# Modern Artificial Intelligence:
# Homework 1 *

Deadline: 2021/03/24 00:00am

March 1, 2021

   **Compress all of your code and pdf files into a zip file. Then upload it to LMS system on time. Please cite references (e.g., websites or books) if you learn something from them.**

**1. Heuristic search (50%):**

There is a delivery robot in NCU campus (see Fig.1). It locates at Math department (M node) and wants to arrive at the post office (P node). Please write a program to help it! The evaluation function is as follows:

$f(n) = g(n) + h(n)$

$f$ : evaluation function $h$ : heuristic function, and $g$ : cost function

The cost function is defined as the Fig. 1(b). The heuristic function is defined as the geometric distance of two nodes ($h = \sqrt{\Delta x^2 + \Delta y^2}$). The location of each nodes is shown in Fig. 1(a). Please write five search algorithms (e.g., BFS, DFS, UCS, greedy, and A*) to find the path.

Please answer the following questions.

1) The output sequence and overall path cost of five algorithms.(40%)

2) What's the relationship between BFS, UCS and A*. (5%)

3) What's the relationship between DFS, Greedy and A*. (5%)

**Hints:**

For example, A algorithm is a special case of B algorithm under C condition.

Code Delivery: Matlab code (.m file). Compress all of your code into a zip file. This code should display: The output sequence and the overall path cost of each algorithm.

**NOTICE: DO NOT use any toolbox for this homework. If you use any library, you should make sure it is included correctly. If your code cannot independently run on Prof. Tseng's Matlab. You only got partial points.**

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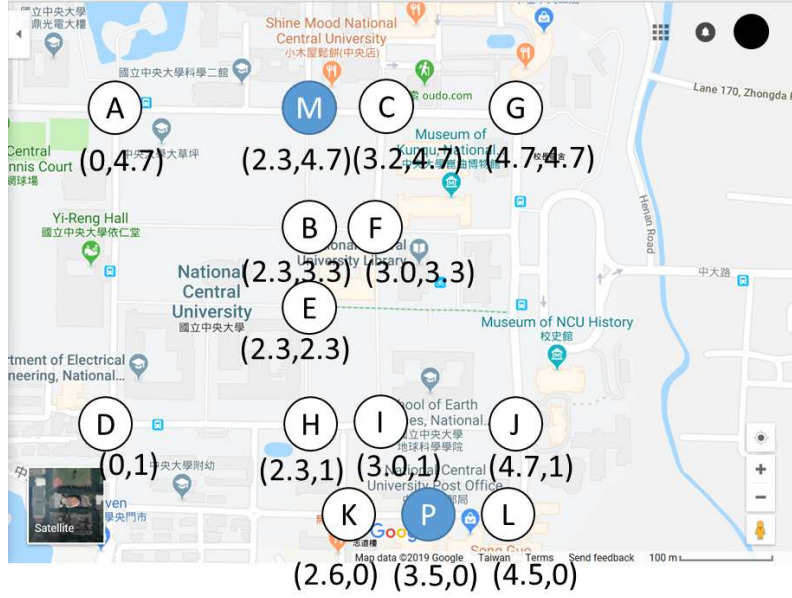
(a) NCU map

| Edge | Path cost | Edge | Path cost |
|------|-----------|------|-----------|
| M-A | 2.3 | F-E | 1.8 |
| M-B | 1.4 | F-I | 2.3 |
| M-C | 0.9 | G-J | 4 |
| A-D | 3.7 | H-I | 0.7 |
| B-E | 1.0 | H-K | 1.5 |
| B-F | 0.7 | I-K | 1.4 |
| C-F | 1.5 | I-J | 1.7 |
| C-G | 1.5 | J-L | 1.5 |
| D-H | 2.3 | K-P | 0.9 |
| E-H | 1.3 | L-P | 1.0 |

(b) path cost table

Figure 1: Illustration of planning problem. (a) The circles shows the nodes. The numbers indicate their locations. (b) The table shows the edge between two nodes and its path cost.

## 2. LRTA* (25%):

There is a cleaner robot with bumpers, charging sensors and encoders in a 4×3 world (see Fig.2). Its goal is to move to the battery station. The environment is defined as follows:

$state : s \in S = \{1..4, 1..3\}$
$initial \quad state : s = \{4, 1\}$
The search problem is defined as follows:
$action : a \in A = \{left, up, right\}$
$cost : c(s'|s, a) = 1$ when $s' \neq (4, 3)$ or $s' \neq (4, 2)$
$c(s'|s, a) = 0$ when $s' = (4, 3)$
$c(s'|s, a) = 10$ when $s' = (4, 2)$
$terminal : s = \{4, 3\}$
If the robot hits the walls or $s = \{4, 2\}$, it will be bounced.
Please answer the following questions:
1) Assume the initial action is "up" and the robot runs LRTA* to find the goal. Plot the search tree, H table and record table in step $1 \sim 3$? (15%)
2) Explain what's the similar and different properities between A* and LRTA*? (10%)
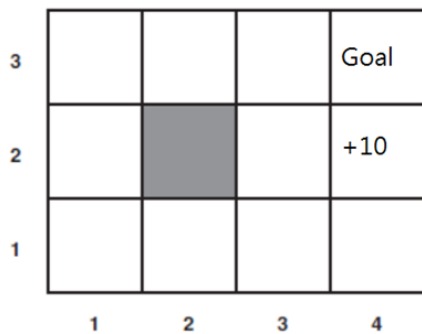


Figure 2: Illustration of $4 \times 3$ world.

### 3. Games and Monte-carlo tree search (MCTS) (25%):
As Fig. 3(a) shows, Tactics Core is a turned-based strategy game [1]. The goal is to terminate enemies. Monte-carlo tree search of this game is shown in Fig. 3(b). Please answer the following questions:
1) Please find 5 features of evaluation function which leads to win the game and explain why they are good features. (15%)
$h(s) = \sum_{i=1}^{5} w_i f_i(s)$
2) Please plot 4 steps (e.g., selection, expansion, simulation and backpropagation) of MCTS if the simulation outcome for you is win and no exploration in the selection step. (5%)
3) Please plot 4 steps (e.g., selection, expansion, simulation and backpropagation) of MCTS if the simulation outcome for you is lose and no exploration in the selection step. (5%)
**Hints:**
The action ordering is the enemy's turn, your turn, and your turn.
   [1] https://zh.y8.com/games/tactics_core
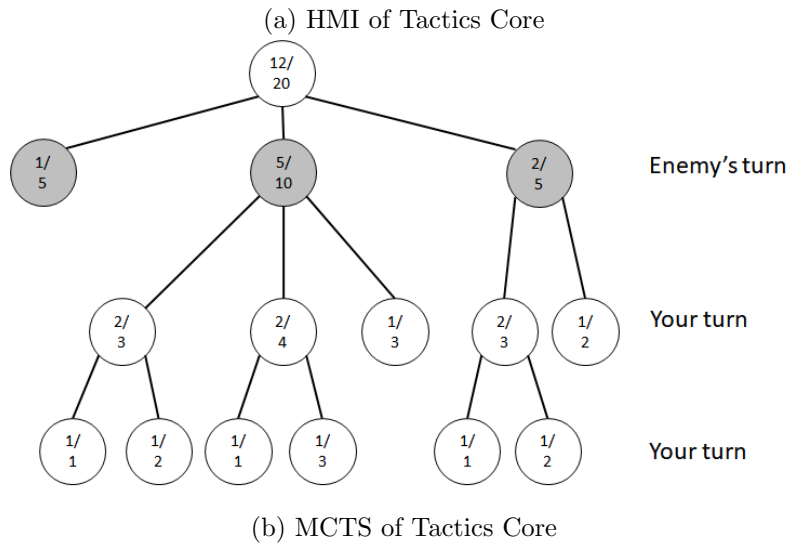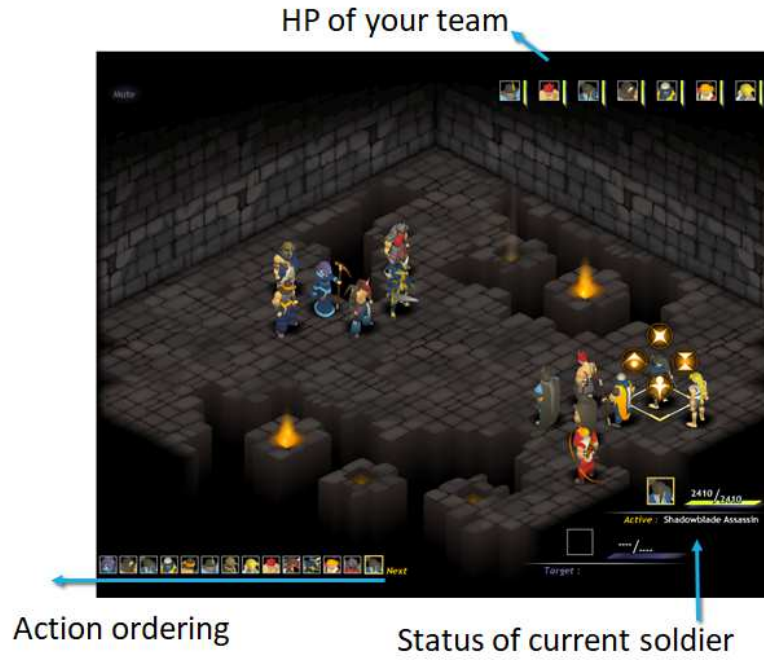
(a) HMI of Tactics Core



(b) MCTS of Tactics Core

Figure 3: Illustration of Tactics Core. (a) The interface shows the action ordering, HP of your team and the status of the current soldier. (b) The white and black circles represent the node of you and the enemy's turn, respectively.