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

- 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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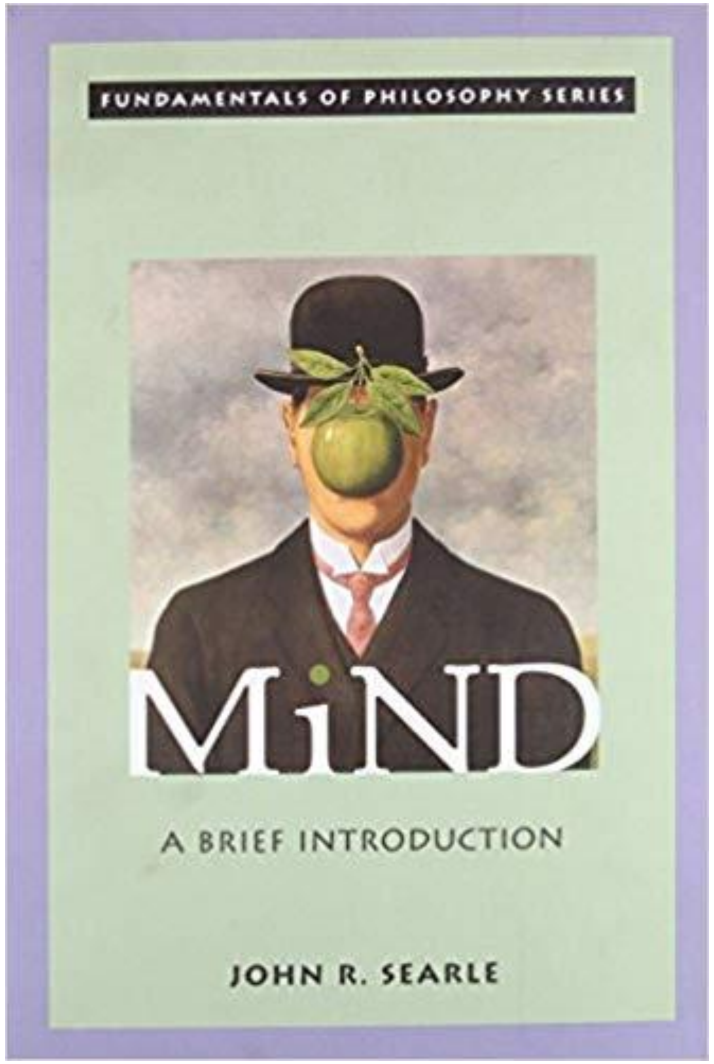

Reifying philosophy with code

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

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

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- Generally is some confusion
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- Let's unpack this with code!

What we're not doing

- Not trying to propose a cognitive architecture
- Not trying to propose a new AI or machine learning algorithm
- Not trying to claim that the software agent is conscious
- Not trying to convince anyone these are the correct/best/most useful definitions of consciousness or brain states
- Not trying to 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 – the built 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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- 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

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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

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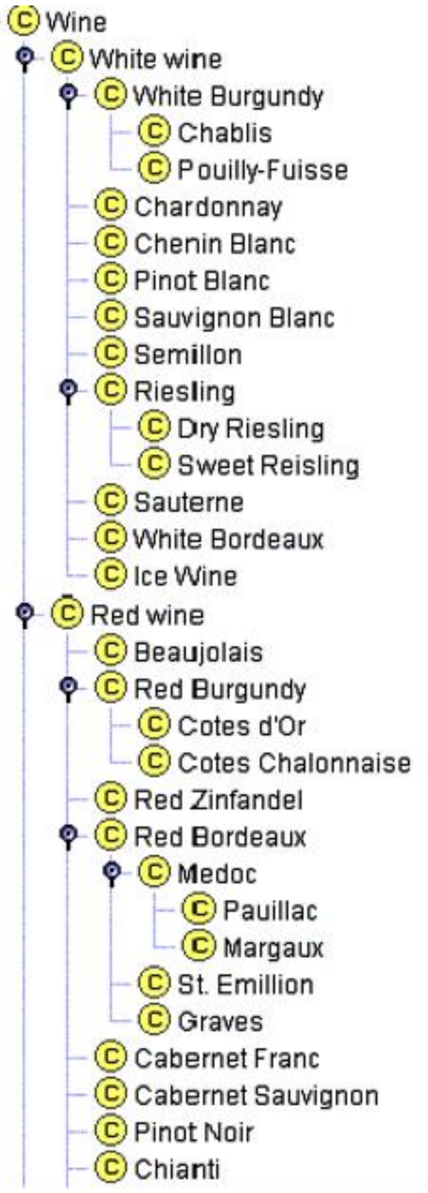

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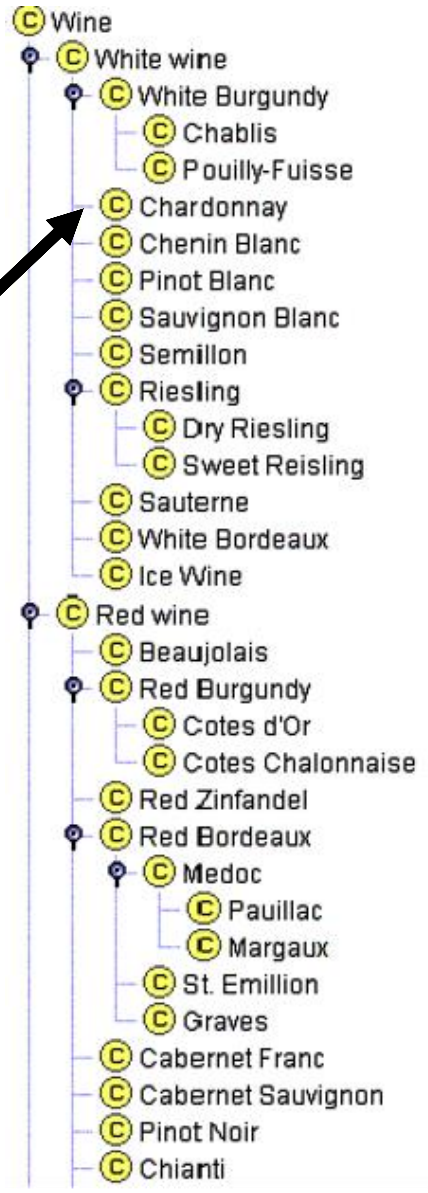

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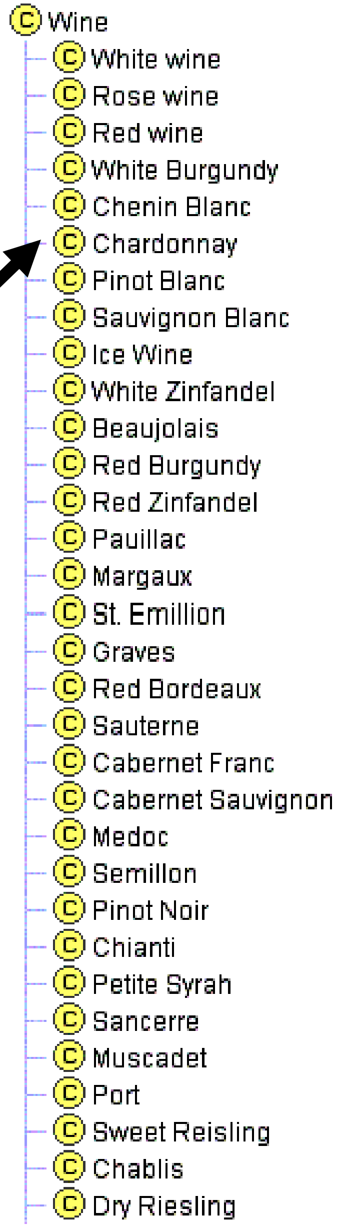

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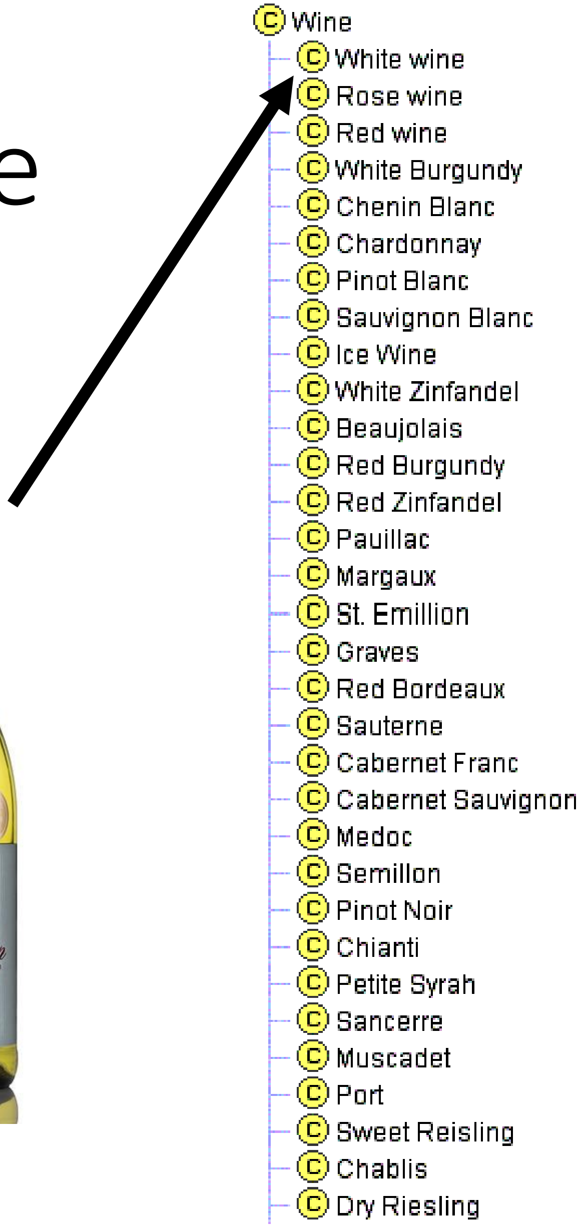

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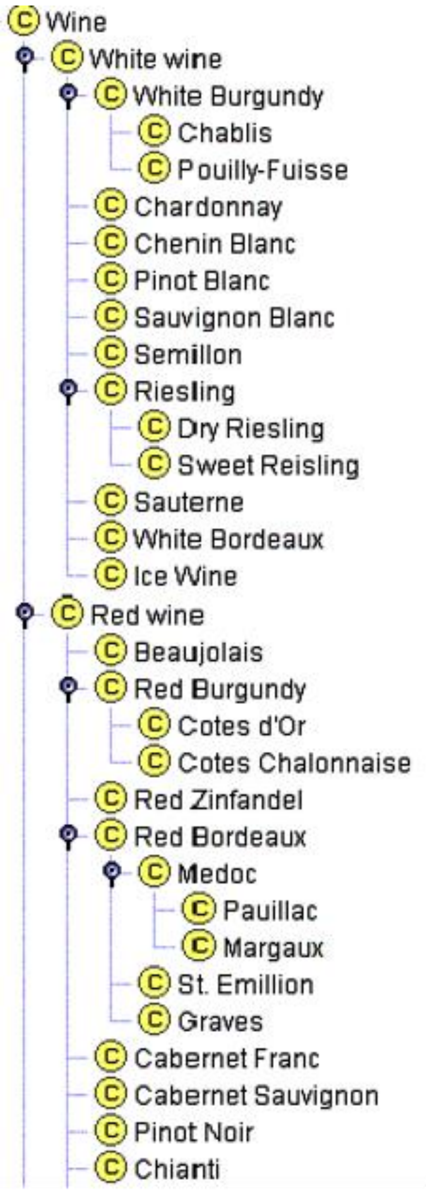

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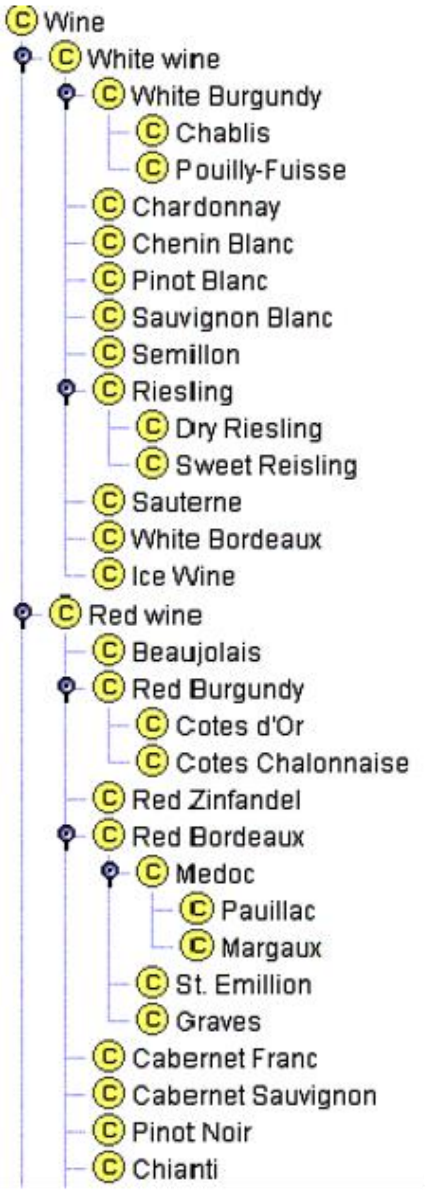
      - (the 2003 Toyota Corolla with VIN: 2QFBORHE4KP911561)



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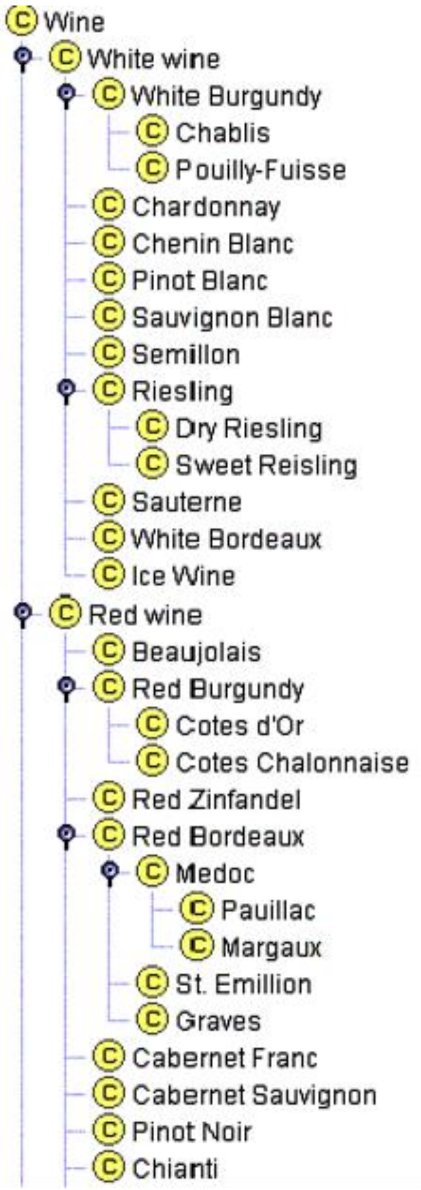

(C) A set of wine bottles

(C) Case of wine

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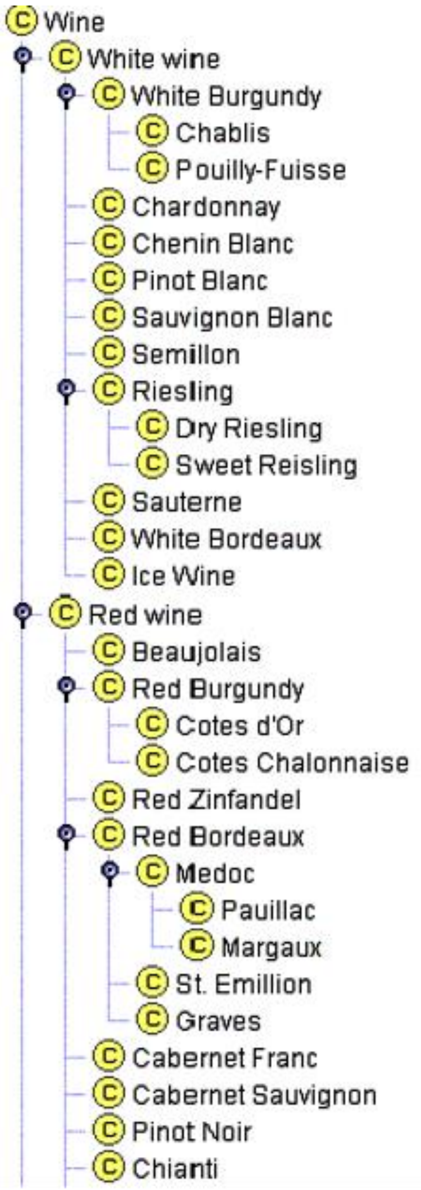

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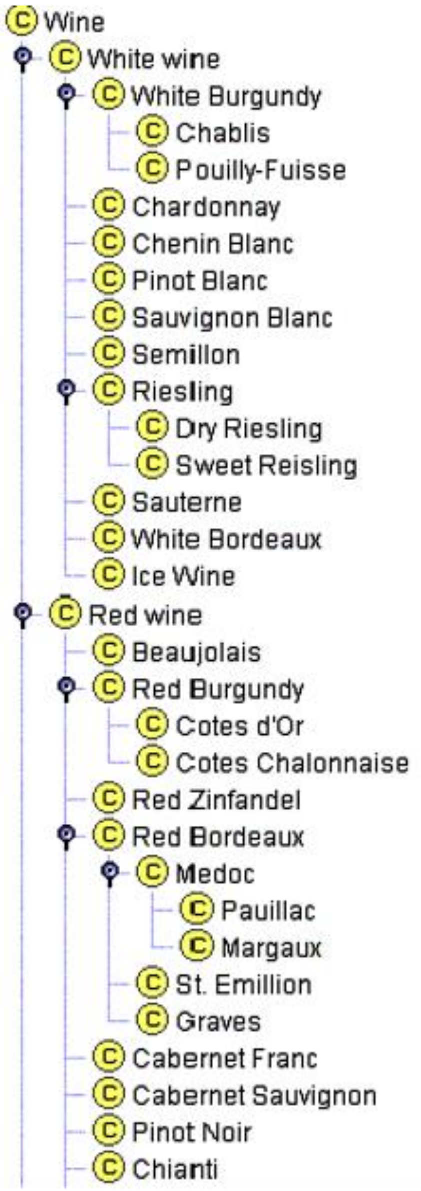

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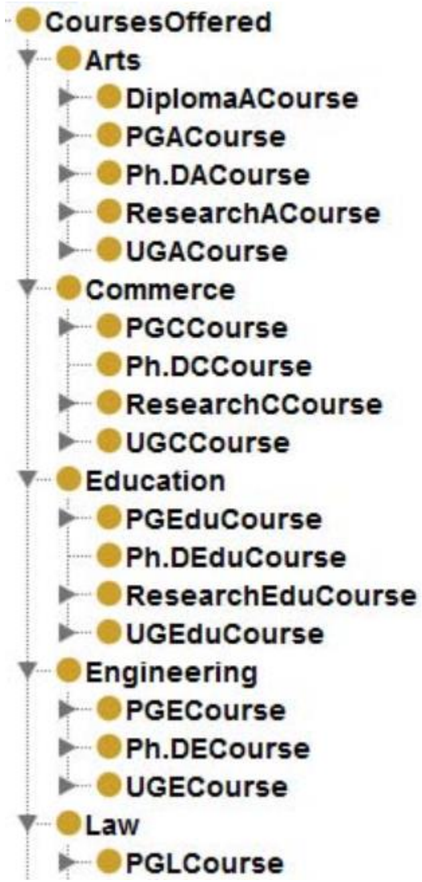

- CoursesOffered
  - Arts
    - DiplomaACourse
    - PGACourse
    - Ph.DACourse
    - ResearchACourse
    - UGACourse
  - Commerce
    - PGCCourse
    - Ph.DCCourse
    - ResearchCCourse
    - UGCCourse
  - Education
    - PGEduCourse
    - Ph.DEduCourse
    - ResearchEduCourse
    - UGEduCourse
  - Engineering
    - PGECourse
    - Ph.DECourse
    - UGECourse
  - Law
    - PGLCourse

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Requirements: unpacking Searle's view

- V0
  - Internal states are casually 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 casually explained by the behavior of B’s
- A’s have no causal powers in addition to the powers of B’s

Requirements, V0

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

Design, V0

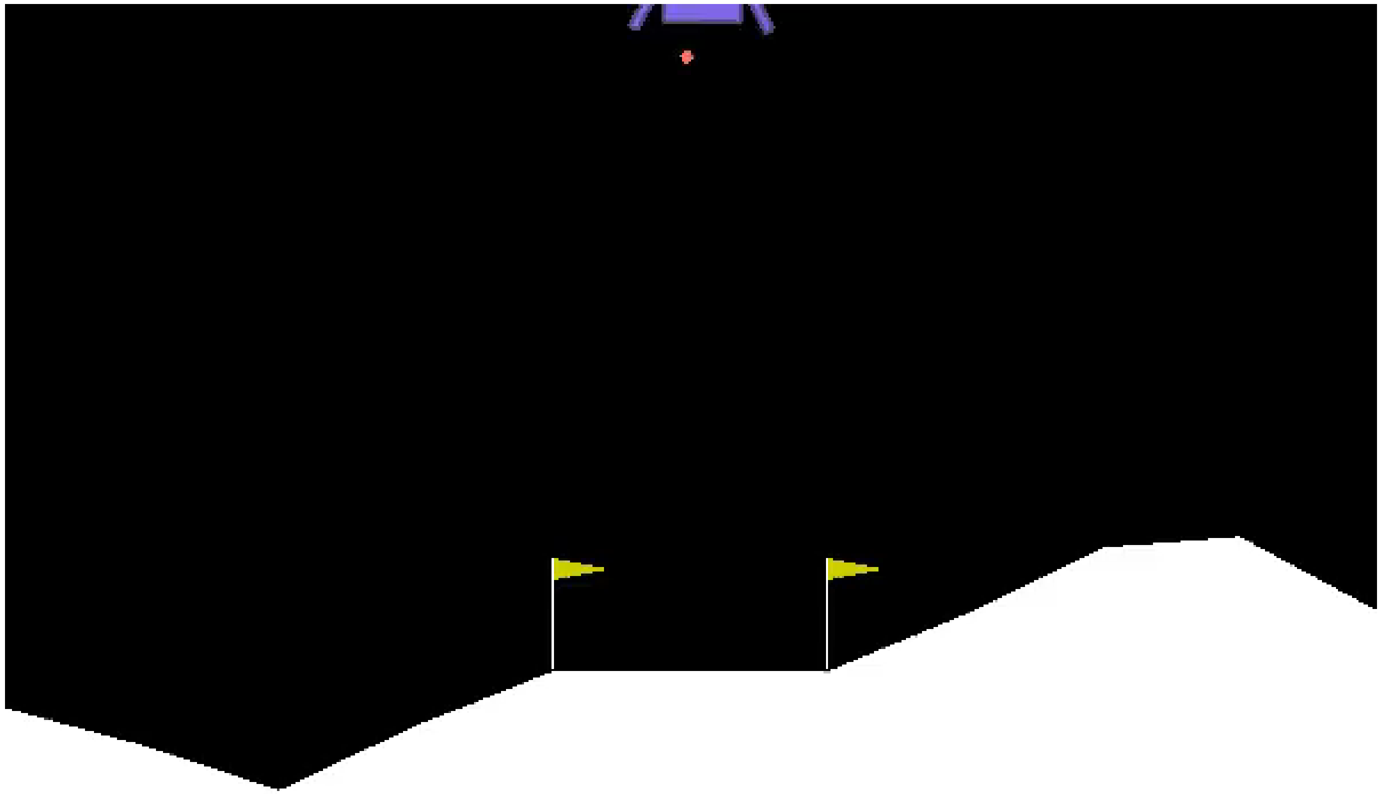
- Design decisions

Design, V0

- Design decisions
    - Environment and the agent’s “physical” form

Design, V0

- OpenAI's LunarLander benchmark environment



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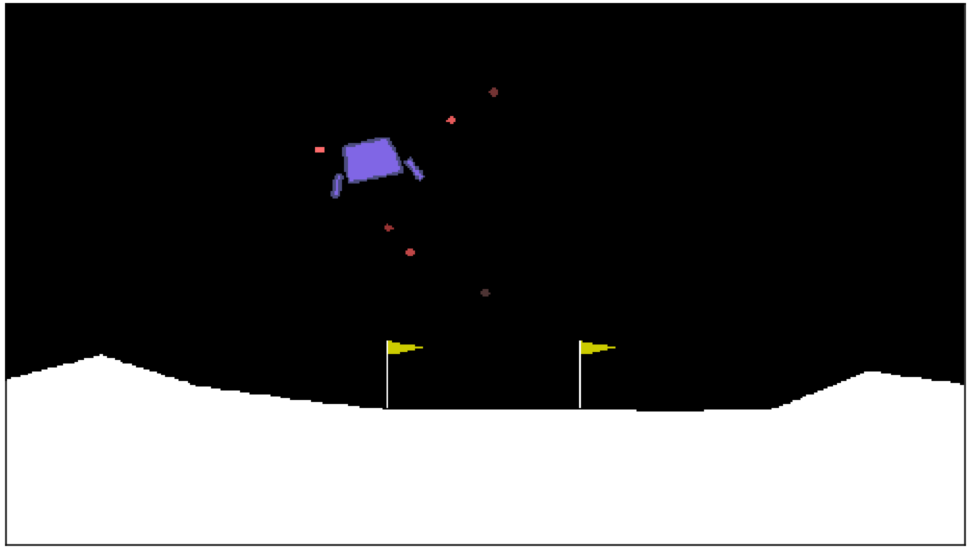
    - Environment and the agent's "physical" form

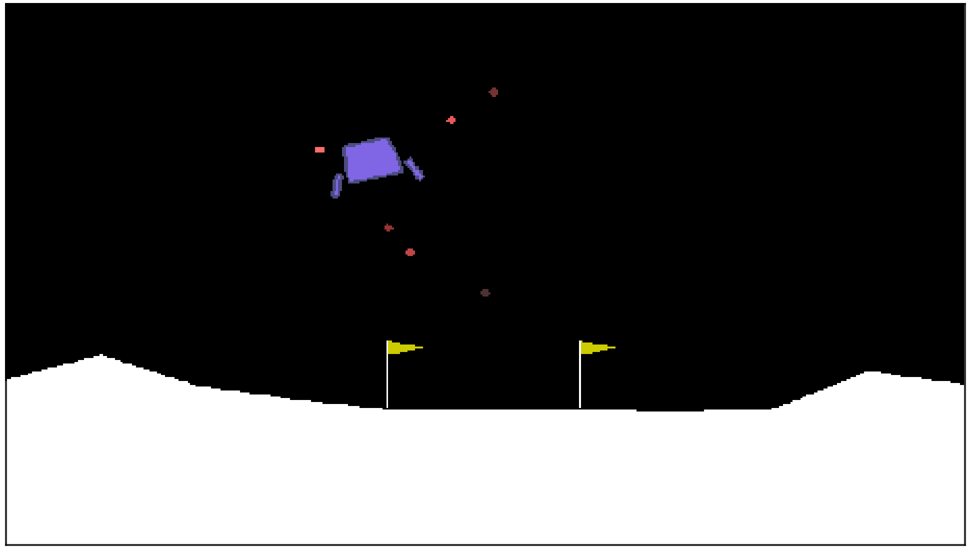
Design, V0

- Design decisions
  - Environment and the agent’s “physical” form
  - Internal state of the agent



Design, V0

- Design decisions
  - Environment and the agent's "physical" form
  - Internal state of the agent
    - Beliefs about itself relative to semantically important regions



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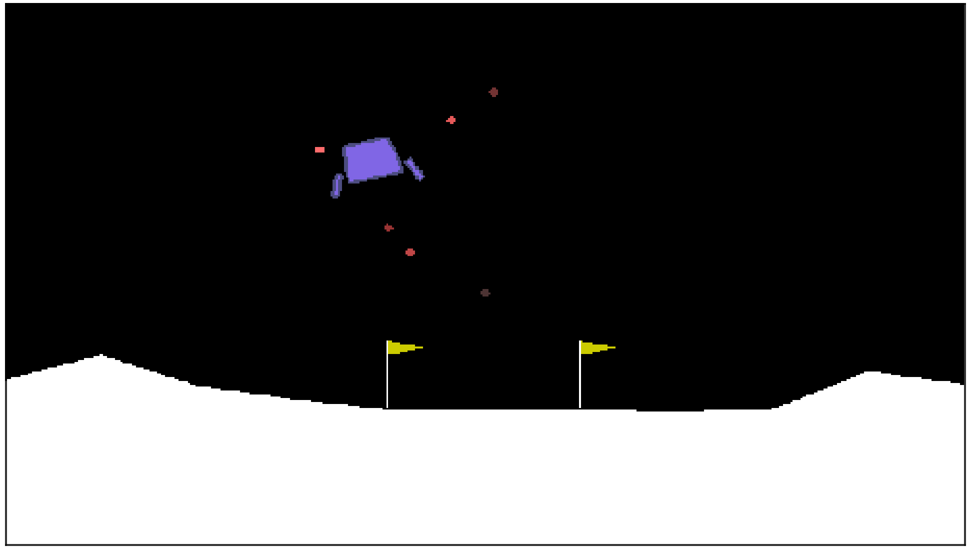
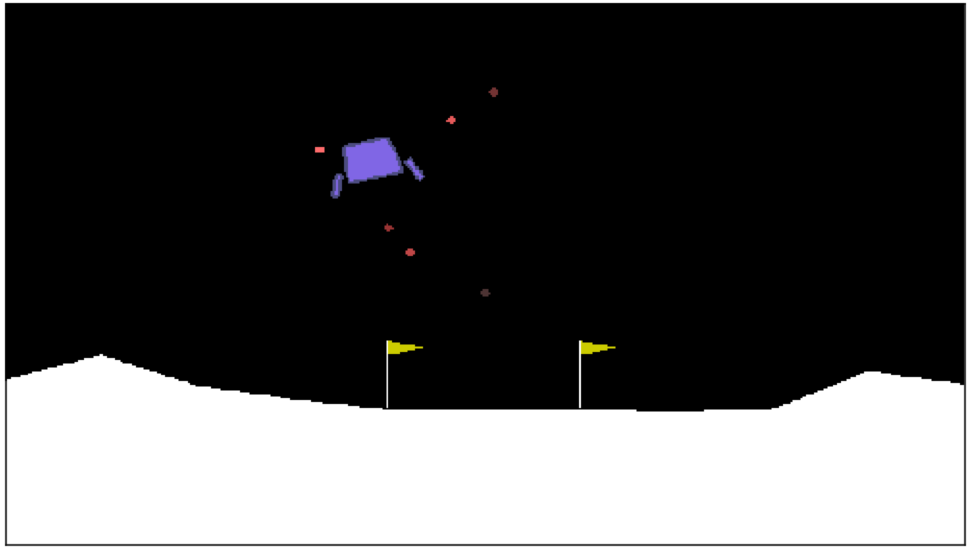


- Design decisions
  - Environment and the agent’s “physical” form
  - Internal state of the agent
    - Beliefs about itself relative to semantically important regions
      - Left of the flags, right of the flags, high above the ground, close to the ground, falling too fast

Design, V0



- Design decisions
  - Environment and the agent’s “physical” form
  - Internal state of the agent
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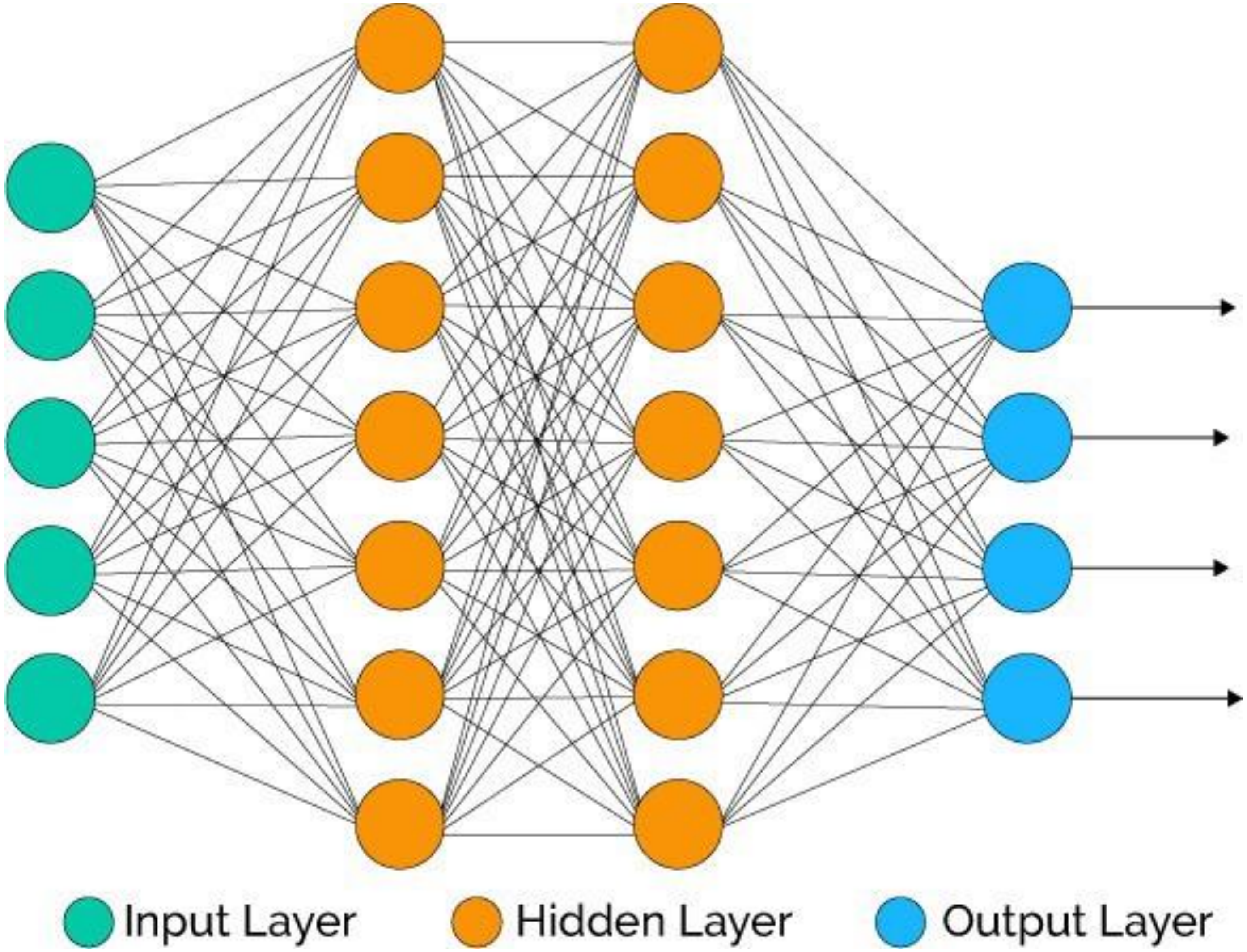
      - Left of the flags, right of the flags, high above the ground, close to the ground, falling too fast
  - Brain state of the agent

(Artificial) Neural networks



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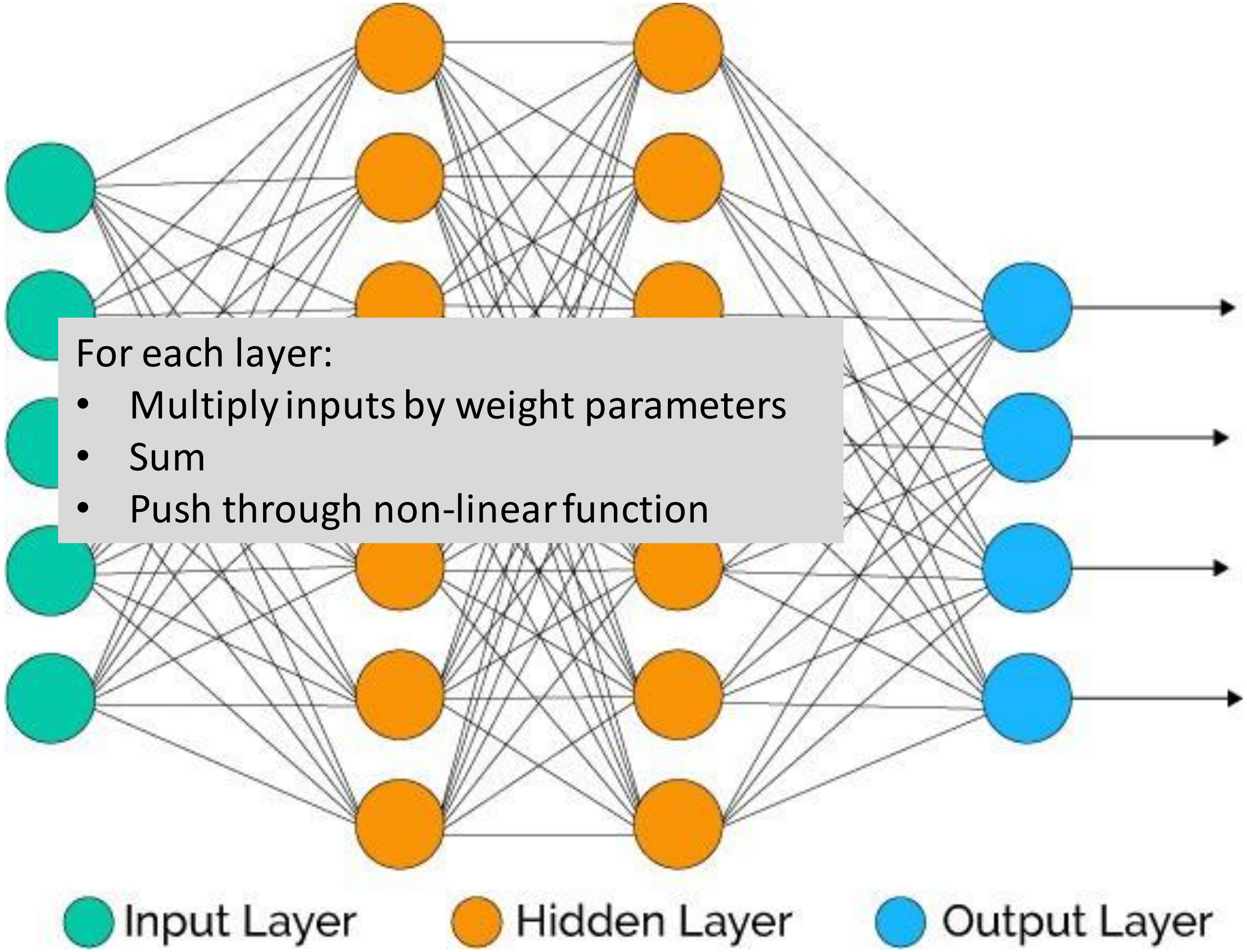

For each layer:

- Multiply inputs by weight parameters
- Sum
- Push through non-linear function

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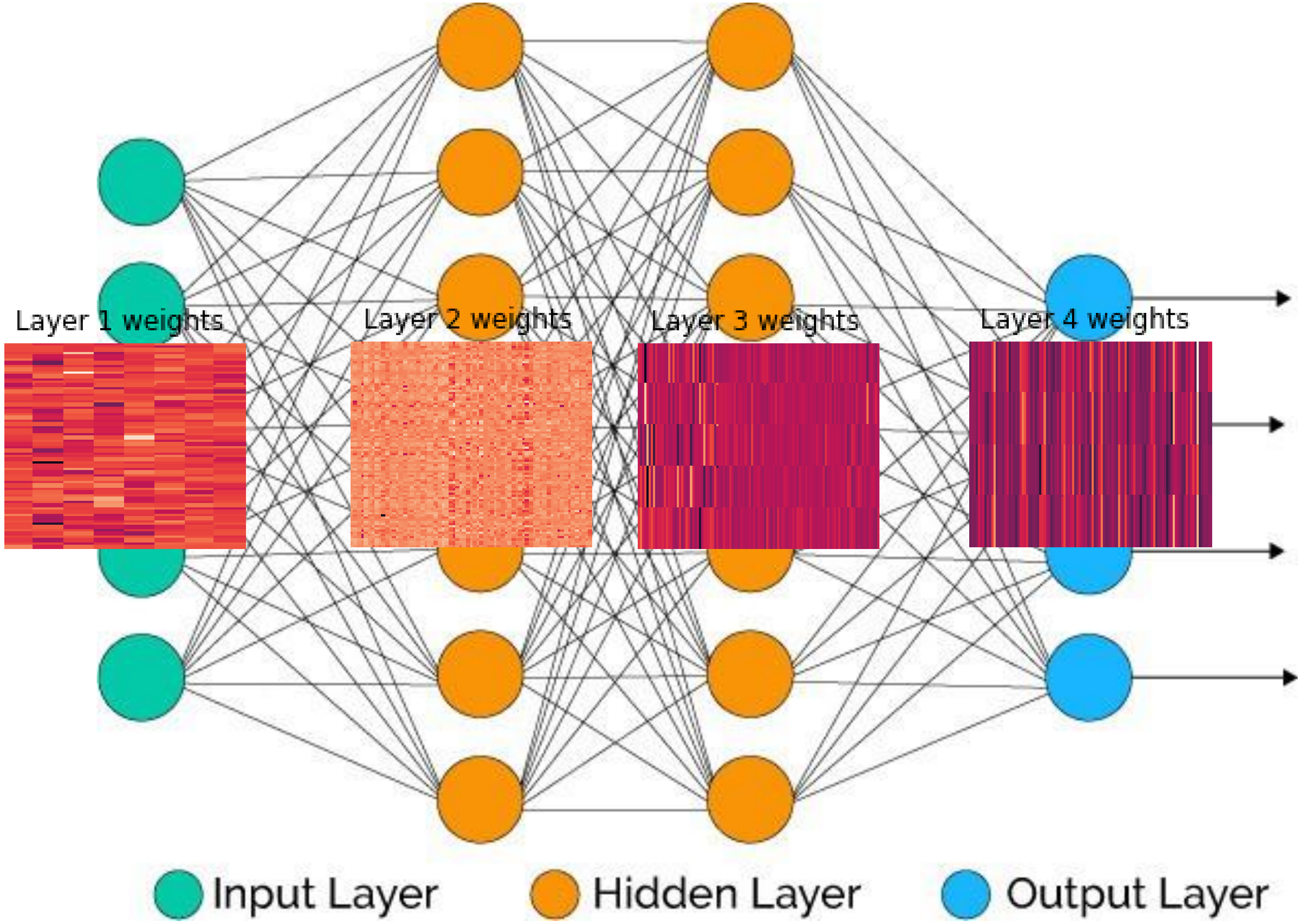

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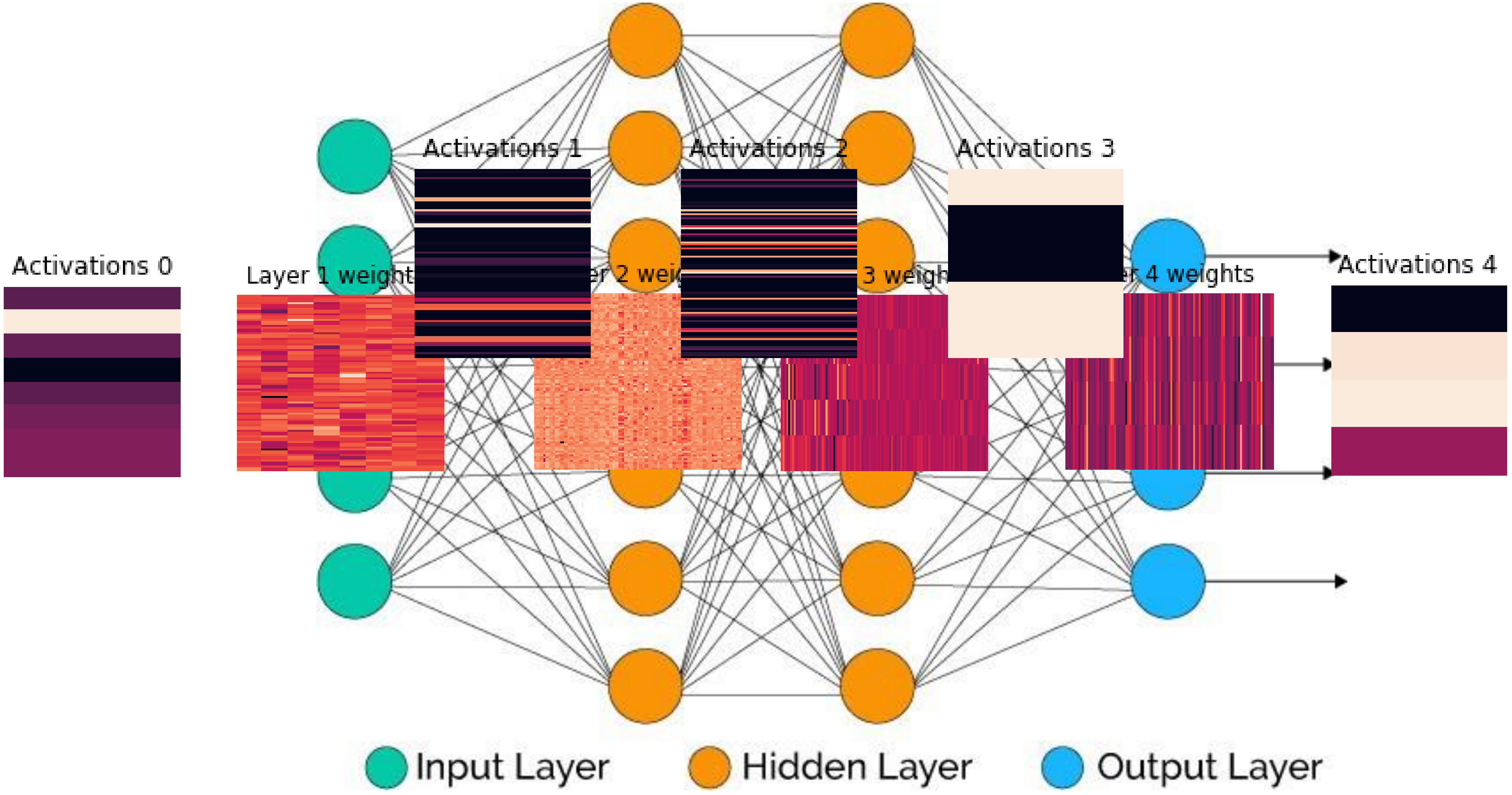

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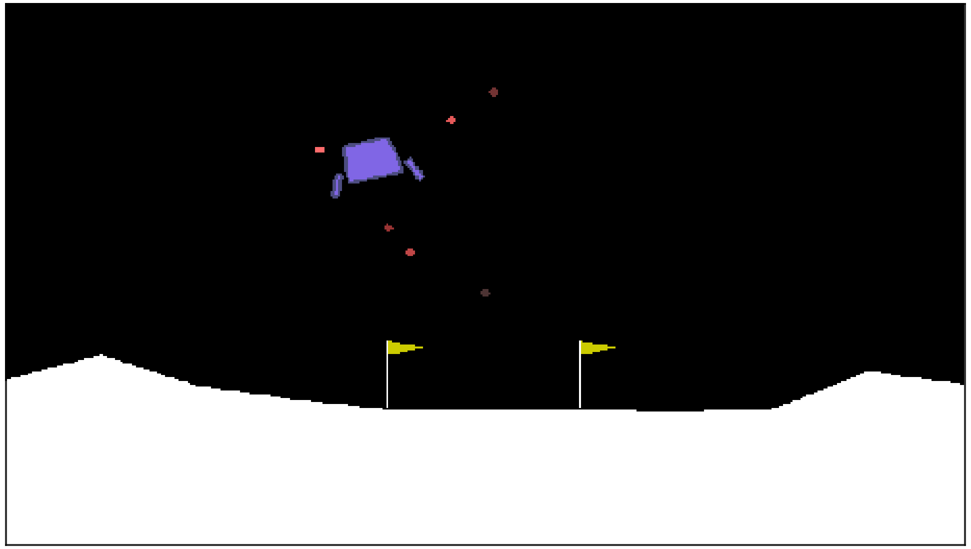
Design, V0



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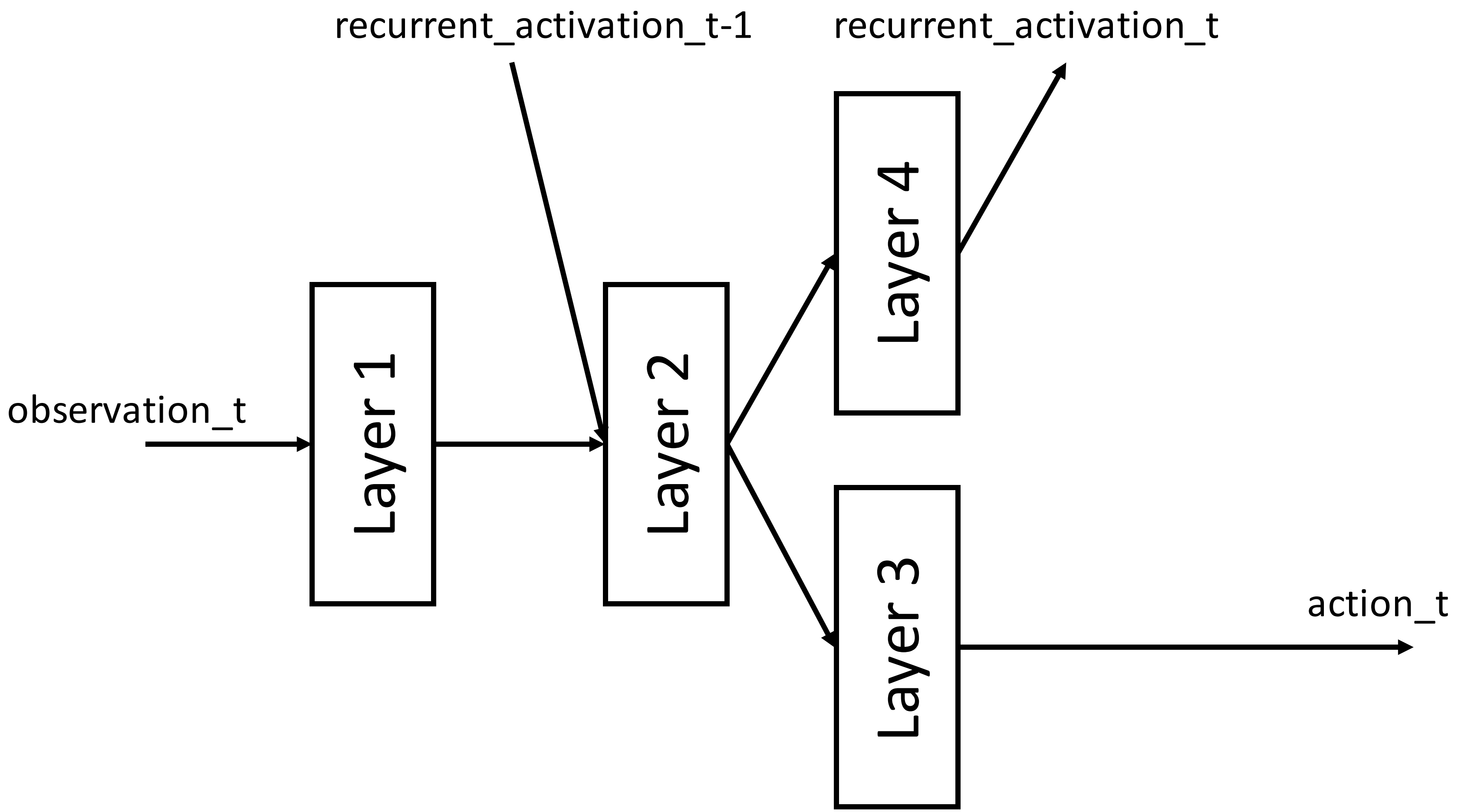
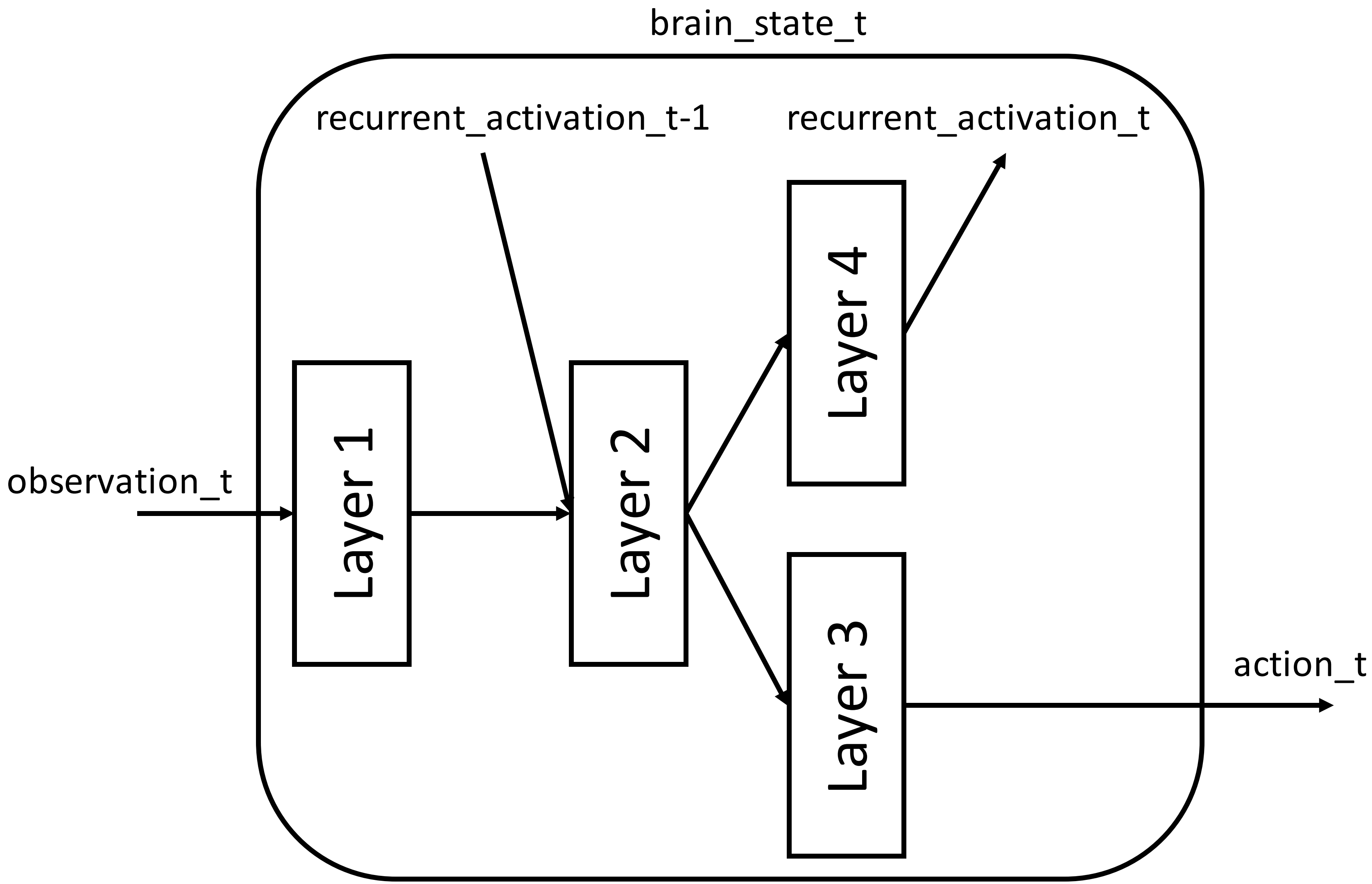

recurrent_activation_t-1
recurrent_activation_t
Layer 4
observation_t
Layer 1
Layer 2
Layer 3
action_t

Design, V0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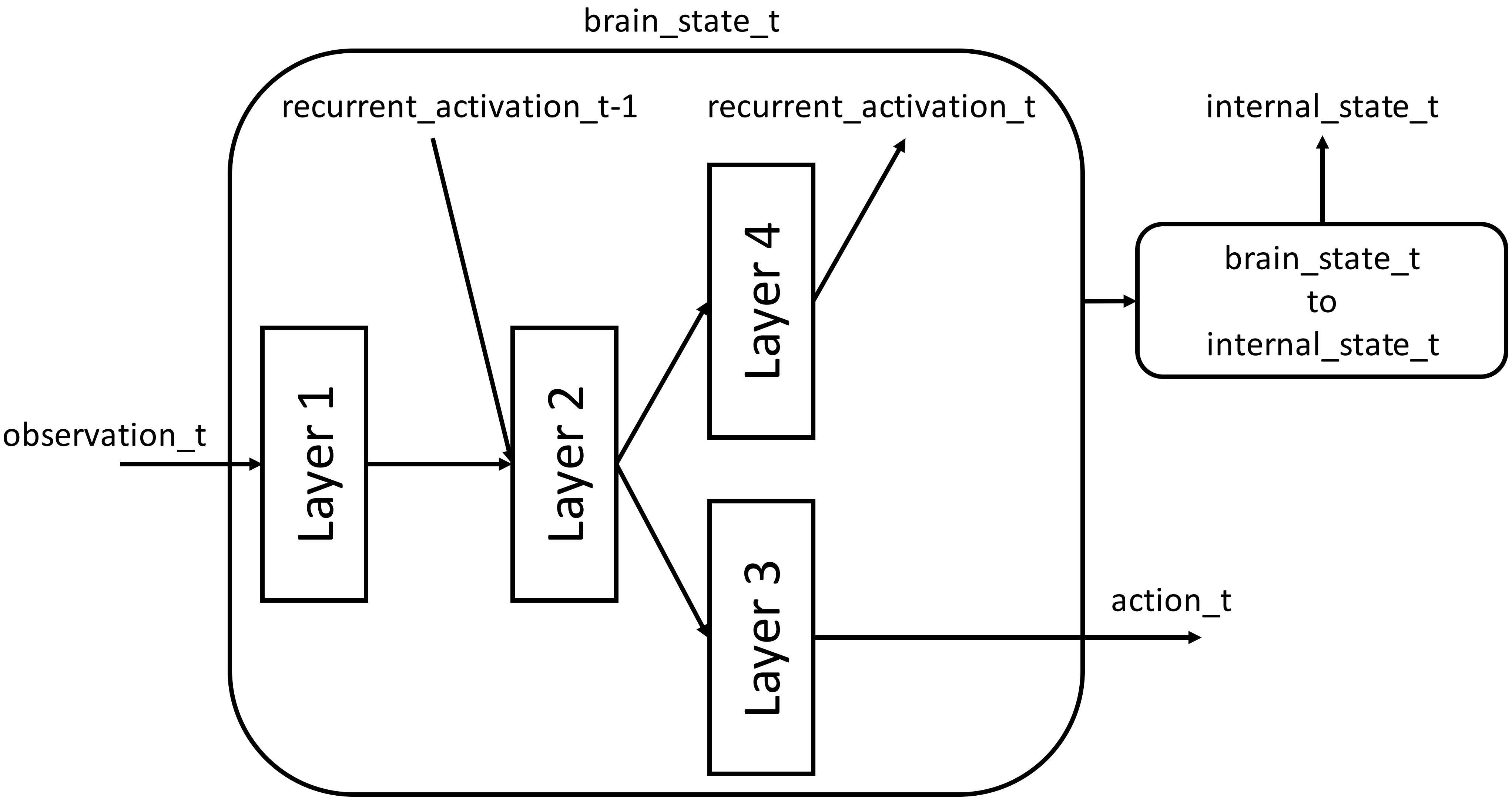
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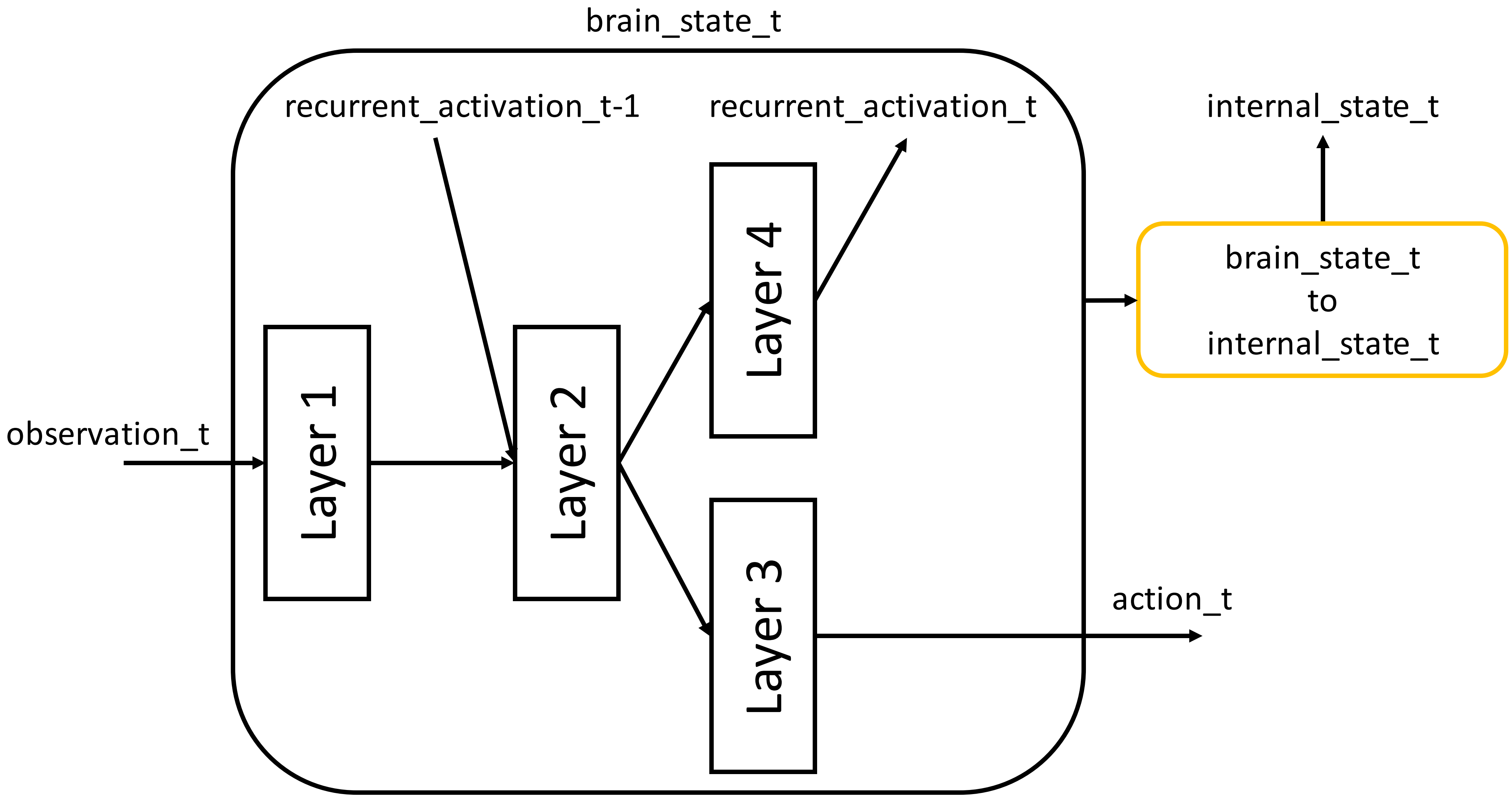
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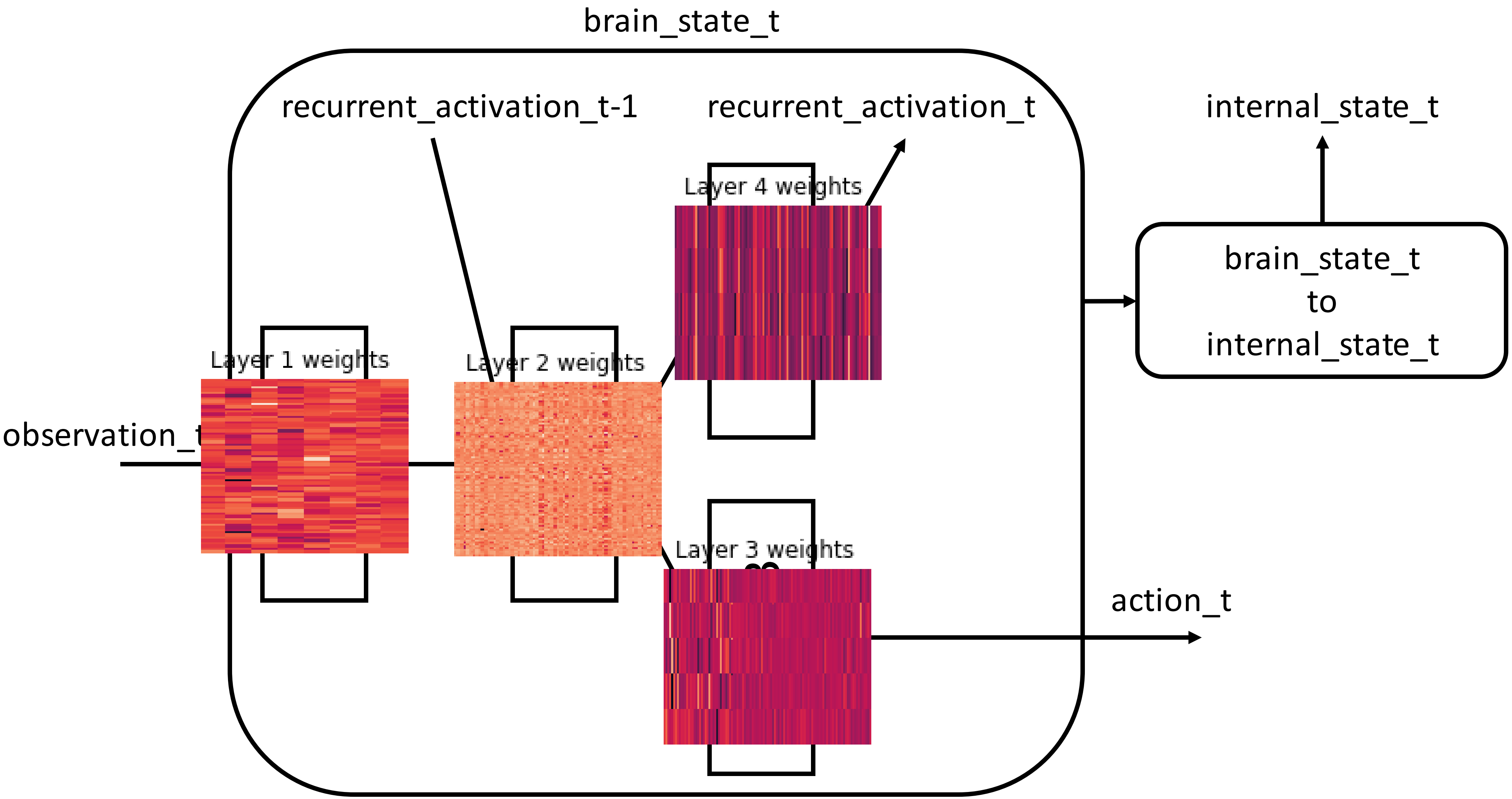
brain_state_t
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Layer 4 weights
brain_state_t
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Layer 1 weights
Layer 2 weights
observation_t
Layer 3 weights
action_t

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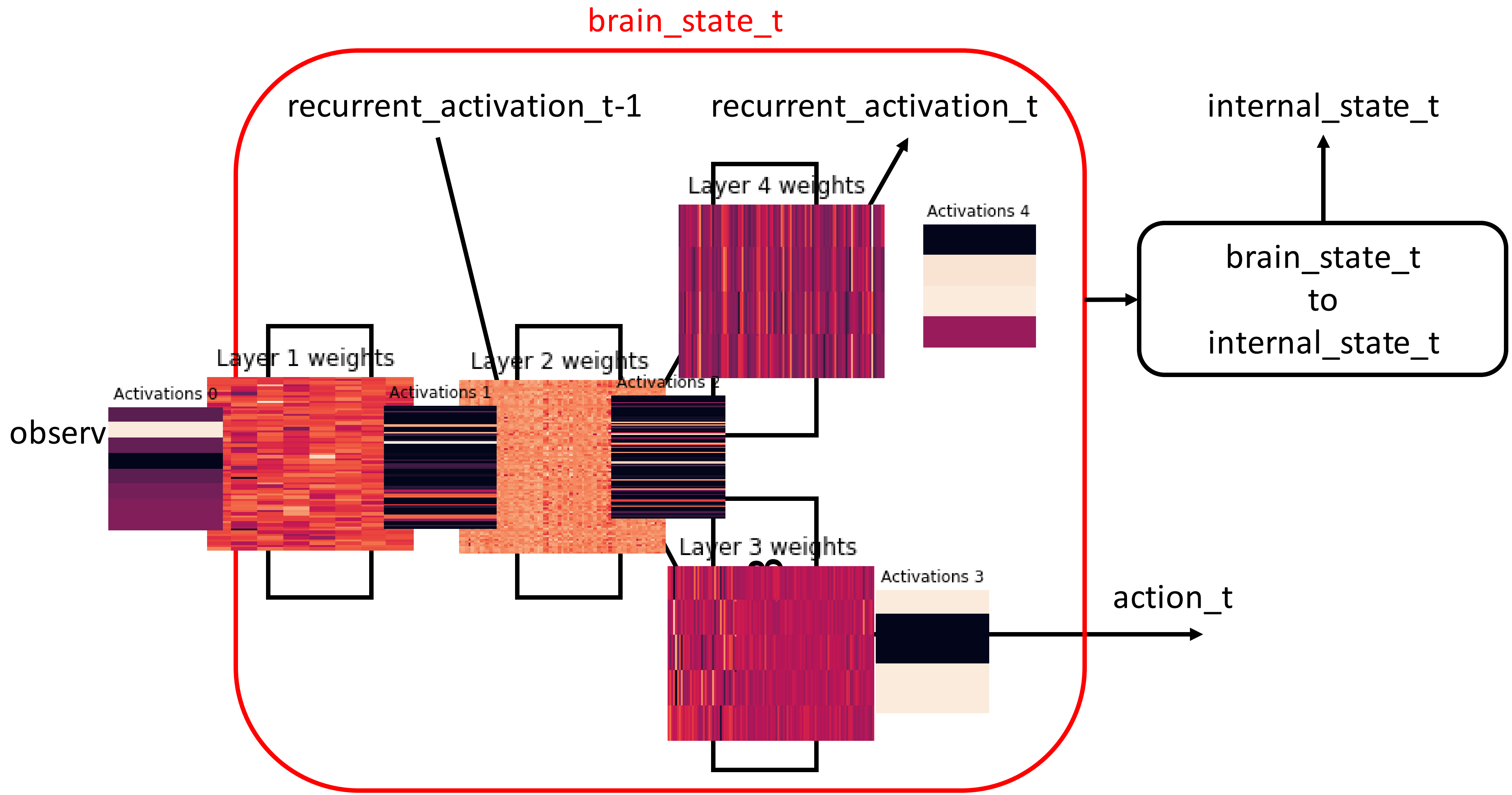

brain_state_t
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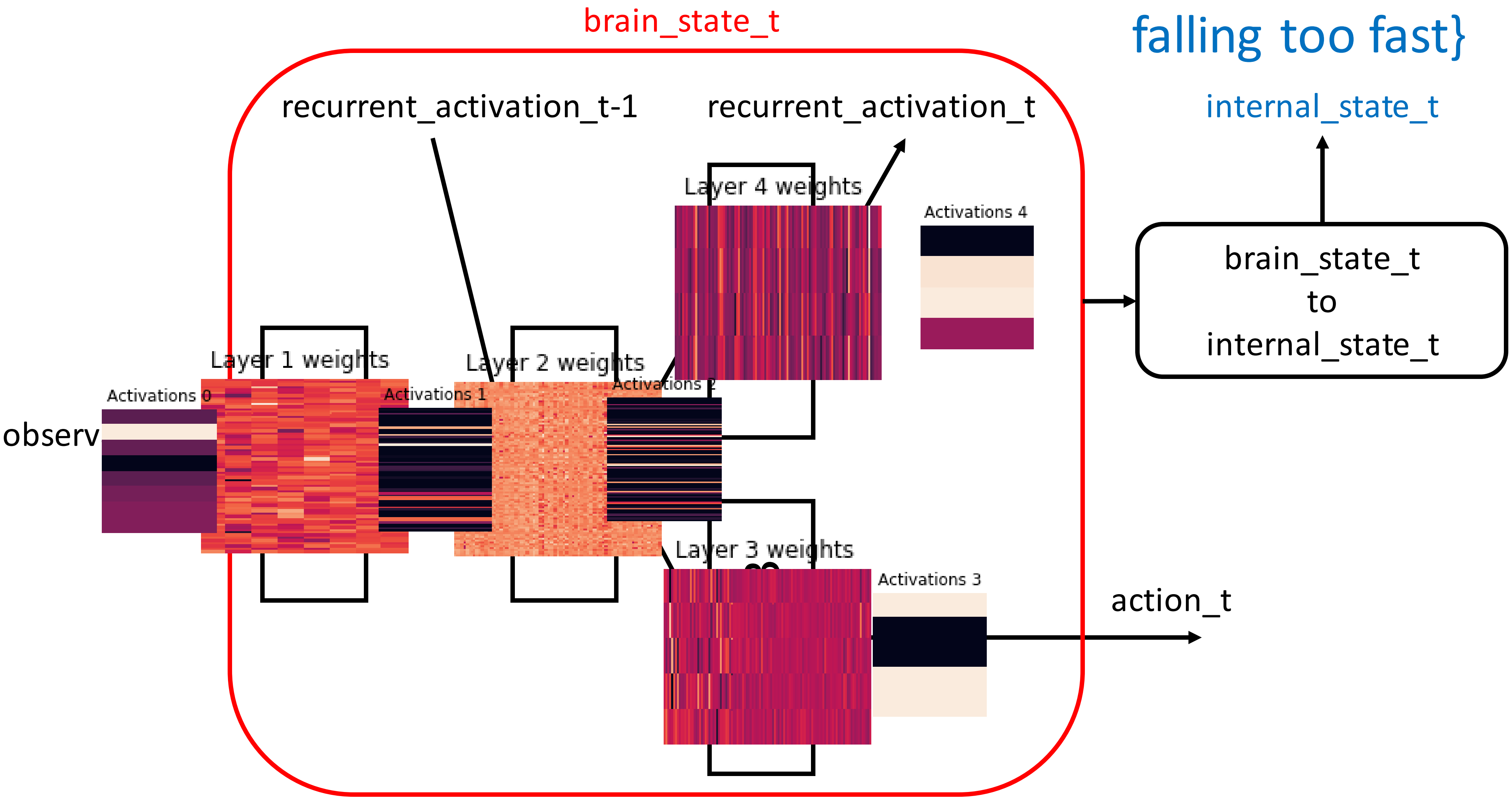
recurrent_activation_t
internal_state_t
Layer 4 weights
Activations 4
brain_state_t
to
internal_state_t
Layer 1 weights
Layer 2 weights
Activations 0
Activations 1
Activations 2
observ
Layer 3 weights
Activations 3
action_t

Design, V0

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



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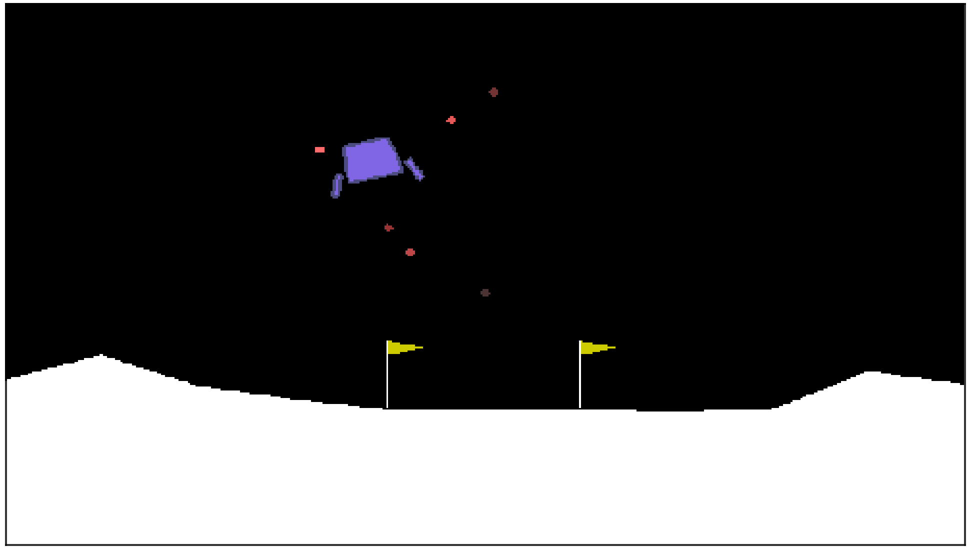

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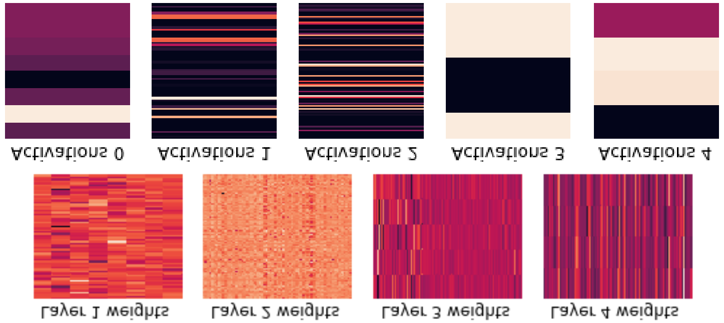

Design, V0

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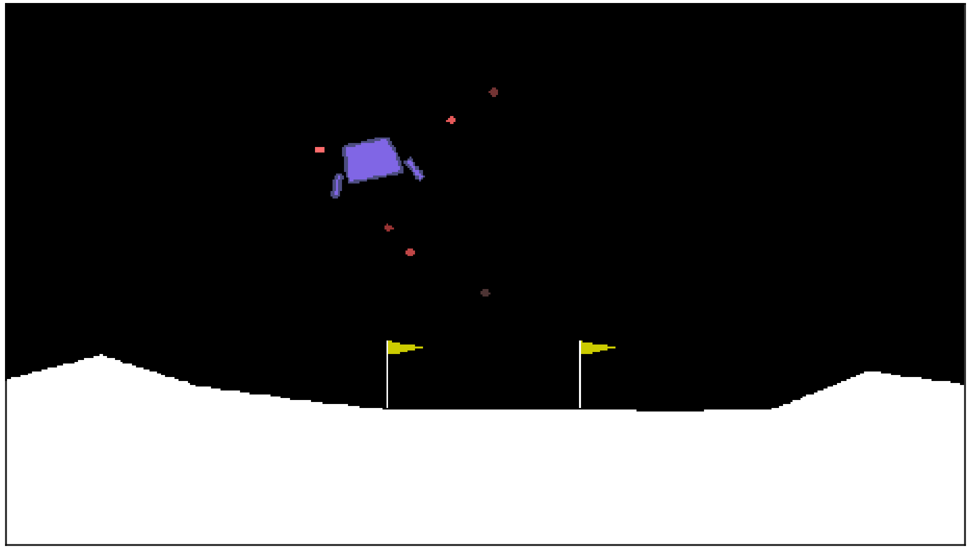

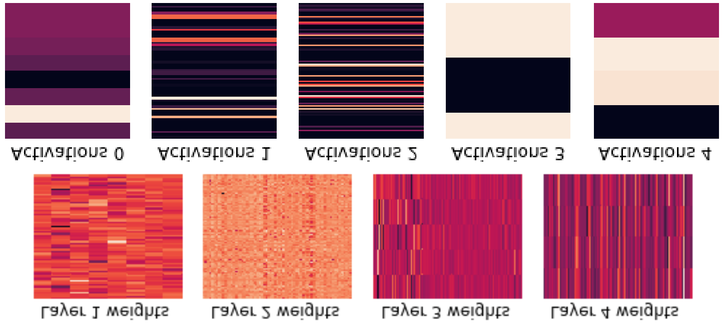

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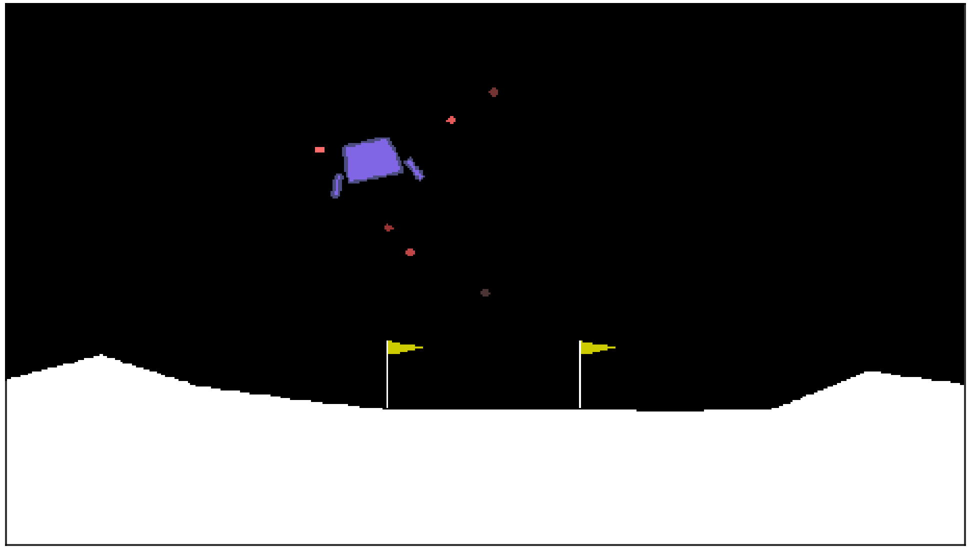

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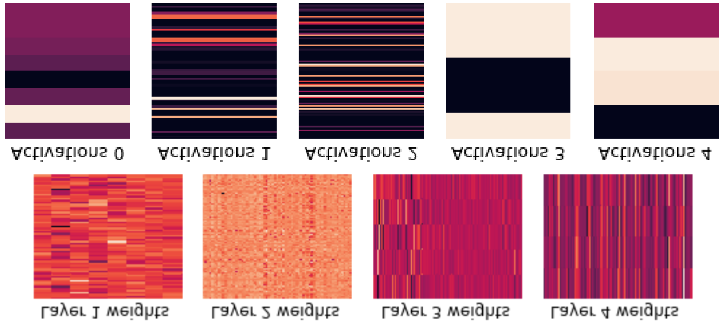

Reinforcement learning

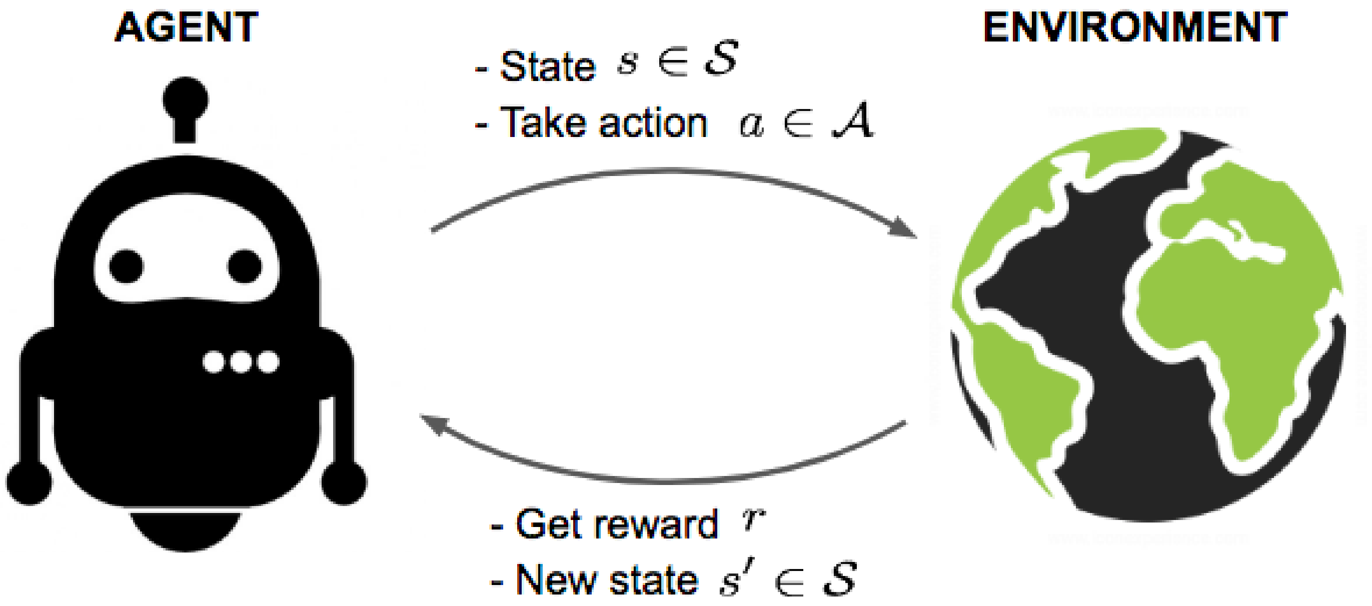
AGENT
ENVIRONMENT
- State $s \in \mathcal{S}$
- Take action $a \in \mathcal{A}$
- Get reward r
- New state $s' \in \mathcal{S}$

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
  - Internal states are ontologically irreducible to brain states

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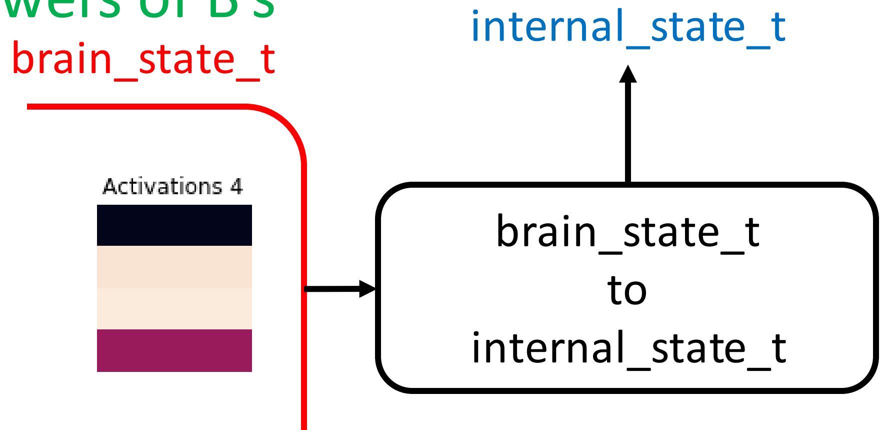

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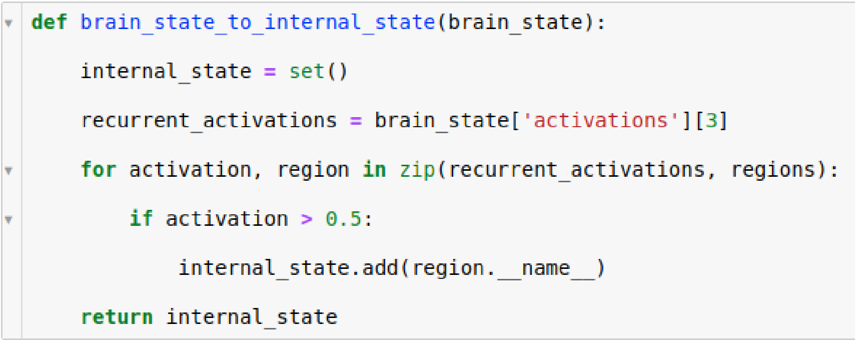

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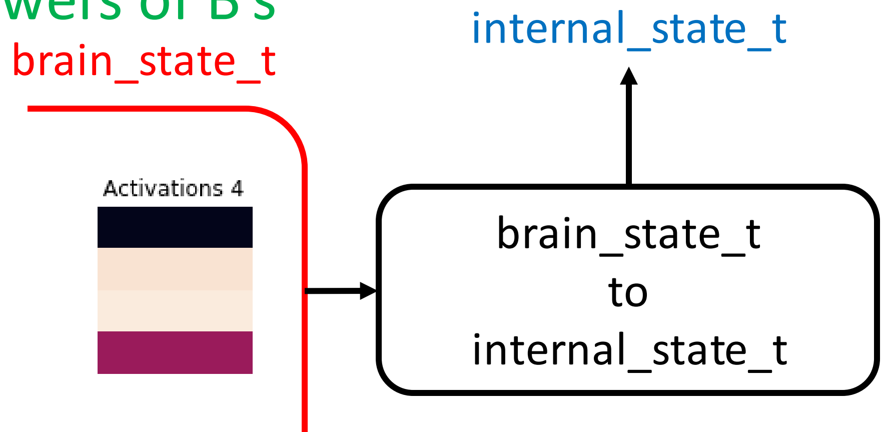
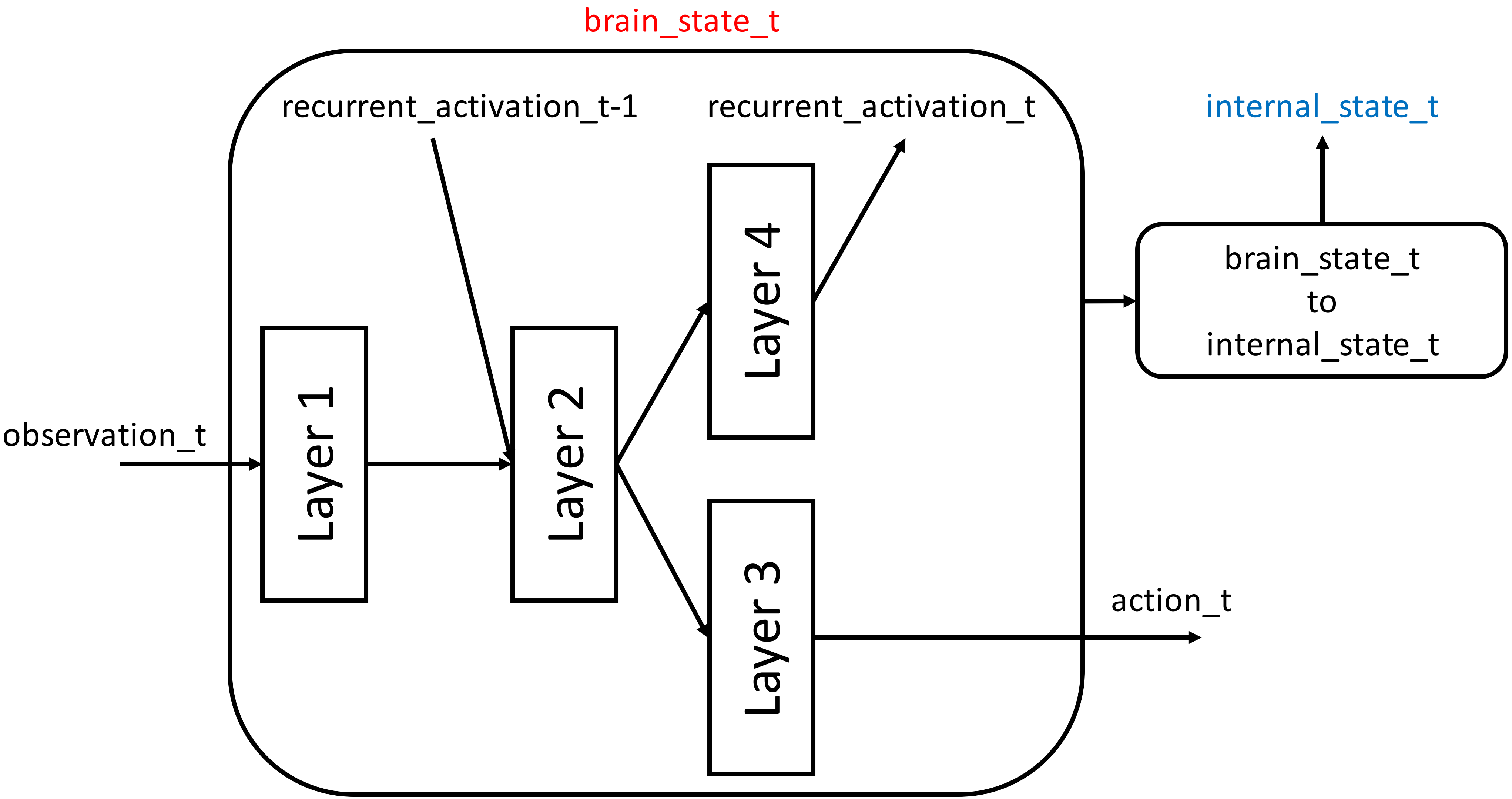


Design, V0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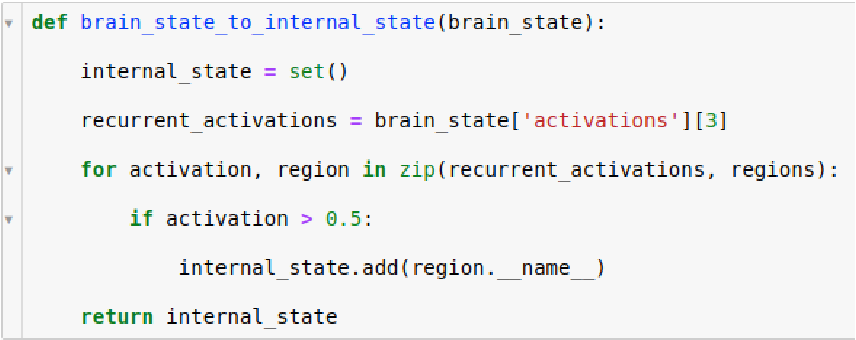

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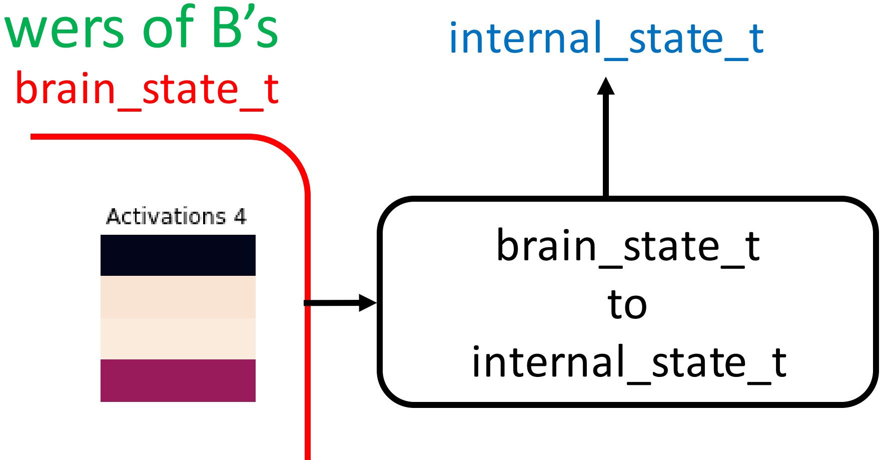

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brain_state_t

brain_state_t
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Internal state:
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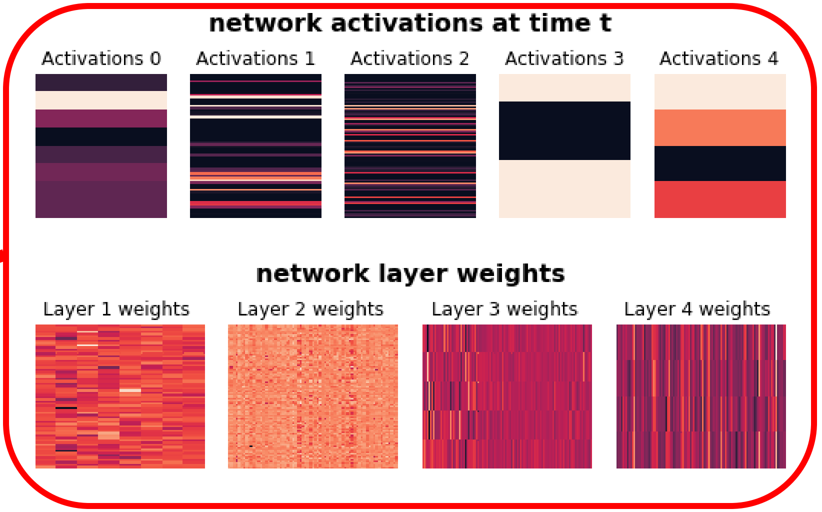

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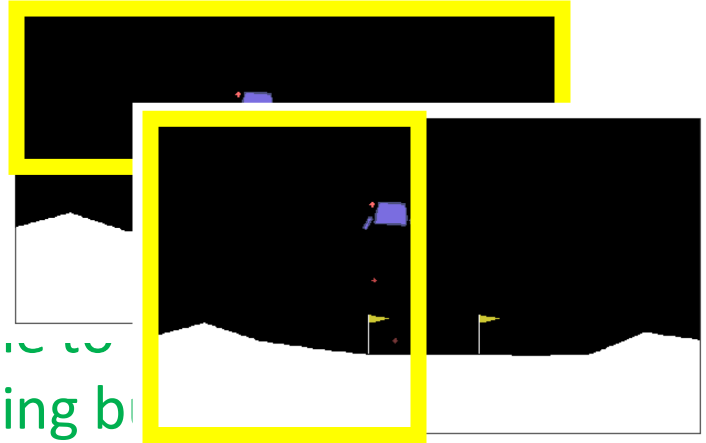

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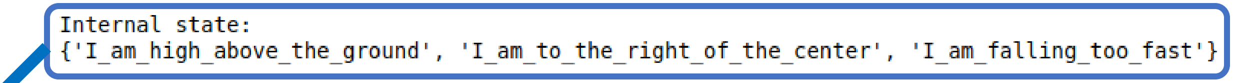

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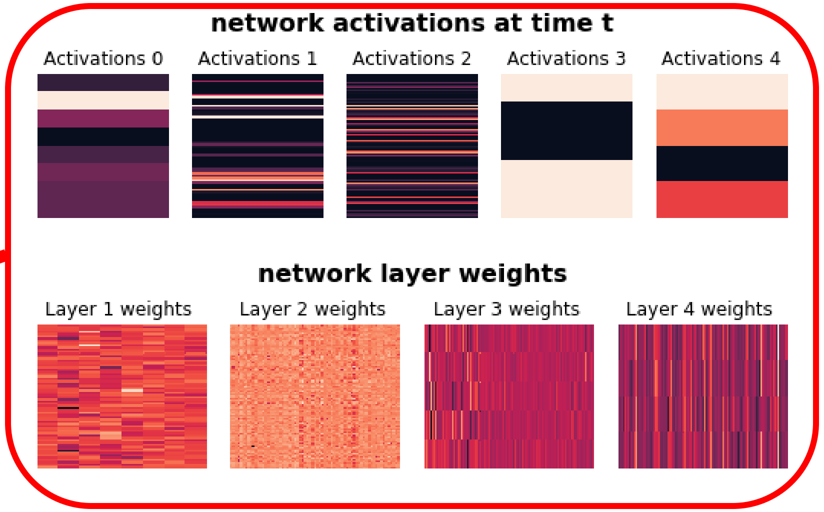

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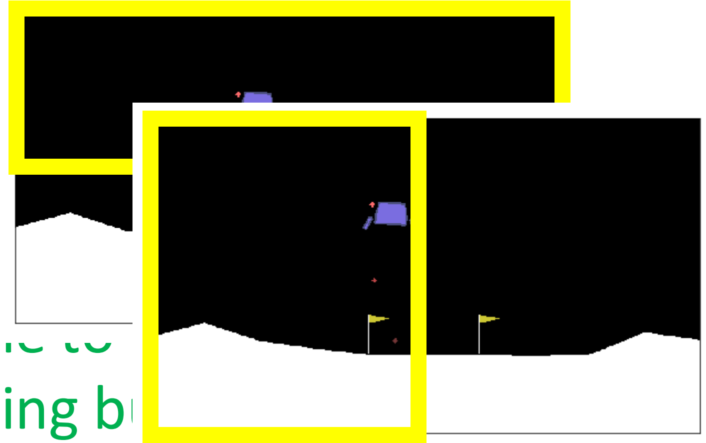

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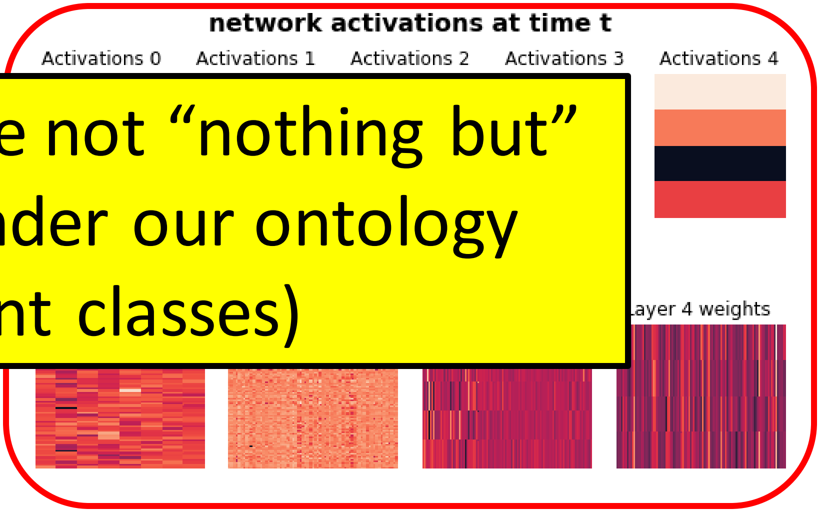

Internal state instances are not "nothing but" brain state instances under our ontology (they are different classes)

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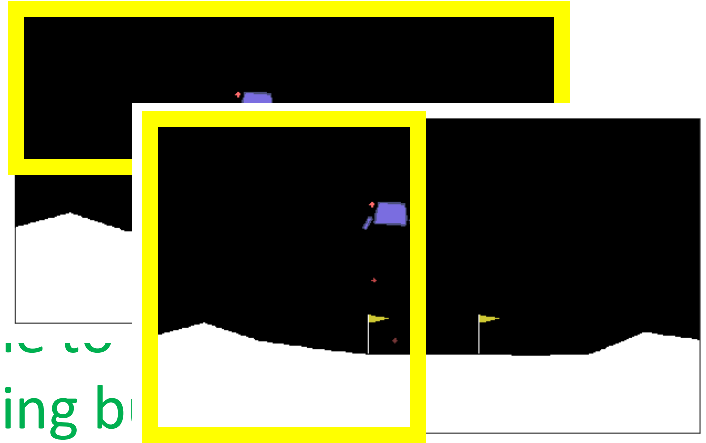

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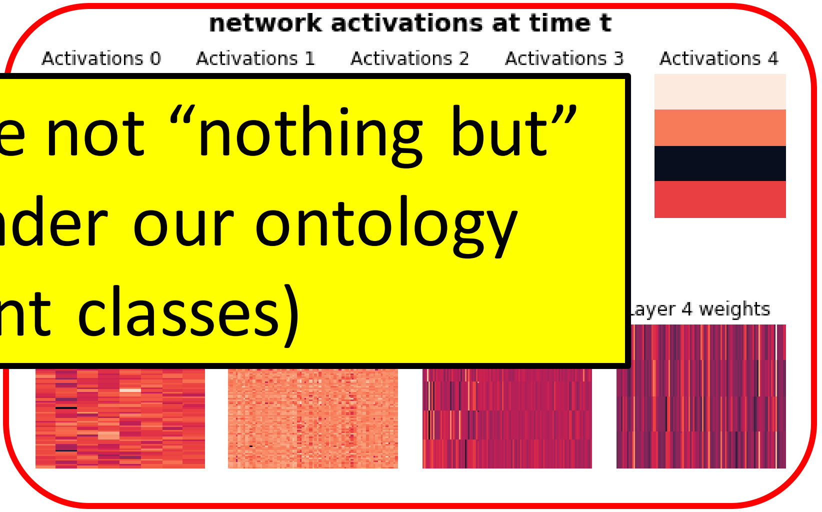

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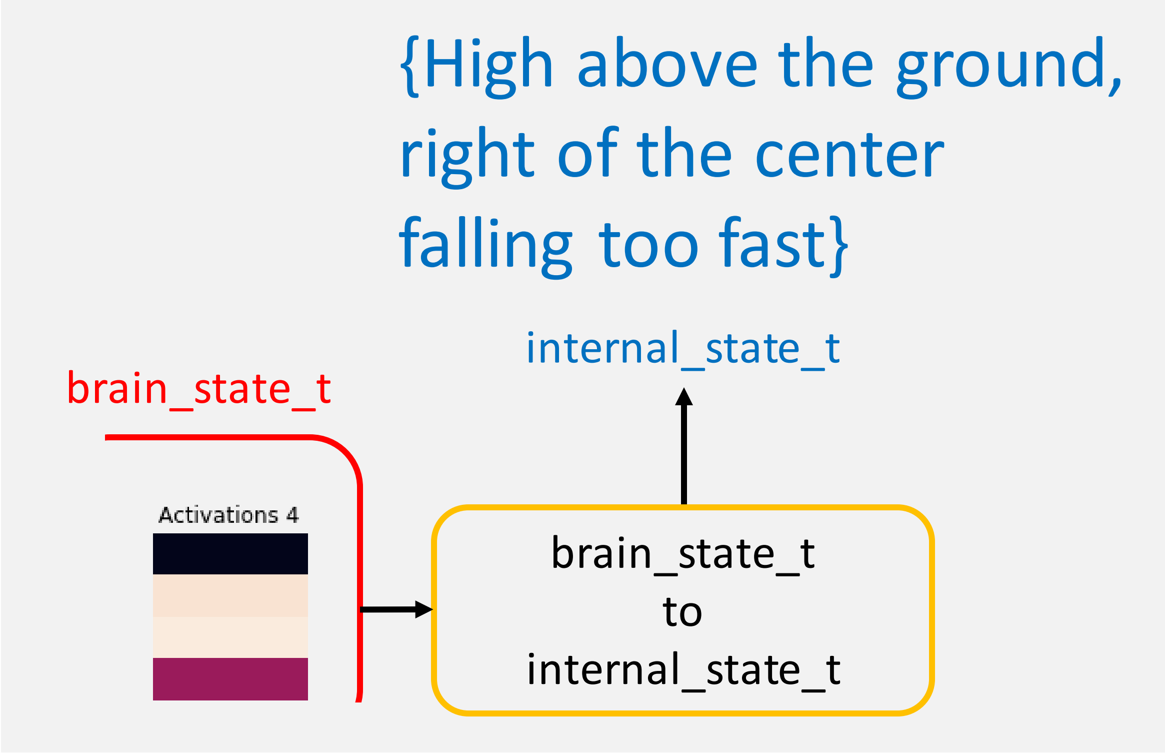
What's the deal with that function?



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internal_state_t

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brain_state_t
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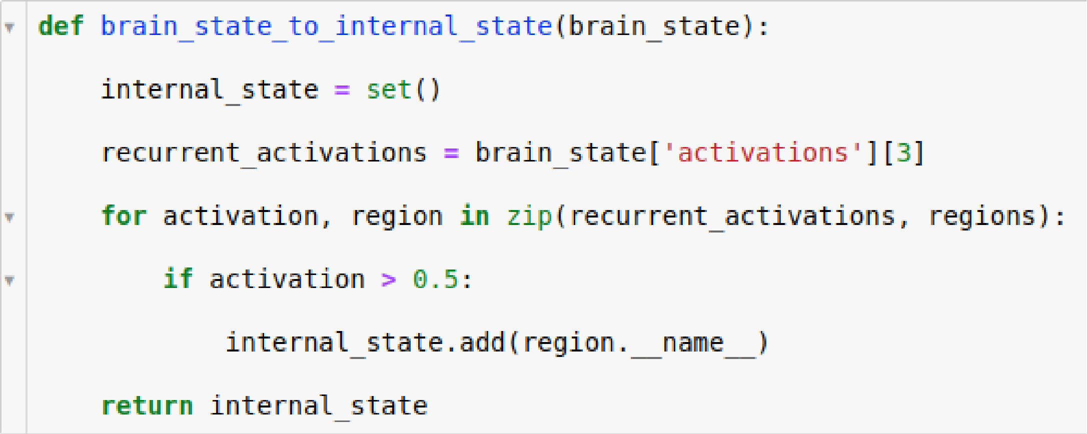

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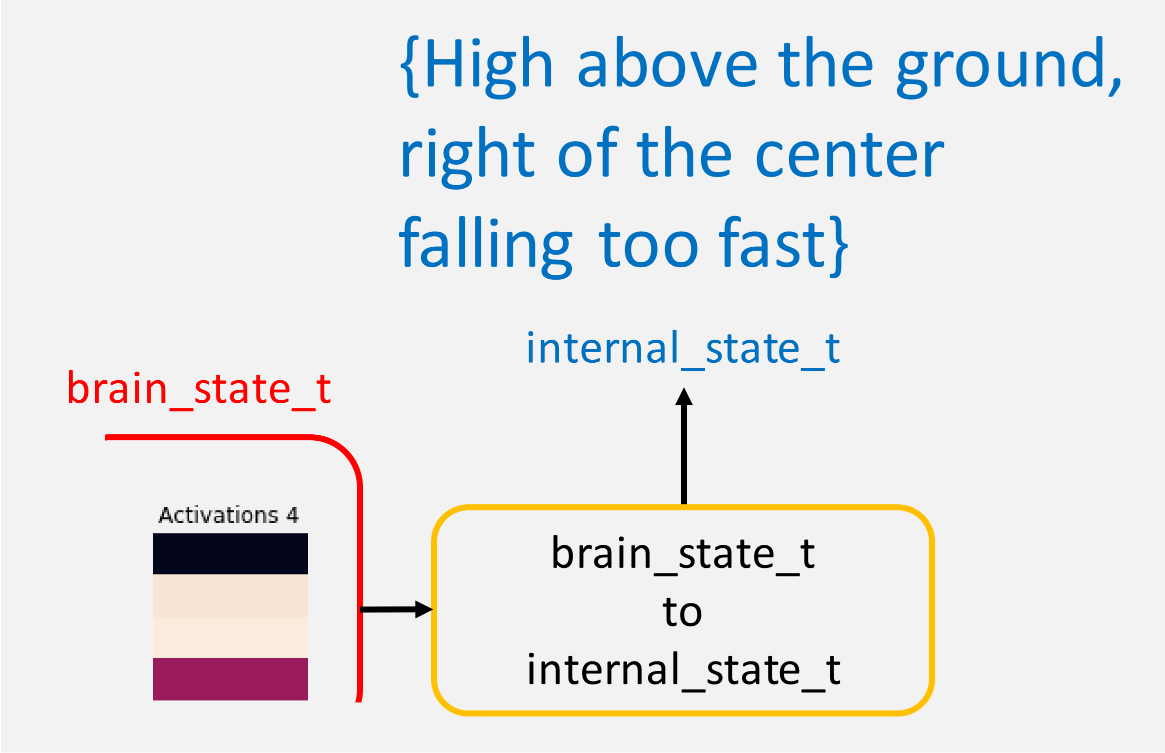

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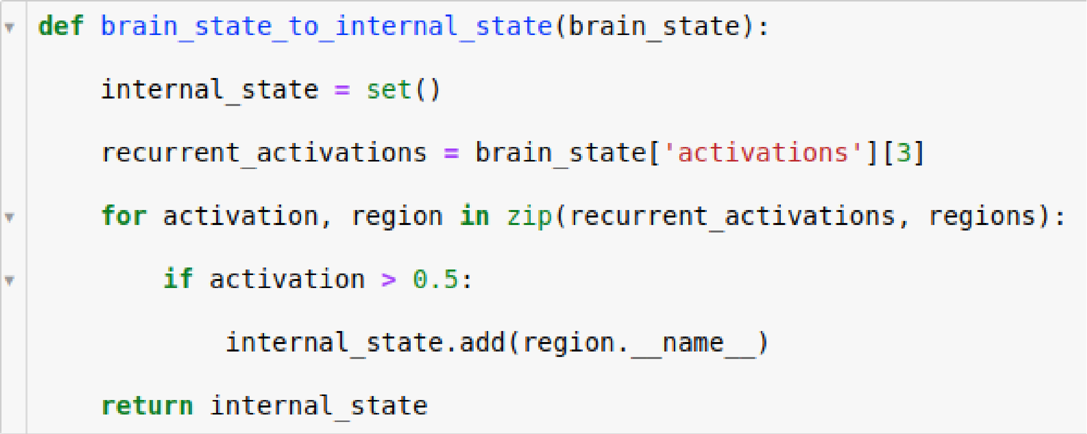

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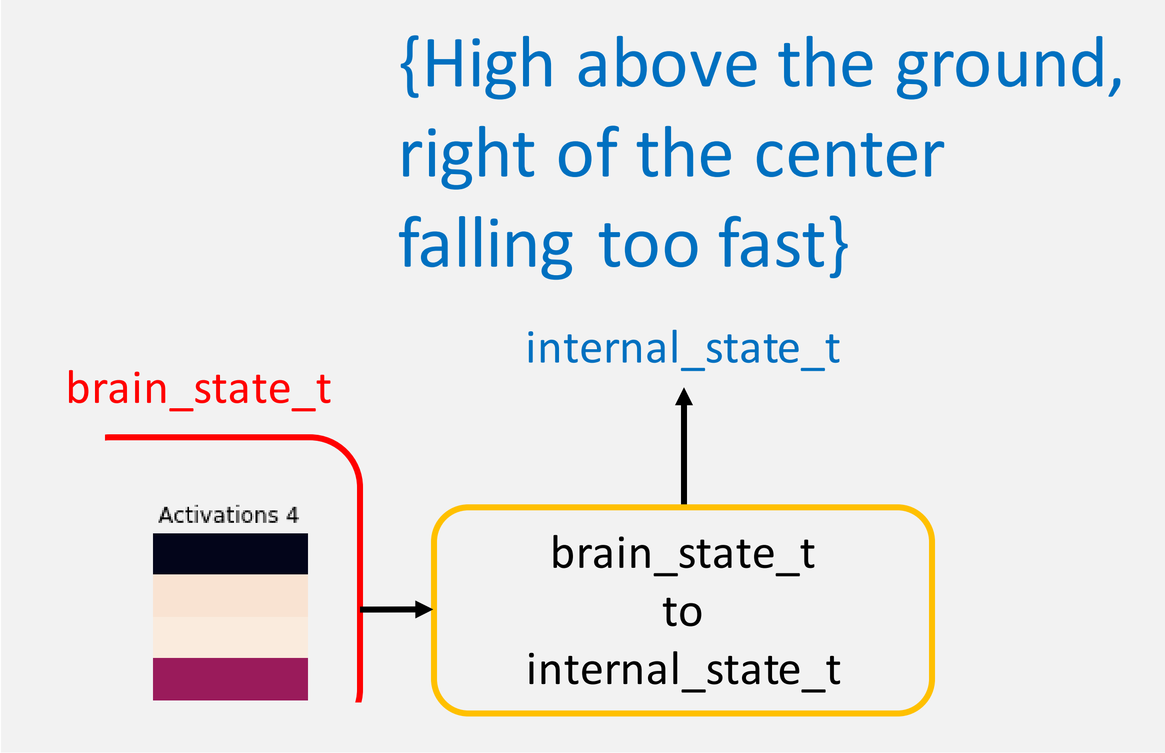

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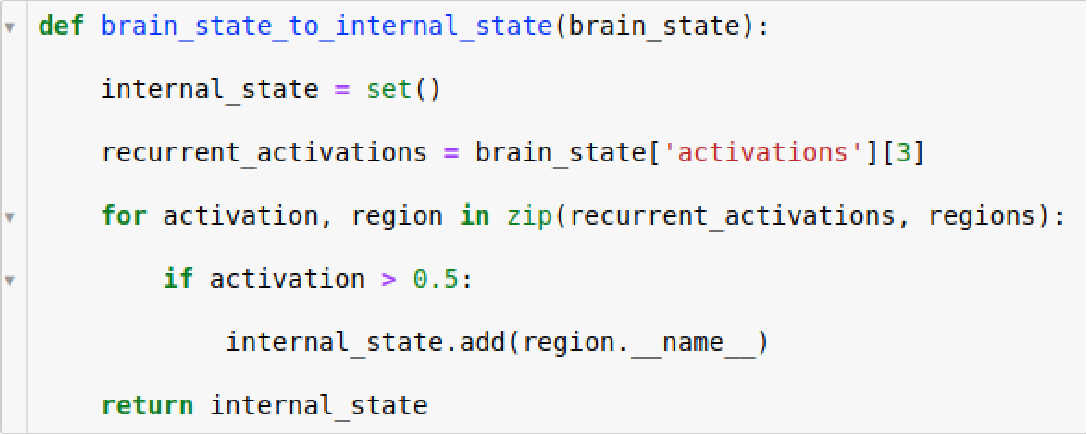

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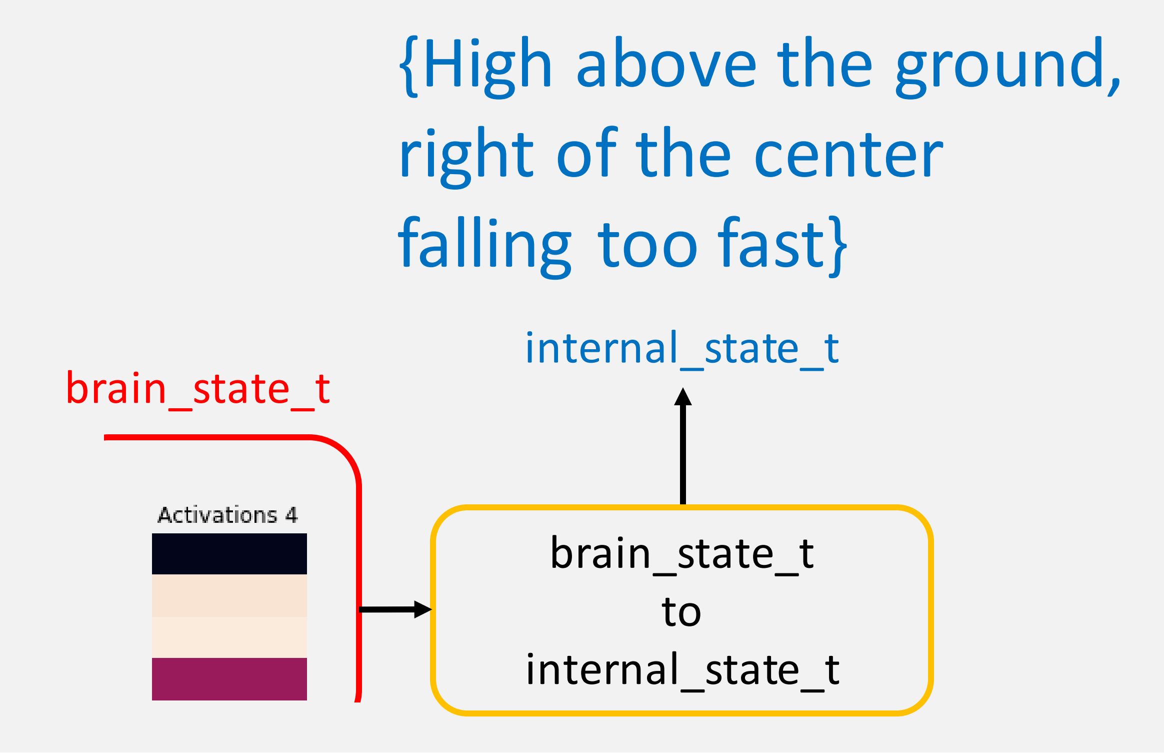
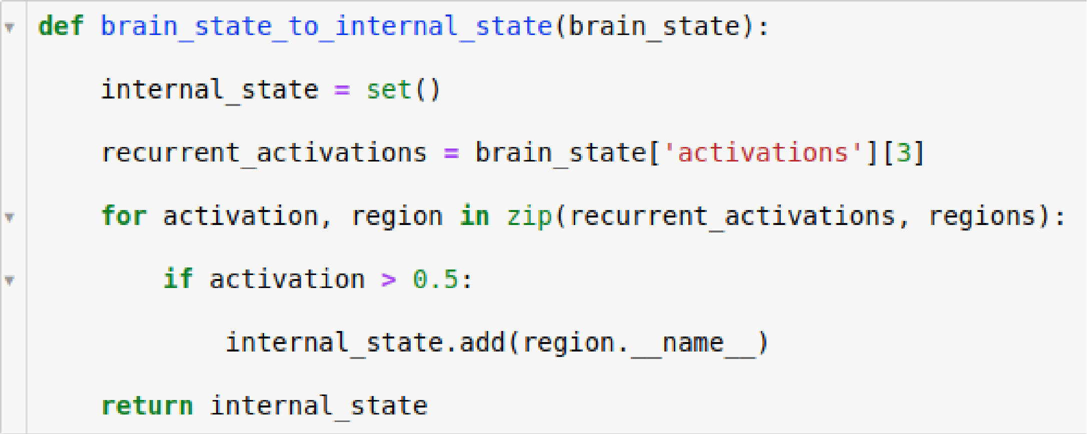
- Is this something closer to summarization?

What's the deal with that function?



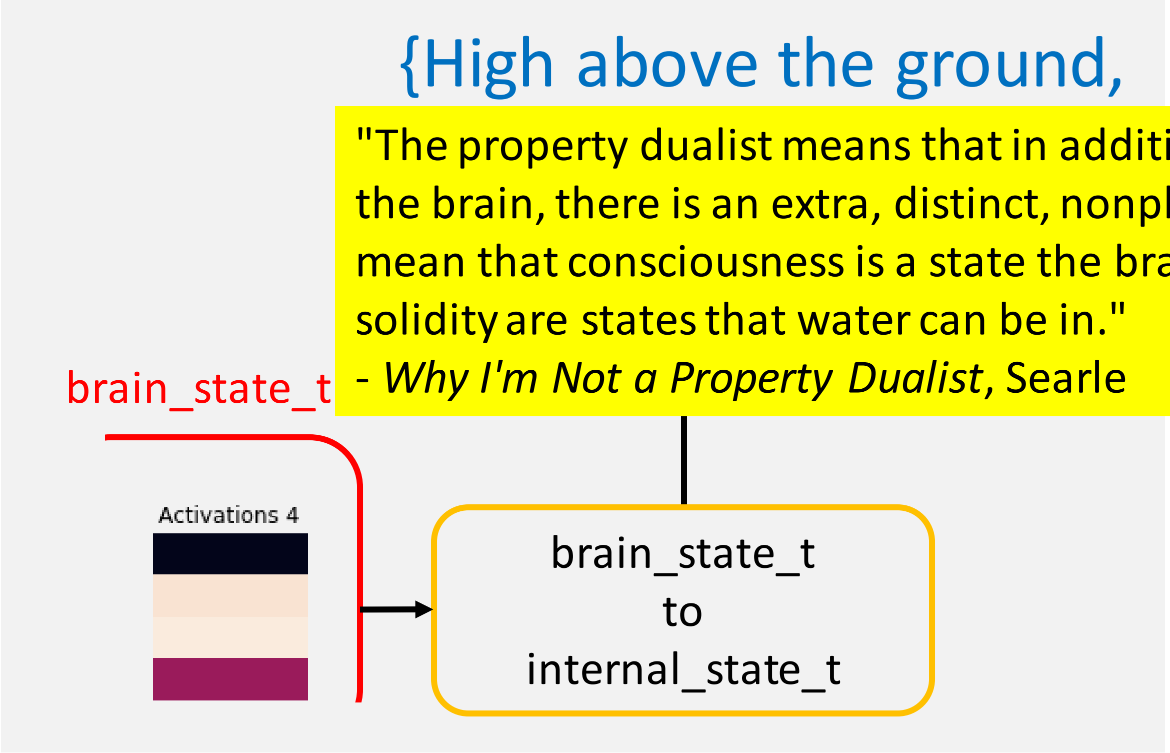
{High above the ground, right of the center falling too fast}



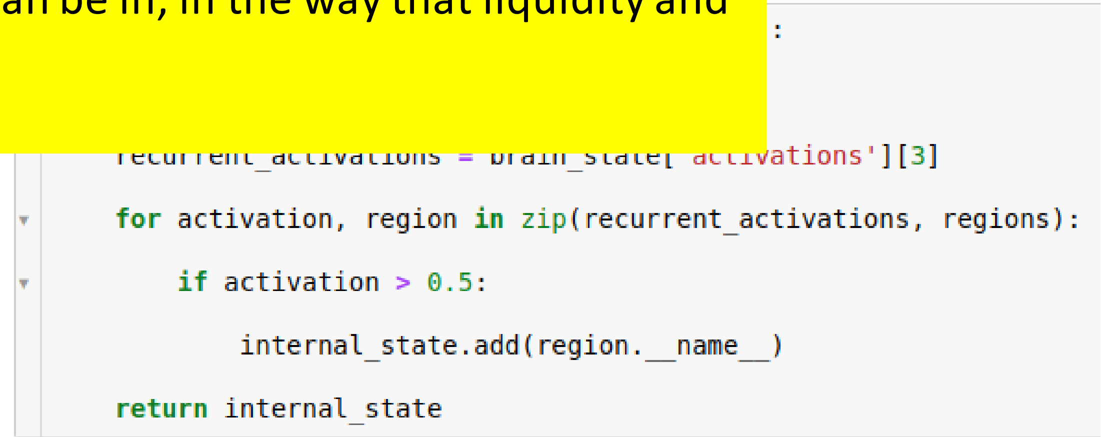
```python
def brain_state_to_internal_state(brain_state):
    internal_state = set()
    recurrent_activations = brain_state['activations'][3]
    for activation, region in zip(recurrent_activations, regions):
        if activation > 0.5:
            internal_state.add(region.__name__)
    return internal_state
```

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

What's the deal with that function?



"The property dualist means that in addition to all the neurobiological features of the brain, there is an extra, distinct, nonphysical feature of the brain; whereas I mean that 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*, Searle



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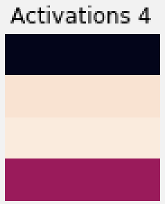
{High above the ground,

brain_state_t



```
:
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)
```

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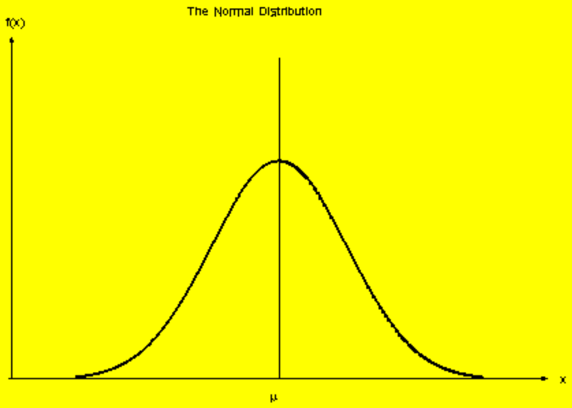
Just like a gaussian and its parameters...



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

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

- Is this jus
- Is this so
- (or both?)

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 our implementation?
  - 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?