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

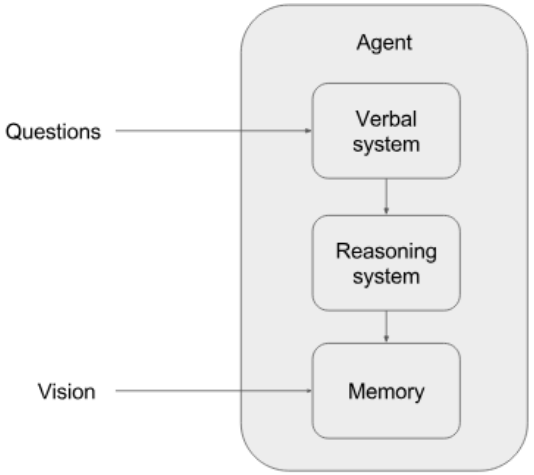
Why attempt to reify philosophy with code

- Lots of the words philosophers use describing aspects of consciousness tends shows up in CS/AI research
  - Mind, awareness, imagination, reasoning, consciousness, etc.
- 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!
- Possibly benefit philosophy by bringing code-style concreteness
  - (TBD, will let the philosophers in the room speak to this!)

- (Disclaimer: our backgrounds are CS/AI)

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

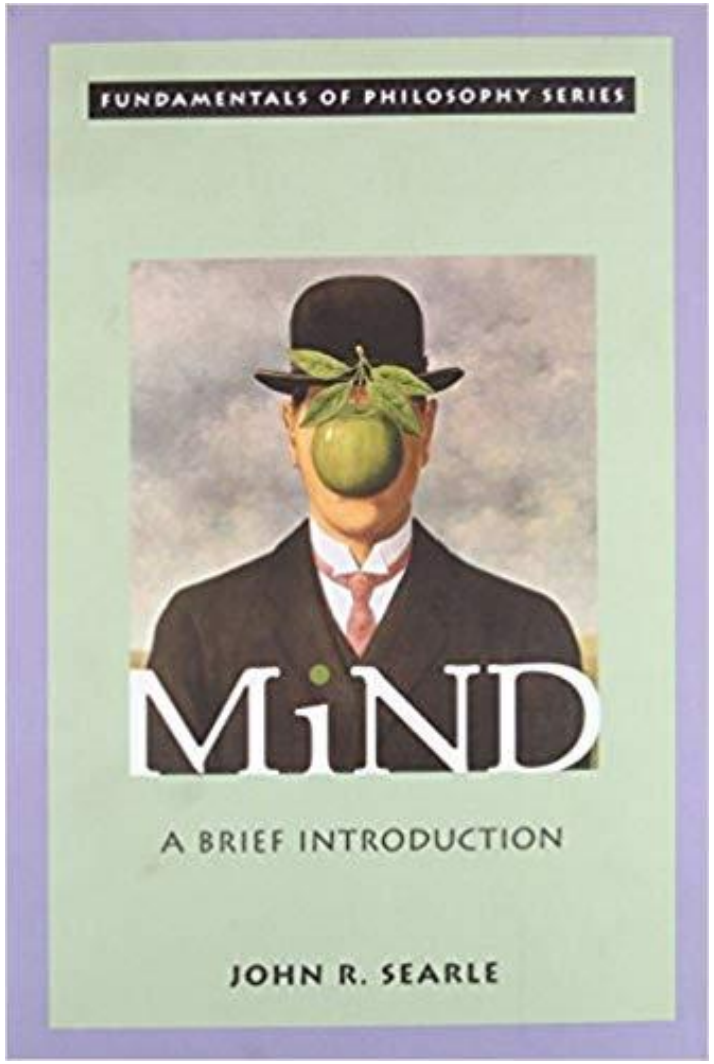



```
Q: What's 2 + 2?
4

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



Reifying philosophy with code

- Searle's view of the relationship between consciousness and brain states
  - Consciousness is causally reducible to brain states but consciousness is ontologically irreducible to brain states
    - ...what does that mean?
- Generally is some confusion
  - Enough disagreement that Searle wrote the paper: "Why I'm Not a Property Dualist"
- 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)
- (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

- Consciousness is causally reducible to brain states
- Consciousness is ontologically irreducible to brain states

Requirements: unpacking Searle's view

- Brain state
  - The full physical-chemical state of the brain and nervous system
  - Third person, objective
- Internal state
  - Representations, goals, rewards, observations, actions, etc.
  - Subjective
- Mental state
  - Beliefs, desires, thoughts, perceptions, emotions, knowledge, etc.
  - 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

Requirements: unpacking Searle's view

- Searle’s view
  - Consciousness is causally reducible to brain states
  - Consciousness is ontologically irreducible to brain states
- ...simpler
  - Conscious mental states are causally reducible to brain states
  - Conscious mental states are ontologically irreducible to brain states
- ...simpler
  - Mental states are causally reducible to brain states
  - Mental states are ontologically irreducible to brain states
- ...simpler
  - Internal states are causally reducible to brain states
  - Internal states are ontologically irreducible to brain states

Requirements: unpacking Searle's view

- Searle’s view
  - Consciousness is causally reducible to brain states
  - Consciousness is ontologically irreducible to brain states
- V2
  - Conscious mental states are causally reducible to brain states
  - Conscious mental states are ontologically irreducible to brain states
- V1
  - Mental states are causally reducible to brain states
  - Mental states are ontologically irreducible to brain states
- V0
  - Internal states are causally reducible to brain states
  - Internal states are ontologically irreducible to brain states

Requirements: unpacking Searle's view

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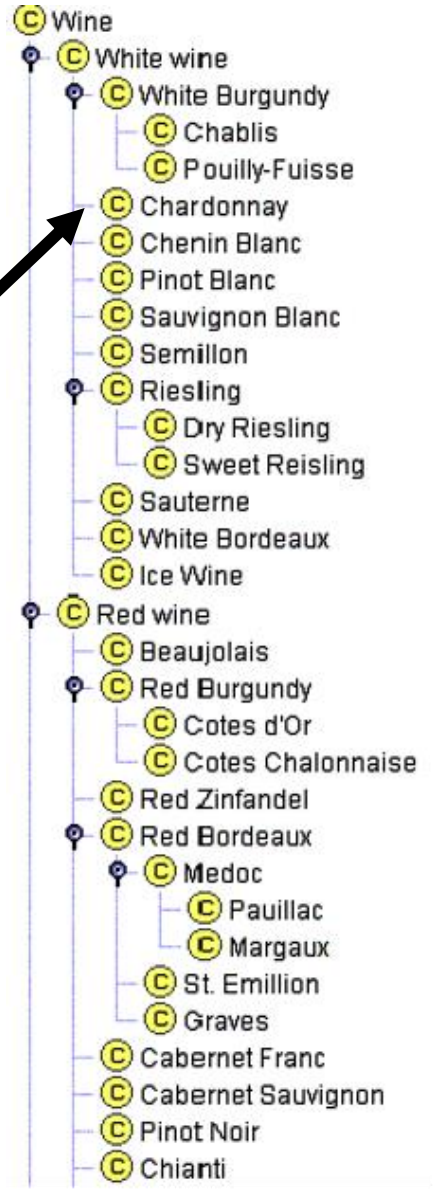
Phenomena of type A are ontologically reducible to phenomena of type B if and only if A's are nothing but B's

Ontologies in Computer Science

- Class-instance distinction



(C) A set of wine bottles

(C) Case of wine

Images from:
https://protege.stanford.edu/publications/ontology_development/ontology101-noy-mcguinness.html
https://www.researchgate.net/figure/Owl-Viz-view-of-course-ontology_fig1_261339041

Ontologies in Computer Science

- Class-instance distinction

- Wine
  - White wine
  - 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
  - Sancerre
  - Muscadet
  - Port
  - Sweet Reisling
  - Chablis
  - Dry Riesling

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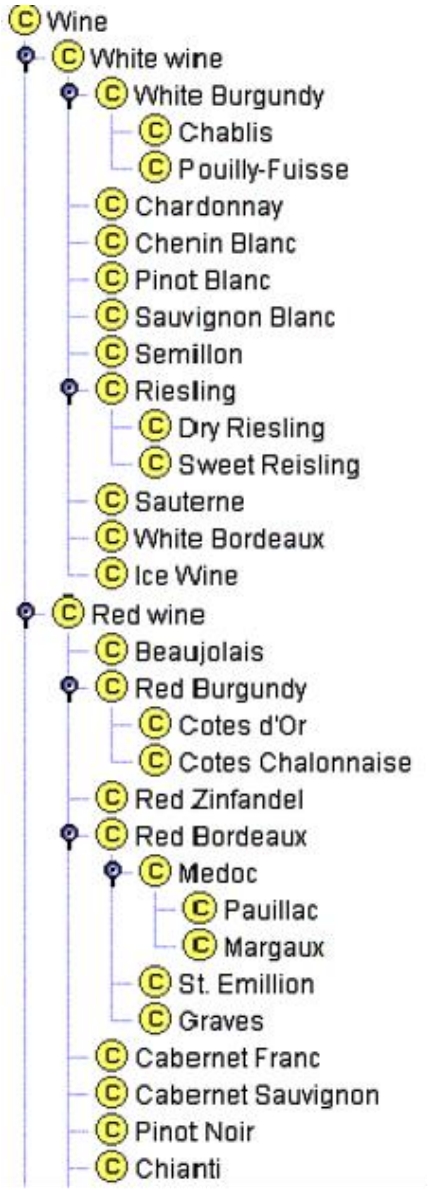
Ontologies in Computer Science

- 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)
- Representing tokens of one type as tokens of another type



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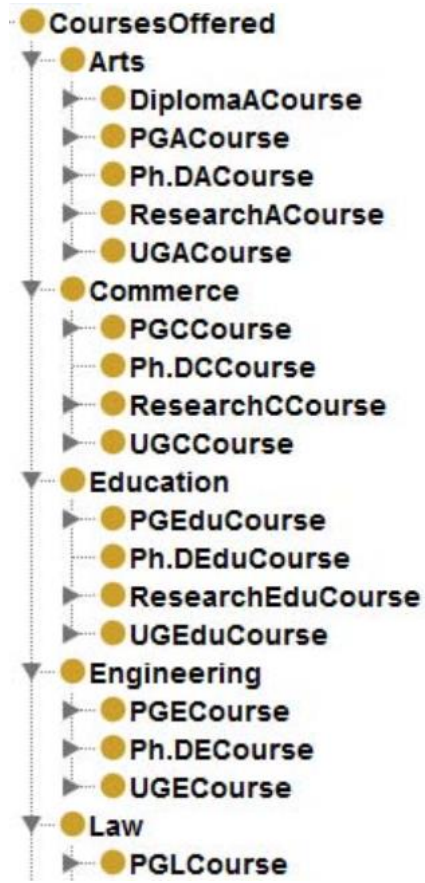

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Requirements, V0

- Internal states are causally reducible to brain states
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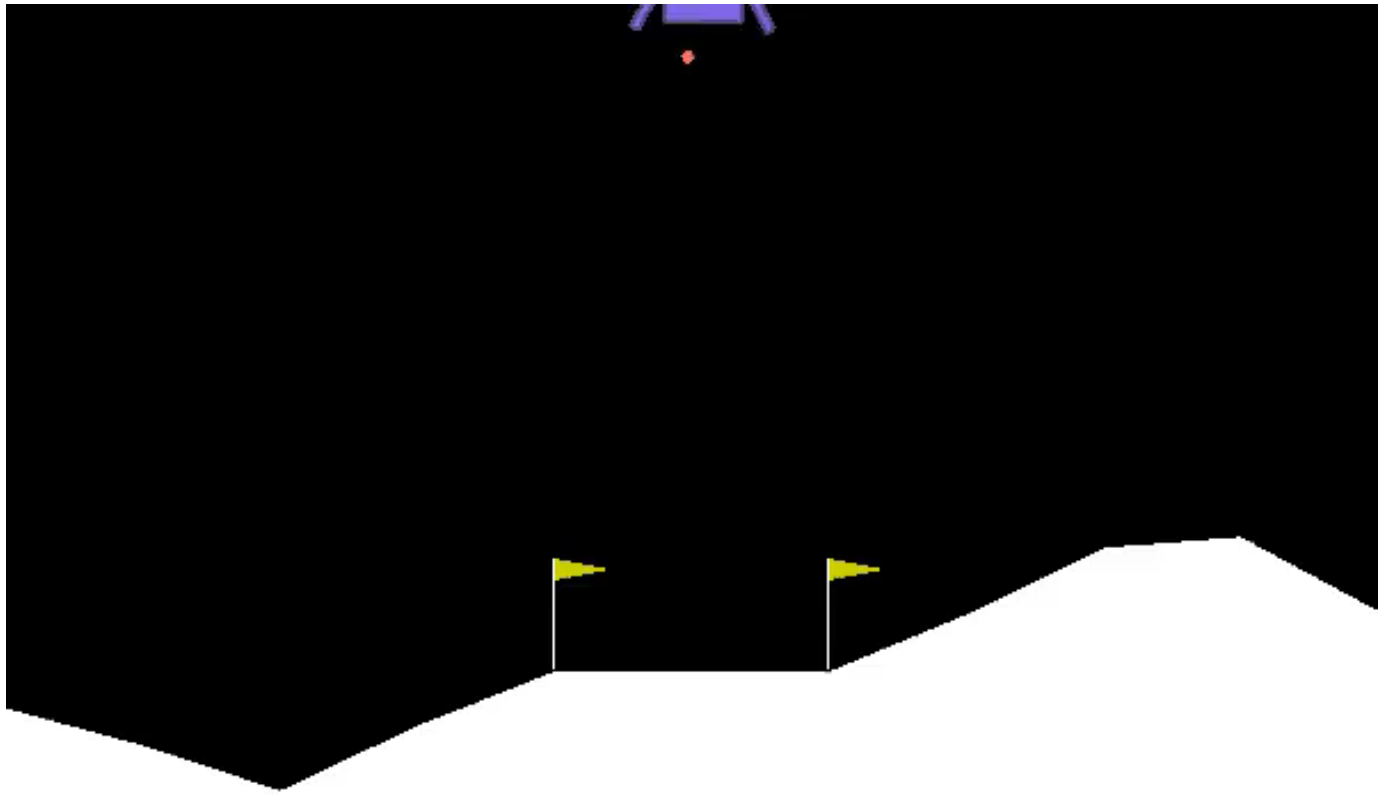
Design, V0

- Design decisions

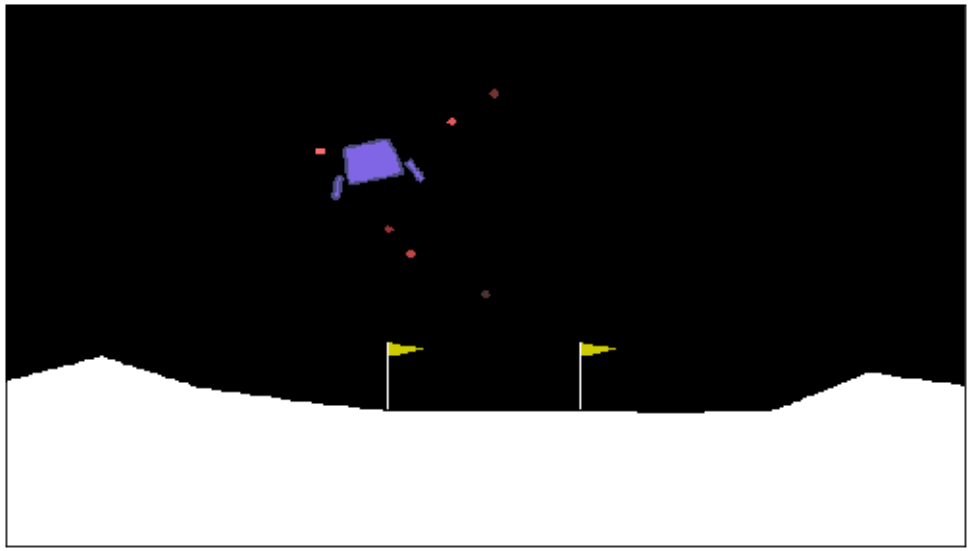
Design, V0

- OpenAI's LunarLander benchmark environment

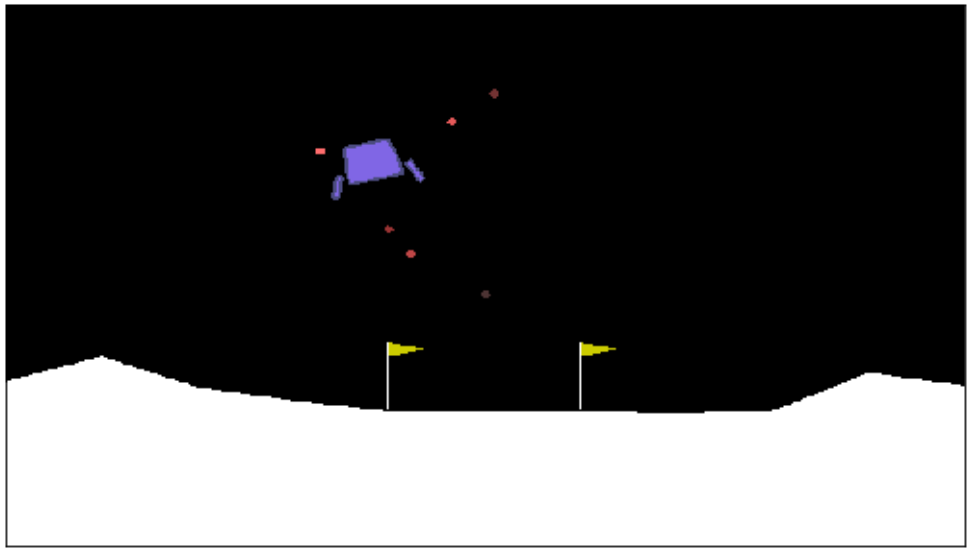


Design, V0

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

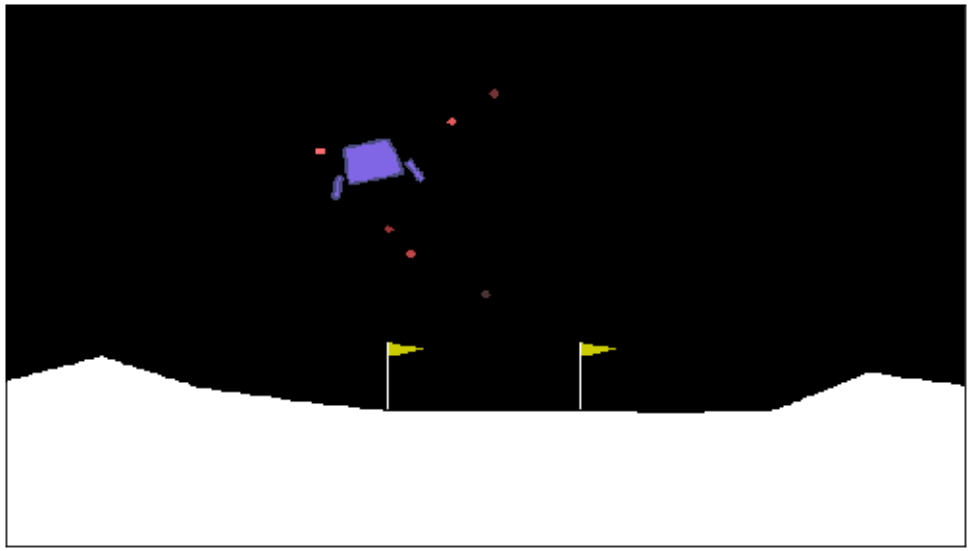


Design, V0



- 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

Design, V0



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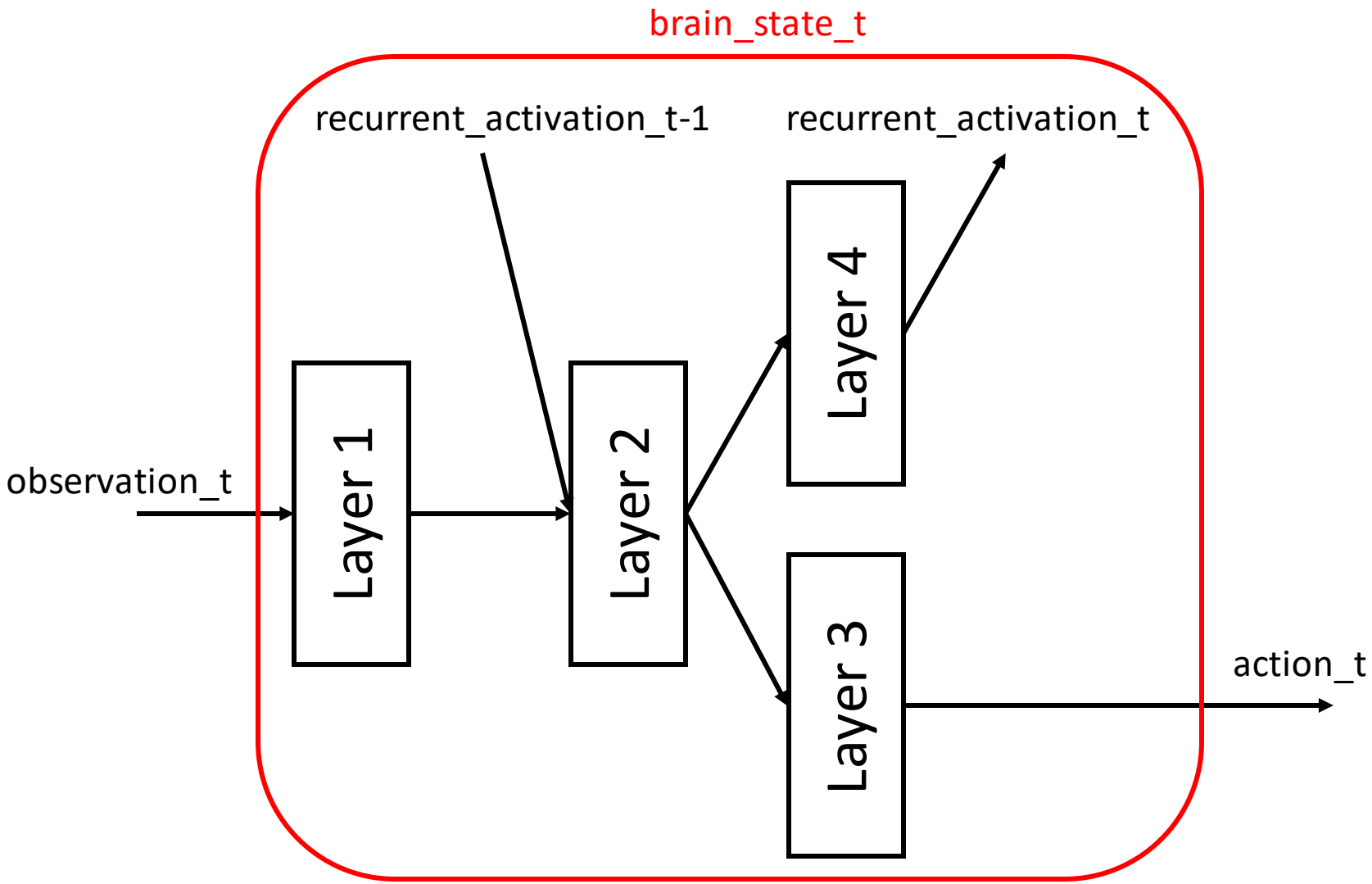
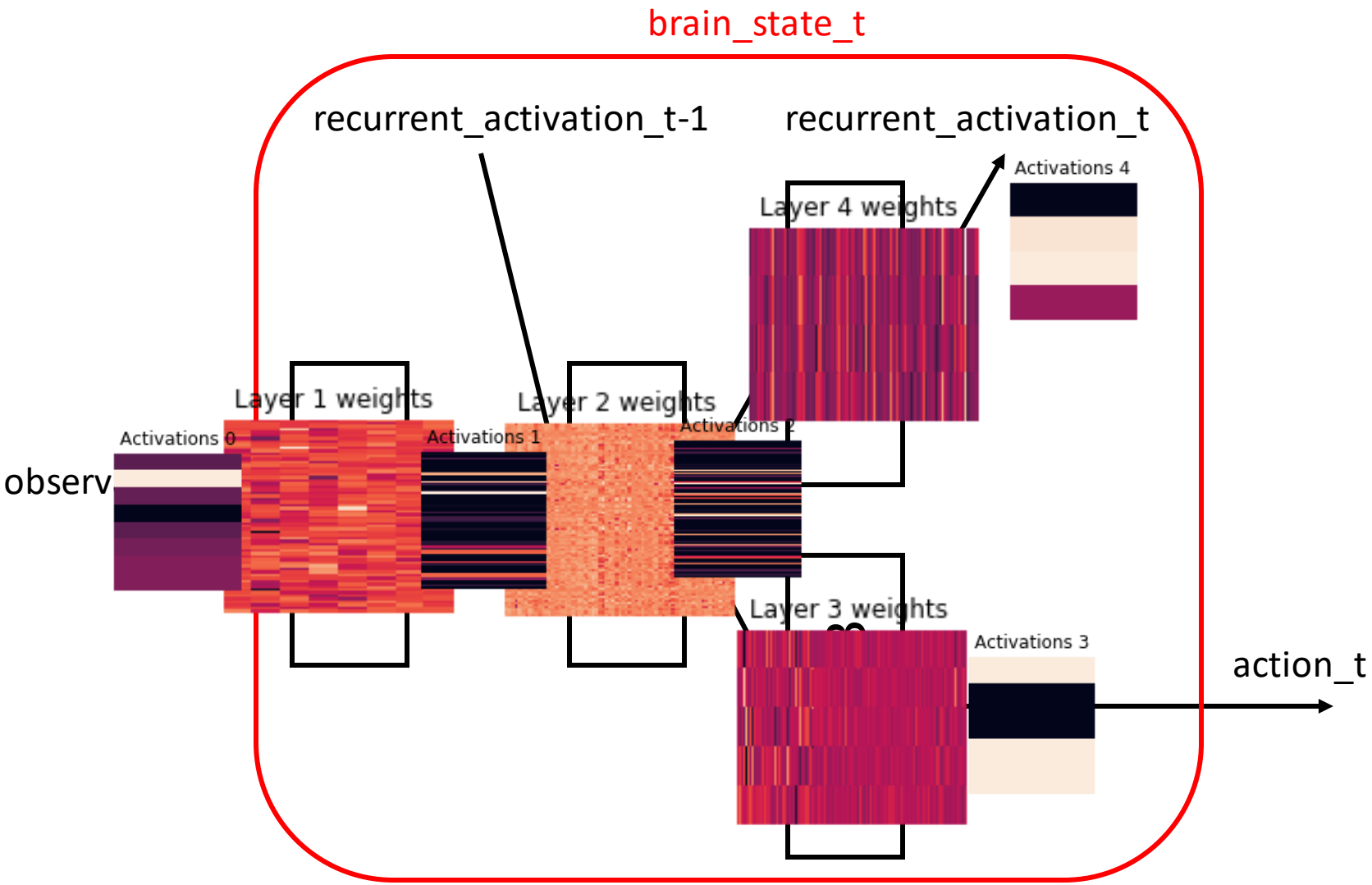
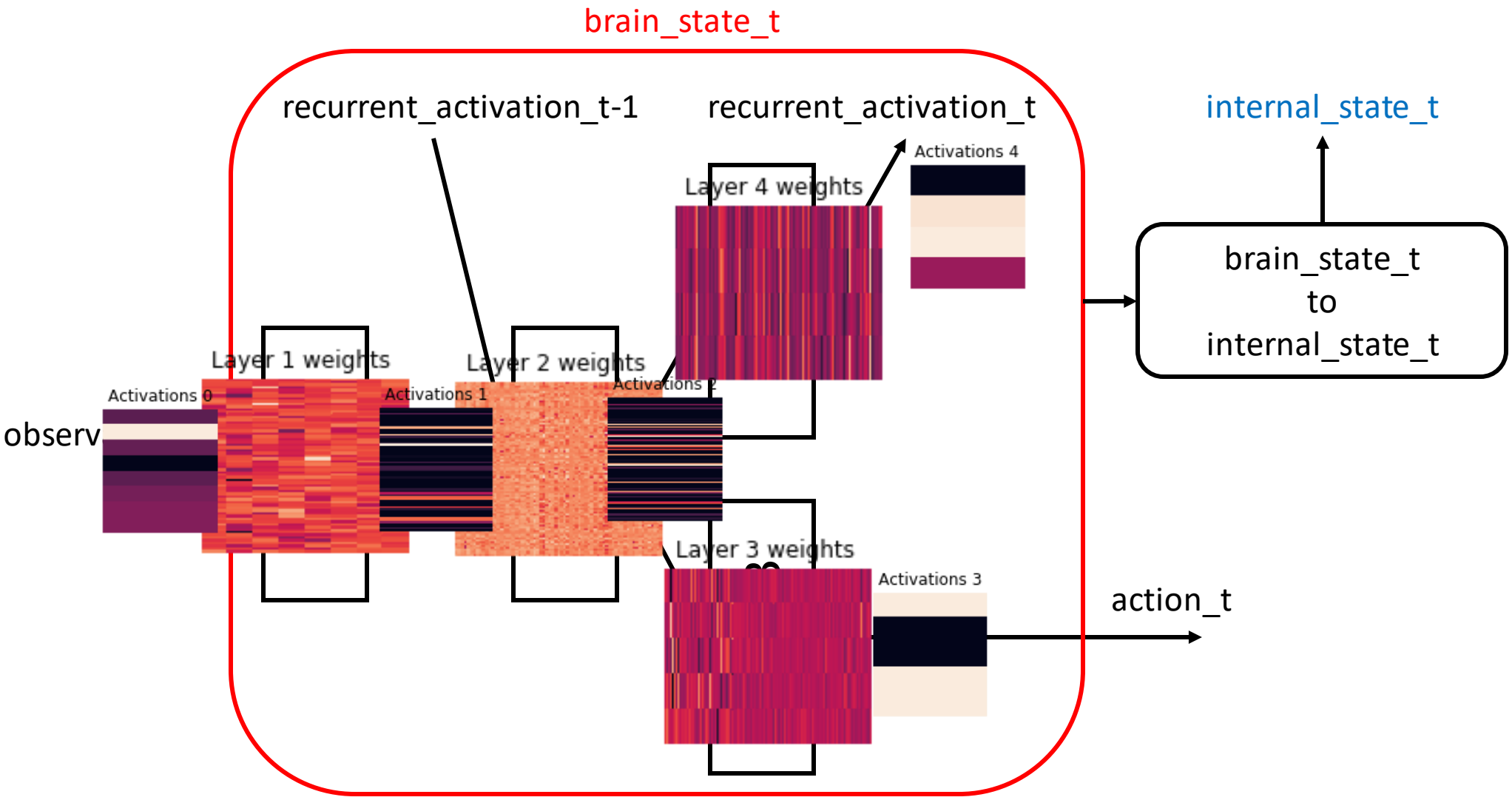

brain_state_t
recurrent_activation_t-1
recurrent_activation_t
observation_t
Layer 1
Layer 2
Layer 4
Layer 3
action_t

Design, V0


brain_state_t
recurrent_activation_t-1
recurrent_activation_t
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
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recurrent_activation_t
internal_state_t
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Layer 4 weights
brain_state_t
to
internal_state_t
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Layer 2 weights
Activations 0
Activations 1
observ
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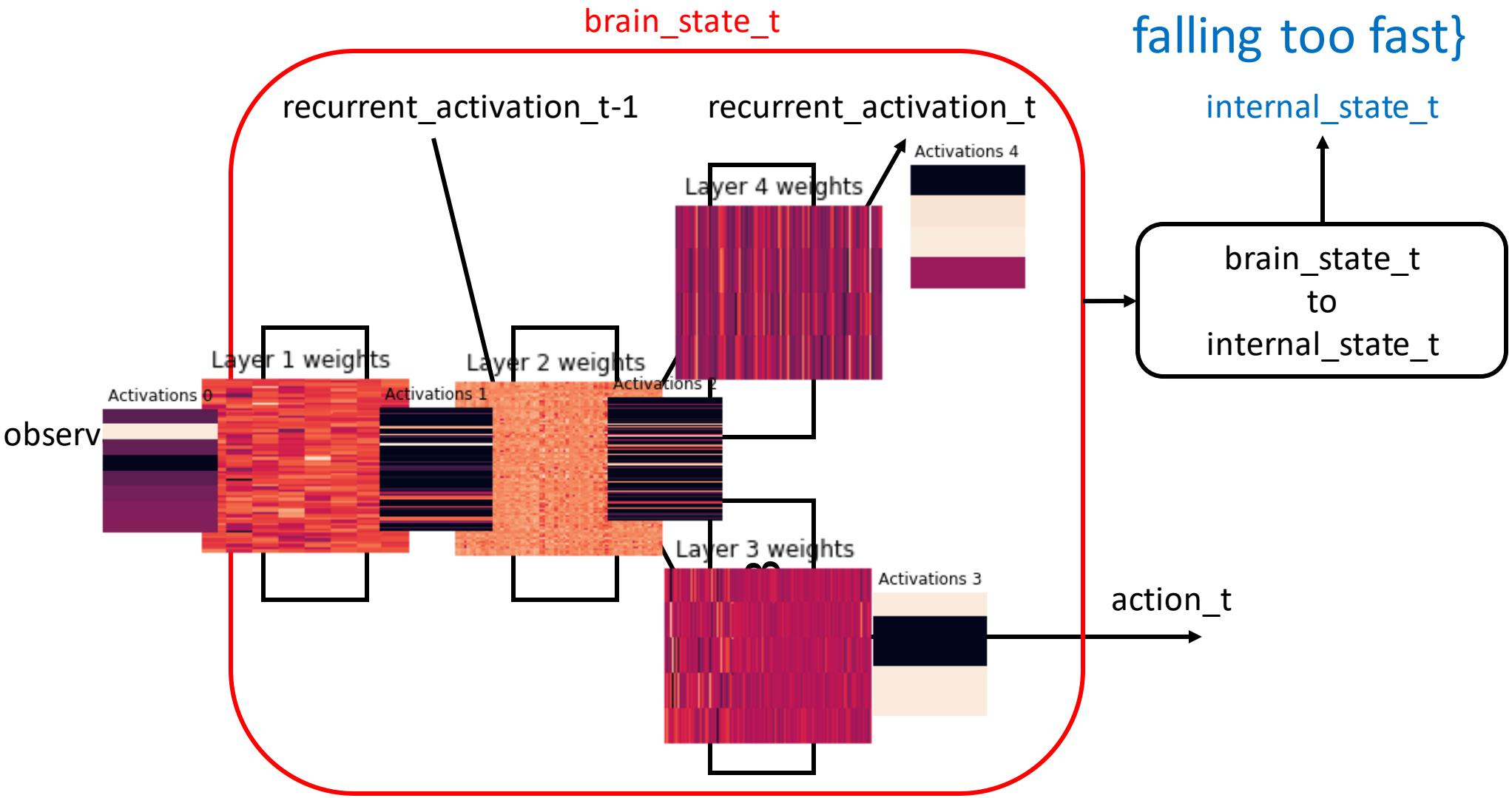
Activations 3
action_t

Design, V0

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



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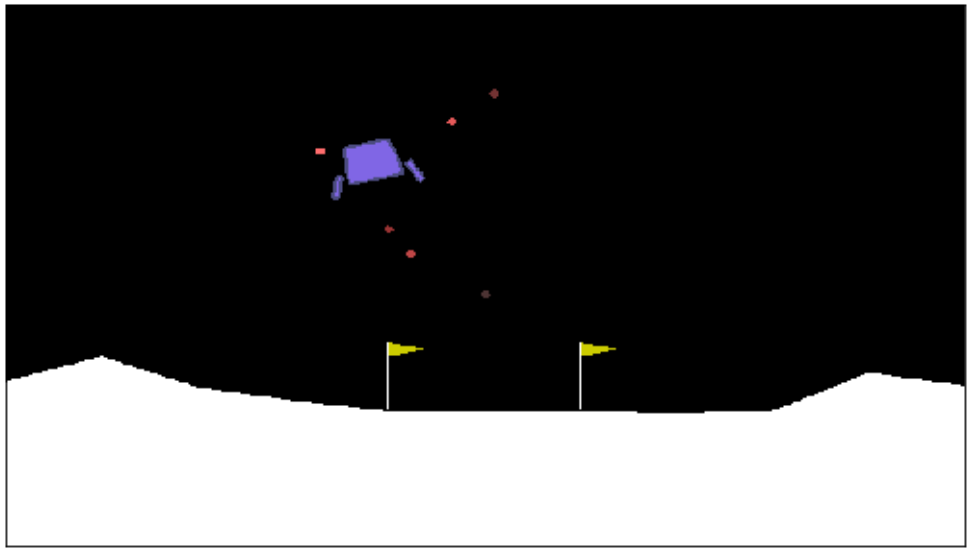

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  - Internal state of the agent
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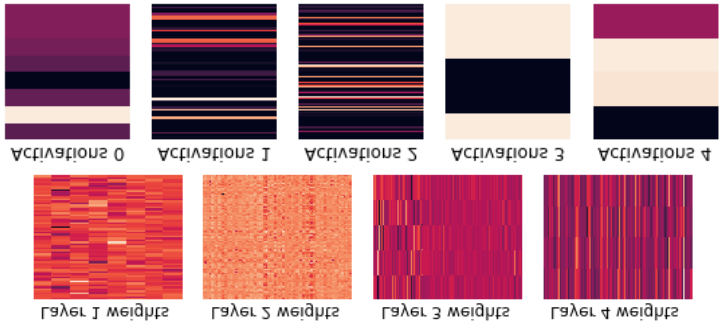
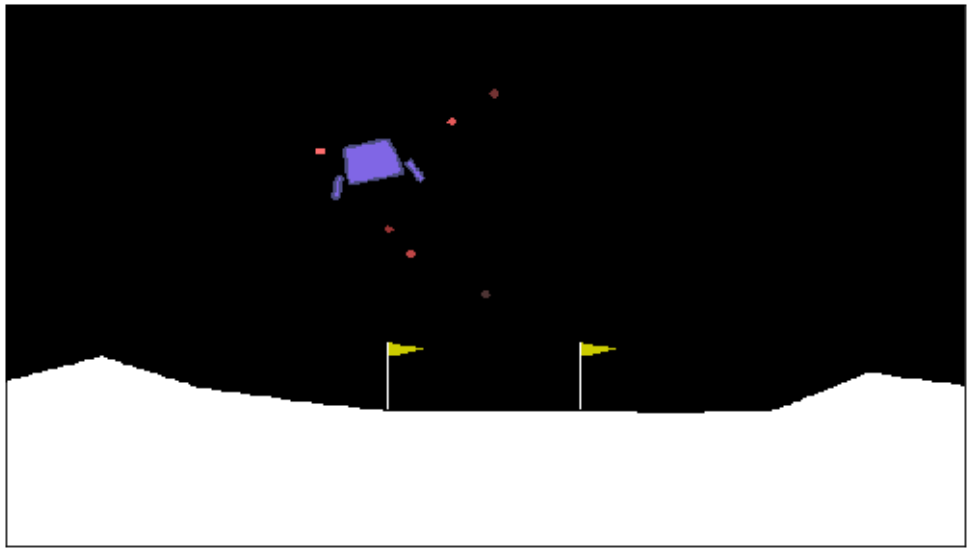


Design, V0



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  - Our ontology
    - Layer weights of the neural network
    - Connectivity of the neural network
    - Activations of the neural network at time t
    - The agent's observation at time t
    - The agent's action at time t
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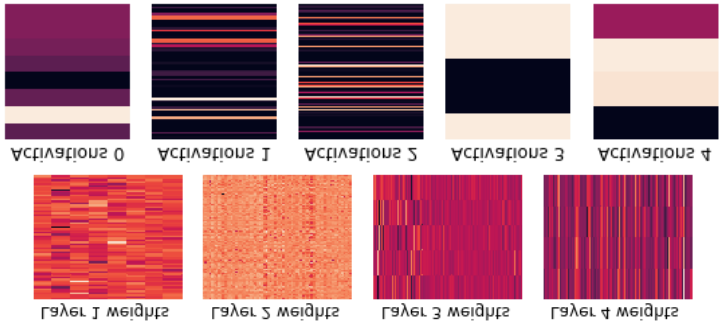

Reinforcement learning

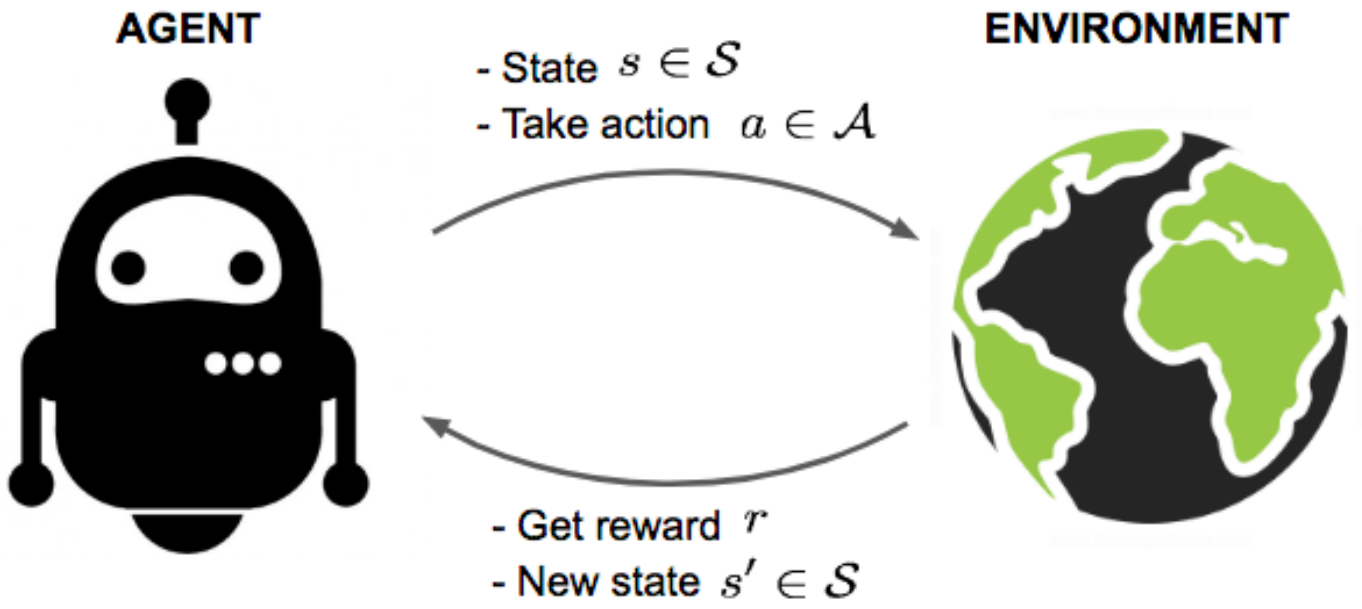

Image from:
https://lilianweng.github.io/lil-log/2018/02/19/a-long-peek-into-reinforcement-learning.html

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
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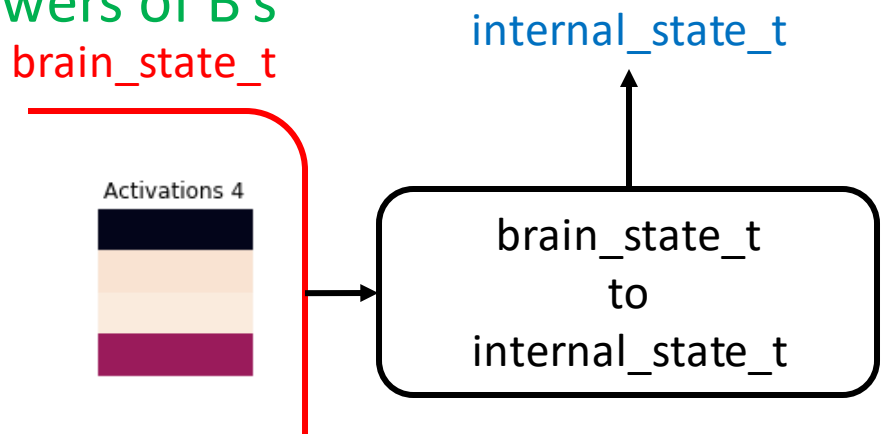
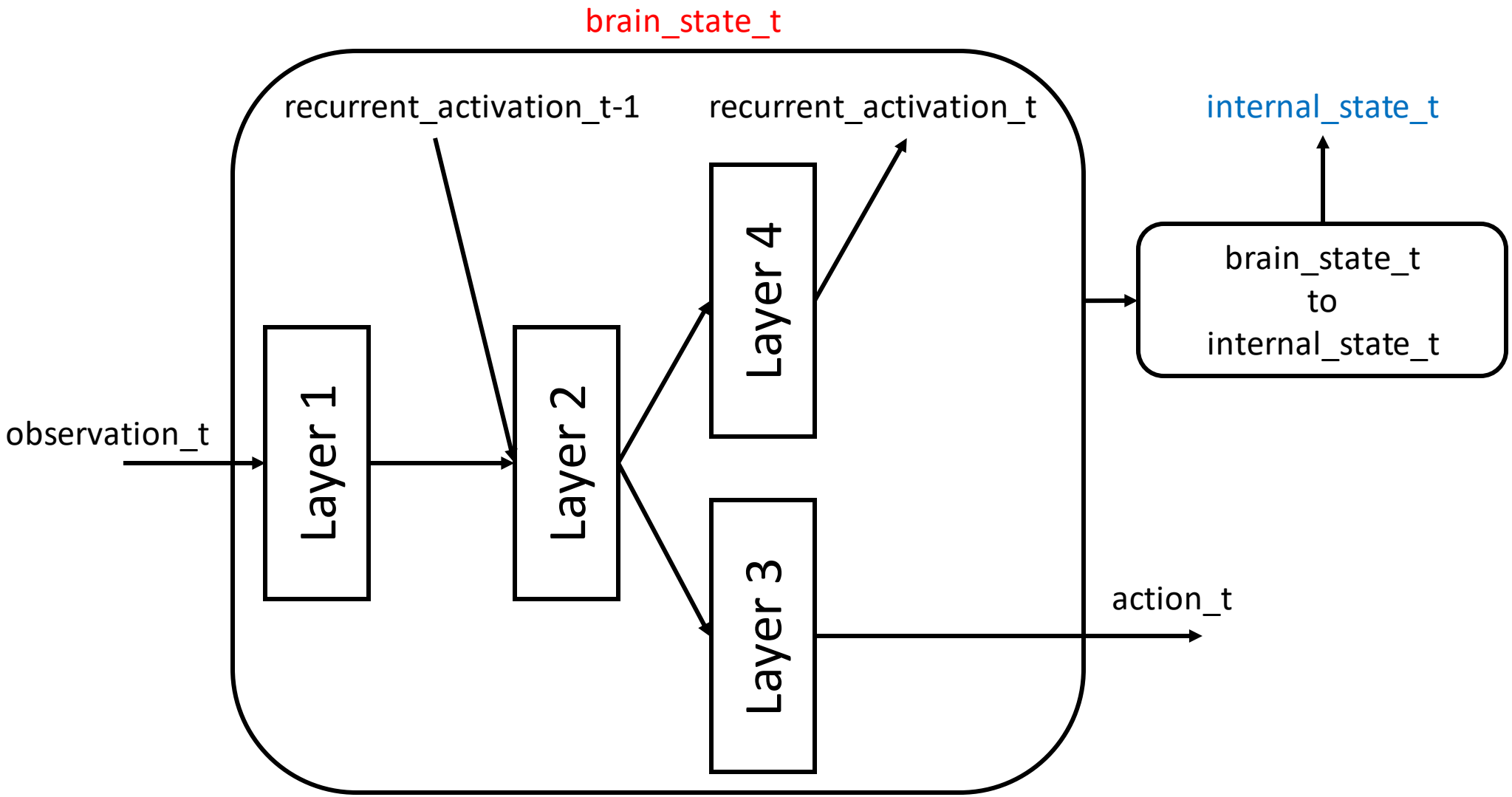


Design, V0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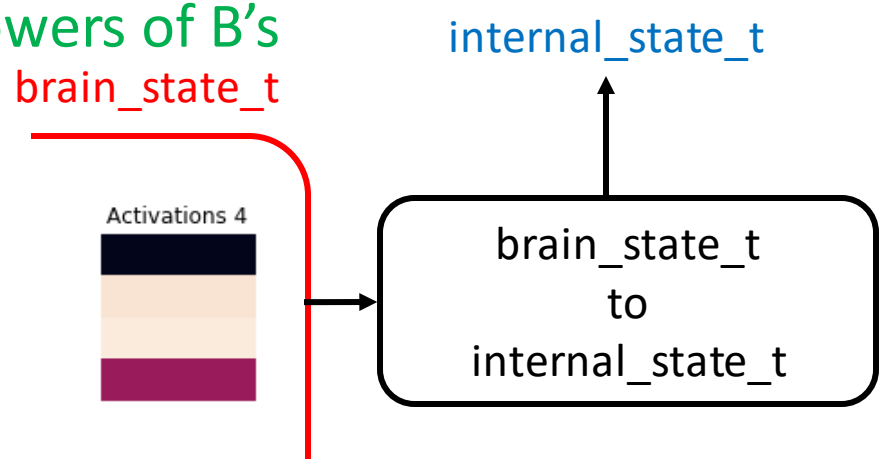

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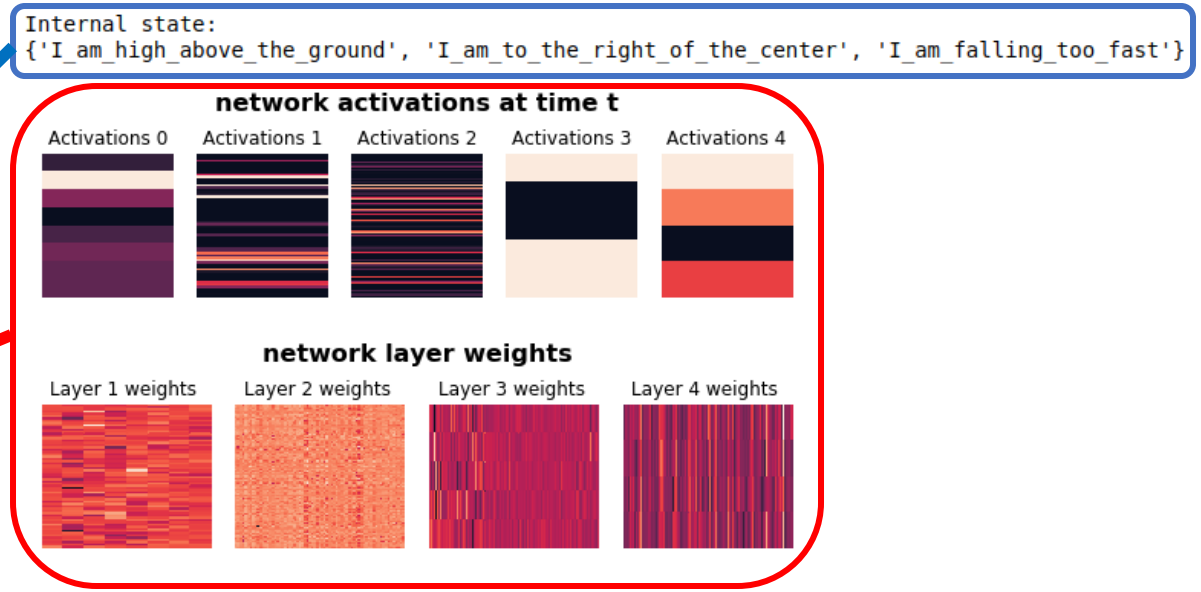
Our ontology

- Layer weights of the neural network
- Connectivity of the neural network
- Activations of the neural network at time t
- The agent's observation at time t
- The agent's action at time t
- The position and velocity of the agent at time t
- A region the agent believes it's in
- Brain state at time t (set of layer weights, activations, and connectivity)
- Internal state at time t (set of regions the agent believes it's in)



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- The agent's action at time
- The position and velocity c
- A region the agent believes
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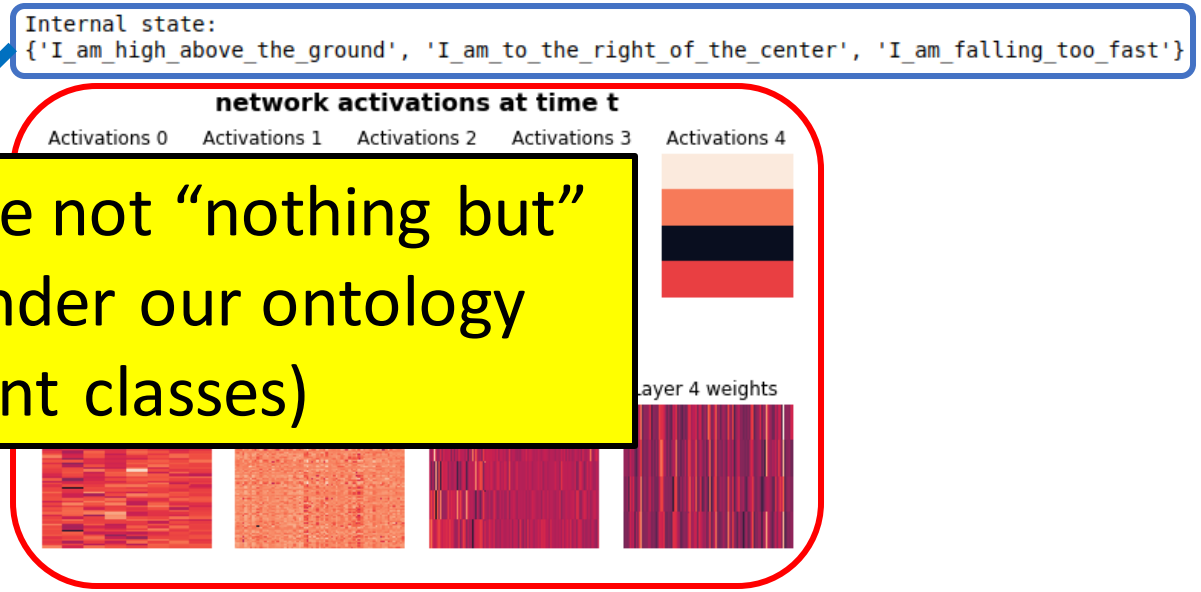
Internal state instances are not "nothing but" brain state instances under our ontology (they are different classes)



Is that the “real” ontology though?

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

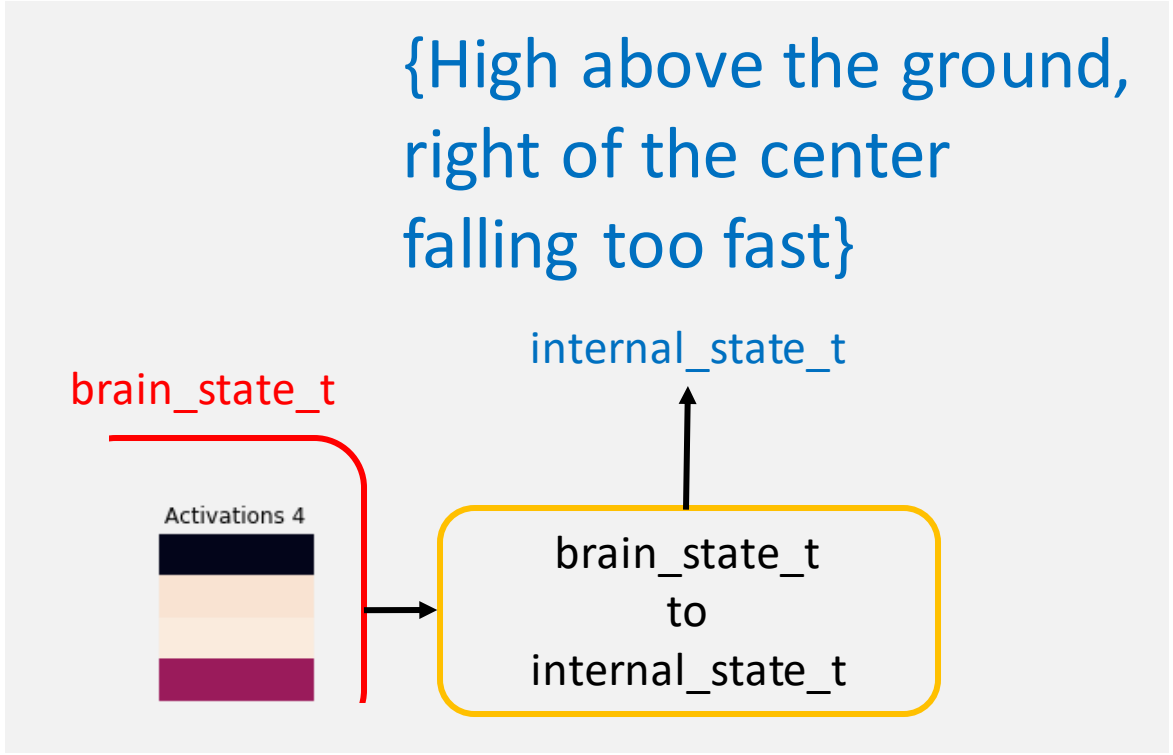
Phenomena of type A are ontologically reducible to phenomena of type B if and only if A’s are nothing but B’s

Our ontology

- Layer weights of the neural network
- Connectivity of the neural network
- Activations of the neural network at time t
- The agent's observation at time t
- The agent's action at time t
- The position and velocity of the agent at time t
- A region the agent believes it's in
- Brain state at time t (all of the bits contained in my computer)
- Internal state at time t (set of regions the agent believes it's in)

- Bits
- Python objects
- Electrons
- Quarks
- …

What's the deal with that function?




```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

    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?)

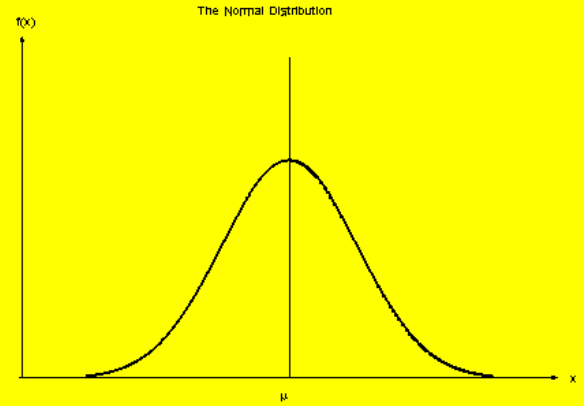
What's the deal with that function?

{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."
- *Why I'm Not a Property Dualist*, John Searle

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?)

```
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    def i_am_low_to_the_ground(observation):
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                                                ):
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                                                ):
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                                                    s'][3]
                                                    tions, regions):
        if activation > 0.5:
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    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?