TÉCNICO LISBOA

Artificial Intelligence in Games

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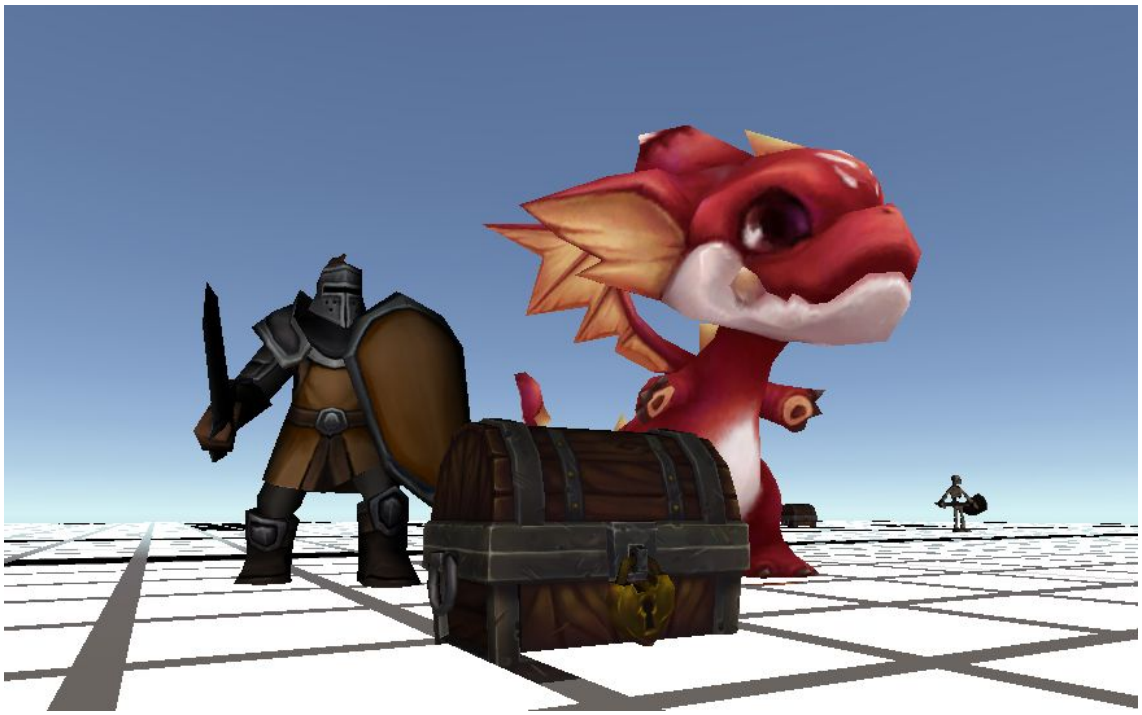
Laboratory Guide

Lab 5 – Depth Limited Goal Oriented Action Planning



In this Laboratory we will explore the use of a Depth Limited GOAP (Goal Oriented Action Planning) algorithm, to consider multiple sequences of actions in order to select the best action to perform in a particular game scenario.

The scenario to be used in this Laboratory consists in a simple game environment, where the character, brave Sir Uthgard the Paladin has the goal of finding the treasure chests in a dangerous dungeon. Uthgard has the following properties:

- **HP** – represents Uthgard's current hit points. When it reaches 0, Uthgard dies and the game is lost.
- **MaxHP** – represents Uthgard's maximum hit points for the current level (initially 10 HP).
- **ShieldHP** – represents Uthgard's Shield of Faith HPs.
- **Mana** – represents Uthgard's mana, which is spent by performing magical abilities. Getting a mana potion restores mana to its full value. Sir Uthgard starts the game with 0 mana (he wasted it outside the dungeon).
- **Level** – Uthgard's current level. As Uthgard levels up he will gain additional HP.
- **XP** – Uthgard's current experience level.
- **Money** – how much money Uthgard has collected (from the treasure chests)
- **Time** – how much time elapsed since level started

There will be several distinct objects and enemies scattered across the level:

- Mana Potions – blue potions, fully restore the character's mana (10 mana).
- Health Potions – red potions, fully restore the character's health to its maximum.
- Chests –treasure chests that Sir Uthgard must get. Each one gives 5 coins.
- Skeletons –The weakest type of enemy. They deal 2 damage to the character in melee combat. They also give 3 XP each.
- Orcs –Deal 5 damage to the character in melee combat. They give 10 xp.
- Dragon – Deals 10 damage to the character in melee combat. It gives 20 XP.

In addition Sir Uthgard can perform the following actions in the environment:

- **Sword Attack** – attack a foe with your iron sword. Can only be performed at melee range, and monsters will attack you back. Attacking an enemy with your sword will decrease your HP according to their type as specified above. The enemy will be dead, and the character will gain XP accordingly.
- **Divine Smite –** only usable against undead (skeletons), this ranged special attack allows you to kill an undead immediately without suffering any damage. It uses 2 mana for each attack.
- **Shield of Faith** – Gives you a temporary 5 HP Shield that stacks on top of your HP. Whenever you take damage, damage is first deducted from the Shield and the remaining damage (if any) is then deducted from your HP. If you recast Shield of Faith while under the effect of a shield of faith, the new shield will replace the old one. Cost 5 mana points.
- **Pick Up Chest** – Pick up a chest to give the character 5 gold coins.
- **Get Health Potion** – Pick up a health potion and drink it, regaining full health equal to the character's maximum health.
- **Get Mana Potion** – Pick up a mana potion and drink it, regaining full mana (10 points of mana).

1) Explore the provided scene and the source code

a) Open the downloaded project in Unity and explore the scene *Dungeon*. You will find the several distinct game objects scattered across the level.

b) Start by analyzing the classes inside the Game Manager folder. The *GameManager* class contains the methods for action execution and for updating the character's variables.

c) **If you want**, you can integrate your code from project 2, into the new project (both the Pathfinding and the Pathsmoothing). Update the *AutonomousCharacter* class to properly initialize and use your algorithms.

d) Analyze the classes inside the *DecisionMaking* Folder. You will find two main classes, the *WorldModel* and the *DepthLimitedGOAPDecisionMaking*. The latter contains the code for the algorithm that you will need to implement. The *WorldModel* class is already implemented but it is very important for you to understand it. It represents the current or a future (simulated) state of the world. The current implementation uses a recursive *WorldModel* structure with dictionaries to store properties and goals. This is not the most efficient approach but allows for more flexibility (i.e. easily adding new properties/goals).

e) Also take a look at the *SwordAttack* and *PickUpChest* actions, and the abstract *WalkToTargetAndExecuteAction* inside the *FowardModelActions* Folder. The abstract action contains all the common functionalities to actions that involve moving before performing anything. All actions implement two *CanExecute* methods. The first one is the *CanExecute* that receives the *WorldModel* as argument. This method is similar to the

CanExecute() without arguments, but instead of testing the game state to check if the action is possible to execute, it will test the received *WorldState*. The *ApplyActionEffects* assumes that the action was successfully executed in the received *WorldModel*, and therefore adds all predicted changes (in terms of goals and properties) to the *WorldModel*.

f) Also take a look at the class *CurrentStateWorldModel*. This class corresponds to a very particular case of a *WorldModel* where the *WorldModel* is actually the current game state. It serves as a kind of wrapper so that the current game state is handled by the GOAP algorithm in the same way as a *WorldModel*.

2) Implement the DepthLimited GOAP Decision Making

a) Implement the missing method in the *DepthLimitedGOAPDecisionMaking* class. Use the method *GenerateChildWorldModel* to perform a "copy" of a *WorldModel*. Use the *GetNextAction* to iterate over all possible actions for a *WorldModel*, and use the action's *ApplyActionEffects* to apply the results of an action to a newly generated *WorldModel*.

b) In addition to the standard algorithm, you will need to implement a mechanism that limits the number of action combinations (basically the number of actions that reach the last level) to be processed per frame (something very similar to what you did for the A* algorithm). Moreover, you will need to implement additional information that can be used for debugging, such as the *TotalProcessingTime*, the best action sequence (and not just the best first action), and the *TotalActionCombinationsProcessed*.

You will also need to implement the code for the *DivineSmite, ShieldOfFaith* and the *GetHealthPotion* action used in the Decision Making Process. Use the other implemented actions as examples.

3) Examine resulting behavior and experiment different parametrizations

a) Try out the resulting behavior and examine if the resulting behavior is according to the behavior you were expecting. Notice that you have two flags in the controller to define how difficult life is to Sir Uthgard. You can start with the enemies sleeping and a non-stochastic world.

b) It is easy to realize that very often the character will select objects to go to that are further away than other closer alternatives. Discuss with your group why does this happen, and try to figure a way how could you partially fix this.

c) You can experiment changing the defined value for the maximum depth. How many action combinations are processed by your algorithm at a maximum depth of 3? Can you roughly calculate how many will be at a maximum depth of 4? Experiment with a maximum level of 4. Why doesn't the character move? Discuss with your colleagues possible fixes to the problem.