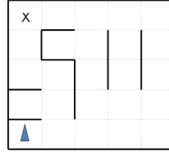


### 3 Search and Heuristics

Imagine a car-like agent wishes to exit a maze like the one shown below:



The agent is directional and at all times faces some direction  $d \in (N, S, E, W)$ . With a single action, the agent can *either* move forward at an adjustable velocity  $v$  *or* turn. The turning actions are *left* and *right*, which change the agent's direction by 90 degrees. Turning is only permitted when the velocity is zero (and leaves it at zero). The moving actions are *fast* and *slow*. *Fast* increments the velocity by 1 and *slow* decrements the velocity by 1; in both cases the agent then moves a number of squares equal to its NEW adjusted velocity (see example below). A consequence of this formulation is that it is impossible for the agent to move in the same nonzero velocity for two consecutive timesteps. Any action that would result in a collision with a wall crashes the agent and is illegal. Any action that would reduce  $v$  below 0 or above a maximum speed  $V_{\max}$  is also illegal. The agent's goal is to find a plan which parks it (stationary) on the exit square using as few actions (time steps) as possible.

As an example: if at timestep  $t$  the agent's current velocity is 2, by taking the *fast* action, the agent first increases the velocity to 3 and move 3 squares forward, such that at timestep  $t + 1$  the agent's current velocity will be 3 and will be 3 squares away from where it was at timestep  $t$ . If instead the agent takes the *slow* action, it first decreases its velocity to 1 and then moves 1 square forward, such that at timestep  $t + 1$  the agent's current velocity will be 1 and will be 1 squares away from where it was at timestep  $t$ . If, with an instantaneous velocity of 1 at timestep  $t + 1$ , it takes the slow action again, the agent's current velocity will become 0, and it will not move at timestep  $t + 1$ . Then at timestep  $t + 2$ , it will be free to turn if it wishes. Note that the agent could not have turned at timestep  $t + 1$  when it had a current velocity of 1, because it has to be stationary to turn.

1. If the grid is  $M$  by  $N$ , what is the size of the state space? Justify your answer. You should assume that all configurations are reachable from the start state.
  
  
  
  
  
  
  
  
  
  
2. Is the Manhattan distance from the agent's location to the exit's location admissible? Why or why not?

