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Generating Character Narrative AI

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# Abstract

Many developers have attempted to procedurally generate narrative using AI but this is seen in very few games with common examples being Rimworld (2016) and Dwarf Fortress (2006) which have managed to develop a way for randomly generated characters to interact with the environment and each other to create a narrative which the player is invested in. in this study there will be a discussion of different methods to create a narrative AI for characters to interact with each other, develop relations and to call back on previous events for those interactions. Overall, in this project many methods were considered but via the use of Narrative scaffolding a narrative AI could be developed alongside emotional and personality based AI to deliver a reactive and expressive AI although with room for improvement.

# Literature Review

## Introduction

### What is narrative AI

Narrative AI is the use of artificial intelligence techniques to generate stories this could be a whole story generator as seen with (Deutsch, 2016)’s deep learning algorithm which generates entire stories from a top-down approach or (Bay12Games, 2021)’s Dwarf Fortress multiple agents and ai systems that create an emerging narrative i.e. each character have likes and dislikes which decides what they do or a personality that affects relations with other characters.

### History of Narrative AI

While it may be hard to define narrative AI so dating the first use of it may be difficult but, according to (procedural story telling book ref ) The history of narrative generation in games could be dated back as far as 1949 with the board game Cluedo and some of the earliest games to utilize narrative ai was the EA developed, Murder on the Zinderneuf which was a murder mystery game that generated a new mystery with each playthrough having a variety of characters any of which could be the murderer which the player had to deduce with in game clues that they could find by exploring and while being a very basic story generator with the only features changing in each playthrough being who murdered someone, the name of the victim and the clues for them, the game had to deal with the extreme computational limits of the time having only 48 kilobytes of memory which is minuscule compared to average gaming memory nowadays so since then narrative AI has been able to encompass more of the narrative in certain games like Dwarf Fortress (Bay12Games, 2021). which released in 2006 which heavily utilized narrative AI to generate an entire world with whole characters, nations and history being generated to create a unique and immersive world which has inspired many more games such as Rimworld in 2018 (Ludeon Studios, 2018). which focuses more on individual relationships between the generated characters.

### How narrative AI is used

As mentioned before narrative AI can be used to create whole stories as seen with Jamie Brew’s predictive text program (Hudson, 2016). which was used to generate a story feeding stories like Harry Potter to generate its own telling of the story. It worked by using a long-short term memory (LSTM) neural network which allowed the program to generate the story using the books as a reference and estimate what words would be used to create the story.

Other ways narrative AI can generate stories is through having individual AI agents and systems which can create emergent behaviours as seen in the previously mentioned games like Rimworld and Dwarf Fortress which generate a narrative using multiple methods with both games recording events that happened in the game and then reusing them for other things for example both games a an art creation system where a character makes a piece of art and its description is generated using those events to create art unique to the playthrough as seen in fig 1. Rimworld also has dialog between characters where they can talk about a number of things, flirt or insult each other which can raise or lower their reputation with each other fig 2. Another system in the storytelling AI in Rimworld that uses the value of the settlement you built as a heuristic to decide what events to throw at you with the more money you have the worse the events the AI can throw at i.e. large raids of hostile characters that could kill characters fig 3. All of these events together create the emerging story for the purpose of getting the player more invested.



Figure 1: art description from Rimworld generated using characters from the playthrough i.e. Boomrat and the Muffalo. this also show events being used with a date and the event of Boomrat catching fire

https://ojs.aaai.org/index.php/AIIDE/article/view/12973/12821

Other examples of narrative AI can be seen in games outside this genre as seen stated by ??? with game series like The Sims or Crusader Kings using a personality-based AI where actions are chosen based on the various attributes of each character in the game. these traits created easily identifiable archetypes for the character to help aid in developing the generated characters personality this can be seen in the image below showing how the player character’s attributes react to the other character’s attributes with attributes like personality traits (patient vs wroth) being considered in the game opposing traits cause the opinion of the characters towards each other to be lowered.

Graphical user interface

Description automatically generated

Figure : image showing trait based AI in Crusader Kings 2 ???

A picture containing indoor, furniture

Description automatically generated

Figure : Sims 4 emotional AI reacting and expressing an emotional response

??? also wrote that it is important to consider the emotional aspect to a narrative driven game, ensuring all generated character are expressive and can react to different situations within the game. this is seen in games like The Sims where character react to different situations with emotions creating the expressive AI seen in narrative driven games while being unscripted generated AI.

## Research methodology

### What are methodologies

Whilst there are many programming methodologies each are used for certain situations and deciding which to use can be very important for any project. Here the discussion will be limited to just waterfall and scrum methodologies, and which one is more suitable for a research project.

### Waterfall

Waterfall according to (M. Mahalakshmi, 2013) is a methodology where a project is developed on a set path with no deviation. The methodology is made up of 5 stages first being the requirements stage where all of the project features, software and hardware requirements are assessed this is done to aid the next step. the design stage is where the development of the features is planned out often with pseudocode and diagrams to help developers understand how the project will work. next is the implementation stage where the designs are implemented, in terms of programming this is taking the pseudocode and the diagrams from the design phase and physically programming it to develop the project, next is the verification stage where the project is tested to see if it meets the requirements from the first stage and is it fails the verification then the project would be repaired to meet the requirements. The final stage is the maintenance stage where the project is released and maintained to ensure it still works as the original requirements asked for.

<https://www.researchgate.net/figure/Modern-Waterfall-Diagram-adapted-from-36_fig2_306446532>

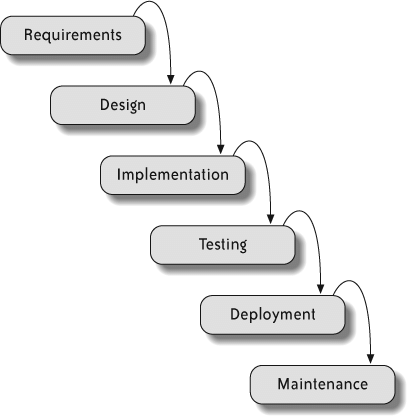


Figure :image showing the waterfall methodology where each stage of development when complete will move to the next with no ability to return to a previous stage

This model is very useful for developing a project with that can or should be fully planned out as the advantages for a project created using the waterfall methodology as stated by (M. Mahalakshmi, 2013) are that because it is a sequential model with no deviations in its development means that development can be comparatively fast compared to other models like scrum as all of the features are planned out and just need to be applied stopping the scope of the project from getting larger than expected bringing development times down. However, there are also some disadvantages to using this model which are that because it is sequential once one stage of the methodology is complete you can not go back to a previous stage meaning any issues that are found from one stage of the project can not be changed resulting in poor quality project unless plenty of time and resources are given to ensure that the project has no or at least few mistakes. This is also an issue as if a client or project manager wants any additional features halfway through development there is no mechanism within the waterfall methodology that would allow for those features to be added.

### Agile

According to (Khalil & Kotaiah, 2017)the Agile methodology is an adaption of waterfall to help avoid the issues of the Waterfall methodology as mentioned above, while the stages on an Agile project are similar there is a major difference with the Agile methodology is that previous stages can be revisited to add additional features allowing any project to be expandable resulting in a better project overall this can also be backed up by (Khalil & Kotaiah, 2017)showing the total number of failed projects using the waterfall and agile methodology as well as challenged projects i.e. incomplete project and a successful project with all required features added and as seen in appendix 1.1 the average fail rate for agile(9%) is lower than waterfall (20%) with success rates being 54% for Agile and 35% for Waterfall showing how Agile can be have better odds of being either successful or at least partially successful project. However according to (Sheetal Sharma, 2012) the disadvantages of an agile project are that the time and cost requirements can go greatly over the target if managed poorly as the project is poorly planned as the scope is increasing causing unpredictable time and development costs which can cause the project to fail. Also due to the constantly changing project it may be harder to document the project as the documentation is also constantly being changed and expanded making maintenance of the project harder.

<https://www.scrum.org/resources/what-is-scrum>

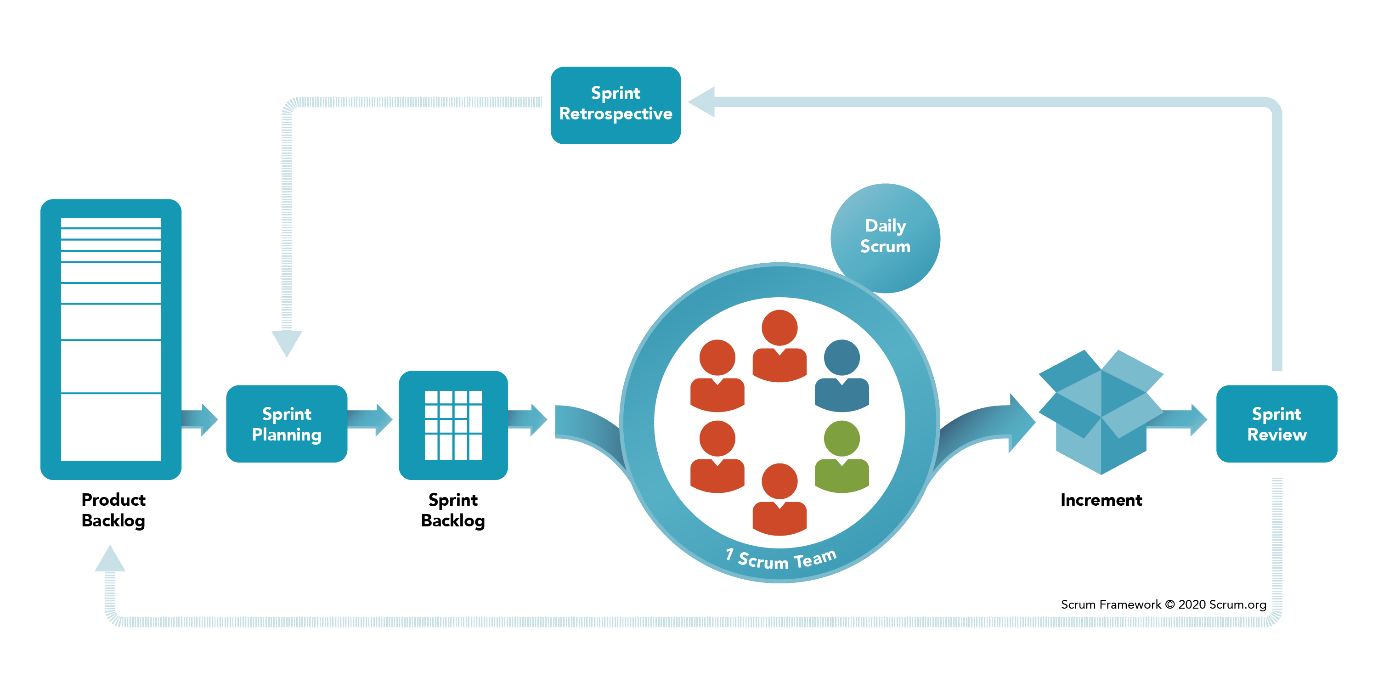


Figure : image show the SCRUM methodology using a agile framework to allow a project to be reviewed and changed after a sprint of development

### Which is better for the research project

Choosing a methodology for this research project is crucial as a bad choice may cause this project to fail as according to (Kaushal Chari, 2017) many projects fail due to not choosing a methodology compatible with the type of project being made. As this is a research project waterfall could be useful as the research for the project could be for its design elements however there is a risk in utilizing this methodology as mentioned before there is no back-tracking allowed on a Waterfall project, if the project fails then there is no more planning whereas Agile allows for a failed project to be reiterated on although at the cost of extra time. Another reason to use an Agile framework for this project is that extra features and discussions can be had if time is available. However Agile is a whole group of methodologies and picking a specific methodology should be considered. According to (Igor Ribeiro Lima, 2012) Scrum is a methodology that could be useful in research setting as it allows a project to be developed in a series of sprints to get individual tasks done. This makes it useful as a research project is difficult to define the scope of early on and having this be the methodology for researching and developing the artifact means that the project can be expanded for as long as there is time. An important feature of the scrum methodology would have to be changed however as according to (Marchesi, Mannaro, Uras, & Locci, 2007)Scrum works with teams for example a Scrum master, product owner and individual team members however this is a research project with only one member of the team meaning that many of these roles are redundant and are not required is the planned implementation of the Scrum.

Overall Agile should be used in the research project as it allows flexibility in a field currently being studied and likely to need reiteration and redesigns to create the project successfully as well as further discuss potential features that could be added to the project or alternate ways for the project to be implemented. The specific Agile methodology chosen shall be Scrum as it provides the ability to sprint through features that can be expanded on as the research expands giving more liberty to research to add to the project.

## Methods of generating narrative AI

There are many methods to creating narrative AI each being useful for different mechanics such as character behaviour as well as dialog and other text generation needs. Each method will be discussed to see how they work and how they can be utilized in this project.

### Behaviour Trees

To create behaviours for characters in games there many methods and a popular one to look at are behaviour trees. Behaviour trees according to (Anurag Sarkar, 2021). as the name implies are a tree of nodes which run behaviours with several transition methods to control how the AI agent flows between the nodes. These transition methods are sequence which will sequentially run through each child node and run the behaviour for them however it only succeeds if all child nodes were successful is running their behaviours. Parallel which works by simultaneously running all child behaviours at once and only succeeds its tasks if a given number of child nodes were successful at running their behaviours. Selector is like sequence as it will sequentially run all child nodes however it will be successful when any child is successful ignoring the rest however the selector transition type will fail if all child nodes fail to run their behaviours. According to (Simpson, 2014), the managing director of the game Project Zomboid. all previously discussed transition types are known as composite nodes as they require one or more children however decorator nodes can only have one child these include inverter nodes which returns a success or failure opposite to what the child node returns, a succeeder that always returns success and a repeater which will repeat running its child node a given number of times before continuing but there is also a version that can repeat until the child returns a fail known as a repeat until fail node.

Behaviour trees are popular for modelling AI behaviours because according to (Anurag Sarkar, 2021). they allow for relatively complex reactive AI as the tree structure con be made more complex to suit a number of emerging characteristics from few behaviours which could be useful for making an AI agent decide what to do for example throughout the day an AI agent has a number of items on their to-do list with the priority being eating breakfast before going to work then going out with friends later in the day. This allows for priority tasks to be completed first but could transition between behaviours when required as if the AI agent’s car breaks down, they may stop to call a mechanic and wait before heading to work as the behaviour tree unsuccessfully attempt to get to work the behaviour would change. This can also have extra behaviours to be added on without adding much complexity as all the behaviours are modular and can just be added onto the tree in a clear order for what behaviours will trigger making ideal for relatively complex AI behaviours. Overall behaviour trees allow characters to establish their behaviours and run them for each character making it ideal for individual bottom-up approach for games like Rimworld where there are many characters with their own goals.

Diagram

Description automatically generated

Figure : graph showing behaviour trees with different node types (Simpson, 2014)

### HTN plans

According to (Humphreys, 2021). a HTN which stands for Hierarchical Task Networks are type of behaviour tree that are often used for planning in AI agents and is a behaviour tree made up of either primitive tasks which are simple tasks like opening a door or compound tasks which are a set of primitive tasks which have multiple solutions so for example a locked door may require a key so the AI agent would have to first find a key, then unlocking the door with the key before finally opening it or an alternative solution could be to bash the door down to open a door. This makes HTNs very similar to behaviour trees however HTNs differ by essentially generating its own tree from a pool of tasks known as the search space. The search space is a set of primitive or composite tasks which are then used by the HTN planner by taking all the primitive tasks and integrating them into the HTN’s behaviour tree and then deconstructing the composite tasks into primitive tasks and implementing those into the behaviour tree all these primitive tasks are then decomposed into a planned goal allowing a given AI agent to develop a plan. This could be for example an enemy AI soldier attacking the player, they will shoot, roll into cover and throw grenades however if a player gets to close new tasks will present a new way for the AI to achieve its goal of killing a player i.e. melee attack. According to (Ilche Georgievski, 2014). this makes HTNs useful for creating interactive stories as each character in a given story could be given a goal which they can make a plan for using the search space to gather tasks to achieve that goal with for example a exiled king character in charge of a small county could have a number of actions available to them to either to do nothing however it may have a goal to retake their land so they may focus on tasks that build them an army to take back that land driving a narrative. While this is useful to generate an overarching narrative between all characters this however might not be ideal as it undermines the individuality of the characters as it forces the behaviours of multiple characters to work for one goal rather than to work for their own which behaviour trees are more suitable for as for the overarching plot while it may be less capable at making reactive AI as a group of behaviour trees are preferable for this project.

Diagram

Description automatically generated

Figure : Graph of a HTN applied to an individual (Marc Cavazza, 2003).

### Recursive narrative scaffolding

Recursive narrative scaffolding is a term given by (Garbe, 2018). to describe the use of events in a narrative AI being used to generate a history which can be referred to. This comes from an idea by the works of Russian psychologist Lev Vygotsky you wrote about the psychology of narrative scaffolding where history can be codified into events which eventually develop into goals.

This takes into consideration the use of narrative scaffolding for use in world building where for a character could be born into a noble family and that family could have a rival noble family which may have wronged the character’s family in the past i.e., sided against the king in a civil war. This lays the groundwork for this character as when the story for the character starts there is a predefined history for the character that makes other characters in their family, or the rival family have history with them and drives a narrative. Now this can be used is a procedural generation model as mentioned by (Jason Grinblat, 2017). where events are generated before the character exists which defines how they will subsequently interact with the world.

How recursive narrative scaffolding could be implemented is by applying this model to all generated characters in a similar manner to projects like (Max Kreminski, 2020). Where the scaffolding of the narrative is built off previous events and individual character’s behaviours with each character in the project being generated with a series of traits and personal quirks with predetermined behaviours assigned to them with those traits also affecting the character’s history which will then be generated. This has the benefit of creating stories that are both guided and customisable for the player with the scaffolding creating stories and the player choosing the traits that then generate the character’s history. However, unlike methods like natural language processing as narrative scaffolding will require traits and events to be determined and programmed in which may take time to set and requires knowledge of good story crafting as well as balancing how events that will cause narrative scaffolding to take place will transpire.

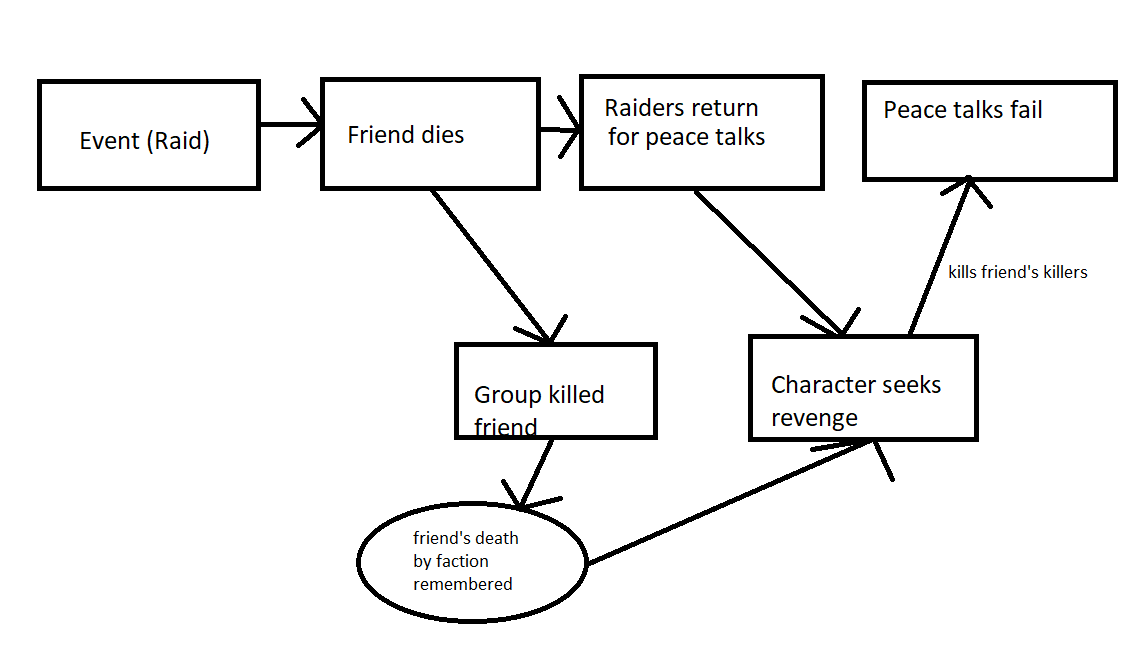


Figure : diagram showing reverse narrative scaffolding playing out through events and characters reactions to those events

### Natural language processing

According to (IBM, 2020). Natural language processing or NLP is the process of using a computer to process and understand language using statistical and often with machine learning principals. NLPs like are able to recognize speech and the intent behind its content for example the word catch could mean the verb ‘to catch’ but an AI may not be able to understand the saying “what’s the catch” as catch here means a downside of something rather than the typical meaning of the word with speech tagging through machine learning and/ or statistical analysis an NLP can be taught the difference between these to saying to add context and understanding of the content given. Models like GPT-2 (Alec Radford, 2019). an AI agent could be able to talk and understand dialog between different characters using GPT-2’s NLP to use the sentences given by other characters and process a response to them and this response could even implement the characters background and relation with other characters as a way to guide how a given character would respond to a sentence for example a character (Bob) talks about cats to another character (Dave) however Dave hates so the response could be tagged as an angry response about how the character hates cats and the NLP will attempt to generate the response and if Bob likes cats the NLP could use that fact as a tag to attempt to argue back to Dave. This could massively improve any narrative AI however NLPs face many flaws that may make it unusable in this project as according to (Vincent, 2020). many NLPs like GTP-2 and its successor GTP-3 still have many issues with speech recognition and intent with one example of an AI with GTP-3 being asked “which is heavier a pencil or a toaster” with the NLP simply responding “a pencil is heavier than a toaster” so while NLPs like GTP-2/3 are very capable of understanding language and context they often can have issues and require fine tuning with its complexity being very difficult to work with. This complexity can also cause issues with speed as implemented an NLP into a real-time game into even a single character could greatly affect performance let alone multiple characters talking with each other. These performance issues can be seen in games like the text-based dungeon crawler, AI dungeon (Latitude, 2022). which can take up to a few seconds to generate a line of dialog making it very difficult to implement into a real-time game without any major slowdown issues or major optimisation which may be too large in scope for this project to handle. Another issue with the text generation in NLP is how they can be unpredictable in what they will say, and game designers and writers may want to make sure that the content they are producing is suitable for what they want in the game and NLPs are naturally unpredictable as previously seen. As stated by (Emily Sheng, 2019). in the case of GTP-2 natural bias in the AI could contribute to undesired stereotypes in what characters would say an example stated in the paper shows the AI being asked a number of statements and were judged on what someone from a demographic is and the results showed a net negative for certain groups such as black and gay people which could create unwanted bias in dialog created by NLPs which may require further tweaking to solve.

https://dl.acm.org/doi/pdf/10.1145/2436256.2436274

GTP-2 can be used to create and respond to dialog but to recognize and act of the dialog effectively it could be developed with sentiment analysis as well to effectively tag an emotional response and react to it appropriately. Sentiment analysis according to ??? is another NLP system that works using a neural network to evaluate the emotional output of a text so that an AI can tell if what if being said to them is meant to be happy or angry as well as various other emotional variables. This could be used to tag the dialog sent to the system as a emotional response so that when a response is decided by the character, the tagged emotion can be used to influence a response through the GTP-2 system. Overall while it is an effective strategy to utilize an NLP as a text generator its unwieldy, unpredictable and performance intensive problems make it unusable in this project.

<https://www.diva-portal.org/smash/get/diva2:1369106/FULLTEXT01.pdf>

As mentioned by ??? there are ways to develop more lightweight NLPs that are more predictable in know what they will say, this can be done via a microplanning system to break down what words will be used in a given sentence as seen with the example "A pie was swiftly eaten by the large dog". Pie and Dog are separate entities that are broken up with the connected text like eaten being used to string the sentence together. This can be used in a more simplistic system to break down sentences and allow the characters to refer to objects or each other for example this could be used in a dialog system to create a sentence like [Character name] I like [insert item] when talking in general.

### Emotive programming

According to (Marc Cavazza, 2003). there is a need for an emotional layer to inform the narrative layer on how to act as the narrative layer uses emotional responses and goals to create events this can be developed to a similar manner as discussed by (Alvim & Cruz, 2008). where a fuzzy state machine is applied to simulate emotions in the AI agent which can change depending on what happens to a given character making happy or sad when something that is good for them happens this could be something like a gift which makes them happy or someone they liked dying driving an emotional response from the emotional layer to the narrative layer this can also be further expanded with the addition of a relations emotional response where peoples actions change depending on how much they think of each different character. Each of these emotions can be added just by a variable to store the value of the emotion and the rules relating to that emotion as seen with a similar system used by (Li & Campbell, 2010). where each emotion is valued from -1 for negative values i.e., sad and +1 for positive values happy however this model is more used for player vs non-player interactions and for emotions like relation i.e. admiration or hatred for a character a list of all relations for each character the character has interacted with will be required. This overall adds a dynamic system to simulate emotional states in the AI to control behaviours.

A picture containing diagram

Description automatically generated

Figure : Image showing a diagram of how the emotions can be shown (Li & Campbell, 2010)..

Table

Description automatically generated

Figure : diagram showing how events can change a character’s emotion (Li & Campbell, 2010)

## Personality trait system

As mentioned by ??? narrative AI should have a strong and expressive personality to make any character generated to be easily understood by the player. This can be done by adding a trait system that can change the way a character behaves both their actions and emotionally with characters being assigned a trait for example aggressive. This could be interpreted by the emotional AI to be more sensitive to changes in the anger emotion, but it could also influence behaviour by lowering the threshold before a character gets enraged and starts a fight. This system also has a benefit of helping players to identify the personalities of the character as the ‘aggressive’ trait could be shown to the player which could help the player understand how the player will likely act to certain stimulus. An issue with this system is also expressed by ??? with the personalities and how they interact with other personalities are entirely dependent on subjective interpretation by the developer when applying this model to the system requiring the developer to be more creative in creating the AI to be entertaining and/or believable.

## Conclusion

Overall the decision of what behaviour system would be better for characters to use depends on how the narrative will be utilized and as the project will have more individualised characters, behaviour trees will be preferred to HTNs as an adaptive behaviour tree can be applied to each character with each decision the character making being for their own set traits making the narrative overall more individual in scope whereas HTNs can provide a more greater scope narrative with all characters working together following a combined goal overall either system could work for creating narrative in the artifact with character relationships and drama between individuals whereas HTNs may be better for generating narrative through wars and factional drama but as the scope of the project is focusing on smaller groups of around a dozen or so characters it may be more suitable for the characters to have behaviour trees instead of HTNs for that reason however for greater numbers of characters making their narrative harder to keep track of and thus less important it may be better to focus on the narrative of the society the characters live in only following major characters controlling less individual characters. As for the generation of narrative text, the use of reverse narrative scaffolding methods to develop text based on the simulated traits and attributes of a character or entity will be used instead of natural language processing due to the issues of language processing having with efficiency and general ability to create comprehensive text due to the experimental nature of the technology making it not useful for this project with reverse narrative scaffolding being able to build up a history of events and reuse those events as context for new decisions or text for the character to utilize. With the addition of emotional and personality systems this AI can be developed to keep some of the expressive behaviour that the natural language processing like GTP-2 would generate if its decided for the project to not use NLPs although this would require the developer to make choices of how these personalities and emotions are expressed and generated these systems could be used to replace NLPs to reduce performance cost to the project.

## Artifact – Design

After researching for the project the design stage of the artefact must start with the further development and testing to see if it helps to generate narrative. First step for this is to plan out how this project will work with the software requirements, wireframe of how the artifact will look and a discussing on how the research will be applied to the project.

### Project requirements

The project will utilize the Unity game engine to develop the project. This was chosen instead of an inhouse crafted game engine or an engine such as Unreal Engine 4 as the engine will not affect any parts of this project as the performance of the project is not expected to make the choice of engine crucial with prior experience in using Unity and not as much in Unreal Engine 4. As for not using the inhouse engine and instead using Unity may even benefit them with ease-of-use features and the time saved from the engine being already developed. Overall, the small scope and need for computation resources of the project mixed with the time constraints to finish the project means that prebuilt engines are going to be the best option for this project and as the choice of engine will have minimal effect on this project Unity will be chosen due to prior experience.

### Wireframe for artifact

To help visualise how this project will be set up a wireframe for the artifact has been made with each feature shown in the image below having a number assigned to detail what parts of the project mock-up ui represent (underlined in red).

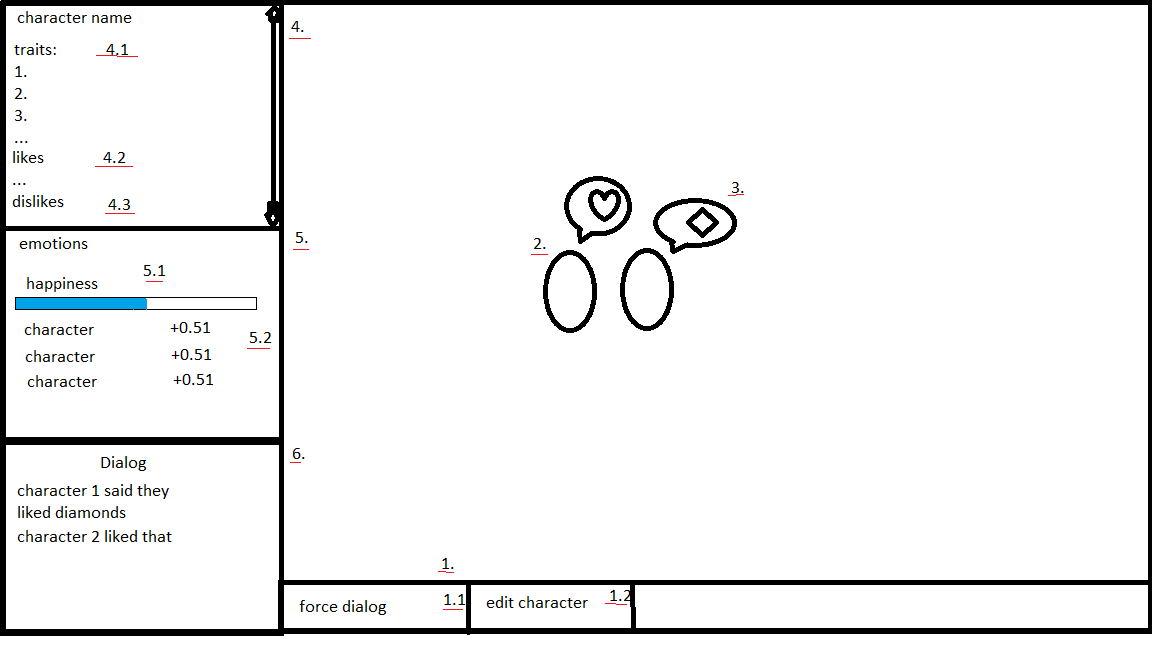


Figure 11: image for the wireframe

1. This represent the testing buttons for the project giving the user the ability to affect the artifact this is not limits to forcing dialog (1.1) and editing character to change their traits, likes, dislikes and emotional state of the character.
2. Represents the character on the screen (ovals) which will move around carrying out basic actions and interacting with other characters.
3. To aid in understanding what is going on between characters without having to look at the dialog box, speech bubbles will be added to the artifact which symbolize what the character is doing be it chatting (and what about i.e. a dog symbol could represent a conversation about pets), flirting or fighting.
4. To understand what a character’s traits, likes and dislikes are with those details just being listed.
5. This represents the emotional state of the character with meters showing the happiness level of the character as well as a list of relations with other characters in the artifact.
6. The dialog box will list all dialog between characters in the artifact allowing the user to determine how well the narrative system is working with events also being shown i.e. a characters declaring that they are in love/ friends with someone or someone swearing vengeance on a attacking party.

### How the artifact will be set up

The plan behind this project is to mimic much of the emerging narrative systems in Rimworld and dwarf fortress with a small settlement filled with auto generated people each with different personalities, like and dislikes which change how they interact with each other some could have an abrasive personality that might make them more likely to insult someone if they talk about something they do not like. As mentioned in the research each character is given a set of relation scores which determine how friendly or intimate, they are with each character which can change with the dialog they have with each other. Other features can be added in the future such as the art feature like Rimworld where actions are recorded and can be referred again by the characters to create a simple art piece with a description on it showing what inspired the art piece.

#### Environment of the project

First part of the artifact to set up is the basic environment for the artifact this will be the UI as discussed in the wireframe to aid in interactivity for the scene. The next feature will be the resources for the settlement which can be used to establish the characters place in the world i.e. soil can be turned into farmland so that a character that is a farmer can farm or rocks for a miner to mine as well as basic houses for characters to live in. another feature is animals which have basic behaviours like roam, flee and attack but could also be tamed. Finally, a simple faction system where factions’ leaders can declare wars against the user for added narrative.

#### Character systems

First the characters will need basic systems implemented such as movement which can be either a basic move to position or an A\* implementation as well as a health system so that a character can be killed off or simply injured giving the environment the ability to affect the characters another feature is a simple job system so a farmer if they are not doing anything can tend to a farm building providing food.

Next feature to add will be the character behaviour tree so that the character can decide on how to interact with the game world. This will update what the character can do whenever an event is triggered so that if an event that changes the behaviour occurs then the character with the behaviour tree can act in the appropriate way for that character’s traits.

The character narrative layer will be set up with a system which picks up events in the game world and utilizes them to populate a memory system which then in turns affects the emotional layer. Each event will have to be pre-written for example an event could be “friend murdered” which will be triggered if a character is killed with high relation with other characters. This event will have a context (the person who died) a recipient (the character’s close friends) and a cause (the character’s killer) each of these events will have an effect on the emotional layer using the emotional layer’s lookup system to find the effect the event will have on the player.

The emotional layer will have a system for record the emotional status of the character with as discussed in the research a system to record the emotional values with a range from +1 to -1 representing the positive and negative version of that emotion respectively i.e. +1 being happy and -1 being sad. This will then be extended into the relations with a list of relation values to show how friendly or unfriendly a character is with another given character. To affect this layer the narrative layer will give data about certain events that happened to them which are then compared to their traits which has a list of effects on the character so for example is a character has a trait like aggressive then they will when an event that is tagged as being angry happens, the character will be more likely to start getting aggressive at whoever caused the event like if a given character (Dave) shouts at another character’s (John) dog and john had the aggressive trait then John may fight Dave. Other effects from personality traits can be added like edgy which can make a character more to say something that loses relation or emotionally sensitive which makes gains and losses of emotion and relation values have a increased modifier.

#### History System

The likes/ dislikes and the traits of the character need to be determined on initialisation so the plan would be to develop a system which would develop multiple characters at once initialising their history together. Each character in the predefined list would be put though a number of events with the reverse narrative scaffolding system to predefine their history. This would be a system that would pick from a number of events for different moments in their life for example a child could have a “rough upbringing” event that would give them various traits based on that moment some that could be negative but later on in the history generation there could be a follow up event that rectifies that previous event removing the features applied to them or replacing them with different features.

This history could be given supplementary text which then makes up a history log which can then show the history of the character overall showing how the character has developed.

#### UML

To plan out how the AI will work a UML (Unified Modelling Language) Diagram was created to design how the AI for the characters will need to be set up to work.

Diagram, schematic

Description automatically generated

Figure : UML showing how the character AI is built up and how it interacts with various systems in the project

#### Sequence Diagrams

Use of sequence diagrams is also used to plan out how the various AI systems for the character will interact with each other.

Diagram

Description automatically generated

Figure : sequence diagram character behavioural AI

## Artifact – Implementation

### Project development

Its important here to note how the project has been implemented logging any changes from the previous design overall the project was completed with some changes from the original design as seen below with…

#### Basic artifact design

For the basic artifact design what will be covered is the basic components of the artifact such as UI or project set up. The project was set up in unity and had the UI developed in a similar manner to the original design with the specified features being added such as…

* A character info section (top left) which shows information about each character for their names, likes/dislikes and their traits. The character assigned to the character info box can be changed by simply clicking with a mouse to a different character which uses Unity’s 2D ray cast system to identify and select a new character.
* The emotional box (middle left) which records the selected characters emotional and relationship data. This shows a number of values for the character with the current values of the emotional behaviours being shown first for both happiness and anger. This emotional box UI then gets the relation ship list to display the selected characters current relation with each character.
* The dialog box (bottom left) simply shows a list of dialogs provided by the character’s dialog system. This box shows which shows the list uses a scrollbar along with Unity’s mask system to hide the dialog text that is not required to be showing keeping the text confined to the dialog box while making it easier to read than to simply display all at once.
* The action bar (bottom) has been added from the initial design to allow for testing and various actions for the project. The initial design only called for the force dialog system and an edit character button which the force dialog button has been fully implement which simply forces a random character to change its behaviour to the “talk” state although the edit character was removed as the unity editor worked fine as a alternative to change each characters actions. Further additions were made from the design that were not thought of at the time to improve the testing of the project. This includes an “add character” button which initialises a new character and places them in the artifact similar to the starting 3 characters. Another addition is the start event button which can have force an event to be added to a given character for example the “murder” event where one character will move towards another character with the “kill” behaviour state and “kill” them which will then follow into the rest of the memory creation system and so on. This could be changed for any event and any member of the cast in the artifact.
* An addition UI element was also added for the history system which is seen in the “?” button in the character info box which then opens up a screen which takes the history script provided by the history system and simply show it as text in the centre of the screen (see fig 9) so the user is able to see the selected characters history.

A screenshot of a computer

Description automatically generated with medium confidence

Figure 14: finished UI for the artifact

Graphical user interface

Description automatically generated

Figure 15: image showing the history script in UI

#### Removed features

Some removed features in the artifact from the original design is the animal system which while would be simple to build as it only requires a basic behaviour tree for walking around random positions and being interacted with by the characters. It was a feature that is not required to show the emotional behaviour aspects of each character and therefore can be removed to limit the scope of the project.

Another feature removed is the art system which while would be an extension of the history system would simply be unnecessary for showing the recursive narrative system so was removed.

The emotion UI was also removed due to time constraints however the dialog system and characters vocalising their feeling/action can help people see what the characters are thinking or doing without visual cues, so it does not affect the project.

#### Behaviour tree to state machine

During the development of the behaviour tree as wanted through the design there were a number of problems during its development which caused errors when the behaviour was updated as the design required a behaviour tree that was dynamic and allowed for new behaviours to be made available for evaluation when needed. The errors that resulted during its creation made the system too time intensive to implement so it was instead replaced with a state machine.

<https://link.springer.com/chapter/10.1007/978-3-319-62533-1_4>

A state machine as stated by ??? is a system where a program takes actions depending on the state of the subject in question an example of this is the behaviours of the characters in the game where their states could be idle, talking or attacking other characters the state is applied when it meets a condition i.e. if a character is angry then the “attack” state is triggered before it then applies that behaviour to the character’s AI. This system overall creates a simple AI that can be built up from ‘if statements’ that then activate a state and drives the character’s behaviour.

This will not greatly affect the character behaviour AI as it is very similar to the previously preposed behaviour trees as a behaviour tree without the extra transition nodes would essentially be a state machine although this does come at a cost of scope as behaviour trees are easier to scope as the tree based modular node system in a behaviour tree will be easier to read and edit then a long list of the ‘if statements’ required to build out the state machine for all behaviours although, the character will have very few behaviours as will be seen below

#### Characters

The job system is used for the character’s behaviour AI to activate the behaviours which are decided by the various systems in the emotion, narrative and the event scaffolding systems as mentioned before the system uses a finite state machine to decide which behaviour should be triggered, the conditions for this change being found in the various other systems in the character’s AI and has a state for multiple behaviours including idle where the character will move along random paths to simulate them idly walking around the map, chat where the AI will walk towards a character while starting the dialog system and attack/ murder which are 2 separate behaviours but act very differently where they both have a character walk up to a targeted character and attack but murder will only kill the other character whereas attack will only have a chance to while heavily lowering relations with that character. All behaviours when will then return to idle after completion

Graphical user interface, application

Description automatically generated

Figure : image showing a character with a kill job

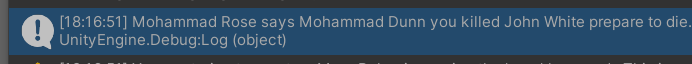


Figure :image showing debug message for the character dialog before start a revenge murder plot

The movement AI for the characters as mentioned in the design would either take an A\* pathfinding algorithm or a simple move to vector system. The move to system was chosen as while A\* has more proficient pathfinding than move to, A\* would be unnecessary as there are no obstacles to path find around. As mentioned previously this system is used to move characters from point A to B to carry out the behavioural actions required from them.

Graphical user interface, text, application, chat or text message

Description automatically generated

Figure : character moving towards target position using character movement script

#### Emotional AI

The emotional AI for the characters follows the design set out with a very simple emotional AI that works with the attributes of happiness and anger which can influence some of the actions the character AI can take with the character going into a mental break if they have low happiness (< 0.3) and high anger (> 0.9) this would cause a number of events relating to the break that would randomly pick between events like an insult spree where the character picks a another character and will force the dialog system into insulting the second character several times or it can start a murder behaviour where the character will attempt to murder a second character which after these events have been carried out their happiness and anger will be reset to 0.5 to stop the mental break. The Emotional AI will also be used in the dialog system to decide certain speech options as seen in the dialog system.

Text

Description automatically generated

Figure : image showing a debug message explaining that a character has had a mental break. insult spree results in the dialog system forcing multiple insults to a random character

#### Narrative layer

The narrative layer for the character AI comprised of the dialog system which can interact with the emotional layer and the scaffold system in various ways to influence characters. The narrative layer can be split into 2 sections which are the ‘character info’ system and the dialog system which overall determine how the characters will interact with each other.

The character info system is essentially a list of various character descriptors which also includes the characters traits, likes and dislikes of the character, their name as well as their relations with other characters. Some of this information is decided randomly such as names whereas other information is decided through the various systems in the project like the likes/dislike/traits which are decided using the history system as it returns theses descriptors to the character. Others like the relations is decided initial by the traits between the 2 characters for example abrasive and sensitive characters could start with a reduced relation as they can be made out as opposite traits for characters to have however these are chosen based on judgements are used as an example. The relation is also decided by the dialog system as certain interactions between players with specified emotional conditions and traits will affect the relation between characters.

A screenshot of a computer

Description automatically generated with medium confidence

Figure :image showing the character descriptors as well as the trait system, emotional values and the relations with other characters

The dialog system is another element in the narrative layer where characters will randomly choose to interact with each other as mentioned before this will affect their emotional status and relationship values with other characters as interacting with each other will lead to outcomes that will lower or raise these attributes. The system works by first an update function for a character which will randomly call a function to select someone to talk to. Then the dialog system will evaluate the 1st character’s emotions for which talking types are allowed for example if the character is angry then it could be assumed that they are more likely to argue while unhappy characters are more likely to mope. The odds for which chat type is selected are run through a weighted random system which works by having a list of weights for each option and a random number generator which takes a random number from the total of these weights and uses the weighted values as thresholds for which option is picked. When the dialog option is picked by the AI it then sends the dialog type to the recipient character who then will react to the dialog based on their own traits for example sensitive people will have increase effect on mood with dialog causing happiness or anger having a modifier. A similar system is done when the characters talk about their likes or dislikes where is character ‘A’ talks about something they hate, and character ‘B’ likes that item then character ‘A’ will lose relation with character ‘B’. after the reaction to the dialog there is a random chance that the second character will continue the dialog creating a system where conversations can go back and forth between characters.

Text

Description automatically generated

Figure : image showing the dialog box recording a conversation between the characters in the scene with characters talking about their likes and dislikes as well as engaging in various conversation types such as insulting, flirting and chatting

#### Event scaffold system

The event scaffolding system is a system as preposed by ??? where events for characters can be turned into “scaffolds” for future events to create an emerging narrative in a generative story. This has been applied to the project from the design creating 2 separate systems, the event system and the history system.

The history system works by creating multiple lists of possible events to represent the character throughout their simulated life before they are fully initialised. It works first by simply taking a random event and applying it to the character to act as an origin story for example one added was a dog attack event which made the character dislike dogs or an event for a farm upbringing this then adds text for the event so that the character’s history can be displayed. The history event can then get a follow up event after the initial where for example a dog saves the character removing the dog dislike trait replacing it for a dog like trait. Overall, this system is used to generate a backstory for the characters and apply the like/dislike/trait system to add the attributes for the character to develop a simulated personality.

Text, letter

Description automatically generated

Figure : image showing the text output from the history generator which gives text for each event upon initialisation of the character which can represent the development of the character’s personality with the character gaining traits like forgiving or likes such as dogs and farming

The event system takes the recursive narrative scaffolding system and uses it instead on a update based system to allow for new scaffolded events to be selected throughout the run time of the character. This works by checking the memory in each character for any events for the event system to trigger for example if someone was murdered during runtime then a character may get a memory about that murder which would then be triggered by the event system. The event system would get the id from that memory to decide what type of memory before running a precondition function for that memory type to decide if the memory should be acted as a precondition system allows for memories to be triggered under certain conditions this could be used in any event that might not want to be immediately resolved unless other circumstances have happen before. For the murder event however it only checks if the character who caused the event is still alive which if true will then start the logic and behaviour changes for the event. If an affected character is vengeful they may attempt to kill the character that caused the event however if they are forgiving they may forgive the character that caused the event increasing relations between the 2 characters. After the logic for the event is complete the memory is removed from the characters affected by the event completing the system.

Text

Description automatically generated

Figure : image showing the precondition for a murder remember event. shows how the events work with the trait system with trait type 1 being the vengeful trait and how that can change the behaviour of the character i.e. attempting murder

### Testing

Testing for this project will be difficult due to the nature of this project being more focused on design and story believability than any one technical feature so to test the project it will be broken up into 2 sections, a test log to check for various errors and an evaluation of the behaviours of each character which will be given a judgement based on its believability.

#### Test log

### Evaluation

#### Methodology

The use of the SCRUM methodology was a good choice for the project as the issues of time constraints in the project proved to be an issue this allowed for the project to be rescoped when it became apparent that not all features would be developed comparing this with the Waterfall methodology which if used would simply result in the failure of the project as the methodology would not allow the project to be redesigned once the design stage was completed.

#### Character AI

Overall, the characters perform well compared to the reference of games like Rimworld where characters will go through the day while randomly initiating narrative based behaviours. Characters can initiate dramatic events such as murders and love triangles, get into fights and befriend each other. The dialog system works well to create a reactive interaction between characters which changes with their emotional status as well as reactions to the system based on their personalities with what they like/ dislike and their personality traits weighing in on how they react, create and respond to different dialog types.

The narrative scaffolding system on the other hand, has a number of issues due to lack of content as mentioned by ??? having plenty of possible scaffolding events in the project can add to the believability of the naturally emerging narrative whereas currently there are only very few events being the murder and love triangle events leaving very little variety to the character behaviour. Another issue is how the behaviours interact with each other due to the nature of this project as a story generator how the stories are generated between the character is left up to the developer so creating believable stories can be difficult as the values for how these events are started and how they influence the characters are ultimately subjective. Its with this limitation of the model that its important to keep in mind that this project is unable to fully generate a story fully but instead relies on the developer to make choices on how the events work together although this was expected from the research as the project was intended to be an aid to story development via the use of generation with pre-existing events and attributes to the story generation systems.

Comparing this system to other games with some of these other systems like Rimworld or The Sims 4 is where some issues are seen which while compared to Rimworld the AI is reactive and able to build reputation the lack of extra context in relationships can show the issues the narrative seen in the project with Rimworld AI being able to form friendships/ rivals, fall in love, and be a part of a family where as everyone in this project acts more like acquaintances acting out based on reaction to that character with no extra context to each characters relationship other than a positive or negative status which decides whether they will act hostile to them or not.

With the emotional AI issues are also seen with the lack of expressiveness as seen in games like Sims 4 where the AI is only able to be Happy/ Sad or Angry with no extra emotions being present and while this changes the dialog appropriately its limitations make it so that the AI has little variety in how expressive it can be making the characters seen more emotionless than what was wanted.

## Further improvements

### Greater goals and relationships

Pre-simulating characters to have history with each other could also improve the believability of the project as it can be used to generate characters to have history with each other this could be familial ties and friendships/ rivals that can be built using the history event scaffolding to give a greater sense of time to each character’s generated history. Another change to the history system could be the addition of greater goals for the characters to act on which could be around scaffolding for events like becoming the leader of a group or getting revenge against someone in the character’s history overall these sorts of events could present a stronger narrative to the users of the program.

### JSON functionality

https://www.json.org/json-en.html

Issues with the current system make it difficult to add new events into the project so being able to speed the development of new events would be useful so it should be propose that the system be rebuilt around the use of JSON file entries as the events require the use of a character cast and the effect the event will have it could be made with the JSON for all the events scaffolded for the project to improve readability of the code and allow for quick and easy additions which can be done with little programming knowledge

JSON also known as JavaScript Object Notation is a format of data storage that can be used to make easily parsed while being easy to add data to it making ideal for storing the data for events in the narrative scaffolding system, storing the data for the event like the cast involved or tags on what its effects could be. This data could then be parsed and used by the event scaffolding system overall making the system easier to program allowing for more content to be created for the system in the same time frame than with the current system.

Text, letter

Description automatically generated

Figure : image showing how an event could be formatted into the JSON file format with data like

### Natural language processing with machine learning

As previously mentioned in the research the project could be improved using the use of NLPs to procedurally generate the interactions between characters although as previously mention this will still have issues around believability and efficiency however as also seen in the complete project the current system needs plenty of content from someone who is effective at planning and balancing the values need to create the narrative scaffold so replacing the scaffolding with natural language processing can be a valid substitute if the project needs completely procedural content.

https://monkeylearn.com/sentiment-analysis/

Also, as mentioned sentiment analysis could also be applied to the NLP model to aid the GTP-2 system so that it can detect and respond with the correct emotion for the dialog spoken. Overall, this can make the AI more expressive and reaction although this will only further increase the performance issues and is more suited to a one-on-one discussion between characters that a project which could have dozens of characters involved.

## Conclusion

Overall, the conclusion of the project is that the use of emotional AI with narrative scaffolding can create a reactive narrative AI in individual characters allowing them to create small stories through the runtime of the project. While the project is heavily dependant on content variety and subjective balancing it can be used well as a story generation system using only a small amount of developer guidance and could very well be used in projects like Rimworld. The dialog system and history system can both show the current development of the characters with the lightweight NLP working to create basic dialog which is able to reference people and objects. The system also has plenty of room for improvement as the current system is to be intertwined with each element of AI modifications are difficult to do to the project although there are many allowing the project to be modified with different technologies for the different purpose if needed.

The project can certainly be improved with these different technologies as well with JSON or any other type of system to abstract the variables in each event or personality trait so that it can be easily added helping to develop new content quicker and with less expertise, so the system be better used as a story making aide while also making it easier to develop more complex and compelling stories to make the AI more expressive and believable to the user. Using other technologies such as NLPs for character-on-character interaction and sentiment analysis as a reactive AI could be useful as a generator for narrative AI that would use little or no interaction from a developer however the issues of resource use and reliability of this method still leaves little to be desired for a narrative AI that people can effectively interact with but overall as it stands the current system is capable of creating a basic narrative AI.

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