Name:

Roll No: e.g. 170001

Dept.: e.g. CSE

Indian Institute of Technology, Kanpur
CS638 Formal Methods in Robotics and Automation
Homework Assignment 3
Deadline: March 15, 2020

Instructions:

Total: **40 marks**

1. This question paper contains a total of 14 pages (14 sides of paper). Please verify.
2. Write your name, roll number, department on **every side of every sheet** of this booklet

Problem 1. Model-checker as a motion planner (20 points)

Consider a 2D workspace which is divided into small rectangular blocks using a grid. The size of the workspace is 5×5. The lower left grid block has the ID $(0, 0)$, and the upper right grid block has the ID $(4, 4)$. The blocks $(2, 0)$, $(3, 0)$, $(1, 2)$, $(3, 2)$, $(1, 4)$, and $(2, 4)$ are covered with obstacles. We have two robots whose initial locations are $(0, 0)$ and $(4, 4)$, respectively. The robots have four motion primitives: L, R, U, D that can take the robot from its current block location to the left, right, upper and lower block respectively. The robots have to move to the blocks $(4, 4)$ and $(0, 0)$, respectively. Moreover, The second robot should reach its destination $(0, 0)$ strictly after the first robot reaches its destination. Capture the behavior of the robots as a transition system and the requirement stated above as an LTL formula. Then through model checking, synthesize a trajectory for the robots. Use NuSMV model checker.

Submit the following:

- NuSMV model and specification.
- A snapshot of the terminal showing the execution of the model-checker.
- Provide a visual representation of the trajectories synthesized by NuSMV.

NuSMV Wbdpage: `http://nusmv.fbk.eu`

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Problem 2. Reactive motion planning (20 points)

Consider an office with 7 rooms for work and one kitchen room. A robot has been entrusted with the responsibility of collecting used coffee mugs from the rooms and bring them to the kitchen. The robot can carry only one cup at a time. It keeps on visiting the rooms and if there is an empty cup in a room, it brings it to the kitchen. If it does not find a cup, it visits another room.

Capture the requirements stated above in the form of an LTL formula. Construct the layout of the office space based on the layout shown in Figure 2 in [KFP09], where region 1 is the kitchen and region 2-8 are the office rooms. Then with the help of LTLMoP tool, synthesize a reactive controller for the robot and simulate its behavior.

[KFP09] H. Kress-Gazit, G. E. Fainekos, and G. J. Pappas. Temporal-logic-based reactive mission and motion planning. IEEE Transactions on Robotics, 25(6):1370-1381, 2009.

Submit the following:

- Specification using LTL symbols.
- Specification in LTLMoP syntax.
- Synthesized Controller.
- Snapshot of the trajectories.

LTLMoP Webpage: `https://ltlmop.github.io`

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