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

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Why attempt to reify philosophy with code

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  - Mind, awareness, imagination, reasoning, consciousness, etc.

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  - But telling people to read more books/papers is not how to make this happen
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- Possibly benefit philosophy by bringing code-style concreteness
  - (TBD, will let the philosophers in the room speak to this!)

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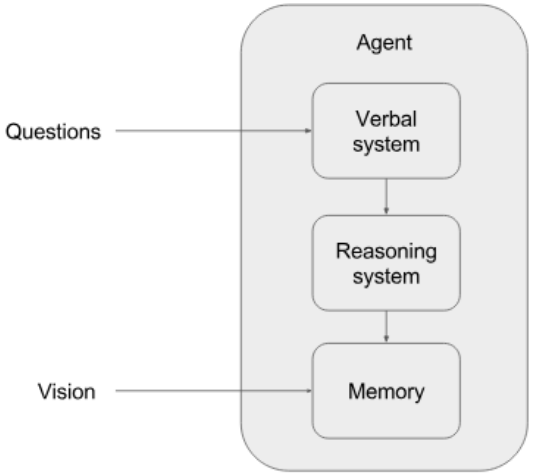
Reifying philosophy with code

- Muehlhauser, Shlegeris: A Software Agent Illustrating Some Features of an Illusionist Account of Consciousness
- An agent that observes the world and uses a theorem prover to answer questions asked of it




```
Q: What's 2 + 2?
4

Q: Suppose there are two agents Bob and Jane, do they have the same qualia associated with every color?
Both that statement and its negation are possible.

Q: For all y, does there exist an x such that x = y + 1?
Yes.

Q: For all two agents, do they see colors the same?
Both that statement and its negation are possible.

Q: Are your memories at timestep 0 and 1 of the same color?
Yes.

Q: Are you seeing the same color now as you saw at timestep 0?
No.

Q: Is it possible for an agent to have an illusion of red?
Yes.

Q: Is it possible for you to have the illusion that Buck is experiencing a color?
Yes.

Q: Is it possible for Buck to have an illusion that he is having the experience of redness?
No, that's impossible.
```

Image from shlegris.com

Dialog from https://github.com/bshlgrs/consciousness/blob/master/README.md

Reifying philosophy with code

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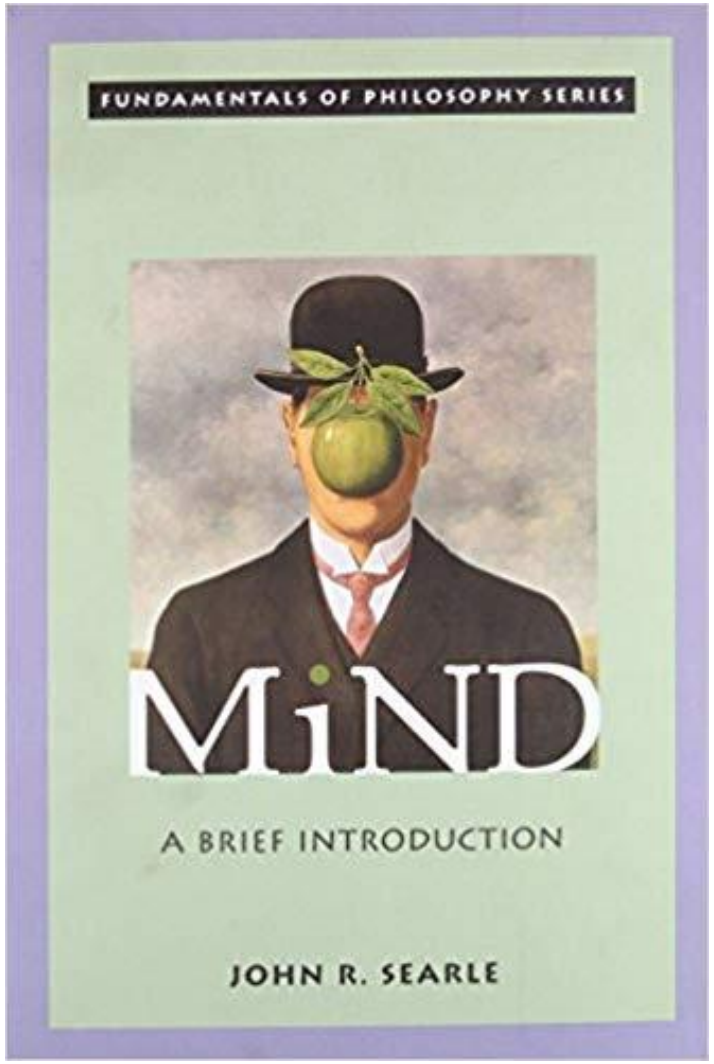

Reifying philosophy with code

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

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  - Consciousness is causally reducible to brain states but consciousness is ontologically irreducible to 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)

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- 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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  - The full physical-chemical state of the brain and nervous system
  - 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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- V1
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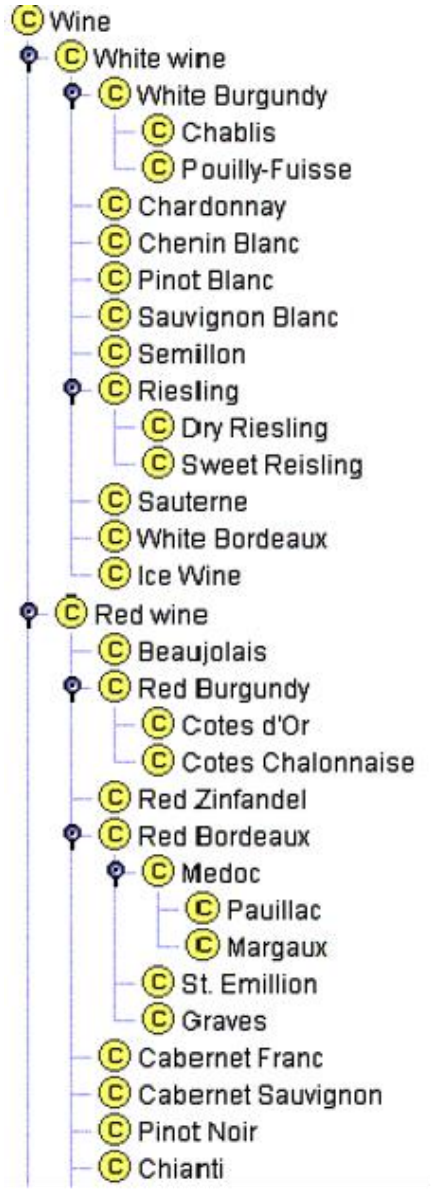
Ontologies in Computer Science



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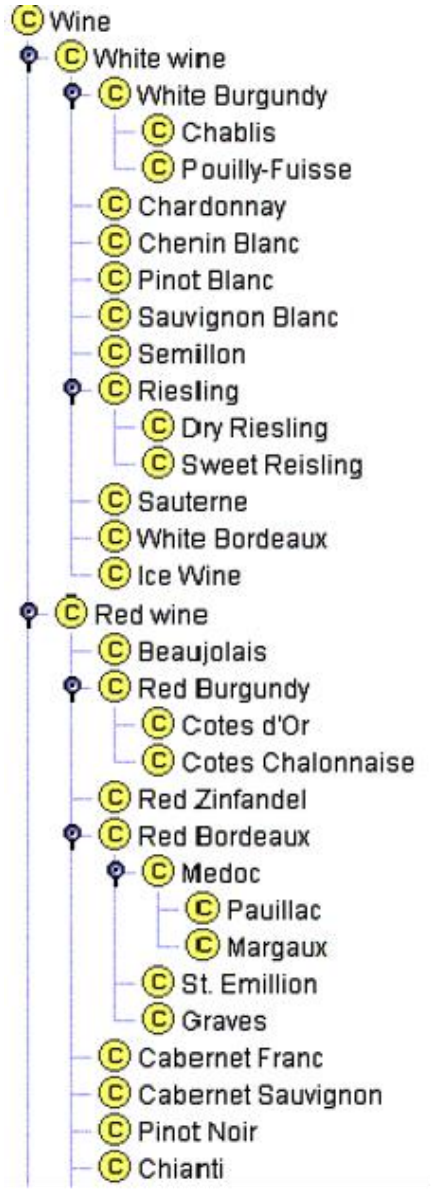
Ontologies in Computer Science

- Class-instance distinction



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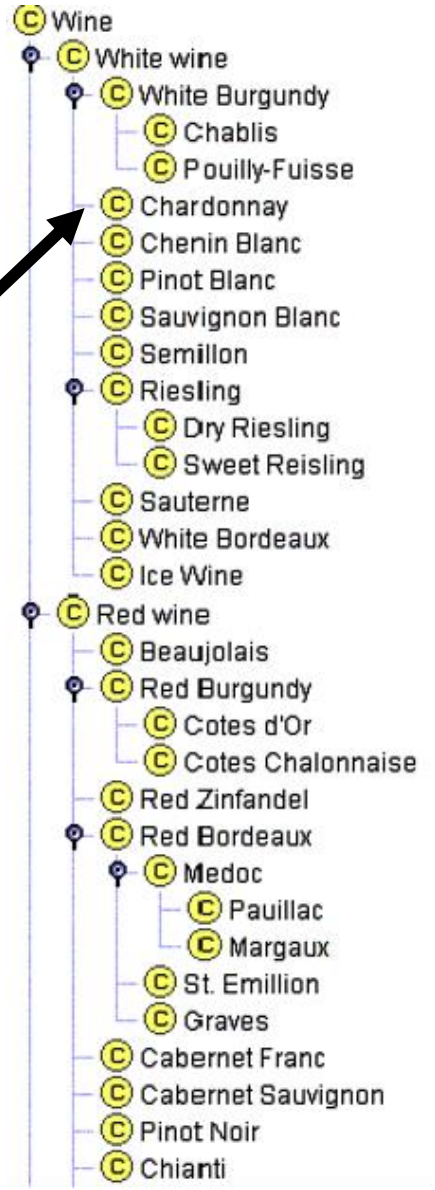

(C) A set of wine bottles

(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
  - Red Zinfandel
  - Pauillac
  - Margaux
  - St. Emillion
  - Graves
  - Red Bordeaux
  - Sauterne
  - Cabernet Franc
  - Cabernet Sauvignon
  - Medoc
  - Semillon
  - Pinot Noir
  - Chianti
  - Petite Syrah
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  - Muscadet
  - Port
  - Sweet Reisling
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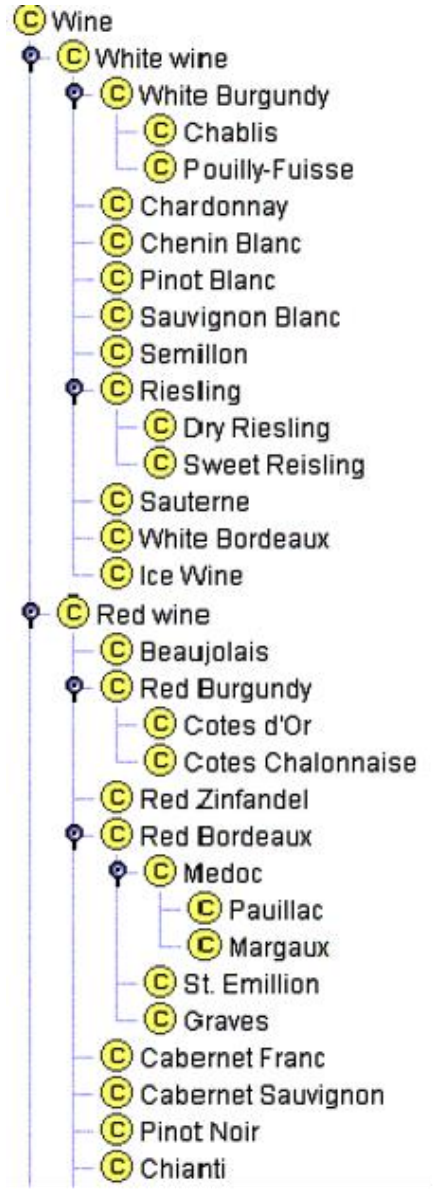

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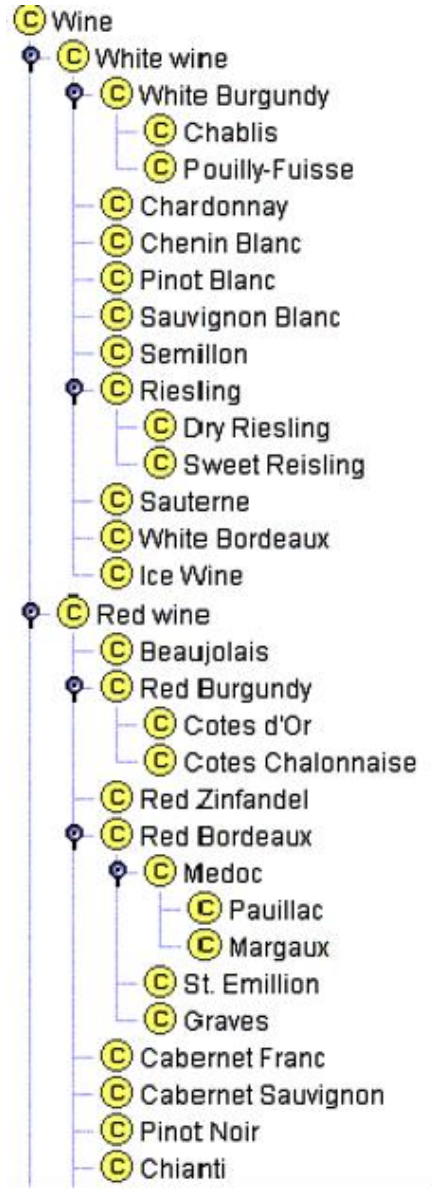
- Class-instance distinction
- Type-token distinction
  - "They drive the same car“
    - They drive the same car type
      - (a Toyota)
    - They drive the same car token
      - (the 2003 Toyota Corolla with VIN: 2QFBORHE4KP911561)



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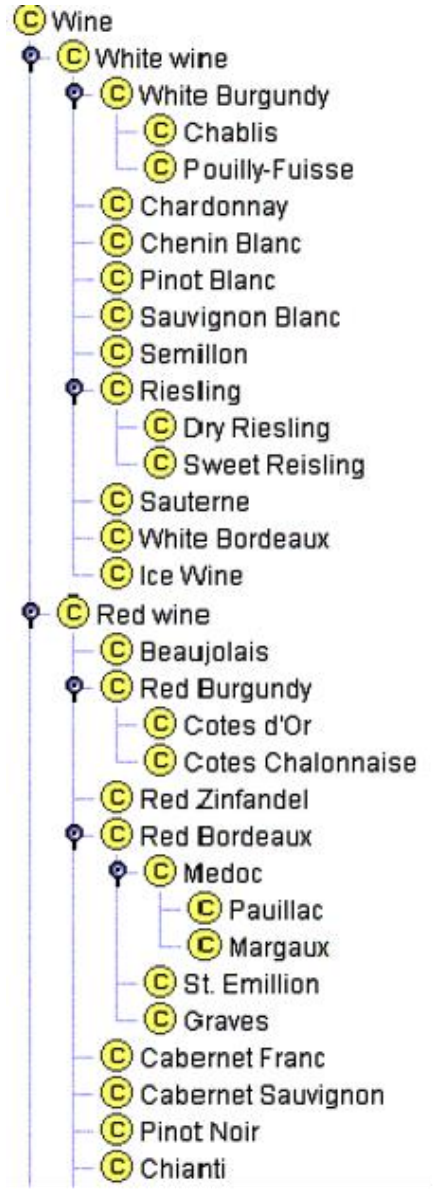

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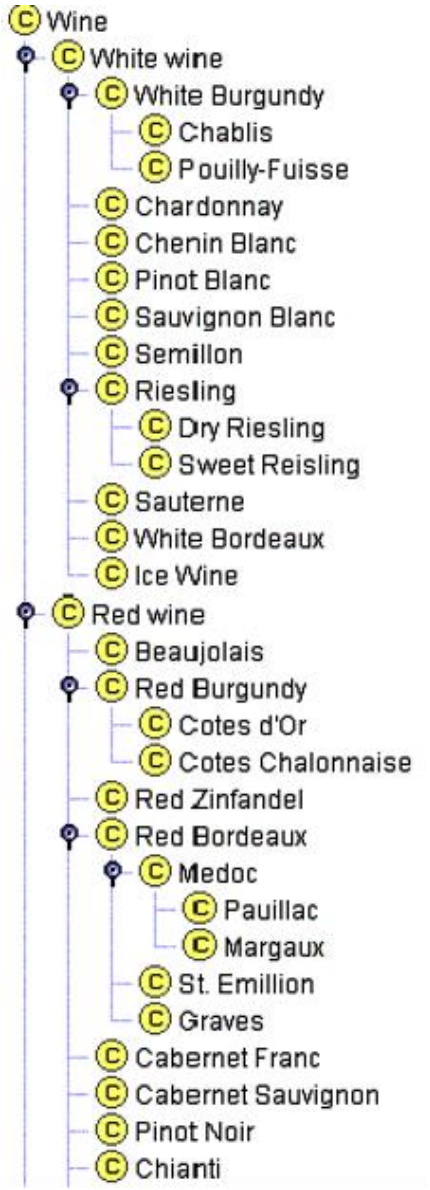

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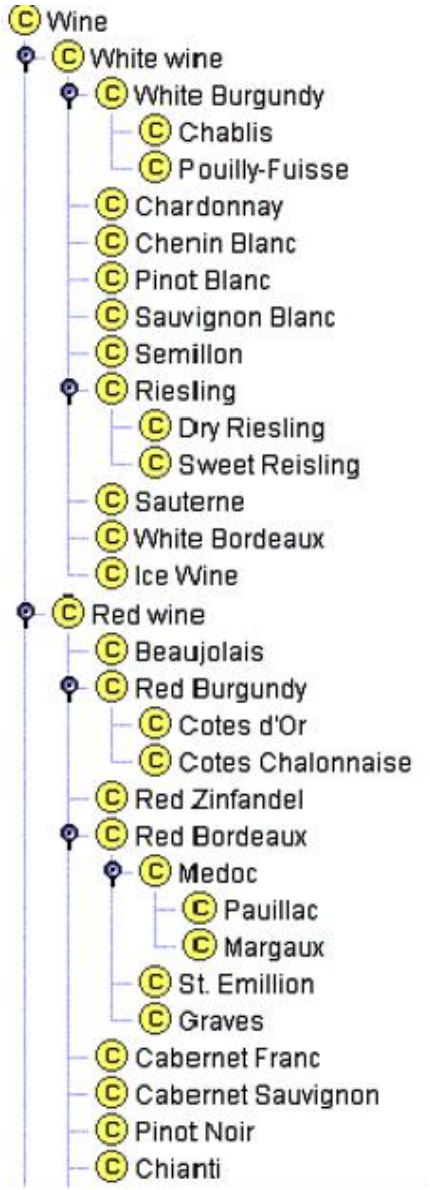

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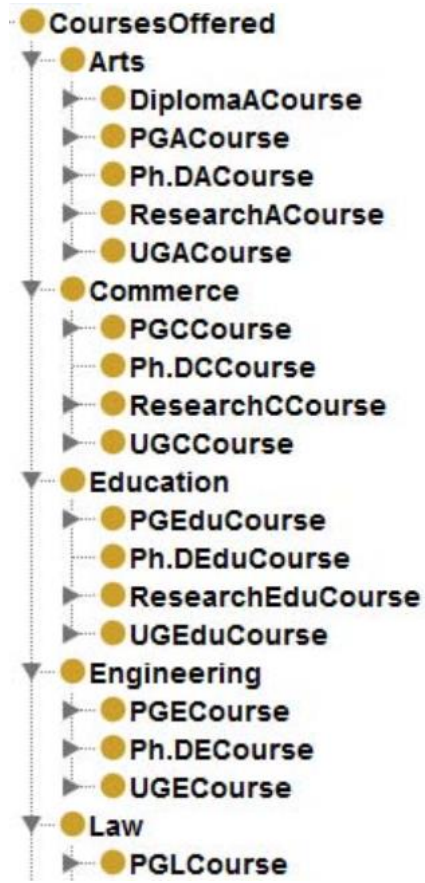

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Requirements: unpacking Searle's view

- V0
  - Internal states are causally reducible to brain states
  - Internal states are ontologically irreducible to brain states

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 causally 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

Design, V0

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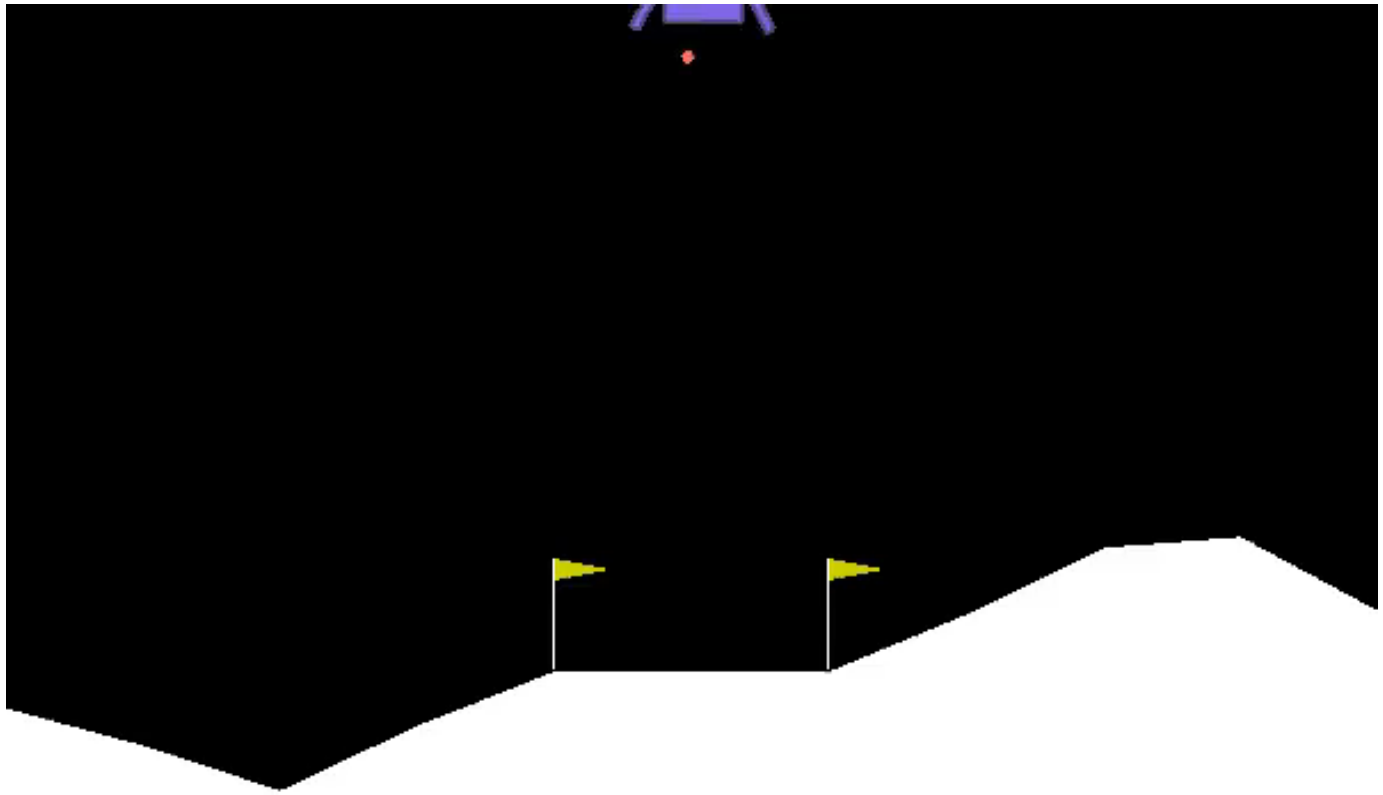
  - Environment and the agent's "physical" form

Design, V0

- OpenAI's LunarLander benchmark environment



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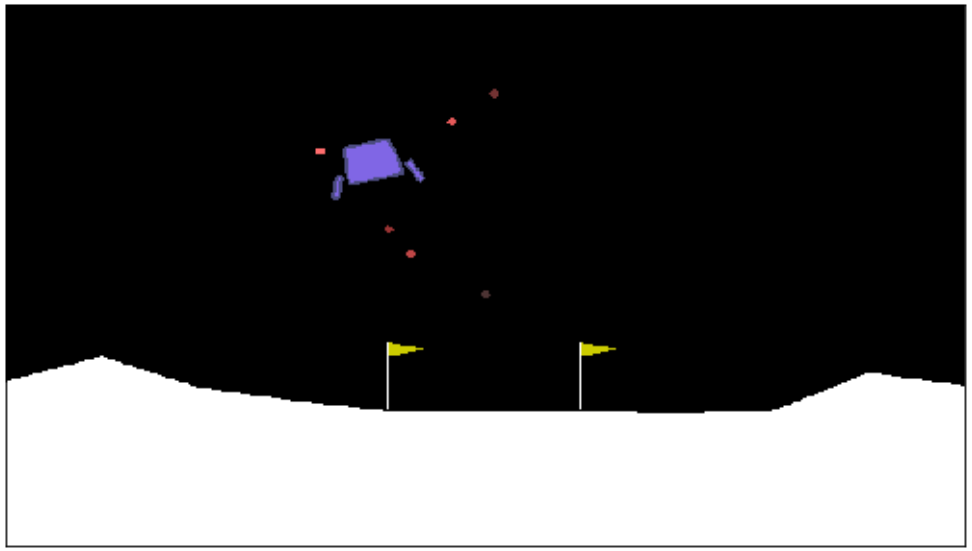
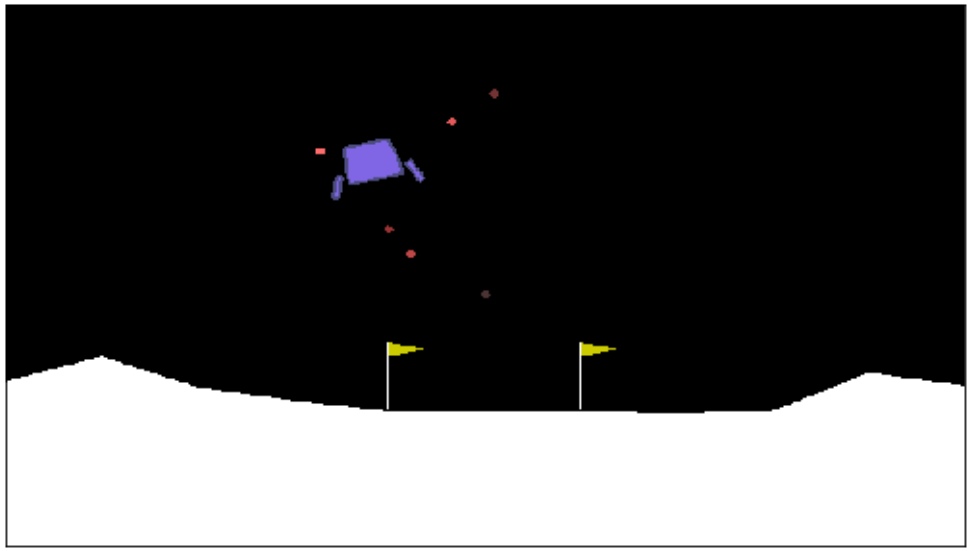


Design, V0

- Design decisions
  - Environment and the agent's "physical" form
  - Internal state of the agent



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- Design decisions
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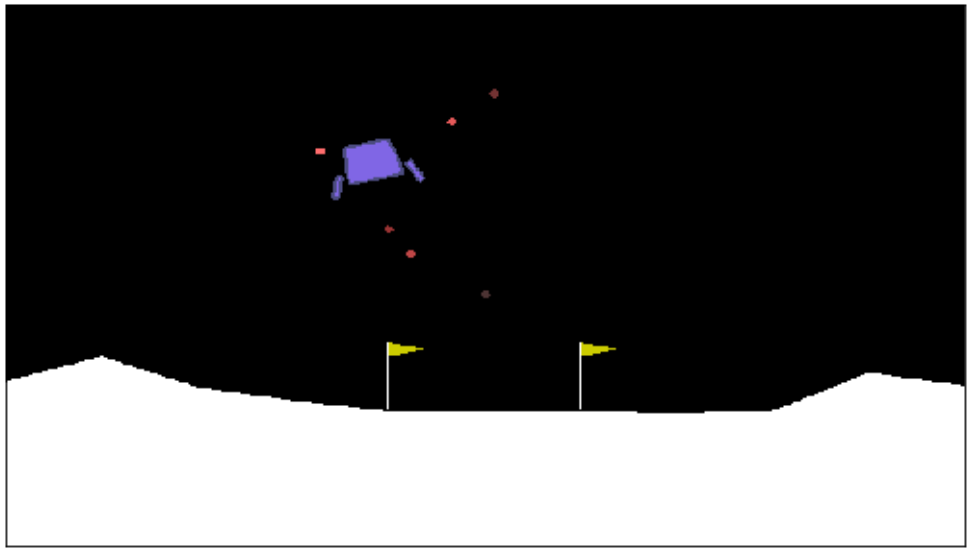
    - Beliefs about itself relative to semantically important regions



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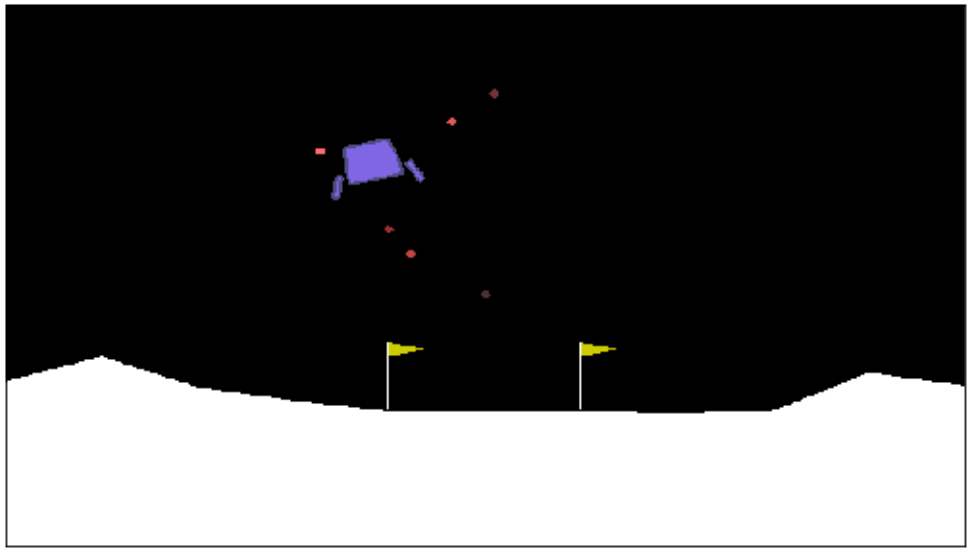

- Design decisions
  - Environment and the agent's "physical" form
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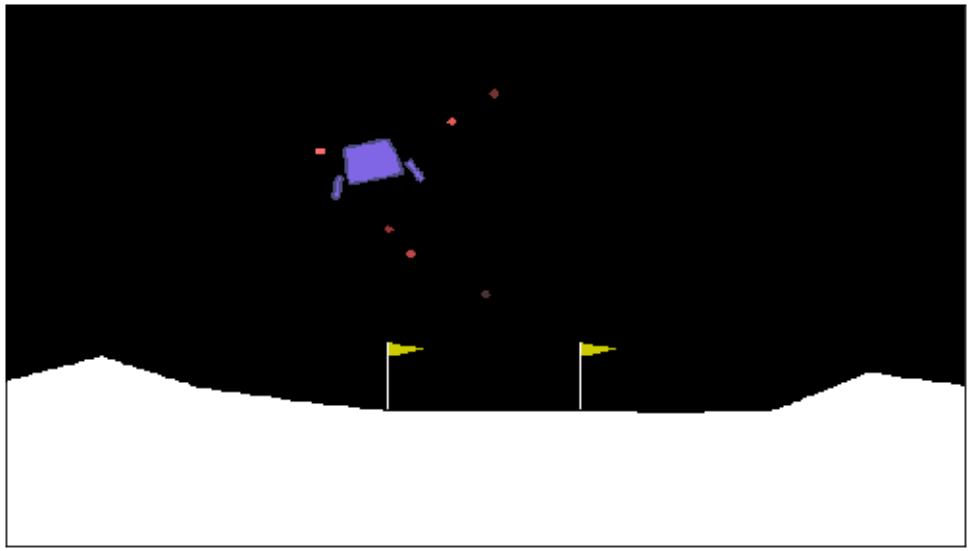
    - Beliefs about itself relative to semantically important regions
      - Left of the flags, right of the flags, high above the ground, close to the ground, falling too fast

Design, V0



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  - Brain state of the agent

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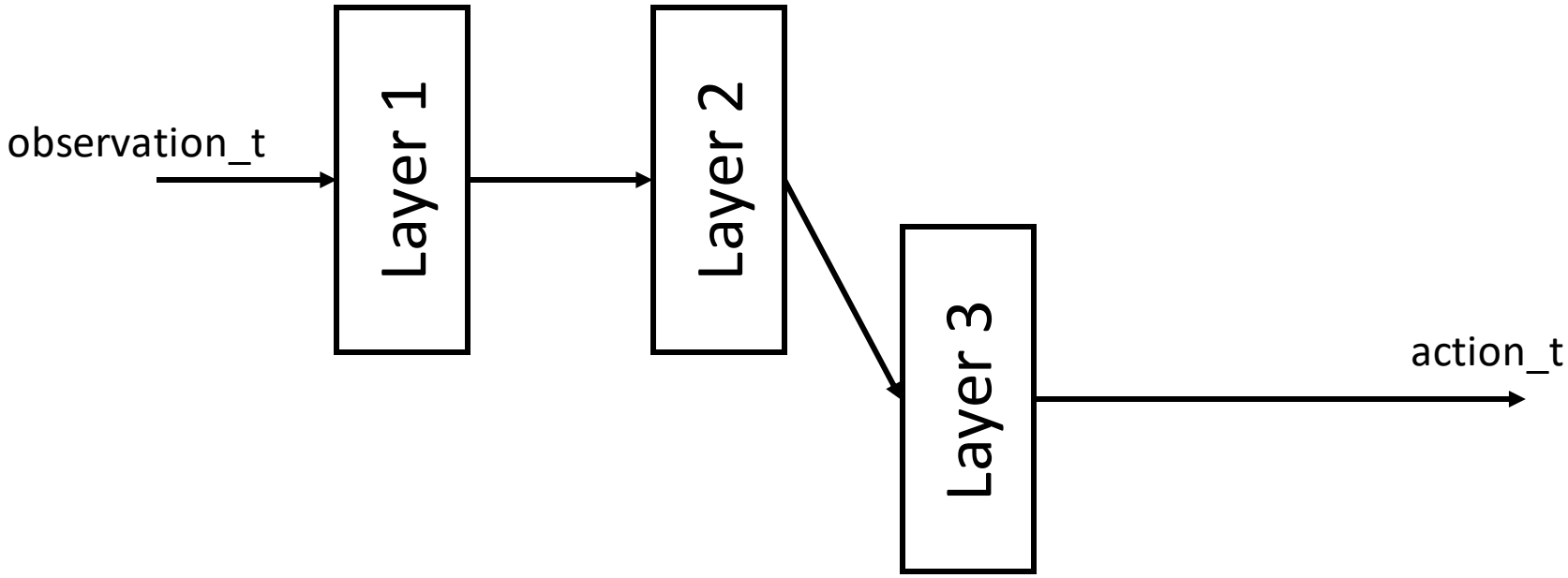

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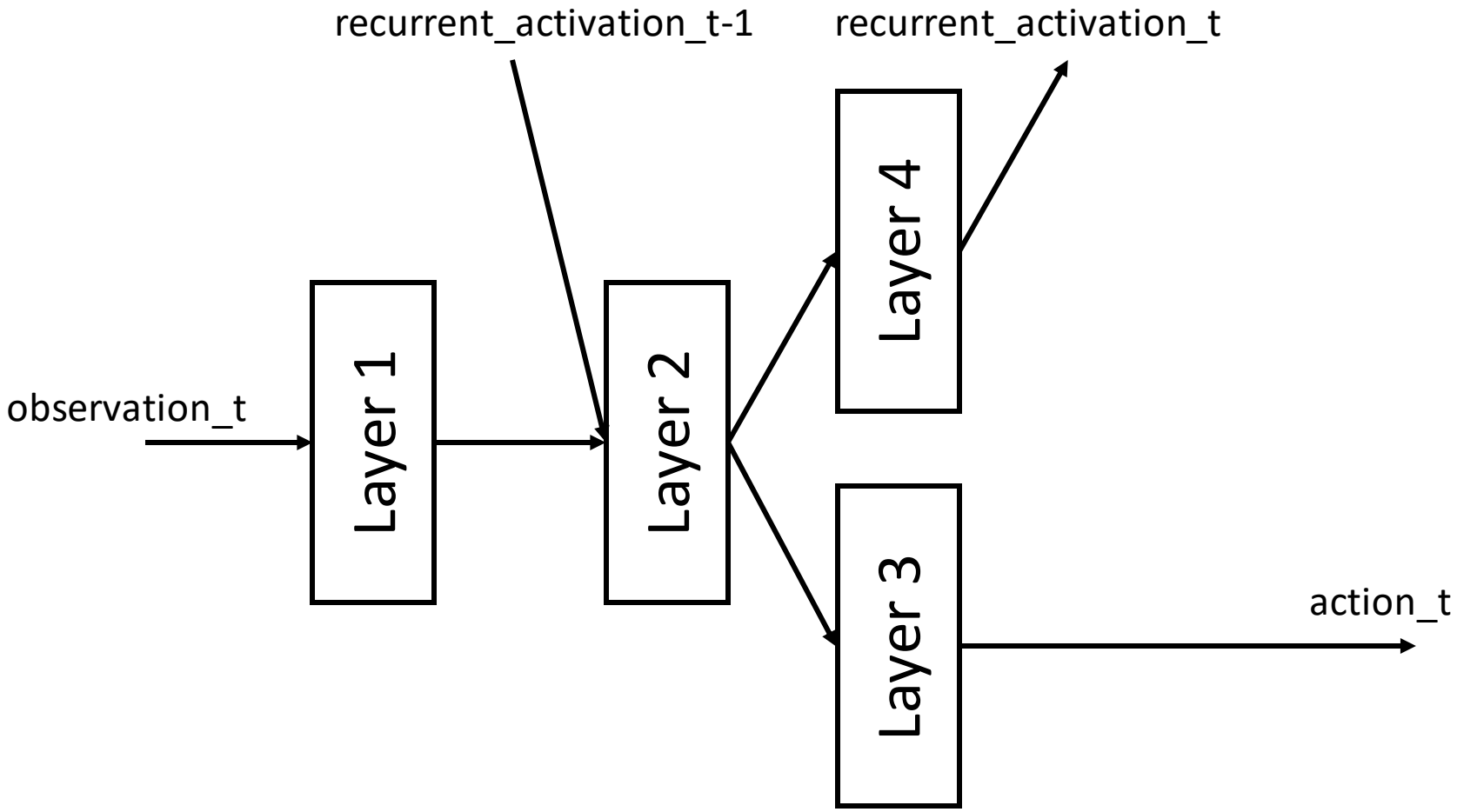
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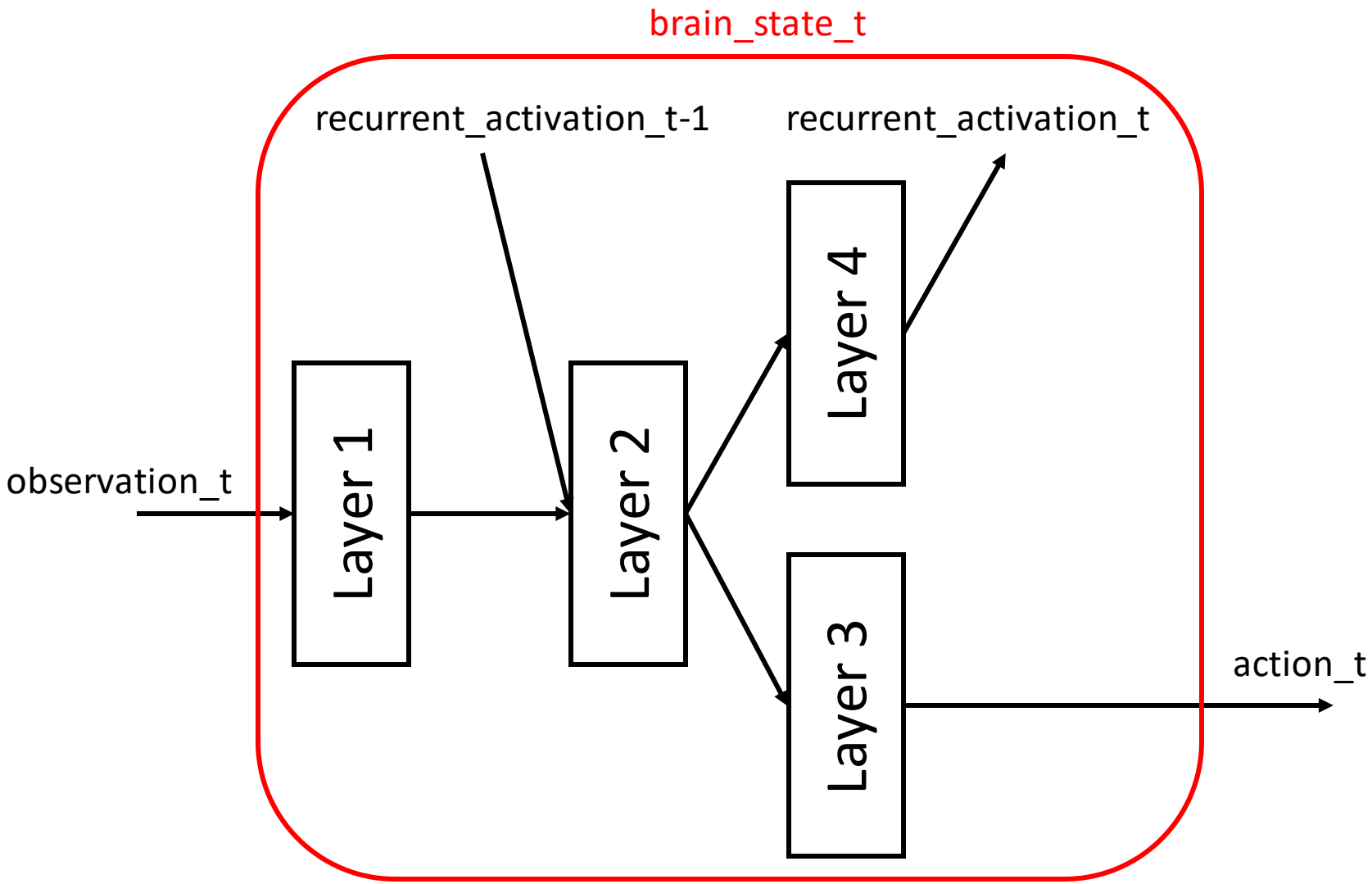
recurrent_activation_t
observation_t
Layer 1
Layer 2
Layer 4
Layer 3
action_t

Design, V0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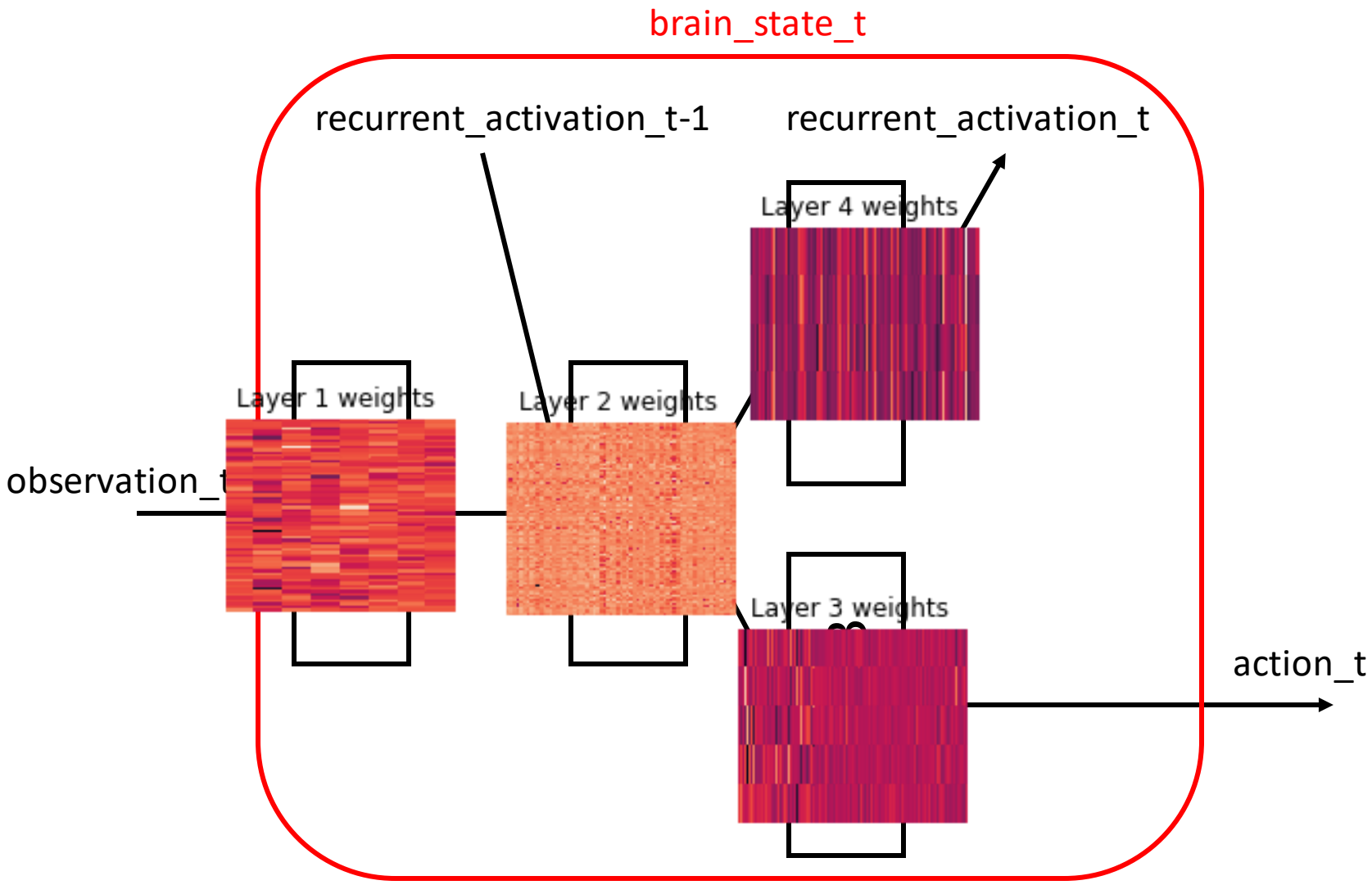
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Layer 4 weights
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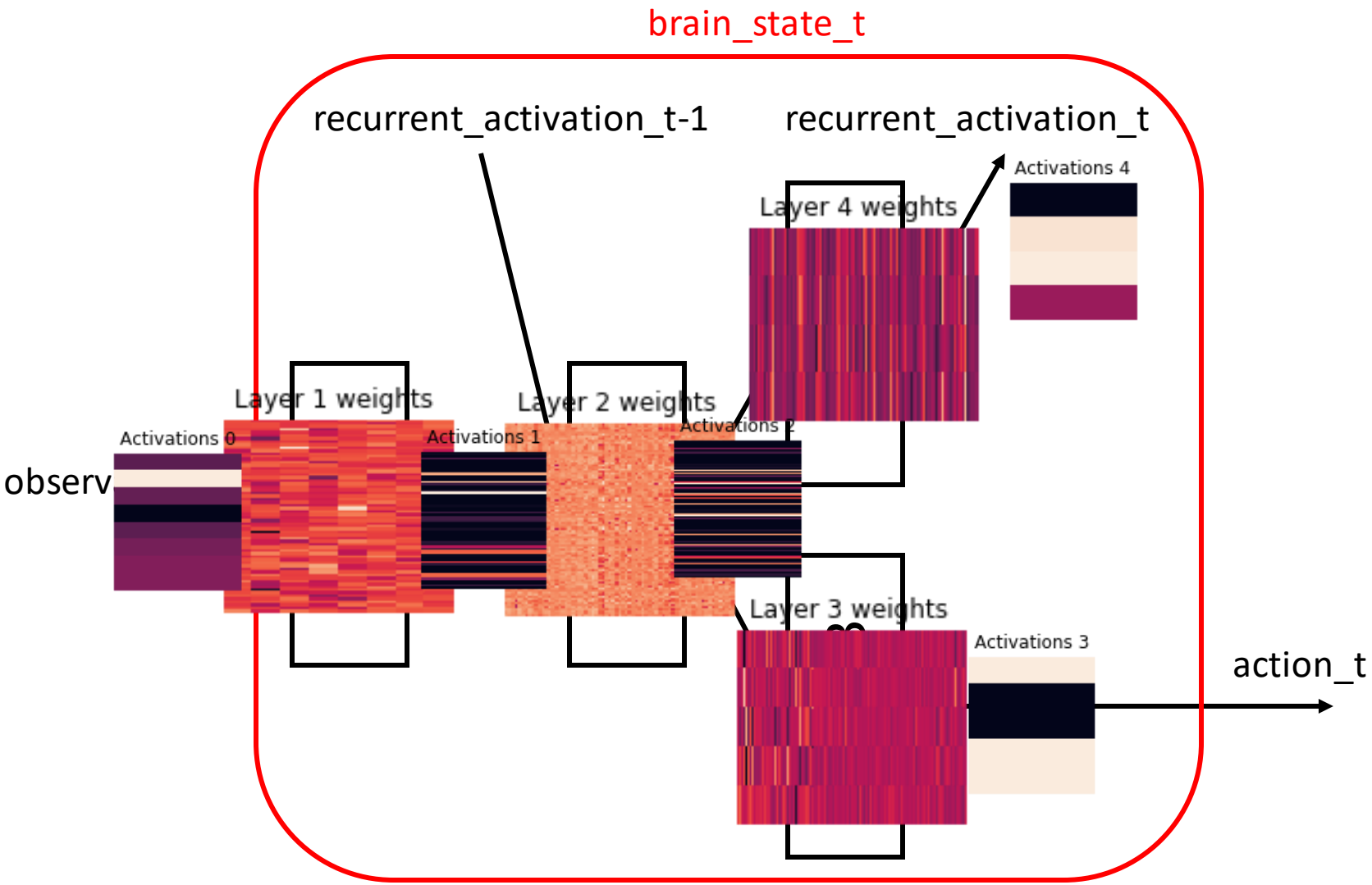
brain_state_t
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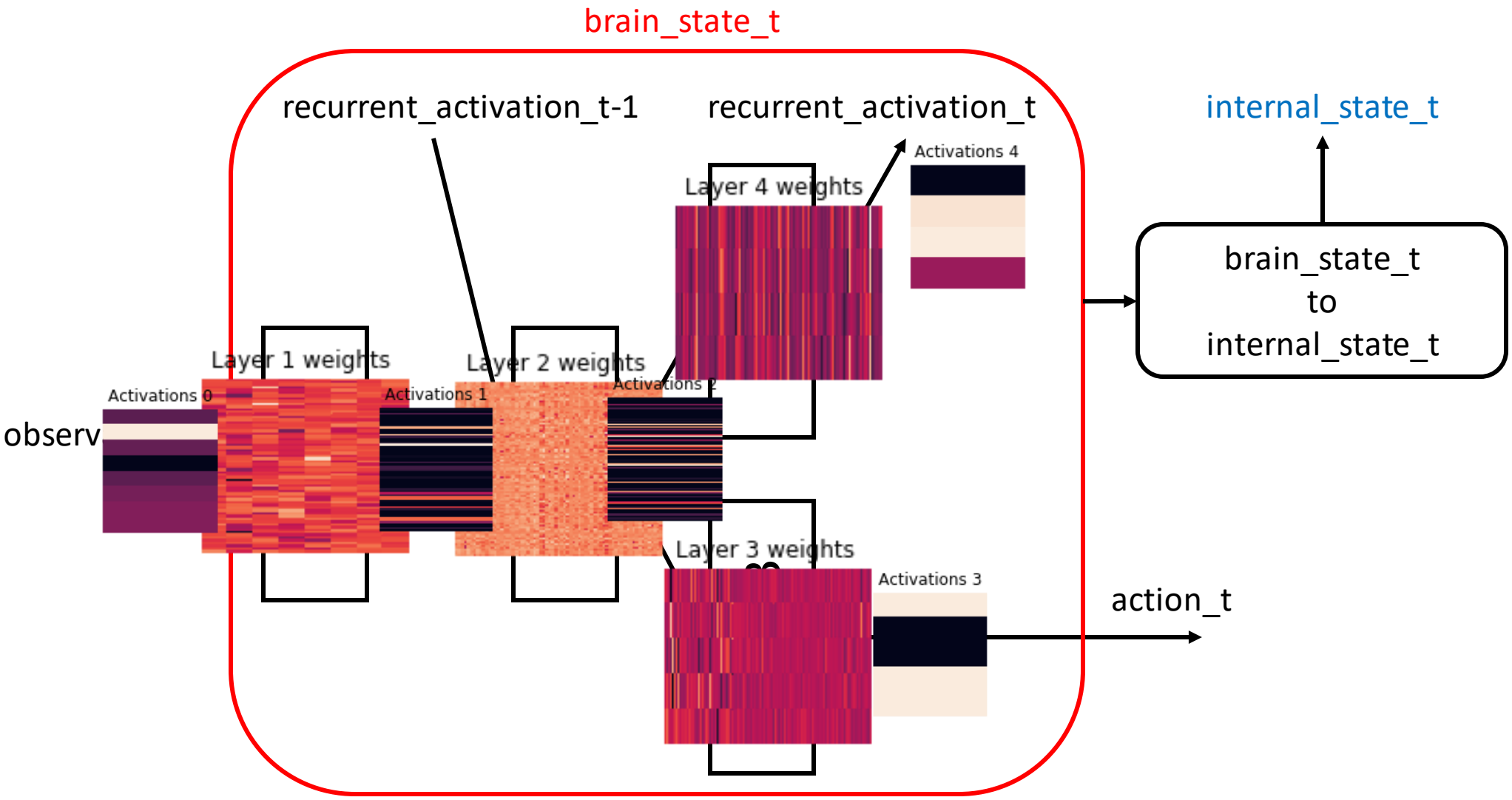
Activations 4
Layer 4 weights
Layer 1 weights
Layer 2 weights
Activations 0
Activations 1
Activations 2
observ
Layer 3 weights
Activations 3
action_t

Design, V0


brain_state_t
recurrent_activation_t-1
recurrent_activation_t
internal_state_t
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Layer 4 weights
brain_state_t
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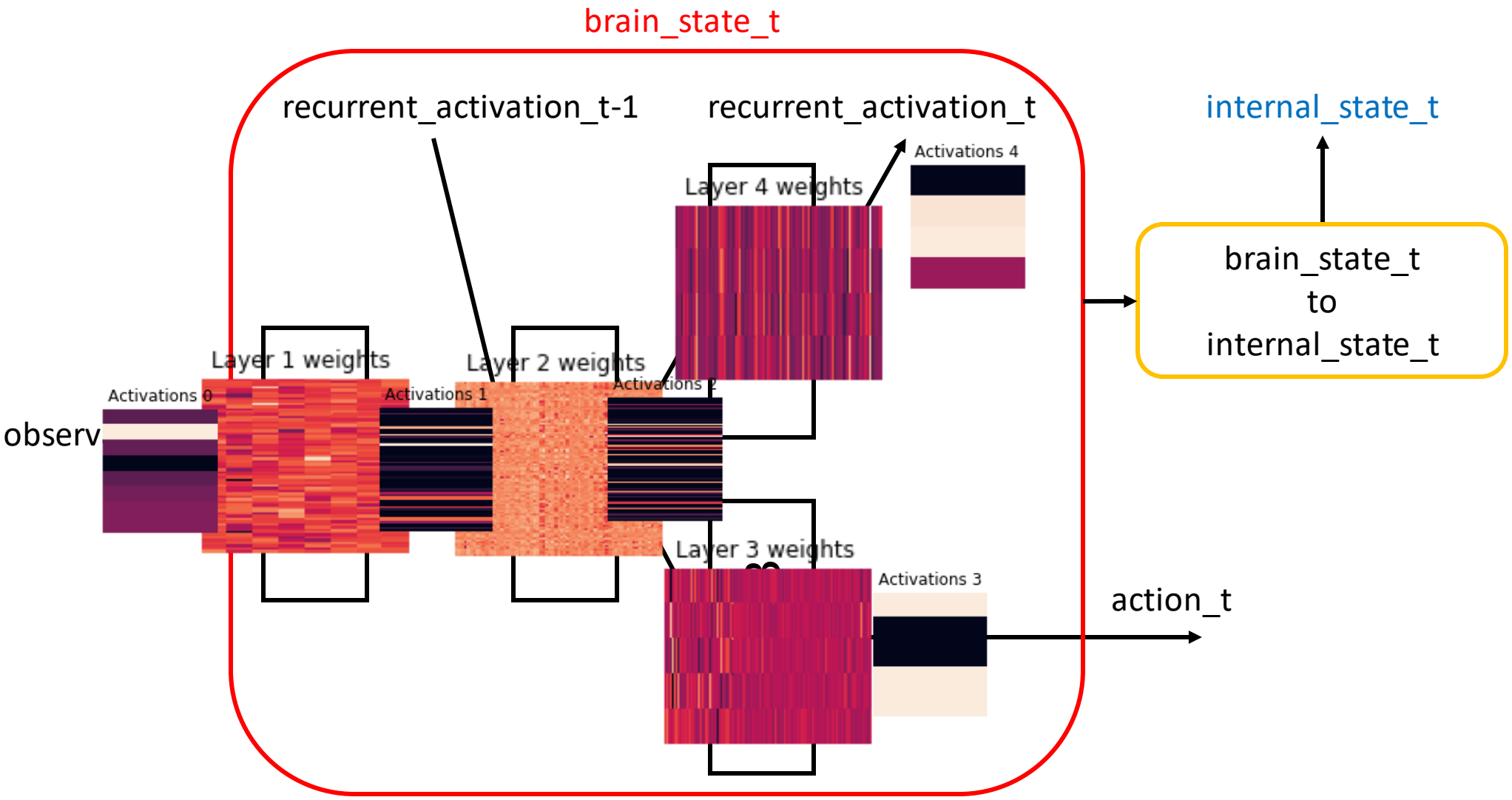
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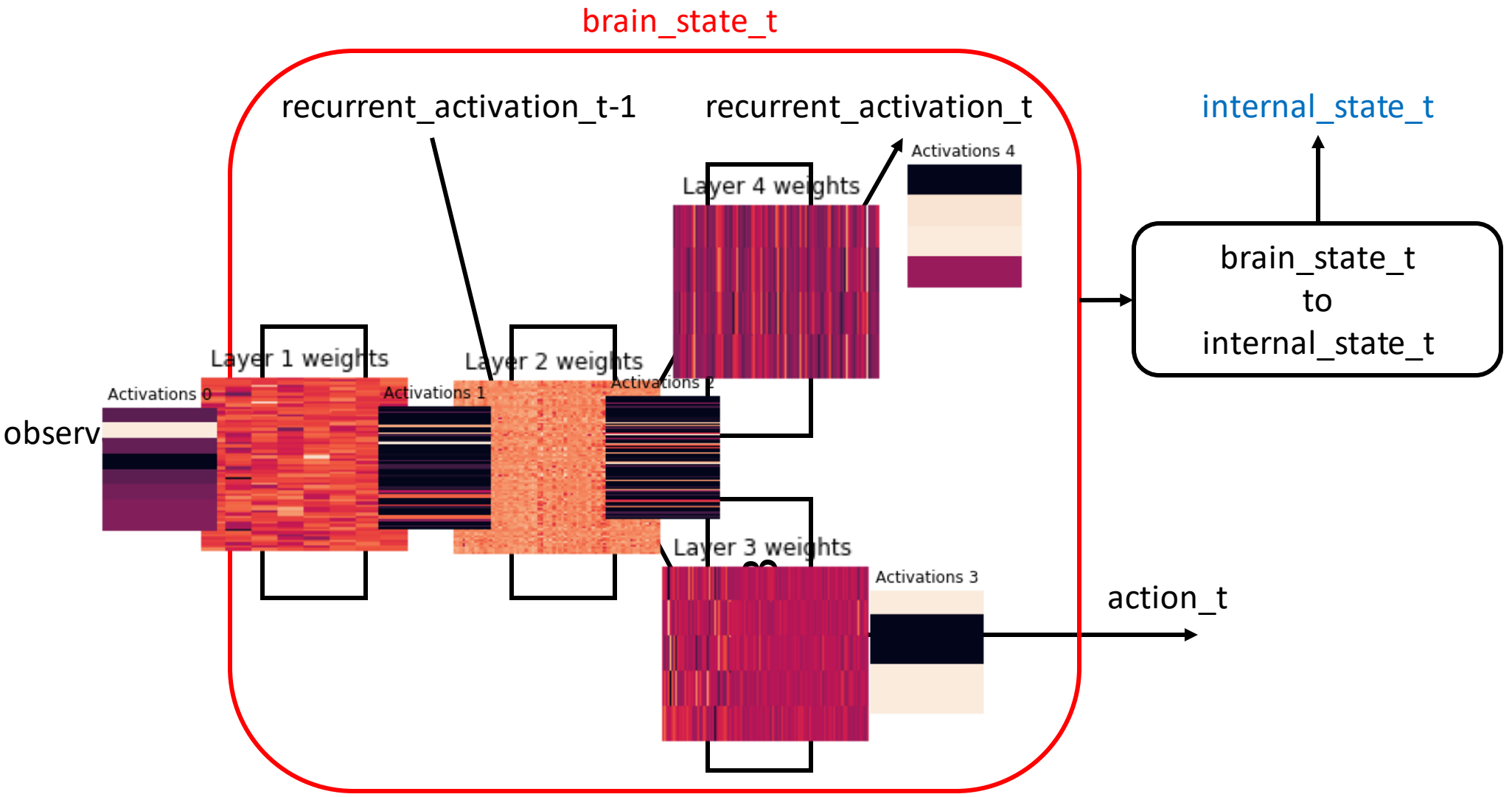
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Design, V0

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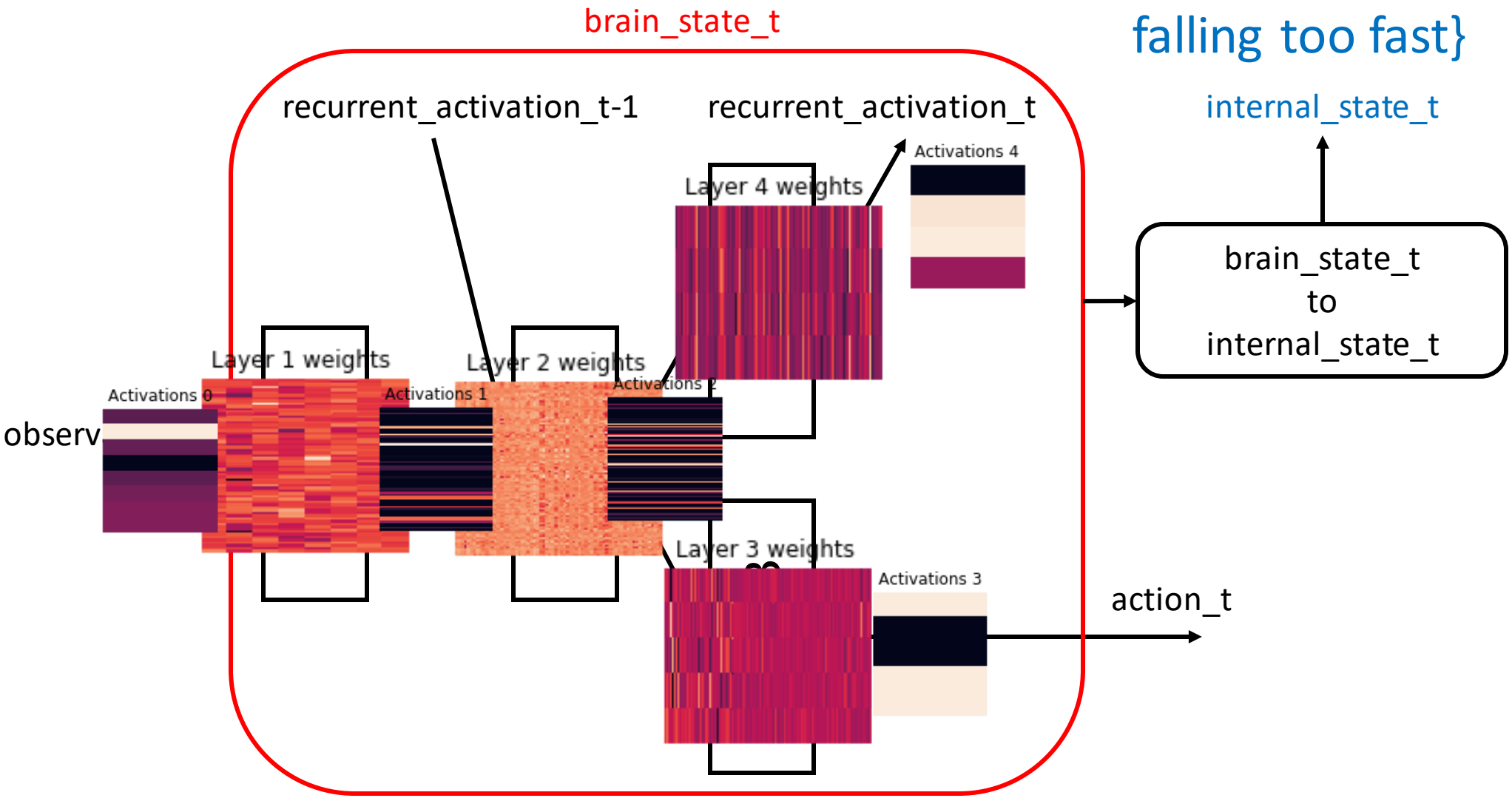

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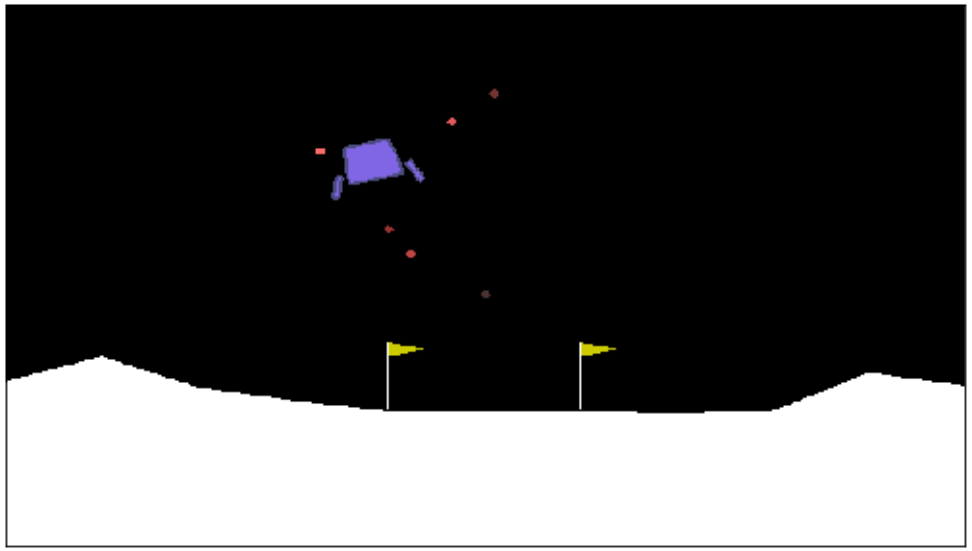

- Design decisions
  - Environment and the agent's "physical" form
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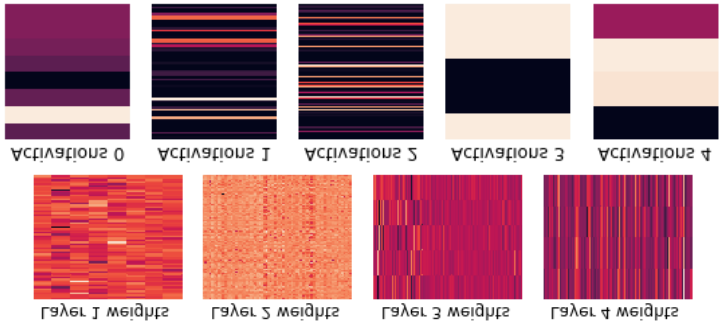
    - Beliefs about itself relative to semantically important regions
      - Left of the flags, right of the flags, high above the ground, close to the ground, falling too fast
  - Brain state of the agent



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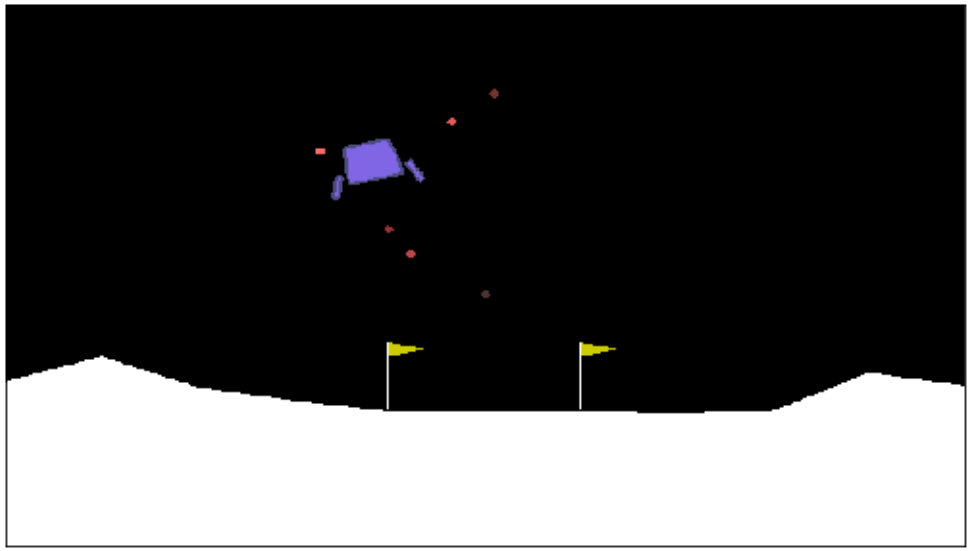

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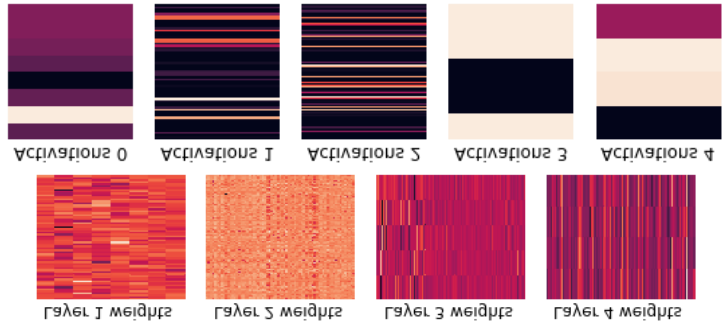

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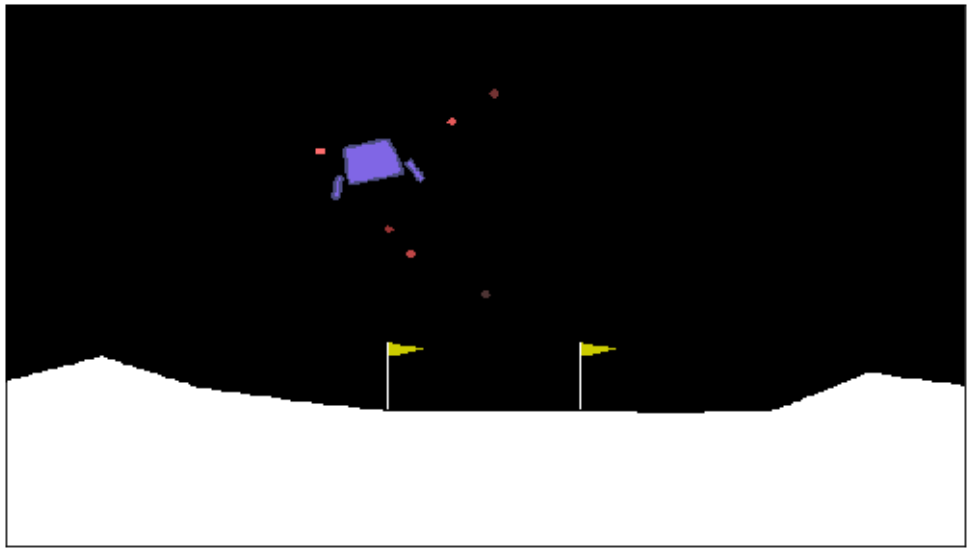

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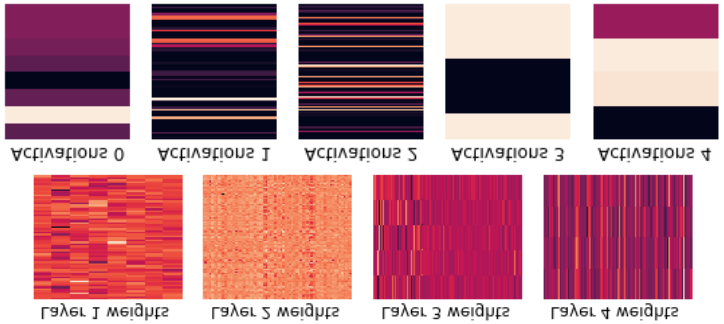

Reinforcement learning

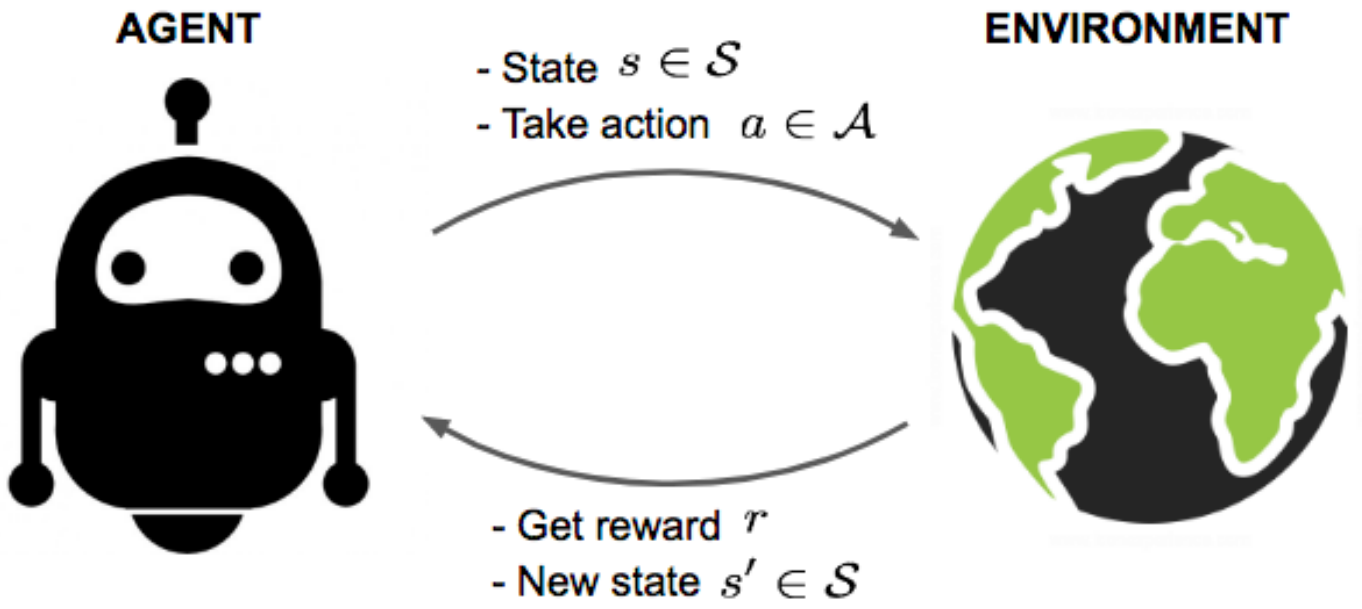

Image from:
https://lilianweng.github.io/lil-log/2018/02/19/a-long-peek-into-reinforcement-learning.html

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 causally reducible to brain states
  - Internal states are ontologically irreducible to brain states

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- the behavior of A's are entirely causally explained by the behavior of B's
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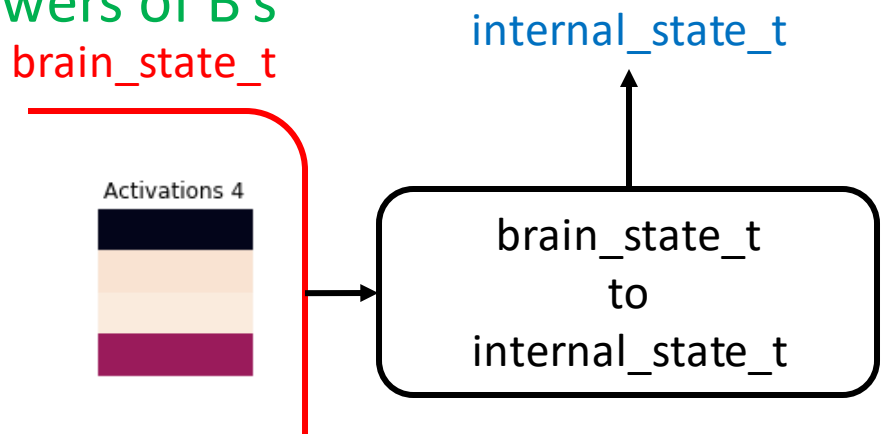

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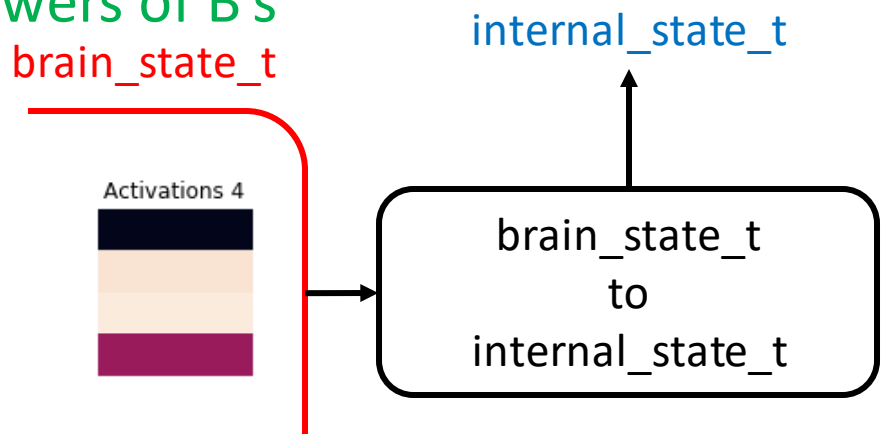
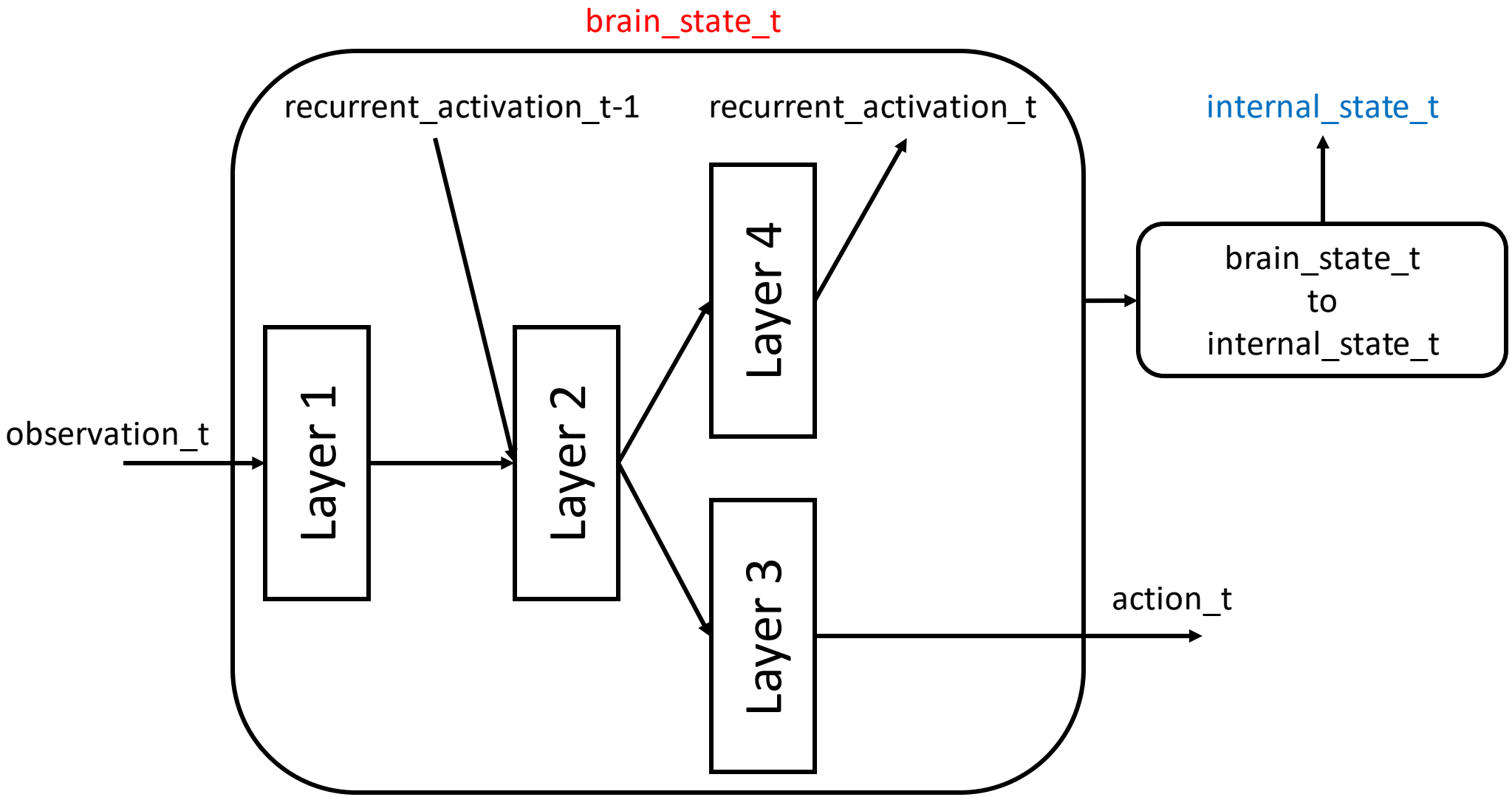


Design, V0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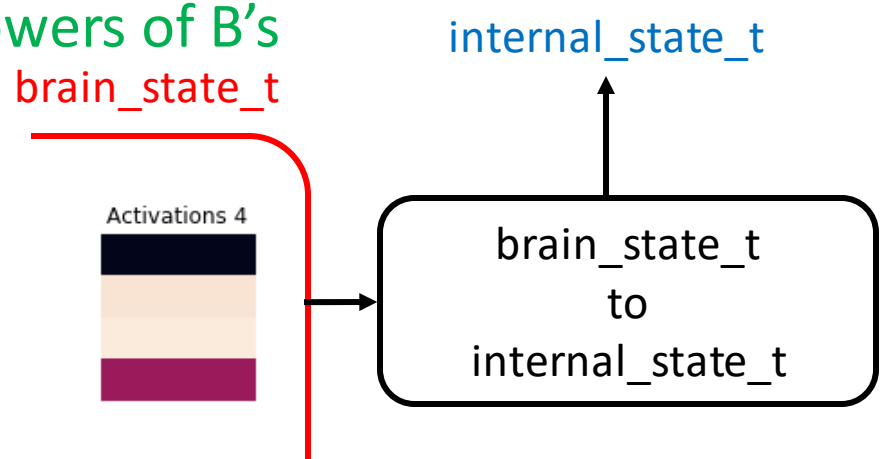

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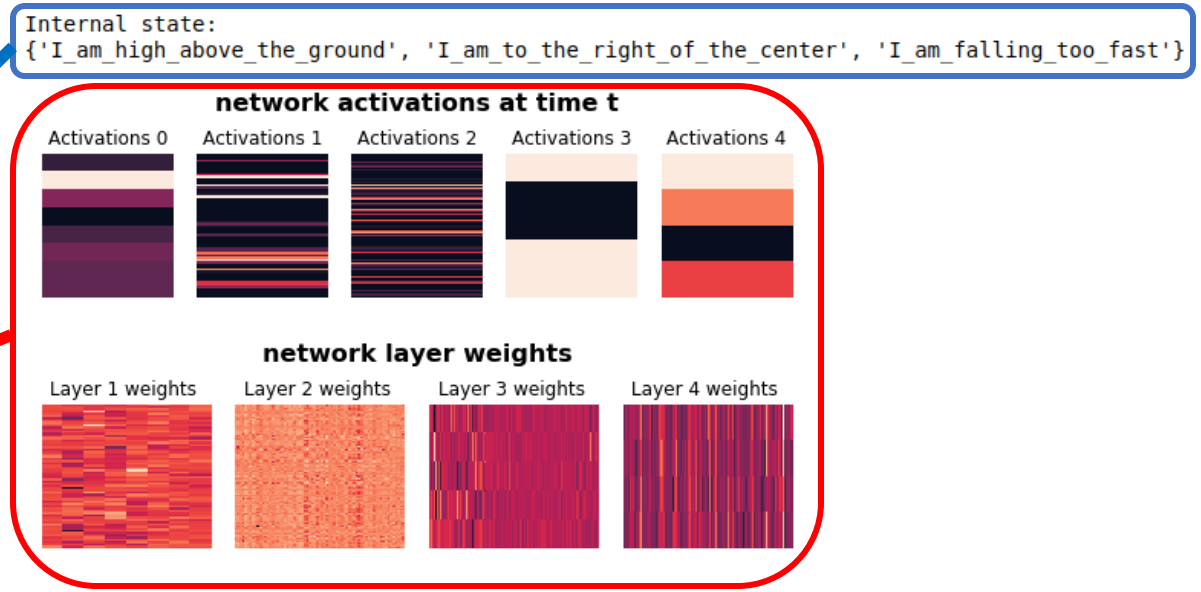

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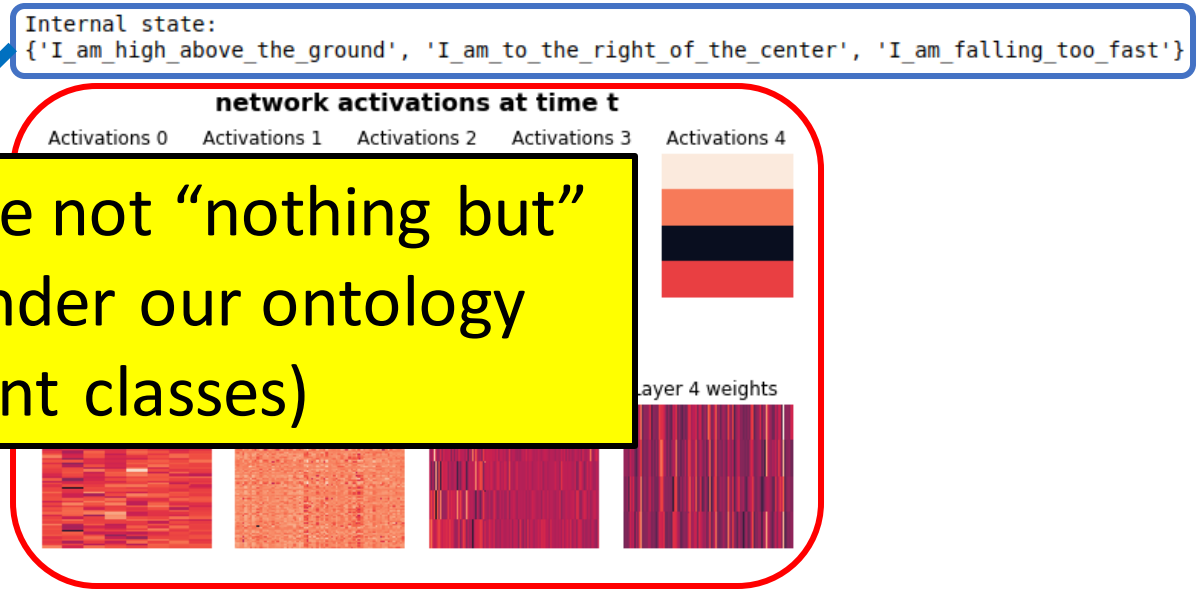
Internal state instances are not "nothing but" brain state instances under our ontology (they are different classes)



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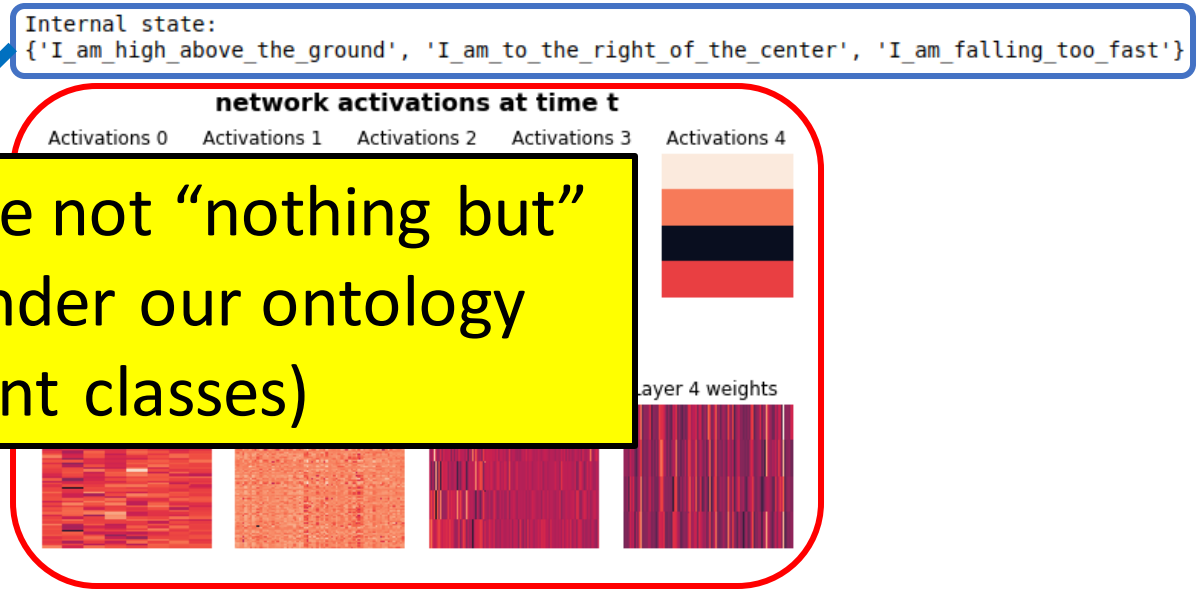

Is that the “real” ontology though?

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- Bits
- Python objects
- Electrons
- Quarks
- …

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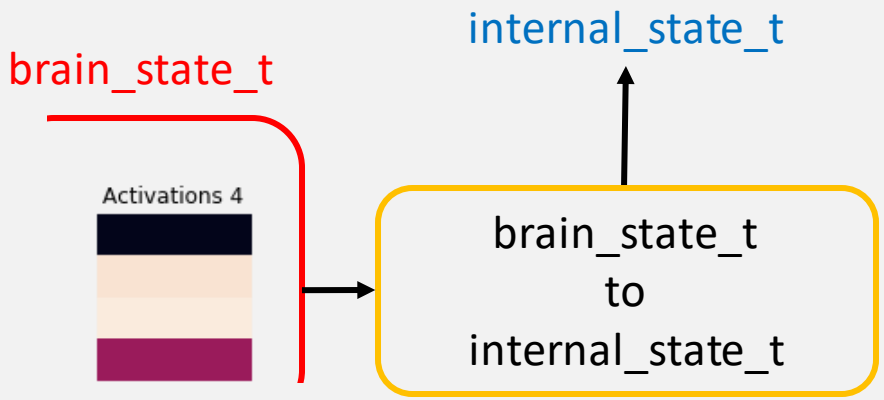
What's the deal with that function?

{High above the ground,
right of the center
falling too fast}



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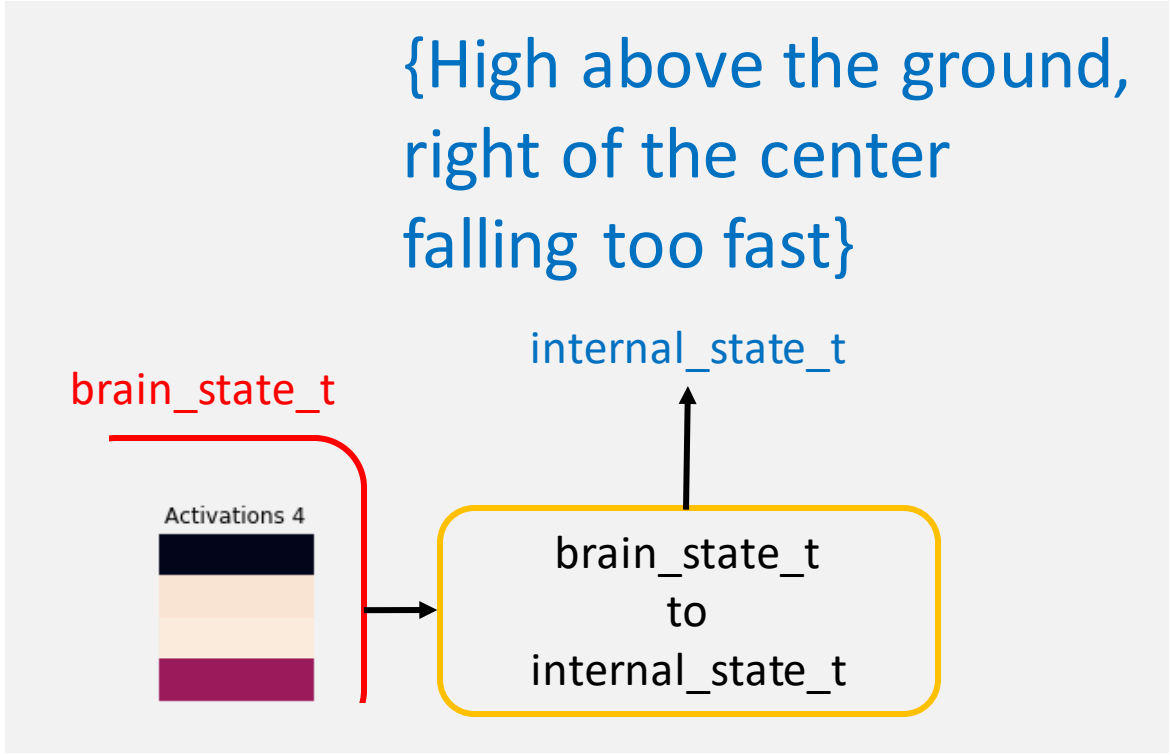


```python
def brain_state_to_internal_state(brain_state):
    def i_am_high_above_the_ground(observation):
        return observation[1] > 0.5  # observation[1] accesses y position

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        return observation[3] < -0.2  # observation[0] accesses y velocity

    regions = [
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        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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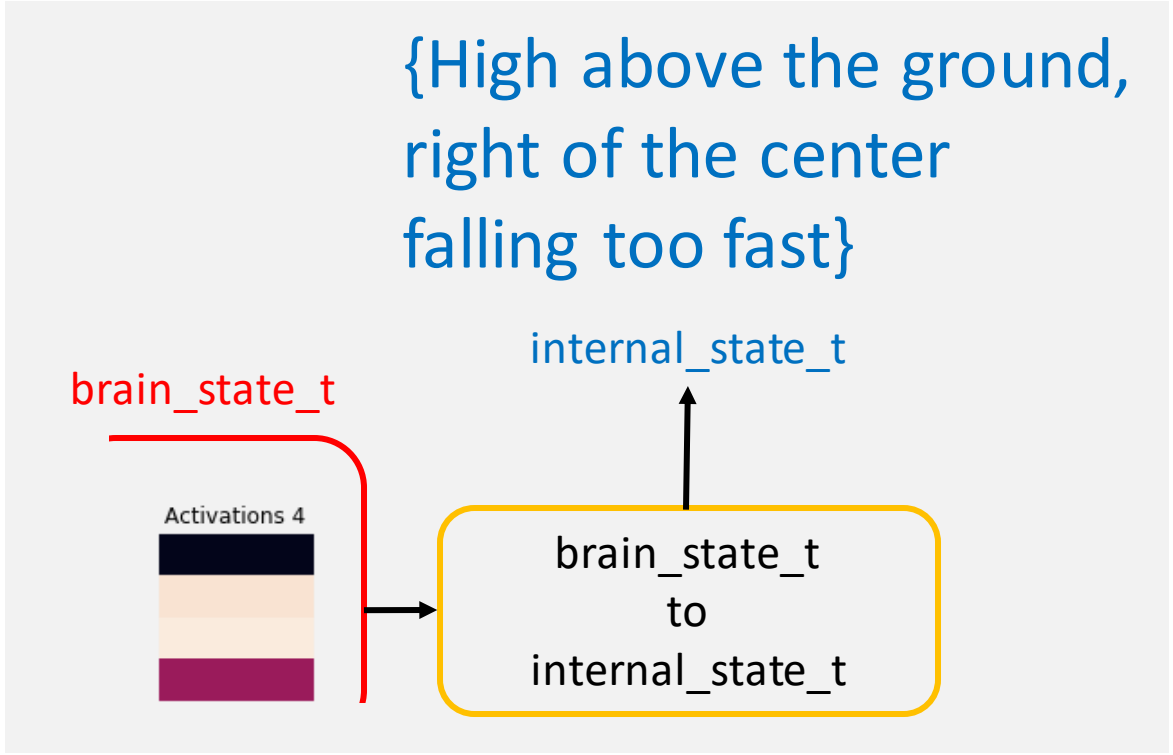


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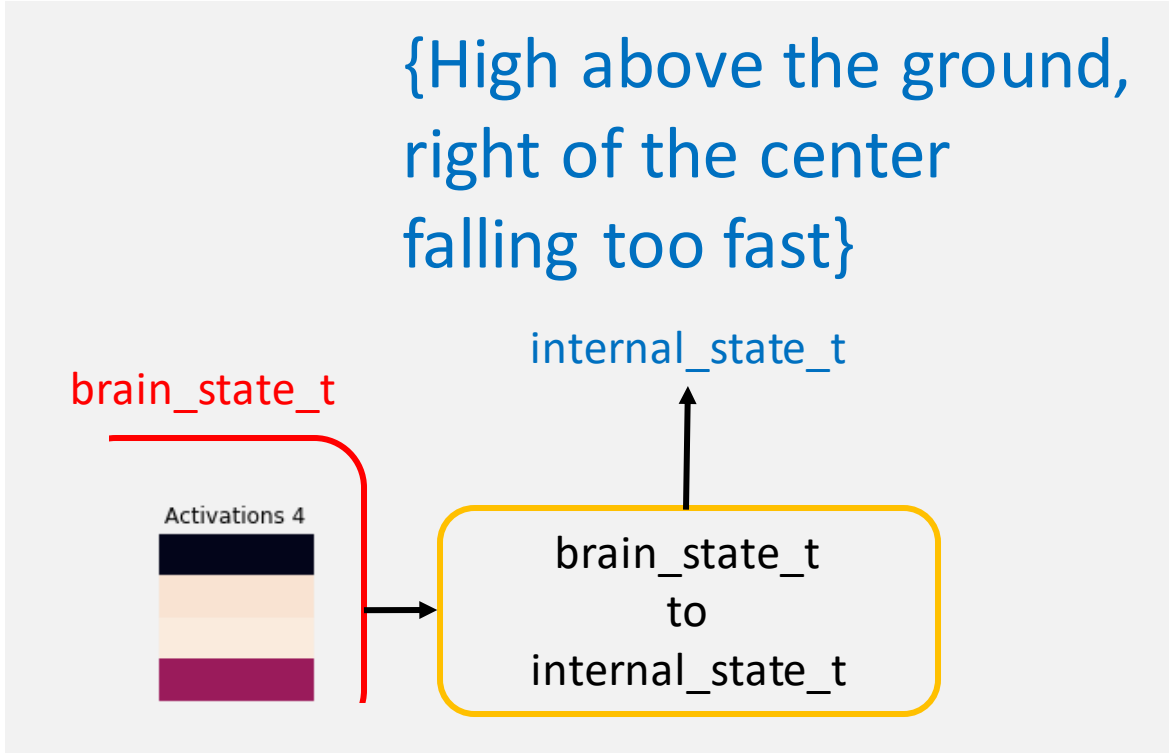


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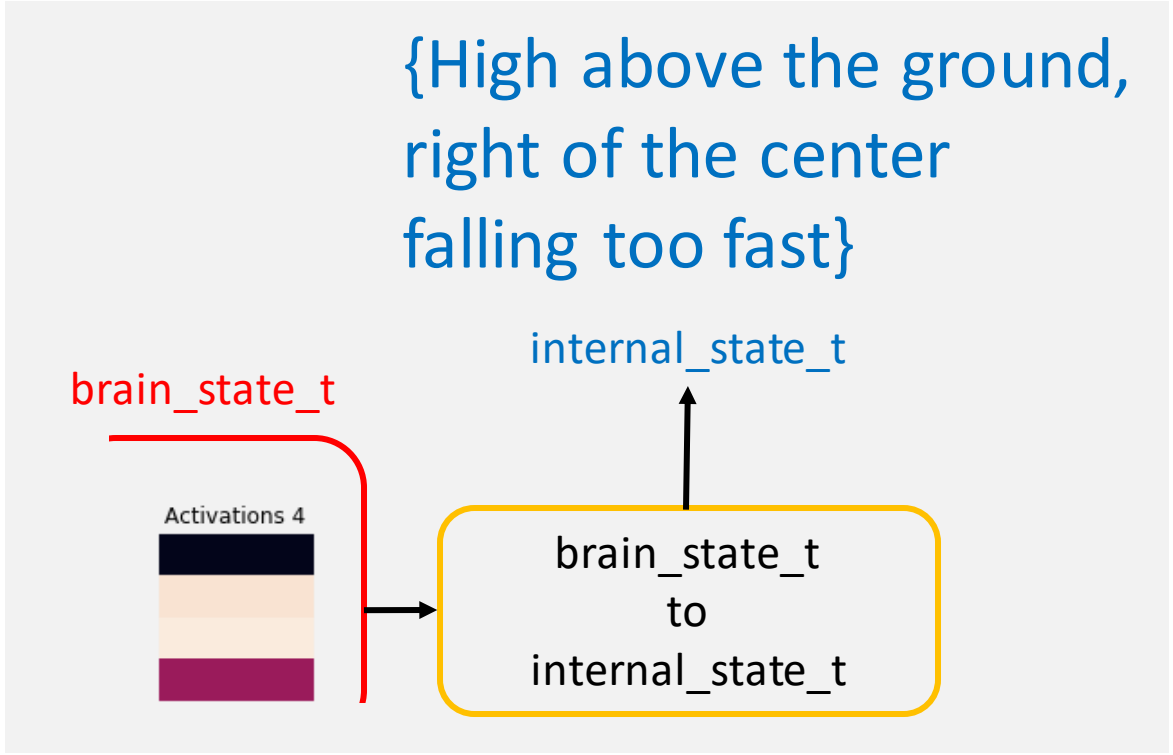


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- (or both?)

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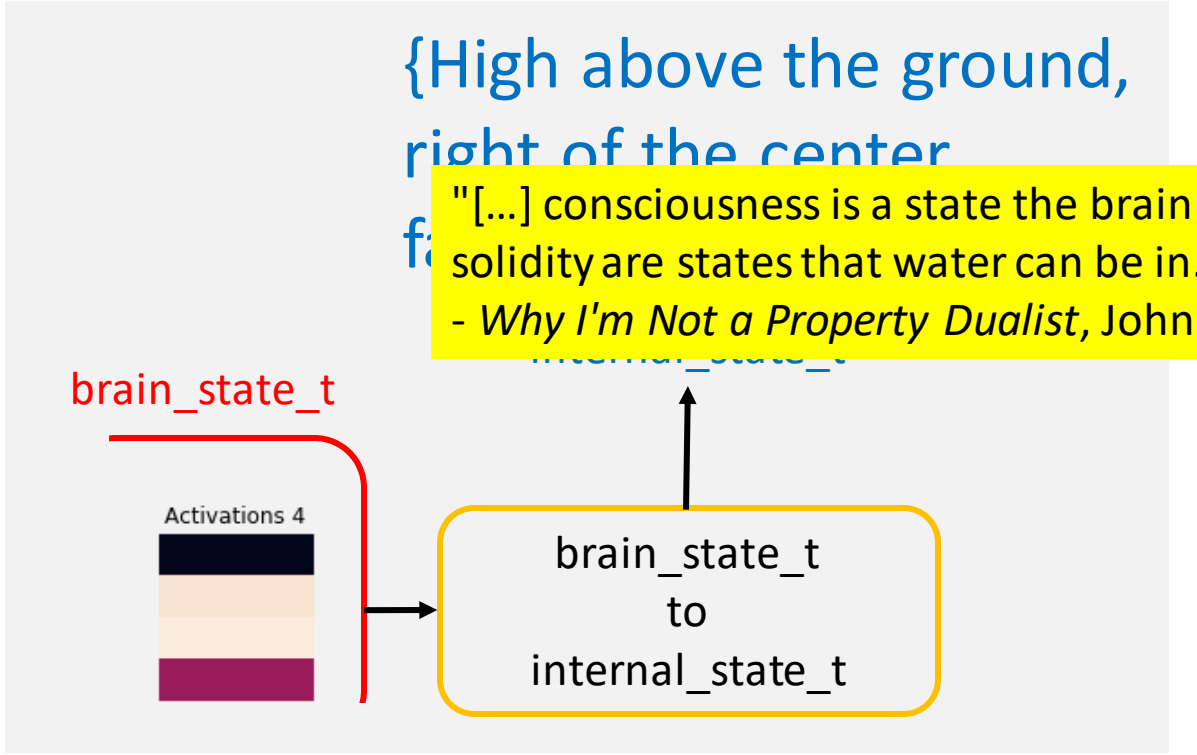

"[…] consciousness is a state the brain can be in, in the way that liquidity and solidity are states that water can be in."
- *Why I'm Not a Property Dualist*, John Searle

```
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.  # observation[1] accesses y position

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

    def i_am_to_the_left_of_the_center(observation):
        return observation[0] <= 0.  # observation[0] accesses x position

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

    regions = [
        i_am_high_above_the_ground,
        i_am_low_to_the_ground,
        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
```

- Is this just some representation of "data flow"?
- Is this something closer to summarization?
- (or both?)

What's the deal with that function?

{High above the ground,
right of the center
f

brain_state_t

"[…] consciousness is a state the brain can be in, in the way that liquidity and solidity are states that water can be in."
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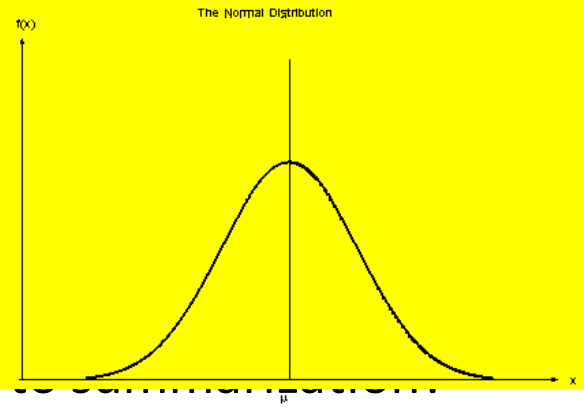
Just like a gaussian and its parameters...



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

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

- Is this just some
- Is this something
- (or both?)

```
def brain_state_to_internal_state(brain_state):
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    def i_am_low_to_the_ground(observation):
                                                    [1] accesses y position
                                                    ):
                                                    0] accesses x position
                                                    ):
                                                    [0] accesses x position
                                                    [0] accesses y velocity
                                                    ns'][3]
                                                    tions, regions):
        if activation > 0.5:
            internal_state.add(region.__name__)

    return internal_state
```

Conclusion

- Software engineer style philosophy reifying seemed to work well
- Created a V0 software agent who's
  - Internal states are causally 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?