

My little document

August 23, 2016

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We use Panda3D to generate the

1 root

1.1 Reinforcement Learning

1.1.1 Q Learning

$$Q(s_t, a_t) \leftarrow \underbrace{Q(s_t, a_t)}_{\text{old value}} + \underbrace{\alpha}_{\text{learning rate}} \cdot \left(\underbrace{\overbrace{r_{t+1} + \gamma \cdot \max_a Q(s_{t+1}, a)}^{\text{learned value}}}_{\substack{\text{reward} \quad \text{discount factor} \quad \text{estimate of optimal future value}}} - \underbrace{Q(s_t, a_t)}_{\text{old value}} \right)$$

1.2 The video

<https://www.youtube.com/watch?v=z0gSC---rgM>

The video illustrates a car learning to avoid obstacles. As shown in Figure 1, the environment is a 2D scenario. The whole scenario is surrounded by fences. There are 4 irregularly shaped obstacles. To show the learned ability generalizes well with different layouts of obstacles, the obstacles will revolve about the center of the room slowly, at a constant speed, during running.

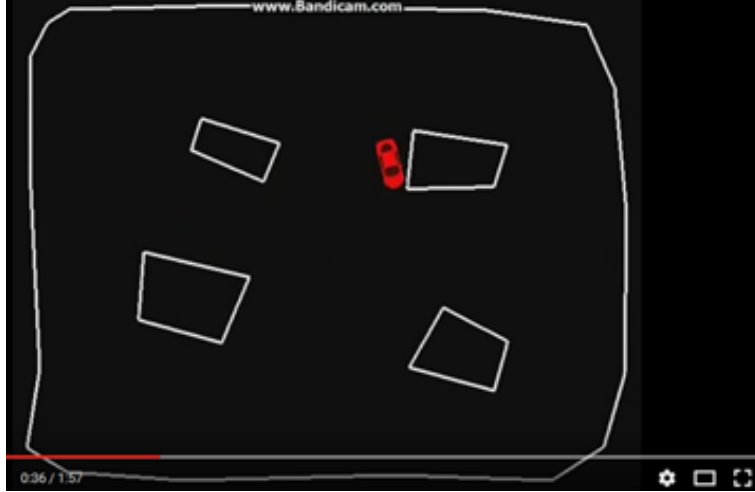


Figure 1: youtube_{screenshot}

For each period, the car starts from the center of the room, with a randomly chosen direction. Its action is controlled by a reinforcement learning algorithm. During the early periods, the actions are like randomly decided. When the car runs into obstacles or fences, it will be repositioned to the center of the room, and a new period begins. The car learns over time.

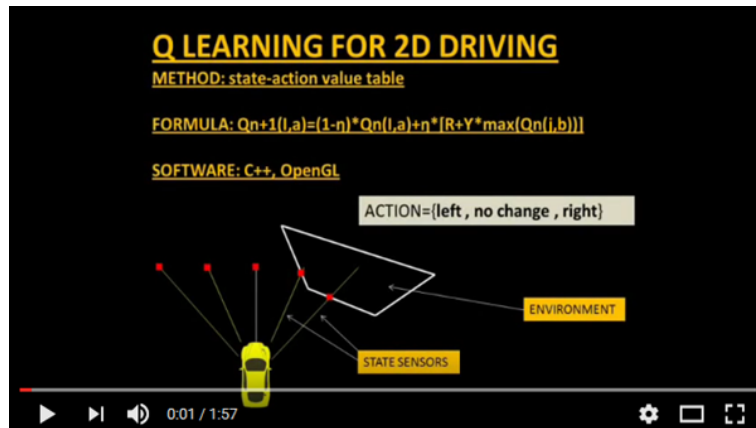


Figure 2: youtube_{structure}

The illustration comprises two parts, a 2D environment described above, and a learning algorithm which controls the action of the car. The algorithm learns from and makes decisions on specified data provided by the environment. The environment emulates 5 state sensors, corresponding to 5 different direction in front of the car. These sensors find the nearest obstacle, and measure the distance from the obstacle to the car. The distance information is transferred to the car in the form of a 5D vector. During running,

the algorithm will predict an action based on the distance information and then feed it back to the environment, to control the movement of the car.

1.3 Re-Implementation

For our further research, we need a verified code base to start with. So we want to implement the application in this video.

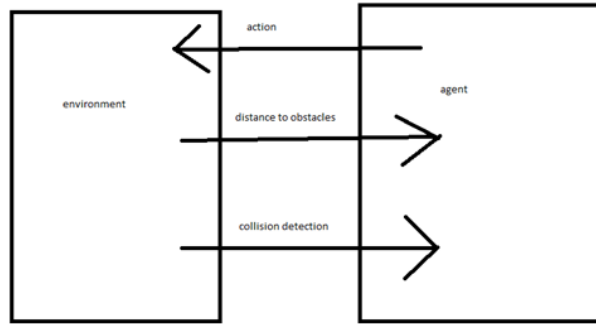


Figure 3: structure

The implementation takes 3 steps.

- Build an environment.
- Implement a reinforcement learning algorithm to control the car.
- Provide and transfer learning data and actions between the environment and the algorithm.

1.3.1 Reinforcement Learning

We started this part with a project on Github.com. In further research, we will build a variant algorithm of the deep q network. So we choose this implementation of deep q network as the code base of our reinforcement learning algorithm. This implementation is written in python, and based on Theano and Lasagne.

Paper <http://arxiv.org/abs/1312.5602>

Code https://github.com/spragunr/deep_q_rl

Adaptation The deep q network takes the raw images of a game as its inputs to predict actions. The network includes convolutional layers to handle the image data. But the current environment provides only distance information, in the form of a vector, instead of the raw images. So we replaced the convolutional neural network with a simple multi-layer neural network, to handle the distance information.

1.3.2 The Environment

We choose to build this 2D environment on a real-time 3D rendering engine. It is for the convenience of later transition. Because our later goal is to train the car to avoid obstacles in 3D environments.

Panda3D The 3D rendering task will be accomplished by Panda3D, a game development environment. It is written in C++ and supports both C++ and python.

Intra Process Communication In future research, it is required to frequently transfer raw images from the environment to the learning model. To make this process more efficient, we want to be able to transfer image data as an intra-process pointer. Choosing python as the programming language for both the environment and the learning model will allow us to conveniently implement this mechanism.

Models The 3D models used to build the 3D environment come from Panda3D’s example games.

- The models of the room are provided by the example bump-mapping.
- The models of the chess pieces are provided by the example chessboard.

Layout As shown in Figure 4, the scenario is located in a cubic room. A round pole is fixed at the left bottom corner (Figure 5). And a square pole is fixed at the top right corner. 200 chess pieces are randomly positioned in the room.

1.3.3 Learning Data

Required learning data includes distance information and collision signals.

Depth Maps Within a 3D render engine, a convenient way to generate distance information is to extract a depth map from the 3D models.

A depth map is a type of distance information. Like a raw image, it can be represented by a real-valued matrix. Corresponding to a raw image (Figure 4), each point on a depth map (Figure 6) represents the distance from that point to the viewpoint.

In real world, there are many algorithms able to generate depth maps from raw images. Within a 3D rendering engine, a depth map can be generated by calculating the distance to a nearest 3D model for all directions. Depth maps are widely used in 3D rendering algorithms. For example, they are necessary intermediate data in shadow algorithms. Rendering depth maps with 3D models is a basic function of a 3D engine, like Panda3D.

By cropping the horizon (Figure 7), the depth map can be converted into 1D distance information. In our experiments, the pixel size of the depth map is 90x90 and the size of the distance information vector is 90 in contrast to the only 5 state sensors existing in the original video.

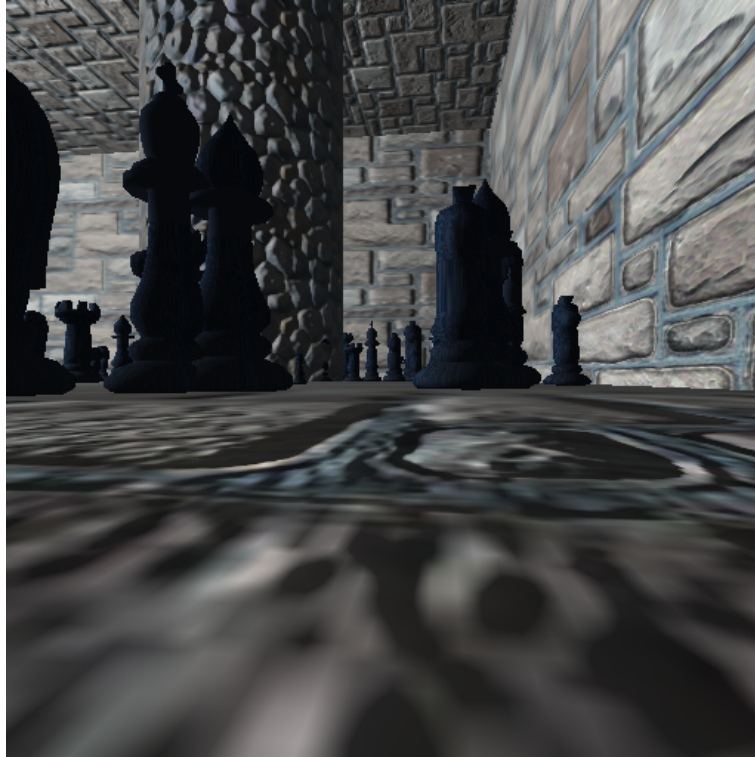


Figure 4: A 3D first person view of the car

Collision Detection We use a physics engine Bullet to detect collisions and send signals to the agent. This is one of the physics engine integrated with Panda3D. A physics engine is a simulation software for physical systems. For example, in rigid body dynamics, the engine detects collisions of different objects, and calculates the results of the collisions. But in this experiments, only the collision detection function is required.

1.3.4 Training

Random Actions

1.3.5 Results and discussion:

,agent. .

Problems . ,agent.. ,agent

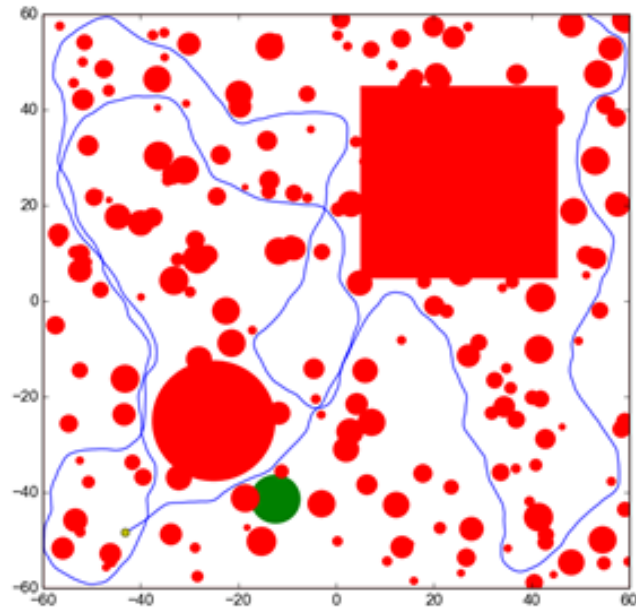


Figure 5: A top-down view. Red shapes represents obstacles. (mark the poles later)(Green circle/blue lines remove later) Green destination(remove)Blue line routes (remove)



Figure 6: A depth map. Light colors represents for rear objects. Dark colors represents for near objects.



Figure 7: cropping the horizon from the depth map