CS409 Interactive Entertainment Software
Not available for CS 809 students
Assignment 6, 2024
Due: December 6, 23:59
(Late assignments accepted with no penalty until Dec. 12, 23:59)

Do any 100 marks worth of questions. You may want to choose the topics you most want to review for the final examination rather than simply the easiest questions.

Q1. [20 marks] Suppose a computer game is running using the frame rate independent method of updating with separate update intervals for physics (13 ms) and AI (30 ms). Assume that at a particular moment, the update lags for both physics and AI are 0 ms. It happens that the next five intervals between when the overall update function is called are G1 8 ms, G2 14 ms, G3 20 ms, G4 11 ms, and G5 10 ms. Give the sequence of physics (P) and AI (AI) updates (in order) that will occur in each of the five graphics intervals G1-G5.

Q2. [20 marks] Suppose the maximum steering force is 800 kg m/s^2 and the maximum speed is 30 m/s. Given a character with mass 40 kg at position (13 m, 14 m, 15 m) with current velocity (-3 m/s, -4 m/s, -5 m/s). Also suppose the character is pursuing an opponent at (-7 m, 5 m, 8 m) with velocity (9 m/s, 0 m/s, 11 m/s). The solution to a similar question is given in Section 5.4 of the online notes.

a. Show how to calculate the **steering vector** S for the **pursue** behavior for the first character, based on the opponent's position $t = 3$ seconds in the future.
b. Show how to calculate the updated velocity and position for the character for the next frame, given that delta time $\Delta t = 1/10$ seconds, i.e., a frame rate of 10 fps.

Q3. [20 marks] One steering behavior described by Reynolds, but not discussed in class, is **hide**. His description is as follows: "**Hide** behavior involves identifying a target location which is on the opposite side of an obstacle from the opponent, and steering toward it using seek." The position and radius of the obstacle are known. The positions and velocities of two characters are known. Hint: Don't steer through the obstacle!

a. [5 marks] Draw diagrams corresponding to several situations and explain what IF conditions would be checked to decide on the relevant situation.
b. [15 marks] For two of the situations you identified in part (a), give a series of formulas to calculate the steering vector **S** for Character 1 trying to hide from Character 2 behind a stationary spherical obstacle in that situation. Draw a diagram of the situation with the main vectors labelled. Put a comment beside each formula explaining what it is doing. Hint: You only have to deal with the immediate situation because the steering vector will be recomputed many times before a distant target is reached.

Q4. [20 marks] Suppose we have a game set on a 100x100 2D checkerboard where about 5000 "solid" squares (each 1m x 1m) move around at random from time to time and the other "lava" squares are impassible. Suppose the player has the task of passing from the north side of the board to the south side, and five AI-controlled monsters are trying to stop the player by firing projectiles from a distance of up to 10 m at the player.

a. [15 marks] Describe Sense-Think-Act models for the AI-controlled monsters by identifying the senses you would implement (give types and ranges, any communication?), the thinking that would be performed for each monster (what type, any limitations?), and what "instructions to act" would be available.

b. [5 marks] How would your agents be affected if the AI was run less often than every frame?

Q5. [20 marks] Pirate Quest:

Given the plot line for the "Pirate Quest" game below, draw a **situation-action graph.** A situation-action graph is a type of game FSM (finite state machine) where nodes represent situations that force choices and transitions represent the responses to these choices. A node can have one of four types of choices: (i) the user chooses from a small number of choices, (ii) the game makes a choice based on a random number, (iii) the game always forces the same choice, or (iv) a Boolean choice is made based on a comparison between a variable and some constant, e.g., choice = gold_pieces < 1000. Note: In the "Pirate Quest" game, the count of the gold pieces and the pirate rank are maintained separately from the game state.

Jack Swallow is the hero of the game "Pirate Quest". He wants to either become the top pirate of the Seven Seas or marry the girl of his dreams Molly Moll. Initially, he is at the Blackbeard Inn with 5 gold pieces. If he goes out the front door, he meets Molly and she tells him she will only marry him if he has 1000 gold pieces. If he has 1000 gold pieces, he marries her and the player wins the game. Otherwise, she leads him to the counting house. At the counting house, he works for a month, which earns him from 0 to 100 gold pieces. Then he can either stay in the counting house or return to Molly.

On the other hand, if Jack goes out the back door of the Blackbeard Inn, he meets Captain Flint, who offers him a job aboard the *Santa Crista*, his pirate ship. If Jack accepts, he goes on a pirate cruise with 19 other pirates. Otherwise, he meets with Captain Blueblood, who impresses (i.e., forces) him into the Royal Navy.

On the pirate cruise, Jack gets to choose whether they go south or north. If they go south, they meet the Royal Navy and their ship is destroyed and the player loses the game. If they go north, they meet a Spanish merchantman. They can either try to capture it or not. If they try to capture it, they have an 80% chance of success, and if they succeed they gain 200 gold pieces each and Jack is promoted by one position, e.g., from 20th to 19th chief pirate. If Jack is promoted all the way to number one pirate, the player wins the game. If they don't try to capture the Spanish merchantman or if they try and fail, they gain nothing and Jack is not promoted. In all cases after meeting the Spanish merchantman, they continue their cruise and Jack gets to choose whether to go south or north. If they go south, they meet the Royal Navy, as before, and if they go north, they meet another Spanish merchantman, as before.

If Jack is impressed into the Royal Navy, Captain Blueblood asks his advice: should they go south or north? If they go south, they capture a pirate ship and Jack earns 100 gold pieces in prize money; then Captain Blueblood asks his advice again with same possibilities and consequences as before. If they go north, they find no ships for a long time and then finally meet a ship carrying Molly and she tells him she will only marry him if he has 1000 gold pieces. If the Jack has 1000 gold pieces, the player wins, and otherwise Captain Blueblood asks Jack's advice, with the same possibilities and consequences as before.

Q6. [20 marks] Imagine that the following ten 2D points are added in the order shown to an Axis-Aligned Binary Space Partitioning (AABSP):

- (64, 36)
- (95, 64)
- (96, 53)
- (87, 23)
- (86, 66)
- (43, 56)
- (95, 34)
- (94, 72)
- (83, 38)
- (95, 62)

Assume that when constructing the AABSP, the axes are split for a particular region in the order X, Y, X, Y, …, and at most two points can be in a partition (if a third point is added, the region is immediately split). Draw a diagram of a 100x100 space and place the points on the picture and label them from A to J. Then, assuming the points are added in the order shown, calculate the partitioning values for each split that occurs and draw a straight line on the diagram for each such split. The partitioning value should be the average (mean) of the relevant values of the three points. Label both ends of the first line with 1, both ends of the second line with 2, etc. If any point is placed in two regions, show it as two dots on your diagram. Draw a line only in the region of space where the relevant split is applicable. Draw the AABSP tree with a "XY < line LLL" condition shown for each node, where XY is one of X or Y and LLL is the number of one of the lines that you drew and labelled at both ends.

Q7. [20 marks] Game Design

a. [10 marks] Using a diagram, show the design of two games (real ones or ones that you imagine), one with each of following types of structure: (a) **golden-path structure** and (b) **convexity**.
b. [10 marks] Writers of literature are told to obey the principle "show, don't tell." Illustrate what this means by choosing any example(s) from any story. The corresponding principle for computer game designers is "do, don't show." Explain what this principle means. Illustrate using any examples(s) from any real game or imaginary game.