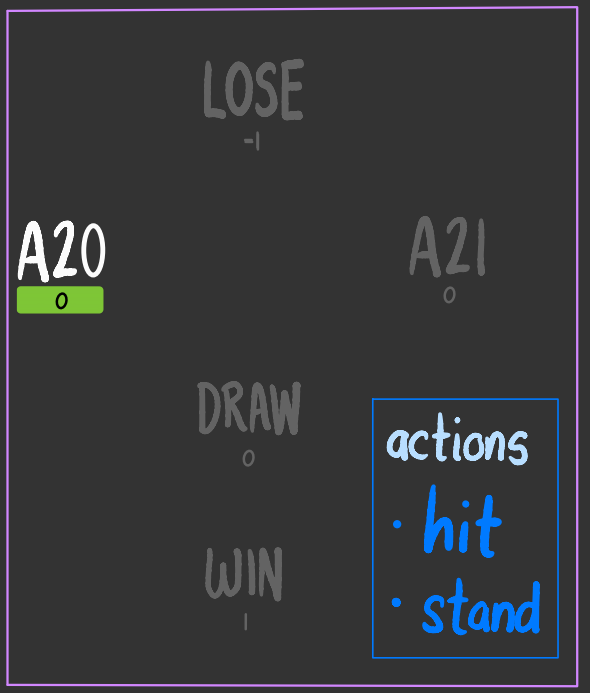
active reinforcement learning

CSCI 373



temporal difference learning

compute an online average of expected utilities

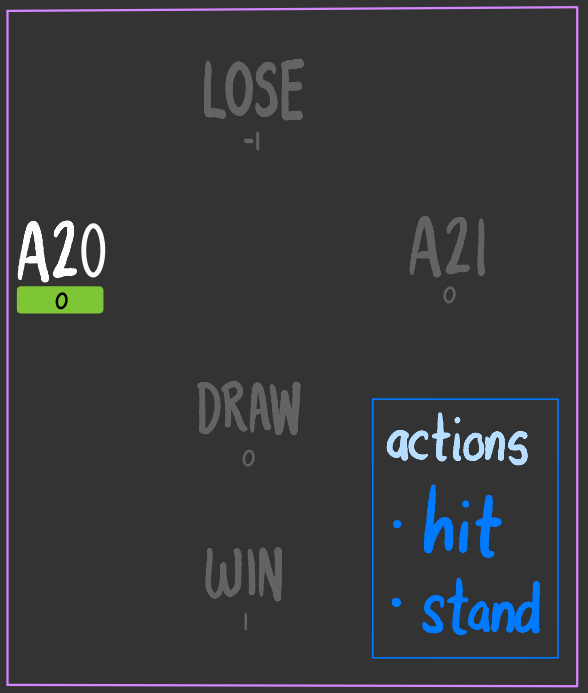
$U^{\pi}(q) = 0$ for every state q

repeat:

observe transition $q \xrightarrow{\pi(q)} q'$ with expected utility $R(q) + \gamma U^{\pi}(q')$

$$U^{\pi}(q) \mathrel{+}= \frac{R(q) + \gamma U^{\pi}(q') - U^{\pi}(q)}{n_q}$$

last time we found a way to compute the expected utility of a policy in an environment where we know only our current state, reward, and available actions



temporal difference learning

compute an online average of expected utilities

$U^{\pi}(q) = 0$ for every state q

repeat:

observe transition $q \xrightarrow{\pi(q)} q'$ with expected utility $R(q) + \gamma U^{\pi}(q')$

$$U^{\pi}(q) \mathrel{+}= \frac{R(q) + \gamma U^{\pi}(q') - U^{\pi}(q)}{n_q}$$

rather than evaluating a single policy,
we usually want to know the best policy

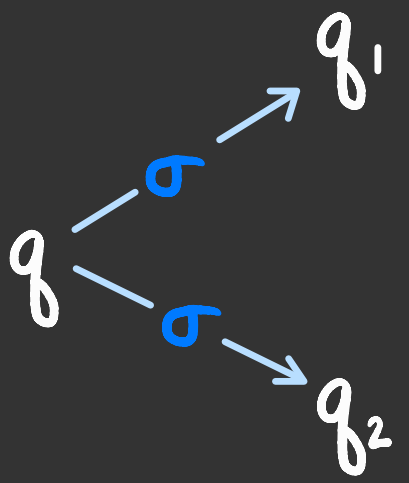
in other words, what's the best action to perform in each state?

$$U^{\pi}(q) \rightsquigarrow U(q, \sigma)$$

expected utility of state q under policy π

expected utility of action σ in state q

$$R(q) + \gamma\, p_1 U(q_1)$$

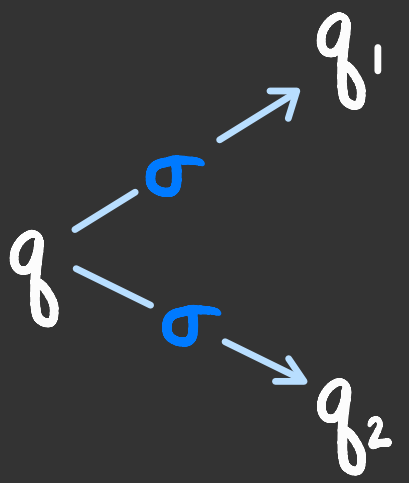


$$+ \gamma\, p_2 U(q_2)$$

$$U(q, \sigma)$$

expected utility of action σ in state q

$$R(q) + \gamma \, p_1 \max_{\sigma'} U(q_1, \sigma')$$



$$+ \gamma \, p_2 \max_{\sigma'} U(q_2, \sigma')$$

$$U(q, \sigma)$$

expected utility of action σ in state q

$$U(q, \sigma) = R(q) + \gamma \sum_{q'} P(q \xrightarrow{\sigma} q') \max_{\sigma'} U(q', \sigma')$$

$U(q, \sigma)$: expected utility of action σ in state q

$U(q', \sigma')$: expected utility of action σ' in state q'

$$U(q,\sigma) = R(q) + \gamma \sum_{q'} P(q \xrightarrow{\sigma} q') \max_{\sigma'} U(q',\sigma')$$

expected utility of action σ in state q

expected utility of action σ' in state q'

let's compute an online average of these

temporal difference learning

compute an online average of expected utilities

$U^{\pi}(q) = 0$ for every state q

repeat:

observe transition $q \xrightarrow{\pi(q)} q'$ with expected utility $R(q) + \gamma U^{\pi}(q')$

$$U^{\pi}(q) \mathrel{+}= \frac{R(q) + \gamma U^{\pi}(q') - U^{\pi}(q)}{n_q}$$

not

temporal difference learning

compute an online average of expected utilities

$U^{\pi}(q) = 0$ for every state q

repeat:

observe transition $q \xrightarrow{\pi(q)} q'$ with expected utility $R(q) + \gamma U^{\pi}(q')$

$$U^{\pi}(q) \mathrel{+}= \frac{R(q) + \gamma U^{\pi}(q') - U^{\pi}(q)}{n_q}$$

not ∨

temporal difference learning

compute an online average of expected utilities

$U(q, \sigma) = 0$ for every state q, action σ

repeat:

observe transition $q \xrightarrow{\pi(q)} q'$ with expected utility $R(q) + \gamma U^{\pi}(q')$

$$U^{\pi}(q) \mathrel{+}= \frac{R(q) + \gamma U^{\pi}(q') - U^{\pi}(q)}{n_q}$$

not

temporal difference learning

compute an online average of expected utilities

$U(q, \sigma) = 0$ for every state q, action σ

repeat:

no policy now, so we'll choose an action

observe transition $q \xrightarrow{\pi(q)} q'$ with expected utility $R(q) + \gamma U^{\pi}(q')$

$$U^{\pi}(q) \mathrel{+}= \frac{R(q) + \gamma U^{\pi}(q') - U^{\pi}(q)}{n_q}$$

not

temporal difference learning

compute an online average of expected utilities

$U(q, \sigma) = 0$ for every state q, action σ

repeat:

choose action σ

observe transition $q \xrightarrow{\sigma} q'$ with expected utility $R(q) + \gamma \max_{\sigma'} U(q', \sigma')$

$$U^{\pi}(q) \mathrel{+}= \frac{R(q) + \gamma U^{\pi}(q') - U^{\pi}(q)}{n_q}$$

not ✓

temporal difference learning

compute an online average of expected utilities

$U(q, \sigma) = 0$ for every state q, action σ

repeat:

choose action σ

observe transition $q \xrightarrow{\sigma} q'$ with expected utility $R(q) + \gamma \max_{\sigma'} U(q', \sigma')$

$$U(q, \sigma) \mathrel{+}= \frac{R(q) + \gamma \max_{\sigma'} U(q', \sigma') - U(q, \sigma)}{n_{q,\sigma}}$$

qlearning

compute an online average of expected utilities

$U(q, \sigma) = 0$ for every state q, action σ

repeat:

choose action σ

observe transition $q \xrightarrow{\sigma} q'$ with expected utility $R(q) + \gamma \max_{\sigma'} U(q', \sigma')$

$$U(q, \sigma) \mathrel{+}= \frac{R(q) + \gamma \max_{\sigma'} U(q', \sigma') - U(q, \sigma)}{n_{q,\sigma}}$$

qlearning

compute an online average of expected utilities

$U(q, \sigma) = 0$ for every state q, action σ

repeat:

choose action σ

observe transition $q \xrightarrow{\sigma} q'$ with expected utility $R(q) + \gamma \max_{\sigma'} U(q', \sigma')$

$$U(q, \sigma) \mathrel{+}= \frac{R(q) + \gamma \max_{\sigma'} U(q', \sigma') - U(q, \sigma)}{n_{q,\sigma}}$$

qlearning

these are called **qvalues**

compute an online average of expected utilities

$U(q, \sigma) = 0$ for every state q, action σ

repeat:

choose action σ

observe transition $q \xrightarrow{\sigma} q'$ with expected utility $R(q) + \gamma \max_{\sigma'} U(q', \sigma')$

$$U(q, \sigma) \mathrel{+}= \frac{R(q) + \gamma \max_{\sigma'} U(q', \sigma') - U(q, \sigma)}{n_{q,\sigma}}$$

qlearning

how do we do this?

compute an online average of expected utilities

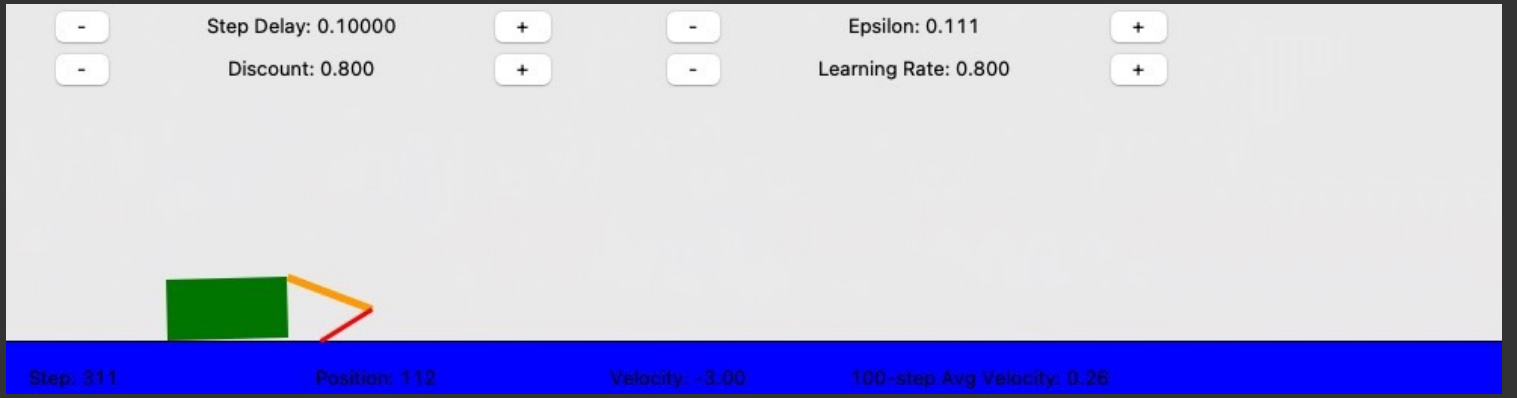
$U(q, \sigma) = 0$ for every state q, action σ

repeat:

choose action σ

observe transition $q \xrightarrow{\sigma} q'$ with expected utility $R(q) + \gamma \max_{\sigma'} U(q', \sigma')$

$$U(q, \sigma) \mathrel{+}= \frac{R(q) + \gamma \max_{\sigma'} U(q', \sigma') - U(q, \sigma)}{n_{q,\sigma}}$$



to the laptop!

qlearning

compute an online average of expected utilities

$U(q, \sigma) = 0$ for every state q, action σ

repeat:

$$\sigma = \begin{cases} \text{random } \sigma & \text{with prob } \epsilon \quad (\text{"exploration"}) \\ \underset{\sigma}{\text{argmax}}\ U(q, \sigma) & \text{otherwise} \quad (\text{"exploitation"}) \end{cases}$$

observe transition $q \xrightarrow{\sigma} q'$ with expected utility $R(q) + \gamma \max_{\sigma'} U(q', \sigma')$

$$U(q, \sigma) \mathrel{+}= \frac{R(q) + \gamma \max_{\sigma'} U(q', \sigma') - U(q, \sigma)}{n_{q, \sigma}}$$

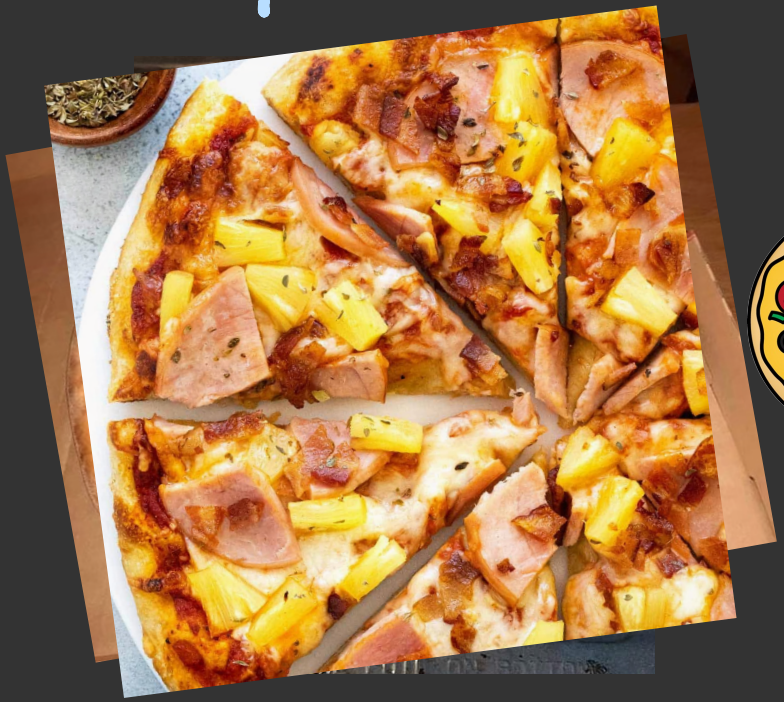
exploration VS. exploitation

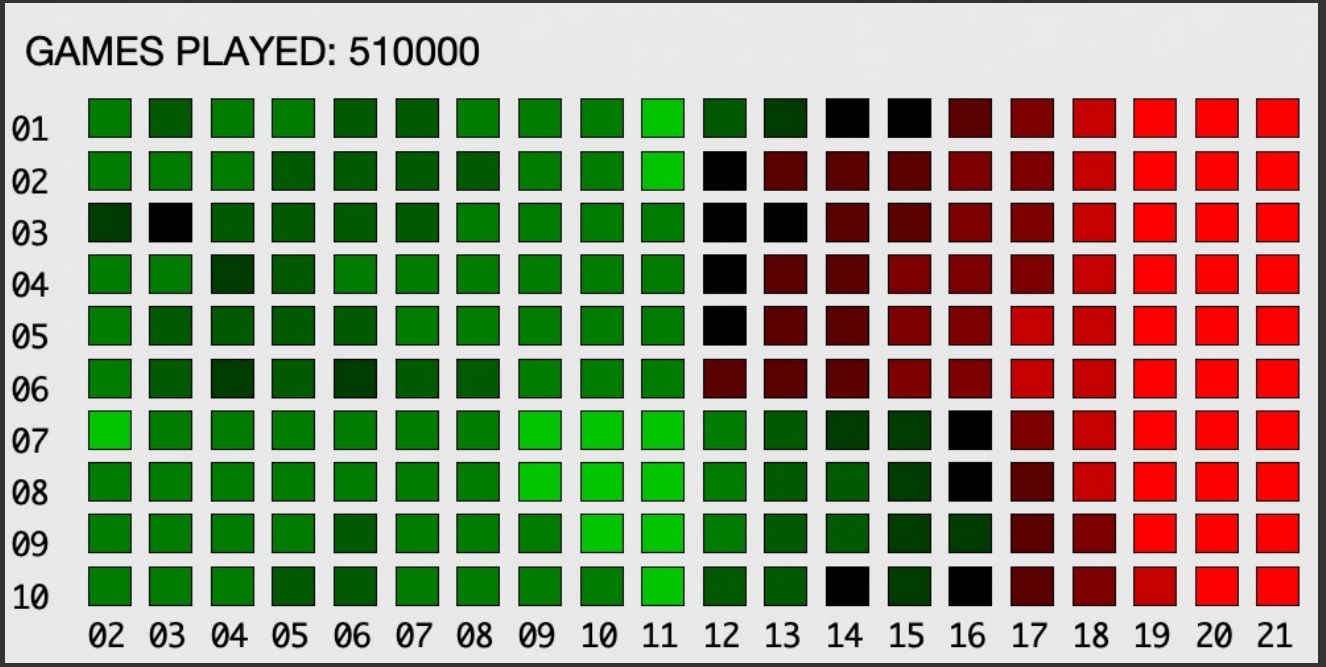
exploration VS. exploitation

exploration VS. exploitation

exploration VS. exploitation

exploration VS. exploitation

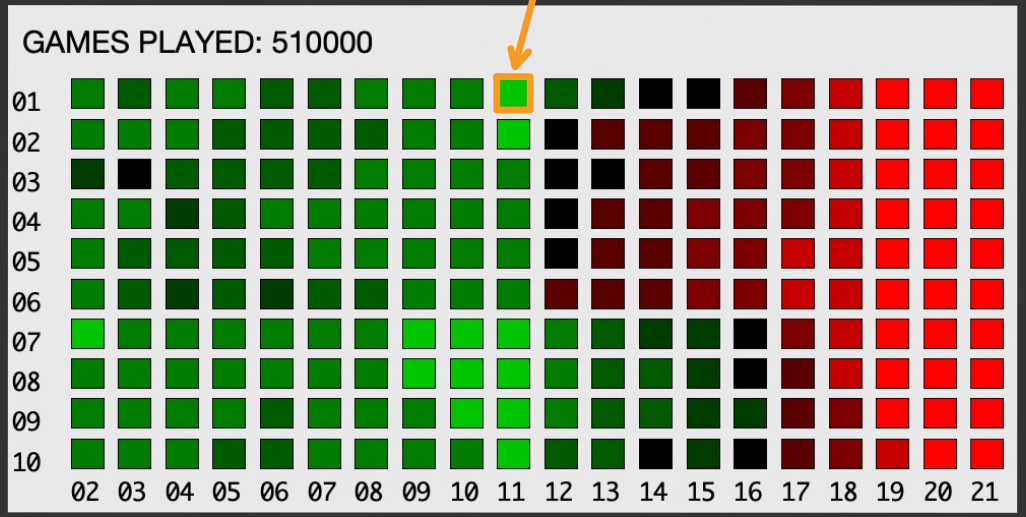




to the laptop!

if $U(q, \text{hit}) - U(q, \text{stand}) > 0$

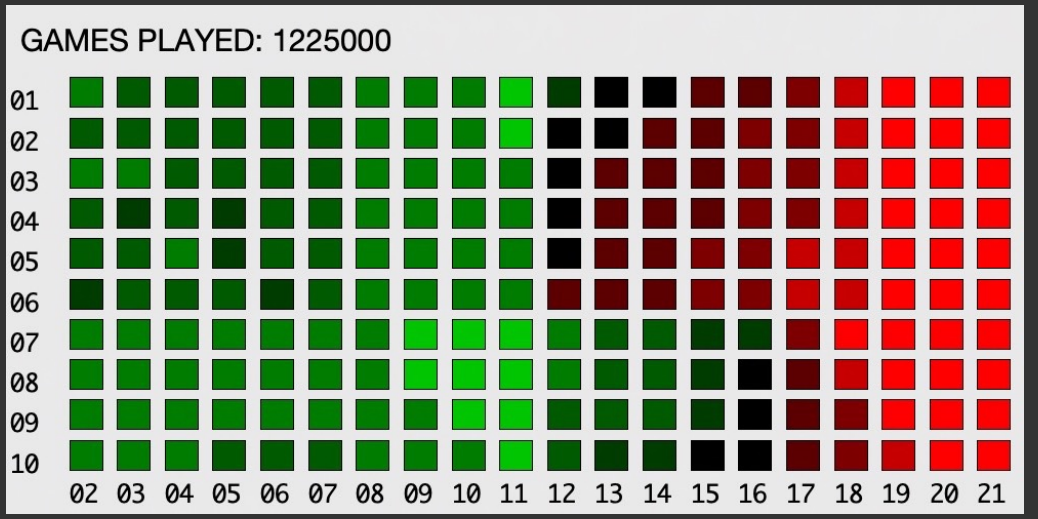
if $U(q, \text{hit}) - U(q, \text{stand}) < 0$



dealer's up card

player's card total

aces count as one



aces count as one or eleven