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UNIVERSITY OF LIVERPOOL

Second Semester Examinations 2012/13

Principles of Computer Game Design and Implementation

TIME ALLOWED : Two Hours

INSTRUCTIONS TO CANDIDATES

Answer FOUR questions.

If you attempt to answer more questions than the required number of questions (in any section), the marks awarded for the excess questions answered will be discarded (starting with your lowest mark).

Question 1

A. Describe the role and functionality of the main game loop. Give a diagrammatic representation of the key steps of the main game loop. **7 marks**

B. Most modern games make a distinction between game-specific code and game-engine code. In your opinion, for each of the two distinctive parts of code, what kind of programming language is best suited for it? In your answer, discuss the role of game-specific code and game-engine code and reflect on what programming languages features make them a better candidate for the corresponding code part. **8 marks**

C. Describe a *Layered Architecture* used to organise modules in the game code. Illustrate your description with a diagram. In your answer, mention at least one advantage and one disadvantage of a layered architecture. Give an example of a game subsystem which is well suited to a layered architecture. **8 marks**

D. The *golden path* in a game in the optimum path for a player to take through the game to experience the game as intended and to get the maximum rewards. Name two methods used by computer game designers to keep a player on the golden path. **2 marks**

Question 2

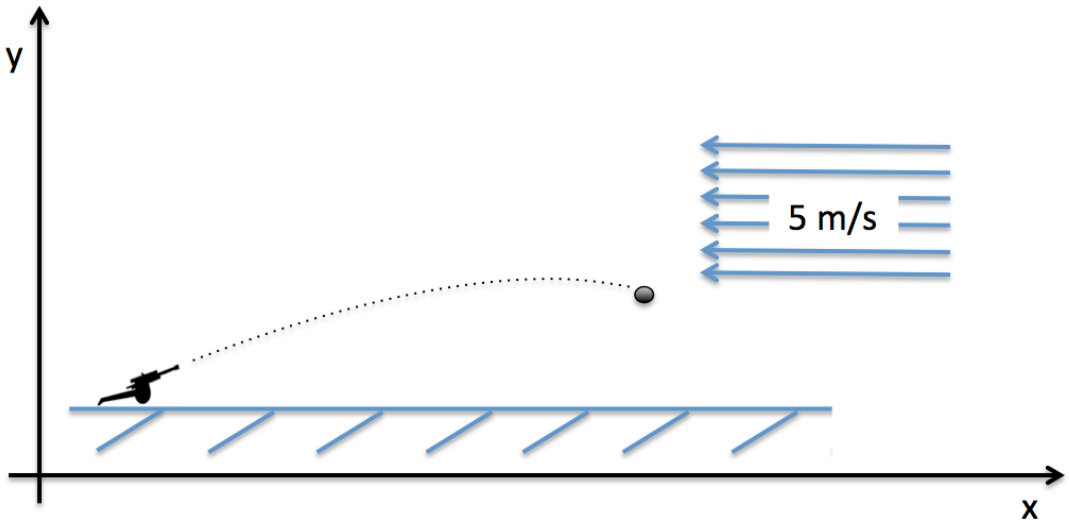
A. Let $\mathbf{V} = (3, 1, 2)$ and $\mathbf{W} = (6, 5, 4)$ be 3D-vectors. Compute (and show your working)

(a) $\mathbf{V} \cdot \mathbf{W}$ **2 marks**

(b) $\text{proj}_{\mathbf{V}}\mathbf{W}$ **2 marks**

(c) $\mathbf{V} \times \mathbf{W}$ **4 marks**

B. Consider a 2D game, in which a gun fires a cannonball. As part of the gameplay, you are modelling the effect of the air resistance on the cannonball. Additionally, the cannonball moves against the 5m/s wind. The mass of the cannonball is 50kg. The initial speed vector for the cannonball is $(100, 50)$.



Assuming the linear model of drag,

(a) give a graphical representation of all the forces acting on the cannonball as it flies through the air; **2 marks**

(b) describe the discrete motion of the cannonball as a sequence of its positions using Euler steps; **5 marks**

(c) sketch the `simpleUpdate()` method that implements the described motion in jMonkeyEngine. You are not required to write finished working code, but you must clearly convey the idea. **3 marks**

C. Let $\mathbf{V} = \begin{bmatrix} 2 \\ 3 \end{bmatrix}$ be a vertical representation of a 2D vector and $\mathbf{M} = \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}$ be a 2x2 matrix.

(a) Compute $\mathbf{MV}$, the result of multiplication of $\mathbf{M}$ and $\mathbf{V}$. **3 marks**

(b) In lay terms, what transformation does $\mathbf{M}$ define? **4 marks**

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Question 3

A. Consider the following jMonkeyEngine code fragment:

```
Box b  = new Box("B", Vector3f.ZERO, 10, .3f, 10);
Box b1 = new Box("B1", Vector3f.ZERO, 1,5,1);
Box b2 = new Box("B2", Vector3f.ZERO, 1,5,1);
Box b3 = new Box("B2", Vector3f.ZERO, 1,5,1);
Box b4 = new Box("B2", Vector3f.ZERO, 1,5,1);

b1.setLocalTranslation( 7, 0, 7);
b2.setLocalTranslation(-7, 0, 7);
b3.setLocalTranslation( 7, 0,-7);
b4.setLocalTranslation(-7, 0,-7);

Node bs = new Node("BS");
bs.attachChild(b1);
bs.attachChild(b2);
bs.attachChild(b3);
bs.attachChild(b4);

Node thing = new Node("Thing");
thing.attachChild(b);
thing.attachChild(bs);

rootNode.attachChild(table);
```

(a) Draw coordinate axis and sketch the resulting scene indicating the coordinate origin and coordinates of all geometries. **7 marks**

(b) Draw the scene graph specified by this code fragment. Name at least three advantages of this form of data representation as compared with unstructured collections of geometries, light sources, textures, etc. **7 marks**

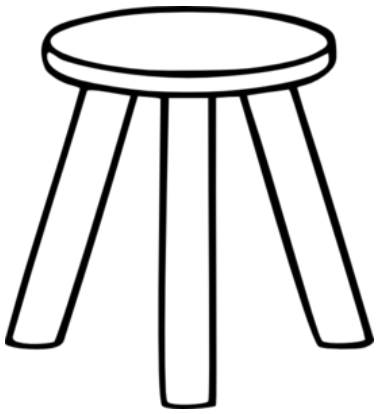
B. What is a physics engine? Name at least two advantages of using a third-party physics engine and at least two advantages of using an in-house physics routine. **6 marks**

C. Sketch the main game loop to model the uniform motion of a particle starting from $(0, 0, 0)$ in the direction specified by vector $(1, 2, 3)$ with a constant speed of 5 units per second. You answer should take the frame rate into account. **5 marks**

Question 4

A. In this module we studied two major approaches to collision detection: overlap testing and intersection testing. Define these approaches and discuss their advantages and disadvantages. **7 marks**

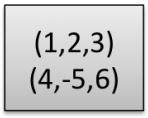
B. Bounding volume hierarchies are used in computer games to facilitate collision detection. How are they used? Sketch a bounding volume hierarchy based on OBBs for the shape given below and use it as an example to illustrate your answer. Your answer should contain a definition of OBBs and state the main principles underpinning the construction of bounding volume hierarchies.



8 marks

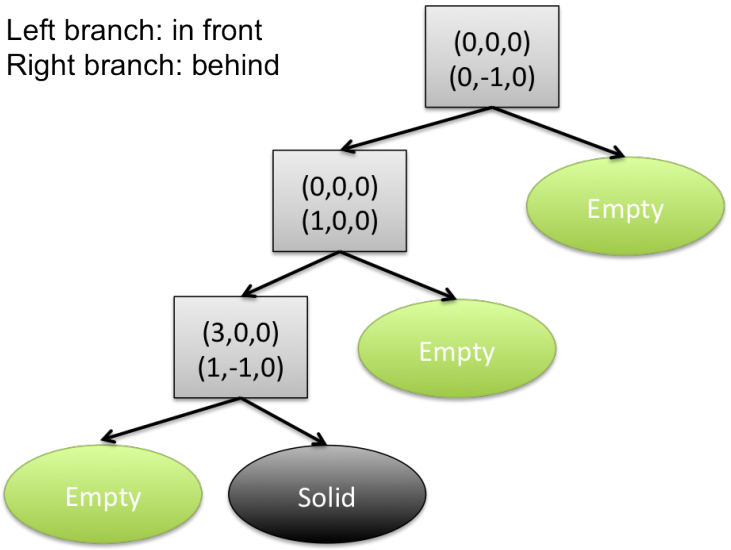
C. What will be the speed vector of a particle moving with the speed given by vector $(1, 1, 1)$ after the collision with a plain given by its normal $(0, 0, -1)$? **3 marks**

D. Recall that a node of a solid-leaf BSP tree can be *solid*, *empty*, or it can be an internal node associated with the plain that partitions the space. In the diagram below, the plain associated with an internal (shown as a box) node is determined by a position vector (first three numbers) and a normal vector (the second line). For example, for the internal node



the position vector is (1,2,3) and the plain normal is (4,-5,6).

Sketch the geometrical shape defined by the solid-leaf BSP tree shown below.



Mark clearly on your drawing the position and normal vectors for each plain. **7 marks**

Question 5

A. In agent-based computer game AI, intelligent agents continually step through the *sense-think-act* cycle. In your opinion, what is the necessity of the *sense* step of the cycle since the game world is always entirely represented inside the game and perfect information about the state of the world is always available? **5 marks**

B. Consider the following behaviour of a fighter game agent. The agent can be in three possible states, *idle*, *patrol*, or *attack*. In the *idle* state the agent remains motionless, in the *patrol* state the agent moves to the next checkpoint, and in the *attack* state the agent attacks another player. If the agent sees the other player, it goes into the *attack* state; otherwise, from being idle it changes, on a timeout, to the *patrol* state and, once completed the move to the next checkpoint, returns to the *idle* state. If the enemy unit is destroyed, the agent goes from the *attack* state to the *idle* state.

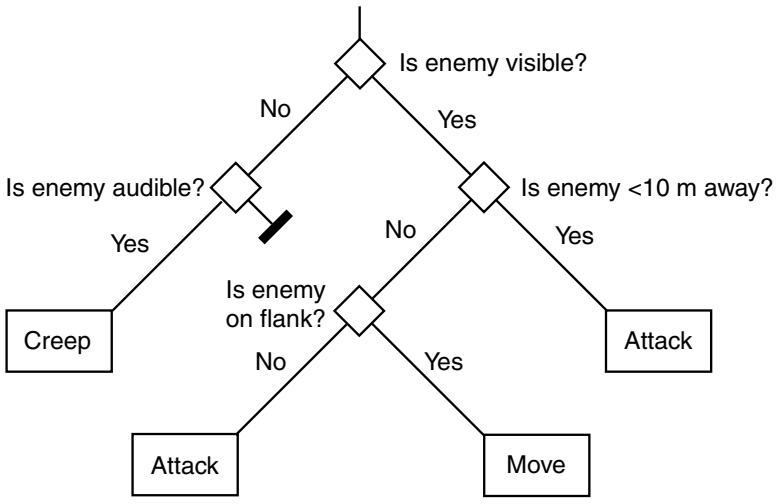
(a) What AI technique is best suitable to represent the behaviour of such an agent? **2 marks**

(b) Give a graphical representation of this model of agent behaviour. Indicate clearly conditions under which one state changes into another. 5 **marks**

(c) Assume now that you want the agent to show more complicated behaviour: in the *patrol* state the agent patrols four stations S_1,...,S_4 in the order $S_1 \rightarrow S_2 \rightarrow S_3 \rightarrow S_4 \rightarrow S_1 \rightarrow \ldots$ and in the *attack* state the agent goes through three consecutive stages: *approach*, *aim*, *fire*.

In your opinion, what is the best way to accommodate these modifications to the agent behaviour? Give a graphical representation of the new model of agent behaviour. **8 marks**

C. Describe in plain English the agent strategy given diagrammatically by the following decision tree.



5 marks

Question 6

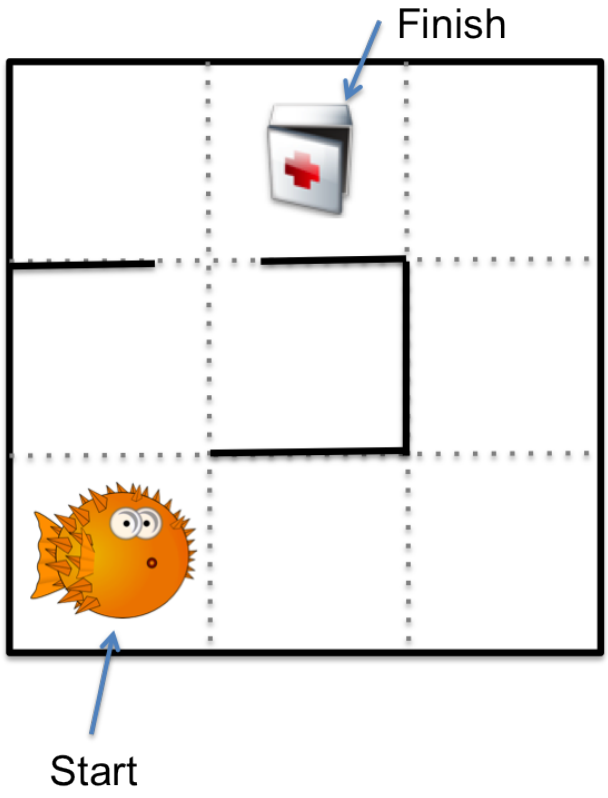
A. Describe the difference between Goal Oriented Behaviour (GOB) and Goal Oriented Action Planning (GOAP) as defined in the lectures. **3 marks**

B. Suppose that a computer character has three goals: Eat(3); Sleep(3); Go_to_bathroom(2). The insistence of every goal is given in the brackets. Which of the following actions should the character choose based on the *overall utility* approach? The effect of every action is given in the brackets.

- Drink-soda (Eat – 1; Go_to_bathroom + 1)
- Visit-Bathroom (Go_to_bathroom – 4)
- Eat-dinner (Eat – 3)
- Take a nap (Sleep – 2)

2 marks

C. Consider the following floor plan of a 3x3 room. The globefish filled its stomach with water and can only move between adjacent tiles where there are no obstacles.



(a) Construct the tile-based pathfinding graph. **5 marks**

(b) Using the Manhattan block distance between tiles as a heuristic, apply the A* algorithm to the graph constructed and find a path between Start and Finish. Illustrate the work of the A* algorithm with a diagram. For every node of the diagram indicate clearly the cost so far and the estimated cost to the goal. **5 marks**

D. Why is machine learning not used in many games? **4 marks**

E. What is hierarchical pathfinding? Give at least one advantage and one disadvantage of hierarchical pathfinding. **6 marks**