LAB 3

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Deadline: 2022/04/05(Tue) 23:59

Demo: 2021/04/12(Tue)

In this lab,

Must use sample code, otherwise no credit.

Outline

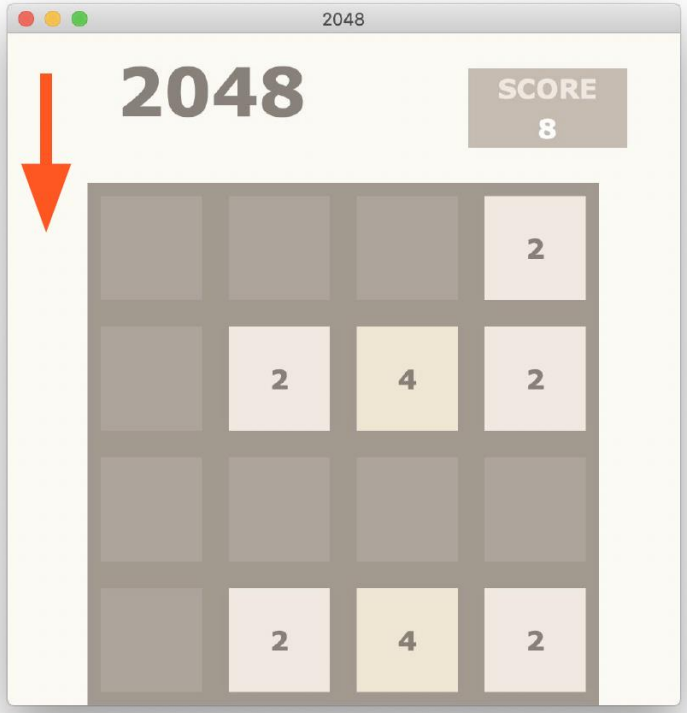
1. 2048 Game Rule
2. Game State
3. Temporal Difference Learning
4. n-tuple Network
5. Modify and Run Sample Code
6. Scoring Criteria
7. Reminders

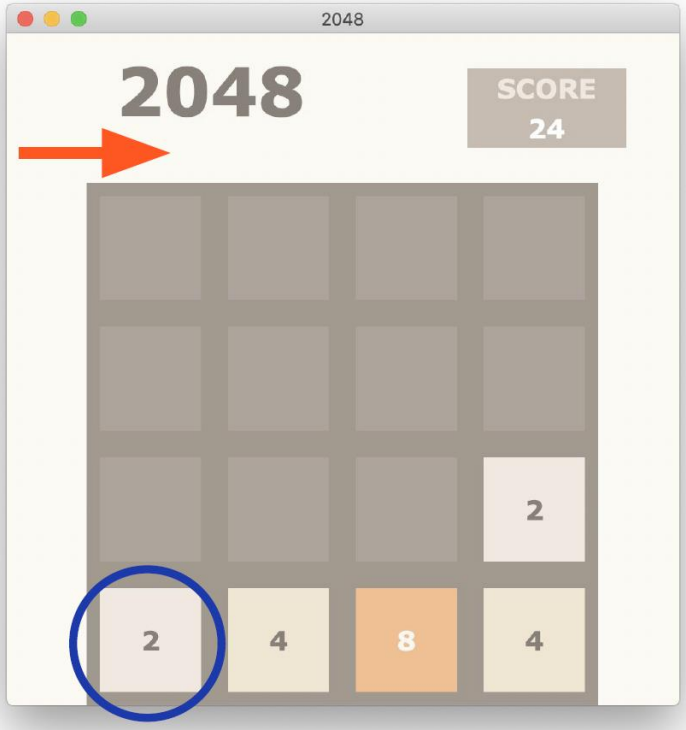
2048 Game Rules (1/2)

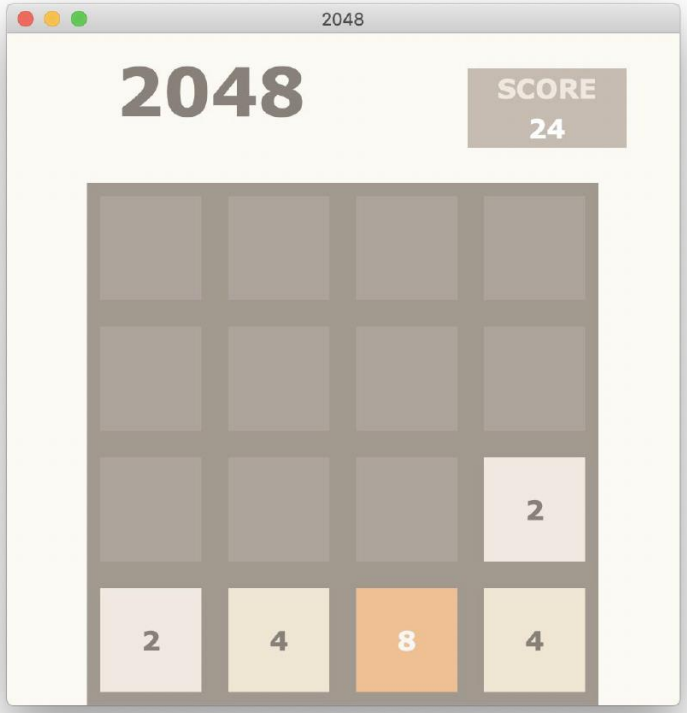
popup: **2** (90%), **4** (10%)

2048 Game Rules (2/2)

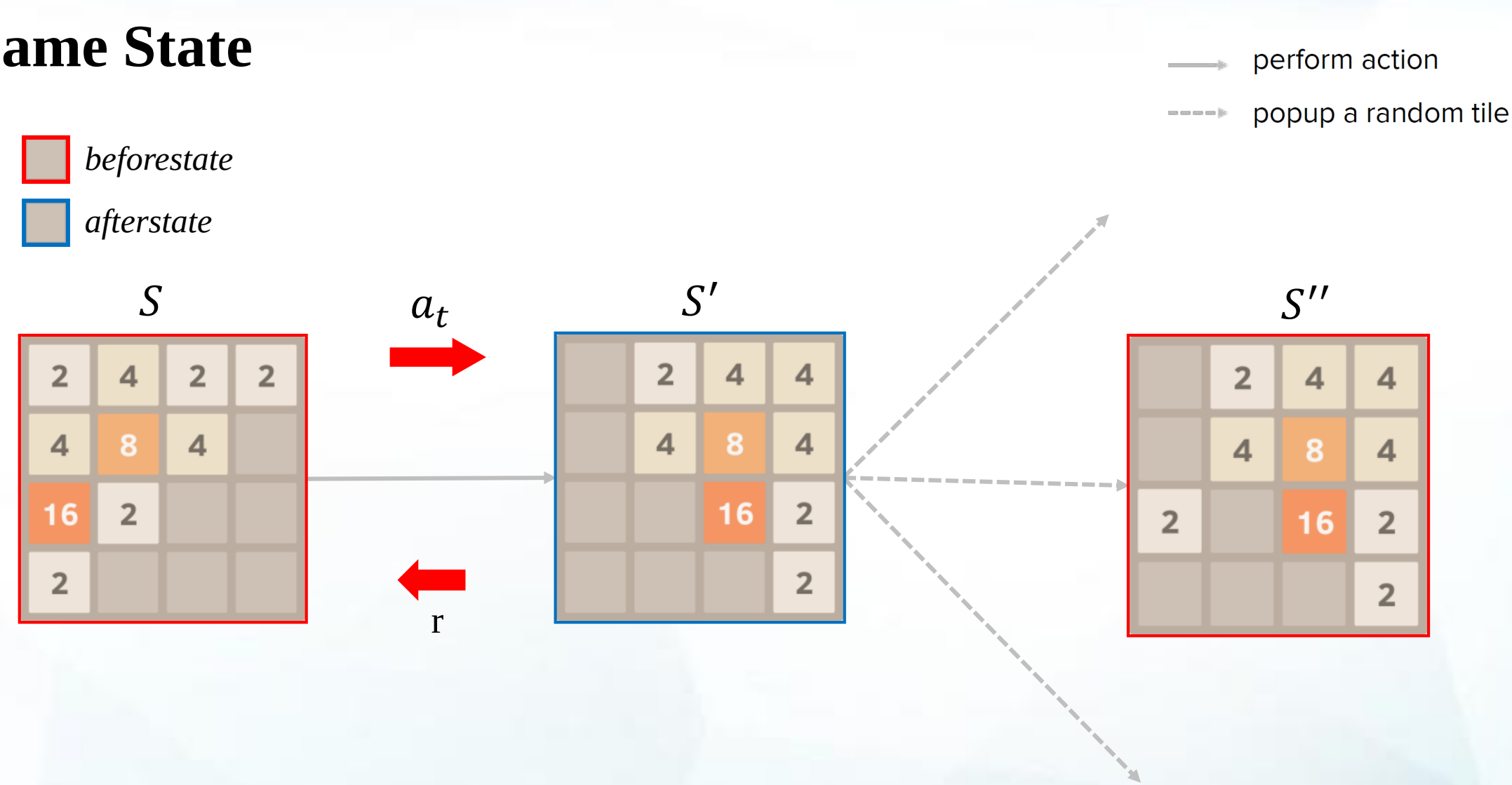
does not popup







Game State


perform action
popup a random tile
beforestate
afterstate
S
a_t
S'
S''
r

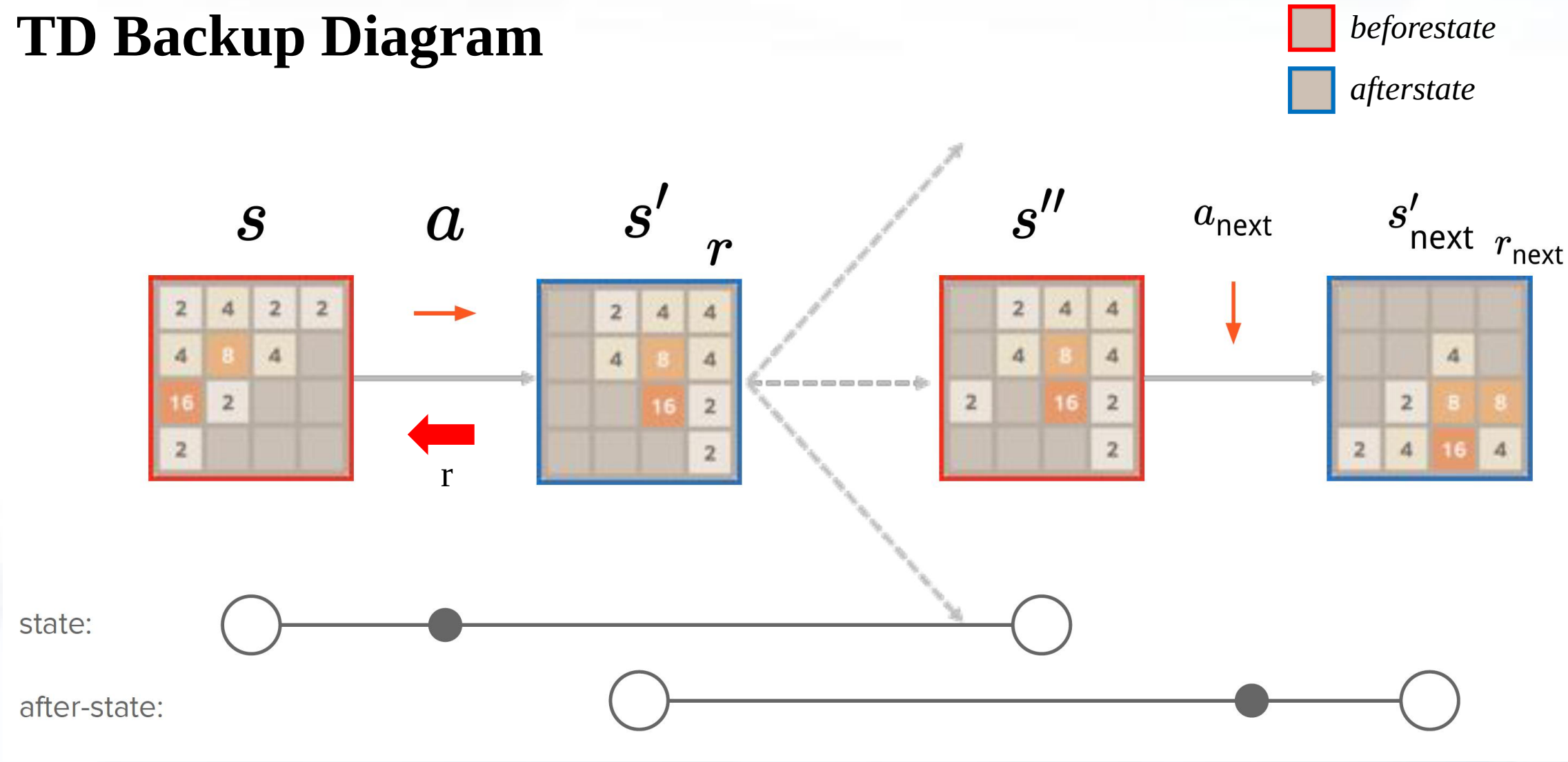
Temporal Difference Learning (TD)

For each episode,

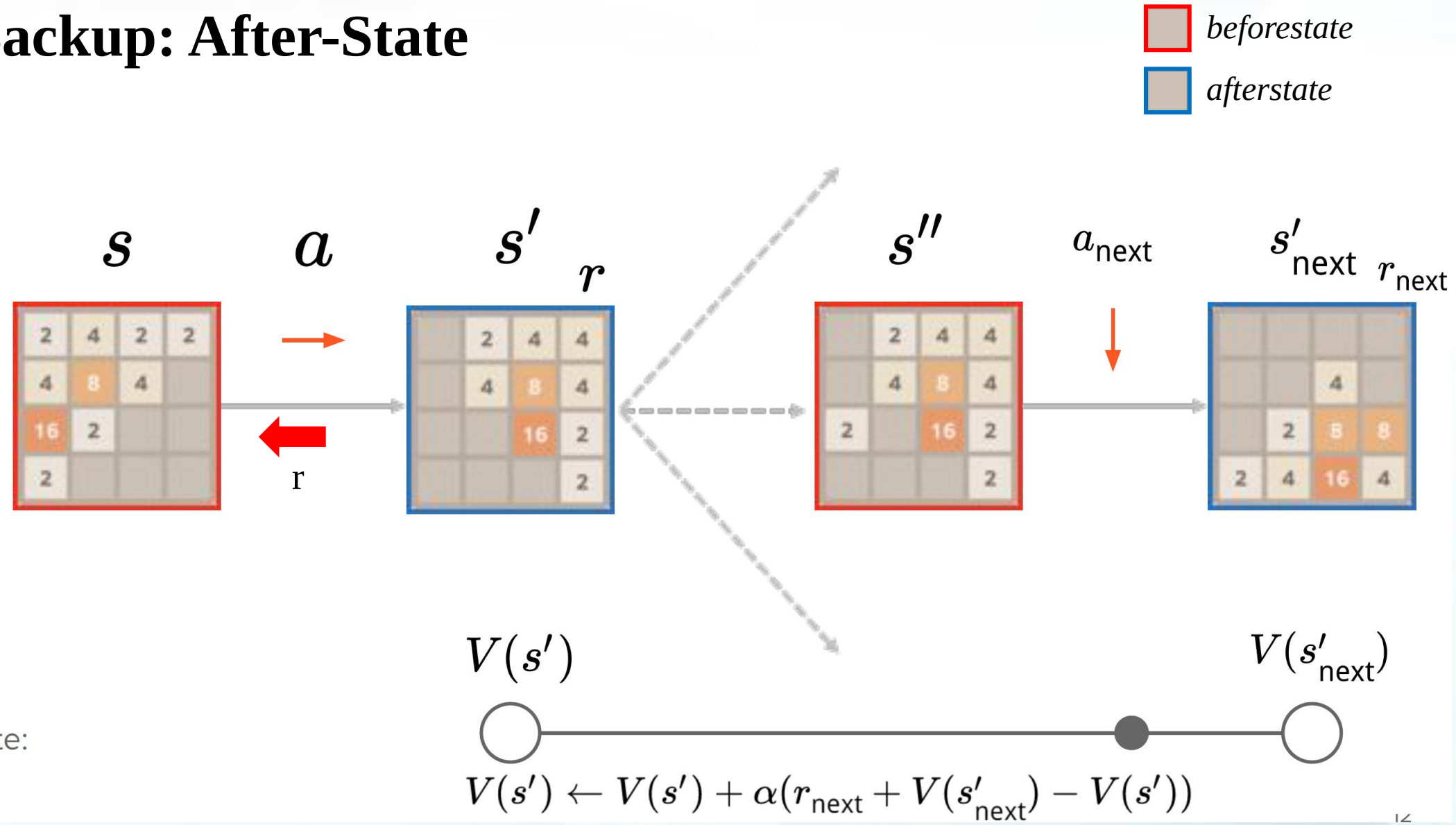
```
Initialize (before-)state s
While s is not terminal do
  a ← argmax_a' EVALUATE(s, a')
  r, s', s'' ← MAKE_MOVE(s, a)
  STORE(s, a, r, s', s'')
  s ← s''
End While
For (s, a, r, s’, s’’) from terminal down to initial do
  LEARN_EVALUATION(s, a, r, s', s'')
End For
```

perform TD backup

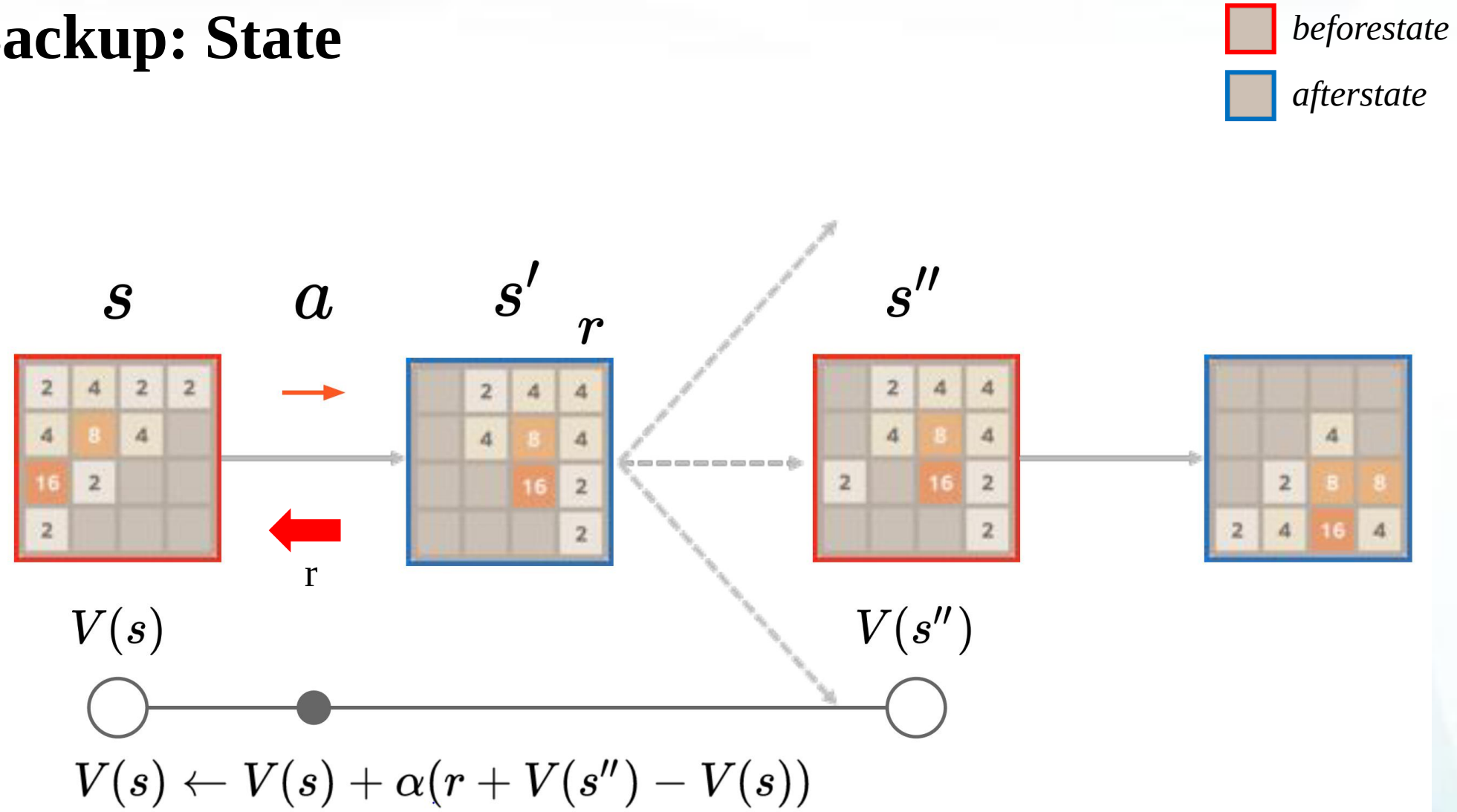
TD Backup Diagram



TD Backup: After-State



TD Backup: State



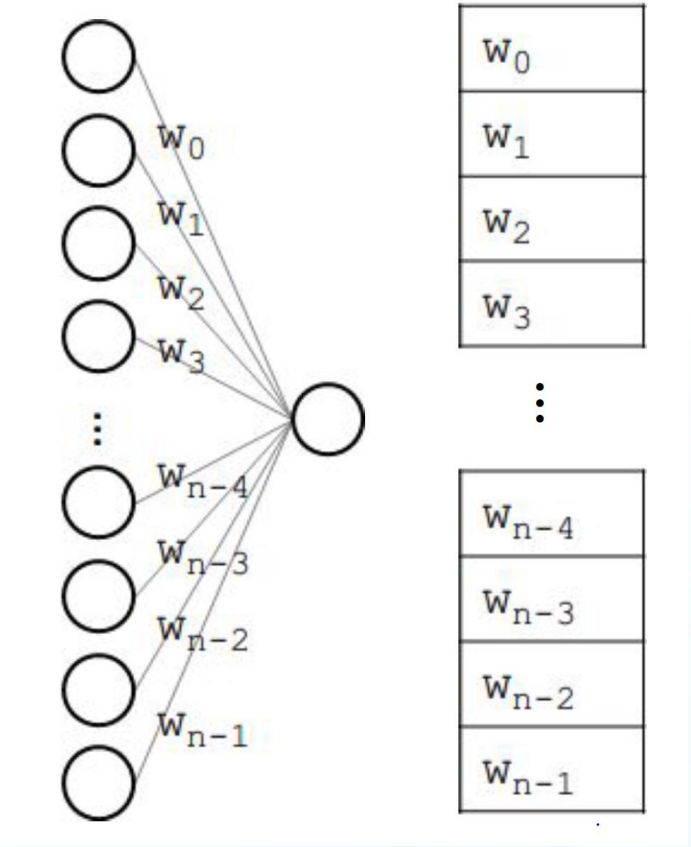
Why use n-tuple network?

- The expected score/return G_t from a board S
- But, #states is huge
  - About 17^{16} ($=10^{20}$).
    - Empty ($\rightarrow 0$), 2 ($=2^1 \rightarrow 1$), 4 ($=2^2 \rightarrow 2$), 8 ($=2^3 \rightarrow 3$), …, 65536 ($=2^{16} \rightarrow 16$).
- Need to use value function approximator.

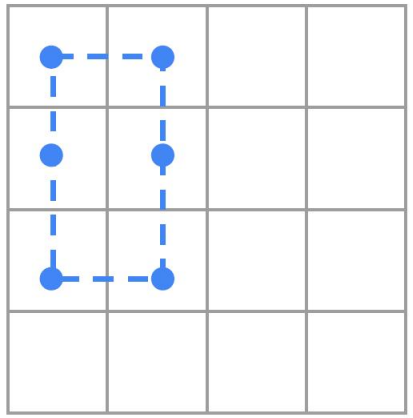
n-tuple network

n-tuple network (a.k.a. RAM-based neural network) is a type of artificial neural network.

- A large number of input nodes.
  - Input values are either 1 or 0.
  - Input is a sparse vector.
- No hidden layers.
- Only 1 output node.



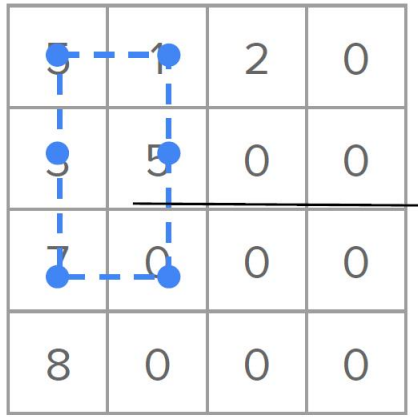
Example: 2048 with n-tuple network



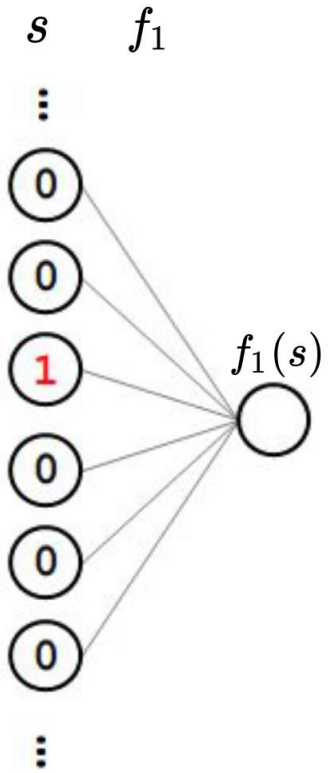
a 6-tuple pattern f_1

5	1	2	0
3	5	0	0
7	0	0	0
8	0	0	0

board s



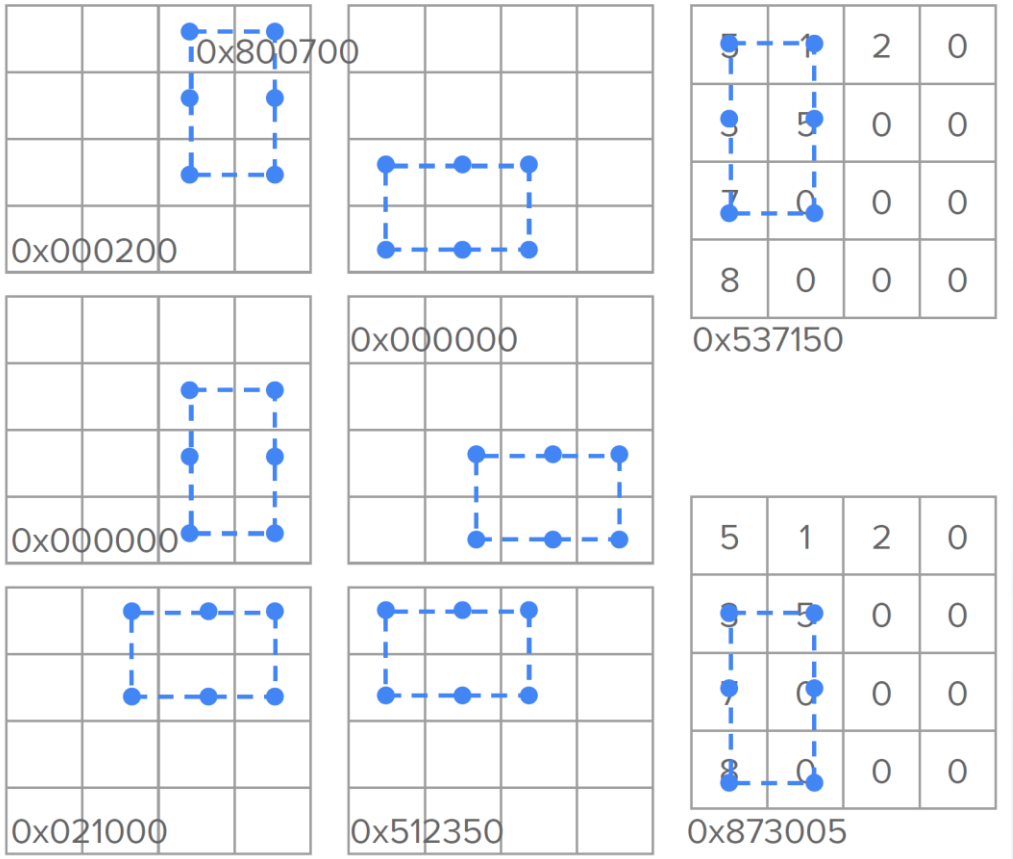
0x537150

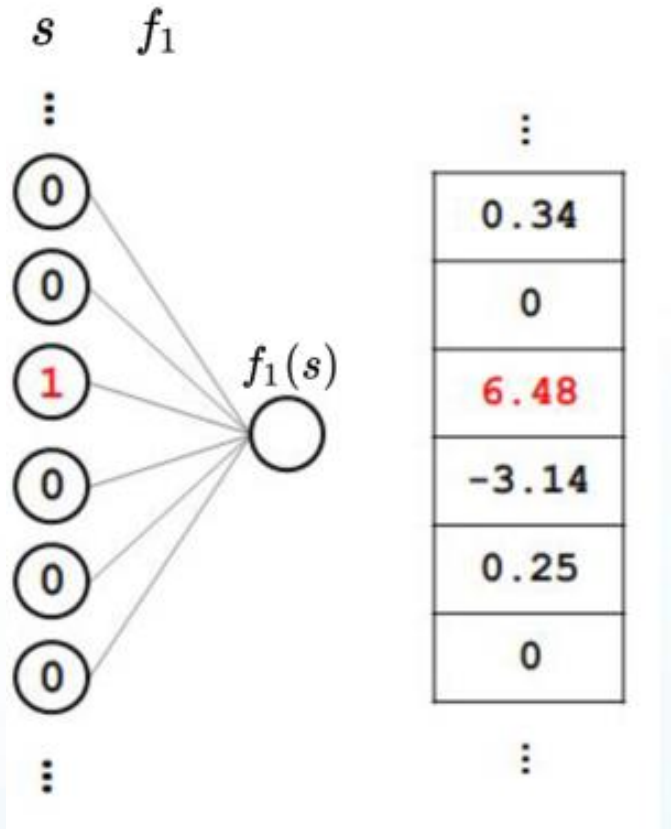


0.34
0
6.48
-3.14
0.25
0

All Isomorphism

- Rotations and Reflections
- The sum of the eight values can represents the board.

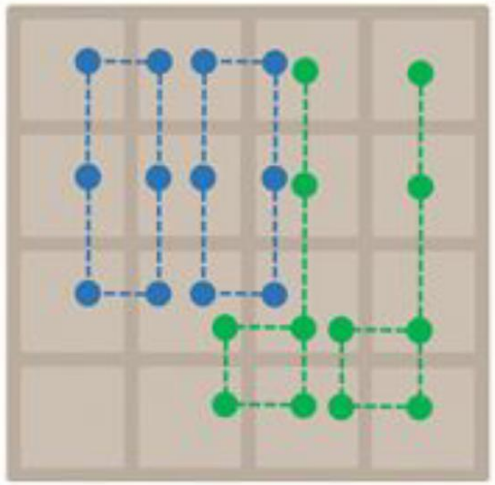


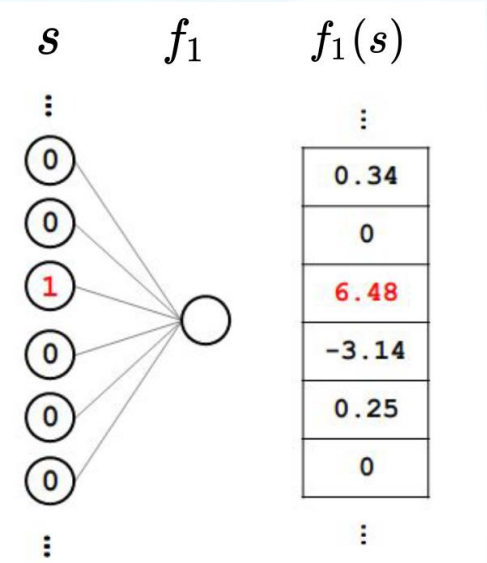


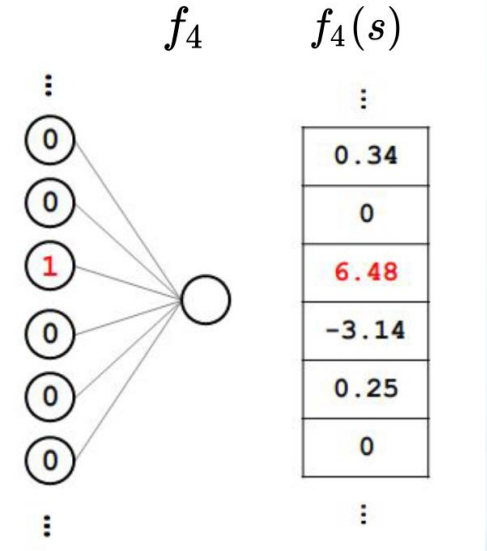
Multiple n-tuple

- Example: 4 kinds of 6-tuple.
- Calculate (use int):
  - Size: 4* 15^6 * 4 byte

$$V(s) = f_1(s) + f_2(s) + f_3(s) + f_4(s)$$







Sample Code

- Implement V(state)
  - Compile with C++11 support
  - ex: g++ -std=c++11 -O3 -o 2048 2048.cpp
- Run and Train

Scoring Criteria

Show your work, otherwise no credit will be granted.

- Report (60%)
  - (DO explain; do not only copy and paste your codes.)
- Performance (40%)
  - The 2048-tile win rate in 1000 games,$\lceil \text{winrate}_{2048} \rceil$.(20%)
  - Questions. (20%)

Reminders

- You can design your n-tuple.
- You should avoid using CNN in this lab.
- 2048-tile should appear within 10,000 episodes.

References

1. Szubert, Marcin, and Wojciech Jaśkowski. "Temporal difference learning of N-tuple networks for the game 2048." 2014 IEEE Conference on Computational Intelligence and Games. IEEE, 2014.
2. Kun-Hao Yeh, I-Chen Wu, Chu-Hsuan Hsueh, Chia-Chuan Chang, Chao-Chin Liang, and Han Chiang,
Multi-Stage Temporal Difference Learning for 2048-like Games, accepted by IEEE Transactions on Computational Intelligence and AI in Games (SCI), doi: 10.1109/TCIAIG.2016.2593710, 2016.
3. Oka, Kazuto, and Kiminori Matsuzaki. "Systematic selection of n-tuple networks for 2048." International Conference on Computers and Games. Springer International Publishing, 2016.
4. moporgic. “Basic implementation of 2048 in Python.” Retrieved from Github: https://github.com/moporgic/2048-Demo-Python .
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6. lukewayne123. “2048-Framework” Retrieved from Github: https://github.com/lukewayne123/2048-Framework