Task: Task 21

Title: Custom Project

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# Goals / Deliverables

* A customizable box world
  + Corridors formed from wall tiles
  + Patrolled by a squad of soldier agents
    - Using group behaviours adapted for graph-based navigation.
    - Attack fugitives on sight.
    - If fugitives flee beyond soldiers’ awareness, they scout the immediate area, resume attacking if they find them, resume patrolling if they don’t.
    - If overwhelmed by fugitives, one soldier returns to base to lead reinforcements up to max squad size back to the rest of the soldiers.
    - Squad respawns if all soldiers die.
  + Populated with fugitive agents
    - Stay hidden until they see the soldiers, then attack.
    - On attack, fear increases. If it gets too high, fugitives flee.
    - Respawn at random points on map when they die.
  + All agents flee explosives they’re in range of until they finish detonating.

# Technologies, Tools, and Resources Used

* SublimeText (for editing, executing and testing the code)
* Learning materials on Canvas (for instructions and sample code)

# Tasks Undertaken

* I started by copying the project from Task 18: Navigation with Graphs and my custom project plan into the Task 20: Custom Project folder, stripping the spike report down to what was needed for the custom project.
* Next, I devised a larger map for the agents to wander around in, making a blank 30 x 30 map text file, designing it in the simulation itself, and copying it over to the text file. To adapt the mobile classes to it, I reduced the size of the agents, made the projectiles split their movement into several steps to ensure they don’t jump over agents or walls they’re supposed to hit, modified the speed of projectiles so that they don’t move too fast but not so slow that the agents can overtake them and set them off, and reduced the inaccuracy margin of the handgun, hand grenade, and shotgun.
* I modified the soldiers’ code so that while patrolling, the lead soldier would decide where the soldiers were going, and that the rest would calculate their own paths to the same location, recalculating if the lead soldier’s target changed. However, I noticed that occasionally the soldiers would move “backwards” then continue along their path when they recalculated their path to the lead soldier’s target, so I also tweaked agent.plan\_path() so that when a path was calculated, if the distance between the soldier and the second waypoint was less than the distance between the first and second waypoints, the first would be discarded and the soldier would just head to the second.
* I changed the read-from-file code to read the patrol waypoint box numbers from the map file and store the corresponding boxes in a list of waypoints in the box world class. While doing so, I got sick of the low framerate, I changed box.draw() to not fill the circle rendered for walls, but just do a thick outline, saving iterations of circle outline drawing and increasing the framerate.
* I altered the agent setup code so that the soldier leader would have its target set at the start and plan a path to the first waypoint, prompting the rest of the soldiers to follow it. Then I reorganised the various conditions for planning a new path into one method that could manage target selection and path planning for all of its preceding code, and replaced them with a call to that method. This way, the target selection and call of self.plan\_path() is all in one location and can be more easily modified as needed.
* Ran into errors where target\_enemy was None when it shouldn’t have been, put it down to misalignment between how look() calculated if the agent could see an enemy, and how update\_soldier() got the closest enemy. While testing, also removed explosive weapons from the list of weapons, as explosives weren’t working and just kept detonating behind the soldier.
* Noticed after attacking, soldiers would sometimes patrol in the reverse direction, so created a directional map for soldiers to follow. However, realised this would require the customizability of the simulation to be disabled or for functionality to allow the changing of a tile’s preferred direction for soldier agents, so decided against this. Instead decided to use a similar technique to how the agent bypasses redundant nodes on the path, using a path-length calculation method similar to what’s used for the aiming and shooting predictive calculations. However, this ran into the issue of the soldier agent somehow bouncing back and forth between the first two nodes.
* Solution: waypoints aren’t single boxes, but a line of them such that when the lead soldier moves backwards along the patrol path while attacking, if it triggers the boxes, it decrements its waypoint so that when it finishes attacking, it knows which one is the next one along the patrol path. However, to retain customizability of the box world, also requires keyboard controls for customizing waypoints. First changed code so that the box world reads in all boxes for a waypoint, then added a waypoint class that lists all boxes within the waypoint. Then added drawing code for displaying waypoints, inputs for editing waypoints, and a method to handle adding and removing boxes from a waypoint.
* Added methods for switching between waypoints both when the soldiers are patrolling, and when they are not, incrementing and decrementing the index of the current and last waypoints as appropriate. Spotted weird errors with the waypoint editing code in that on every number, clicking a box to add it to a waypoint would attempt to add or remove it from the correct box, but display 9 as its waypoint, and waypoints read from file would be unable to be removed. Fixed this by reworking BoxWorld.edit\_waypoint\_node() to perform checked based on the waypoint number of the node passed to it, and BoxWorld.active\_waypoint rather than searching through waypoints to check if the node was present in their lists of nodes or not. Tweaked rendering of soldier leader’s path to highlight path nodes with circles, so as to distinguish between it and other paths.
* BUG: Sometimes spots then loses a fugitive, but still goes to the fugitive. Fix: when looking and checking which enemy agent in range is the closest, it first checks if, ignoring walls, the enemy agent is within the soldier’s range. Then, gets a path to it and checks if the path does not extend outside the awareness range. If even a single node does, the soldier agent ignores it.
* BUG: If multiple soldiers, on spotting a fugitive, appears to just aggressively judge it rather than attacking it. Seems to be changing weapons repeatedly. Suggestion: single weapon with ridiculously high ammo so that it effectively won’t run out, and when it does it just refills. Remove exchange weapon as a movement mode. Implemented, but retaining exchange weapon in the unlikely scenario that the weapon runs out. Still having issues with even two soldiers attacking at once. Added a print to check who they were attacking, as it looked like they were attacking each other, and they were, as the enemy selection code only checked that the nearest agent wasn’t themselves, rather than an agent of the same agent type. Changed, working much nicer now.
* Additional tweaks: not allowing projectiles to hit agents of the same type as the agent that fired it, rather than ignoring the firing agent until the projectile was out of the agent’s radius. Also, stopping soldier agents from moving if doing so would overlap them with a soldier agent of higher rank (i.e. a lower index in BoxWorld.soldiers), or if they’re pursuing an enemy agent and moving would put them inside a wall. Added inputs for toggling awareness ranges and weapon ranges on and off. Changed soldier agents to green to better differentiate between soldiers and fugitives.
* Fugitives now stay stationary until they spot a soldier, merely updating their heading to face the closest soldier, and attack on spotting the soldier, using their own weapons to shoot back.
* Fugitives now have greater health and a fear measure that kicks in inversely proportionate to the distance between a fugitive and its attack target. When the fear is too high, it flees. When it encounters a “higher-ranking” fugitive or reaches the end of its fleeing path, it sits still and starts reducing its fear each second.
* Did some reorganising and refactoring of update\_soldier(), as some of its if statements seemed unnecessary and like they were duplicating functionality unnecessarily.
* Added another menu togglable by the spacebar: on clicking an empty, non-wall box, spawns a new fugitive agent. Added the checks, UI elements, and functionality appropriate for spawning new fugitive agents.
* Added scouting behaviour for the soldiers. When they kill or lose a fugitive, they get paths to random boxes within 1.5 times the lead soldier’s awareness radius, and travel there. When they get there, they stay there and look around. When the lead soldier gets to theirs, if none of them have spotted anything, it gets a new patrol path, then gets the other soldiers to do the same.
* Allowing fugitives to shoot while fleeing. Added a random element to fleeing triggering. Added soldiers’ ability to die, and health bars for all agents. Removed ability for fugitives spawned by player to respawn. Did some minor reorganising of update\_fugitive() akin to what was done to update\_soldier(). Updated look() to just return the value rather than setting see\_target, and renamed to see\_target().
* Added functionality for soldiers to be respawned at the start and head to waypoint 0 if all soldiers die. Modified fugitive spawning on mouse click to instead manage agents generally: if the clicked box has agents, they’re destroyed. If it doesn’t and it’s not a wall, spawns a fugitive instead.
* Added new box kind “base” to indicate where soldiers spawn, and implemented functionality for box editing to be able to make boxes bases or change the type of a base box, provided the max no. of bases hasn’t already been reached and the base box being changed isn’t the last one. No. of soldiers respawned is now tied to the no. of bases.
* Added the functionality for the last soldier in the squad to seek out reinforcements when the squad is overwhelmed. Reconfigured soldier spawning to work with spawning them at the start, when they’re all dead, and when a soldier is seeking reinforcements, and to allocate names according to what letters are available yet nearest the start of the alphabet.
* Lastly, disabled ability to change diagonal calculation type, search type, or search depth limit. Restricting it to diagonal = max, search type = A\*, and depth limit = None
* Spotted handling of waypoint triggering while soldiers weren’t patrolling had vanished, so put that back into update\_soldier(), also added handling of waypoint changes when the lead soldier dies and the path to the new lead soldier would go through a waypoint. Reorganised and split some soldier and fugitive functionality to make more readable.

# Instructions for Operating the Code

* M: alternate between placing blocks, managing agents, and modifying waypoints.
* Placing blocks:
  + Left mouse click: change a box’s kind to the currently selected kind.
  + 1: mouse clicks now clear blocks (there must be at least one soldier base).
  + 2: mouse clicks now place mud.
  + 3: mouse clicks now place water.
  + 4: mouse clicks now place walls.
  + 5: moves clicks now place soldier bases, with a maximum of 9.
* Managing agents:
  + Left mouse click: if the box is occupied, destroy all agents in the box. If the box is unoccupied and not a wall box, spawn a fugitive in the selected box.
* Modifying waypoints:
  + [0-9]: select a waypoint.
  + Left mouse click: toggle whether a box is in the currently selected waypoint. Cannot add a box to a waypoint if it belongs to another waypoint.
* Display options:
  + B: alternate thickness of box lines.
  + C: toggles markers of the centre of boxes.
  + E: toggles displaying of movement network edges.
  + F: toggles fugitives’ awareness ranges.
  + L: toggles box labels.
  + O: toggles highlighting of agents’ optimal paths in red.
  + S: toggles soldiers’ awareness ranges.
  + T: toggles display of graph options that were considered but did not end up being the optimal path.
  + U: toggles circle markers of boxes considered during the search.
  + W: toggles weapons’ effective ranges.
* P: (un)pause the simulation.

# State Diagrams

# UML Class Diagram

# Code Snippets

# In-Simulation Screenshots

# Retrospective

* What I found out / what I now know
  + Grid-based directional map > wouldn’t be as easy to do as changing box types would mean the directions would need to be customizable as well.
  + Single nodes for a waypoint aren’t enough when agents can move backwards along the patrol path to attack. Need to be enough that it acts like a trigger collider.
  + Graph searches are good for checking whether an enemy agent within range can reasonably be reached or if it is on the opposite side of a wall and there isn’t a gap in the wall close enough for the agent to reach the enemy agent.
* what I’d do different
* what I’d change
* further changes I’d suggest