1. **In your report, mention what you see in the agent’s behavior. Does it eventually make it to the target location?**

No. It is drive like randomly. Does follow some command as i write. But it has no sense of traffic rule,and target location.

### ***Identify and update state. Justify why you picked these set of states,* and how they model the agent and its environment.**

State should include all things that can affect the agent’s decision making.

There i am taking the combine of following things as state:

1.Light, 2) next\_waypoint, 3)presence of other cars( from oncoming, right, and left of oncoming).4)deadline

Justification: the reward the agent get based on light signal, whether it move to right direction, and whether it follow traffic rule. And if the agent can reach the destination within the deadline, then it will get big reward; otherwise, it will be fail for that trial.so we should also include deadline.

How the state model the agent: by providing reward or punishment based on the action taking on state combined from above these inputs, it stimulate the agent to follow a certain pattern of traffic rule. I

In a word, by considering these states and rewards based on it, make the agent follow traffic rule, avoid accident, and reach to the destination within the time.

3.***What changes do you notice in the agent’s behavior?***

At first it will select action like randomly since it has no information available for select better action. But as some information the agent get(from Q matrix), it will try to behavior better and better.

I am using following structure to store the information( for the brain of agent):

Fomrat: { (state):{action1:qValue1,action2:qValue2},....}

So the agent will able to select the best action or the biggest q value for any given state. Example:

{('green', 'right', 'left', None): {'forward': 0, None: 2.04755, 'right': 0, 'left': 0}, ('green', 'forward', 'right', None): {'forward': 0, None: 0.5, 'right': 0, 'left': 0}......

1. **Report what changes you made to your basic implementation of Q-Learning to achieve the final version of the agent. How well does it perform?**

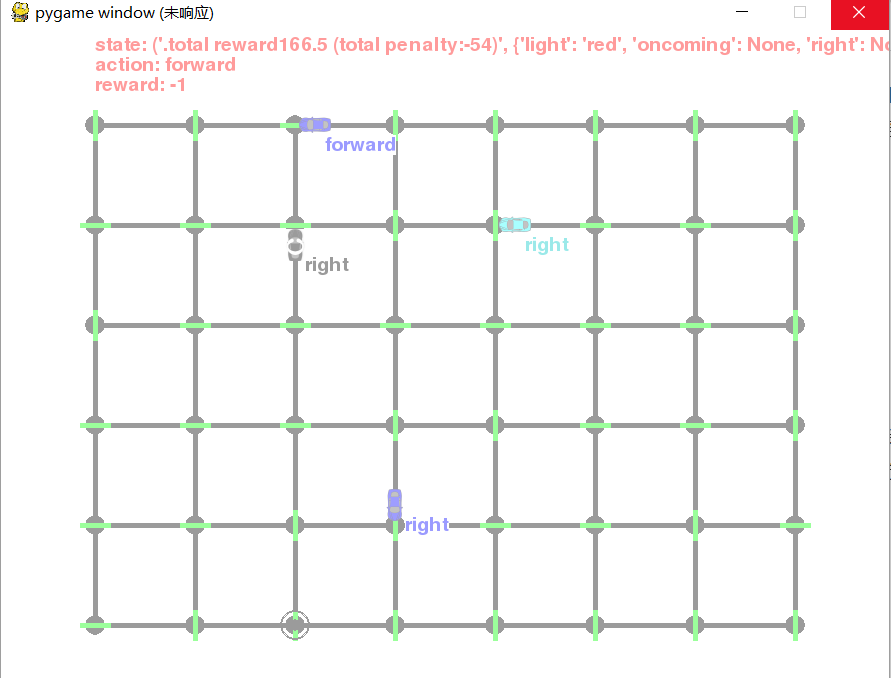
I changed parameters of gamma,alpha, epsilon many times. And finally i tried to use a small GAMMA(0.2), a big starting alpha decay with running times, and a relative small starting epsilon(0.15) decay with running times.

but i can not find a well defined pattern which improve the successful rate. My agent able to learn some rules. But it can not learn the traffic rule effectively.

1. **Does your agent get close to finding an optimal policy, i.e. reach the destination in the minimum possible time, and not incur any penalties?**

Not yet. It seems my agent sometime can, sometime can not, which mean it is not very reliable.

The ideal or optimal policy would be the agent follow the traffic rule, goes toward target location.



*Learning information after 10 trials:*

{('green', 'right', 22, None, None): {'forward': 0, None: 0.00912, 'right': 0, 'left': 0}, ('red', 'left', 17, None, None): {'forward': -0.00025, None: 0, 'right': 0, 'left': 0}, **('red', 'right', 11, None, None): {'forward': -0.17937, None: 0, 'right': 0.00041, 'left': 0}**, ('green', 'right', 5, None, None): {'forward': 0.0281, None: 0, 'right': 0, 'left': 0}, ('green', 'right', 38, None, None): {'forward': 0, None: 0.02072, 'right': 0, 'left': 0}, ('green', 'left', 0, None, None): {'forward': 0, None: 0, 'right': 0.21355, 'left': 0}, ('green', 'forward', 8, None, None): {'forward': 0, None: 0, 'right': 0.03345, 'left': 0}, ('green', 'right', 0, None, None): {'forward': 0.5104, None: 0, 'right': 0, 'left': 0}, ('red', 'right', 7, None, None): {'forward': 0, None: 0.00471, 'right': 0, 'left': 0}, ('green', 'forward', 3, None, None): {'forward': 0, None: 0, 'right': 0.00172, 'left': 0}, ('red', 'left', 13, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -1e-05}, ('green', 'right', 24, None, None): {'forward': 0, None: 2e-05, 'right': 0, 'left': 0}, ('red', 'forward', 6, None, None): {'forward': 0, None: 0, 'right': 0.08792, 'left': 0}, ('green', 'right', 15, None, None): {'forward': 0, None: 1.22333, 'right': 0, 'left': 0}, ('green', 'forward', 7, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -1.46302}, ('green', 'right', 28, None, None): {'forward': 0.0062, None: 0, 'right': 0, 'left': 0}, ('red', 'right', 47, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -0.03287}, ('red', 'forward', 33, None, None): {'forward': -3e-05, None: 0, 'right': 0, 'left': 0}, ('red', 'left', 22, None, None): {'forward': -9e-05, None: 0, 'right': 0, 'left': 0}, ('green', 'right', 44, None, None): {'forward': 0, None: 0, 'right': 0.05636, 'left': 0}, ('red', 'forward', 18, None, None): {'forward': 0, None: 0.00833, 'right': 0, 'left': 0}, ('red', 'left', 1, None, None): {'forward': 0, None: 0.44531, 'right': 0, 'left': 0}, ('red', 'right', 6, None, None): {'forward': 0, None: 0.00047, 'right': 0, 'left': -0.00401}, ('green', 'left', 15, None, None): {'forward': 0.05025, None: 0, 'right': 0, 'left': 0}, ('green', 'right', 3, None, None): {'forward': 0, None: 0, 'right': 0.00107, 'left': 0}, ('green', 'right', 21, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -0.00866}, ('green', 'left', 18, None, None): {'forward': 0, None: 0, 'right': 0.43798, 'left': 0}, ('green', 'right', 14, None, None): {'forward': 0.0417, None: 0, 'right': 0, 'left': -0.24298}, ('green', 'forward', 19, None, None): {'forward': 1.84414, None: 0, 'right': 0, 'left': 0}, ('red', 'right', 9, None, None): {'forward': 0, None: 1.2763, 'right': 0, 'left': 0}, ('green', 'right', 37, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -0.01968}, ('green', 'forward', 40, None, None): {'forward': 0, None: 0, 'right': 0.01148, 'left': 0}, ('red', 'right', 12, None, None): {'forward': 0, None: 0, 'right': 2.69206, 'left': 0}, ('green', 'right', 32, None, None): {'forward': 0, None: 0.01523, 'right': 0, 'left': 0}, ('green', 'left', 25, None, None): {'forward': 0, None: 0.00011, 'right': 0, 'left': 0}, ('green', 'forward', 10, None, None): {'forward': 0.1377, None: 0, 'right': 0, 'left': 0}, ('red', 'left', 11, None, None): {'forward': 0, None: 0, 'right': 0.0386, 'left': 0}, ('red', 'forward', 49, None, None): {'forward': 0, None: 0, 'right': 0.01821, 'left': 0}, ('red', 'forward', 4, None, None): {'forward': 0, None: 0.00123, 'right': 0, 'left': 0}, ('green', 'forward', 4, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -0.00362}, ('green', 'left', 24, None, None): {'forward': 5e-05, None: 0, 'right': 0, 'left': 0}, ('red', 'forward', 34, None, None): {'forward': 0, None: 3e-05, 'right': 0, 'left': 0}, ('red', 'forward', 1, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -0.00106}, ('green', 'right', 7, None, None): {'forward': 0, None: 0.53356, 'right': 0, 'left': 0}, ('green', 'forward', 1, None, None): {'forward': 0, None: 0, 'right': 0.00173, 'left': 0}, ('red', 'right', 19, None, None): {'forward': 0, None: 0.31402, 'right': 5.02962, 'left': 0}, ('red', 'left', 4, None, None): {'forward': -0.13958, None: 4e-05, 'right': 0, 'left': -0.42719}, ('green', 'left', 10, None, 'left'): {'forward': 0, None: 0, 'right': 0, 'left': -1e-05}, ('red', 'right', 22, None, None): {'forward': -1e-05, None: 0, 'right': 0, 'left': 0}, ('green', 'forward', 41, None, None): {'forward': 0, None: 0.02416, 'right': 0, 'left': 0}, ('red', 'left', 23, None, None): {'forward': -0.0001, None: 0, 'right': 0, 'left': 0}, ('green', 'right', 19, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -0.00266}, ('red', 'left', 18, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -0.00029}, ('green', 'right', 35, None, None): {'forward': 0.00888, None: 0, 'right': 0, 'left': 0}, ('green', 'right', 13, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -0.23083}, ('red', 'left', 29, None, None): {'forward': 0, None: 0, 'right': 0.00654, 'left': 0}, ('green', 'right', 8, None, None): {'forward': 0, None: 0.52447, 'right': 2.88542, 'left': 0}, ('red', 'right', 1, None, None): {'forward': 0, None: 1.07225, 'right': 0, 'left': 0}, ('green', 'left', 4, None, None): {'forward': 0, None: 0, 'right': 0.62716, 'left': 0}, ('green', 'right', 1, None, None): {'forward': 0, None: 0, 'right': 0.00031, 'left': 0}, ('red', 'right', 4, None, None): {'forward': 0, None: 0.05545, 'right': 0, 'left': 0}, ('green', 'forward', 20, None, None): {'forward': 1.9412, None: 0, 'right': 0, 'left': 0}, ('green', 'right', 12, None, None): {'forward': 0.11066, None: 0, 'right': 0, 'left': 0}, ('red', 'forward', 17, None, None): {'forward': 0, None: 0, 'right': 1.22171, 'left': 0}, ('green', 'left', 8, None, 'left'): {'forward': 0, None: 0, 'right': 0, 'left': -1e-05}, ('green', 'forward', 15, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -0.00637}, ('green', 'left', 9, None, 'left'): {'forward': 0, None: 0, 'right': 0, 'left': -1e-05}, ('red', 'forward', 2, None, None): {'forward': -0.00111, None: 0, 'right': 0, 'left': 0}, ('red', 'right', 24, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -0.0101}, ('green', 'left', 16, None, None): {'forward': 0.00017, None: 0, 'right': 0, 'left': 0}, ('green', 'left', 48, None, 'forward'): {'forward': 0, None: 0, 'right': 0.0173, 'left': 0}, ('red', 'left', 7, None, 'right'): {'forward': 0, None: 1e-05, 'right': 0, 'left': 0}, ('red', 'left', 2, None, None): {'forward': -0.38554, None: 0, 'right': 0.00165, 'left': -0.12649}, ('red', 'right', 14, None, None): {'forward': -2.09501, None: 0.71407, 'right': 0, 'left': 0}, ('red', 'forward', 13, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -0.00575}, ('green', 'forward', 6, None, None): {'forward': 0, None: 0, 'right': 0.69494, 'left': 0}, ('red', 'forward', 43, None, None): {'forward': -0.02677, None: 0, 'right': 0, 'left': 0}, ('red', 'right', 10, None, None): {'forward': 0, None: 1.3895, 'right': 0, 'left': 0}, ('red', 'right', 17, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -0.09652}, ('green', 'right', 45, None, None): {'forward': 0.01483, None: 0, 'right': 0, 'left': 0}, ('green', 'right', 17, None, None): {'forward': 0, None: 0.93009, 'right': 0, 'left': 0}, ('red', 'right', 20, None, None): {'forward': -2.85, None: 0.63302, 'right': 0, 'left': 0}, ('red', 'forward', 3, None, None): {'forward': 0, None: 0.00117, 'right': 0, 'left': 0}, ('green', 'forward', 18, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -2.57212}, ('green', 'right', 10, None, None): {'forward': 0.1016, None: 0, 'right': 0, 'left': 0}, ('red', 'right', 33, None, None): {'forward': -0.01603, None: 0, 'right': 0, 'left': 0}, ('green', 'forward', 31, None, None): {'forward': 0, None: 0, 'right': 1e-05, 'left': 0}, ('red', 'right', 13, None, None): {'forward': -0.42149, None: 0.00332, 'right': 0, 'left': -1.99026}, ('green', 'left', 5, None, None): {'forward': 0.08624, None: 0, 'right': 0, 'left': -1.32038}, ('red', 'left', 16, None, None): {'forward': 0, None: 0, 'right': 1.16067, 'left': 0}, ('red', 'right', 16, None, None): {'forward': 0, None: 0.00228, 'right': 0, 'left': 0}, ('red', 'forward', 7, None, None): {'forward': 0, None: 0.00017, 'right': 0, 'left': -0.16968}, ('green', 'right', 4, None, None): {'forward': 0, None: 0.00042, 'right': 0, 'left': 0}, ('green', 'forward', 9, None, None): {'forward': 0, None: 0.00019, 'right': 0, 'left': 0}, ('red', 'right', 3, None, None): {'forward': 0, None: 1.18795, 'right': 0, 'left': 0}, ('red', 'left', 20, None, None): {'forward': 0, None: 0, 'right': 0.00236, 'left': 0}, ('red', 'left', 21, None, None): {'forward': 0, None: 0, 'right': 5e-05, 'left': 0}, ('red', 'right', 27, None, None): {'forward': 0, None: 2e-05, 'right': 0, 'left': -0.01178}, ('red', 'left', 12, None, None): {'forward': 0, None: 0.07469, 'right': 0, 'left': 0}, ('green', 'forward', 0, None, None): {'forward': 0.00224, None: 0, 'right': 0, 'left': 0}, ('green', 'left', 39, None, None): {'forward': 0, None: 0, 'right': 0.0109, 'left': 0}, ('green', 'forward', 13, None, None): {'forward': 0, None: 0, 'right': 0.03931, 'left': 0}, ('green', 'right', 16, None, None): {'forward': 0, None: 0, 'right': 1.83769, 'left': 0}, ('red', 'right', 23, None, None): {'forward': -2e-05, None: 0, 'right': 0, 'left': 0}, ('red', 'right', 46, None, None): {'forward': 0, None: 0, 'right': 0.06245, 'left': 0}, ('red', 'forward', 14, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -0.00605}, ('red', 'right', 26, None, None): {'forward': 0, None: 0.01121, 'right': 0, 'left': 0}, ('green', 'forward', 18, None, 'forward'): {'forward': 2e-05, None: 0, 'right': 0, 'left': 0}, ('red', 'left', 19, None, None): {'forward': 0, None: 0.00031, 'right': 0, 'left': 0}, ('green', 'right', 31, None, None): {'forward': 0, None: 0, 'right': 0.02893, 'left': 0}, ('red', 'left', 30, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -2e-05}, ('red', 'left', 5, None, None): {'forward': 0, None: 0.44967, 'right': 0, 'left': 0}, ('red', 'right', 2, None, None): {'forward': 0, None: 1.13096, 'right': 0, 'left': 0}, ('green', 'forward', 50, None, None): {'forward': 0.07668, None: 0, 'right': 0, 'left': 0}, ('green', 'right', 9, None, None): {'forward': 0, None: 0, 'right': 0.48001, 'left': 0}, ('green', 'left', 14, None, None): {'forward': 0, None: 0.00024, 'right': 0, 'left': 0}, ('green', 'right', 2, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -0.00013}, ('red', 'right', 8, None, None): {'forward': 0, None: 0, 'right': 0.0001, 'left': -0.00445}, ('green', 'right', 36, None, None): {'forward': 0, None: 0, 'right': 0.03739, 'left': 0}, ('green', 'forward', 16, None, None): {'forward': 0.01497, None: 0, 'right': 0, 'left': 0}, ('green', 'right', 6, None, None): {'forward': 0, None: 0, 'right': 1.00591, 'left': 0}, ('red', 'left', 15, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -1e-05}, ('green', 'forward', 32, None, None): {'forward': 0, None: 3e-05, 'right': 0, 'left': 0}, ('red', 'forward', 30, None, None): {'forward': 0, None: 0, 'right': 0.00687, 'left': 0}, ('red', 'forward', 8, None, None): {'forward': -0.00018, None: 0, 'right': 0, 'left': 0}, ('red', 'right', 28, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -2e-05}, ('green', 'left', 20, None, None): {'forward': 0.00016, None: 0, 'right': 0, 'left': 0}, ('red', 'forward', 5, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -0.0013}, ('green', 'forward', 5, None, None): {'forward': 0, None: 0, 'right': 2e-05, 'left': 0}, ('red', 'left', 3, None, None): {'forward': 0, None: 0.48797, 'right': 0, 'left': 0}, ('red', 'forward', 35, None, None): {'forward': 0, None: 3e-05, 'right': 0, 'left': 0}, ('red', 'left', 14, None, None): {'forward': 0, None: 7e-05, 'right': 0, 'left': 0}, ('red', 'right', 15, None, None): {'forward': 0, None: 0.00232, 'right': 0, 'left': 0}, ('red', 'right', 18, None, None): {'forward': 0, None: 0, 'right': 0.76279, 'left': 0}, ('red', 'forward', 42, None, None): {'forward': -0.02543, None: 0, 'right': 0, 'left': 0}, ('green', 'forward', 2, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -0.00038}, ('green', 'right', 25, None, None): {'forward': 0, None: 0, 'right': 0.0213, 'left': 0}, ('green', 'right', 23, None, None): {'forward': 0, None: 0, 'right': 0, 'left': -0.0096}, ('green', 'forward', 17, None, None): {'forward': 0, None: 0.00788, 'right': 0, 'left': 0}, ('green', 'left', 11, None, 'left'): {'forward': 0, None: 1e-05, 'right': 0, 'left': 0}, ('red', 'right', 34, None, None): {'forward': 0, None: 0.01687, 'right': 0, 'left': 0}, ('green', 'right', 18, None, None): {'forward': 0, None: 0.00276, 'right': 0, 'left': 0}, ('red', 'right', 21, None, None): {'forward': 0, None: 0, 'right': 3e-05, 'left': 0}, ('green', 'left', 13, None, None): {'forward': 0, None: 0, 'right': 0.00015, 'left': 0}, ('red', 'forward', 12, None, None): {'forward': 0, None: 0, 'right': 0.00273, 'left': 0}, ('green', 'right', 11, None, None): {'forward': 0.75867, None: 0, 'right': 0, 'left': 0}}