Assignment-1, CSE643: AI-SecB Deadline: 14-10-2025 Full Marks: 30 06-10-2025

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1. [**Application of SMT solver (that uses DPLL algorithm)**] Consider a grid workspace of size 10×10 with $(1,1)$ being the left-bottom and $(10,10)$ being the top-right cell. There are 10 robots:

   - Initially, robots $r_1, \ldots, r_5$ are placed at $(1,1), (3,1), (5,1), (7,1), (9,1)$ cells respectively.
   - Initially, robots $r_6, \ldots, r_{10}$ are placed at $(1,10), (3,10), (5,10), (7,10), (9,10)$ cells respectively.

   In each transition, a robot can move one cell in $\{\mathtt{N}, \mathtt{S}, \mathtt{E}, \mathtt{W}\}$ direction. Write a program for the following:

   - The initial locations of $r_1, \ldots, r_5$ should be swapped with the initial locations of $r_6, \ldots, r_{10}$ respectively.
     The robots should move through the workspace to capture the new locations. At a time a cell can be occupied by a single robot. Find the path for each robot. Give a visual presentation of the same. What is the makespan ?
   - Is it possible to further improve the makespan ?

   Solve the problem using Microsoft's SMT solver **Z3**. The following link may be helpful – Z3-with-Python. 20

2. [**Variants of A***]

   (a) For A* algorithm we use the $f(n) := g(n) + h(n)$ to estimate the cost of the path to goal via node n. Here, both $g(n)$ and $h(n)$ have equal weights. Now, if we want to assign more weight to the heuristic cost $h(n)$, i.e. $f(n) := g(n) + w \cdot h(n)$ where $w > 1$, what will be the effects in the number of explored nodes and optimality guarantee, and why ? 5

   (b) In conventional A*, we explore the nodes in a single direction – from start to goal node. Now, we modify the procedure and explore the nodes in two opposite directions – a) from the start toward the goal (forward search), and b) from the goal toward the start (backward search). Consider the branching factor of each node is b and the goal is d distance away from the start node. What effect will the new algorithm have in the time complexity of the search algorithm ? 5