Lab 7

TA 余玄

6/15 23:55

Lab7 Deadline

no demo

In this lab,

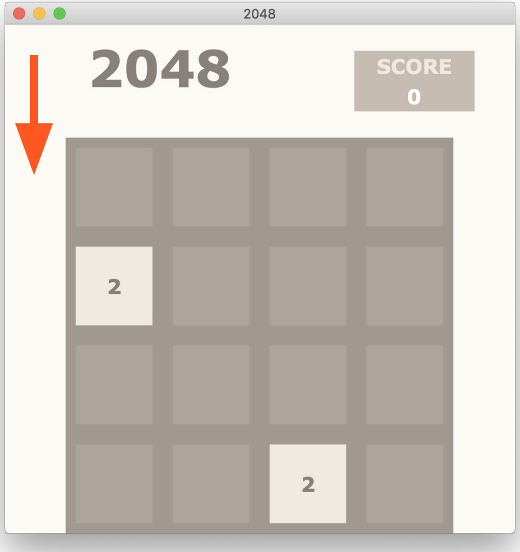
Must use sample code, otherwise no credit.

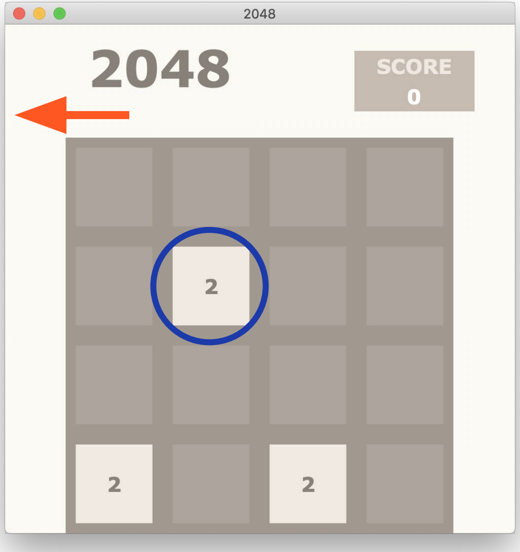
Outline

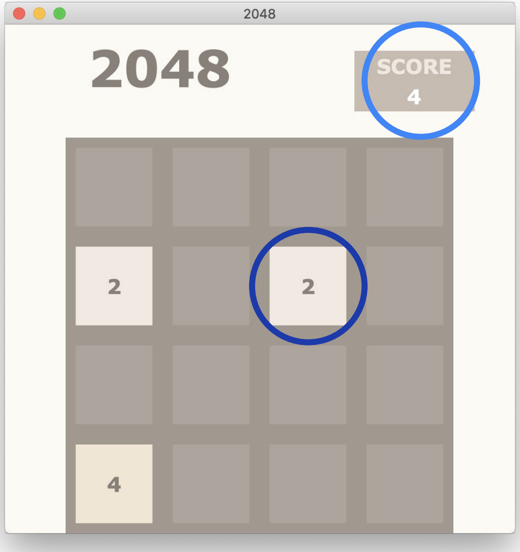
1. 2048 Game Rule
2. Game State
3. Temporal Difference Learning
4. n-tuple Network
5. Modify and Run Sample Code
6. Scoring Criteria
7. Reminders

2048 Game Rules (1/2)

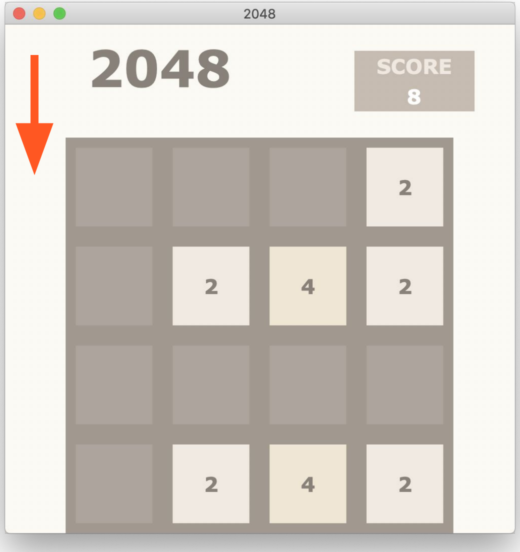
popup: **2** (90%), **4** (10%)







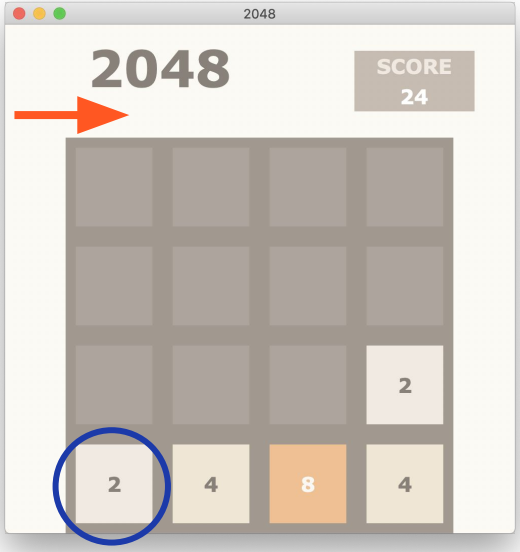
2048 Game Rules (2/2)


2048

2048

SCORE
8

			2
	2	4	2
	2	4	2

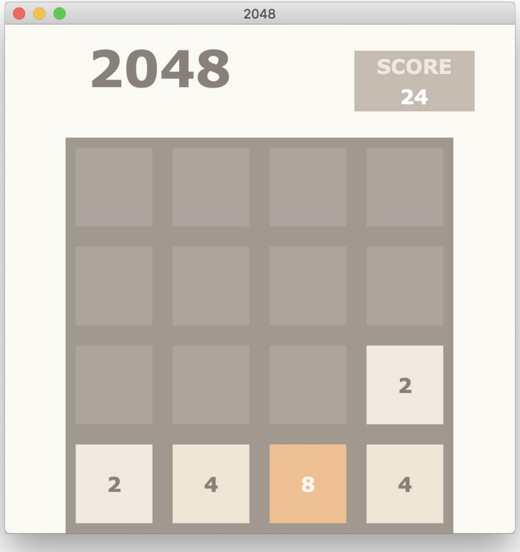

2048

2048

SCORE
24

			2
2	4	8	4

does not popup


2048

2048

SCORE
24

			2
2	4	8	4

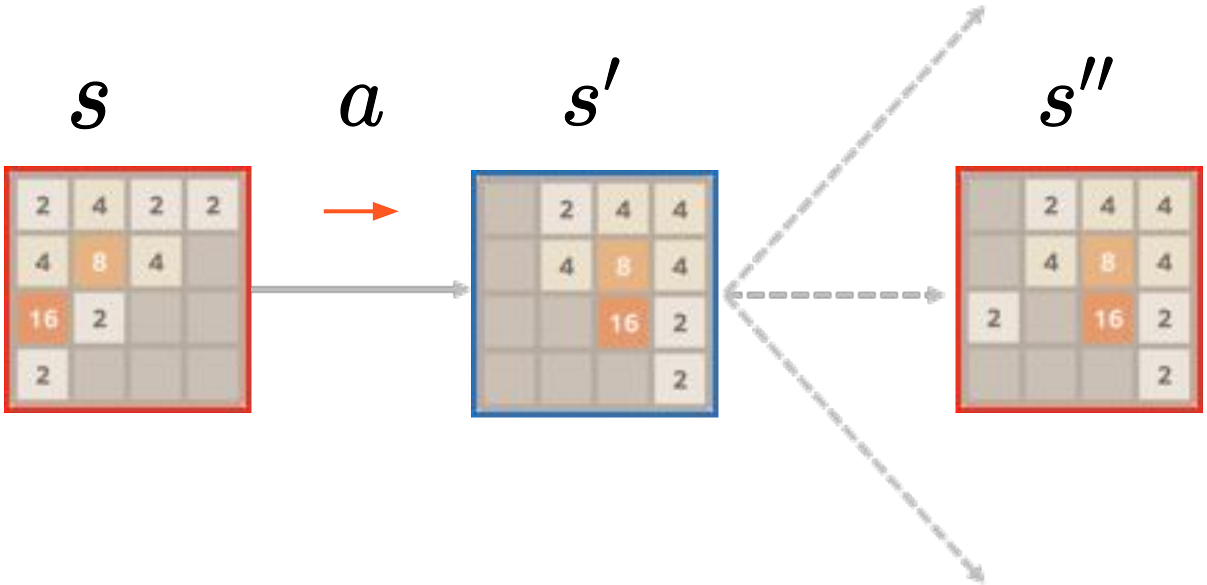
Game State

🟥 state

🟦 after-state

→ perform action

⇢ popup a random tile



2	4	2	2
4	8	4	
16	2		
2			

	2	4	4
	4	8	4
		16	2
			2

	2	4	4
	4	8	4
2		16	2
			2

Temporal Difference Learning (TD)

For each episode,

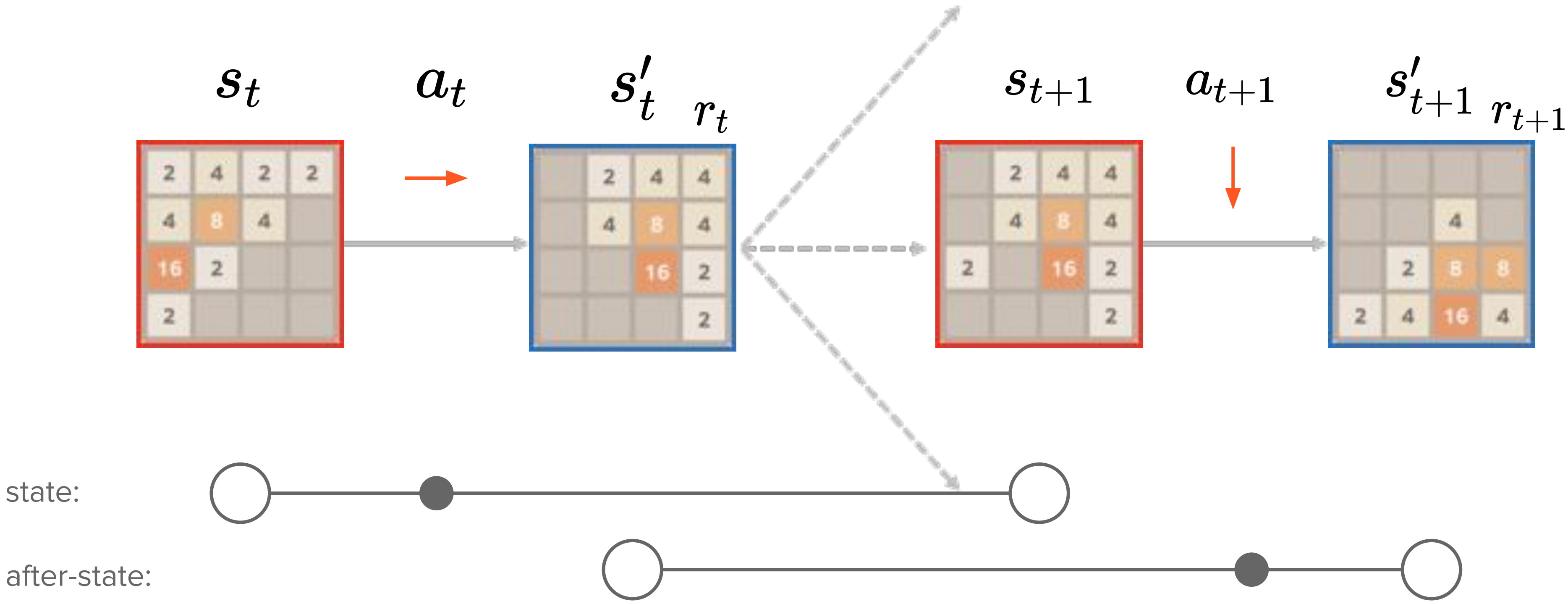
```
Initialize (before-)state s
While s is not terminal do
  a ← $\text{argmax}_{a'}$ EVALUATE(s, a')
  r, s', s'' ← MAKE_MOVE(s, a)
  STORE(s, a, r, s', s'')
  s ← s''
End While
For (s, a, r, s’, s’’) from terminal down to initial do
  LEARN_EVALUATION(s, a, r, s', s'')
End For
```

perform TD backup

TD Backup Diagram

state

after-state



2	4	2	2
4	8	4	
16	2		
2			

	2	4	4
	4	8	4
		16	2
			2

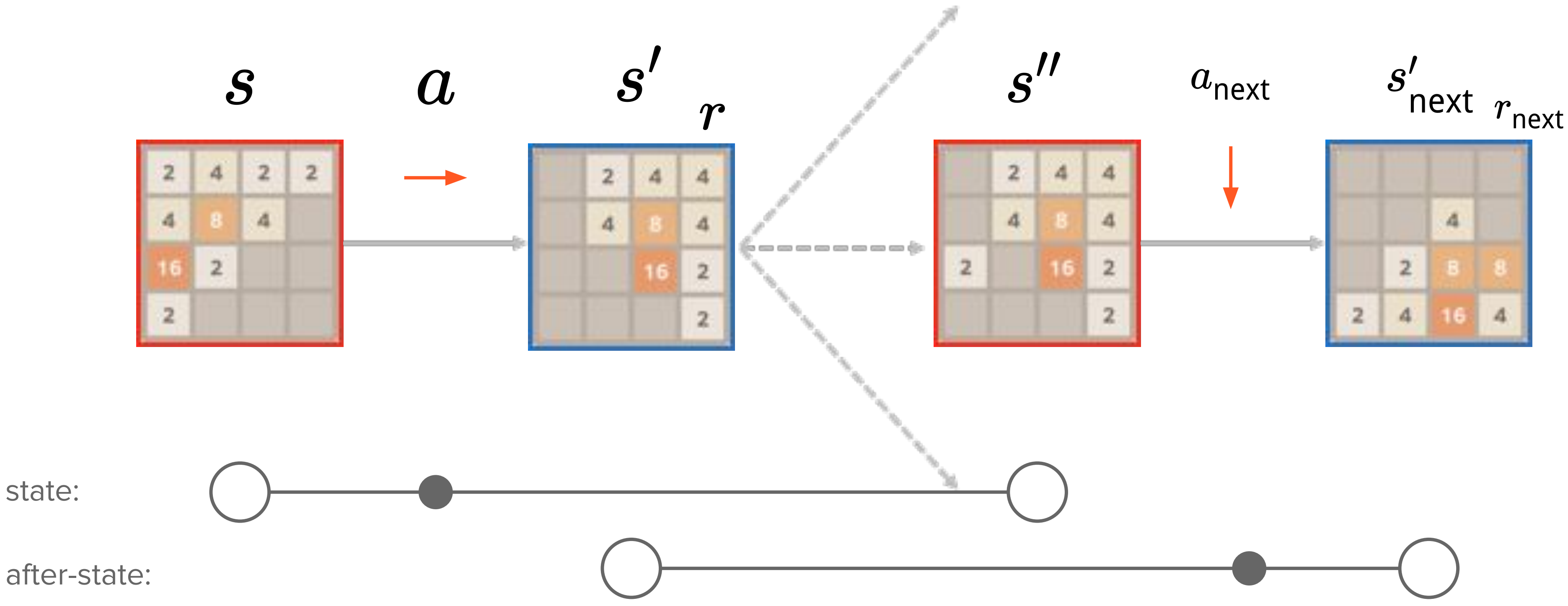
	2	4	4
	4	8	4
2		16	2
			2

		4	
	2	8	8
2	4	16	4

TD Backup Diagram

🟥 state

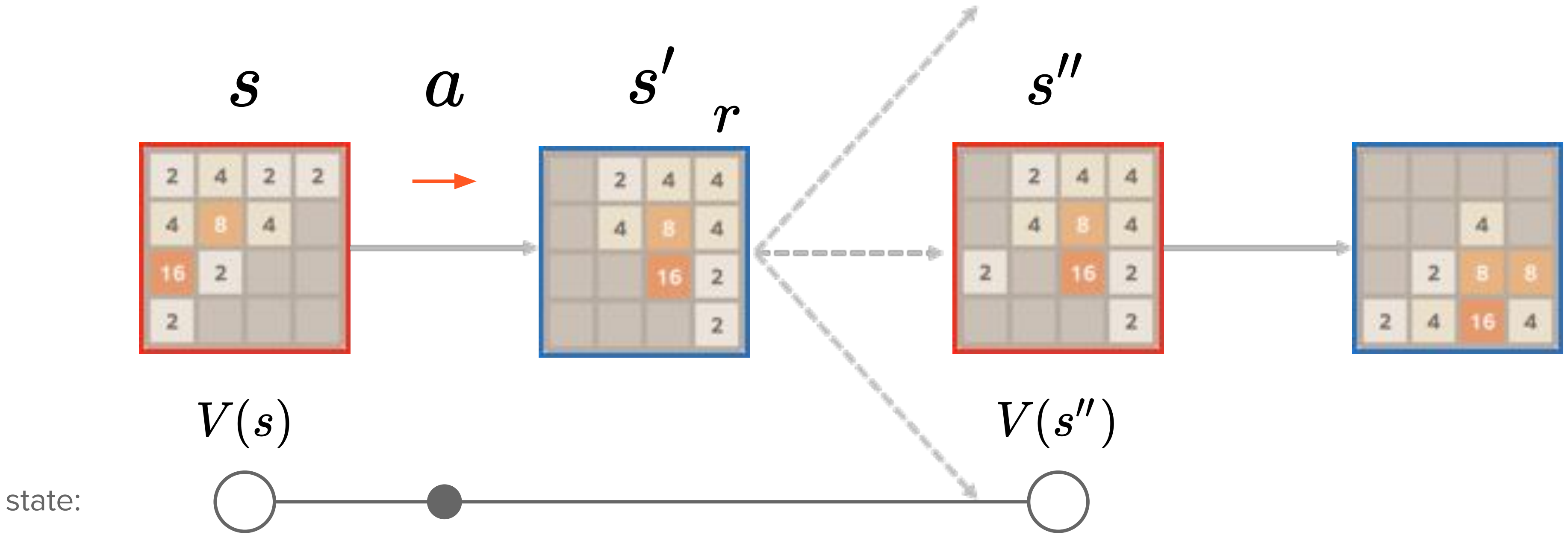
🟦 after-state



TD Backup: State

🟥 state

🟦 after-state

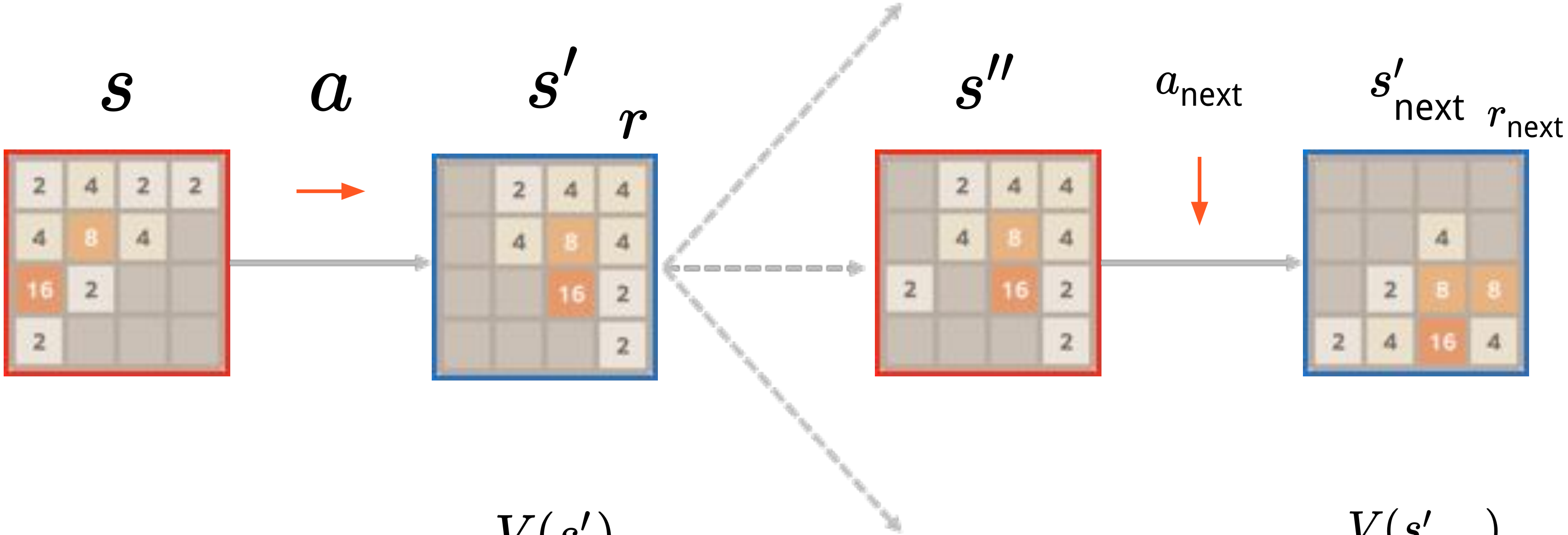


$$V(s) \leftarrow V(s) + \alpha(r + V(s'') - V(s))$$

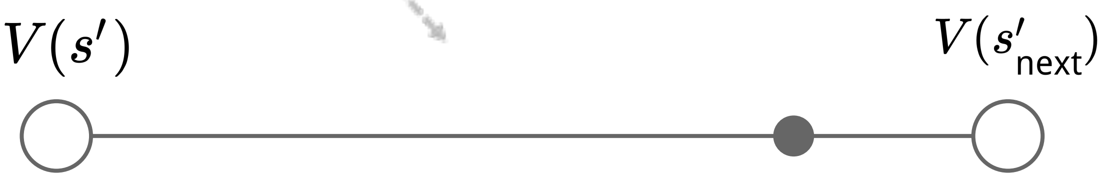
TD Backup: After-State

🟥 state

🟦 after-state



after-state:

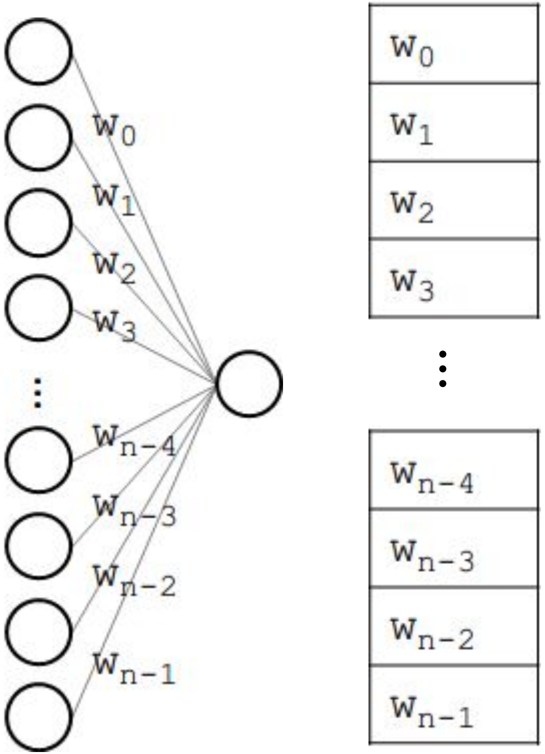


$$V(s') \leftarrow V(s') + \alpha(r_{\text{next}} + V(s'_{\text{next}}) - V(s'))$$

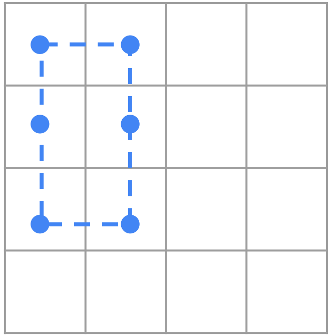
n-tuple network

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

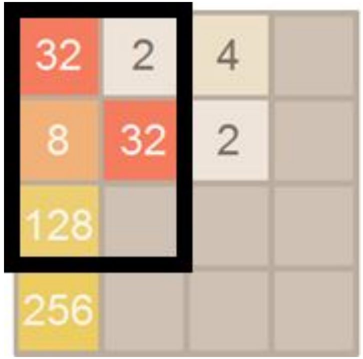
- A large number of input nodes.
  - Input values are either 1 or 0.
  - Input is a sparse vector.
- No hidden layers.
- Only 1 output node.



Example: 2048 with n-tuple network

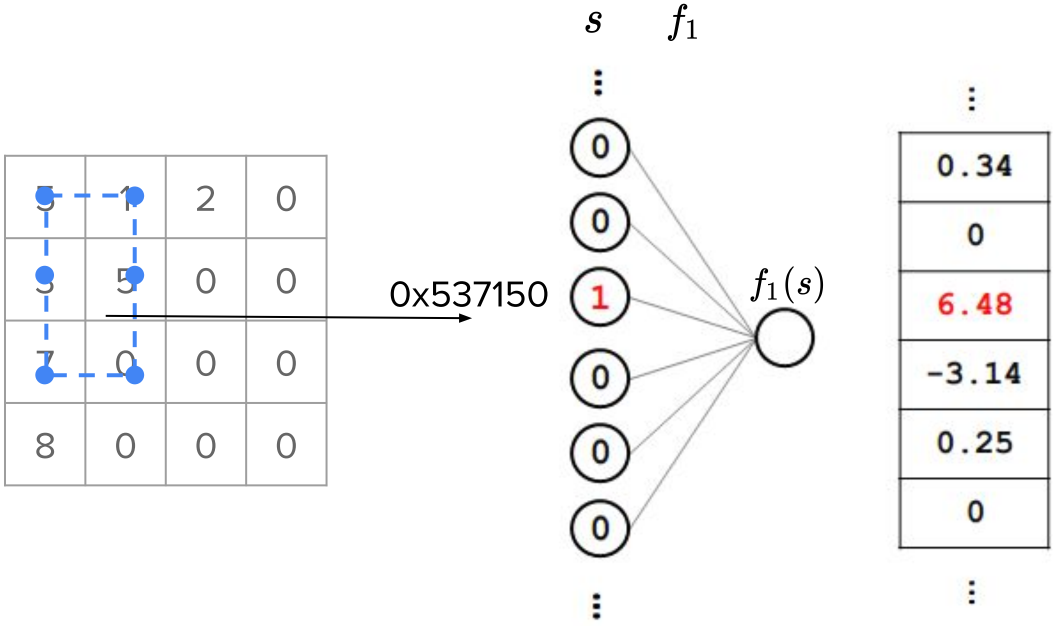


a 6-tuple pattern f_1



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

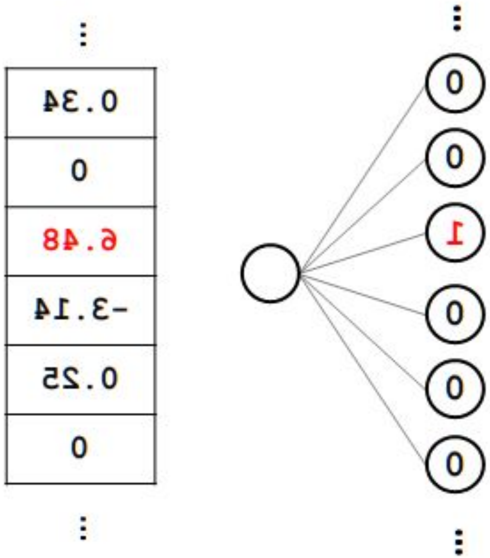
board s

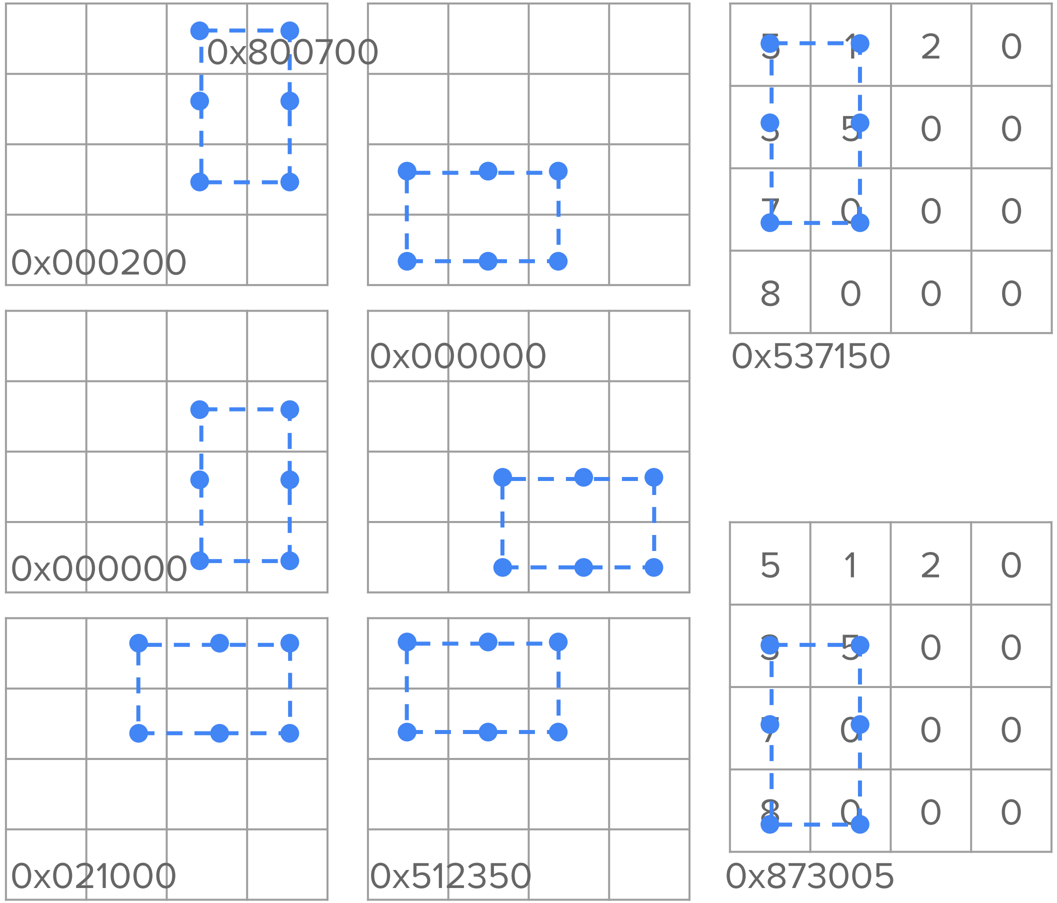


5	1	2	0
3	5	0	0
7	0	0	0
8	0	0	0

All Isomorphisms

(Rotations and Reflections)





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

0x537150

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

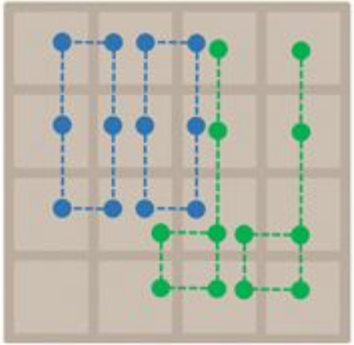
0x873005

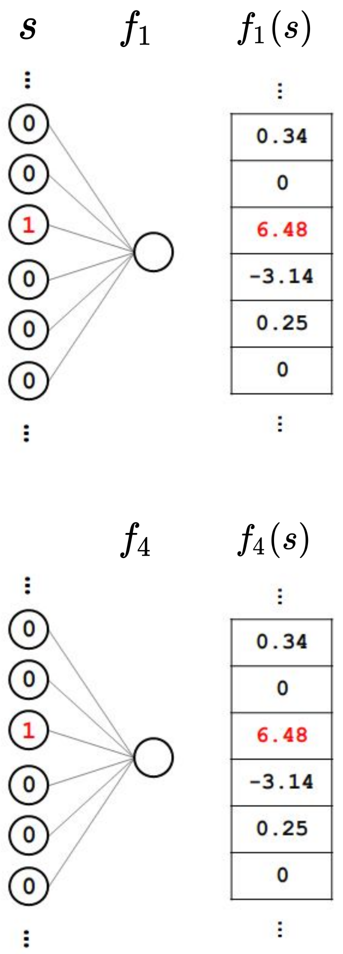
Multiple n-tuple

Example: 4 kinds of 6-tuple

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

… and more





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 (70%)
  - (DO explain; do not only copy and paste your codes.)
- Performance (30%)
  - The 2048-tile win rate in 1000 games, $\lceil \text{winrate}_{2048} \rceil$.

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.
5. moporgic. “Temporal Difference Learning for Game 2048 (Demo).” Retrieved from Github: https://github.com/moporgic/TDL2048-Demo.
6. lukewayne123. “2048-Framework” Retrieved from Github: https://github.com/lukewayne123/2048-Framework.