On attempting to reify a few of the things we may mean by "consciousness" with code

Josh Joseph, Dhaval Adjodah, Joichi Ito

Massachusetts Institute of Technology

mit media lab

MIT Quest for Intelligence

Why attempt to reify philosophy with code

- Lots of the words philosophers use describing aspects of consciousness tends shows up in CS/AI research
  - Mind, awareness, imagination, reasoning, consciousness, etc.

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- Our intuition is CS/AI could benefit from a deeper understanding of philosophy
  - But telling people to read more books/papers is not how to make this happen
  - So let's try to do it with code!

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  - So let's try to do it with code!
- Possibly benefit philosophy by bringing code-style concreteness
  - (TBD, will let the philosophers in the room speak to this!)

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Reifying philosophy with code

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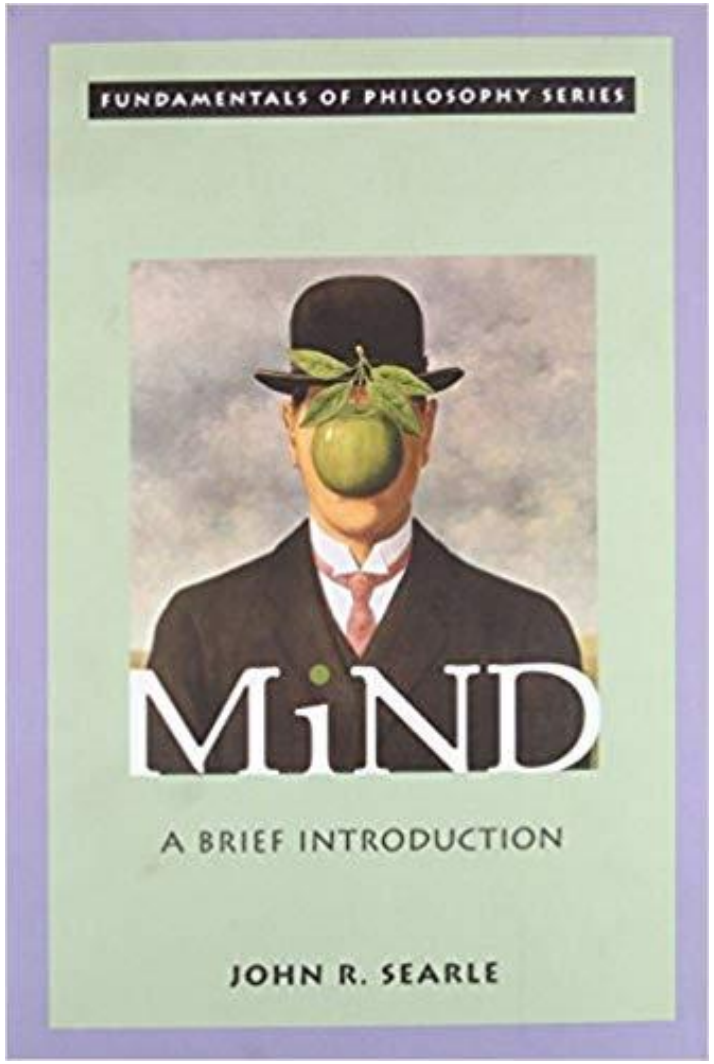

Reifying philosophy with code

- Searle's view of the relationship between consciousness and brain states

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- Let's unpack this with code!

What we're not doing

- Not trying to
  - Propose a cognitive architecture
  - Propose a new AI or machine learning algorithm
  - Claim that the software agent is conscious
  - Convince anyone these are the correct/best/most useful definitions of consciousness or brain states
  - Convince anyone Searle is right or wrong

What we're trying to do

- Trying to create a software agent that is consistent with Searle’s view on consciousness
  - (or at least a simplified version of Searle’s view)

What we're trying to do

- Trying to create a software agent that is consistent with Searle’s view on consciousness
  - (or at least a simplified version of Searle’s view)
- (Hopefully) gain a bit deeper understanding of what we may mean by consciousness, brain states, causal reduction, and ontological reduction along the way

Software Engineering, 101

- Requirements – what the system must do
- Design – how will we build the system to meet the requirements
- Implementation – building the system consistent with the design

Requirements: unpacking Searle's view

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  - Third person, objective

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- Internal state
  - Representations, goals, rewards, observations, actions, etc.
  - Subjective

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  - First person, subjective
- Conscious mental state
  - A mental state in which it is "something it's like to be in"
  - First person, subjective character of experience, phenomenal

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  - Conscious mental states are casually reducible to brain states
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- V1
  - Mental states are casually reducible to brain states
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- V0
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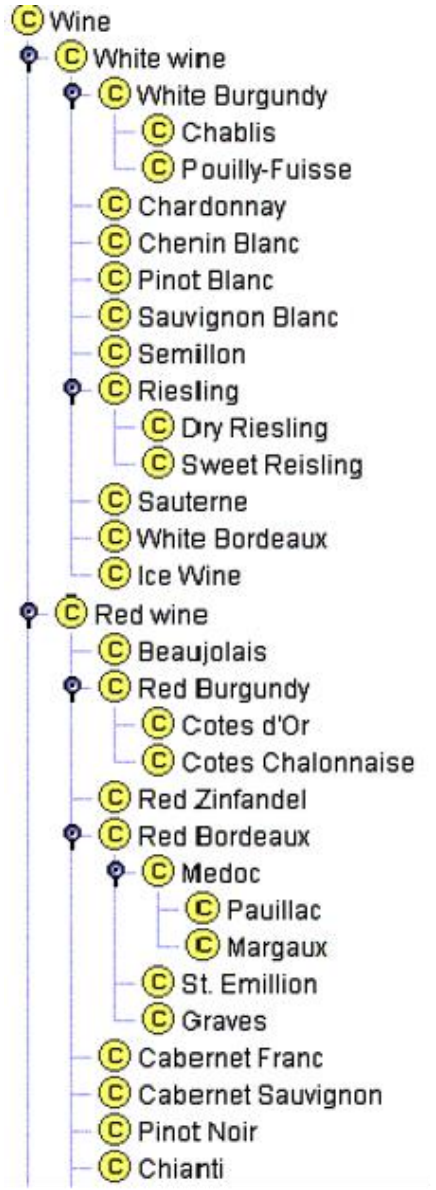
Ontologies in Computer Science



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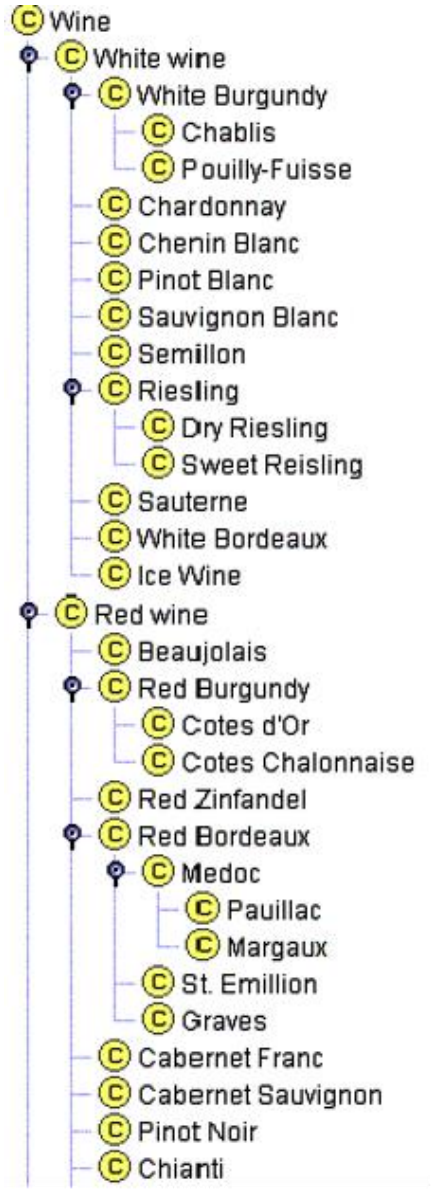
Ontologies in Computer Science

- Class-instance distinction



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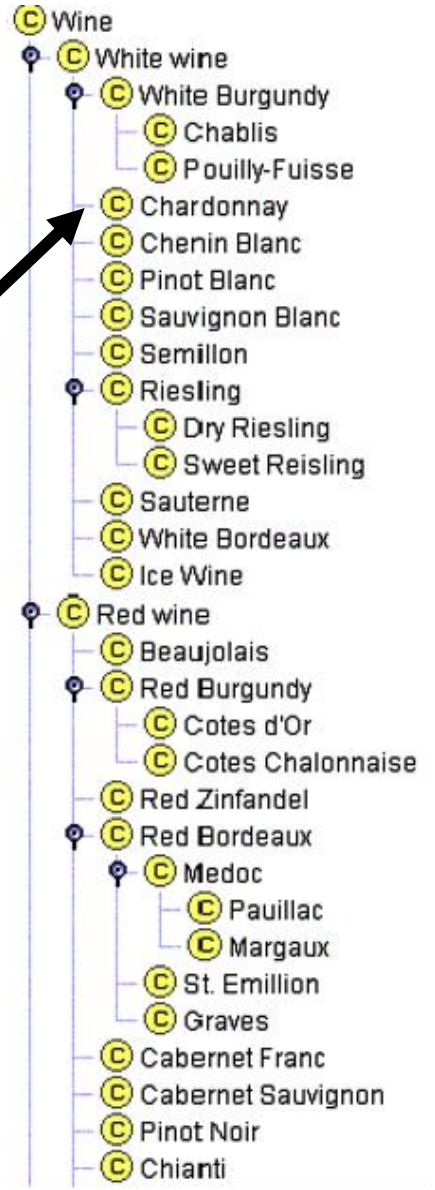

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(C) Case of wine

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  - Rose wine
  - Red wine
  - White Burgundy
  - Chenin Blanc
  - Chardonnay
  - Pinot Blanc
  - Sauvignon Blanc
  - Ice Wine
  - White Zinfandel
  - Beaujolais
  - Red Burgundy
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  - Pauillac
  - Margaux
  - St. Emillion
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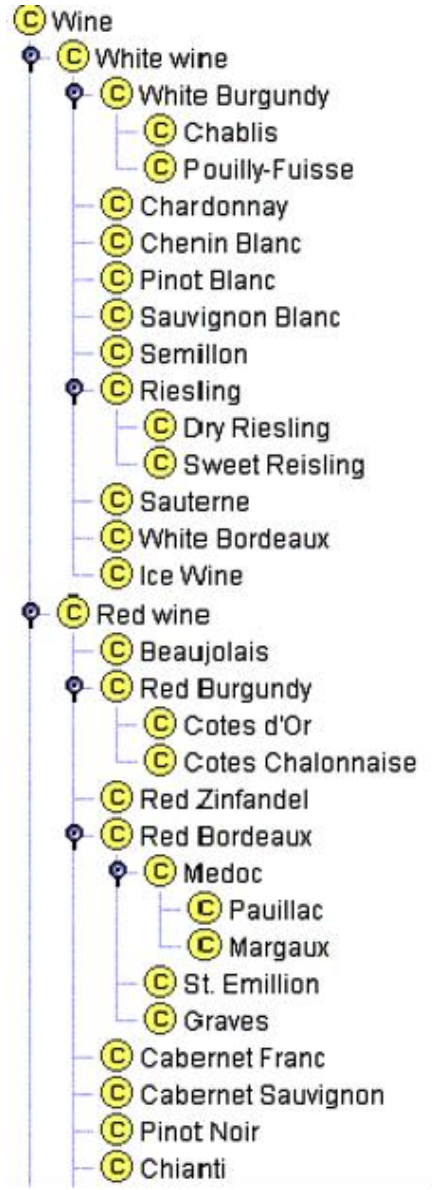

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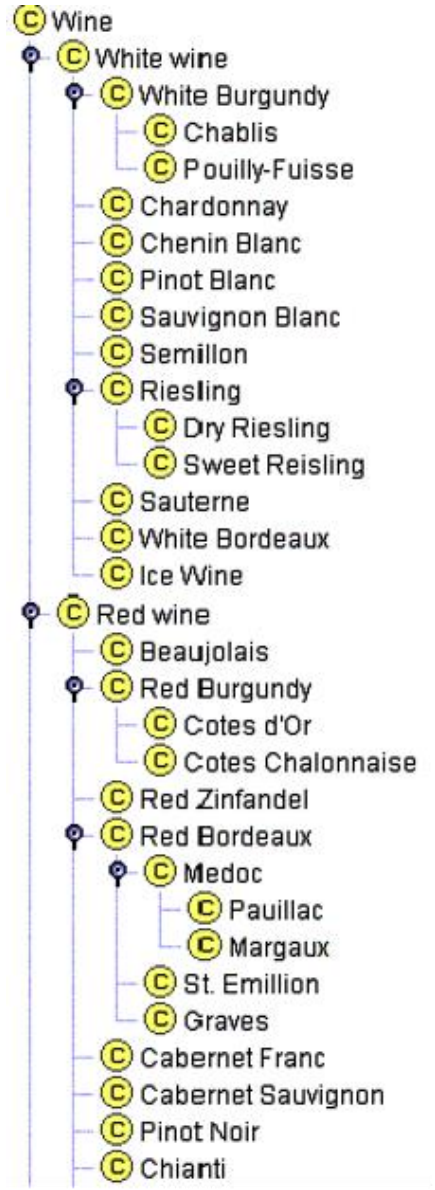

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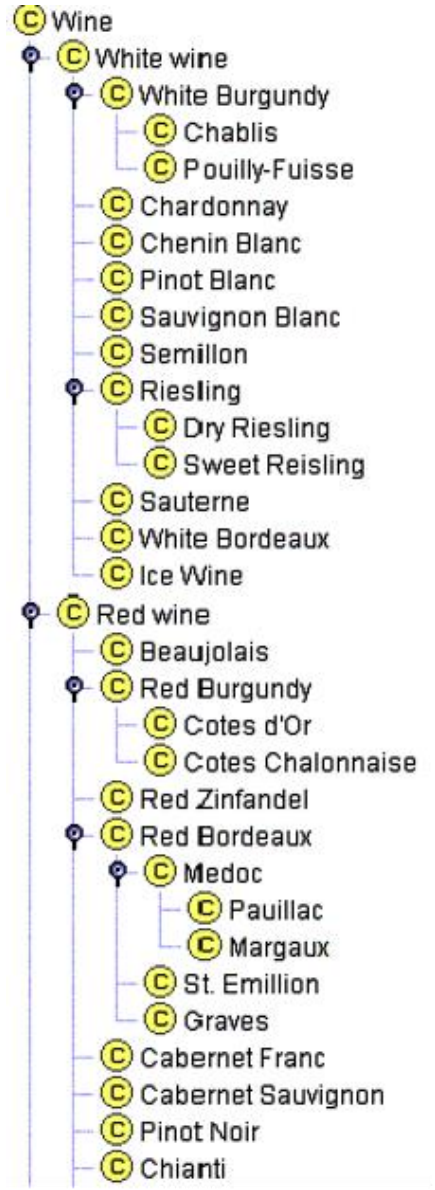

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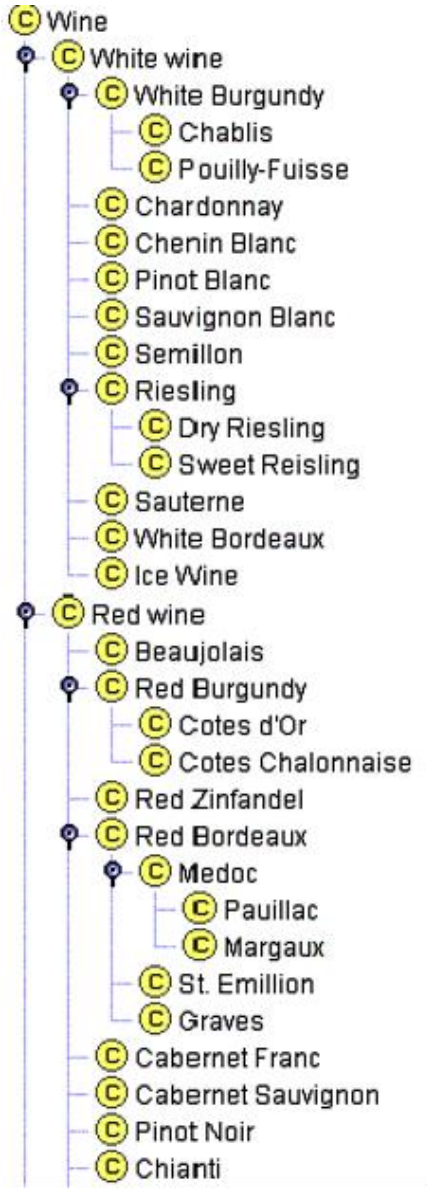

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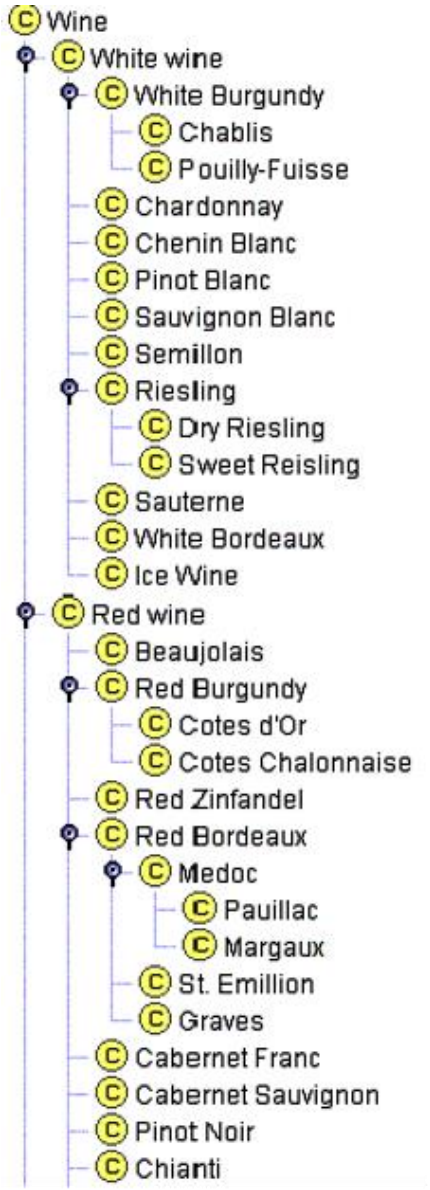

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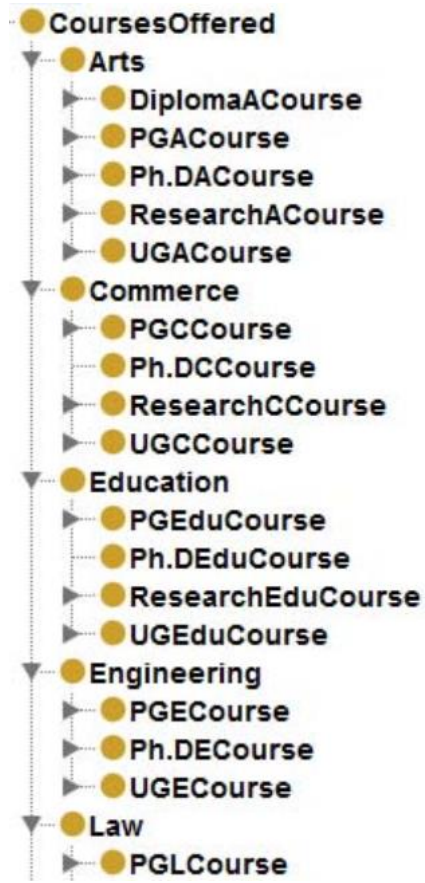

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Requirements: unpacking Searle's view

- V0
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Phenomena of type A are ontologically reducible to phenomena of type B if and only if A's are nothing but B's

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Phenomena of type A are causally reducible to phenomena of type B if and only if:

- the behavior of A's are entirely casually explained by the behavior of B's
- A's have no causal powers in addition to the powers of B's

Requirements, V0

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Design, V0

- Design decisions

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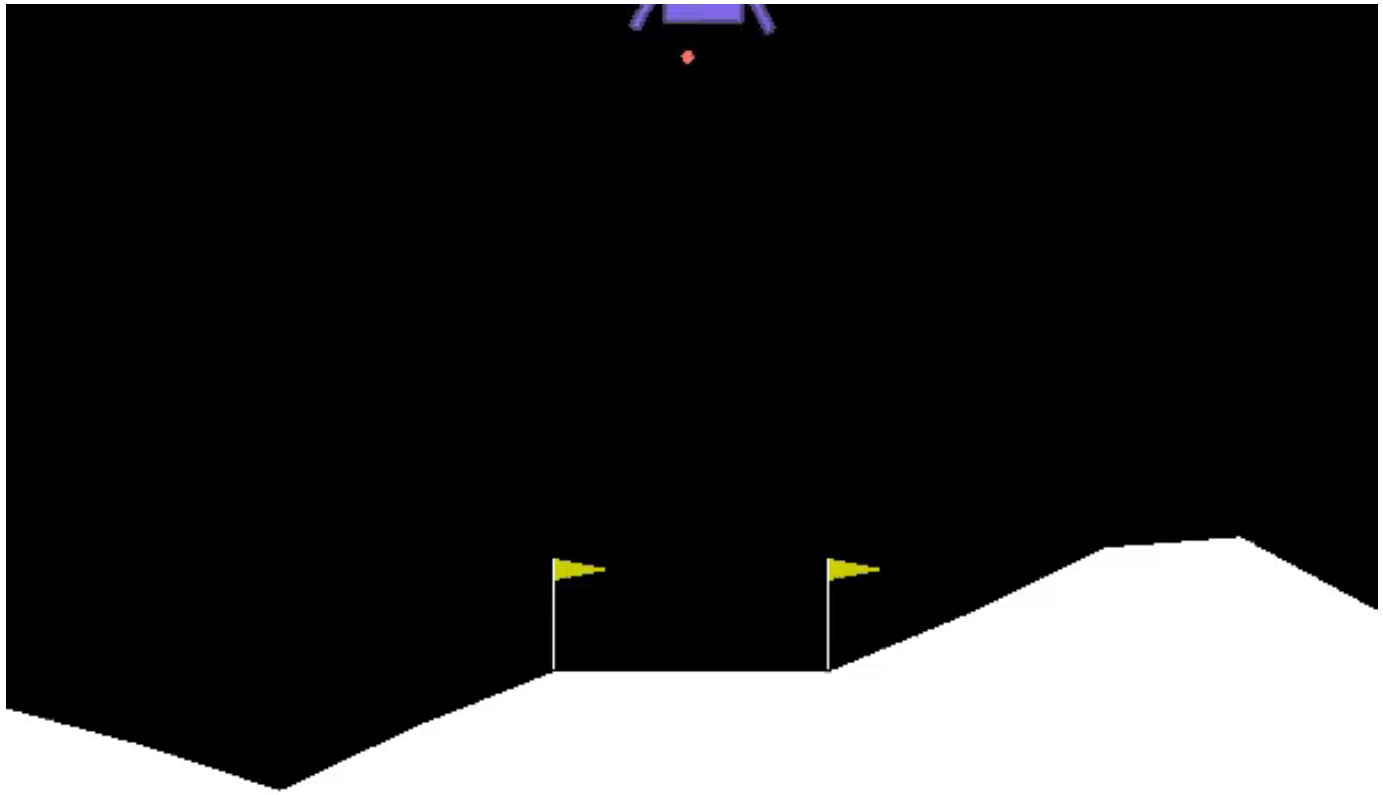
  - Environment and the agent's "physical" form

Design, V0

- OpenAI's LunarLander benchmark environment



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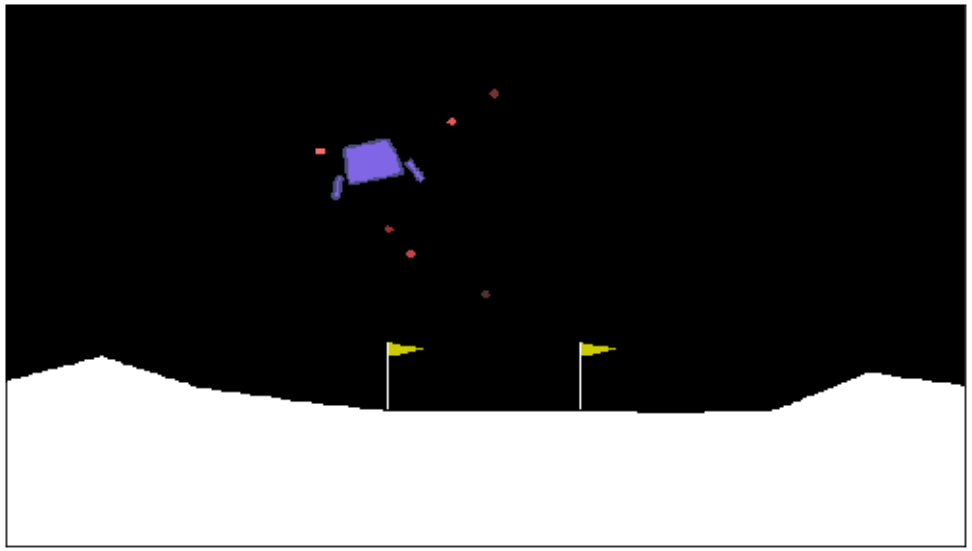
  - Internal state of the agent



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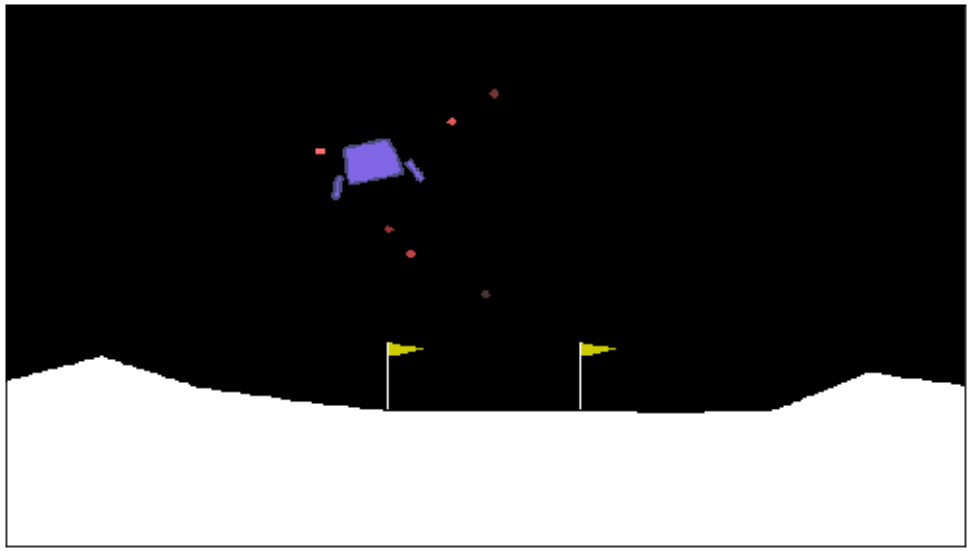

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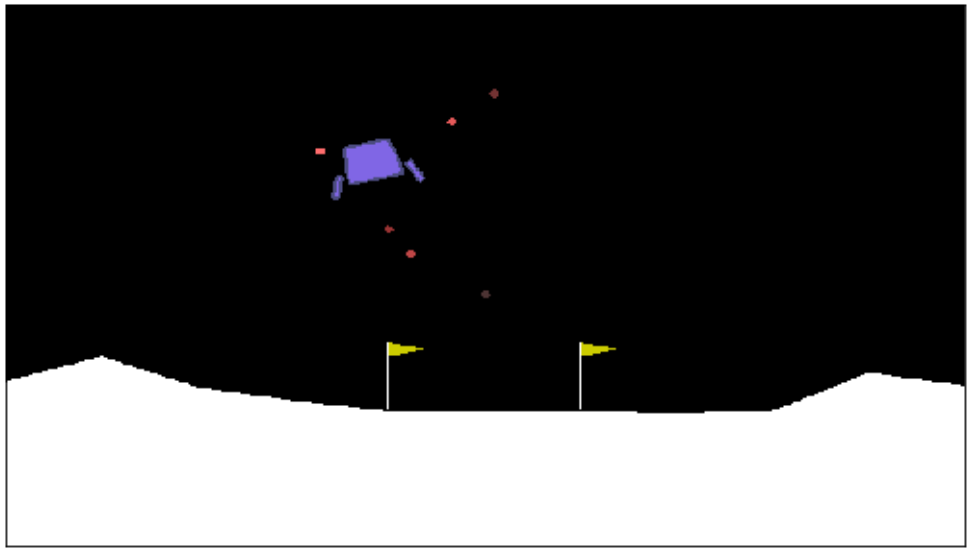

- Design decisions
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      - Left of the flags, right of the flags, high above the ground, close to the ground, falling too fast

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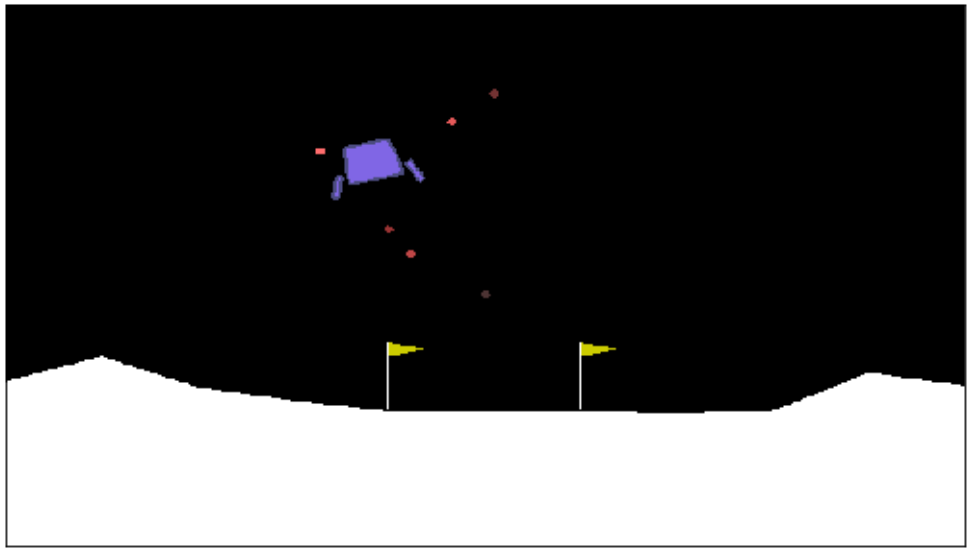

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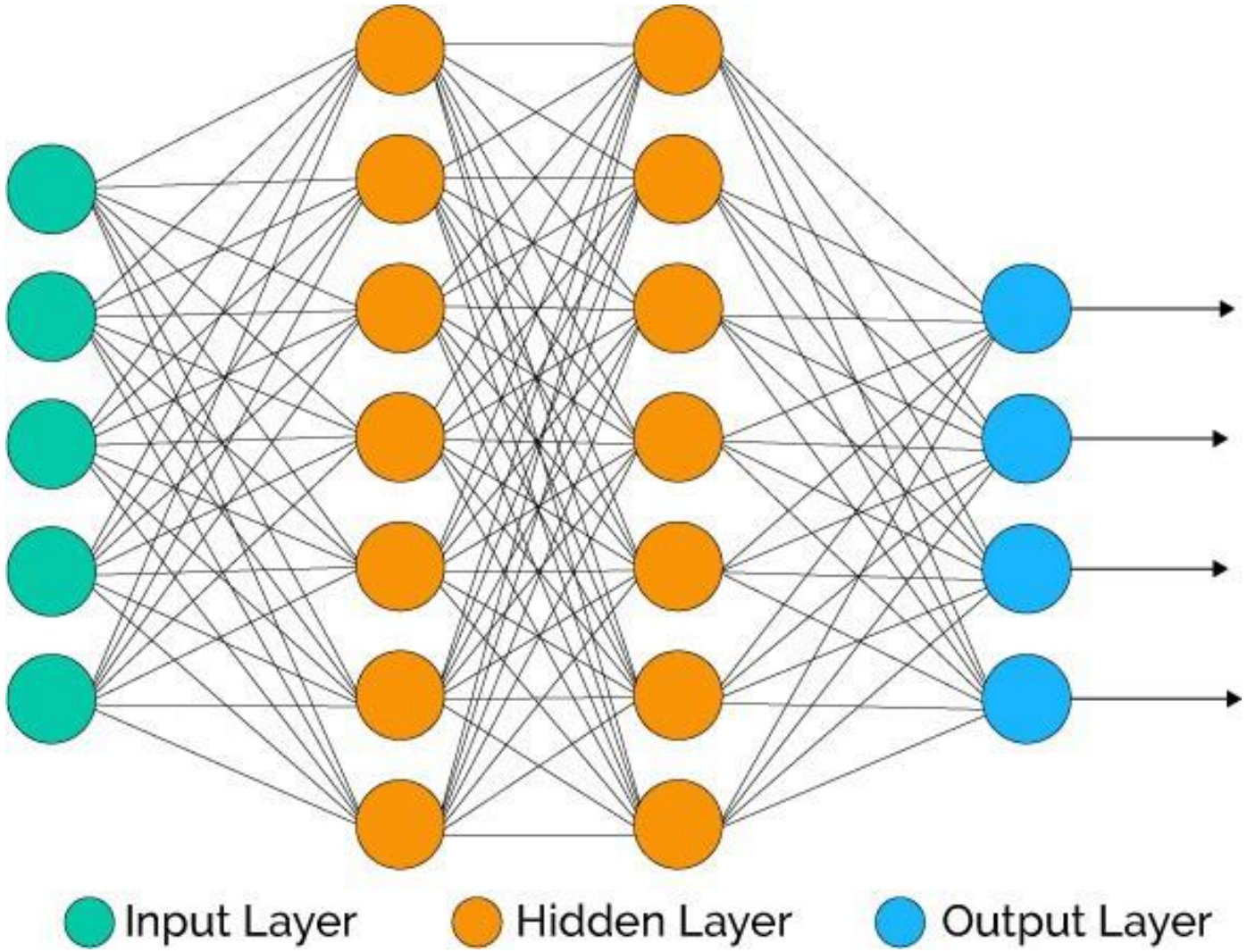
(Artificial) Neural networks



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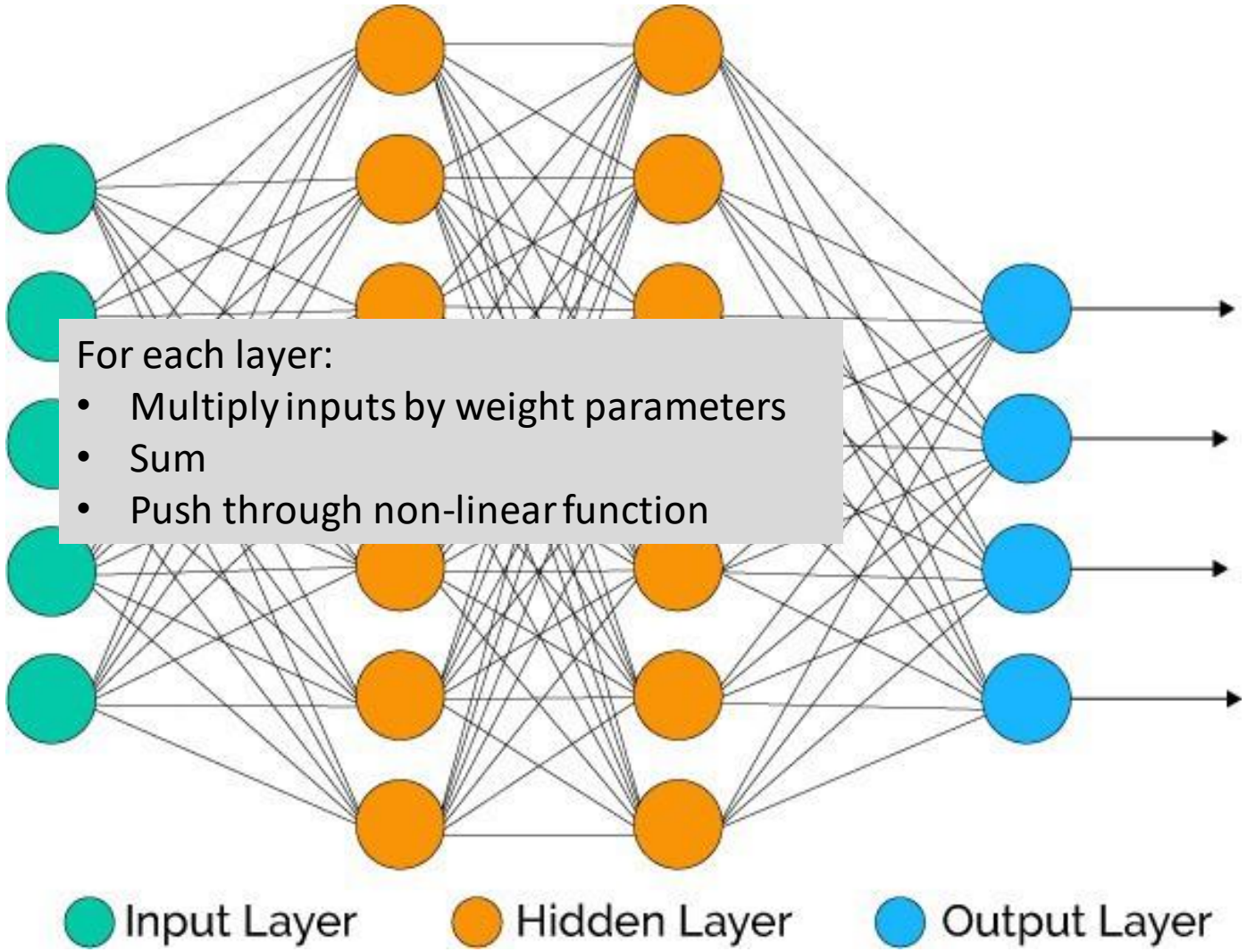

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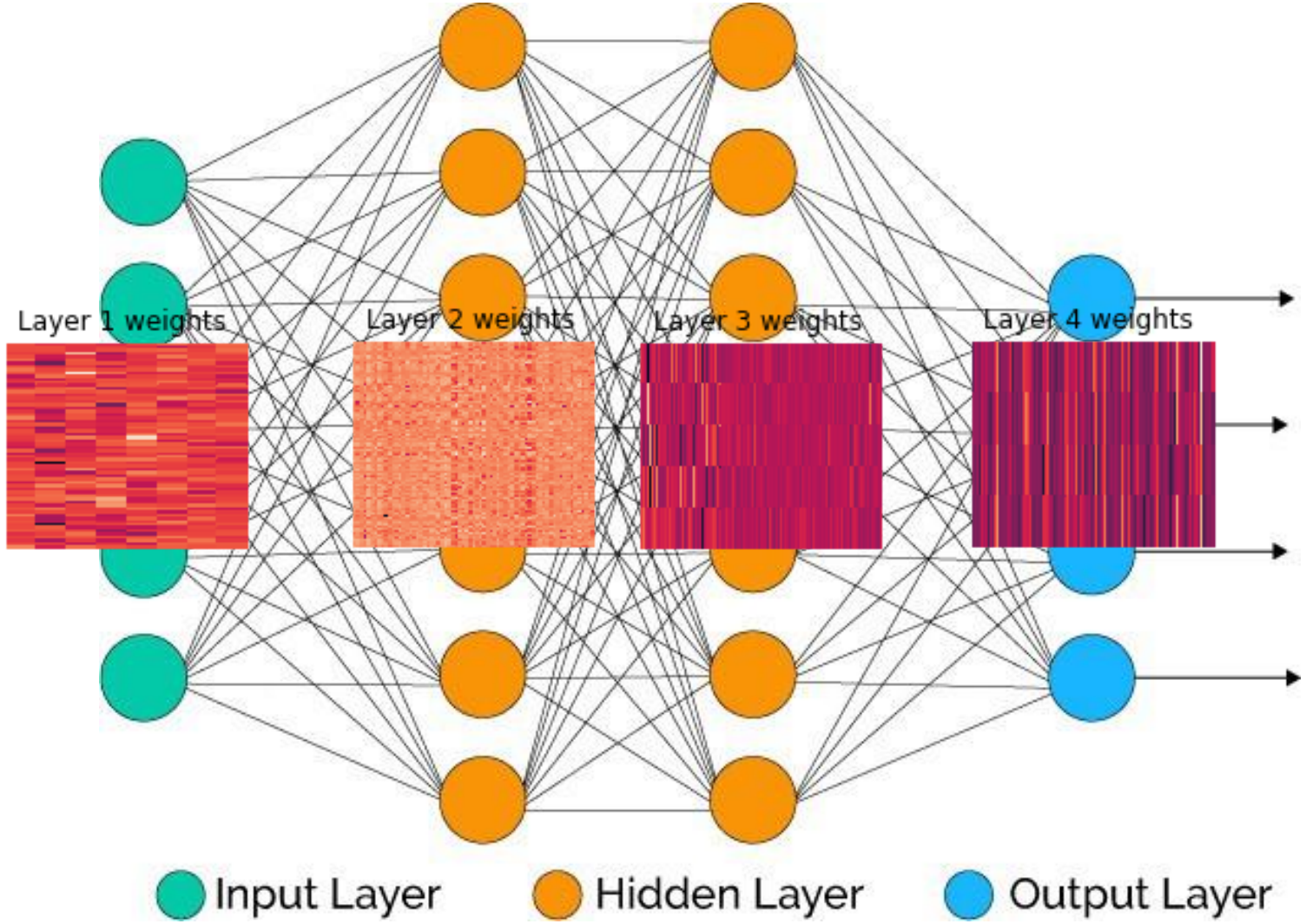

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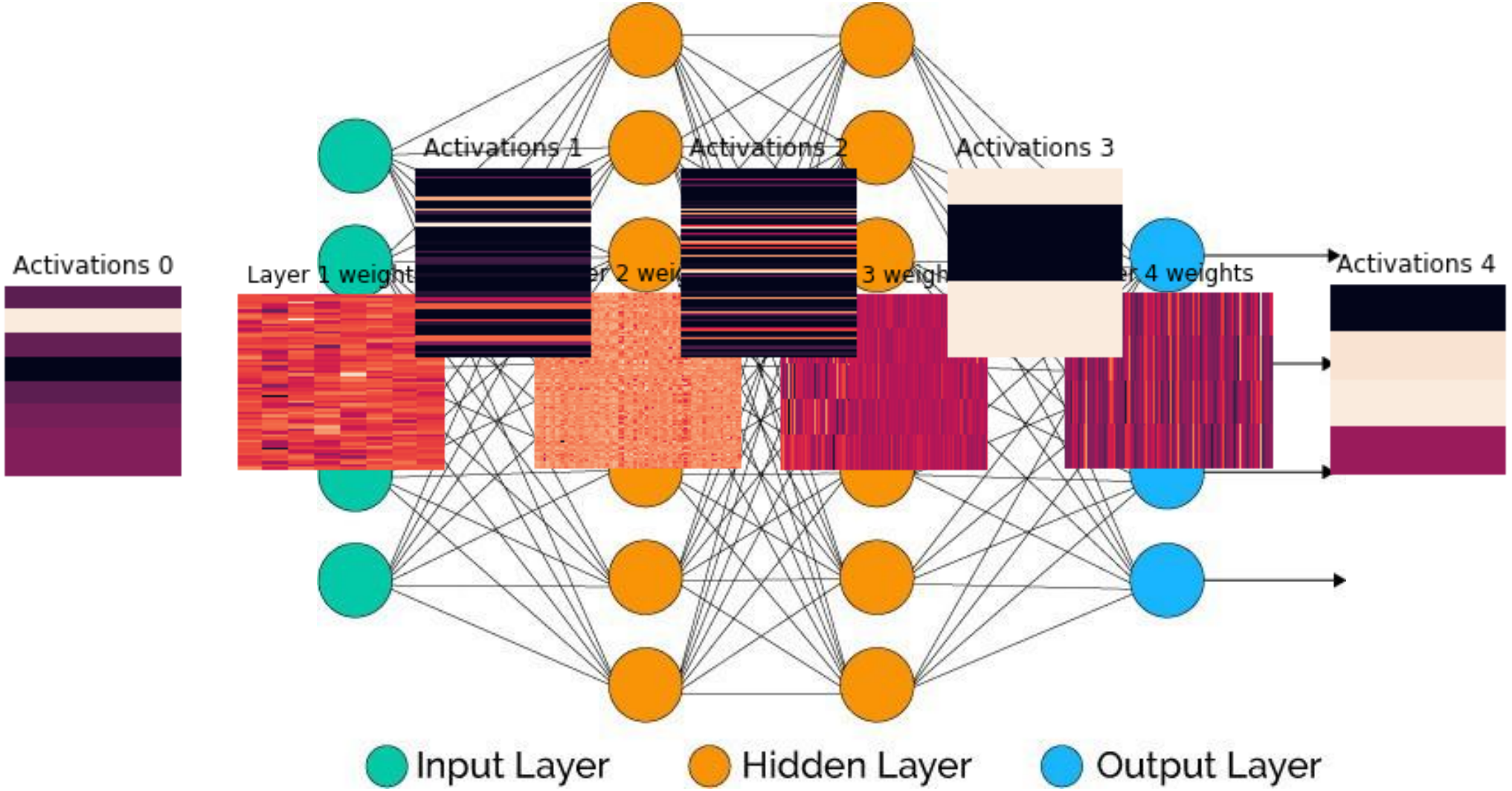

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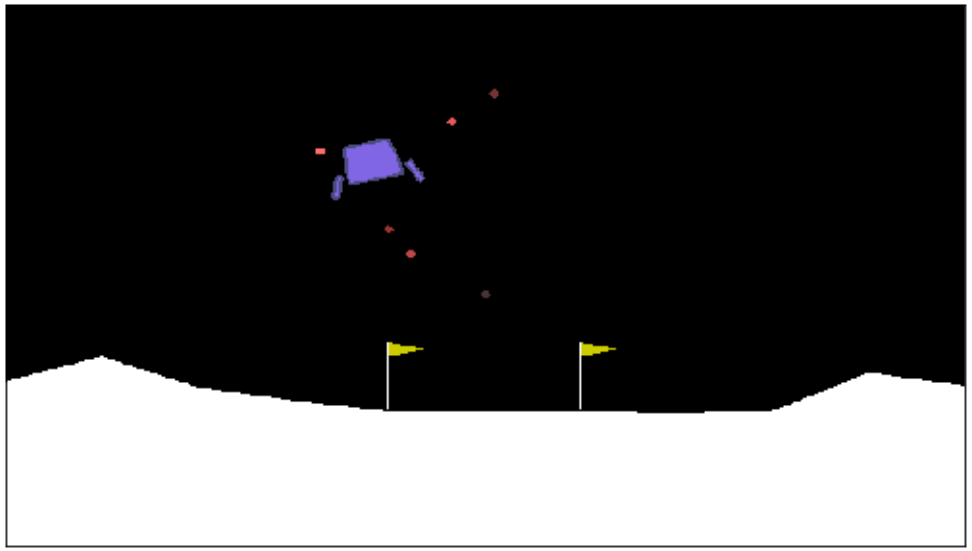

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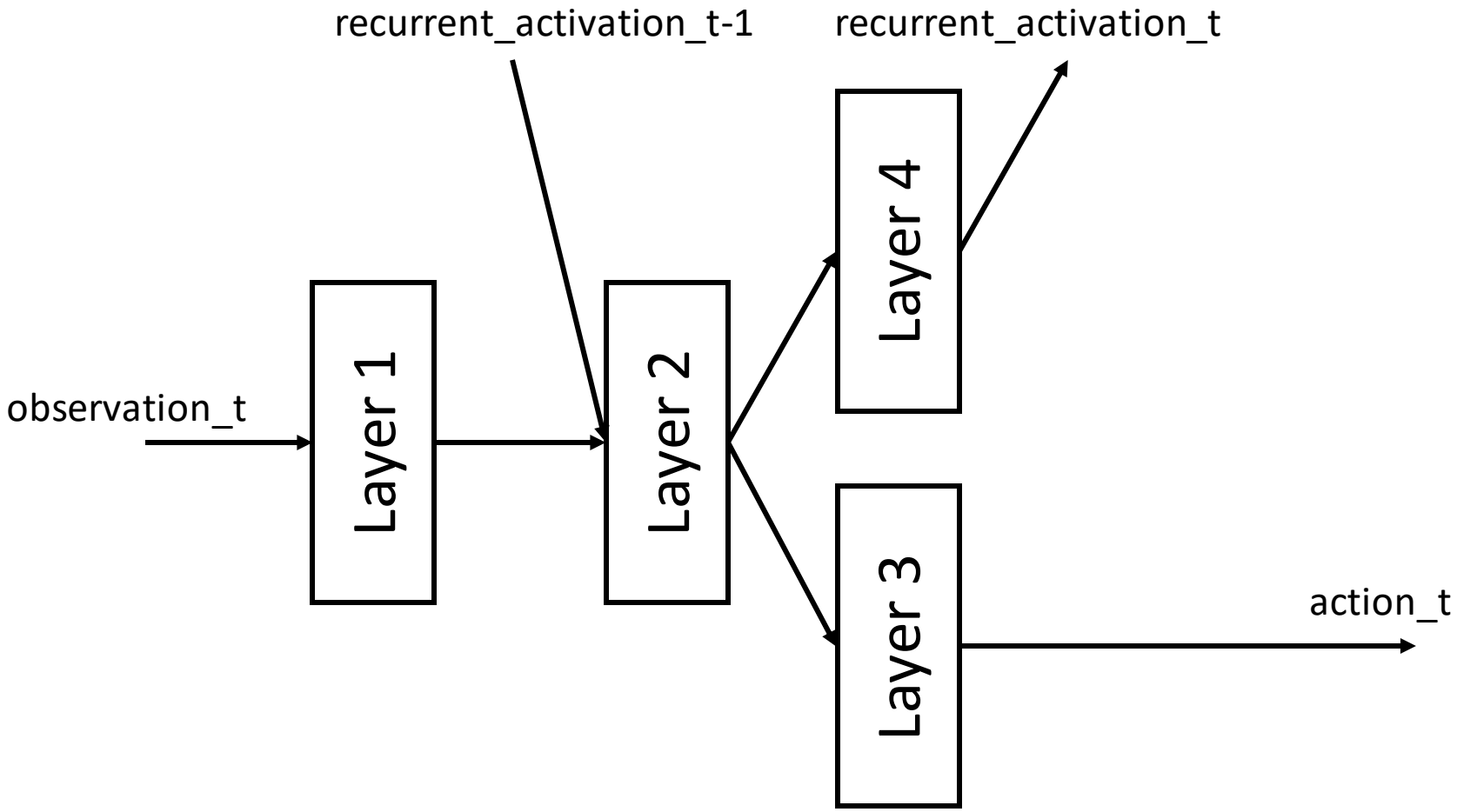
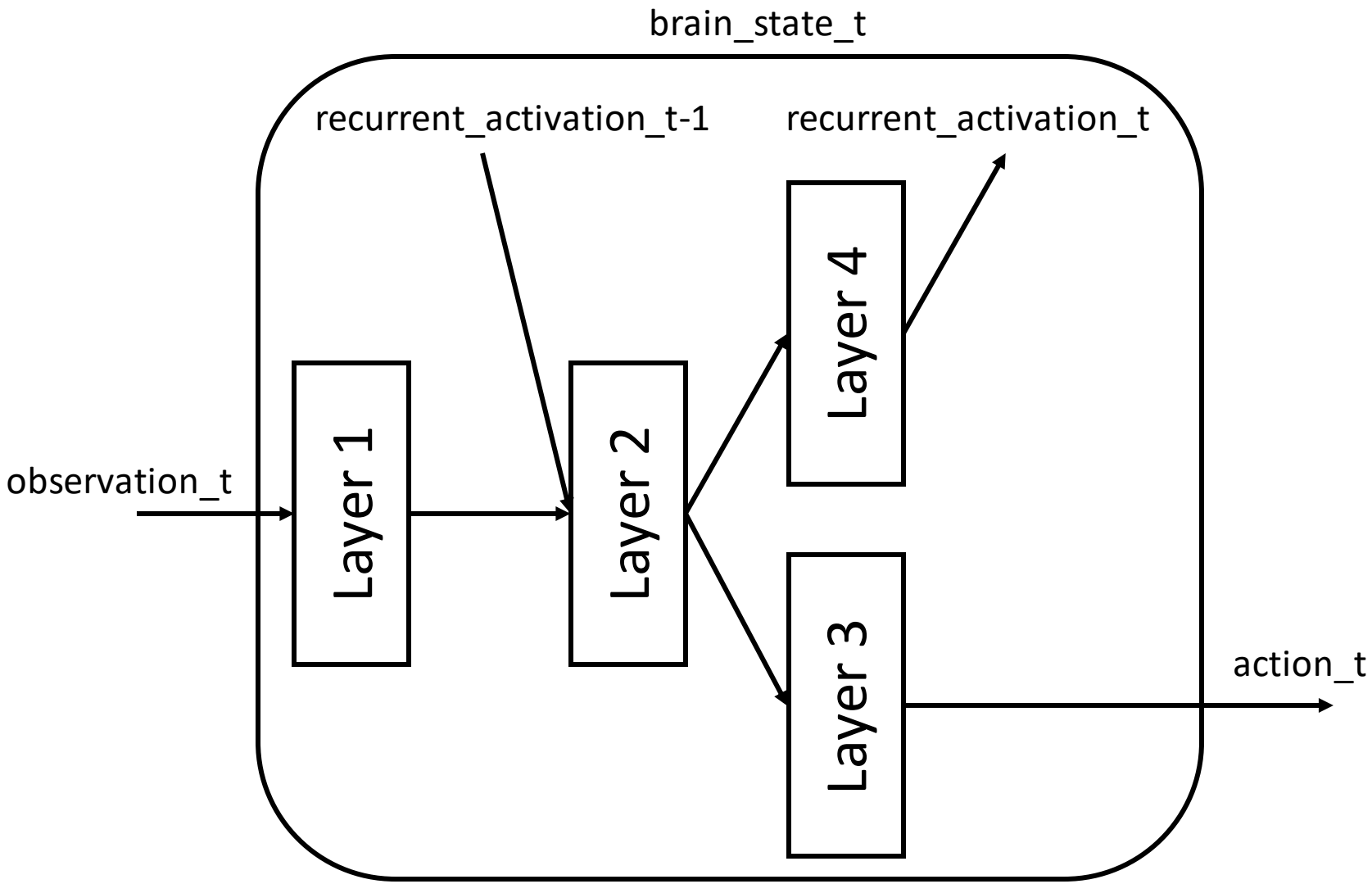

recurrent_activation_t-1
recurrent_activation_t
observation_t
Layer 1
Layer 2
Layer 4
Layer 3
action_t

Design, V0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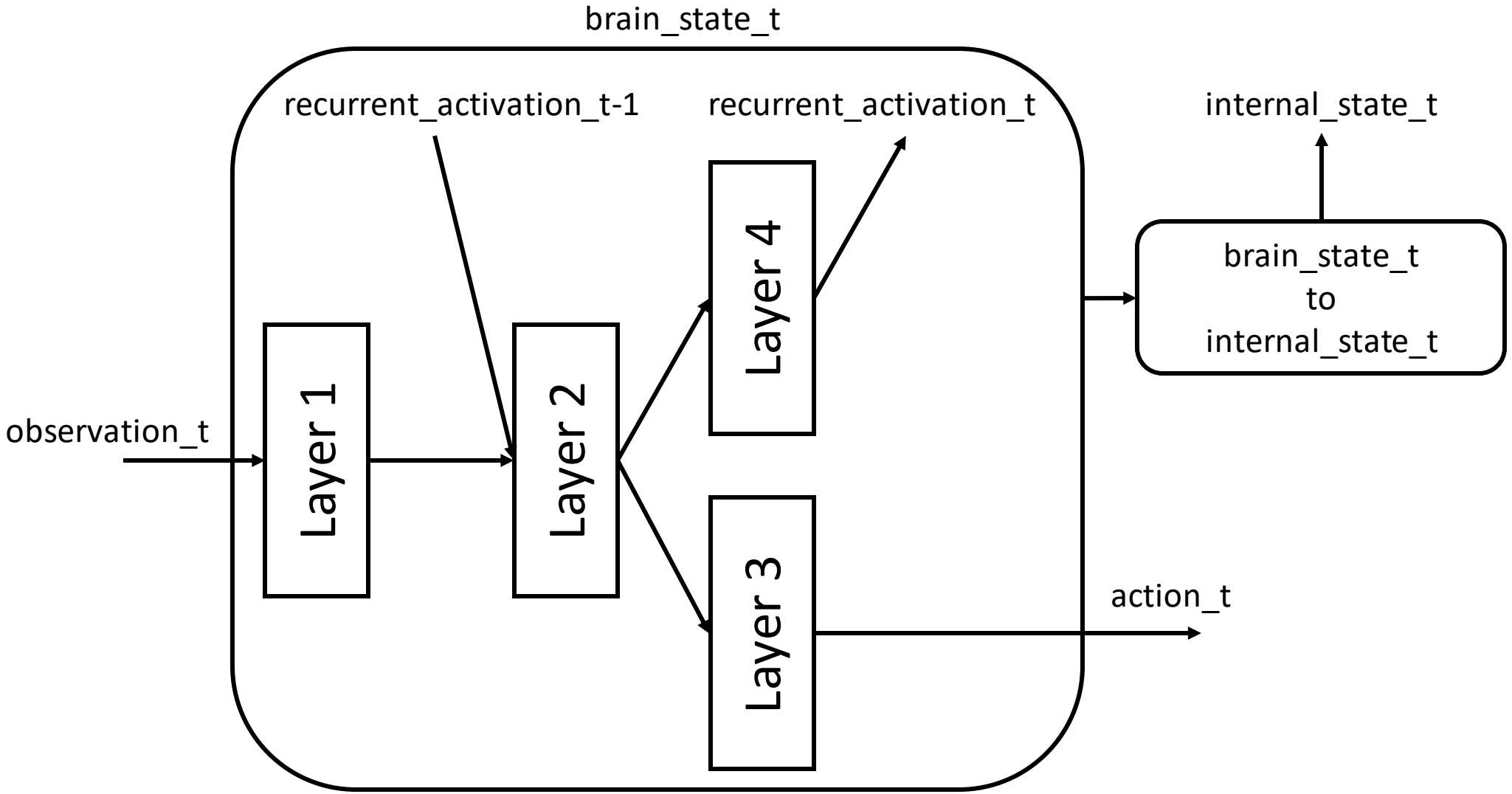
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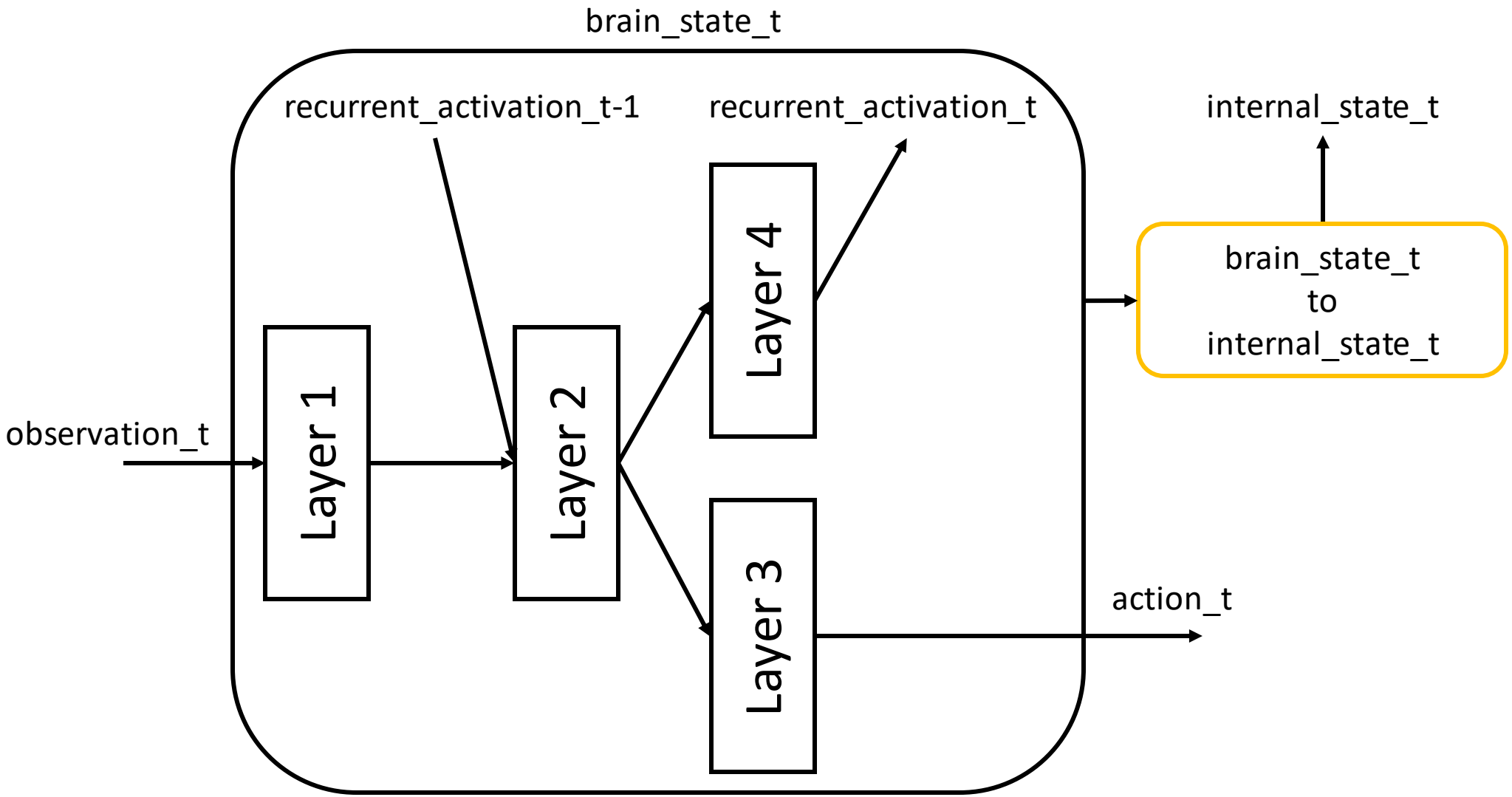
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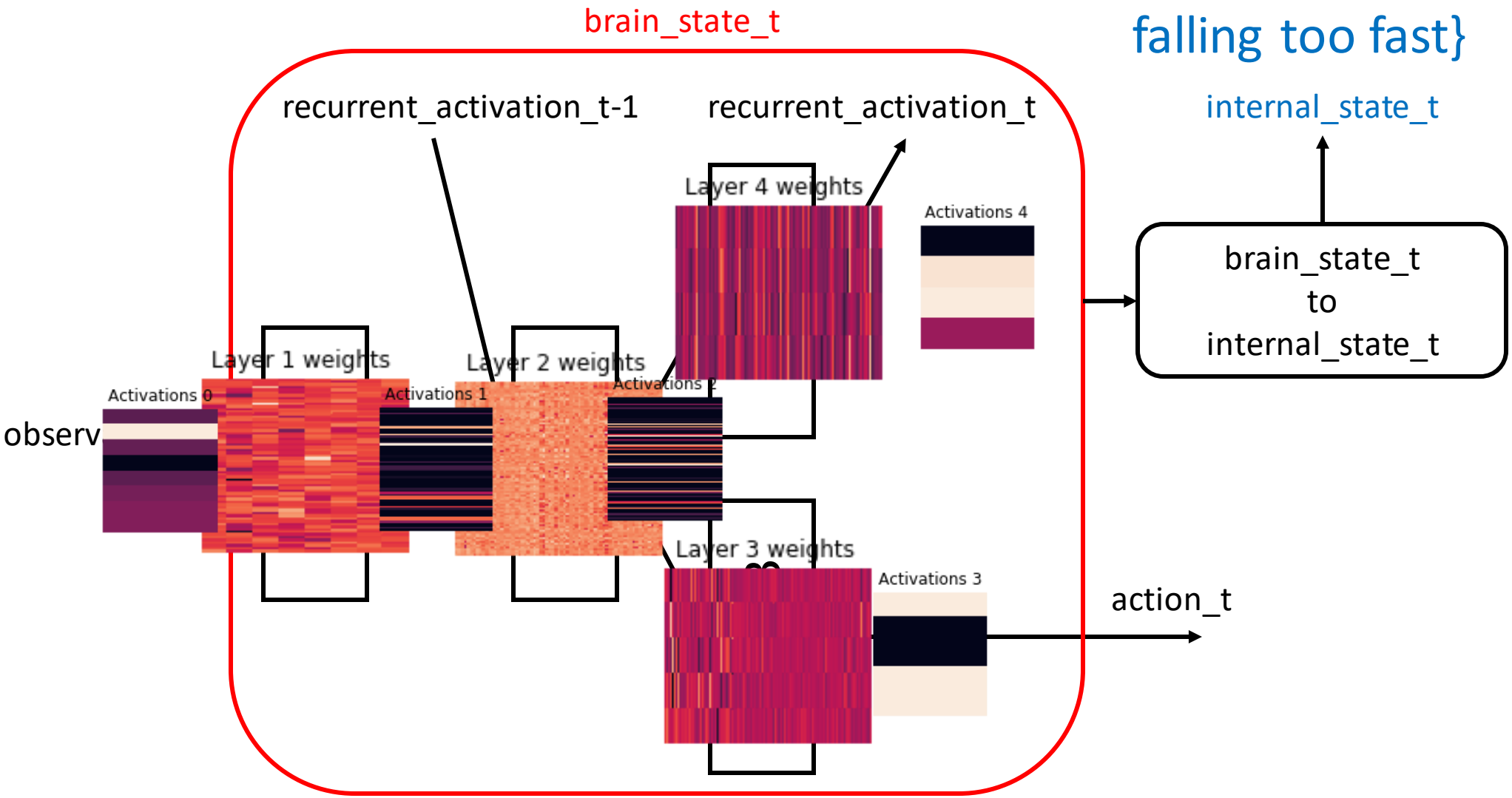

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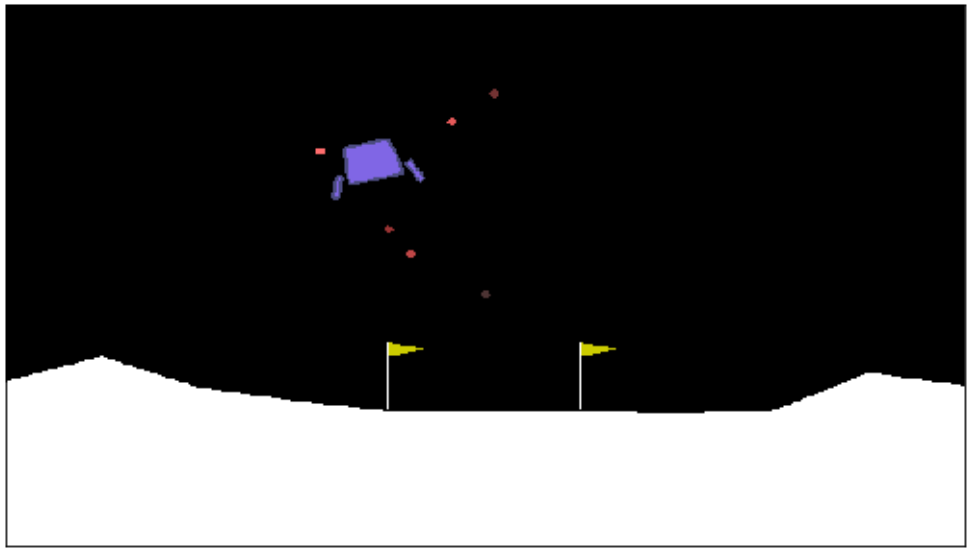
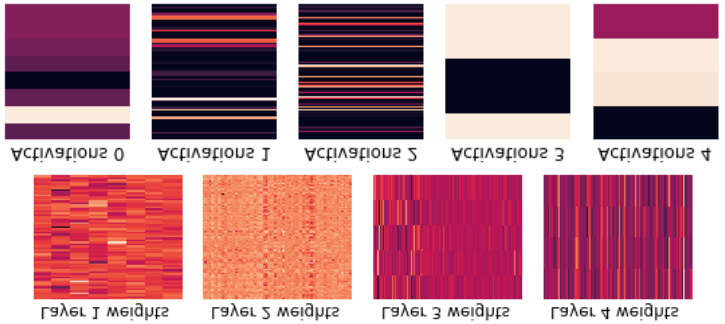


- Design decisions
  - Environment and the agent's "physical" form
  - Internal state of the agent
    - Beliefs about itself relative to semantically important regions
      - Left of the flags, right of the flags, high above the ground, close to the ground, falling too fast
  - Brain state of the agent



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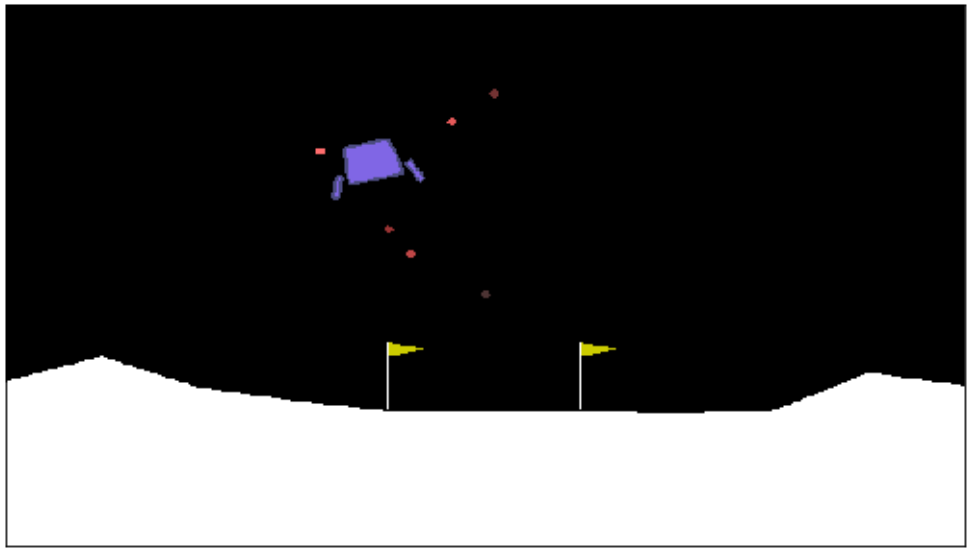

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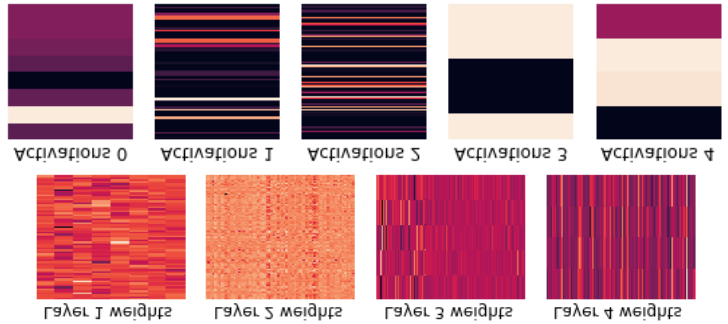

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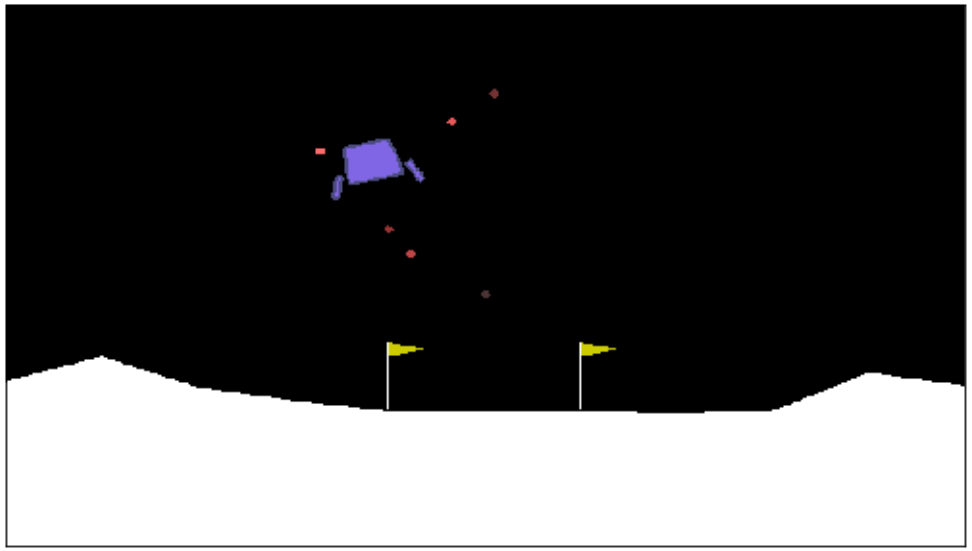

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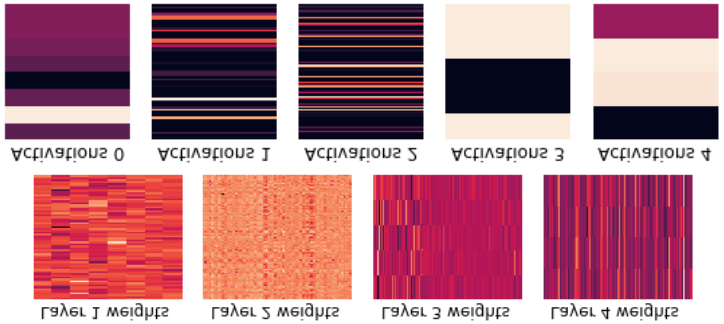

Reinforcement learning

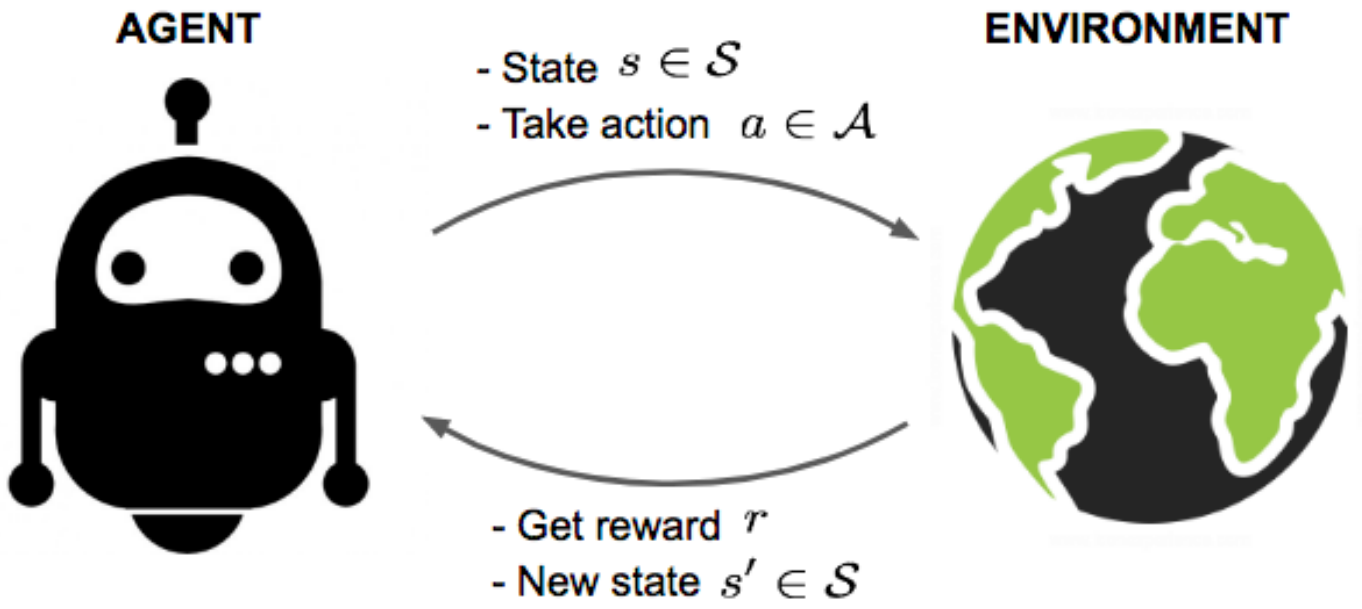

Image from:
https://lilianweng.github.io/lil-log/2018/02/19/a-long-peek-into-reinforcement-learning.html

Implementation, V0

- Jupyter notebook time!
  - http://localhost:8888/notebooks/notebooks/TSC-2019.ipynb
  - https://github.com/Josh-Joseph/tsc-2019/blob/master/notebooks/TSC-2019.ipynb

Did we satisfy our requirements?

- V0
  - Internal states are casually reducible to brain states
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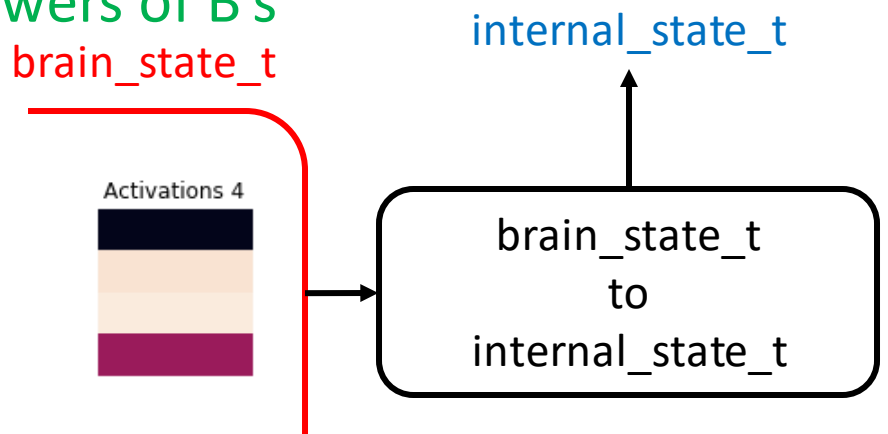

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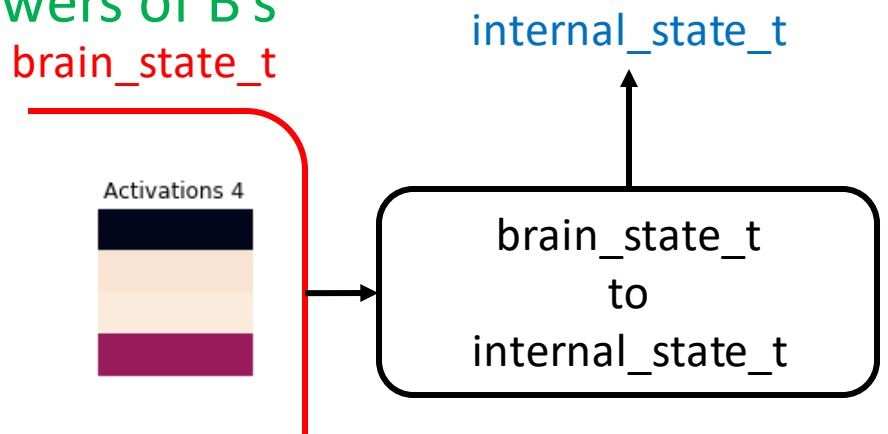
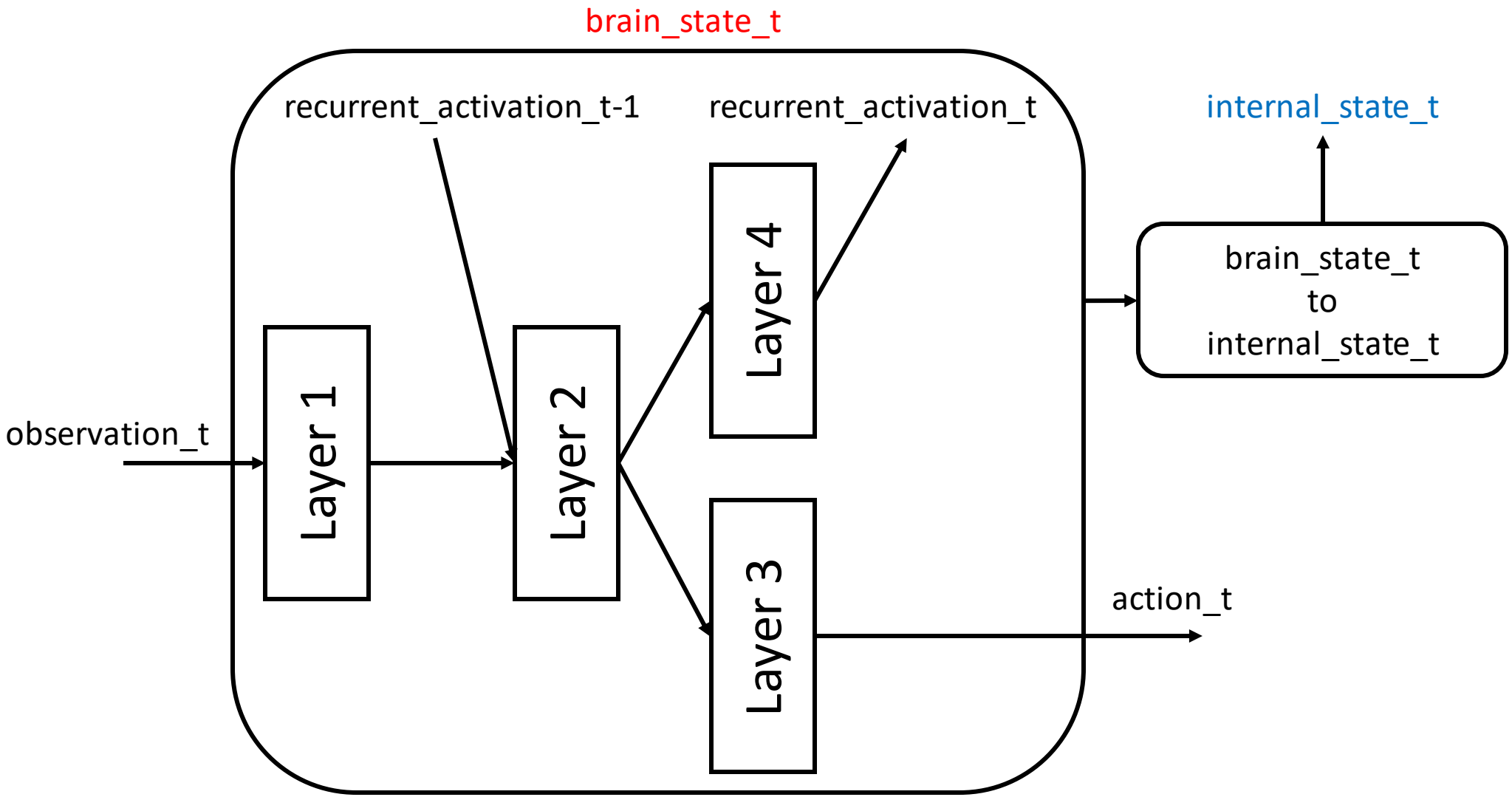


Design, V0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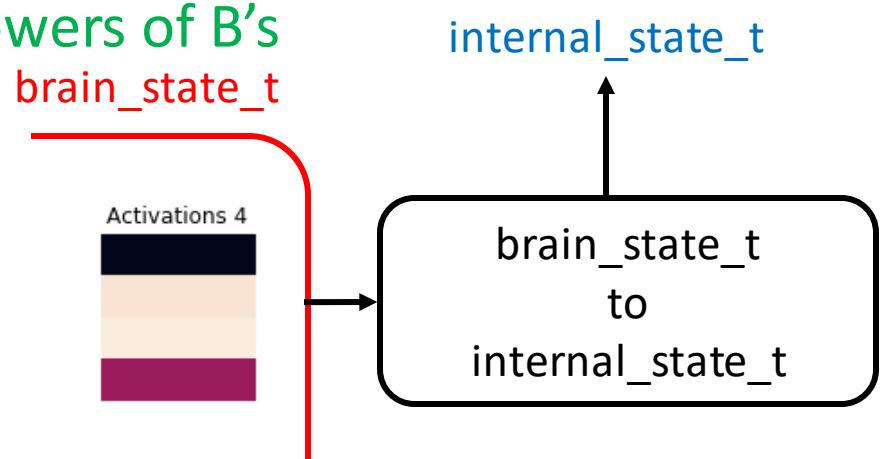

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- Layer weights of the neural network
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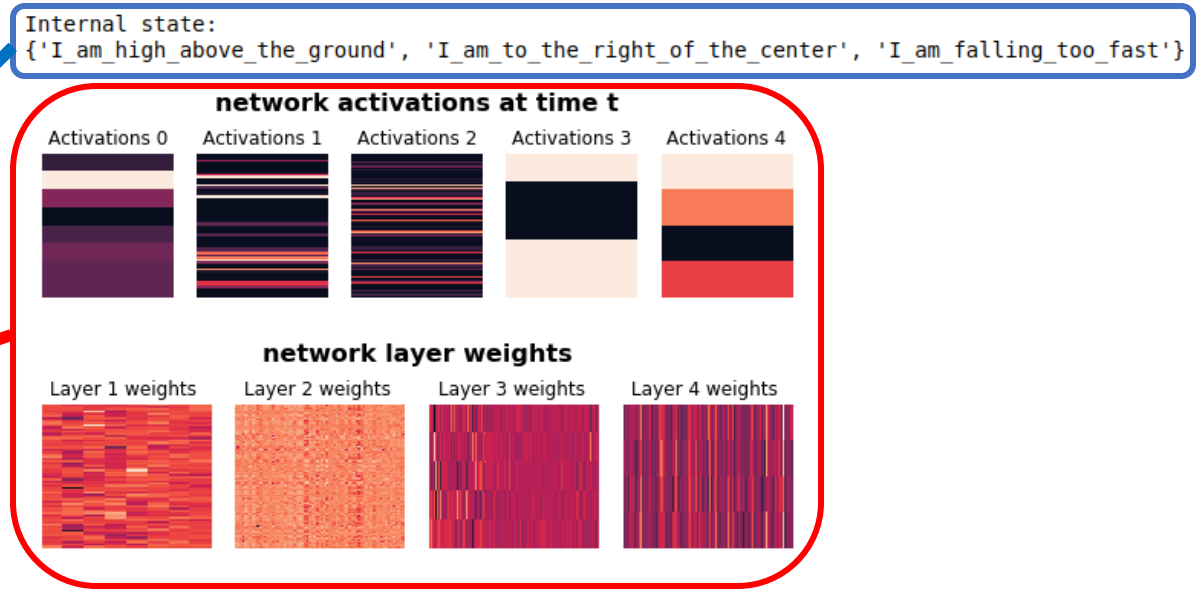

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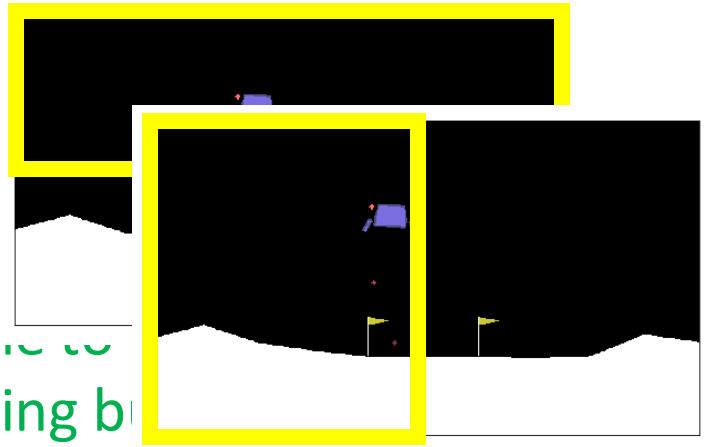

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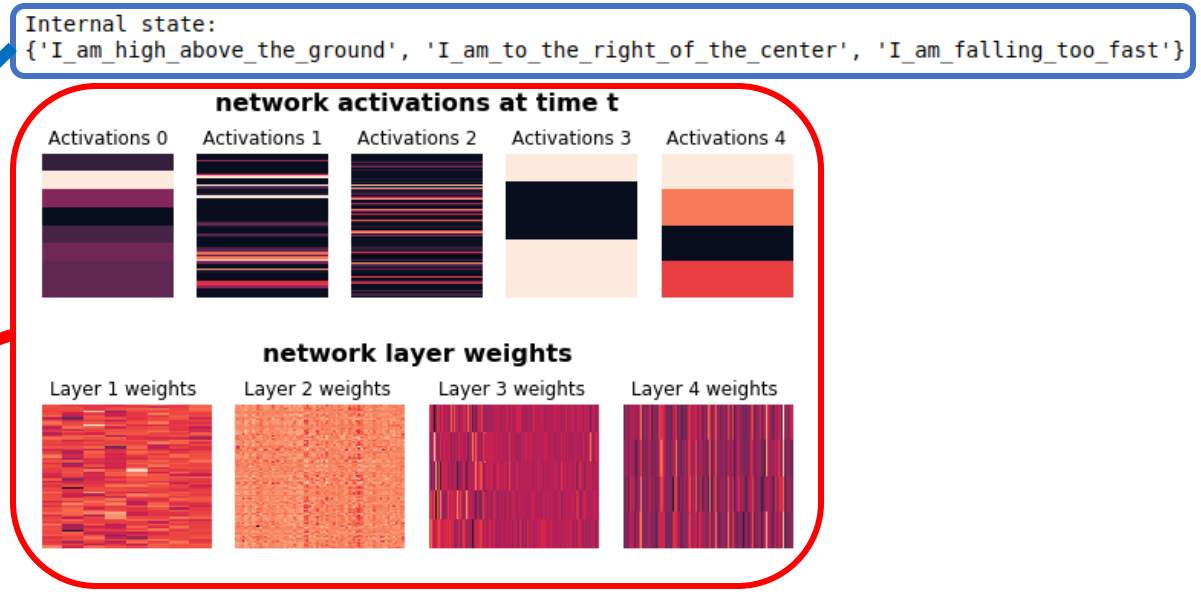

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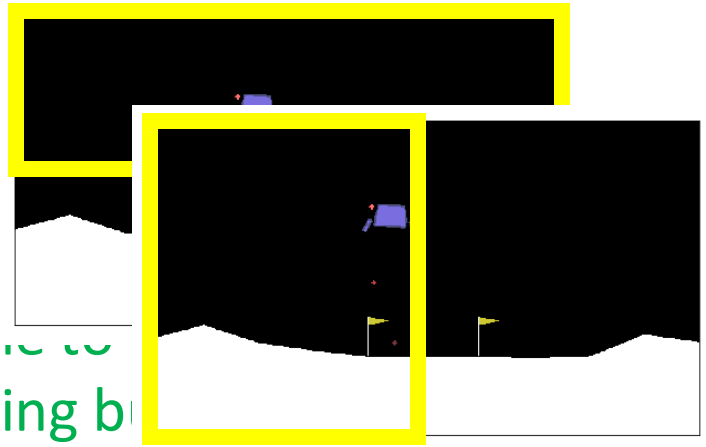

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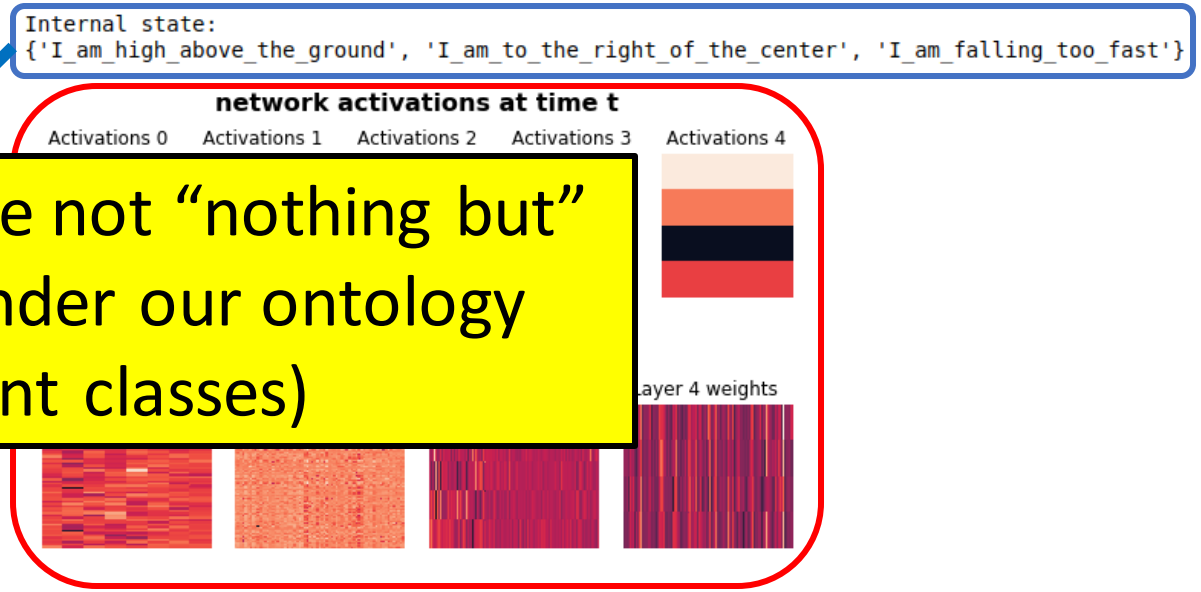
Internal state instances are not "nothing but" brain state instances under our ontology (they are different classes)



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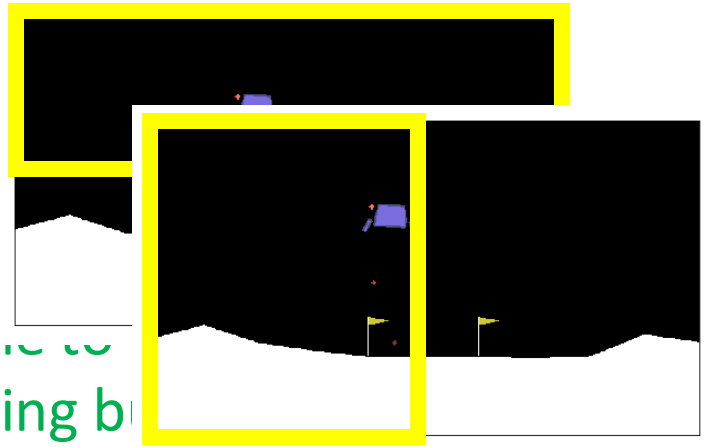

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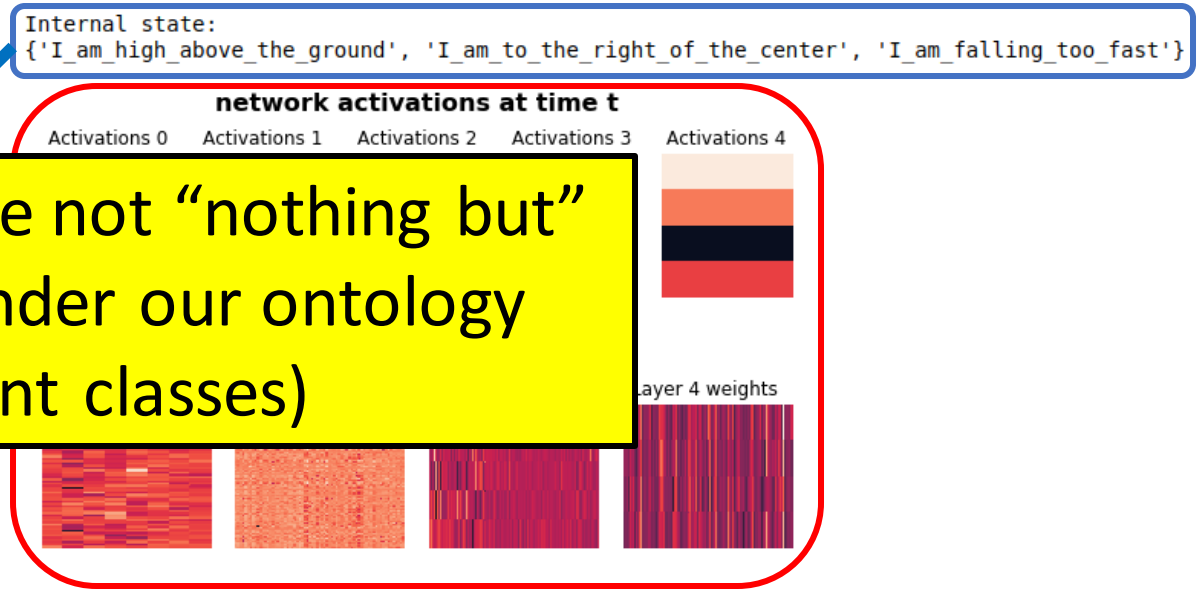

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- Bits
- Python objects
- Electrons
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What's the deal with that function?

{High above the ground,
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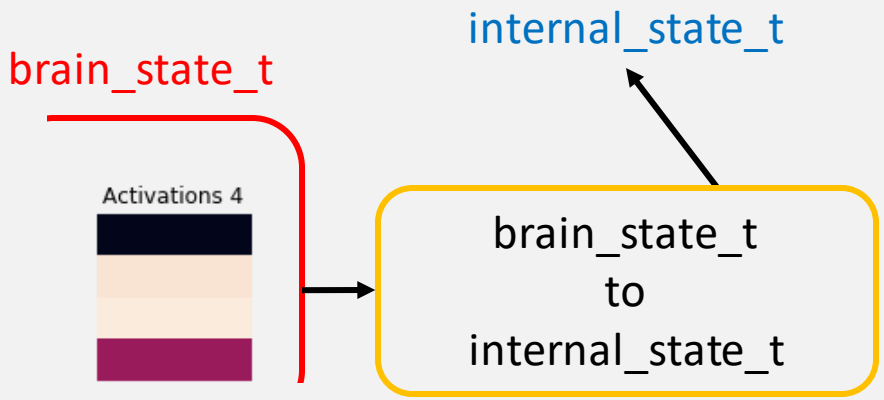

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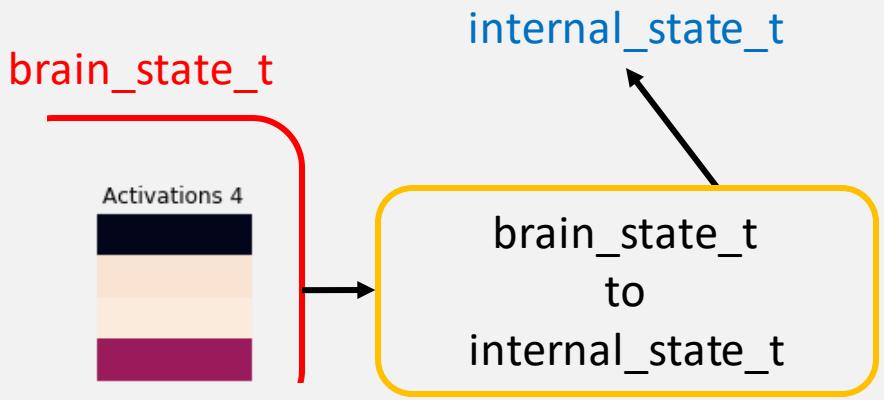


```python
def brain_state_to_internal_state(brain_state):
    def i_am_high_above_the_ground(observation):
        return observation[1] > 0.5  # observation[1] accesses y position

    def i_am_low_to_the_ground(observation):
        return observation[1] <= 0.5  # observation[1] accesses y position

    def i_am_to_the_right_of_the_center(observation):
        return observation[0] > 0.  # observation[0] accesses x position

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    def i_am_falling_too_fast(observation):
        return observation[3] < -0.2  # observation[0] accesses y velocity

    regions = [
        i_am_high_above_the_ground,
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        i_am_to_the_right_of_the_center,
        i_am_to_the_left_of_the_center,
        i_am_falling_too_fast
    ]

    internal_state = set()

    recurrent_activations = brain_state['activations'][3]

    for activation, region in zip(recurrent_activations, regions):

        if activation > 0.5:
            internal_state.add(region.__name__)

    return internal_state
```

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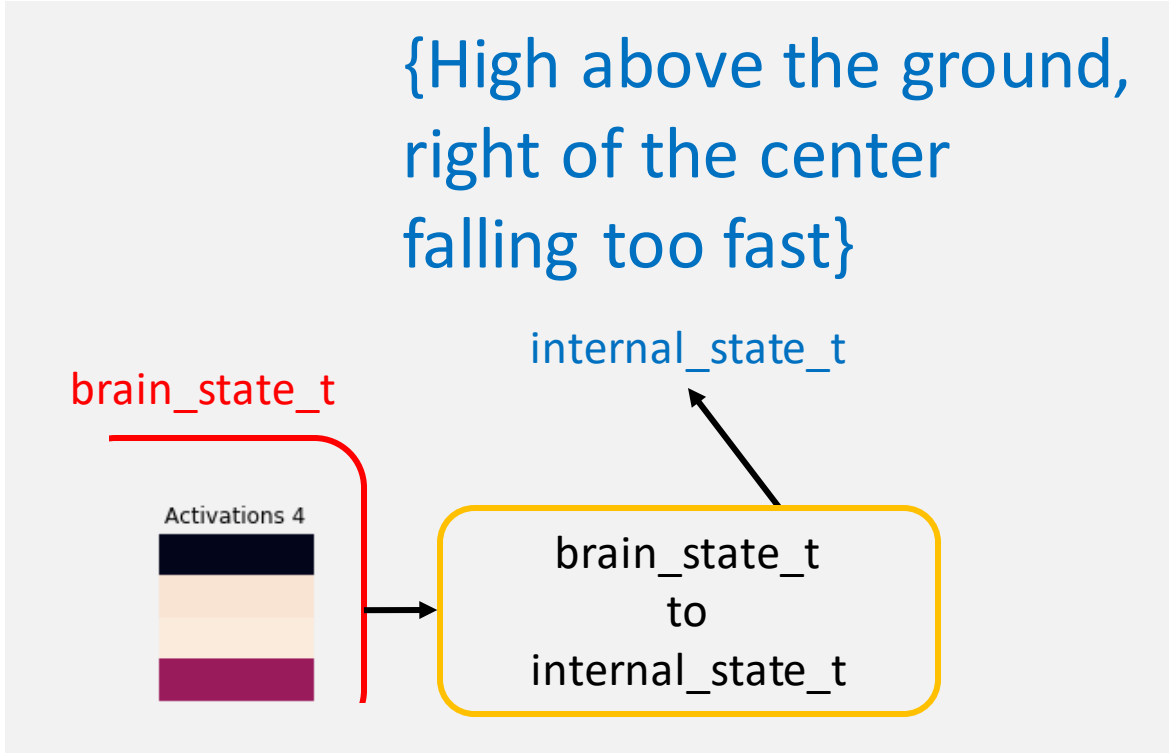


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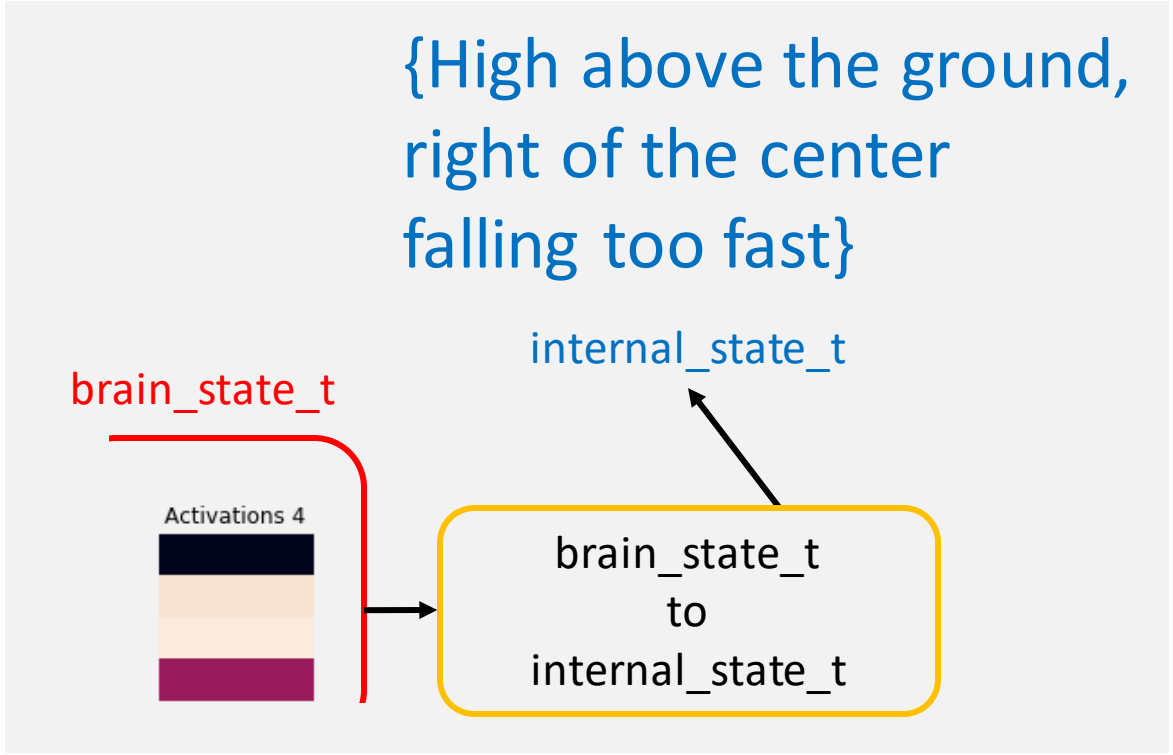
- Is this just some representation of "data flow"?

What's the deal with that function?

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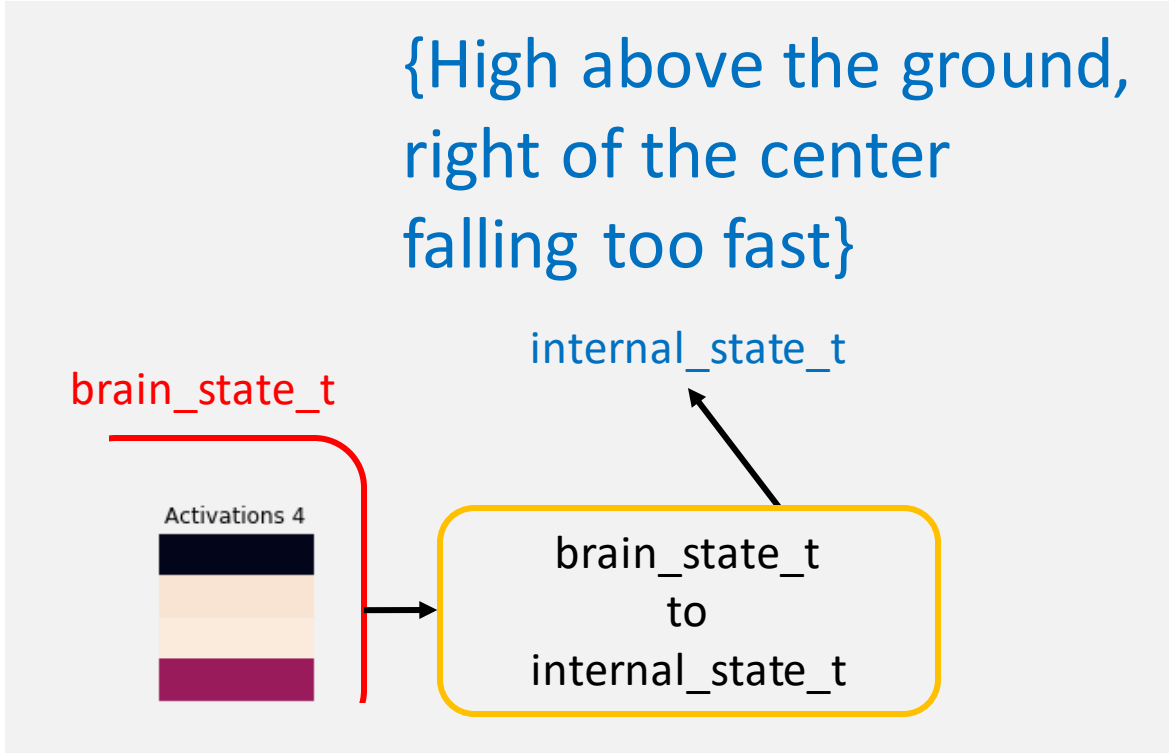


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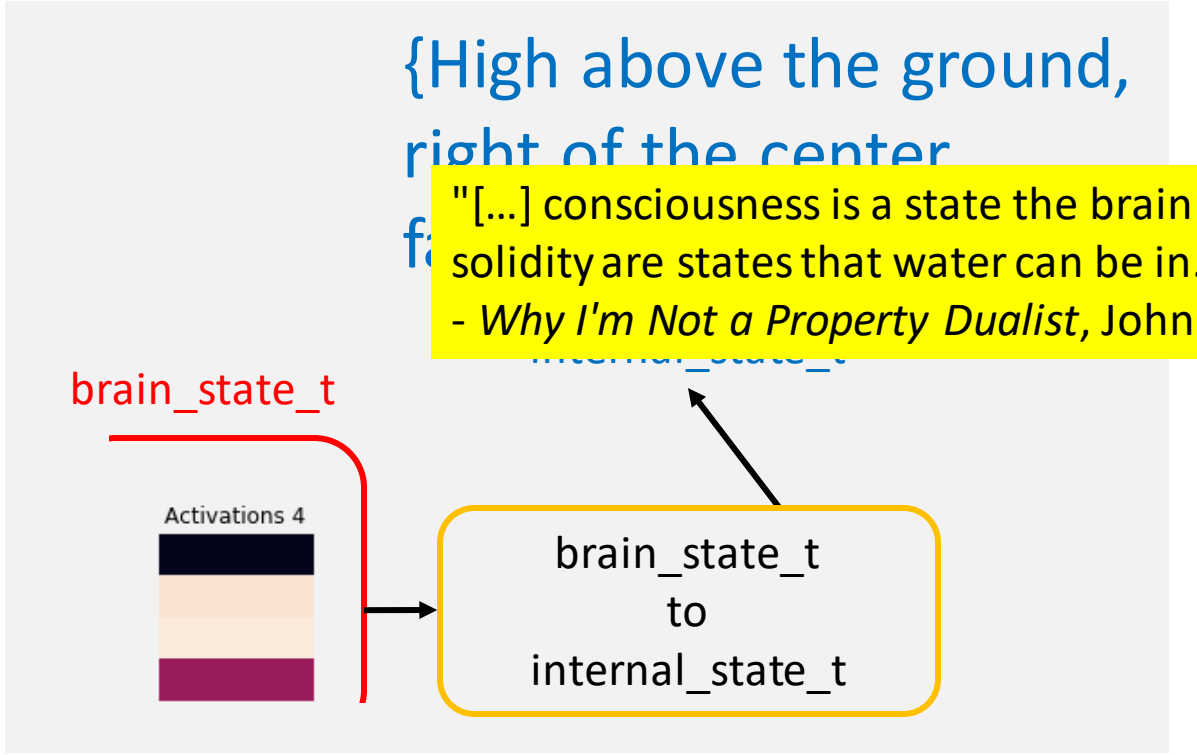

"[…] consciousness is a state the brain can be in, in the way that liquidity and solidity are states that water can be in."
- *Why I'm Not a Property Dualist*, John Searle

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{High above the ground,
right of the center
f

brain_state_t

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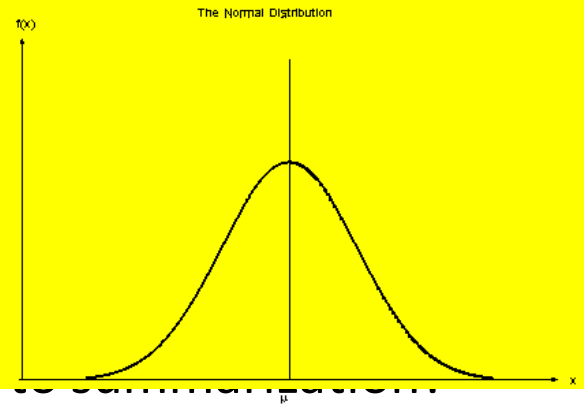
Just like a gaussian and its parameters...



$$\hat{\mu} = \bar{X} = \frac{1}{n}\sum X_i$$

$$\hat{\sigma}^2 = \frac{1}{n-1}\sum (X_i - \bar{X})^2$$

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Conclusion

- Software engineer style philosophy reifying seemed to work well
- Created a V0 software agent who's
  - Internal states are casually reducible to brain states
  - Internal states are ontologically irreducible to brain states
- Download and play with the code yourself
  - https://github.com/Josh-Joseph/tsc-2019
- Disagree with us?
  - Great! Open an issue and/or submit a pull request in GitHub
- Thoughts on other theories of mind/consciousness that may be particularly well suited for this type of approach?