Field Exam – Autonomy

You are responsible for one of the core questions, and one of the specializations.

Core 1: Motion Planning

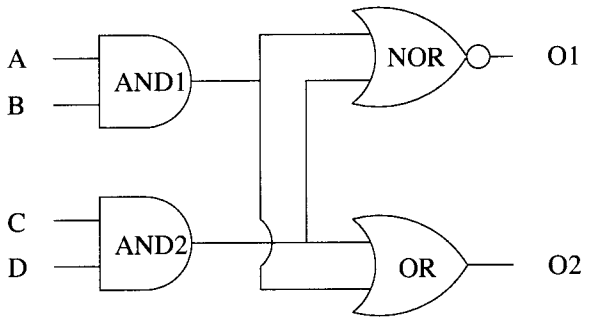
Please design a motion planner to move a ground vehicle through a field of 21 dynamic agents. Your dynamics can be represented using a deterministic Dubins car model, and you know all the relevant parameters of your model. The 21 other agents are also modelled as Dubins cars. 10 of the agents are co-operative; their motion is deterministic and you have a perfect model of their motion. 11 of the agents are non-co-operative. You have bounds on the parameters of their dynamics, but within these bounds, the motion of the non-co-operative agents is stochastic and uniformly distributed. In other words, the predicted position of each non-co-operative agent has set-bounded uncertainty, where the location and size of the set for each future time t can be calculated exactly. You know the position of all agents at every point in time. It may (or may not) help to know that you are the fastest of all agents by a small margin ϵ.

Assume your goal is to find a plan (if one exists) for moving a fixed distance (e.g., 10 yards) towards a goal position without collision with any other agents (co-operative or non-co-operative). Once a collision occurs, the problem resets to new initial conditions. What motion planning algorithm would you choose?

Now assume that your goal is to move as far as possible in expectation towards a goal without colliding with any other agent (co-operative or non-co-operative), and your reward is proportional to the length of your run. You are willing to be stopped for short gain sometimes, in order to sometimes get a long run. Would you choose a different motion planning algorithm?

Core 2: Constraint Propagation

Your DeLorean is having electrical problems. The problem appears to be in the flux capacitor, described by the circuit below:



The inputs to the flux capacitor, A, B, C, D are all true, and the outputs $O1$ and $O2$ are also both high. Let us determine if this is a fault condition, and which components may have failed.

A) Please provide a propositional logic theory of the flux capacitor in terms of $A, B, C, D, O1$ and $O2$ in CNF form. You may introduce new variables whenever necessary.

B) We know that the inputs A, B, C, D are all $True$, as are the outputs $O1$ and $O2$. Please use unit propagation to determine if this is a failure condition.

Specialization: Estimation and Inference

Imagine you are a line judge for an NFL game. To assist in spotting the ball, the NFL football now contains point markers that can be tracked by a fixed number of cameras in the stadium. Please design an estimator that will allow you to determine the position of the football, and the probability that the football broke the plane of the goal line and a touchdown was scored at any point during each play.

Note that as a line judge, you make the call at the end of the play when the referee blows his whistle, not earlier. You know all relevant properties of the cameras (position, etc.) and properties of the ball (size of the ball, position of the markers, etc.). However, in an outdoor stadium such as Gillette stadium, the camera image of each marker position is noisy, sometimes obscured by players, and the markers cannot be uniquely distinguished from one another.

Specialization: Machine Learning

A spacecraft contains a camera that is to be used for classifying star types. Properties of each star image (colour, brightness, size in the image plane, etc.) can be used to classify the stars into different types. The spacecraft does not know the type of each star (the images are not labelled by star type) but must learn to recognize types of stars over time. The spacecraft has a prior estimate of how many star types there are and roughly how the star types might be distributed, but this prior estimate is very inexact. Please describe an algorithm for learning to recognize star types from a series of images. You may assume that each image contains a star and only a star.