Faculty of Science and Technology

BSc (Hons) Games Programming

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Shop Simulator Focused on AI

by

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Contents

Abstract

There are currently very few shop management games, and training simulators. Games currently available are very simplistic and hard to navigate. Working as a Customer Service Assistant (CSA) and working as a manager, or supervisor, are very different tasks and sometimes the jump from one to the other is too large. A big problem is the lack of ways to show how managing a shop works and how to be good at organizing and running a shop.

Creating a realistic, in-depth simulator/game, to show off the shop environment would be a great addition to a shop's training system, and can be a great way for people to spend their time, while also developing their skills in important real-life ways, such as money management, customer satisfaction, team management etc.

The program created during this project will not be a full game, it will be a stripped down, simpler version to simulate and show off the AI systems.

Chapter 1:

Introduction and Aims

Introduction

Working in a shop, of any kind, can be overwhelming at first. There is such a huge range of personalities that cashiers and supervisors need to deal with daily. Usually, it is a learn-as-you-work experience since there is no manual, or cut and paste solution for dealing with difficult customers. The program developed throughout this project will be the baseline for a complex, and AI intensive simulation which can be used by shop employers to help train their employees by manufacturing complex and involved scenarios. The program will provide intelligent AI, which reacts realistically to the employees in the simulation, and a user can control an employee, so that they can try different solutions for dealing with difficult customers. The employees can be taught, and practice dealing with complicated customers and situations without it happening in real-life, which means that if they perform badly, the shop's reputation does not get damaged and customers do not get upset or angry.

Upon initial research shrouding this type of educational program, it was discovered that there are very few, if not any, exceptional simulations that can be used in the way described above. One 3D version of a shop management game [1] is made for mobile only, and at first glance does not look too advanced or developed. Due to the lack of good research material being available for shop management games specifically, the next best place to take inspiration from would be simulation games with highly intelligent AI, such as RimWorld [2] and Prison Architect [3].

Figure 1: RimWorld Pathfinding Example

Using management games with intelligent AI as main points of inspiration, this project will be focused upon creating a basic program, with basic user interactions, but with a complex and advanced AI, which will show off the potential educational

simulation that will be developed using this program as its baseline. The program will have a top-down/bird's eye view camera set-up, as this allows the most amount of visibility of the entire shop, and helps the user get the best assessment of the AI systems.

Aims

The final program that will be developed by the end of this project, will be used as an example, and proof of concept item, of a potential simulation full of complex and realistic AI decisions, which can be manipulated by the user to create scenarios which then can be used to train and teach employees about how to deal with an enormous amount of different shop interactions and scenarios.

This project's AI systems will include:

- Pathfinding – Research will be done to find the best pathfinding algorithms, which will then be implemented to create a realistic looking pathfinding system.
- Job Decisions – The employees will need to decide which job should be done depending upon criteria such as customers in the store, and the time of day. Research will be done on games already using this system, such as RimWorld [2]
- Shopping Choices – The customers will need to know what products they are after and then look for them. If the customer finds the items they want, they need to decide on whether to purchase them based upon price, quality etc.
- Relationships – The characters in the program, employees and customers, will have different relationship levels. These levels will be used to determine if two characters want to engage in a conversation, and then their relationship will increase or decrease based upon that interaction, and the characters' traits.

The base program system/UI implementation needs to be completed so that the user can interact with the world. The user should be able to play the program and get a feel for what a final, fully developed version of this program will be like. The main systems that will be developed and implemented are as follows:

- World/Tile Interactions.
- General Character Pathfinding and Interactions
- Employee Job Decisions
- Customer Decisions

All these features will be tested and feedback will be given in Alpha and Beta testing.

Objectives

Most the project time will be on developing the AI for the characters, employees and customers, and will be the key focus of the project. Some time, but a limited amount, will be used to develop the backbone/outline of the game to demonstrate the AI in a realistic environment and so that users can get a good sense of the final program once it has been fully developed beyond this project's deadline.

There shall be investigations and research on different pathfinding techniques to find out which is best for the situation and to create the most realistic looking simulation. The A* algorithm would be a good place to start but research will also be conducted on others such as Dijkstra's algorithm.

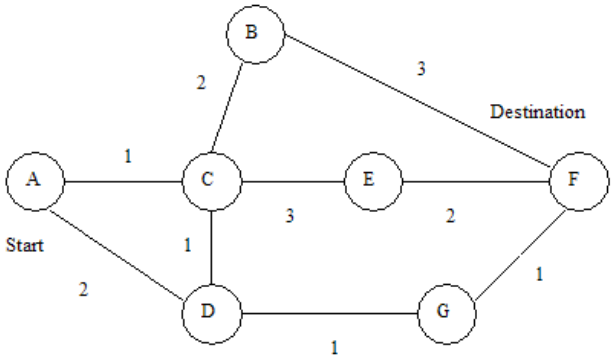


Figure 2: Dijkstra's Pathfinding Algorithm.

The backbone/outline of the program will be a top-down/bird's-eye-view tile-based world which can be interacted with, and the player will be able to click on tiles/furniture/characters so that they can receive a realistic simulation of what the full game experience shall be like.

The player will not have a physical character to represent them in-game, but they will be able to interact with the world. Due to it strictly being a simulation, a pre-made scenario will be used as the demonstration, and will contain two employees, which will have randomly assigned traits, and the shop will be set up so the layout is

the same each time. After that the spawning of the characters, their traits, and their shopping lists will all be randomised from a pre-built selection. This is so that if the user runs the simulation more than once, there is a very high chance that the way the simulation plays will be very different.

Methodology

The main stages will be carried out using the waterfall method. The base/outline of the program will need to be the first thing that is developed. Investigations will be carried out to implement world/tile interactivity and then development of the tile features such as furniture will be conducted.

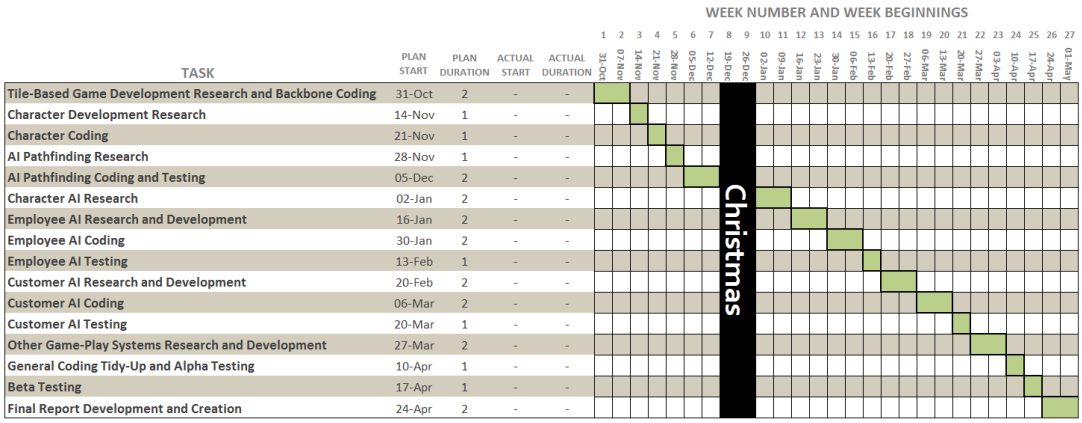
The second part will be the character development, and will be where the characters are made and given traits. This whole step is required second due to the world needing to exist first, but the character's existence is needed before any AI can be developed.

The third stage is the largest and most important part. The AI will be the core of the project and will require the most amount of time and research. Within the AI section, 3 sub-sections are required: Pathfinding, Jobs, and Customer Decisions. The pathfinding will need to be done at the start of the AI system, due to this being essential for every character regardless of whether they are an employee or a customer. The employee AI and the customer AI are interchangeable as they are independent from each other. For this reason, the decision has been made to develop the employee AI second and the customer AI third. The employee AI is more important than the customer AI, and more complex, this is because the employee AI better demonstrates the final version of the game's AI than the customer AI.

Research will be done throughout the development through finding documents about already developed management games, and tile-base games, and using their systems and information as a basis for the project's development. General game-creation documents and reports will also be used when developing the pathfinding, and the other AI systems. Examples of good topics to focus on are fuzzy logic, finite-state-machines, and decision trees.

The final stage of the project will be testing. There will of course be brief testing for each section throughout the project and on completion of each stage, which will all be documented appropriately, but also a final alpha testing stage at the end of the program development based upon the proposal, and other initial planning stages created throughout the project. After this, beta testing will be conducted where other people outside the project will be asked to play the game and give feedback on their thoughts and opinions. The game will be sent off to selected persons who are believed to be experienced in real-life shop environments, ideally in positions of management. Upon receiving the feedback and testing results, a final report will be created based upon them and comparisons to the initial predictions and alpha testing will be conducted.

Development Project Planner



TASK	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION
Tile-Based Game Development Research and Backbone Coding	31-Oct	2	-	-
Character Development Research	14-Nov	1	-	-
Character Coding	21-Nov	1	-	-
AI Pathfinding Research	28-Nov	1	-	-
AI Pathfinding Coding and Testing	05-Dec	2	-	-
Character AI Research	02-Jan	2	-	-
Employee AI Research and Development	16-Jan	2	-	-
Employee AI Coding	30-Jan	2	-	-
Employee AI Testing	13-Feb	1	-	-
Customer AI Research and Development	20-Feb	2	-	-
Customer AI Coding	06-Mar	2	-	-
Customer AI Testing	20-Mar	1	-	-
Other Game-Play Systems Research and Development	27-Mar	2	-	-
General Coding Tidy-Up and Alpha Testing	10-Apr	1	-	-
Beta Testing	17-Apr	1	-	-
Final Report Development and Creation	24-Apr	2	-	-

Here is the initial project gantt chart. These deadlines will be kept to as much as possible. All work will be documented in the project journal and so the dates can be compared.

Chapter 2:

Background Theory

Due to this program being a tile-based game, research will need to be done on general tile-based game development, as well as research on successful ways to create a backbone structure which will provide a secure and strong foundation for the rest of the more complex systems' developments.

A peer reviewed literature paper Spuy (2010) [4] has been found and will be looked at as an example of a way to begin the development. It explains general tile creation, and how to use those tiles efficiently such as by creating an array of tiles to represent the world, and collision detection should be done on a tile by tile basis rather than object to object. Through this research, ideas have arisen about using tile sheets for the sprites used within the program, this would save memory and processing power due to one large sprite needed to be accessed instead of smaller sprites.

C# Unity3D Code was discovered (Project Porcupine, 2015) [5], which links to a set of tutorials for a tile-based base building game. After looking through the code, the baseline code is very useful, and its logic is similar to what is required for this project.

The project's general set-up is that the visual aspects of the game are separate from the hidden game logic. It uses controllers to link the two together. These controllers are the only classes derived from Monobehaviour and so are the only ones that can use Unity's GameObject functions and methods.

A class called WorldController is the center point of the code, and all the other classes, and instances can be reached via this class, either directly or through other classes, and it is the only class in the project that has been developed using a singleton system.

Other controllers such as the FurnitureSpriteController and the CharacterSpriteController are used to link the furniture and character logic with Unity's GameObject logic, respectively. These classes collect data from standard C# classes and use that data to place and move GameObjects in Unity to where they need to be. There are other controllers but their logic will not be used in this project so will be skipped.

The rest of the classes are not derived from monobehaviour, and therefore they represent the hidden game logic. The main class is named World and contains all the general game data such as the world's tiles, lists that contain references to all the characters and furniture in the world, and the jobQueue.

Some of the classes are models and represent templates for different things in the game such as characters, furniture, tiles etc.

There is a set of classes that are used for the program's pathfinding system, which uses the A* pathfinding algorithm. This algorithm is generally known as the best algorithm as proven in a DePaul University technical report (Krishnaswamy, 2009) [6]. Research will be done at a later point to compare A* with other algorithms and a decision will be made on the best algorithm for this project. If A* is used for the development, then the A* logic shown will be used as it is already integrated with the rest of the logic.

The Project Porcupine code is licensed as shown in Appendix 2.

A major influence on this project is the tile-based colony management game RimWorld (2013) [2], because of this, here is an insight into its systems and similarities with this project.

RimWorld allows the player to indirectly control characters in-game known as colonists. The player assigns jobs and the colonists fulfil those jobs based upon their own personal job priority lists, also set by the player. The colonists have moods, relationships, and thoughts. They also have traits which affect their speed, moods, relationships, and thoughts. The player can place a range of furniture, which must be built by the colonists using inventory. Due to the player not controlling the colonists directly, RimWorld has a very complex and integrated AI system which is used to make the characters seem life-like by changing their moods and thoughts.

The similarities with RimWorld and this project are as follows: uncontrollable characters, traits, relationships, and conversations. In RimWorld these systems are much more advanced and developed than what will be created in this project, however, the general idea and backbone of them will be used as inspiration throughout this project.

Chapter 3:

Design, Development and Testing

Initial Coding

Using the Project Porcupine code as influence, the program began development with a WorldController, a World class, and a Tile class. The WorldController and World class are the center points of the rest of the code. After this the MouseController was developed, along with the Furniture class, FurnitureSpriteController, and the Furniture Actions class. The furniture actions class represents the Update function for furniture, however, due to not all furniture needing an update function, this class allows specific types of updates and only when the furniture needs it, such as when a door opens, or a piece of furniture moves.

All this coding was backbone, basic coding and put into place the basic functions needed to create these in-game objects which were developed further into the project.

Research was done on general character coding, however not many useful publications were found. Research was then done on RimWorld's [2] character systems, such as their traits, moods and thoughts. Using this system, and the Project Porcupine character code, this project's character code was started, and the Character class and the CharacterSpriteController class were created. These were again developed in such a way that the basics were completed, with lots of room and help for future development in several ways, such as pathfinding which was the next step in development.

Pathfinding

Many pathfinding literatures were reviewed and a few of them were focused on. By briefly explaining the major literatures found, reasons for the pathfinding choice made should become apparent.

Hybrid Pathfinding in StarCraft (2015)

Hybrid Pathfinding in StarCraft (2015) [7] describes the use of A* algorithms for long-range pathfinding, but also the use of potential fields for short-range and combat based pathfinding. It evaluates the possibility of replacing the potential fields part of the hybrid pathfinding with a system based upon flocking algorithms. The

work of Olssen (P. M. Olsson, 2008) [8] addresses the issue of changes in the pathfinding graph due to the construction and deconstruction of buildings. Koenig and Likachev (S. Koenig, 2004) [9] (S. Koenig and M. Likachev, 2006) [10] have made contributions to the field with their work on real-time A* pathfinding. Both works were considered useful for this project since some of the furniture can move.

Direction Based Heuristic Pathfinding in Video Games (2015)

Direction Based Heuristic Pathfinding in Video Games (2015) [11] explains a general pathfinding concept and then talks about the two primary problems which are to find a path between two nodes in a graph, and to find the optimal shortest path [12].

It then explains A* pathfinding. A* is a generic search algorithm that can be used to find solutions to many problems, pathfinding is just one of them. A* is the most popular and widely used AI pathfinding algorithm proposed by Hart, Nilsson and Raphael in 1967. Due to its simplicity, A* is almost always the search method of choice. This is because A* is guaranteed to find the shortest path on a graph.

A problem with A* is that a shortest path on a graph is not equivalent to the shortest path in the continuous environment. Another issue is when the map size is significantly large, it cannot find a minimum path to the goal state in a limited amount of time. For larger maps, A* uses memory extensively. A* uses a heuristic to improve on the behaviour to Dijkstra's algorithm.

Search Algorithm A*:

1. *Add the starting node to the open list.*
2. *Repeat the following steps:*
   a. *Look for the node which has the lowest f on the open list. Refer to this node as the current node.*
   b. *Switch it to the closed list.*
   c. *For each reachable node from the current node*
   i. *If it is on the closed list, ignore it.*
   ii. *If it isn't on the open list, add it to the open list. Make the current node the parent of this node. Record the f, g, and h value of this node.*
   iii. *If it is on the open list already, check to see if this is a better path. If so, change its parent to the current node, and recalculate the f and g value.*
   d. *Stop when*
   i. *Add the target node to the closed list.*
   ii. *Fail to find the target node, and the open list is empty.*
3. *Tracing backwards from the target node to the starting node. That is your path.*

Figure 3: A*'s Pseudo Code.

Next the publication goes on to talk about general heuristic features. The trade-off between speed and accuracy can be exploited to create a good balance. One way to construct an exact heuristic is to precompute the length of the shortest path between every pair of nodes. This is not feasible for most game maps. However, there any many ways to approximate this heuristic:

1. Fit a coarse grid on top of the fine grid. Precompute the shortest path between any pair of coarse grid locations.
2. Precompute the shortest path between any pair of waypoints. This is a generalization of the coarse grid approach.

Links between the publication and the project were then made. The downside of the large maps being slow does not matter in this situation due to the map in the program only being 2030 tiles high and wide. Also, only a maximum of perhaps 10 characters will be present in the world at any time, so the high memory demand is not a problem unless the world is expanded and more characters were present on the map, at which point A* may become less viable

Uninformed Multigoal Pathfinding on Grid Maps (2014)

Uninformed Multigoal Pathfinding on Grid Maps (2014) [13] is a publication focused on implementing multigoal logic into standard pathfinding algorithms.

There are two classifications of pathfinding algorithms; informed and uninformed. Informed involves the use of a heuristic function [14] to estimate the location of the goal. The direction of the pathfinding is guided towards the estimate, making informed searches typically faster than uninformed searches, but can be less optimal. Uninformed algorithms have been developed using different pathfinding models, such as iterative-deepening searches [15], boundary searches [16], bidirectional searches [17] and multigoal searches [18] [19].

The publication tested two algorithms: Dijkstra's Shortest Path Multigoal Algorithm with Multigoal Boundary Iterative-Deepening Depth-First Search. The results showed that when multiply goals are required in the game, using the multigoal algorithm significantly decreased pathfinding times. There is an exponential increase in pathfinding times recorded by single-goal algorithms to search for multiple goals on open maps. This project does not require multigoal pathfinding due

to the nature of the AI system that was implemented, however, this is very interesting and will defiantly be considered for the future if a more complex AI is developed with the ability to stack destinations for more efficient pathfinding.

Pathfinding in Partially Explored Games Environments (2014)

Pathfinding in Partially Explored Games Environments (2014) [20] talks about a very big problem with pathfinding and the fact that usually the characters in the game know everything about the layout of the map, and because of this, they can create perfect routes to their destination which is often unrealistic. It proposes a system using a hybrid approach [21] that allows characters to path-find as normal, but they do not know everything about the map. This system would require some way for the characters to 'learn' about the environment with, for example, line-of-sight. The character will detect changes in their environment as they move, and adapt and change their pathing accordingly. For example, they could turn a corner assuming they can walk down it, and as they carried on walking they realised that it was a dead end and be forced to turn around and come back, which is much more realistic than them knowing the dead end was there without seeing it.

The publication tests this system in Unity3D using ray casting as a sensor to 'see' the environment. The raycast works in a similar way to a sonar or LIDAR based

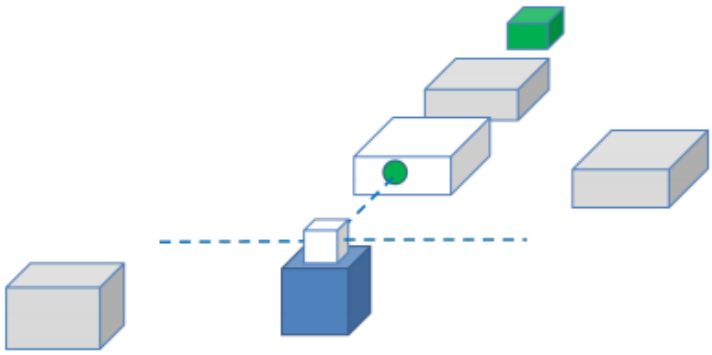


Figure 4: Raycast 'Sight' Example.

system in that a single point is projected outwards. If the raycast intersects with an object, the system records the collision point. The character will be able to see any object the raycast intersects with.

This publication is very interesting and very relevant for this project. Having our characters not be able to see the entire map and require them to learn as they

move would increase the realism and allow a move in-depth and advanced AI. The problem with this however, is the requirement for line-of-sight, as well as each character having their own perception of the world. Both these things require more coding, and additional systems be put in place for them to work successfully. This partially explored environments system was not implemented due to time constraints but the idea behind it was a huge possibility and will be one of the first additions for future work.

After pathfinding research was completed, the A* pathfinding algorithm was chosen as the best for this project. Thought was given to the partially explored environments system, and it was decided that if enough time was available near the end of the project, then that system would be implemented along with line-of-sight system. Due to Project Porcupine [5] already having a successful A* pathfinding system, it was looked at and its basic outline was used. The pathfinding system was tweaked later in the project when moveable furniture was fully implemented.

The pathfinding uses a weighted system which allows furniture, and others things if required, to have a weight, and moving through a tile with furniture will change the time it takes to move through it, and therefore sometimes moving around the tile can be quicker.

Tiles contain one of three 'enterability' states: YES, NO, and SOON. YES means that the character can walk onto the tile, NO means that the tile is now occupied and the character will re-evaluate their path, SOON means that currently the tile cannot be entered but if they character waits then it should be able to be moved soon, such as with a tile with a door. The character will wait, inform the tile they are waiting, and then furniture or character on that tile will perform their own logic for when a character wants to enter their tile.

Once this code was developed it needed to be tested. A basic character was created and a 'GoTo' button was created to allow the user to click on a tile, which then set the character's destination tile to the clicked tile. Simple walking with no obstacles was tested, as well as testing with a single line of walls, and finally a closed off room with only a door to leave by. The character correctly stood next to the door until the door opened using its furniture actions, and when it was open the tile had an 'enterability' of YES instead of soon, and the character carried on their

path. When the character left the tile, the 'enterability' changed back to SOON and the door closed.

AI Development

The next section of the research and development was the most intensive and important part. In a similar way to the pathfinding, several publications were looked at, but only a few were focused on.

Emotion-Based Synthetic Characters in Games (2008)

Emotion-Based Synthetic Characters in Games (2008) [22] talks about emotions for characters in video games, and proposes a model using fuzzy logic to create facial expressions and body positions to represent emotions, and other characters used those emotions to learn about the character. It used basic emotions such as happiness, anger, fear, sadness etc. It talks also about keeping these moods around for a given amount of time, and so these moods can stack, or oppose each other if they happen at the same time.

The use of facial expressions and body positions is not relevant for this project; however, the idea of fuzzy logic is something that needs to be thought about and is used slightly in the moods and conversation responses in the characters in the program. The idea of keeping moods around was not relevant in this project as the characters don't exactly have moods, they instead change their relationships with each other. The idea of them having moods, and the mood changes sticking around for a time is interesting and will be considered for future work. Having a bad conversation with someone could cause a character to be angry and may cause them to be more irritable to other characters, which is realistic.

Towards the Design of Human-Like FPS NPC using Pheromone Maps (2013)

This publication [23] begins by talking about different ways to model decisions for NPCs such as state machines, fuzzy logic, behaviour trees etc. and talks about their advantages and disadvantages [24]. The paper goes on to talk about different ways that characters can choose where to go or what to do. The example given was Quake 3. It talked about how if a certain location has had a lot of fire, and was being

attacked more than other locations, then that logic should be worked into the AI to allow more solders to go to that location to defend, as they should know it is more likely to get overrun.

This logic can easily be used in a shop environment, but was not implemented into this project due to it not needing to be due to the very short space of time the simulation would run for. However, the idea behind it would be if it should be a normal day, with a normal number of customers, but today for some reason it was much busier due to some kind of event, then employees should use that information and perhaps not go off and do their normal jobs and instead stay near the tills or around the shop front to help the increased number of customers.

Adaptive Behaviour Control Model of Non Player Character (2013)

This paper [25] talks about a model using fuzzy logic to help define the behaviour in a non-player character. It takes the basic fuzzy logic system and creates an adaptive version. This allows the character to learn in an independent way from the other characters, meaning that the same event will cause different characters to react differently even if other things such as traits are the same, as the fuzzy logic values changes the more the character interacts with the world.

This logic is not useful in this project due to the limited time the simulation is run but is something very advanced and will create a very interesting AI for future work on this project.

Component-Based Hierarchical State Machine – A Reusable and Flexible Game AI Technology (2011)

This publication [26] begins by talking about general finite state machines (FSMs) and talks about how these are the most common in video games [27] [28]. These are used to model the behaviour of computer-controlled game objects to make the NPCs react to game events in the most natural and intelligent way possible. FSMs consist of a set of states which represent actions or behaviours and a collection of transitions from state to state.

It then proposes a new technique called Component-Based Hierarchical State Machine (CSHSM) which introduces software component techniques to the

implementation of hierarchical state machines. It overcomes the limitations of Object Oriented Hierarchical State Machines (OOHSM) and has three significant advantages:

- Compile Time Composability. At compile time, new high-level and complex states are created.
- Design Time Configurability. CBHSMs are no longer completely fixed at compile time by programmers, and so can be configured at design time according to the game's high-level design.
- Run Time Flexibility. A run time, CBHSMs can be reconfigured as needed. This feature frees CBHSMs from fixed hierarchical structure and greatly improves their flexibility and adaptability to the changing game environment.

The paper goes on to talk about standard OOHSMs and their limitations such as the defective 'white-box reuse' [29], and talks about decoupling the state and the context, but that requires an Asynchronous Event-Driven System (AEDS). It explains the process of establishing the AEDS and the implementation of the CBHSM system.

This paper, although useful for considering an advanced FSM system, is not relevant for this project. The complexity is unnecessary due to the simple simulation design the of program and so was not used for the development of the AI. For future development, where the scenarios are not predetermined, this may be something that should be implemented.

Game Coding Complete (2013)

This book contains a huge amount of content about all aspects of game creation. Looking in the AI section provided lots of insight into the best and most known techniques such as: Finite State Machines, Decision Trees and Fuzzy Logic. Each one is shown and explained in detail and allowed a good source of knowledge to make an informed and correct decision into which approach was best.

With this book's large amount of information and the rest of the AI research, the chosen system was the use of a finite state machine (FSM) for the employee job code and the customer code. The different jobs that the employee needs to do works well with the different states needed. The FSM has primary states and secondary states. The primary states represent the major jobs required, and the secondary

states are smaller tasks that the major tasks are made up of, for examples moving position or emptying a stockcage.

The characters' relationships, interactions and traits will use simple fuzzy logic to add randomness to the simulation so that it isn't the same each time, which would allow the user to keep repeating the simulation with different results to get a good grasp of the realism.

Coding and Development

The AI development began with creating employees that inherit from the Character class. These will use certain conditions to decide on the job they need to do. The FSM first begin in the Job class, but this was quickly abandoned as the employee didn't have complete control over the machine, and the FSM now is implemented into the employee class. This means the machine acts as the employee's 'brain' which is realistic. All characters have a DoThink() function but the logic will be overridden for the employees and the customers independently since they are in the shop for different reasons. The employee has a DoJob() function which is different from the DoThink() function as the DoJob() function only runs when the employee is not moving and needs to perform an action on the tile where they are.

After there were simple jobs, and the employees had simple logic, stock was added to the game. Stock can be added to furniture and characters can pick up stock. Character stock logic was then developed so that characters can try to pick up stock from furniture. They can try to pick up any stock from the furniture, a specific type of stock based upon the stock ID, or an exact piece of stock. Stock is a model class that acts as a template just like the furniture class or the character class.

Next was the advancement of the selection logic, which allows the user to select furniture and see what stock is on that furniture, this was done at this point due to the need for it when it came to testing the employee's take stock code.

Once that was working successfully, then all the other furniture was implemented. The only moveable furniture is the Trolley, so that the employees can use the Trolley to take stock to and from the warehouse.

A very complex and important part of the development process was the moveable furniture. This caused the most amount of problems due to furniture needing to be moved by a character rather than independently, also the way the furniture is implemented it does not work well if it needs to be moved from tile to tile.

Characters can set a piece of furniture as their own piece, and then move it if they require it to be moved. This was simple when just moving to another tile, but became complicated when a Trolley was in their way and needed to move it just to go around it. This links closely with AI since there are several ways the character could choose to move the trolley. Initially, the character would just push the Trolley until they reached their destination, but this quickly because unrealistic as it may make more sense for the character to move the trolley to the side and walk through the tile where the trolley used to be. This was when a small bit of pathfinding was implemented. The character would perform a floodfill from the trolley's tile. This would return the nearest empty tile away from the trolley that is not in the character's path to get to their task's location. The character would then move to that tile with the trolley, once there they would return to the task they were performing.

After testing, this again became unrealistic as often the floodfill would return the tile behind the character, at which point the character would reverse and then once they moved back, the trolley would be again in their way. This would repeat until the character literally trapped themselves in the corner of the store. The problem is that the character wasn't thinking about where they were going to be once they did move. This sparked the creation of a complex function which used recursion to predict where the character and trolley would be if the character moved to the tile found by the floodfill. If the trolley would still be in the character's way, the process would repeat, and a new tile would be found, once again reclusively checking where the character and trolley would be. This is all being done without the character moving anywhere. The recursion stops when either the trolley will reach a tile that will not be in the character's path, or the character gets trapped. If the character won't get trapped, then the character proceeds as normal, but if they would get trapped, then that tile they would have moved to gets flagged as an invalid tile, and the process repeats until a valid tile is found. After testing this, it was found that it is a very realistic AI which successfully moves a blocking trolley somewhere logically and allows the character to pass.

Once the trolley movement logic was in place, the rest of the employee AI logic was completed. Buttons were developed to change the speed of the simulation so that already tested parts could be moved through quickly, and other parts could be tested without the wait. Once the employee code was close to complete, the customer code was added.

The customer FSM is much simpler and more straightforward than the employee one due to the simpler tasks the customers need to complete. The FSM still contains primary and secondary states, but they are not as plentiful, and did not take as much time to develop and plan. The customers spawn, and then are given a list of items they require, which they will then go and find. They begin from the start of the store and look in each shelf to find the item they need. Once they have found all their items, they floodfill from their current tile, until they find a tile marked as queue. All queue tiles have a number; the number is how far away that queue tile is from the checkout. If a customer is in the queue, and there is a queue tile adjacent to them, and the queue number is less than theirs, they check to see if it is free, and if it is they move there. Once at queue tile 1, they put their stock on the checkout, and the employee scans the stock, and the customer then picks the scanned items back up and pays and leaves when they have them all.

This is the point at which the line-of-sight/partially explored environment code would make the most sense. The customers may not have been to the store before and it would be realistic if they got confused and move around the store a lot, and sometimes missed shelves that they couldn't see.

After the customer logic was completed, the employee logic was completed. It had to happen in this order as some employee logic, such as scanning and finishing a transaction, relied upon the customer AI being completed.

After this, general character AI code was added which caused the characters to not occupy the same tile, and this meant that when moving into a tile, in the same way a door causing the character to stop and wait, the character will stop and wait if the tile contains a character already. This would not always work however, as if two characters wanted to move to each other's tiles, they would stop forever, and would never be able to move. This caused some logic to be added which meant that the characters would wait for five seconds, after which the character would try to find

another way to their destination without going through the tile that is causing the problem. Sometimes there is no other way, and so they need to ask the other character to move so they can pass. This is the first character interaction required and so before this was done, the interaction logic needed to be developed.

Characters can request interactions with characters next to them, and could be rejected if the character receiving the request is busy, or doesn't want to talk. This allowed the asking to move logic to be completed. At which point relationships and traits were added. Traits change the way that characters respond to other characters and there are positive, such as understanding, and negative traits, such as lazy. After this, character selection was added to allow the user to select characters and see the stock they are carrying, and the traits they have. If a character is interacting then that can also be seen, along with the character they are interacting with, and the relationship level of that character.

The rest of the development was small additions such as a message pop-up. The scenario used in the testing was developed, with two employees, and the beginning and finish screens were created.

Testing

Once the scenario was created, and the program was ready, testing began to find bugs in the game. The simulation was repeated numerous times and various bugs were found and dealt with. Unfortunately, a couple of significant bugs were found, and due to the short time remaining on the project, these could not be fixed fully. Instead, to make sure the simulation was ready for release to additional testers, the bug needed to be fixed using bad coding practises, which will be the first things looked at in the future to make sure the bad coding practises do not exist.

Once the simulation was run more than a dozen times, and no additional bugs were found, the alpha testing began. This was done by an in-house tester, James Jamieson, who ran the simulation and completed the same set of questions which would be given to the beta testers.

The questions were broken down into different categories. This helps the tester think about how to answer the question be thinking only about a certain aspect of the AI, and not the AI as a whole unless the question asked for it.

The first section was about the general simulation concept. This section allowed the tester to give their feedback on their thoughts about the general idea of having a program to help train employees. This means that later, if their answers seemed odd it might be down to them not agreeing with the concept in the first place, which of course if good and helpful feedback.

1.1) Imagining a fully developed, intelligent program which allows users to create very complex and fully customizable maps and scenarios, do you think that with enough development this program can be used as a good tool to train shop employees to allows them to experience unique scenarios and optimize their customer service skills? Please explain reasons for your response.

1.2) If you and think that both the concept is good, and this program can be used a good baseline, and you did not cover it above, please describe why.

1.3) If you think that the concept is good, but this program is not a good baseline for further development, and you didn't cover it above, please describe why.

1.4) If you think that the main concept of this program is bad, and that this idea couldn't be developed well, and you didn't cover it above, please describe why.

The second section is about the general AI as a whole. This allowed the tester to give their opinion on the general realism of the simulation and not think about individual characters yet. This was the basic idea behind question 2.1. Question 2.2 was looking at the intelligence of the AI in their decision making, and allowed the tester to perhaps explain why they thought it didn't seem smart, if that's what they thought. They were also able to give opinions on improvements which can be taken in the future. Question 2.3 talks about a general interaction with the trolley. Since the moving trolley logic links so closely with the general AI logic, this question allowed

2.1) Please describe your thoughts on the general AI used in the program? Please think about the decisions they made, and compare their decision to ones you would typically see in real life.

2.2) Did the AI seem simple, and not very smart? If so, please describe how you came to that conclusion, and maybe some suggestions for making the AI seem more realistic. If you think the AI was smart, and it did seem to make some good decisions, can you pin point why it seemed smart, and if there is anything that can improve it even more?

2.3) If a trolley was in a character's way, they were programmed to find the nearest free tile from the trolley that wasn't in their way and then move the trolley there. Did you notice this behaviour? If you did, did you think it looked realistic?

the tester to give their opinion on the interaction and talk about whether it was realistic or unrealistic.

The third section is the employee specific AI. Question 3.1 talks about the general intelligence of the employee AI, and asked the tester to give their opinion and an example of how they came to their conclusion. Question 3.2 talked about the interaction when an employee is in a customer's way, and asks the tester if they noticed the interaction and if they did to comment on whether it looked realistic. This is important since this is a realistic part of a real-life shop environment. The final question, 3.3, asks for their feedback on what they thought could be added to make the employees more intelligent.

3.1) Do you think that the employees made good, and realistic decisions? Please describe how you came to your conclusion.

3.2) The employees were programmed to get out of the way of a customer if they were asked to move. Did you notice this? If you did, did you think it looked realistic?

3.3) Could you describe any ways that the employee could be made more intelligent?

Section four was on the customer AI. Question 4.1 asks the tester about the customer AI logic of waiting for another character to move, then finding a way around, and then asking for that character to move and whether they though it looked realistic. Question 4.2 was a general question about the tester opinions in ways to improve the customer AI.

4.1) The customers were programmed to pick up the items they needed and then head to the checkout. If another character was in their way, they would wait 5 seconds, and then try and find a way around the character, if both of those failed, they would ask the character to move. Did you notice this behaviour? If you did, did you feel that it looked realistic?

4.2) Could you describe any ways that the customers could be made more intelligent?

Section five was focused on the relationship AI logic. Question 5.1 asks the tester if they noticed any conversations taking place, and then if it looked realistic. This is important since this could be a UI issue, and this needs to be addressed in the future if the interactions weren't noticed. The next question, 5.2, asks if there are any ways to make it more clear when characters are conversing. The question lists two ways so that the tester can get an idea of what sort of things might be good.

Subtle relationship behaviour was programmed into the characters. If they found themselves next to another character they had a good enough relationship with they would say help to them, then they would choose to have a conversation with that character. Depending upon what they talk about, and the traits of the characters that are talking, the characters' relationship with each other would either increase or decrease.

5.1) Did you notice any conversations taking place? If you did, did they look realistic? Is there anything that would make it look more realistic?

5.2) Can you think of anyways to make it more clear when characters are conversing? Such as speech bubbles above their heads, or happy and sad faces appearing when they gain or lose relationship.

The sixth section was on the characters' traits. 6.1 asks if the tester if they noticed these traits being used, and if it seemed realistic. The traits were the less obvious part of the AI and so this question allowed the tester to realise it was there, and to give an opinion of whether it added anything to the simulation.

6.1) All the characters have their own personal traits such as friendly, and lazy. These traits were used to affect how characters interacted with each other, as well as certain attributes associated with the characters such as their maximum speed etc. Did you notice these traits? If you did, did you feel like they were used in a realistic way? Is there anything that could be further developed with the traits to make the character more realistic and interact with each other in a more realistic way?

The next section was about the pathfinding. If explains the system and then 7.1 asked the tester if the pathfinding looked realistic, it also said to keep in mind that perfect paths are not always realistic.

The pathfinding is the first step in any advanced AI system. The system in this program uses the A* pathfinding algorithm which is the fastest and more optimal algorithm currently developed.

7.1) Do you think that the characters took realistic paths to their destinations? Sometimes if the AI takes the most optimal path, it may look unrealistic so keep that in mind. Please explain your answer with examples of why or why not you agree.

The final section was added to allow the tester to give their opinions on additional features and ways of increasing the AI's realism. Questions 8.1 and 8.2 described already planned additions, and asks for the tester's opinions. This is important as if the testers in general think that idea won't add anything then it will probably not be added in the future. The final question, 8.3, is a general and very open question where the tester can give their ideas on additions to the program. The box is larger and encourages the tester to go into detail about their idea. This is a vital part of the analysis since this can potential give some great ideas for future work that were not thought.

There were a few systems that could have been added into this program given more time to fully develop them. After describing them, please give your feedback on whether these systems would advance the AI and make the character more realistic.

8.1) Line-Of-Sight was the first thing to be implemented given more time. Currently all the characters have a full awareness of the entire world, they can find any item on any shelf, and find any character in the world even if they are very far away. With line-of-sight, systems could be developed and added which allows characters to need to walk tile by tile and search for their needs. They would also be able to 'see' other character that are not next to them and engage with them in a more realistic way. Do you agree that line-of-sight would advance the realism and intelligence of the AI considerable? If you do not agree, please explain why, and perhaps suggest your own ways the AI could become more realistic in terms of knowing things about their environment.

8.2) Linked closely with line-of-sight; partially explored pathfinding algorithms could be developed. The idea behind this is that currently, a character can make a perfect path from any tile to any other tile, even if it is 100s of tile away. This is because they can 'see' the entire map. Partially explored pathfinding would mean that characters would have a blank view of the map and only know about other characters and furniture if they see them using their line-of-sight. This would create a realistic looking pathfinding system which could take characters down dead-ends and non-optimal paths, which is impossible with full map awareness. Do you agree that partially explored pathfinding algorithms would create a more realistic looking pathfinding AI? If not, why do you disagree, and can you think of any ways to create a more realistic pathfinding system?

8.3) Please think about other ideas and concepts that could be added into the program to create a more realistic AI. Maybe talk about it at a general level and if you can, go into details about possible ways to implement the ideas. The box is a lot larger than the other. Please do not feel like you must fill the entire box. Any amount of feedback here is fine.

The alpha testing analysis will be gone through during chapter 4 since that analysis will be compared to the beta analysis and the results will be joined to give a final conclusion. The general response from the beta feedback will be summed up now, but will still be gone through question by question. Each response can be seen in full as appendices.

1.1 There was a mixed response in regards to the concept as a training tool, however, most responses agreed that with more development and additions this program can be used as a baseline for future development of a training tool. An issue raised was the fact that this simulation does not help to teach employees about general interactions such as not being shy, and talking confidently to customers. Another point was that this simulation is good since it will help teach employees without the risk of doing something wrong, and not hurting the shop's reputation; which was one of the originals aims of the program. A suggestion of a VR version was made to immerse the user into the simulation. This was very interested and something not considered before.

1.2 A response suggested this be used as a tool for general job training, and will help people learn about other job environments such as offices.

2.1 General thoughts were that the AI was realistic. There were some good and bad points. Good points:

- The characters chose a wide variety of products instead of lots of the same product.
- The connection between the customers and the employees was excellent and the cashier never stopped serving to keep customer satisfaction.
- The employees got out of the way and showed courtesy to the customers.
- The negotiations between characters when bunched around a trolley worked well.

Bad points:

- The AI seemed confusing and was hard to judge.

- The customers seemed to keep choosing the same items, but this may be down to the lack of items available in the simulation.
- The customers all seemed to follow the same path.
- The customers never forgot what they needed and never went back on themselves.

2.2 The response was split. Some thought it looked good, and others thought it looked robotic. The customers seemed simpler than the employees. The customers should skip shelves they know are not required, and maybe forget things and go back on themselves to get missed items.

2.3 The interaction was noticed for the most part. The customers should get annoyed if they need to move a trolley that is in their way. For the most part, characters never got stuck, and moved the trolley to realistic places. Some interactions took too long.

3.1 The employee AI looked fairly realistic. They restocked large bulks of items instead of small amounts which is good. The interactions between employees and customers worked well. The important parts of the employees' jobs were highlighted which is good for a training tool. Sometimes another employee was required at the shop front but did not go and help, and a few times it was hard to notice what the employees were doing. Occasionally the employees did not interact with a customer when they should have done.

3.2 The general opinion was that it was noticed and seemed realistic. Sometimes it was hard to notice, but the shop always flowed well and so this interaction may have just been missed. Employees would often take too long to move, and should be much quicker.

3.3 Here is a list of different responses:

- Customers could ask employees to show them around the store to find items.
- Adding damages to stock, and the employees need to sort of damaged stock as it cannot be sold.
- Duties off the shop floor such as phone calls.
- Employees could greet customers into the store if they are near the entrance.
- Not enough use of interactions and traits.

- The employees could help on the checkout more.
- Check shelves before loading trolleys.

4.1 In general the AI seemed realistic. The employees should move out of the way of customers without being asked instead of the customer asking for the employee to move. Sometimes people won't wait and barge through, which was not shown. The time for the interactions was too long. A few of the responses didn't notice the interaction.

4.2 Here is a list of the responses:

- The customers should have a budget and react to high prices or if they run out of budget for the items.
- The customers should not always take the same path.
- Ask employees for stock not on the shop floor.

5.1 There was a mixed bag between the responses. Some saw the interaction and thought it looked realistic, some did not think it was realistic and some did not notice the interaction. The cashier and customer interaction seemed good especially with the relationship level going up and down. A suggestion was made for good and bad moods that would change depending on recent interactions. Another suggestion was made which said that if two customers know each other they may move around the shop together while talking.

5.2 Both these additions were responded to as positive, perhaps with the addition of an emoji. Other suggestions were coloured numbers representing the relationship change such as "+10" or "-5", and the addition of voices when characters were talking.

6.1 the general response was that the traits were not noticed, or didn't do enough to warranty being in the simulation. Someone wrote that some traits should be visible as they may be seen by others, but some shouldn't be and been hidden traits. The traits should affect the employees' work ethics.

7.1 The general pathfinding was good as the shortest routes were taken, but sometimes characters were too robotic. Suggestions included characters backtracking to find other items they missed, and that the most optimal route isn't always the most realistic.

8.1 Line-of-sight would be a great addition. It would allow older and newer customers to act differently. Customers could walk past a shelf they need but not see the item they need, which is realistic. Characters could have conversations with people not right next to them.

8.2 This would be a great addition, and would allow much more room for advanced development which is good if this should become a training tool. Old customers would already know the layout of the store which is realistic. Having dead-ends that the customers walk down would look realistic.

8.3 Here is listed all the suggestions from the responses:

- More interaction logic with traits.
- Events occurring such as spillages and breakages which the employees will need to go and sort out.
- Someone wrote that proper shop skills cannot be gained using this simulation and so they couldn't make any suggestions.
- More situations such as phone calls, and angry customers.
- Employees becoming tired.
- Generally, more input from the user to train them.
- Shop lifters.
- Customers returning items.
- Health and safety, like when there are spillages.
- Fire alarms.
- Disabled customer help.
- Deliveries.
- Rush of customers.

There was a mixed bag of responses which was great since it gave the opportunity for all kinds of responses and suggestions. The beta responses will be looked at and compared to the alpha response in the next chapter.

Chapter 4:

Results of Evaluation

The range of responses were positive and allowed plenty of room for constructive criticism and suggestions for improvements. The responses in general matched the alpha testing, which confirms that the AI was fairly smart, however it did prove to be a highly intelligent AI that would be required for a fully completed simulation. The program can be used as a good baseline since there are hints of all kinds of AI which can be developed further and worked on to create a very powerful simulation. The point of real-life skills such as people skills not being learnt in this simulation was brought up and is a great point to make. Regardless of the level of intelligence in the characters, the user can never actually worry about the decisions they make and so their skills can never fully be taught just in the program. The suggestion of adding VR into the program was very interested and was not considered before. This would allow a much more real feeling for the user, and may help to increase the maximum help the program can provide when training customers.

It was agreed that the employees were much more realistic than the customers, which makes sense since their system is a lot more advanced and they need to make more complex decisions, which seemed to add to the realism. The employees should be given more jobs, such as phone calls to answer, as well as more customer interactions such as complaints and customers not finding items. These were great suggestions and would help the advancement of the AI and the realism. Often the employees seemed too robotic and too set on their tasks, which could be good as a training tool to help future employees work harder when they do start in real-life, but was also bad in terms of the realism.

The customers were generally talked about as robotic and seemed to follow the same path. They should sometimes forget what they need and backtrack, but also know exactly what they want and where to get it, and so go straight to the correct location in the shop to pick up the items. More interactions could be made between customers to allow them to move while talking for example. A more completed program with more items and shopping lists may add to the realism by itself. The trolley interactions seemed good but sometimes took too long and the customer moved the trolley to odd places.

Character interactions could be developed more to make it easier to notice, but in general were good and realistic. The addition of moods which linger with the character would be a nice development. The problem with the interactions was the lack of messages to the user that there were interactions, which is a shame, but a good point for development. The suggestion of numbers to represent relationship changes is a good idea, and the addition of voices, since this would cause busy shops to be louder, which is realistic.

The consensus on the traits were that they added basically nothing to the simulation, except the point that they were there. They should do more things, or be less of a 'big' feature. They are not important for training except perhaps to train employees to read the mood of a customer which is sometimes important.

The pathfinding in general seems robotic due to the characters never backtracking or changing their mind. The characters should skip shelves they know won't have their stock, as previously stated. This moves on nicely to the next point.

The addition of line of sight was agreed to be a positive feature and would add a lot of realism, by allowing customers to talk to each other while further away, and to not notice some items which is realistic. The partially explored pathfinding addition was agreed to also be a great improvement. It would allow different behaviour between old and new customers, and open room for a huge amount of development which is required to change the program into a full training tool. This would also allow customers to walk down dead-ends which is realistic too.

Most of the given suggestions were great, with good potential. They were thought about before development but was not added to keep the project within the defined scope, and due to the time constraints. Some ideas were not thought about before or during development, and would add great training situations such as disabled customer help, and fire alarms. Both these situations can be tough for someone not experienced and the additional help may be vital for customer satisfaction and safety.

Chapter 5:

Discussion, Future Work and Final Conclusion

Comparison

Here will be the comparisons between the initial aims, goals and methodology and the finish project and program.

Firstly, the pathfinding was successfully completed. After research, A* was found to the be best choice, and so that was used to create the pathfinding. The pathfinding looked mostly realistic, however in the testing it was decided that sometimes the optimal routes made the characters look less realistic. This was a good observation and was a concern throughout the project.

The job decisions were developed well. The employees correctly chose the jobs to complete based upon different conditions such as empty stockcages. Rimworld's system was not used in the end, since the user could not change priorities, but this was a correct choice due to this program being a simulation rather than the final training tool.

The shopping choices were randomly assigned and the customer did not make any attempt to change the list based upon price and quality. This was a fail from the aims first discussed, but was noted and picked up on by the beta testers, and will be a good addition to future work.

The relationships worked in the correct way based on the original aims. The interactions got affected by character traits and already existing relationship levels, but the beta testers found they were not obvious enough and so that change will be made in future work.

The objectives were all reached, with most of the time being spent on the AI, and the character development. Different AI techniques were considered and the best was chosen. The scenario was created correctly with two employees, and customers spawning randomly, and running the simulation more than once would cause different situations to come up, which was proven in the beta testers' responses.

The Methodology was stuck to, with the ordering being mostly the same. The only change would be the final stages of the employee AI needing to wait for the

customer AI, although this was not too crucial was they were interchangeable anyway as stated in the methodology.

Future Work

This program is very clearly far from complete, which was known to be the case even before the project had begun. The aims that were not completed will make good additions to future work, as well as ideas created throughout the project, and the final suggestions by the beta testing team.

Firstly, the bad programming practises that were added to get the program ready for testing will be removed. It is never good to have these in the code, and so these must get fixed as a priority.

Next, customer item changes. The customers should care about the price and quality of the stock. This should affect their purchasing decisions and whether they want to spend money at the store.

The addition of line of sight is another huge piece of work which would add a large amount of realism, and of course this links with the partially explored environment code, which would allow the program to open up more and help development in a lot of different directions. Line of sight would allow signs to be added, which helps customers find different parts of the store.

Sales could be added to the game, which would mean signs for the sales could be added. This in turn, would allow the possibility of a bad looking sign to cause a customer to believe an item is a different price than it actually is. The customer may buy the item, and then realise the price was wrong which would then cause the customer to perhaps come back for a refund. All of these additions would add to the realism and be great for future work.

Other smaller pieces of work which would add to the improvements would be breakages, and spillages, this would add more jobs for employees, and more issues such as health and safety. Other additional jobs for employees could be phone calls, and deliveries of stock.

Fire alarms and disabled customer help would be good additions and will be worked on in the future.

To allow this program to be used as a training tool, which is the main point of the program, the world would need to be able to be fully customizable which means work must be done to allow furniture to be placed, time of day and year to change. Customers with certain traits and needs will need to be able to be added. This all means an entire scenario editor would need to be developed which would be a huge job, but would excel the program into an advanced and powerful piece of software that would be able to be used by employers for training staff.

Conclusion

This project has been long and has contained lots of problems and obstacles. Time was a big factor in the development of the program, with a few features not being able to be developed as planned due to the time constraints of the project. Despite this, the final program showed a large amount of the originals aims and objectives, and these were the most vital ones. It was easy to keep to the bounds and scope of the project, since the AI was the main focus. Some of the AI features, such as the traits and conversations, could not be fully shown without UI, which was unforeseen at the beginning of the project, but did not cause too much trouble in terms of the time it took to complete this.

The testing process has proved the program to be a success at being a good baseline for future development of a full integrated training tool. Feedback has shown that the AI is not as developed and sophisticated as originally planned, but was still good enough to show off the basic idea behind the project. Because of this, the project has been a success. The employee AI was shown to be more advanced that the customer AI, which was the plan since the employee AI did a better job at showing off the best features of a fully functional program.

The program was finished at a very good point, with all the systems that were begun, being finished to a standard that could be tested by outsiders. The program can also be restarted at any point, with any of its systems to carry on the development of the training tool.

In conclusion, the program, and therefore the project, is a success. With the program being able to demonstrate the best features of a training tool once development has created a more in-depth and advanced set of systems. All the

objectives were met, and most of the aims were met with the ones not being met being the smaller and less important features. This program can be used successfully as a great baseline for future work and a potential training tool.

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Figure 1: Murtaq, 2016. *Rimworld Pathfinding in a Nutshell* [online]. Reddit. Available from: https://i.redd.it/psgedjzr5ykx.png [Accessed November 2016]

Figure 2: dotstarmoney, 2015. *Generalized Platformer AI Pathfinding (A Guide!)* [online]. Available at: http://www.reviewmylife.co.uk/data/2008/0715/dijkstras-graph.gif [Accessed November 2016]

Figure 3: Björnsson, Yngvi; Enzenberger, Markus; Holte, Robert C. *Fringe Search: Beating A* at Pathfinding Game Maps*; IEEE 2005 Symposium on Computational Intelligence and Games, 2005, 128.

Figure 4: Stamford, J., Khuman, A. S., Carter, J. and Ahmadi, S. 2014. Pathfinding in Partially Explored Games Environments: The Application of the A* Algorithm with Occupy Grids in Unity3D [online]. *In 14th UK Workshop on Computational Intelligence (UKCI)*. Bradford 8-10 September 2014. IEEE. Available at: https://ieeexplore.ieee.org/document/6930151/ [Accessed 3rd December 2016]

Appendices

Appendix 1

Research Ethics Checklist

Reference Id	13727
Status	Approved
Date Approved	24/11/2016

Researcher Details

Name	James Jamieson
School	Faculty of Science & Technology
Status	Undergraduate (BA, BSc)
Course	BSc Games Programming
Have you received external funding to support this research project?	No

Project Details

Title	Shop Manager Game
Proposed Start Date of Data Collection	01/11/2016
Proposed End Date of Project	08/05/2017
Supervisor	Alain Simons
Approver	Alain Simons

Summary - no more than 500 words (including detail on background methodology, sample, outcomes, etc.)

This project will be focused on developing a tile-based shop management game using the Unity Engine. The final vision of the game includes the player hiring employees as well as building and laying out a shop. Artificial intelligence is an essential part of the game and will be the main focus throughout the development. AI is so important because the player will not have direct control over their employees, or their customers, and therefore a good AI system is needed to keep the game realistic and the NPCs will be required to make correct decisions. The employees will need to decide what jobs to do, and the customers will need to find items, and decide whether to buy them. Due to the importance of AI, this game is going to realistic and will be a very good simulation of a real-world shop environment. Because of this, my game can be altered to be a shop simulator which can be used for educational purposes in the retail world. I will keep referencing this idea throughout, as my game will have two purposes; one to be entertaining, and also to have the potential to be educational.Throughout the project, vast amounts of research will be done on AI, pathfinding, and decision making in games; as well as, research on the best ways to program games using Unity.

External Ethics Review

Does your research require external review through the NHS National Research Ethics Service (NRES) or through another external Ethics Committee?	No

Research Literature

Is your research solely literature based?	No

Human Participants

Will your research project involve interaction with human participants as primary sources of data (e.g. interview, observation, original survey)?	Yes
Does your research specifically involve participants who are considered vulnerable (i.e. children, those with cognitive impairment, those in unequal relationships—such as your own students, prison inmates, etc.)?	No
Does the study involve participants age 16 or over who are unable to give informed consent (i.e. people with learning disabilities)? NOTE: All research that falls under the auspices of the Mental Capacity Act 2005 must be reviewed by NHS NRES.	No
Will the study require the co-operation of a gatekeeper for initial access to the groups or individuals to be recruited? (i.e. students at school, members of self-help group, residents of Nursing home?)	No
Will it be necessary for participants to take part in your study without their knowledge and consent at the time (i.e. covert observation of people in non-public places)?	No
Will the study involve discussion of sensitive topics (i.e. sexual activity, drug use, criminal activity)?	No

Are drugs, placebos or other substances (i.e. food substances, vitamins) to be administered to the study participants or will the study involve invasive, intrusive or potentially harmful procedures of any kind?	No

Will tissue samples (including blood) be obtained from participants? Note: If the answer to this question is 'yes' you will need to be aware of obligations under the Human Tissue Act 2004.	No

Could your research induce psychological stress or anxiety, cause harm or have negative consequences for the participant or researcher (beyond the risks encountered in normal life)?	No
Will your research involve prolonged or repetitive testing?	No
Will the research involve the collection of audio materials?	No
Will your research involve the collection of photographic or video materials?	No
Will financial or other inducements (other than reasonable expenses and compensation for time) be offered to participants?	No

Please give a summary of the ethical issues and any action that will be taken to address these. Explain how you will obtain informed consent (and from whom) and how you will inform the participant about the research project (i.e. participant information sheet).
Individuals will be asked to play and assess the program that will be created. They will do with willingly and will have the option to stop playing at any time, or to say no to the assessment. The individual's play through will not be recorded. Their job role will need to be recorded as the assessment will be conducted on persons who have no experience in the shop management role, as well as persons who are paid to manage shops, or shop environments, and a comparison will be compared with their responses.

Final Review

Will you have access to personal data that allows you to identify individuals OR access to confidential corporate or company data (that is not covered by confidentiality terms within an agreement or by a separate confidentiality agreement)?	No
Will your research involve experimentation on any of the following: animals, animal tissue, genetically modified organisms?	No
Will your research take place outside the UK (including any and all stages of research: collection, storage, analysis, etc.)?	No

Please use the below text box to highlight any other ethical concerns or risks that may arise during your research that have not been covered in this form.

Appendix 2

Appendix 3

Thank you for taking part in the testing process. DISCLAIMER: Please be aware while you answer these questions:

The program is in Beta Testing. Bugs are present and are known. Please try to ignore obvious bugs as much as you can. There are a few graphical bugs/glitches which would be solved with the addition of animation, for example.

The focus on this project is the artificial intelligence (AI) systems. The program's UI, art work, and other general program systems such as lack of animations are immensely underdeveloped. Please answer these questions with thought only on the AI and not on the artwork, or lack of other engaging systems which would otherwise be in place in a fully developed program.

1. General Concept Feedback

1.1) Imagining a fully developed, intelligent program which allows users to create very complex and fully customizable maps and scenarios, do you think that with enough development this program can be used as a good tool to train shop employees to allows them to experience unique scenarios and optimize their customer service skills? Please explain reasons for your response.

Yes, I think when fully developed, this program could help to train employees and enable them to experience an array of customisable scenarios. As the shop layout, customers and employees can all be customised to suit the applicable scenario, it would benefit employees from enterprises of all sizes.

1.2) If you and think that both the concept is good, and this program can be used a good baseline, and you did not cover it above, please describe why.

This has the potential to be a fantastic tool to be used be any type of enterprise, not just in retail. It could be personalised to demonstrate and simulate an office environment with employees of different departments working together.

1.3) If you think that the concept is good, but this program is not a good baseline for further development, and you didn't cover it above, please describe why.

1.4) If you think that the main concept of this program is bad, and that this idea couldn't be developed well, and you didn't cover it above, please describe why.

2. General Artificial Intelligence (AI) Feedback

2.1) Please describe your thoughts on the general AI used in the program? Please think about the decisions they made, and compare their decision to ones you would typically see in real life.

The characters chose a variety of products, instead of choosing a large number of the same product. This was realistic, and showed that the AI was programmed well. The characteristics or traits of each character was an interesting addition, which I did not expect when first finding out about this project.

2.2) Did the AI seem simple, and not very smart? If so, please describe how you came to that conclusion, and maybe some suggestions for making the AI seem more realistic. If you think the AI was smart, and it did seem to make some good decisions, can you pin point why it seemed smart, and if there is anything that can improve it even more?

The AI was smart to choose a variety of products, and talk to some characters, but not all. They moved out of the way of each other when crossing paths and when faced with the trolley being in their path.

2.3) If a trolley was in a character's way, they were programmed to find the nearest free tile from the trolley that wasn't in their way and then move the trolley there. Did you notice this behaviour? If you did, did you think it looked realistic?

There were cases where the trolley was in the way of customers, and although I couldn't tell whether the customer or the employee moved it, it was moved so that the customer could get past. The most realistic way to program this in the future would be to have the employee move it out of their way. If the customer had to move the trolley, perhaps the customer's traits could become more angry or annoyed.

3. Employee AI Feedback

3.1) Do you think that the employees made good, and realistic decisions? Please describe how you came to your conclusion.

The employee named James was moving and replacing stock which at most times was necessary, however there was at one point upwards of 100+ items being restocked on the trolley when only a few customers had come in so far during the allocated time. What was realistic, however, is that the employee restocked the items in large quantities, instead of restocking each individual item that had been purchased. I did notice the employees talking to customers at suitable times, for example Michael talking to customers at the checkout, and James talking to customers as they ask to get past him. This was a great addition to the simulation.

3.2) The employees were programmed to get out of the way of a customer if they were asked to move. Did you notice this? If you did, did you think it looked realistic?

I did notice that employees moved out of the way of customers, namely James when he was working on the front shelves in the second half of the simulation. It took a little while for him to move, however once he did, the customer was able to continue their path through the shop.

3.3) Could you describe any ways that the employee could be made more intelligent?

The aforementioned talking between customers and employees is very useful in this simulation, but what could be a great next step is to have employees ask customers around the shop if they need any help with anything, or if there are any items they cannot find. The employee could then take the customer to the requested item.

4. Customer AI Feedback

4.1) The customers were programmed to pick up the items they needed and then head to the checkout. If another character was in their way, they would wait 5 seconds, and then try and find a way around the character, if both of those failed, they would ask the character to move. Did you notice this behaviour? If you did, did you feel that it looked realistic?

I did notice the wait time of 5 seconds, and that the customer would try and find a way around another character. This worked well with a customer-to-customer interaction, however with a customer-to-employee interaction, the customer would not move around the employee. Instead, they would wait 5 seconds and ask the employee to move, which he would. This was quite a realistic behaviour, however in order for it to be more realistic, the employee should move out of a customer's way without being asked.

4.2) Could you describe any ways that the customers could be made more intelligent?

There was one incident of a customer pile-up, whereby around 15 customers were stuck and unable to move past one another. This, however, is something that can be excused for as this program is in its beta stage and bugs are expected at this stage.

5. Relationship AI Feedback

Subtle relationship behaviour was programmed into the characters. If they found themselves next to another character they had a good enough relationship with they would say help to them, then they would choose to have a conversation with that character. Depending upon what they talk about, and the traits of the characters that are talking, the characters' relationship with each other would either increase or decrease.

5.1) Did you notice any conversations taking place? If you did, did they look realistic? Is there anything that would make it look more realistic?

The conversations were realistic, as they would only occur when two characters are next to each other, not when they are far apart or on opposite sides of furniture. In order for it to be more realistic, perhaps the characters' traits could be influenced by the conversation, e.g. happy, annoyed, etc.

5.2) Can you think of anyways to make it more clear when characters are conversing? Such as speech bubbles above their heads, or happy and sad faces appearing when they gain or lose relationship.

Speech bubbles would be a great idea to show that they are conversing, with the addition of happy, neutral or sad faces at the end of the conversation depending on how strong their relationship is and what their traits are.

6. Traits AI Feedback

6.1) All the characters have their own personal traits such as friendly, and lazy. These traits were used to affect how characters interacted with each other, as well as certain attributes

I did not notice much difference between the characters other than their speed walking through the store. I feel like the traits could be emphasized more with the addition of how customers interact with each other – perhaps if two people with the same trait are conversing, it could affect or have an influence on people nearby?

associated with the characters such as their maximum speed etc. Did you notice these traits? If you did, did you feel like they were used in a realistic way? Is there anything that could be further developed with the traits to make the character more realistic and interact with each other in a more realistic way?

7. Pathfinding Feedback

The pathfinding is the first step in any advanced AI system. The system in this program uses the A* pathfinding algorithm which is the fastest and more optimal algorithm currently developed.

7.1) Do you think that the characters took realistic paths to their destinations? Sometimes if the AI takes the most optimal path, it may look unrealistic so keep that in mind. Please explain your answer with examples of why or why not you agree.

Most people do follow the same path when in a shop, particularly a food shop. This is demonstrated through the customers' pathfinding. If some customers only needed items from the big freezers on the right, however, it might make more sense for them to go straight there without first going up and down each aisle of front shelves and big fridges.

8. Additions added to AI in possible further development

8.1) Line-Of-Sight was the first thing to be implemented given more time. Currently all the characters have a full awareness of the entire world, they can find any item on any shelf, and find any character in the world even if they are very far away. With line-of-sight, systems could be developed and added which allows characters to need to walk tile by tile and search for their needs. They would also be able to 'see' other character that are not next to them and engage with them in a more realistic way. Do you agree that line-of-sight would advance the realism and intelligence of the AI considerable? If you do not agree, please explain why, and perhaps suggest your own ways the AI could become more realistic in terms of knowing things about their environment.

I agree that being able to 'see' other characters that are not next to them and being able to engage with them would be more realistic. However, I personally disagree with the notion of using line-of-sight for needing to search for each item – many people use the same supermarket each time and have a good idea as to where most products are located. Perhaps line-of-sight could be used only once the customer has got to the correct aisle?

8.2) Linked closely with line-of-sight; partially explored pathfinding algorithms could be developed. The idea behind this is that currently, a character can make a perfect path from any tile to any other tile, even if it is 100s of tile away. This is because they can 'see' the entire map. Partially explored pathfinding would mean that characters would have a blank view of the map and only know about other characters and furniture if they see them using their line-of-sight. This would create a realistic looking pathfinding system which could take characters down dead-ends and non-optimal paths, which is impossible with full map awareness. Do you agree that partially explored pathfinding algorithms would create a more realistic looking pathfinding AI? If not, why do you disagree, and can you think of any ways to create a more realistic pathfinding system?

This would be a great addition if used for only a percentage of the customers. As aforementioned, many customers often use the same supermarket or shop multiple times and so have a rough idea of the layout already. However, if this idea of partially-explored pathfinding algorithms were to be used for a few of the customers, this could represent a very likely scenario. This would also enable employees to interact with these customers more to offer advice.

8.3) Please think about other ideas and concepts that could be added into the program to create a more realistic AI. Maybe talk about it at a general level and if you can, go into details about possible ways to implement the ideas. The box is a lot larger than the other. Please do not feel like you must fill the entire box. Any amount of feedback here is fine.

More development of the way people interact with each other based on their traits could be an interesting aspect to take into account. This would enable the simulation to show how people realistically interact with each other depending on whether they have positive or negative traits associated with them. For example, if an angry customer were to come into the store, how would that affect other customers, and how would the employees react? The environment could have situations happen in it whereby employees have to react. For example, if a customer were to drop or spill an item that needed to be cleaned up, it would influence the relationship and current task performed by the employee.

Appendix 4

Thank you for taking part in the testing process. DISCLAIMER: Please be aware while you answer these questions:

The program is in Beta Testing. Bugs are present and are known. Please try to ignore obvious bugs as much as you can. There are a few graphical bugs/glitches which would be solved with the addition of animation, for example.

The focus on this project is the artificial intelligence (AI) systems. The program's UI, art work, and other general program systems such as lack of animations are immensely underdeveloped. Please answer these questions with thought only on the AI and not on the artwork, or lack of other engaging systems which would otherwise be in place in a fully developed program.

1. General Concept Feedback

1.1) Imagining a fully developed, intelligent program which allows users to create very complex and fully customizable maps and scenarios, do you think that with enough development this program can be used as a good tool to train shop employees to allows them to experience unique scenarios and optimize their customer service skills? Please explain reasons for your response.

I believe so, I feel that it would be used well with induction day training, rather than in store. With editing and creating different scenarios it'll enable individual stores to tailor it more specifically to their policies, for example Tesco's will have different ways of doing things compared to The Co-operative. I also feel that it would be a good idea to add a questions and answers section, such as multiple choice on situations such as a troublesome customer or enquiries that someone who is in training would be unsure of. This could be done by an exclamation mark appearing over the employees head to alert the user.

1.2) If you and think that both the concept is good, and this program can be used a good baseline, and you did not cover it above, please describe why.

1.3) If you think that the concept is good, but this program is not a good baseline for further development, and you didn't cover it above, please describe why.

1.4) If you think that the main concept of this program is bad, and that this idea couldn't be developed well, and you didn't cover it above, please describe why.

2. General Artificial Intelligence (AI) Feedback

2.1) Please describe your thoughts on the general AI used in the program? Please think about the decisions they made, and compare their decision to ones you would typically see in real life.

I believe that the AI in the program is great as a unfinished product, obviously there is much room for development as I'm sure you have already thought. For example the connection between the employee and the stock level is brilliant and the response of the cashier to an oncoming transaction is excellent. It works well with real life situations in retail where you are expected to respond to customers without hesitation to maintain customer satisfaction. This has been shown brilliantly with the way that the relationship can increase and decrease during the hour of gameplay.

2.2) Did the AI seem simple, and not very smart? If so, please describe how you came to that conclusion, and maybe some suggestions for making the AI seem more realistic. If you think the AI was smart, and it did seem to make some good decisions, can you pin point why it seemed smart, and if there is anything that can improve it even more?

The AI seemed brilliant and had great interaction skills. Response time to situations in the shop was quick and seemed to flow incredibly well for a concept of the program.

2.3) If a trolley was in a character's way, they were programmed to find the nearest free tile from the trolley that wasn't in their way and then move the trolley there. Did you notice this behaviour? If you did, did you think it looked realistic?

The game had excellent flow to it, sure you're going to have the odd imperfection during the hours gameplay, however I didn't notice any faults in staff or customers being stuck with any objects in the way.

3. Employee AI Feedback

3.1) Do you think that the employees made good, and realistic decisions? Please describe how you came to your conclusion.

Employees made good decisions on tasks that needed to be completed and in a real life situation worked efficiently, which would be how employers would like to show trainees how to work. I also noticed that generally the relationship with the cashier and the customers seemed to increase upon every visit, which would be a message that employers would like to address to new staff members (great customer service.)

3.2) The employees were programmed to get out of the way of a customer if they were asked to move. Did you notice this? If you did, did you think it looked realistic?

I will be honest and didn't notice that customers asked the staff to move. But as I've said before the way how the game flowed generally made me feel that customers were not inconvenienced by staff members, with helps this point.

3.3) Could you describe any ways that the employee could be made more intelligent?

Work on different or difficult situations for them. You could also add damage to stock and give a different alert that would make the staff member have to deal with this and then have to go back to the tasks that they were completing before.

I was looking in particular at the relationship with the cashier and the customer, this is was impressed by as it gave me the everyday situation in find myself in with my current working role. I noticed that customers relationship seemed to grow with the odd transaction decreasing in points. This seemed realistic but there could be plenty of developments in it, especially when a finished product would be used in a real life situation.

4. Customer AI Feedback

4.1) The customers were programmed to pick up the items they needed and then head to the checkout. If another character was in their way, they would wait 5 seconds, and then try and find a way around the character, if both of those failed, they would ask the character to move. Did you notice this behaviour? If you did, did you feel that it looked realistic?

I did not notice this behaviour. However this would look realistic in any retail store, customers will often to waiting in the same place in real life.

4.2) Could you describe any ways that the customers could be made more intelligent?

Could have a running total of how much the customer is spending as they're walking through the store. It's far from necessary but could look smarter within the game.

5. Relationship AI Feedback

Subtle relationship behaviour was programmed into the characters. If they found themselves next to another character they had a good enough relationship with they would say help to them, then they would choose to have a conversation with that character. Depending upon what they talk about, and the traits of the characters that are talking, the characters' relationship with each other would either increase or decrease.

5.1) Did you notice any conversations taking place? If you did, did they look realistic? Is there anything that would make it look more realistic?

5.2) Can you think of anyways to make it more clear when characters are conversing? Such as speech bubbles above their heads, or happy and sad faces appearing when they gain or lose relationship.

Speech bubbles would be a brilliant add on, however I feel that a simple icon would be enough with maybe an emoji like icon to see how the customer and staff members are fairing during gameplay.

6. Traits AI Feedback

6.1) All the characters have their own personal traits such as friendly, and lazy. These traits were used to affect how characters interacted with each other, as well as certain attributes associated with the characters such as their maximum speed etc. Did you notice these traits? If you did, did you feel like they were used in a realistic way? Is there anything that could be further developed with the traits to make the character more realistic and interact with each other in a more realistic way?

I feel the traits were obvious within the hour of gameplay however I don't feel that they're particularly that important if they were used to training in a real life situation. For example the employer wouldn't want to promote a staff member as lazy as it'll give of the wrong impression especially if they want them for work with great customer service and efficiency.

7. Pathfinding Feedback

The pathfinding is the first step in any advanced AI system. The system in this program uses the A* pathfinding algorithm which is the fastest and more optimal algorithm currently developed.

7.1) Do you think that the characters took realistic paths to their destinations? Sometimes if the AI takes the most optimal path, it may look unrealistic so keep that in mind. Please explain your answer with examples of why or why not you agree.

The customers seemed to take the quickest path but it make for a more realistic game if they don't every time which was noticeable in the game. It was good because sometimes a customer will back track because they'll have forgotten an item which they wanted to purchase. All in all the game and how the customers and staff walked around the game was good with great flow.

8. Additions added to AI in possible further development

There were a few systems that could have been added into this program given more time to fully develop them. After describing them, please give your feedback on whether these systems would advance the AI and make the character more realistic.

8.1) Line-Of-Sight was the first thing to be implemented given more time. Currently all the characters have a full awareness of the entire world, they can find any item on any shelf, and find any character in the world even if they are very far away. With line-of-sight, systems could be developed and added which allows characters to need to walk tile by tile and search for their needs. They would also be able to 'see' other character that are not next to them and engage with them in a more realistic way. Do you agree that line-of-sight would advance the realism and intelligence of the AI considerable? If you do not agree, please explain why, and perhaps suggest your own ways the AI could become more realistic in terms of knowing things about their environment.

Yes because customers in real life won't necessarily know where an item is in the shop. This would be great cause an alert could come up and a staff member would have to react to that as quickly as possible. For example when I'm working stock that we always get asked to find is eggs which seems to always be in the most ridiculous of places in store.

8.2) Linked closely with line-of-sight; partially explored pathfinding algorithms could be developed. The idea behind this is that currently, a character can make a perfect path from any tile to any other tile, even if it is 100s of tile away. This is because they can 'see' the entire map. Partially explored pathfinding would mean that characters would have a blank view of the map and only know about other characters and furniture if they see them using their line-of-sight. This would create a realistic looking pathfinding system which could take characters down dead-ends and non-optimal paths, which is impossible with full map awareness. Do you agree that partially explored pathfinding algorithms would create a more

Yes, because it would give the game much more room to develop and become more complex, also allowing personalisation of the game to suit the retailers that would be using this is training.

realistic looking pathfinding AI? If not, why do you disagree, and can you think of any ways to create a more realistic pathfinding system?

8.3) Please think about other ideas and concepts that could be added into the program to create a more realistic AI. Maybe talk about it at a general level and if you can, go into details about possible ways to implement the ideas. The box is a lot larger than the other. Please do not feel like you must fill the entire box. Any amount of feedback here is fine.

I believe that I have given enough ideas throughout my feedback in these questions and don't have much else to add. Overall I'm impressed by the concept and feel that it would work brilliantly in a real life situation.

Appendix 5

Thank you for taking part in the testing process. DISCLAIMER: Please be aware while you answer these questions:

The program is in Beta Testing. Bugs are present and are known. Please try to ignore obvious bugs as much as you can. There are a few graphical bugs/glitches which would be solved with the addition of animation, for example.

The focus on this project is the artificial intelligence (AI) systems. The program's UI, art work, and other general program systems such as lack of animations are immensely underdeveloped. Please answer these questions with thought only on the AI and not on the artwork, or lack of other engaging systems which would otherwise be in place in a fully developed program.

1. General Concept Feedback

1.1) Imagining a fully developed, intelligent program which allows users to create very complex and fully customizable maps and scenarios, do you think that with enough development this program can be used as a good tool to train shop employees to allows them to experience unique scenarios and optimize their customer service skills? Please explain reasons for your response.

Perhaps. Immersing employees in real life tasks is better to gain confidence and skills. For example, if a new employee is shy and not good with conversation starters, training already covers ways to greet and start small talk. I found that the program gave an idea of how a shop runs but the trainer can easily say it was well. It also feels like it does not add much to service skills as you do not see the dialogue between the staff and customer, just them walking around and their level of relationship.

1.2) If you and think that both the concept is good, and this program can be used a good baseline, and you did not cover it above, please describe why.

1.3) If you think that the concept is good, but this program is not a good baseline for further development, and you didn't cover it above, please describe why.

It has potential if customizable for example retail versus a grocery store.

1.4) If you think that the main concept of this program is bad, and that this idea couldn't be developed well, and you didn't cover it above, please describe why.

2. General Artificial Intelligence (AI) Feedback

2.1) Please describe your thoughts on the general AI used in the program? Please think about the decisions they made, and compare their decision to ones you would typically see in real life.

I personally found it a little confusing and did not understand decisions made, just the avatars walking around and checking out.

2.2) Did the AI seem simple, and not very smart? If so, please describe how you came to that conclusion, and maybe some suggestions for making the AI seem more realistic. If you think the AI was smart, and it did seem to make some good decisions, can you pin point why it seemed smart, and if there is anything that can improve it even more?

I did find it simple, knowledge gained from it is already known if you go shopping. Eg. Customer walks around, walks past staff, perhaps some small talk, checks out. Positive- it showed what not to do. James character was in the back standing and doing nothing for the majority of the simulation, and Michael character never left the cash desk. In retail that I have experienced you are not meant to stay in one spot for too long and greet people as they enter.

2.3) If a trolley was in a character's way, they were programmed to find the nearest free tile from the trolley that wasn't in their way and then move the trolley there. Did you notice this behaviour? If you did, did you think it looked realistic?

Yes I saw this occur. In terms of realism they took too long to move, usually its subconscious and people move within seconds.

3. Employee AI Feedback

3.1) Do you think that the employees made good, and realistic decisions? Please describe how you came to your conclusion.

Cashier made relationships with those checking out which would occur in real life. Stock person (James) not that good considering he stayed out back for a long period of time and it had gotten busy in the shop, in real life he would have been called out front due to only two members of staff.

3.2) The employees were programmed to get out of the way of a customer if they were asked to move. Did you notice this? If you did, did you think it looked realistic?

Yes this was noticed. And not really, staff usually move for customers quickly and found it took too long.

3.3) Could you describe any ways that the employee could be made more intelligent?

4. Customer AI Feedback

4.1) The customers were programmed to pick up the items they needed and then head to the checkout. If another character was in their way, they would wait 5 seconds, and then try and find a way around the character, if both of those failed, they would ask the character to move. Did you notice this behaviour? If you did, did you feel that it looked realistic?

No I did not notice.

4.2) Could you describe any ways that the customers could be made more intelligent?

5. Relationship AI Feedback

Subtle relationship behaviour was programmed into the characters. If they found themselves next to another character they had a good enough relationship with they would say help to them, then they would choose to have a conversation with that character. Depending upon what they talk about, and the traits of the characters that are talking, the characters' relationship with each other would either increase or decrease.

5.1) Did you notice any conversations taking place? If you did, did they look realistic? Is there anything that would make it look more realistic?

Maybe put a speech bubble to make it more obvious this was happening. In terms of realism not really, however it is over simplified.

5.2) Can you think of anyways to make it more clear when characters are conversing? Such as speech bubbles above their heads, or happy and sad faces appearing when they gain or lose relationship.

Speech bubbles and emotions would make it clearer.

6. Traits AI Feedback

6.1) All the characters have their own personal traits such as friendly, and lazy. These traits were used to affect how characters interacted with each other, as well as certain attributes associated with the characters such as their maximum speed etc. Did you notice these traits? If you did, did you feel like they were used in a realistic way? Is there anything that could be further developed with the traits to make the character more realistic and interact with each other in a more realistic way?

I noticed the traits when I clicked on characters. Not realistic as in a shop environment you do not have access to that information. Sometimes you do not know how a person will react and how to deal with difficult customers until you observe it for yourself.

7. Pathfinding Feedback

The pathfinding is the first step in any advanced AI system. The system in this program uses the A* pathfinding algorithm which is the fastest and more optimal algorithm currently developed.

7.1) Do you think that the characters took realistic paths to their destinations? Sometimes if the AI takes the most optimal path, it may look unrealistic so keep that in mind. Please explain your answer with examples of why or why not you agree.

Yes; Customers seemed to be realistic starting at the front and working their way around.

8. Additions added to AI in possible further development

There were a few systems that could have been added into this program given more time to fully develop them. After describing them, please give your feedback on whether these systems would advance the AI and make the character more realistic.

8.1) Line-Of-Sight was the first thing to be implemented given more time. Currently all the characters have a full awareness of the entire world, they can find any item on any shelf, and find any character in the world even if they are very far away. With line-of-sight, systems could be developed and added which allows characters to need to walk tile by tile and search for their needs. They would also be able to 'see' other character that are not next to them and engage with them in a more realistic way. Do you agree that line-of-sight would advance the realism and intelligence of the AI considerable? If you do not agree, please explain why, and perhaps suggest your own ways the AI could become more realistic in terms of knowing things about their environment.

Yes that would improve the simulations as most people do not know where a specific item they are looking for is located.

8.2) Linked closely with line-of-sight; partially explored pathfinding algorithms could be developed. The idea behind this is that currently, a character can make a perfect path from

Yes not having perfect pathways would be more realistic as dead ends occur in shops and you never know what other people are going to turn a corner and block you.

any tile to any other tile, even if it is 100s of tile away. This is because they can 'see' the entire map. Partially explored pathfinding would mean that characters would have a blank view of the map and only know about other characters and furniture if they see them using their line-of-sight. This would create a realistic looking pathfinding system which could take characters down dead-ends and non-optimal paths, which is impossible with full map awareness. Do you agree that partially explored pathfinding algorithms would create a more realistic looking pathfinding AI? If not, why do you disagree, and can you think of any ways to create a more realistic pathfinding system?

8.3) Please think about other ideas and concepts that could be added into the program to create a more realistic AI. Maybe talk about it at a general level and if you can, go into details about possible ways to implement the ideas. The box is a lot larger than the other. Please do not feel like you must fill the entire box. Any amount of feedback here is fine.

Not sure as I personally would not want to learn skills in this way. Perhaps having the different work places (eg retail and shop) options would better suit the trainee. Seeing the characters walk around and gain 'relationship' is seen in everyday life through observation so I do not feel this added to a skill set. Perhaps scenarios would be better to represent some instances that may be encountered such as Customer A asks where is X item and Employee B escorts them to where the item can be found.

Appendix 6

Thank you for taking part in the testing process. DISCLAIMER: Please be aware while you answer these questions:

The program is in Beta Testing. Bugs are present and are known. Please try to ignore obvious bugs as much as you can. There are a few graphical bugs/glitches which would be solved with the addition of animation, for example.

The focus on this project is the artificial intelligence (AI) systems. The program's UI, art work, and other general program systems such as lack of animations are immensely underdeveloped. Please answer these questions with thought only on the AI and not on the artwork, or lack of other engaging systems which would otherwise be in place in a fully developed program.

1. General Concept Feedback

1.1) Imagining a fully developed, intelligent program which allows users to create very complex and fully customizable maps and scenarios, do you think that with enough development this program can be used as a good tool to train shop employees to allows them to experience unique scenarios and optimize their customer service skills? Please explain reasons for your response.

I believe that this would be a good tool to help users in the service industry get an understanding of the types of scenarios that they would face in day to day work life, however, I believe that there is a certain element of customer service that can only be learned through real life experience and interactions with customers on the sales floor. However, for the purposes of training basic jobs and responsibilities, I believe this tool (fully developed) could be very useful.

1.2) If you and think that both the concept is good, and this program can be used a good baseline, and you did not cover it above, please describe why.

See above

1.3) If you think that the concept is good, but this program is not a good baseline for further development, and you didn't cover it above, please describe why.

See above

1.4) If you think that the main concept of this program is bad, and that this idea couldn't be developed well, and you didn't cover it above, please describe why.

See above

2. General Artificial Intelligence (AI) Feedback

2.1) Please describe your thoughts on the general AI used in the program? Please think about the decisions they made, and compare their decision to ones you would typically see in real life.

The types of foods that the customers were selecting seemed to be quite repetitive – I am not sure if this is because the project is still in early development and there weren't many items of food to choose from. Also, the pathways that the characters took seemed a little random, not really true to life of how my experience of shopping is. However, some people may shop differently to me!

2.2) Did the AI seem simple, and not very smart? If so, please describe how you came to that conclusion, and maybe some suggestions for making the AI seem more realistic. If you think the AI was smart, and it did seem to make some good decisions, can you pin point why it seemed smart, and if there is anything that can improve it even more?

Yes, but I did not experience many interactions, so it may have just been that I was missing something.

2.3) If a trolley was in a character's way, they were programmed to find the nearest free tile from the trolley that wasn't in their way and then move the trolley there. Did you notice this behaviour? If you did, did you think it looked realistic?

I cannot say that I noticed this behaviour

3. Employee AI Feedback

3.1) Do you think that the employees made good, and realistic decisions? Please describe how you came to your conclusion.

Yes, they seemed to be alert when it came to restocking and being at the till. However, it is again hard to know what employees are doing other than just wandering around.

3.2) The employees were programmed to get out of the way of a customer if they were asked to move. Did you notice this? If you did, did you think it looked realistic?

I did notice this, and it was realistic – however, in my experience, shop assistants will just wait patiently for customers to move out of the way!

3.3) Could you describe any ways that the employee could be made more intelligent?

Sometimes there are duties off of the shop floor that require attending to – perhaps a phone call or an email to respond to?

4. Customer AI Feedback

4.1) The customers were programmed to pick up the items they needed and then head to the checkout. If another character was in their way, they would wait 5 seconds, and then try and find a way around the character, if both of those failed, they would ask the character to move. Did you notice this behaviour? If you did, did you feel that it looked realistic?

I noticed that they would try and go around, but did not notice them asking another customer to move. I thought that this was very realistic, however some people would not wait any length of time because they are impatient. Maybe something to put in the future?

4.2) Could you describe any ways that the customers could be made more intelligent?

See above

5. Relationship AI Feedback

Subtle relationship behaviour was programmed into the characters. If they found themselves next to another character they had a good enough relationship with they would say help to them, then they would choose to have a conversation with that character. Depending upon what they talk about, and the traits of the characters that are talking, the characters' relationship with each other would either increase or decrease.

5.1) Did you notice any conversations taking place? If you did, did they look realistic? Is there anything that would make it look more realistic?

I can't say that I noticed any conversations taking place, I don't know if I was just missing something but all the characters seemed to do is just wander around and buy stuff.

5.2) Can you think of anyways to make it more clear when characters are conversing? Such as speech bubbles above their heads, or happy and sad faces appearing when they gain or lose relationship.

Speech bubbles would have been perfect, or even some indication that they needed to be clicked on to see conversation. Plus and minus signs towards positive and negative relationship advancement would have also been useful.

6. Traits AI Feedback

6.1) All the characters have their own personal traits such as friendly, and lazy. These traits were used to affect how characters interacted with each other, as well as certain attributes associated with the characters such as their maximum speed etc. Did you notice these traits? If you did, did you feel like they were used in a realistic way? Is there anything that could be further developed with the traits to make the character more realistic and interact with each other in a more realistic way?

I saw the traits, and noticed that the people with negative traits such as lazy seemed to take longer to shop, perhaps because they were walking slower? Other than this, I am not sure of any further impact that they had on the actions of the individuals.

7. Pathfinding Feedback

The pathfinding is the first step in any advanced AI system. The system in this program uses the A* pathfinding algorithm which is the fastest and more optimal algorithm currently developed.

7.1) Do you think that the characters took realistic paths to their destinations? Sometimes if the AI takes the most optimal path, it may look unrealistic so keep that in mind. Please explain your answer with examples of why or why not you agree.

Yes, most of the characters moved efficiently to their next destination – I noticed a few of the characters moving backwards and forwards in the same space from time to time but I am not sure if this was deliberate to show indecisiveness, etc.

8. Additions added to AI in possible further development

There were a few systems that could have been added into this program given more time to fully develop them. After describing them, please give your feedback on whether these systems would advance the AI and make the character more realistic.

8.1) Line-Of-Sight was the first thing to be implemented given more time. Currently all the characters have a full awareness of the entire world, they can find any item on any shelf, and find any character in the world even if they are very far away. With line-of-sight, systems could be developed and added which allows characters to need to walk tile by tile and search for their needs. They would also be able to 'see' other character that are not next to them and engage with them in a more realistic way. Do you agree that line-of-sight would advance the realism and intelligence of the AI considerable? If you do not agree, please explain why, and perhaps suggest your own ways the AI could become more realistic in terms of knowing things about their environment.

I agree that this would be a logical step to take in developing the AI to act more realistically – in the real world people often have conversations with people that are not directly next to them.

8.2) Linked closely with line-of-sight; partially explored pathfinding algorithms could be developed. The idea behind this is that currently, a character can make a perfect path from any tile to any other tile, even if it is 100s of tile away. This is because they can 'see' the entire map. Partially explored pathfinding would mean that characters would have a blank view of the map and only know about other characters and furniture if they see them using their line-of-sight. This would create a realistic looking pathfinding system which could take characters down dead-ends and non-optimal paths, which is impossible with full map awareness. Do you agree that partially explored pathfinding algorithms would create a more realistic looking pathfinding AI? If not, why do you disagree, and can you think of any ways to create a more realistic pathfinding system?

I do yes, as sometimes situations arise in which a current pathway becomes blocked and the individual must find a way around.

8.3) Please think about other ideas and concepts that could be added into the program to create a more realistic AI. Maybe talk about it at a general level and if you can, go into details about possible ways to implement the ideas. The box is a lot larger than the other. Please do not feel like you must fill the entire box. Any amount of feedback here is fine.

I am not particularly knowledgeable about AI systems but I definitely think that having some visual indication that makes it clear what the individuals are doing (talking in speech bubbles, thought bubbles to show indecisiveness or contemplation) would make the experience better. Also, a greater variety of situations in which the employee/customer has to deal with situations unexpectedly – an angry customer, a phone call from head office, etc.

Appendix 7

Thank you for taking part in the testing process. DISCLAIMER: Please be aware while you answer these questions:

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The focus on this project is the artificial intelligence (AI) systems. The program's UI, art work, and other general program systems such as lack of animations are immensely underdeveloped. Please answer these questions with thought only on the AI and not on the artwork, or lack of other engaging systems which would otherwise be in place in a fully developed program.

- General Concept Feedback

1.1) Imagining a fully developed, intelligent program which allows users to create very complex and fully customizable maps and scenarios, do you think that with enough development this program can be used as a good tool to train shop employees to allows them to experience unique scenarios and optimize their customer service skills? Please explain reasons for your response.

- As a retail employee, I think that this would be a good program if it was fully developed to help train newer staff. If you could customize the maps to replicate your own store and the managers could create different scenarios to play out then I think you could help use it to show how to react in certain situations that new staff haven't experienced yet. It would be helpful to show how the store is laid out and what jobs are happening elsewhere in the store whilst others are also working.
Although to counter that, I also believe that some tasks you can't learn without doing them physically yourself. Some scenarios cannot be prepared for simply by viewing them on a screen, and it takes personal time, effort and experience to learn/prepare yourself for.

1.2) If you and think that both the concept is good, and this program can be used a good baseline, and you did not cover it above, please describe why.

1.3) If you think that the concept is good, but this program is not a good baseline for further development, and you didn't cover it above, please describe why.

1.4) If you think that the main concept of this program is bad, and that this idea couldn't be developed well, and you didn't cover it above, please describe why.

- General Artificial Intelligence (AI) Feedback

2.1) Please describe your thoughts on the general AI used in the program? Please think about the decisions they made, and compare their decision to ones you would typically see in real life.

- Overall I thought the AI was simple but effective! It appeared realistic and both the workers and customers seemed to react normally. Customers were shopping for what they wanted and the workers would work around them, showing courtesy to the customer as you would in real life. You wouldn't push a customer out of the way to get your work done so I was happy to see that didnt happen here!

2.2) Did the AI seem simple, and not very smart? If so, please describe how you came to that conclusion, and maybe some suggestions for making the AI seem more realistic. If you think the AI was smart, and it did seem to make some good decisions, can you pin point why it seemed smart, and if there is anything that can improve it even more?

- The AI seemed simple but I think it works well, even if there were a few minor hiccups. The only problem I experienced was when the store became busy, one of the workers became surrounded by customers in the bottom left corner shelf trying to get to the register. The worker couldnt move the customers out of their tiles and since the customers had the items they wanted but couldnt get to the register they just kept piling up! Although kind of funny to watch I'd like to think in real life there would be a few more registers or staff to help him out haha.

2.3) If a trolley was in a character's way, they were programmed to find the nearest free tile from the trolley that wasn't in their way and then move the trolley there. Did you notice this behaviour? If you did, did you think it looked realistic?

- I did notice this and saw that it worked well. It looked realistic as I've personally done this at my own job many times. You want your customers to view all of your stores stock so if something is in the way you'd happily move it for them.

- Employee AI Feedback

3.1) Do you think that the employees made good, and realistic decisions? Please describe how you came to your conclusion.

- I think the employees made good decisions and worked well. The would move out of the way of customers and do keep the shelves stocked until full. The only time I would suggest they arent realistic is in the bug I experienced in a previous answer. Maybe if the workers could move past customers to the tile behind them when surrounded?

3.2) The employees were programmed to get out of the way of a customer if they were asked to move. Did you notice this? If you did, did you think it looked realistic?

- Yes I did notice this and thought it worked as intended. The instance it did not was when the worker was surrounded by shelves and the remainder of tiles by customers. They couldn't move for the customer as all available tiles have been taken.

3.3) Could you describe any ways that the employee could be made more intelligent?

- If the employees could move past customers if all surrounding tiles are occupied, or if they could greet customers when in proximity to the door.

- Customer AI Feedback

4.1) The customers were programmed to pick up the items they needed and then head to the checkout. If another character was in their way, they would wait 5 seconds, and then try and find a way around the character, if both of those failed, they would ask the character to move. Did you notice this behaviour? If you did, did you feel that it looked realistic?

- I did notice this behaviour, however again in the bug I experienced earlier, there were some tiles free next to other customers, but they did not move even after 5 seconds to let others pass, as they wanted only what was in their pathway. This may have also been part of the bug, I am not sure.
Despite the bug I beleive the original reaction is realistic. All custoemrs wish to shop and view the merchandise in store, and are normally polite to each other and happy enough to move out of the way of others when needed.

4.2) Could you describe any ways that the customers could be made more intelligent?

- If the customers could perhaps not always have a set path through the shelves and store as they seem a little robotic, or if the customers would perhaps speak to each other as well as the workers.

- Relationship AI Feedback

Subtle relationship behaviour was programmed into the characters. If they found themselves next to another character they had a good enough relationship with they would say help to them, then they would choose to have a conversation with that character.

Depending upon what they talk about, and the traits of the characters that are talking, the characters' relationship with each other would either increase or decrease.

5.1) Did you notice any conversations taking place? If you did, did they look realistic? Is there anything that would make it look more realistic?

- Yes I did notice characters interacting and speaking to each other. The actions seemed realistic despite the lack of animations ect. and I think it's also very realistic that the characters relationships change depending on who or what they're talking about. It is a nice subtle addition to the game.
Perhaps if the character lost relationship with another character they would be in a 'bad mood' for a certain time after the conversation. In the case of a worker it could affect their productivity or how slow they work. The customer would perhaps leave the store quicker or not spend as much money.

5.2) Can you think of anyways to make it more clear when characters are conversing? Such as speech bubbles above their heads, or happy and sad faces appearing when they gain or lose relationship.

- The examples given above are exactly what I was going to recommend! Speech bubbles above characters who are talking, happy/sad faces, or even a simple red minus (-) or green plus(+) symbol would give the player more insight into what effects the conversations are having.

Traits AI Feedback

6.1) All the characters have their own personal traits such as friendly, and lazy. These traits were used to affect how characters interacted with each other, as well as certain attributes associated with the characters such as their maximum speed etc. Did you notice these traits? If you did, did you feel like they were used in a realistic way? Is there anything that could be further developed with the traits to make the character more realistic and interact with each other in a more realistic way?

- I did notice these traits and thought they were a nice and realistic addition to the behaviour of the characters! I like the idea of if a character is lazy they will move slower, or if a character is helpful they will speak more to customers. I think this is very realistic interation, and could be used in a lot of different scenarios.
Workers who are alert could move trolleys more quickly, help customers more ect. Workers who are friendly and raise their relationship when in a conversation could put a positive effect on a customer for a short time period and this makes them buy more items. Negative and brash workers would have the opposite effect in conversations, making the customer leave quicker or making the worker slack off more.

- Pathfinding Feedback

The pathfinding is the first step in any advanced AI system. The system in this program uses the A* pathfinding algorithm which is the fastest and more optimal algorithm currently developed.

7.1) Do you think that the characters took realistic paths to their destinations? Sometimes if the AI takes the most optimal path, it may look unrealistic so keep that in mind. Please explain your answer with examples of why or why not you agree.

- Although the path seemed optimal, I noticed most if not around 90% of customers took the exact same path through the store, shelf by shelf, tile by tile. This seems unrealistic as customers in real life back track and look around a lot more, expecially if they've never been to that store before and dont know the layout. Although it may be the quickest and most optimal, it is not the most realistic.

- Additions added to AI in possible further development

There were a few systems that could have been added into this program given more time to fully develop them. After describing them, please give your feedback on whether these systems would advance the AI and make the character more realistic.

8.1) Line-Of-Sight was the first thing to be implemented given more time. Currently all the characters have a full awareness of the entire world, they can find any item on any shelf, and find any character in the world even if they are very far away. With line-of-sight, systems could be developed and added which allows characters to need to walk tile by tile and search for their needs. They would also be able to 'see' other character that are not next to them and engage with them in a more realistic way. Do you agree that line-of-sight would advance the realism and intelligence of the AI considerable? If you do not agree, please explain why, and perhaps suggest your own ways the AI could become more realistic in terms of knowing things about their environment.

- I like this idea and it seems very realistic. Unless youve been to a store a lot you do not know where every item is in there, so for a customer to actively search the shelves and aisles in my opinion would make it far more realistic. New shoppers to the store would not know where they are going straight away, so it would be a nice touch.
It would also make the pathfinding more realistic instead of the customers walking in the exact same path/at the same pace as everyone else. Customer/worker interactions would also be more realistic, as they could look for an employee when needing 'help' or a conversation.

8.2) Linked closely with line-of-sight; partially explored pathfinding algorithms could be developed. The idea behind this is that currently, a character can make a perfect path from any tile to any other tile, even if it is 100s of tile away. This is because they can 'see' the entire map. Partially explored pathfinding would mean that characters would have a blank view of the map and only know about other characters and furniture if they see them using their line-of-sight. This would create a realistic looking pathfinding system which could take characters down dead-ends and non-optimal paths, which is impossible with full map awareness. Do you agree that partially explored pathfinding algorithms would create a more realistic looking pathfinding AI? If not, why do you disagree, and can you think of any ways to create a more realistic pathfinding system?

- I agree with this idea also. Once again, you as a customer do not always know where everything is, so walking around and actively looking for the products they need seems far more realistic than simply following a strict optimal path. They would walk around the store more realisticly, and also spend more time in the store in theory.

8.3) Please think about other ideas and concepts that could be added into the program to create a more realistic AI. Maybe talk about it at a general level and if you can, go into details about possible ways to implement the ideas. The box is a lot larger than the other. Please do not feel like you must fill the entire box. Any amount of feedback here is fine.

- A symbol to show characters conversing. (speech bubble, symbols ect)
- Customers asking for directions to certain items they need, workers walking with them to the desired shelf.
- Negative and psoitive effects of relationship numbers going up or down.
- If a queue is forming of more than a certain number of customers, relationship staus goes down, some customers may leave entirely.
- Workers becoming tired, making their productivity or speed slower.
- Different paths for customers, perhaps some are new and have no knowledge of the store so spend more time looking, others have been before and have a shorter path to the register.

Thank you for taking part in the testing process. DISCLAIMER: Please be aware while you answer these questions:

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The focus on this project is the artificial intelligence (AI) systems. The program's UI, art work, and other general program systems such as lack of animations are immensely underdeveloped. Please answer these questions with thought only on the AI and not on the artwork, or lack of other engaging systems which would otherwise be in place in a fully developed program.

1. General Concept Feedback

1.1) Imagining a fully developed, intelligent program which allows users to create very complex and fully customizable maps and scenarios, do you think that with enough development this program can be used as a good tool to train shop employees to allows them to experience unique scenarios and optimize their customer service skills? Please explain reasons for your response.

If it was linked to VR it might allow an assistant to be trained

1.2) If you and think that both the concept is good, and this program can be used a good baseline, and you did not cover it above, please describe why.

I don't think it offers anything that training in the actual shop couldn't

1.3) If you think that the concept is good, but this program is not a good baseline for further development, and you didn't cover it above, please describe why.

1.4) If you think that the main concept of this program is bad, and that this idea couldn't be developed well, and you didn't cover it above, please describe why.

Appendix 8

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1. General Concept Feedback

1.1) Imagining a fully developed, intelligent program which allows users to create very complex and fully customizable maps and scenarios, do you think that with enough development this program can be used as a good tool to train shop employees to allows them to experience unique scenarios and optimize their customer service skills? Please explain reasons for your response.

If it was linked to VR it might allow an assistant to be trained

1.2) If you and think that both the concept is good, and this program can be used a good baseline, and you did not cover it above, please describe why.

I don't think it offers anything that training in the actual shop couldn't

1.3) If you think that the concept is good, but this program is not a good baseline for further development, and you didn't cover it above, please describe why.

1.4) If you think that the main concept of this program is bad, and that this idea couldn't be developed well, and you didn't cover it above, please describe why.

2. General Artificial Intelligence (AI) Feedback

2.1) Please describe your thoughts on the general AI used in the program? Please think about the decisions they made, and compare their decision to ones you would typically see in real life.

The interactions, particularly between staff and customers work well, when several customers bunched around the assistant and his trolley, the negotiations to move both staff and his trolley worked well

2.2) Did the AI seem simple, and not very smart? If so, please describe how you came to that conclusion, and maybe some suggestions for making the AI seem more realistic. If you think the AI was smart, and it did seem to make some good decisions, can you pin point why it seemed smart, and if there is anything that can improve it even more?

2.3) If a trolley was in a character's way, they were programmed to find the nearest free tile from the trolley that wasn't in their way and then move the trolley there. Did you notice this behaviour? If you did, did you think it looked realistic?

Yes. No it didn't look particularly realistic: customers are generally reluctant to move trolleys out of their way

3. Employee AI Feedback

3.1) Do you think that the employees made good, and realistic decisions? Please describe how you came to your conclusion.

On the whole the employees decisions were realistic. On a couple of runs the one employee got stuck in the stock room and didn't move. Perhaps he'd had enough of putting stock out!

3.2) The employees were programmed to get out of the way of a customer if they were asked to move. Did you notice this? If you did, did you think it looked realistic?

Yes I did notice; this part of the program seemed to work quite well

3.3) Could you describe any ways that the employee could be made more intelligent?

If there were more customers, the staff on the shop floor could help the person on the till if it became busy. The interactions didn't make enough use of the individual's traits and relationships

4. Customer AI Feedback

4.1) The customers were programmed to pick up the items they needed and then head to the checkout. If another character was in their way, they would wait 5 seconds, and then try and find a way around the character, if both of those failed, they would ask the character to move. Did you notice this behaviour? If you did, did you feel that it looked realistic?

Didn't notice this

4.2) Could you describe any ways that the customers could be made more intelligent?

Ask employees for stock not on the shop floor, interact with staff and other customers more

5. Relationship AI Feedback

Subtle relationship behaviour was programmed into the characters. If they found themselves next to another character they had a good enough relationship with they would say help to them, then they would choose to have a conversation with that character. Depending upon what they talk about, and the traits of the characters that are talking, the characters' relationship with each other would either increase or decrease.

5.1) Did you notice any conversations taking place? If you did, did they look realistic? Is there anything that would make it look more realistic?

I noticed some conversations but they didn't seem to have much purpose. I didn't notice any changes in relationship status

5.2) Can you think of anyways to make it more clear when characters are conversing? Such as speech bubbles above their heads, or happy and sad faces appearing when they gain or lose relationship.

Speech bubbles would certainly indicate conversations. I'm not entirely sure of the significance of their relationships to the program

6. Traits AI Feedback

6.1) All the characters have their own personal traits such as friendly, and lazy. These traits were used to affect how characters interacted with each other, as well as certain attributes associated with the characters such as their maximum speed etc. Did you notice these traits? If you did, did you feel like they were used in a realistic way? Is there anything that could be further developed with the traits to make the character more realistic and interact with each other in a more realistic way?

I didn't feel the characters traits were explored thoroughly, particularly the interactions appeared fairly random

7. Pathfinding Feedback

The pathfinding is the first step in any advanced AI system. The system in this program uses the A* pathfinding algorithm which is the fastest and more optimal algorithm currently developed.

7.1) Do you think that the characters took realistic paths to their destinations? Sometimes if the AI takes the most optimal path, it may look unrealistic so keep that in mind. Please explain your answer with examples of why or why not you agree.

Generally, as long as nothing was in their way they seemed to move around fairly purposefully. In a real world situation, particularly in a supermarket, customers do not always move in a purposeful manner, and can go back on themselves, stop for long chats in the middle of aisles etc. while staff are not always operating efficiently

8. Additions added to AI in possible further development

There were a few systems that could have been added into this program given more time to fully develop them. After describing them, please give your feedback on whether these systems would advance the AI and make the character more realistic.

8.1) Line-Of-Sight was the first thing to be implemented given more time. Currently all the characters have a full awareness of the entire world, they can find any item on any shelf, and find any character in the world even if they are very far away. With line-of-sight, systems could be developed and added which allows characters to need to walk tile by tile and search for their needs. They would also be able to 'see' other character that are not next to them and engage with them in a more realistic way. Do you agree that line-of-sight would advance the realism and intelligence of the AI considerable? If you do not agree, please explain why, and perhaps suggest your own ways the AI could become more realistic in terms of knowing things about their environment.

Yes this would make things more realistic

8.2) Linked closely with line-of-sight; partially explored pathfinding algorithms could be developed. The idea behind this is that currently, a character can make a perfect path from any tile to any other tile, even if it is 100s of tile away. This is because they can 'see' the entire map. Partially explored pathfinding would mean that characters would have a blank view of the map and only know about other characters and furniture if they see them using their line-of-sight. This would create a realistic looking pathfinding system which could take characters down dead-ends and non-optimal paths, which is impossible with full map awareness. Do you agree that partially explored pathfinding algorithms would create a more realistic looking pathfinding AI? If not, why do you disagree, and can you think of any ways to create a more realistic pathfinding system?

Again, this would make things more realistic – customers often don't know where an item is located

8.3) Please think about other ideas and concepts that could be added into the program to create a more realistic AI. Maybe talk about it at a general level and if you can, go into details about possible ways to implement the ideas. The box is a lot larger than the other. Please do not feel like you must fill the entire box. Any amount of feedback here is fine.

I do not quite understand whether this is a training program or an "artificial life" system. Perhaps if there was more input from the watcher, or distinct scenarios?

Appendix 9

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1. General Concept Feedback

1.1) Imagining a fully developed, intelligent program which allows users to create very complex and fully customizable maps and scenarios, do you think that with enough development this program can be used as a good tool to train shop employees to allows them to experience unique scenarios and optimize their customer service skills? Please explain reasons for your response.

Absolutely, by accurately replicating the situations new shop employees might find themselves in, they can learn what will happen, and how to be best prepared to deal with it. The fact that it is a program is particularly useful as the customers are not real people, training new shop employees is difficult as it is a fast paced and stressful environment when you are not used to it, so when an employee does not know what to do and asks for help, it can annoy or inconvenience customers, so by using a program there is no risk of annoying customers, and it would allow shops to have new employees who are efficient and knowledgable from the start.

1.2) If you and think that both the concept is good, and this program can be used a good baseline, and you did not cover it above, please describe why.

n/a

1.3) If you think that the concept is good, but this program is not a good baseline for further development, and you didn't cover it above, please describe why.

n/a

1.4) If you think that the main concept of this program is bad, and that this idea couldn't be developed well, and you didn't cover it above, please describe why.

n/a

2. General Artificial Intelligence (AI) Feedback

2.1) Please describe your thoughts on the general AI used in the program? Please think about the decisions they made, and compare their decision to ones you would typically see in real life.

For the most part the behaviours of the customers and workers are very accurate to real life, although I'm not sure as to whether the backshelves are supposed to be a stockroom/ warehouse, if they are, a customer went in there and that would not happen in real life. Customers also went back on themselves a lot, which of course happens sometimes in real life, but from my view not as often as this. There were also not a lot of customers who went straight to the one or two items they needed and left, they often checked the whole shop before buying their one thing, in fact it seems that every customer follows the same path all the way around the shop, which every customer does not do in real life.

2.2) Did the AI seem simple, and not very smart? If so, please describe how you came to that conclusion, and maybe some suggestions for making the AI seem more realistic. If you think the AI was smart, and it did seem to make some good decisions, can you pin point why it seemed smart, and if there is anything that can improve it even more?

It seemed smart, as the customers mostly behaved in very human ways. However, as I said previously, to seem more realistic the customers could follow more different paths around the store.

2.3) If a trolley was in a character's way, they were programmed to find the nearest free tile from the trolley that wasn't in their way and then move the trolley there. Did you notice this behaviour? If you did, did you think it looked realistic?

For the last 40 minutes of my simulation, the worker was in the same place with the trolley by the backshelves, so the customers were not walking past it.

3. Employee AI Feedback

3.1) Do you think that the employees made good, and realistic decisions? Please describe how you came to your conclusion.

Yes, they didn't seem to interact with the customers much, but they did move around them in a realistic way.

3.2) The employees were programmed to get out of the way of a customer if they were asked to move. Did you notice this? If you did, did you think it looked realistic?

Yes, it did look realistic.

3.3) Could you describe any ways that the employee could be made more intelligent?

n/a

4. Customer AI Feedback

4.1) The customers were programmed to pick up the items they needed and then head to the checkout. If another character was in their way, they would wait 5 seconds, and then try and find a way around the character, if both of those failed, they would ask the character to move. Did you notice this behaviour? If you did, did you feel that it looked realistic?

I did not notice them asking to move, but they did wait for others to move. The time they waited almost seemed to be too long as people generally aren't that patient

4.2) Could you describe any ways that the customers could be made more intelligent?

They could follow different paths around the shop

5. Relationship AI Feedback

Subtle relationship behaviour was programmed into the characters. If they found themselves next to another character they had a good enough relationship with they would say help to them, then they would choose to have a conversation with that character. Depending upon what they talk about, and the traits of the characters that are talking, the characters' relationship with each other would either increase or decrease.

5.1) Did you notice any conversations taking place? If you did, did they look realistic? Is there anything that would make it look more realistic?

I noticed a relationship between a customer and an employee when I clicked on one of them. I didn't however know if they were talking

5.2) Can you think of anyways to make it more clear when characters are conversing? Such as speech bubbles above their heads, or happy and sad faces appearing when they gain or lose relationship.

Speech bubbles would definitely make it more clear, and happy and sad faces would help understand their relationship

6. Traits AI Feedback

6.1) All the characters have their own personal traits such as friendly, and lazy. These traits were used to affect how characters interacted with each other, as well as certain attributes associated with the characters such as their maximum speed etc. Did you notice these traits? If you did, did you feel like they were used in a realistic way? Is there anything that could be further developed with the traits to make the character more realistic and interact with each other in a more realistic way?

I did not see any of the traits. However if a trait was lazy for example, they could walk slower than the other customers etc.

7. Pathfinding Feedback

The pathfinding is the first step in any advanced AI system. The system in this program uses the A* pathfinding algorithm which is the fastest and more optimal algorithm currently developed.

7.1) Do you think that the characters took realistic paths to their destinations? Sometimes if the AI takes the most optimal path, it may look unrealistic so keep that in mind. Please explain your answer with examples of why or why not you agree.

I don't think they were all realistic. Some definitely were as people often walk around the whole of the shop to see what they want/need, however almost all of the customers did this, where as in real life many people go to a shop for one or two things so go straight to one aisle or fridge and then leave.

8. Additions added to AI in possible further development

There were a few systems that could have been added into this program given more time to fully develop them. After describing them, please give your feedback on whether these systems would advance the AI and make the character more realistic.

8.1) Line-Of-Sight was the first thing to be implemented given more time. Currently all the characters have a full awareness of the entire world, they can find any item on any shelf, and find any character in the world even if they are very far away. With line-of-sight, systems could be developed and added which allows characters to need to walk tile by tile and search for their needs. They would also be able to 'see' other character that are not next to them and engage with them in a more realistic way. Do you agree that line-of-sight would advance the realism and intelligence of the AI considerable? If you do not agree, please explain why, and perhaps suggest your own ways the AI could become more realistic in terms of knowing things about their environment.

Absolutely, as in real life you can interact with people who are not exactly next to you.

8.2) Linked closely with line-of-sight; partially explored pathfinding algorithms could be developed. The idea behind this is that currently, a character can make a perfect path from any tile to any other tile, even if it is 100s of tile away. This is because they can 'see' the entire map. Partially explored pathfinding would mean that characters would have a blank view of the map and only know about other characters and furniture if they see them using their line-of-sight. This would create a realistic looking pathfinding system which could take characters down dead-ends and non-optimal paths, which is impossible with full map awareness. Do you agree that partially explored pathfinding algorithms would create a more realistic looking pathfinding AI? If not, why do you disagree, and can you think of any ways to create a more realistic pathfinding system?

This would be realistic if come customers used it as in real life some customers know the layout of a shop so know where to go, as if they can see the whole map. But of course some customers would be new to the shop and would have to walk around to find things, or maybe to make it more realistic some could ask an employee where to find things.

8.3) Please think about other ideas and concepts that could be added into the program to create a more realistic AI. Maybe talk about it at a general level and if you can, go into details about possible ways to implement the ideas. The box is a lot larger than the other. Please do not feel like you must fill the entire box. Any amount of feedback here is fine.

I feel as though I have covered what I would say for this in my previous answers?

Appendix 10

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1. General Concept Feedback

1.1) Imagining a fully developed, intelligent program which allows users to create very complex and fully customizable maps and scenarios, do you think that with enough development this program can be used as a good tool to train shop employees to allow them to experience unique scenarios and optimize their customer service skills? Please explain reasons for your response.

Yes, it shows all aspects of the shop, it would be more useful for scenarios like accidents or queues and how to deal with them. However, I don't think that it would really help customer service skills too much because it's not focused on the interactions between the employees and the customers. Maybe there could be a pause in the game to show when they interact at the checkout and then employees could be taught how to deal with difficult customers.

1.2) If you think that both the concept is good, and this program can be used as a good baseline, and you did not cover it above, please describe why.

1.3) If you think that the concept is good, but this program is not a good baseline for further development, and you didn't cover it above, please describe why.

1.4) If you think that the main concept of this program is bad, and that this idea couldn't be developed well, and you didn't cover it above, please describe why.

2. General Artificial Intelligence (AI) Feedback

2.1) Please describe your thoughts on the general AI used in the program? Please think about the decisions they made, and compare their decision to ones you would typically see in real life.

The AI is generally similar to real life except the fact that customers almost always go across the shop in a random pattern, so they go back and forth instead of going from start to finish. Not that it's that important, but customers also forget things when they are at the checkout so maybe there could be a path where they go to the checkout, change their mind and go back across the store to get something else.

2.2) Did the AI seem simple, and not very smart? If so, please describe how you came to that conclusion, and maybe some suggestions for making the AI seem more realistic. If you think the AI was smart, and it did seem to make some good decisions, can you pin point why it seemed smart, and if there is anything that can improve it even more?

The fact that different customers stopped at different shelves and not all the same is realistic just the pattern in which they do it isn't, they come in, go through the shop from left to right but normally people have a list or know where the things they want in the shop are so will jump from place to place. Customers might also go back to the same place a couple of times if they are indecisive. These are all small things though.

2.3) If a trolley was in a character's way, they were programmed to find the nearest free tile from the trolley that wasn't in their way and then move the trolley there. Did you notice this behaviour? If you did, did you think it looked realistic?

It did look realistic and how a customer would normally react to it, another way it could be moved is if the customer interacts with the employee to move it or the employee sees the customer and moves it automatically but it looks fine.

3. Employee AI Feedback

3.1) Do you think that the employees made good, and realistic decisions? Please describe how you came to your conclusion.

Yes, they acted like normal employees and the job changes were good, the employee moving around on the shop floor seemed natural and the one at the checkout put the items through properly and interacted with the customers.

3.2) The employees were programmed to get out of the way of a customer if they were asked to move. Did you notice this? If you did, did you think it looked realistic?

Yes it looked natural because the employee just moved to the next free tile and the customer passed by.

3.3) Could you describe any ways that the employee could be made more intelligent?

The employee could check the shelves before loading a trolley full of products so it could check the stock on the shelves and when one is below a certain amount they could go straight to the back to get the item and restock the shelf, which would make it more realistic.

4. Customer AI Feedback

4.1) The customers were programmed to pick up the items they needed and then head to the checkout. If another character was in their way, they would wait 5 seconds, and then try and find a way around the character, if both of those failed, they would ask the character to move. Did you notice this behaviour? If you did, did you feel that it looked realistic?

It was realistic, obviously there's some bugs so sometimes they end up on the same tile but customers look at the same shelves at the same time in real life anyway.

4.2) Could you describe any ways that the customers could be made more intelligent?

Just as I said above, it's probably not more intelligent because some customers aren't and are all over the shop but moving round the store in a random fashion might be more realistic.

5. Relationship AI Feedback

Subtle relationship behaviour was programmed into the characters. If they found themselves next to another character they had a good enough relationship with they would say help to them, then they would choose to have a conversation with that character. Depending upon what they talk about, and the traits of the characters that are talking, the characters' relationship with each other would either increase or decrease.

5.1) Did you notice any conversations taking place? If you did, did they look realistic? Is there anything that would make it look more realistic?

There were conversations but they were short and a lot of the time customers next to each other wouldn't speak, but normally customers don't talk to long unless they know each other really well so in this case if their relationship level is high. Maybe they could move through the shop together if they were talking or move away from the shelves together as well.

5.2) Can you think of any ways to make it more clear when characters are conversing? Such as speech bubbles above their heads, or happy and sad faces appearing when they gain or lose relationship.

You could have a status bar for the conversation at the top of the screen and have it go different colours such as green when its going up and maybe show the gain or loss in relationships points like "-10" or "+5". You could have sound for the voices but isn't really necessary.

6. Traits AI Feedback

6.1) All the characters have their own personal traits such as friendly, and lazy. These traits were used to affect how characters interacted with each other, as well as certain attributes associated with the characters such as their maximum speed etc. Did you notice these traits? If you did, did you feel like they were used in a realistic way? Is there anything that could be further developed with the traits to make the character more realistic and interact with each other in a more realistic way?

The traits are good and interesting although you could have maybe different moods that they could be in instead so some could be happy so talk to more people and some could be in a bad mood just like the annoying trait you have so could be seen as a more difficult customer. If the traits remain maybe only have ones directly linked to the situation, things like clever and jealous might not be shown in the simulation at all whereas ones like difficult or cheerful or kind can be shown in how they react with other customers and employees.

7. Pathfinding Feedback

The pathfinding is the first step in any advanced AI system. The system in this program uses the A* pathfinding algorithm which is the fastest and more optimal algorithm currently developed.

7.1) Do you think that the characters took realistic paths to their destinations? Sometimes if the AI takes the most optimal path, it may look unrealistic so keep that in mind. Please explain your answer with examples of why or why not you agree.

The way they moved to their destinations seemed natural, they wouldn't always take the quickest way so that's more realistic. When they start off on the left they'll look at the shelves and go up, right and down to their next destination which is most often the longest route instead of going down, right and up.

8. Additions added to AI in possible further development

There were a few systems that could have been added into this program given more time to fully develop them. After describing them, please give your feedback on whether these systems would advance the AI and make the character more realistic.

8.1) Line-Of-Sight was the first thing to be implemented given more time. Currently all the characters have a full awareness of the entire world, they can find any item on any shelf, and find any character in the world even if they are very far away. With line-of-sight, systems could be developed and added which allows characters to need to walk tile by tile and search for their needs. They would also be able to 'see' other characters that are not next to them and engage with them in a more realistic way. Do you agree that line-of-sight would advance the realism and intelligence of the AI considerable? If you do not agree, please explain why, and perhaps suggest your own ways the AI could become more realistic in terms of knowing things about their environment.

Definitely, it would mean that they would be more all over the shop and take longer looking for things which is more realistic. Also if they couldn't find something in their line-of-sight they could always ask the employee to find it for them.

8.2) Linked closely with line-of-sight; partially explored pathfinding algorithms could be developed. The idea behind this is that currently, a character can make a perfect path from any tile to any other tile, even if it is 100s of tile away. This is because they can 'see' the entire map. Partially explored pathfinding would mean that characters would have a blank view of the map and only know about other characters and furniture if they see them using their line-of-sight. This would create a realistic looking pathfinding system which could take characters down dead-ends and non-optimal paths, which is impossible with full map awareness. Do you agree that partially explored pathfinding algorithms would create a more realistic looking pathfinding AI? If not, why do you disagree, and can you think of any ways to create a more realistic pathfinding system?

Yes, it would mean that they would discover the shop aisle by aisle like a normal customer would if they were walking into a shop for the first time. You could even alternate between customers so there could be customers with sight of the whole map (loyal customers who shop there very often) and new customers that have no previous knowledge of the store layout before-hand.

8.3) Please think about other ideas and concepts that could be added into the program to create a more realistic AI. Maybe talk about it at a general level and if you can, go into details about possible ways to implement the ideas. The box is a lot larger than the others. Please do not feel like you must fill the entire box. Any amount of feedback here is fine.

For more tricky situations there could be customers that steal, put things back in the wrong place, return items, break items, spill items. For things such as spilt items it would help the employee put their health and safety training into practice as they'd have to clean it up, have a sign and warn customers about it as well as managing their time to get everything done. There could be random fire alarms so the trainers using the simulation can see what the trainee would do in that situation, how they would get customers out of the store, how they would react and where to go. A lot of the time customers ask for help to find items in the store so maybe (if there isn't already, it didn't happen while I was watching but could still be in there) show the employee showing the customer where it is. A more advanced feature could be a disabled customer because they would have different needs and may need more help or take more time etc. Overall, I think it's a pretty good start it's got all the basic elements, I like that the stock is shown, the relationship levels, the way the items are put through the checkout as well is good.

Appendix 11

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1. General Concept Feedback

1.1) Imagining a fully developed, intelligent program which allows users to create very complex and fully customizable maps and scenarios, do you think that with enough development this program can be used as a good tool to train shop employees to allows them to experience unique scenarios and optimize their customer service skills? Please explain reasons for your response.

Yes. It would provide a complete scenario with the many situations that could happen in the course of a day and hopefully provide solutions to any problems that may occur.

1.2) If you and think that both the concept is good, and this program can be used a good baseline, and you did not cover it above, please describe why.

N/a

1.3) If you think that the concept is good, but this program is not a good baseline for further development, and you didn't cover it above, please describe why.

N/a

1.4) If you think that the main concept of this program is bad, and that this idea couldn't be developed well, and you didn't cover it above, please describe why.

N/a

2. General Artificial Intelligence (AI) Feedback

2.1) Please describe your thoughts on the general AI used in the program? Please think about the decisions they made, and compare their decision to ones you would typically see in real life.

They AI seemed consistent with the daily workings of a retail outlet and as stated in 1.1 with Expansion and optimisation would allow for teaching of the handling for most eventualities.

2.2) Did the AI seem simple, and not very smart? If so, please describe how you came to that conclusion, and maybe some suggestions for making the AI seem more realistic. If you think the AI was smart, and it did seem to make some good decisions, can you pin point why it seemed smart, and if there is anything that can improve it even more?

It was a bit basic but as stated with improvement and optimisation it has the makings of a good retail tool.

2.3) If a trolley was in a character's way, they were programmed to find the nearest free tile from the trolley that wasn't in their way and then move the trolley there. Did you notice this behaviour? If you did, did you think it looked realistic?

Yes. this behaviour was picked up on and it was as realistic as the basic program would allow.

3. Employee AI Feedback

3.1) Do you think that the employees made good, and realistic decisions? Please describe how you came to your conclusion.

The employees made decisions which allowed them to carry out their tasks as required although The employee James when finished facing up seemed to remain in the stock longer than needed Where he could be in the front shop helping out. Was he doing paperwork or just on a tea-break. Now been explained that he was working on back stock.

3.2) The employees were programmed to get out of the way of a customer if they were asked to move. Did you notice this? If you did, did you think it looked realistic?

Yes, it was noticeable and did look realistic.

3.3) Could you describe any ways that the employee could be made more intelligent?

Could the employee be more proactive in helping and talking to the customers.

4. Customer AI Feedback

4.1) The customers were programmed to pick up the items they needed and then head to the checkout. If another character was in their way, they would wait 5 seconds, and then try and find a way around the character, if both of those failed, they would ask the character to move. Did you notice this behaviour? If you did, did you feel that it looked realistic?

Yes this was picked up on and it seemed quite realistic.

4.2) Could you describe any ways that the customers could be made more intelligent?

A lifelong problem for all retail outlets and a lifelong dream to have intelligent customers!

5. Relationship AI Feedback

Subtle relationship behaviour was programmed into the characters. If they found themselves next to another character they had a good enough relationship with they would say help to them, then they would choose to have a conversation with that character. Depending upon what they talk about, and the traits of the characters that are talking, the characters' relationship with each other would either increase or decrease.

5.1) Did you notice any conversations taking place? If you did, did they look realistic? Is there anything that would make it look more realistic?

It was noticed but would it be possible for speech bubbles to be introduced for all conversations to provide an ongoing narrative of what is going on between staff and customers and between customers themselves.

5.2) Can you think of anyways to make it more clear when characters are conversing? Such as speech bubbles above their heads, or happy and sad faces appearing when they gain or lose relationship.

As suggested in 5.1 this would be a great innovation to the program. Also adding emojis would be a good way to progress.

6. Traits AI Feedback

6.1) All the characters have their own personal traits such as friendly, and lazy. These traits were used to affect how characters interacted with each other, as well as certain attributes associated with the characters such as their maximum speed etc. Did you notice these traits? If you did, did you feel like they were used in a realistic way? Is there anything that could be further developed with the traits to make the character more realistic and interact with each other in a more realistic way?

These traits were noticeable when clicking on the character. This could be enhanced as previously suggested by the programmer by using /happy/sad Faces which could be altered when the characters interacted with staff or customers.

7. Pathfinding Feedback

The pathfinding is the first step in any advanced AI system. The system in this program uses the A* pathfinding algorithm which is the fastest and more optimal algorithm currently developed.

7.1) Do you think that the characters took realistic paths to their destinations? Sometimes if the AI takes the most optimal path, it may look unrealistic so keep that in mind. Please explain your answer with examples of why or why not you agree.

It seems all customers use the normal flow through a shop but sometimes a customer should go against the flow in requiring one or two specific items where they would know their locations and would go straight to the shelf or freezer to pick them up.

8. Additions added to AI in possible further development

There were a few systems that could have been added into this program given more time to fully develop them. After describing them, please give your feedback on whether these systems would advance the AI and make the character more realistic.

8.1) Line-Of-Sight was the first thing to be implemented given more time. Currently all the characters have a full awareness of the entire world, they can find any item on any shelf, and find any character in the world even if they are very far away. With line-of-sight, systems could be developed and added which allows characters to need to walk tile by tile and search for their needs. They would also be able to 'see' other character that are not next to them and engage with them in a more realistic way. Do you agree that line-of-sight would advance the realism and intelligence of the AI considerable? If you do not agree, please explain why, and perhaps suggest your own ways the AI could become more realistic in terms of knowing things about their environment.

Yes, line of sight would be better and would allow a more rounded interaction between all characters.

8.2) Linked closely with line-of-sight; partially explored pathfinding algorithms could be developed. The idea behind this is that currently, a character can make a perfect path from any tile to any other tile, even if it is 100s of tile away. This is because they can 'see' the entire map. Partially explored pathfinding would mean that characters would have a blank view of the map and only know about other characters and furniture if they see them using their line-of-sight. This would create a realistic looking pathfinding system which could take characters down dead-ends and non-optimal paths, which is impossible with full map awareness. Do you agree that partially explored pathfinding algorithms would create a more realistic looking pathfinding AI? If not, why do you disagree, and can you think of any ways to create a more realistic pathfinding system?

Yes this would be an improvement which would allow all characters to fully have the control to cover the complete shop and move independently back and forth around the shop giving a more realistic action.

8.3) Please think about other ideas and concepts that could be added into the program to create a more realistic AI. Maybe talk about it at a general level and if you can, go into details about possible ways to implement the ideas. The box is a lot larger than the other. Please do not feel like you must fill the entire box. Any amount of feedback here is fine.

Could outside deliveries into the back stockroom be added which would increase movement into the front shop. Incidental occurrences could be programed in. i.e. spillages, breakages, returns or complaints. Even the occasional shoplifting event would add realism. Also a rush of customers which resulted in excessive queues needing extra staff to go to the till To reduce the congestion.