# Policy Networks vs Value Networks in Reinforcement Learning

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In Reinforcement Learning, the agents take random decisions in their environment and learns on selecting the right one out of many to achieve their goal and play at a super-human level. Policy and Value Networks are used together in algorithms like Monte Carlo Tree Search to perform Reinforcement Learning. Both the networks are an integral part of a method called Exploration in MCTS algorithm.

They are also known as policy iteration & value iteration since they are calculated many times making it an iterative process.

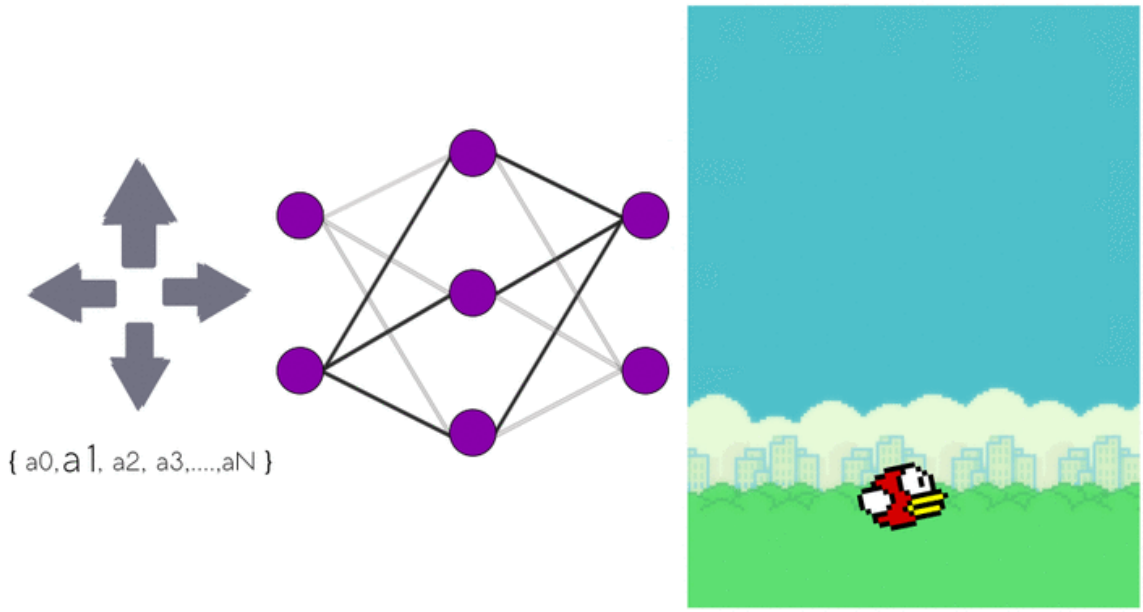
**Let's understand why are they so important in Machine Learning and what's the difference between them?**

## What is a Policy Network?

Consider any game in the world, input 🎮 given by user to the game is known as **actions** $a$ . Every input (action) leads to a different output. These output are known as **states** $s$ of the game.

From this, we can make different state-action pairs $S = \{(s0,a0),s1,a1),...,(sN,aN)\}$ , representing which actions $aN$ leads to which states $sN$. Also, we can say that **S** contains all the policies learned by the policy network.

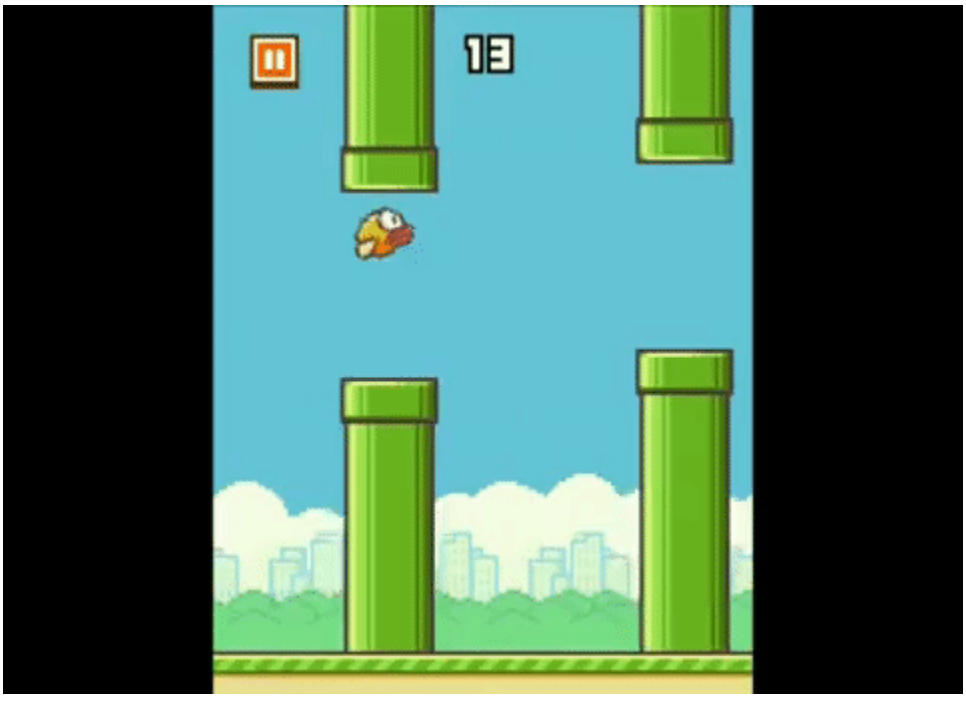
by giving a particular input to the game is known as Policy Network




**Policy Network (**action1, state1**) , (**action2, state2**)**

For Example: Input `a1` gives a state `s1` (moving up) & Input `a2` gives a state `s2` (going down) in the game.

Also, Some actions increase the points of the player lead to reward **r** .



Let's look at some obvious symbols:

$\mathcal{S}$ : set of possible states
$\mathcal{A}$ : set of possible actions
$\mathcal{R}$ : distribution of reward given (state, action) pair
$\mathbb{P}$ : transition probability i.e. distribution over next state given (state, action) pair
$\gamma$ : discount factor

**Usual Notations for RL environments**

$$\pi^* = \arg\max_{\pi} \mathbb{E}\left[\sum_{t\geq 0} \gamma^t r_t | \pi\right]$$

**Optimal Policy**

### Why are we using Discount Factor $\gamma$

> *It is used as a precautionary measure (usually kept below 1). It prevent the reward* ***r*** *to reach infinite.*

An infinite reward for a policy will overwhelm our agent & biased towards that specific action, killing the desire to explore unknown areas and actions of the game😳.

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### But how do we know which state to choose for your next move, eventually leading to the final round?

## What is a Value Network?

> *The value network assigns value/score to the state of the game by calculating an expected cumulative score for the current state* `s` *. Every state goes through the value network. The states which gets more reward obviously get more value in the network.*

Keep in mind that the reward is **expected rewards,** because we are choosing the right one from the set of states.



Value Function

Now, the key objective is always to maximise the reward *(aka Markov Decision Process)*. Actions that results in a good state obviously get greater reward than others.

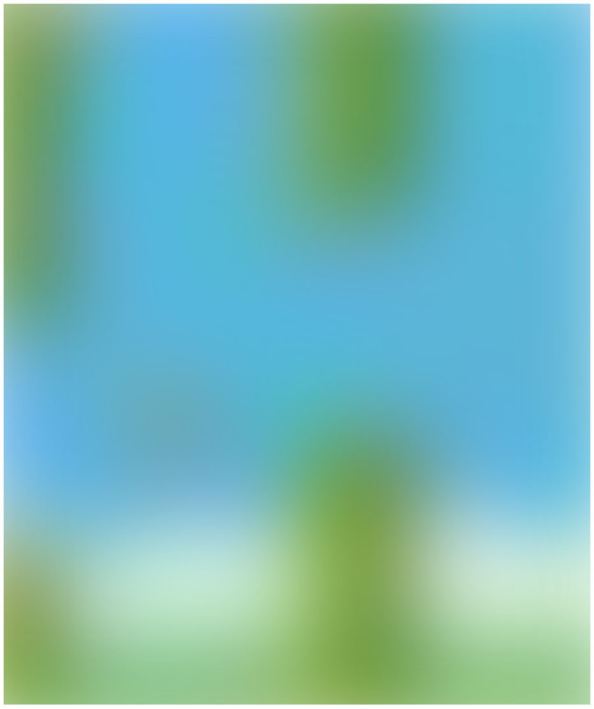
Since any game is won by following a sequence of actions one after the other. The optimal policy $\pi^*$ of the game consists a number of state-action pairs that helps in winning the game.

The state-action pair that achieve most reward is considered as optimal policy.

The equation for optimal policy is formally written using *arg max* as:

**Optimal Policy** $\pi^*$

The optimal policy learned by the policy network knows which actions should be performed at the current state to get maximum reward.



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