]. Android. MKG.

Melis, G. 2011. *Google AI Challenge: Planet Wars*. Available from: http://franz.com/services/conferences_seminars/webinar_1-20-11.gm.pdf [Accessed 03 November 2016]

Melis, G. 2011. *Screenshot of Google's Planet Wars*. [online image]. Available from: http://i.imgur.com/KNqe3PW.png [Accessed 06 November 2016]

McNeill, E. 2011. *Screenshot of Auralux*. Available from: http://i.imgur.com/WdSQHs4.png [Accessed 06 November 2016]

Millington, I. 2006. *Artificial Intelligence for Games.* 1st ed. Elsevier.

MKG. 2011. *Screenshot of Little Stars for Little Wars 2*. [online image]. Available from: http://i.imgur.com/0n1Pl.png [Accessed 06 November 2016]

Scott, B. 2003. *AI Game Programming Wisdom 2*. 1st ed. Charles River Media.

Stellaris. 2016. [computer game]. PC. Paradox Interactive.

Total War. 2000. [computer game series]. PC. The Creative Assembly.

Total War: Rome II. 2014. [computer game]. PC. The Creative Assembly.

Walker, J. 2011. *Look, Single-Player People Are Just Better*. Available from: https://www.rockpapershotgun.com/2011/08/01/look-single-player-people-are-just-better/ [Accessed 03 November 2016]

Zadeh, L.A. 1965. *Fuzzy Sets*. Available from: https://people.eecs.berkeley.edu/~zadeh/papers/Fuzzy%20Sets-1965.pdf [Accessed 03 November 2016]

6. BIBLIOGRAPHY

Anon. 2015. *Multiplayer mind-games and scheming?*. Available from: https://www.reddit.com/r/civ/comments/31msmv/multiplayer_mindgames_and_scheming/ [Accessed 03 November 2016]

Anon. [no date]. *Neuro-fuzzy*. Available from: https://en.wikipedia.org/wiki/Neuro-fuzzy [Accessed 03 November 2016]

D'Anastasio, C. 2016. *A Horror Game Where The AI Learns From Your Every Move*. Available from: http://kotaku.com/a-horror-game-where-the-ai-learns-from-your-every-move-1787241885 [Accessed 03 November 2016]

Dyer, M. 2013. *Stardock's Galactic Civilizations 3 Revealed*. http://uk.ign.com/articles/2013/10/15/stardocks-galactic-civilizations-3-revealed [Accessed 03 November 2016]

Foster, S. [no date]. *Fuzzy Logic*. Available from: http://www.fcet.staffs.ac.uk/rgh1/cai/foster/Fuzzy Logic.ppt [Accessed 03 November 2016]

Macri, D. 2011. *An Introduction to Neural Networks with an Application to Games*. Available from: https://software.intel.com/en-us/articles/an-introduction-to-neural-networks-with-an-application-to-games [Accessed 03 November 2016]

Makedonski, B. 2016. *EVE Online developer has the right attitude about making sandbox games*. Available from: https://www.destructoid.com/eve-online-developer-has-the-right-attitude-about-making-sandbox-games-358211.phtml [Accessed 03 November 2016]

Metz, C. 2016. *What The AI Behind AlphaGo Can Teach Us About Being Human*. Available at: https://www.wired.com/2016/05/google-alpha-go-ai/ [Accessed 03 November 2016]

McNeill, E. 2011. *A New Artificial Intelligence for Auralux*. Available from: http://www.cs.dartmouth.edu/reports/TR2011-692.pdf [Accessed 03 November 2016]

Ontañón, S., et al. 2015. *RTS AI: Problems and Techniques*. Available from: https://webdocs.cs.ualberta.ca/~cdavid/pdf/ecgg15_chapter-rts_ai.pdf [Accessed 03 November 2016]

Patel, P. 2011. *Fuzzy Logic for Games*. Available from: http://purvag.com/blog/?p=284 [Accessed 03 November 2016]

Robertson, G, Watson, I. 2014. *A Review of Real-Time Strategy Game AI*. Available from: http://www.aaai.org/ojs/index.php/aimagazine/article/view/2478 [Accessed 03 November 2016]

See, J. 2016. *Fuzzy Logic*. Available from: http://pesona.mmu.edu.my/~johnsee/teaching/gamealgo/material/GameAI_FuzzyLogic.pptx [Accessed 03 November 2016]

Stene, S.B. 2006. *Artificial Intelligence Techniques in Real-Time Strategy Games - Architecture and Combat Behaviour*. Available from: http://www.diva-portal.org/smash/get/diva2:348419/FULLTEXT01.pdf [Accessed 03 November 2016]

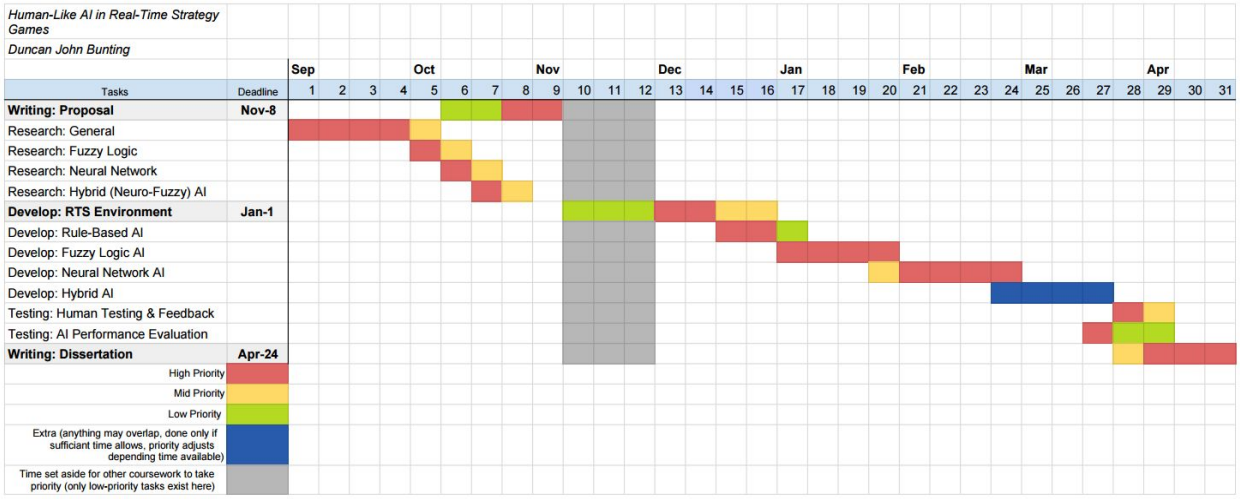
Steve Rabin. 2008. *AI Game Programming Wisdom 4*. 1st ed. Charles River Media.

Weber, B.G., Mateas, M., Jhala, A. 2011. *Building Human-Level AI for Real-Time Strategy Games*. Available from: https://games.soe.ucsc.edu/sites/default/files/weber-acs2011.pdf [Accessed 03 November 2016]

Welch, E. 2007. *Designing AI Algorithms For Turn-Based Strategy Games*. Available from: http://www.gamasutra.com/view/feature/129959/designing_ai_algorithms_for_.php [Accessed 03 November 2016].

Zadeh, L.A. 1979. *Fuzzy Sets And Information Granularity*. Available from: https://people.eecs.berkeley.edu/~zadeh/papers/Fuzzy%20sets%20and%20information%20granularity%201979%20Zadeh.pdf [Accessed 03 November 2016]

7. APPENDICES
A - Project Timeline, Gantt Chart



full resolution image: http://i.imgur.com/1uCAgXy.png