Neural planning

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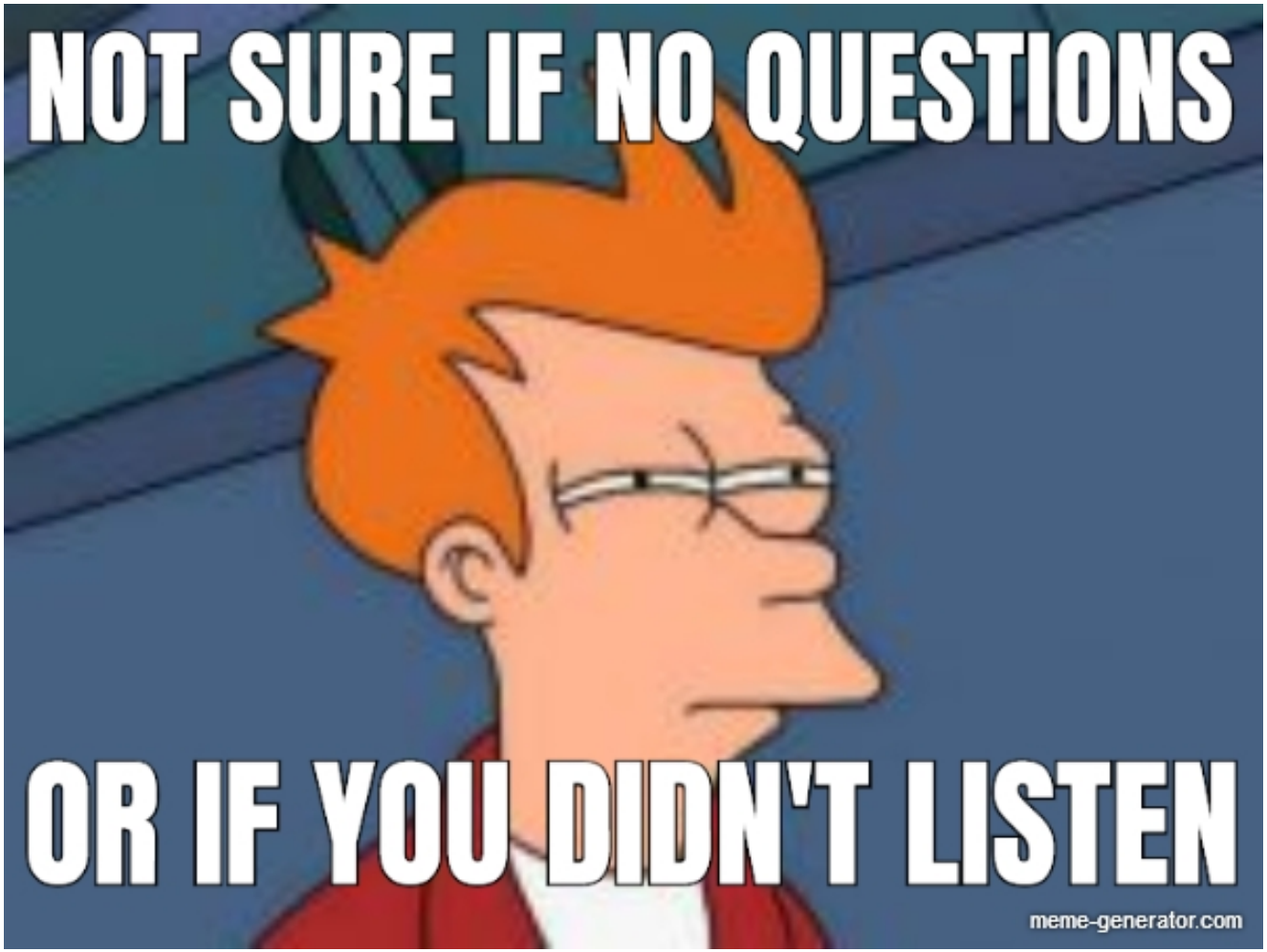
PUI Tutorial
Week 6

Lecture check

- Any questions regarding the lecture?



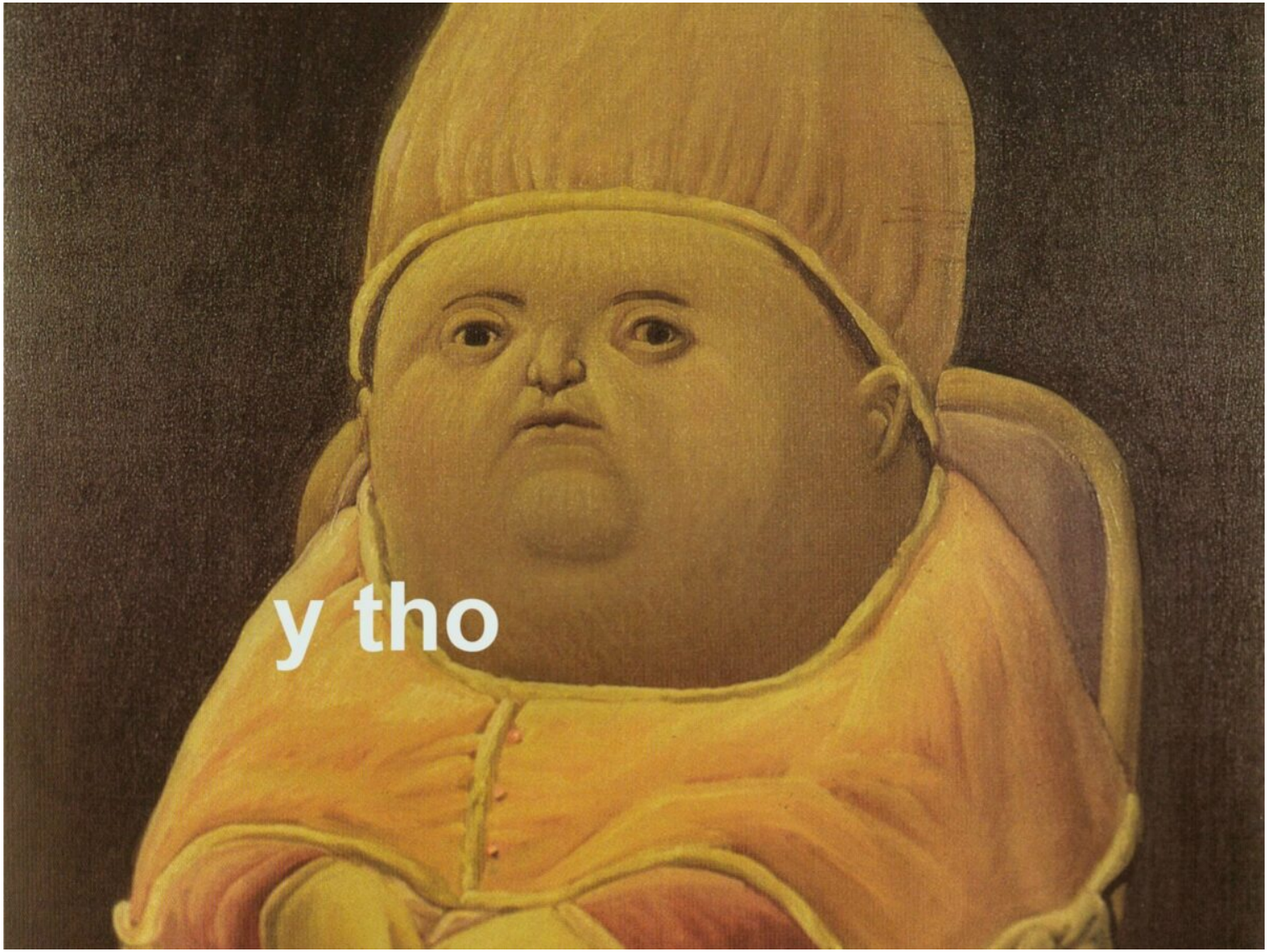
Neural planning

- What is that?

Neural planning

- What is that?
- That's just how I call it to be honest...
- Combining **Classical Planning** aaaaaaaand **Deep Learning**

Neural planning



Neural planning

Neural planning

- Classical planning is great because
  - it can be domain-independent
  - you have powerful heuristics
  - there's a lot of state of the art
  - you have optimized planner implementations

Neural planning

- Classical planning is great because
  - it can be domain-independent
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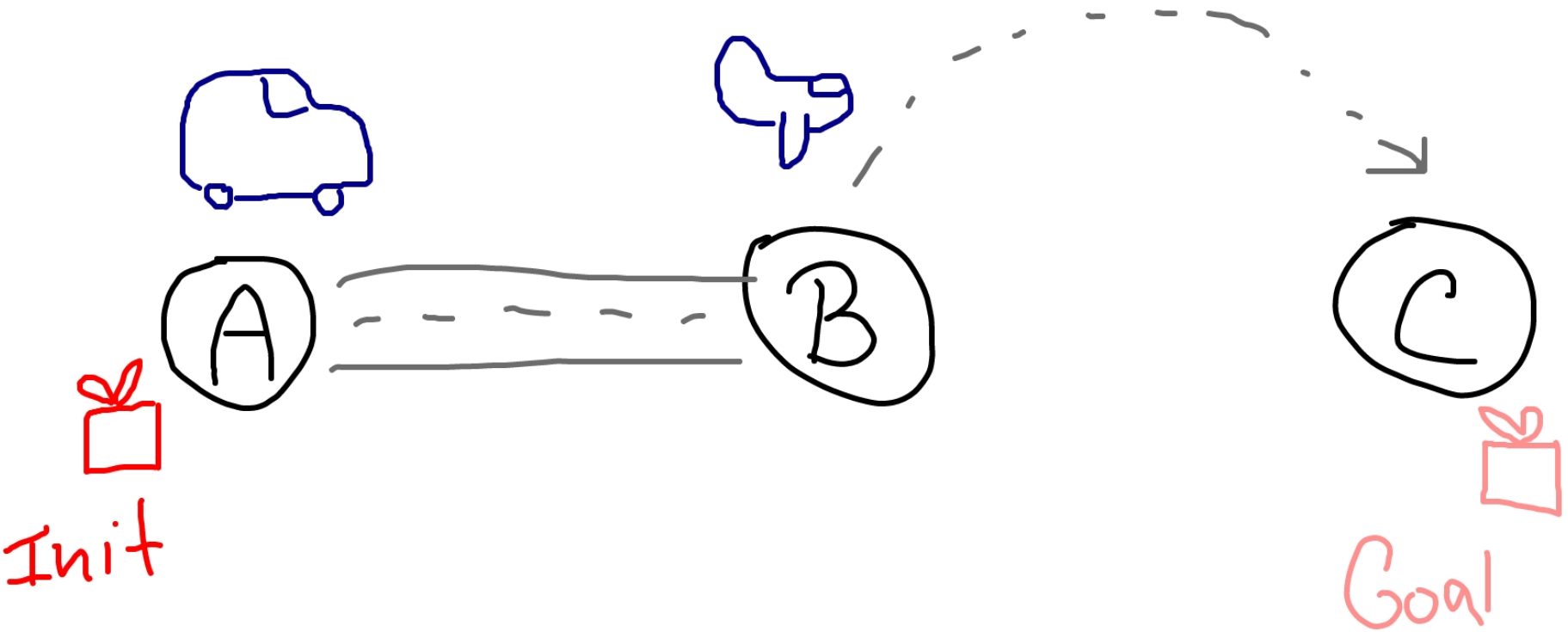
  - there's a lot of state of the art
  - you have optimized planner implementations
- ...but it's less great because
  - you **need a model**
  - you often have to hand-encode the model
  - different planner may need different representation
  - you need languages like PDDL

Neural planning



Neural planning

Neural planning

- Neural networks are great
  - when you have a lot of data
  - because they work on unstructured data
  - because they don't need a model!
- ...but they're less great
  - when you have a difficult task
  - when you don't have data
  - because they don't learn algorithms

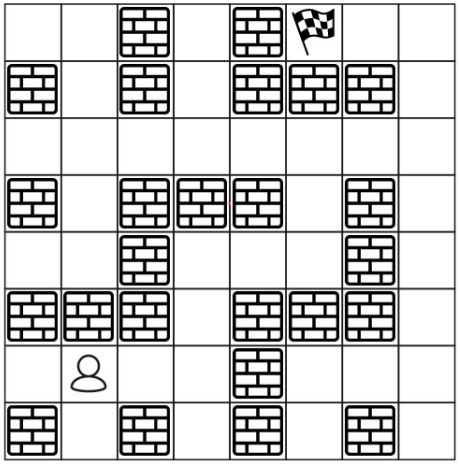
Neural planning

- What if... we used them both?
- Classical planning: algorithms
- Neural networks: replace parts of algorithms that require the costly model
- Different approaches as well
  - learn policy function
  - learn PDDL from the graphic representation
  - ...many more directions

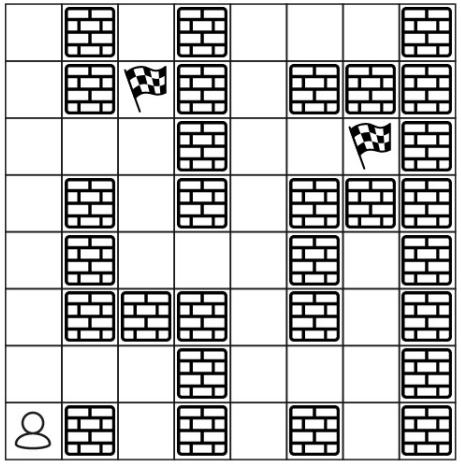
Neural planning - our work

- State space + state-transition function
- **Expansion network** that works with graphic representation
- Heuristic function
- **Heuristic network** that works with graphic representation

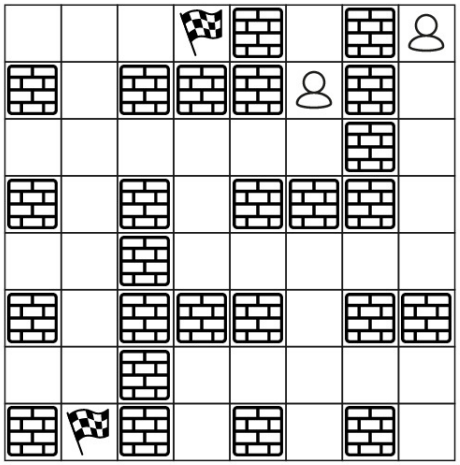
Neural planning - domains



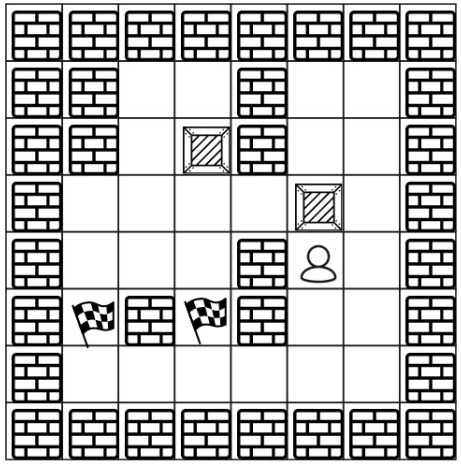
Single-agent maze



Multi-goal maze



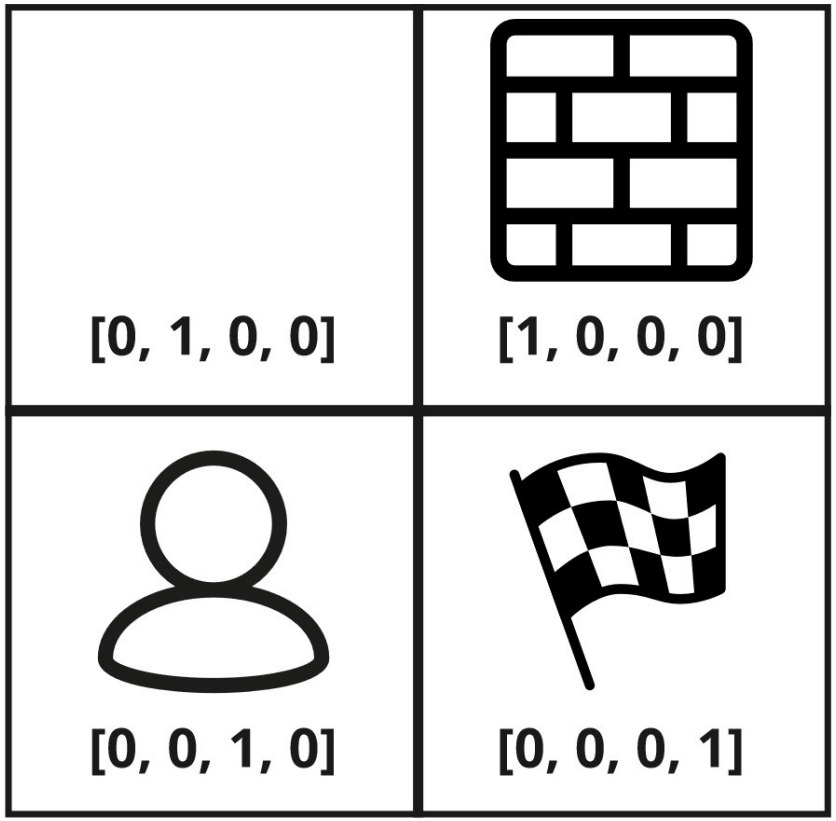
Multi-agent maze



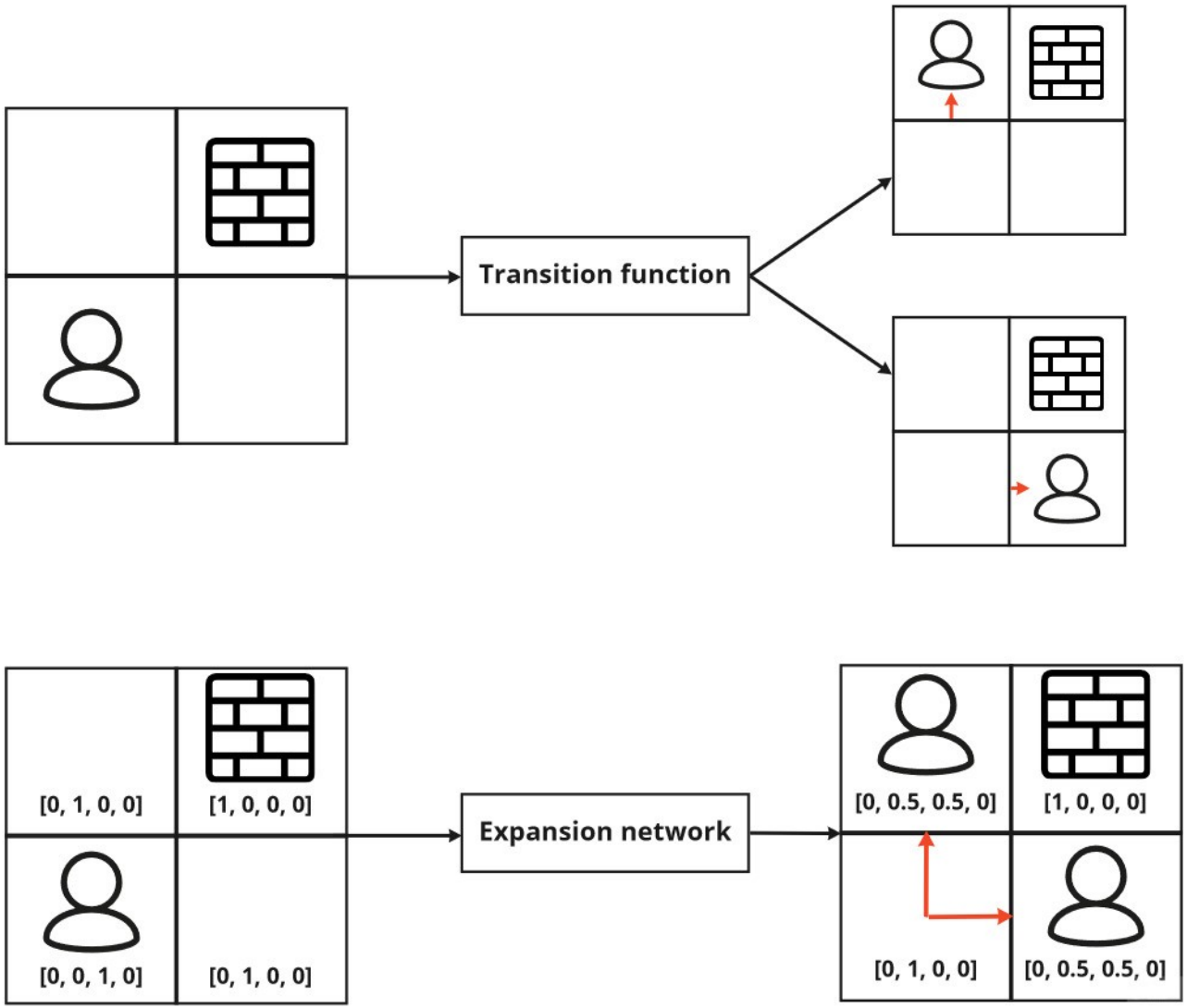
Sokoban

Neural planning

- Grid domains (so far...)
- One-hot encoding of the entities on cells
- Convolutional + recurrent neural networks
- **Scale-free** architectures

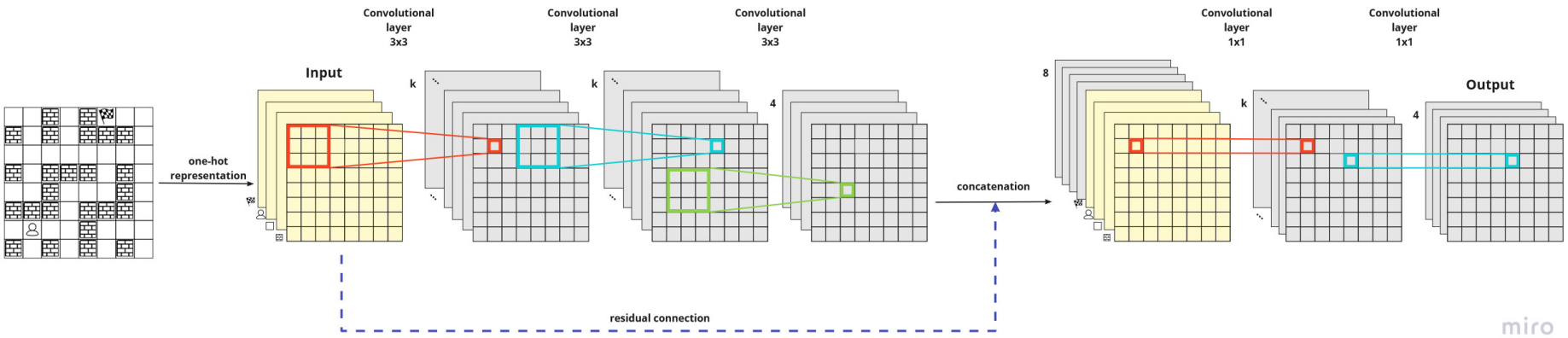


Expansion network



Expansion network

- Convolutional neural network
- 4-neighborhood movement possible
- 3×3 convolutional window to see the surroundings of the agent
- residual connection in the architecture to not loose initial information

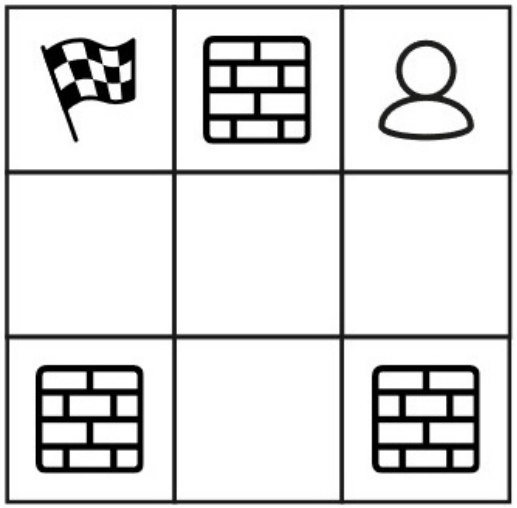


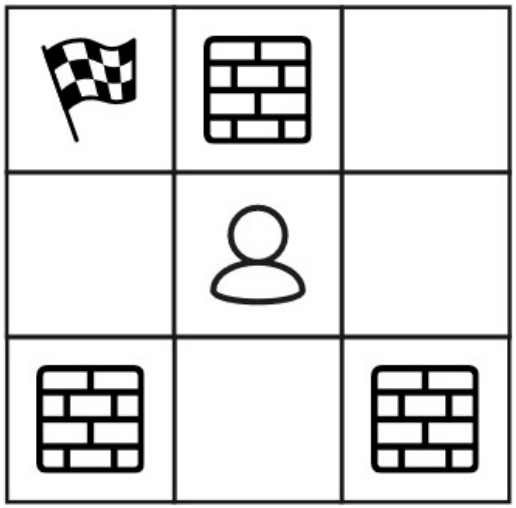
Heuristic network

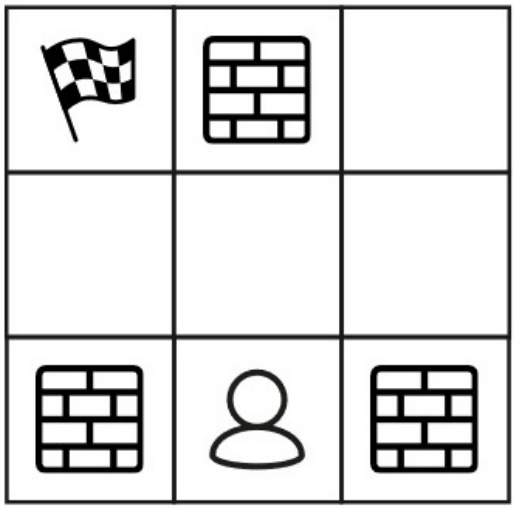
- 3 architectures
- **CNN** - convolutional neural network (most simple)
- **CNN_att** - convolutional neural network using attention
- **RNN** - reasoning recurrent network using MAC cell
- Inspiration in landmarks, relaxations, abstractions...
- Each architecture has intuition

Heuristic network - loss function

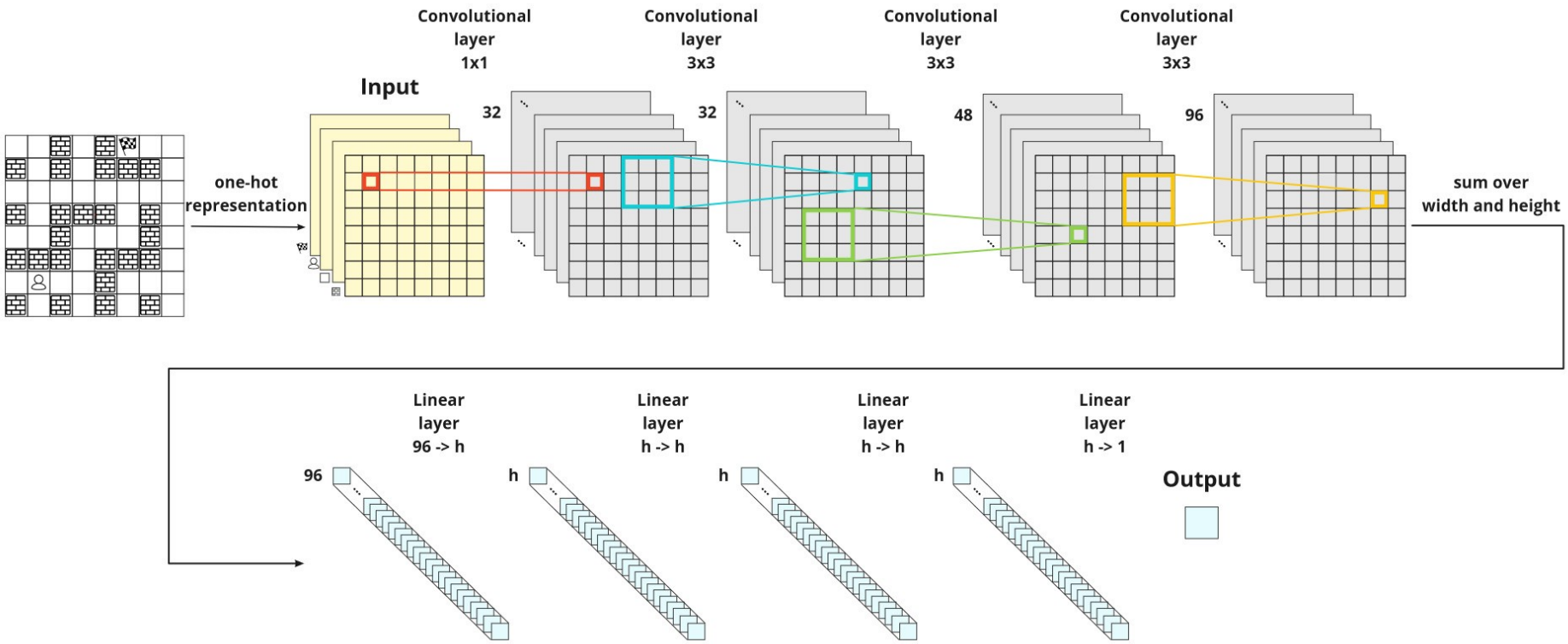
- We're learning **monotonocity**
- Property of any good heuristic
- sample + label pairs aren't enough anymore
- one instance with multiple agent placements



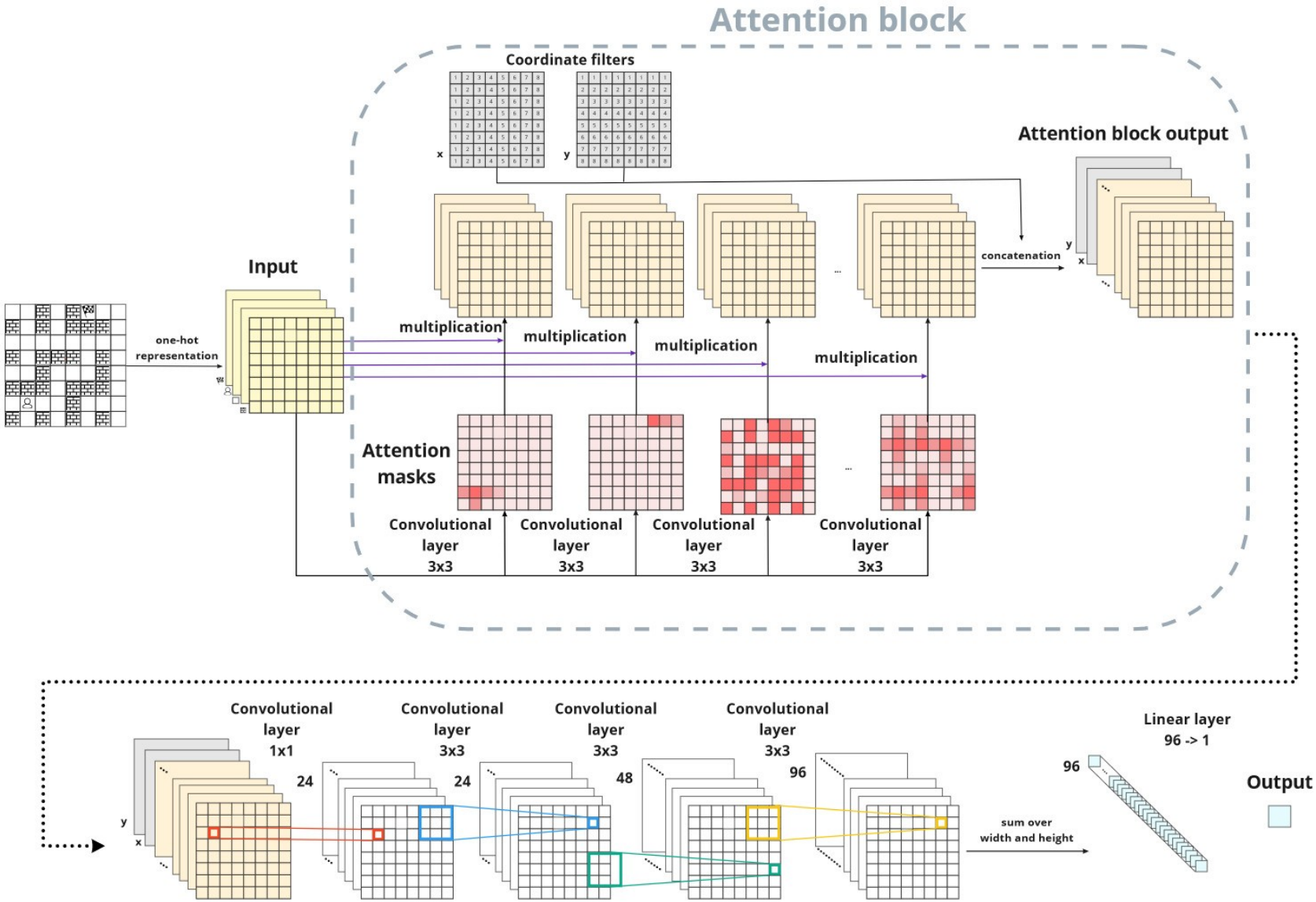




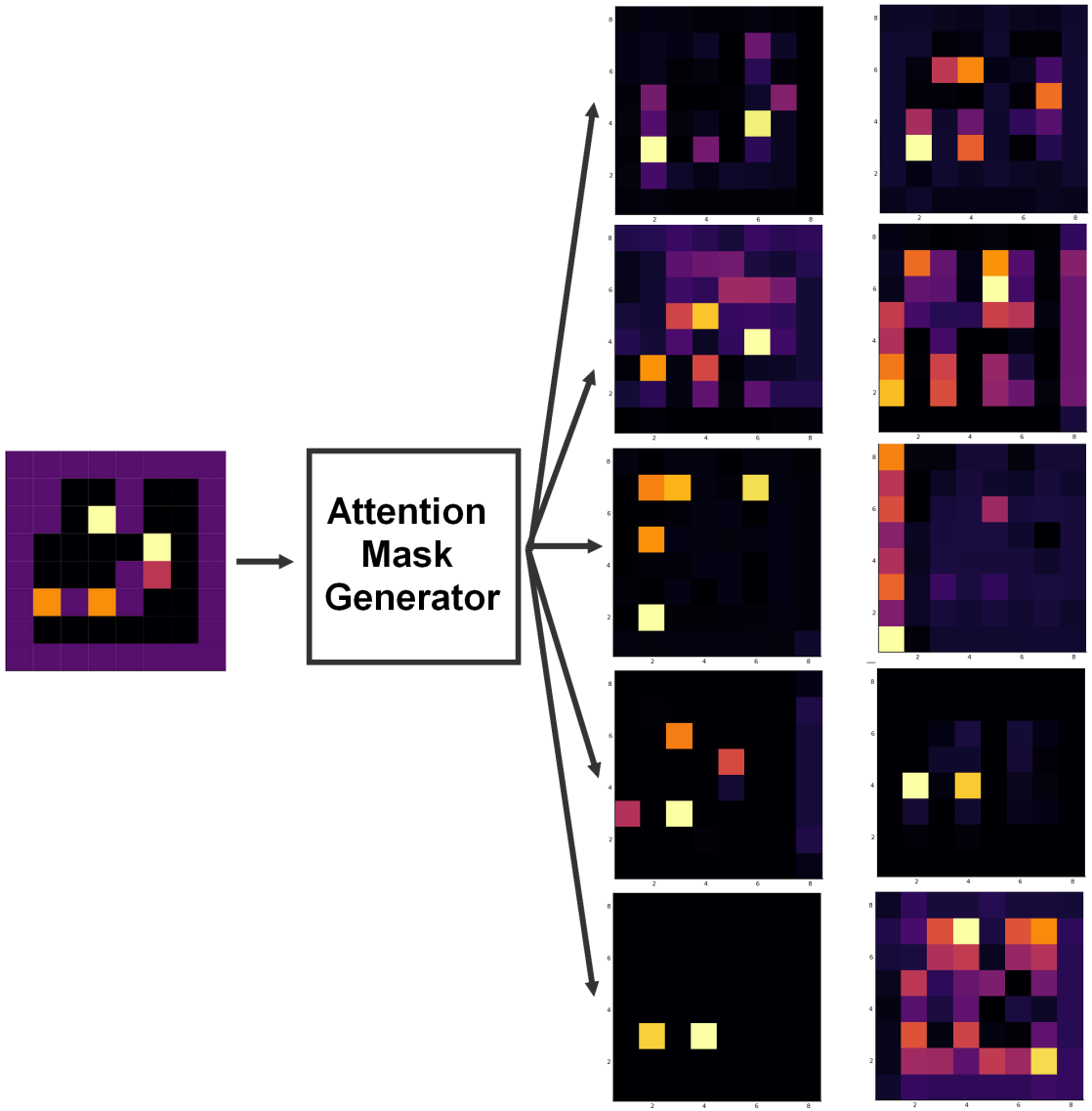
Heuristic network - CNN



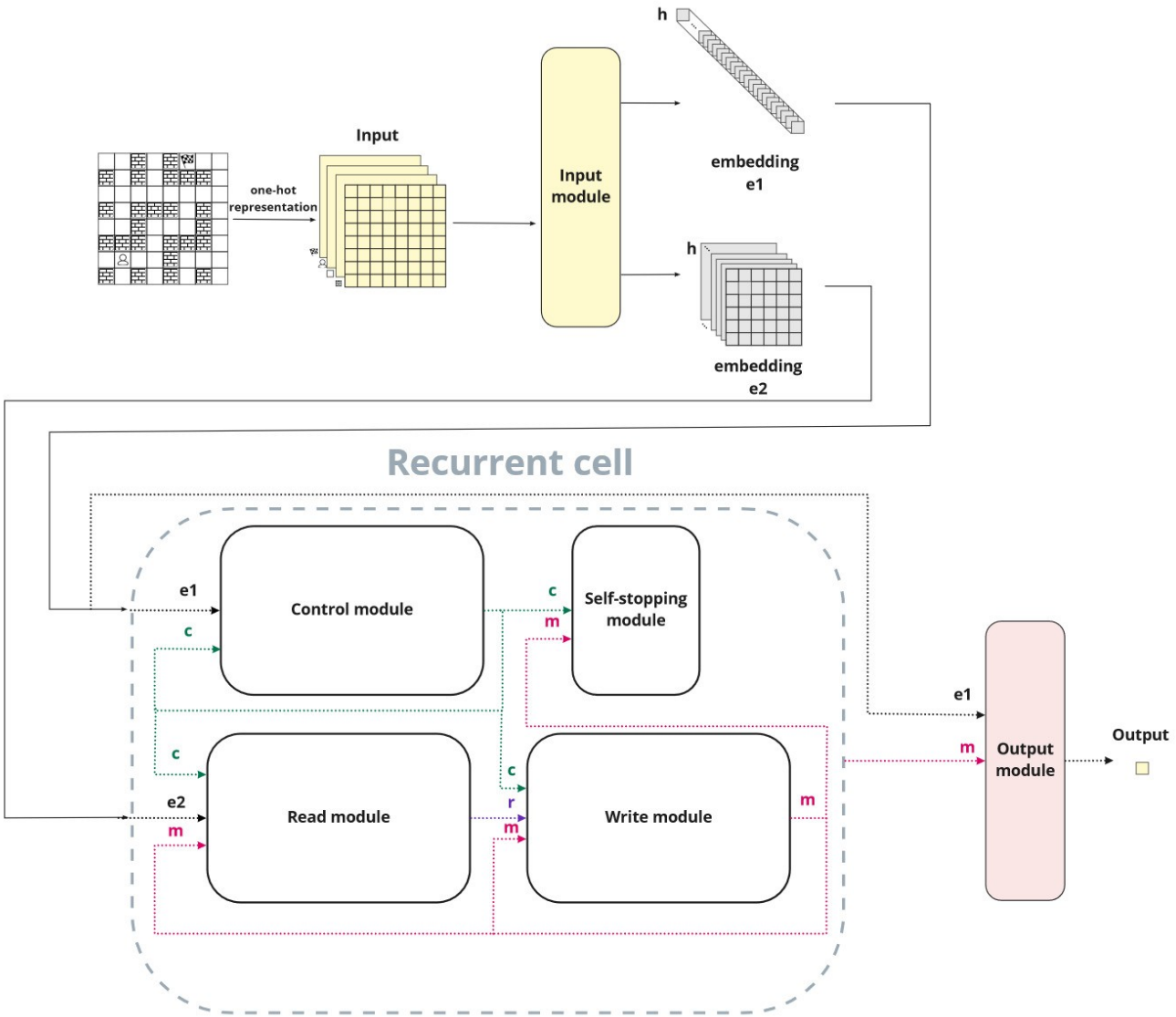
Heuristic network - CNN_att



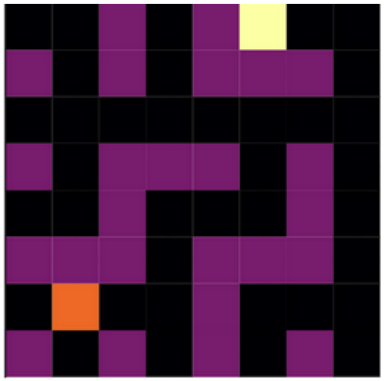
Heuristic network - CNN_att Sokoban attention masks

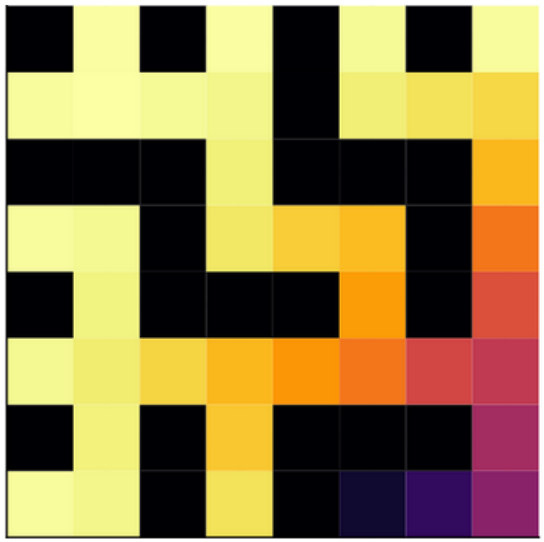


Heuristic network - RNN

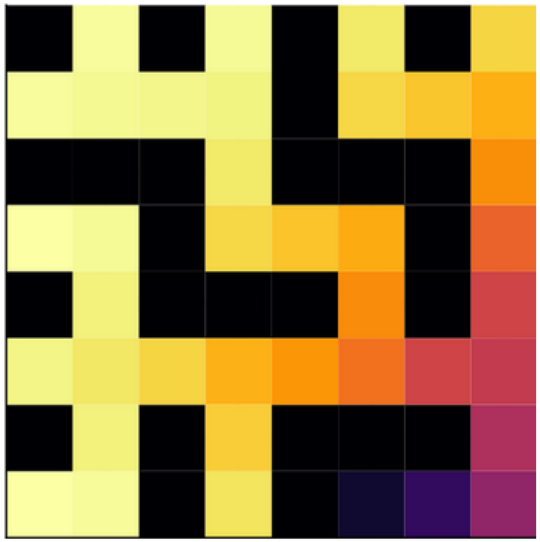


Architecture comparison - 8×8

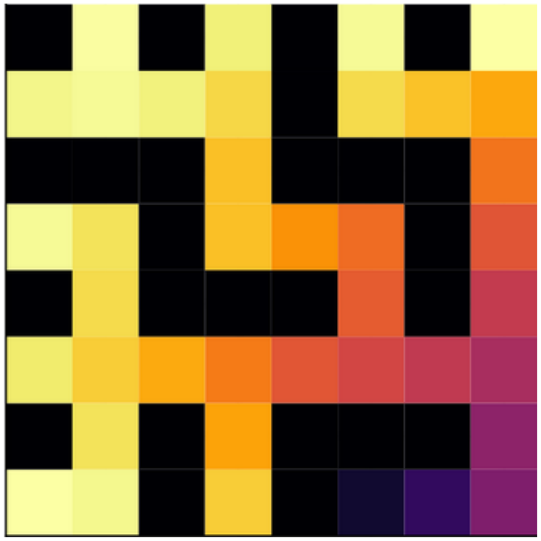




CNN

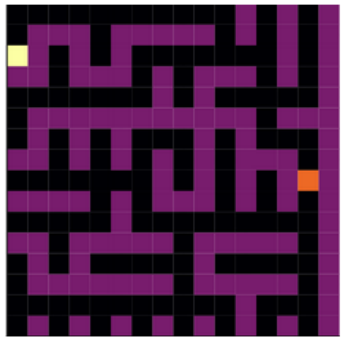


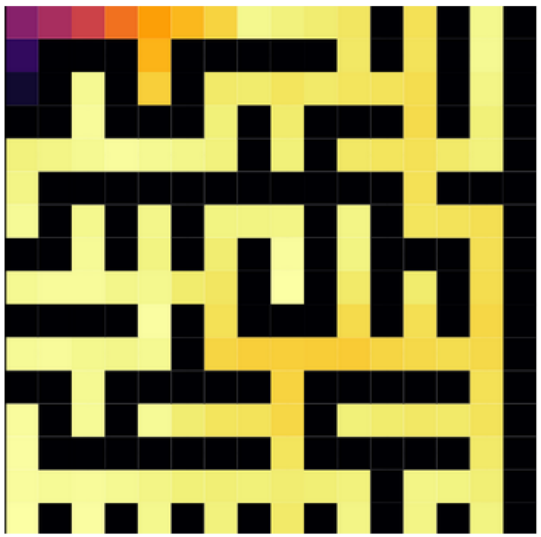
CNN att



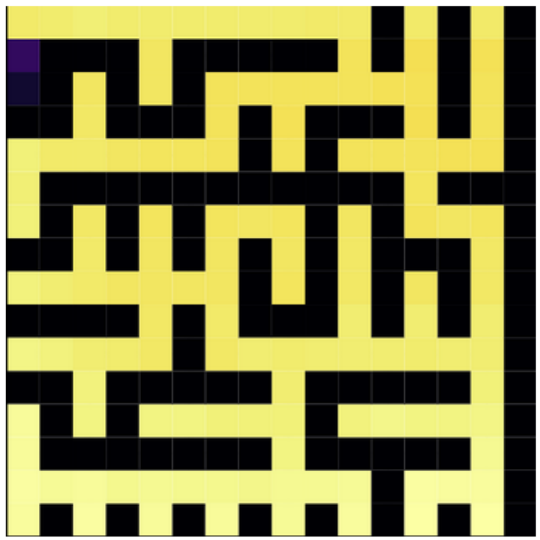
RNN

Architecture comparison - 16 × 16

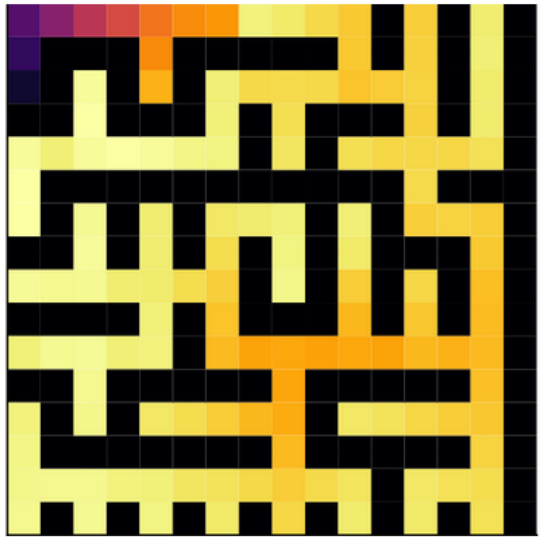




CNN

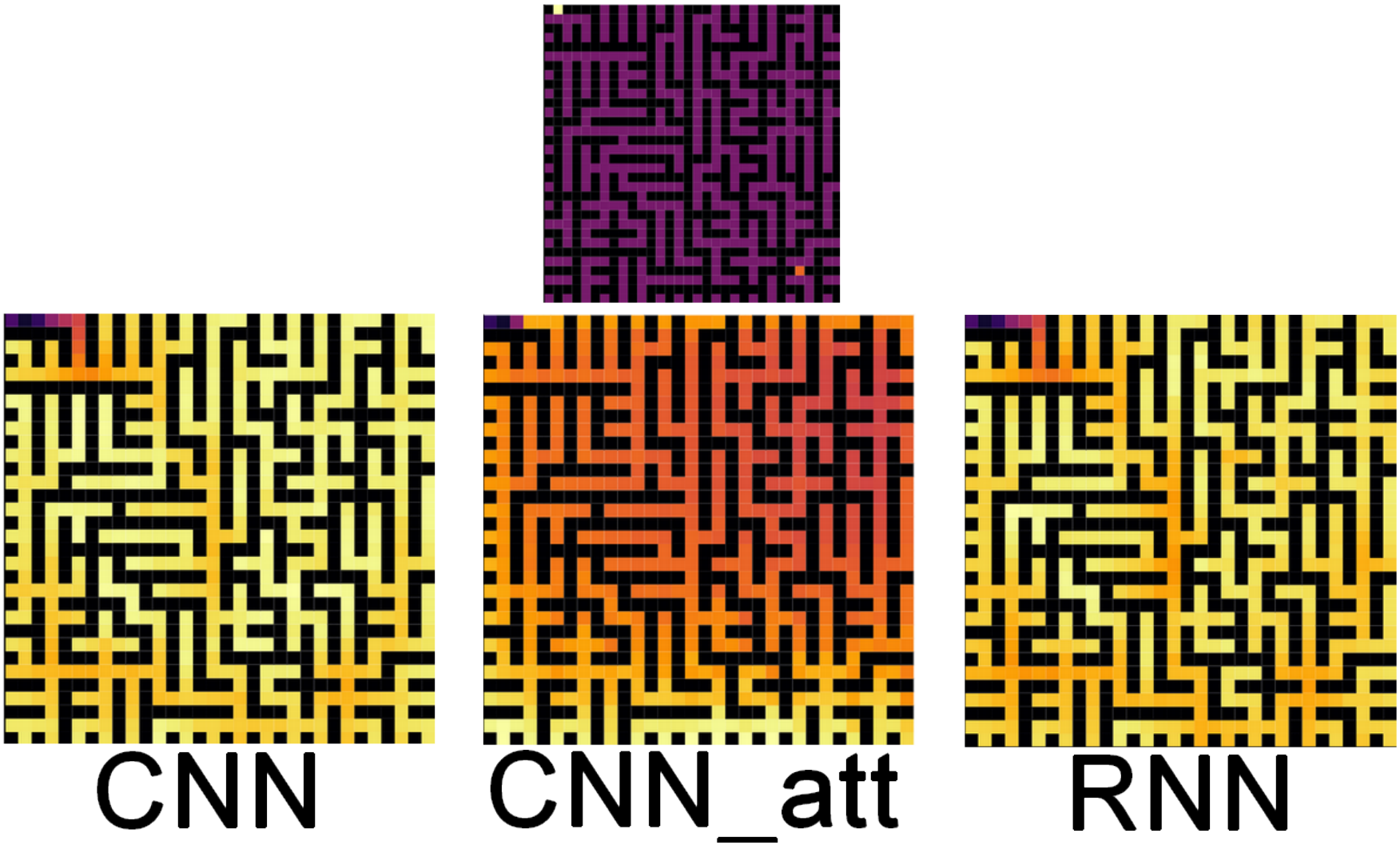


CNN_att

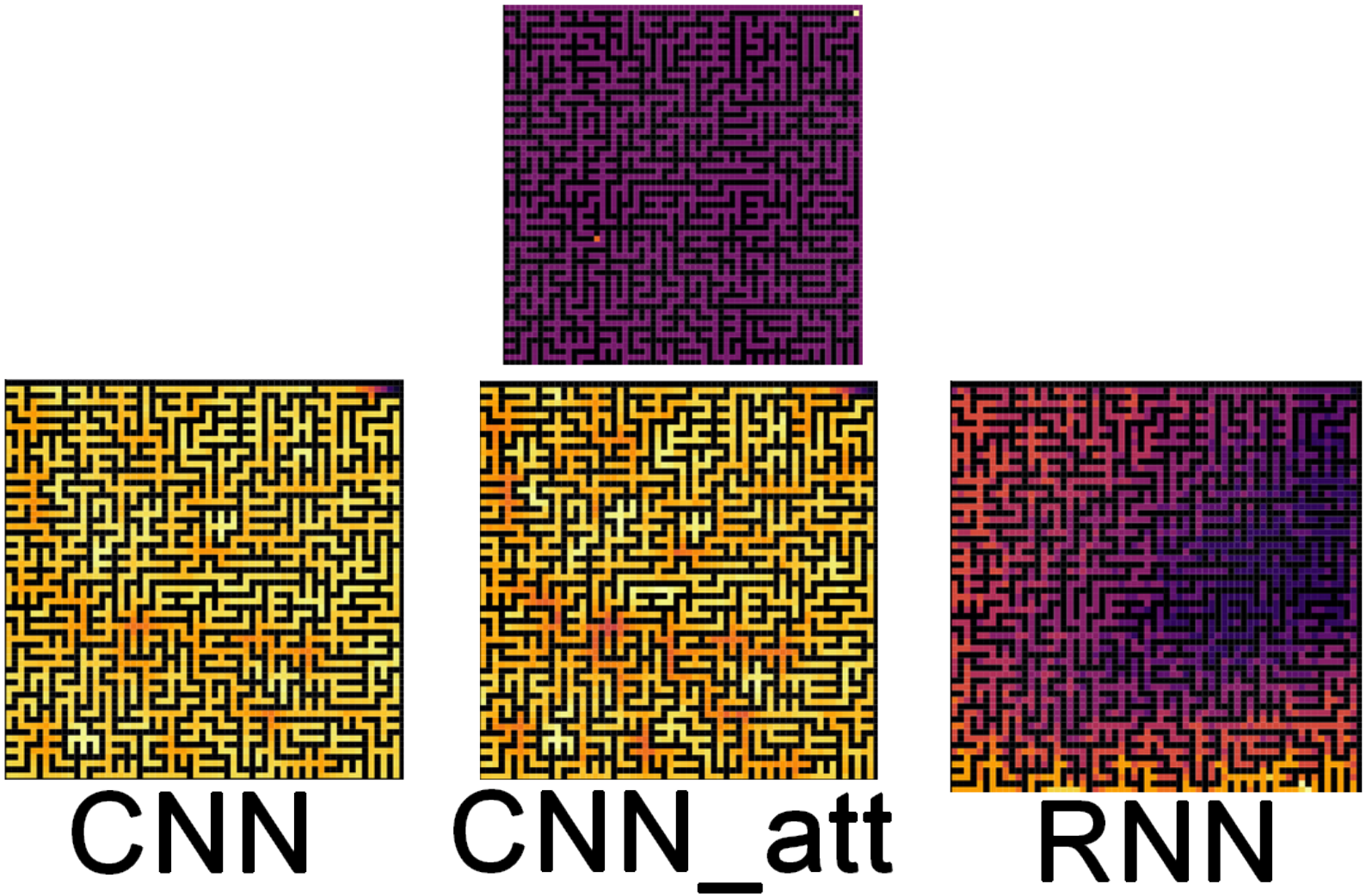


RNN

Architecture comparison - 32×32



Architecture comparison - 64 × 64



Experiments

- We tested all architectures against Euclidean distance, h^{LM-Cut} and h^{FF} heuristics
- Results on par on small domains
- Time advantage in large complex domains
- Less informed values in large state-spaces
- Slower expansion can slow down the search too much

Future plans

- More domains!
- Bootstrapping
- Different approaches entirely?
- Explainability of the architectures

Recap

- Planning can be combined with other disciplines
- Neural networks aren't almighty
- Combination is the key!
- If you're interested in this direction (or any other planning direction) let us know!
  - Thesis topics
  - Possibly summer jobs
  - Other cooperation :)

The End

Feedback form link