Playing Atari games with an Interpretable Agent

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Sylvain Cussat-Blanc and Hervé Luga

June 3, 2021

Playing Atari games (from pixels input)

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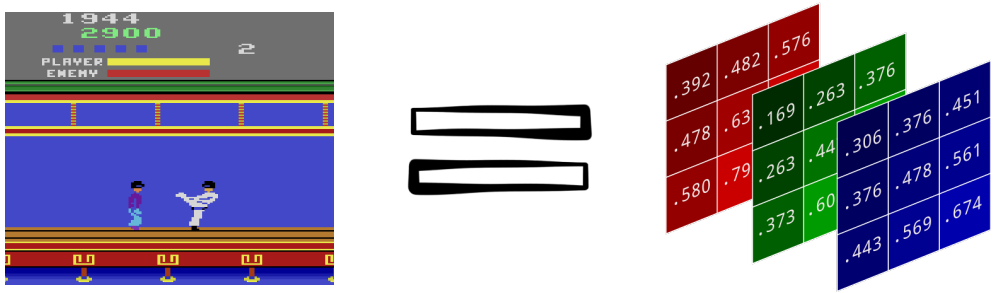
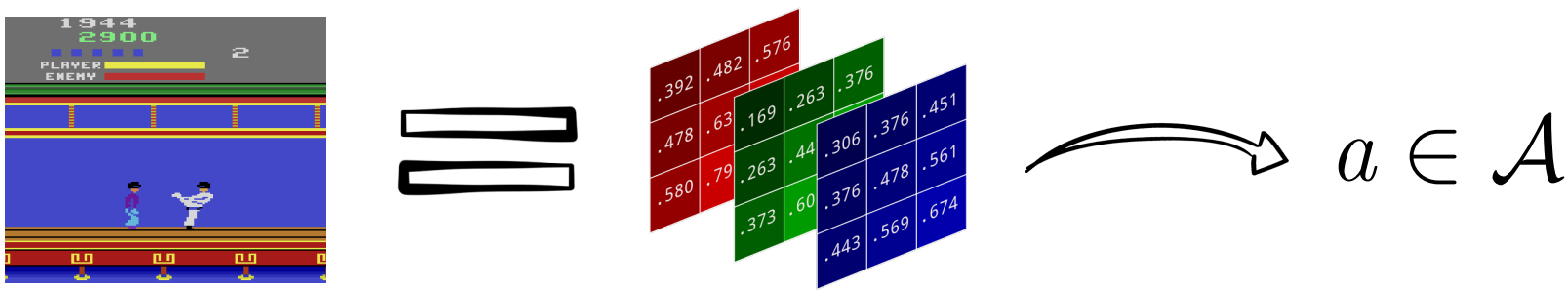


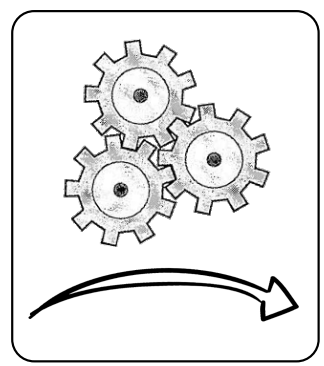
Playing Atari games (from pixels input)



Playing Atari games (from pixels input)

$=$

Agent



$a \in \mathcal{A}$

Interpretability

Interpretability

Interpretability is the degree to which a human can understand the cause of a decision[1].

[1] Miller, Tim. "Explanation in artificial intelligence: Insights from the social sciences." Artificial intelligence 267 (2019): 1-38

Interpretability in Atari

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Why did you take the action “kick”?

Interpretability in Atari

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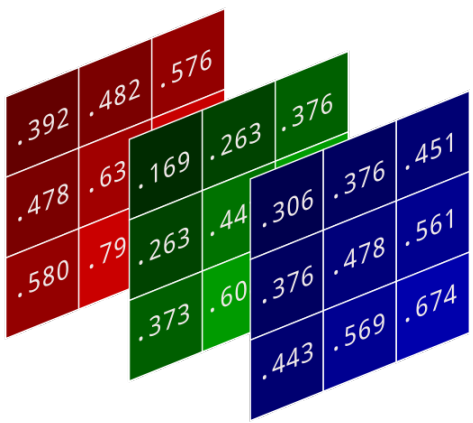
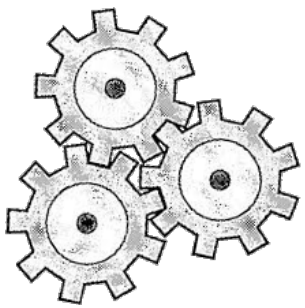
Because:





$a = \text{kick}$

Interpretability in Atari

Why did you take the action “kick”?

Because:

$$\hat{M}\left(a = \text{kick} \;\middle|\; \right) \geq \hat{M}\left(a \neq \text{kick} \;\middle|\; \right)$$

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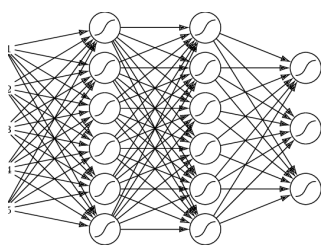

Interpretability in Atari

Why did you take the action “kick”?

Because:

$$\sigma(0.403 \times 0.635 + 0.472 \times 0.687 + 0.281 \times 0.53 + 0.866 \times 0.931 + 0.182 \times 0.427 + 0.834 \times 0.913 + \sigma(0.986 \times 0.993 + 0.169 \times 0.412) + 0.755 \times 0.869 + 0.352 \times 0.593 + 0.366 \times 0.605) + \sigma(0.662 \times 0.813 + 0.639 \times 0.8 + 0.281 \times 0.53 + 0.516 \times 0.718 + 0.187 \times 0.432) + \sigma(0.867 \times 0.931 + 0.917 \times 0.958 + 0.793 \times 0.89 + 0.393 \times 0.627 + 0.281 \times 0.531 + 0.5 \times 0.707 + 0.772 \times 0.879) + \sigma(0.854 \times 0.924 + 0.411 \times 0.641 + 0.052 \times 0.228 + \sigma(0.712 \times 0.844 + 0.959 \times 0.979) + 0.197 \times 0.444 + 0.456 \times 0.675 + 0.785 \times 0.886) + \sigma(0.72 \times 0.849 + 0.998 \times 0.999 + 0.216 \times 0.465 + 0.034 \times 0.184 + 0.003 \times 0.058 + 0.55 \times 0.741 + 0.949 \times 0.974 + 0.815 \times 0.903) + \sigma(0.768 \times 0.876 + 0.494 \times 0.703 + 0.838 \times 0.915) + \sigma(0.153 \times 0.391 + 0.103 \times 0.322 + 0.344 \times 0.587 + 0.136 \times 0.369 + 0.115 \times 0.339 + 0.295 \times 0.543 + 0.656 \times 0.81 + 0.04 \times 0.2) + \sigma(0.403 \times 0.635 + 0.472 \times 0.687 + 0.281 \times 0.53 + 0.866 \times 0.931 + 0.182 \times 0.427 + 0.834 \times 0.913 + \sigma(0.986 \times 0.993 + 0.169 \times 0.412) + 0.755 \times 0.869 + 0.352 \times 0.593 + 0.366 \times 0.605) + \sigma(0.662 \times 0.813 + 0.639 \times 0.8 + 0.281 \times 0.53 + 0.516 \times 0.718 + 0.187 \times 0.432) + \sigma(0.867 \times 0.931 + 0.917 \times 0.958 + 0.793 \times 0.89 + 0.393 \times 0.627 + 0.281 \times 0.531 + 0.5 \times 0.707 + 0.772 \times 0.879) + \sigma(0.854 \times 0.924 + 0.411 \times 0.641 + 0.052 \times 0.228 + \sigma(0.712 \times 0.844 + 0.959 \times 0.979) + 0.197 \times 0.444 + 0.456 \times 0.675 + 0.785 \times 0.886) + \sigma(0.72 \times 0.849 + 0.998 \times 0.999 + 0.216 \times 0.465 + 0.034 \times 0.184 + 0.003 \times 0.058 + 0.55 \times 0.741 + 0.949 \times 0.974 + 0.815 \times 0.903) + \sigma(0.768 \times 0.876 + 0.494 \times 0.703 + 0.838 \times 0.915) + \sigma(0.153 \times 0.391 + 0.103 \times 0.322 + 0.344 \times 0.587 + 0.136 \times 0.369 + 0.115 \times 0.339 + 0.295 \times 0.543 + 0.656 \times 0.81 + 0.04 \times 0.2)$$

$$\geq$$

$$\sigma(0.662 \times 0.813 + 0.639 \times 0.8 + 0.281 \times 0.53 + 0.516 \times 0.718 + 0.187 \times 0.432) + \sigma(0.867 \times 0.931 + 0.917 \times 0.958 + 0.793 \times 0.89 + 0.393 \times 0.627 + 0.281 \times 0.531 + 0.5 \times 0.707 + 0.772 \times 0.879) + \sigma(0.854 \times 0.924 + 0.411 \times 0.641 + 0.052 \times 0.228 + \sigma(0.712 \times 0.844 + 0.959 \times 0.979) + 0.197 \times 0.444 + 0.456 \times 0.675 + 0.785 \times 0.886) + \sigma(0.72 \times 0.849 + 0.998 \times 0.999 + 0.216 \times 0.465 + 0.034 \times 0.184 + 0.003 \times 0.058 + 0.55 \times 0.741 + 0.949 \times 0.974 + 0.815 \times 0.903) + \sigma(0.768 \times 0.876 + 0.494 \times 0.703 + 0.838 \times 0.915) + \sigma(0.403 \times 0.635 + 0.472 \times 0.687 + 0.281 \times 0.53 + 0.866 \times 0.931 + 0.182 \times 0.427 + 0.834 \times 0.913 + \sigma(0.986 \times 0.993 + 0.169 \times 0.412) + 0.755 \times 0.869 + 0.352 \times 0.593 + 0.366 \times 0.605) + \sigma(0.153 \times 0.391 + 0.103 \times 0.322 + 0.344 \times 0.587 + 0.136 \times 0.369 + 0.115 \times 0.339 + 0.295 \times 0.543 + 0.656 \times 0.81 + 0.04 \times 0.2)$$

Goal: Interpretable Agent

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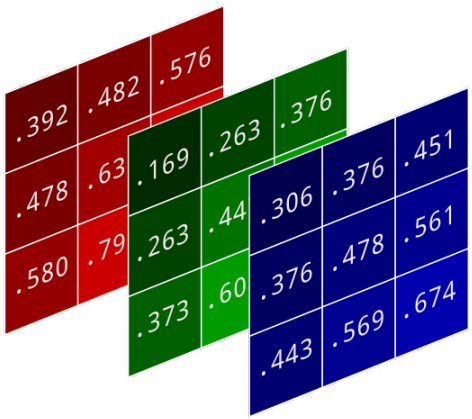

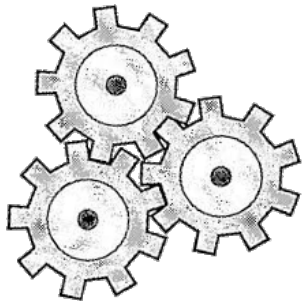

$$a \in \mathcal{A}$$

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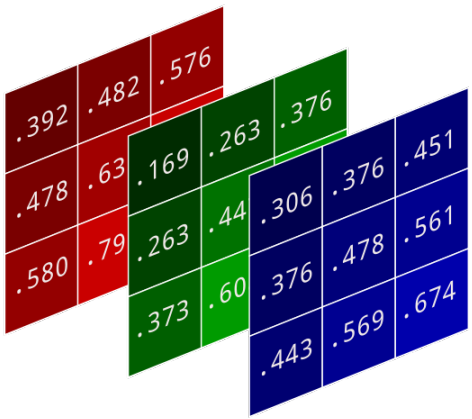

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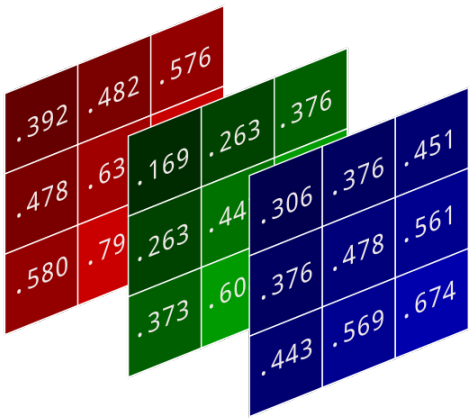

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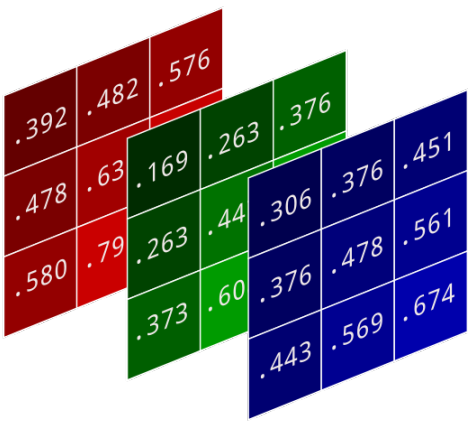

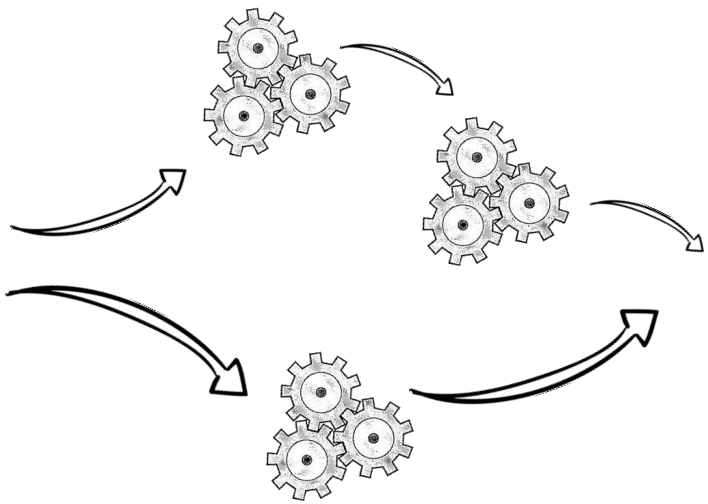

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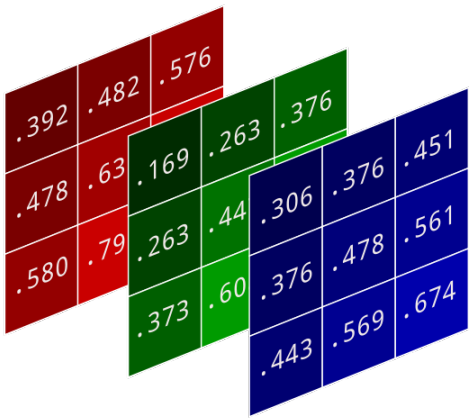

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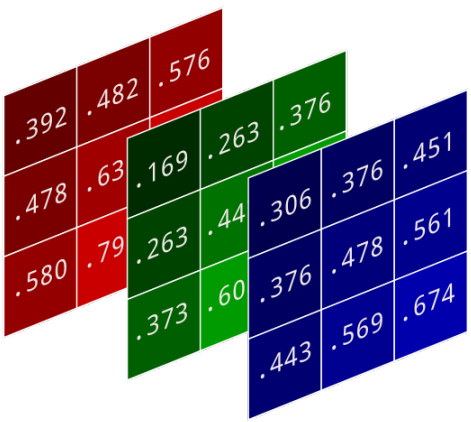

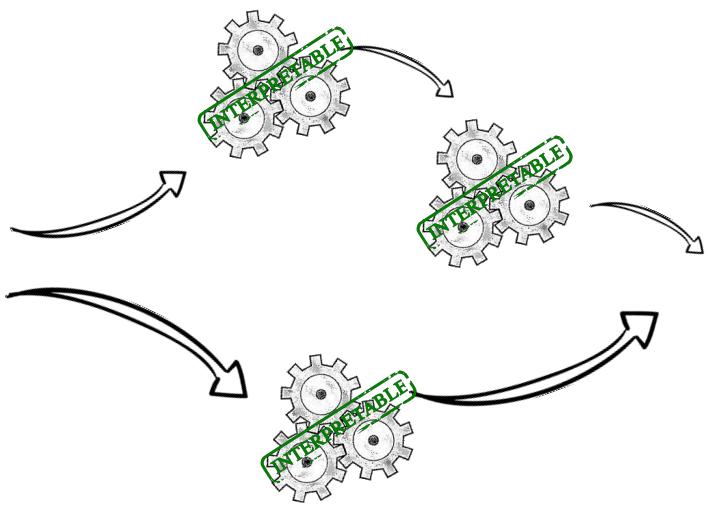

$$a \in \mathcal{A}$$

Approach: Interpretable Encoder – Controller

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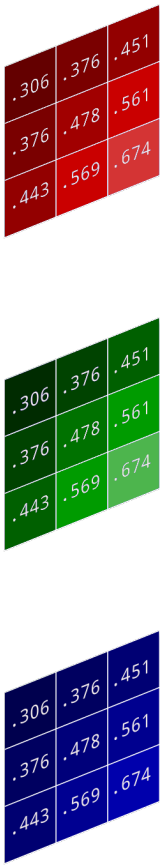
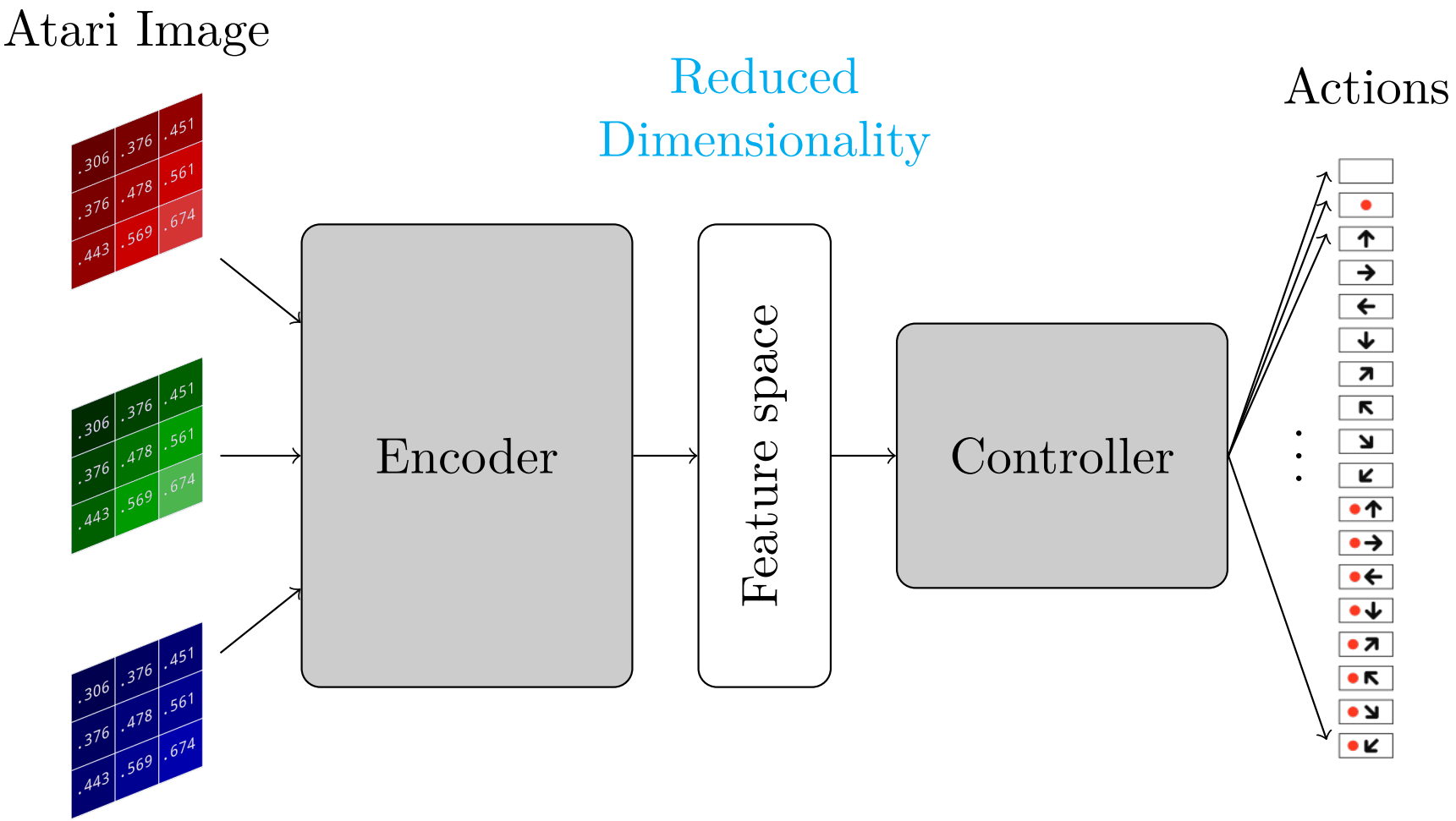
Atari Image



Actions

Approach: Interpretable Encoder – Controller



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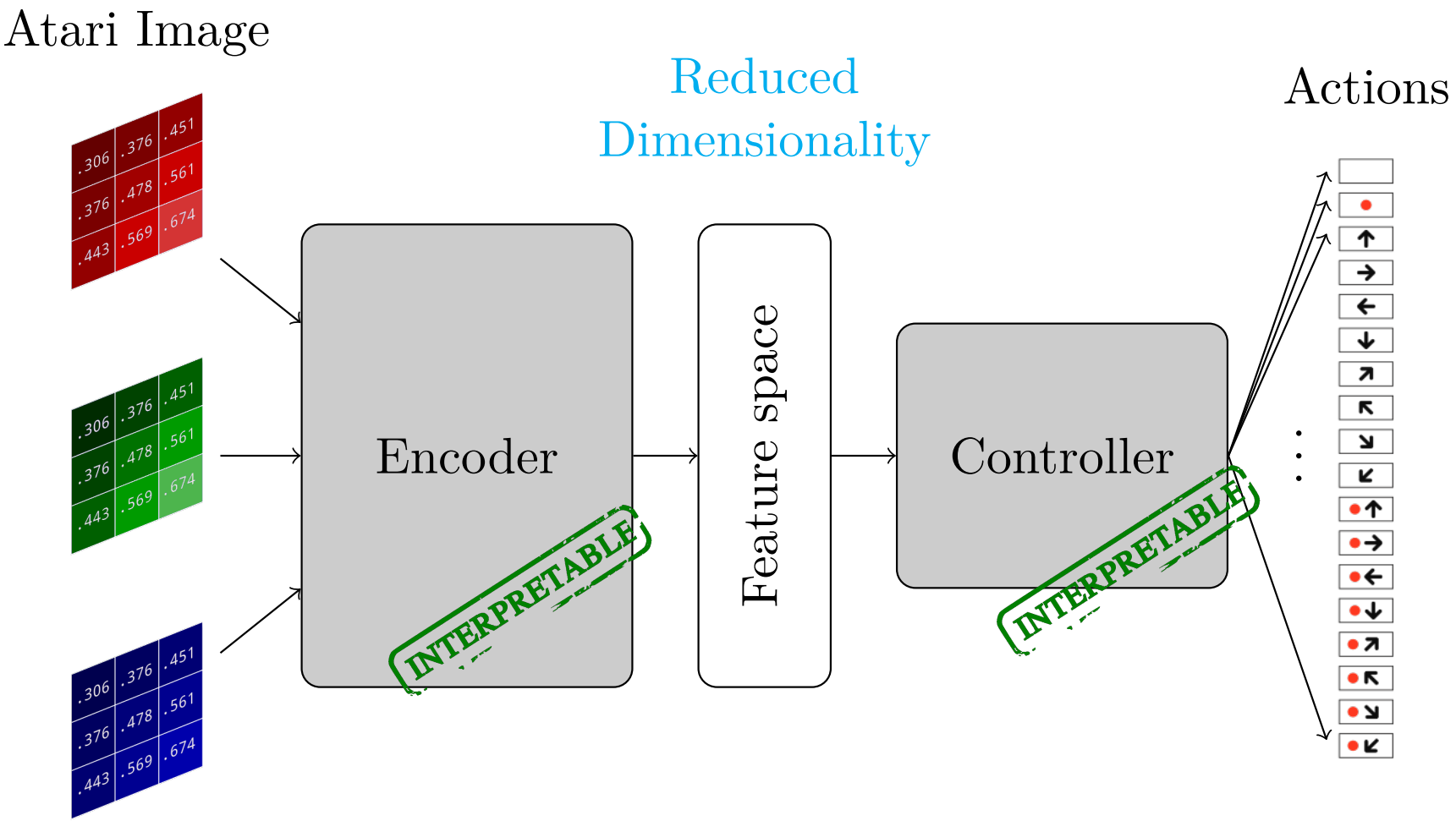
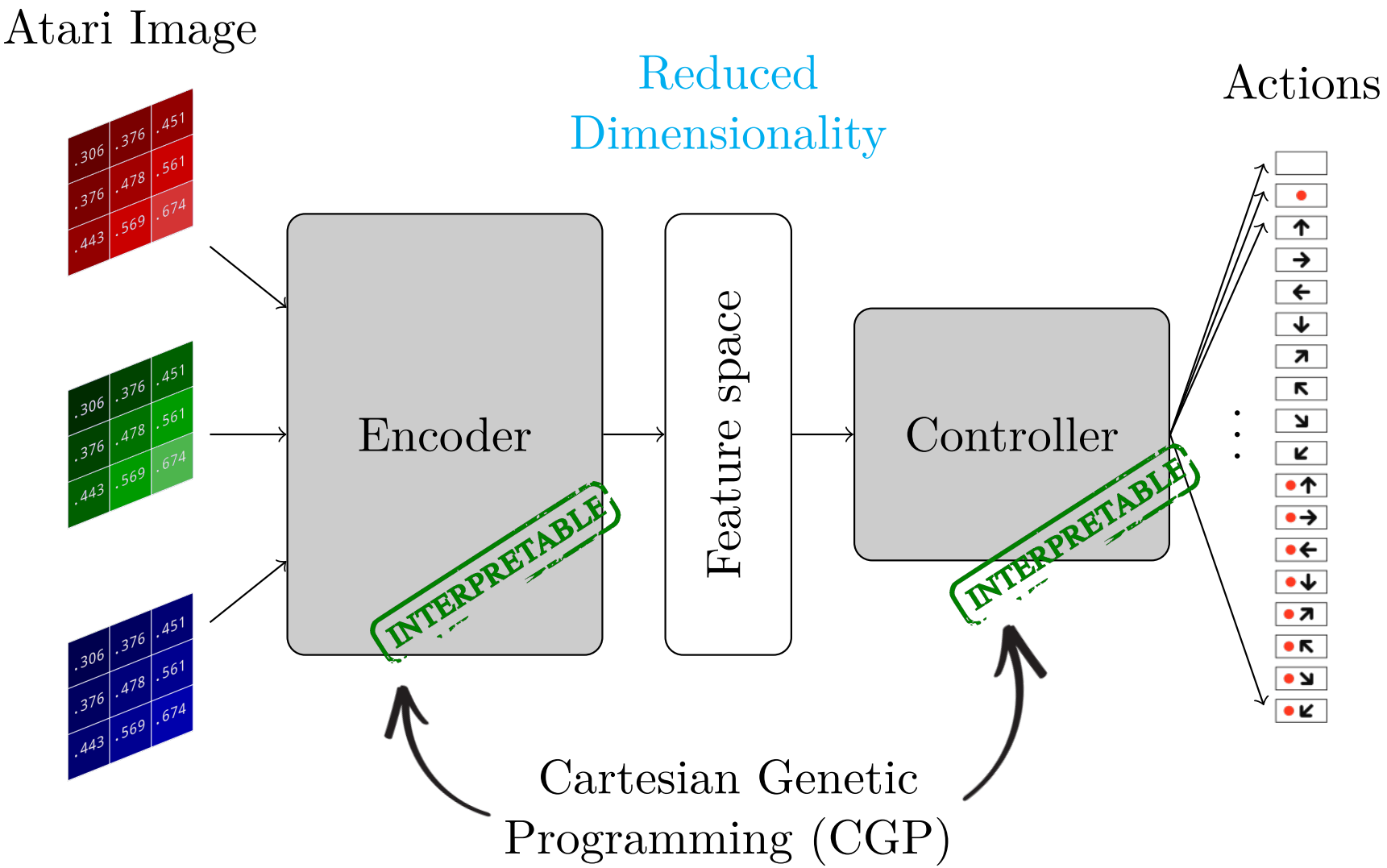


Approach: Interpretable Encoder – Controller



Cartesian Genetic Programming (CGP)

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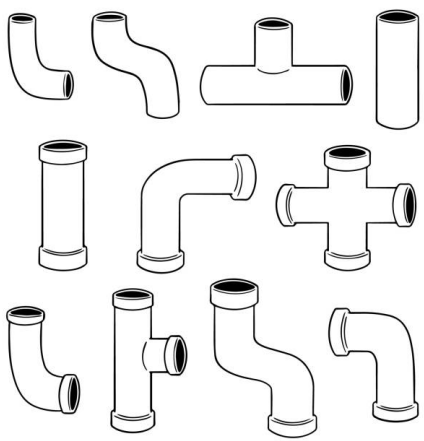
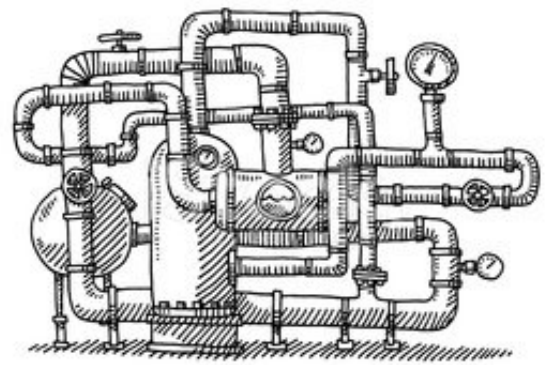


Evolutionary
Algorithm



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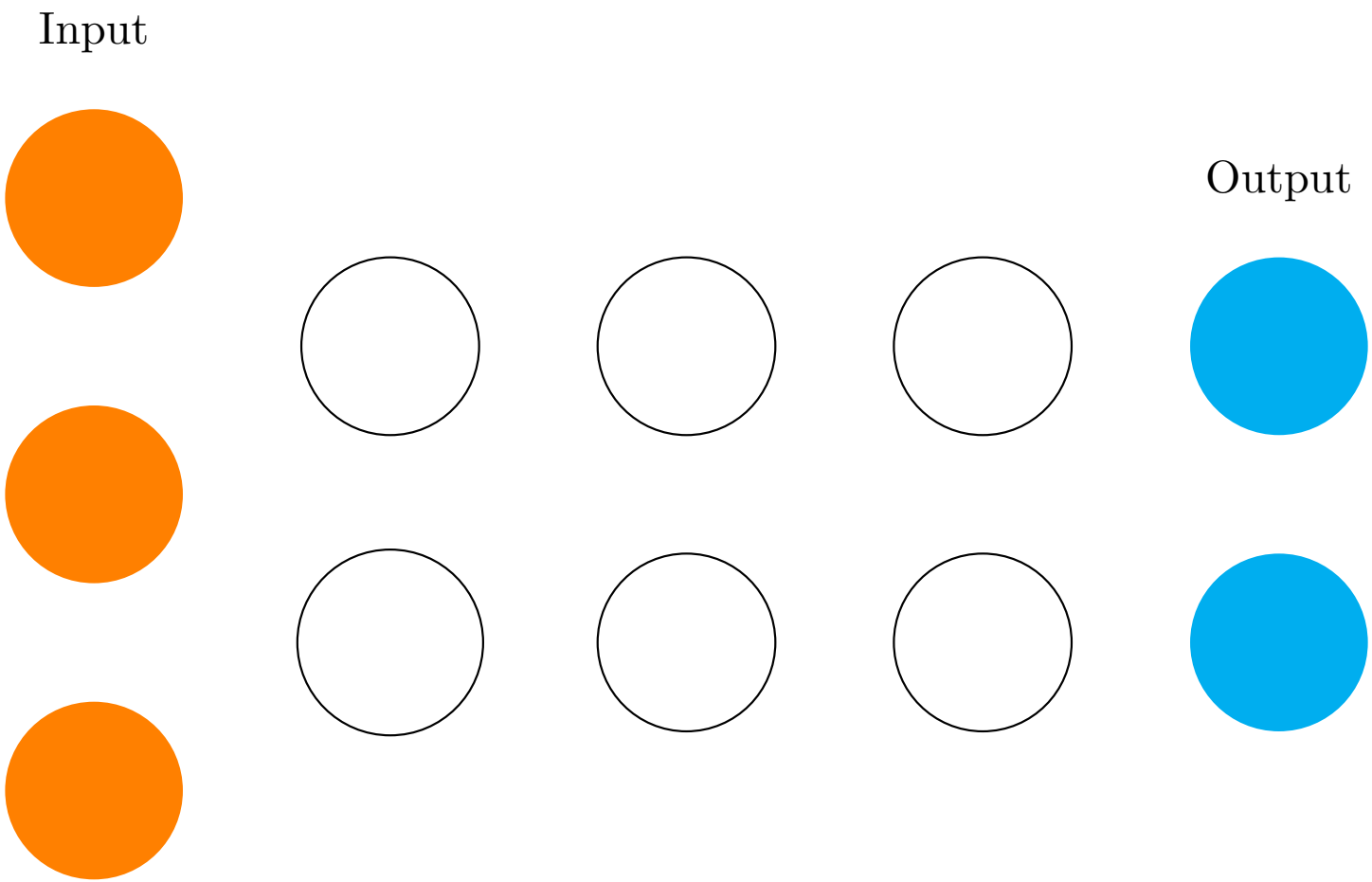

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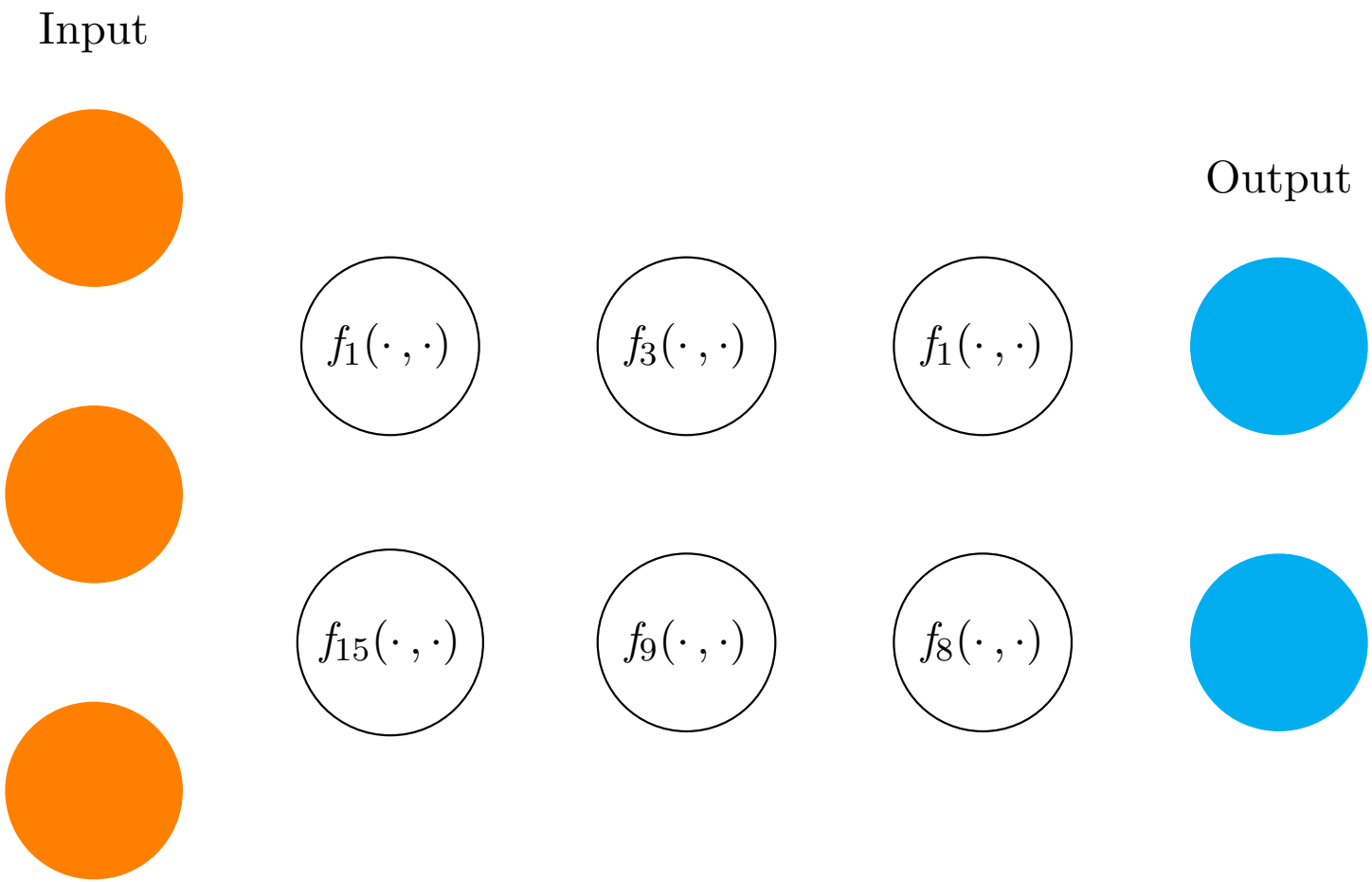

Function pool: $\{f_i : \mathcal{X}^2 \to \mathcal{X}\}_i$

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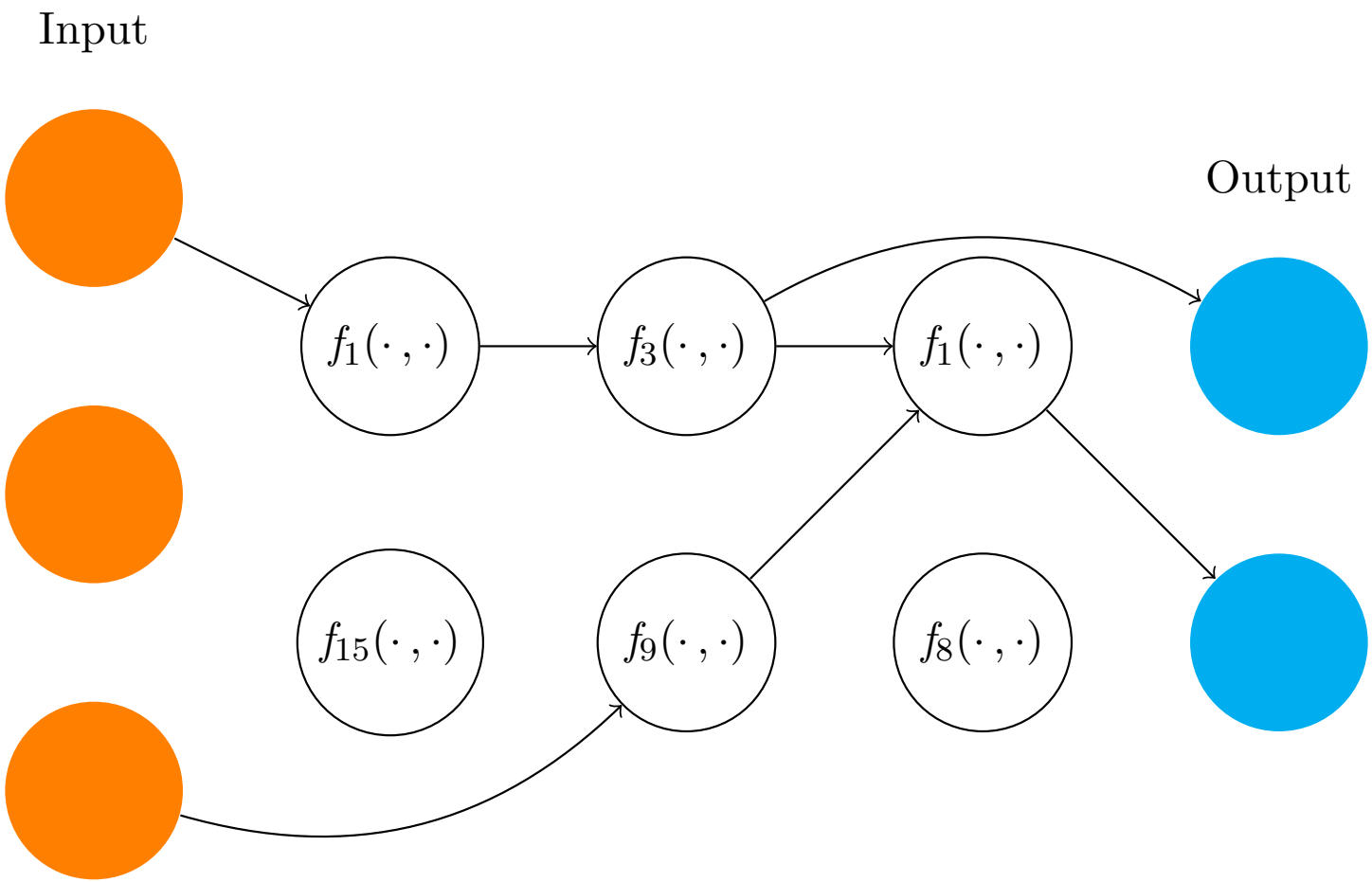

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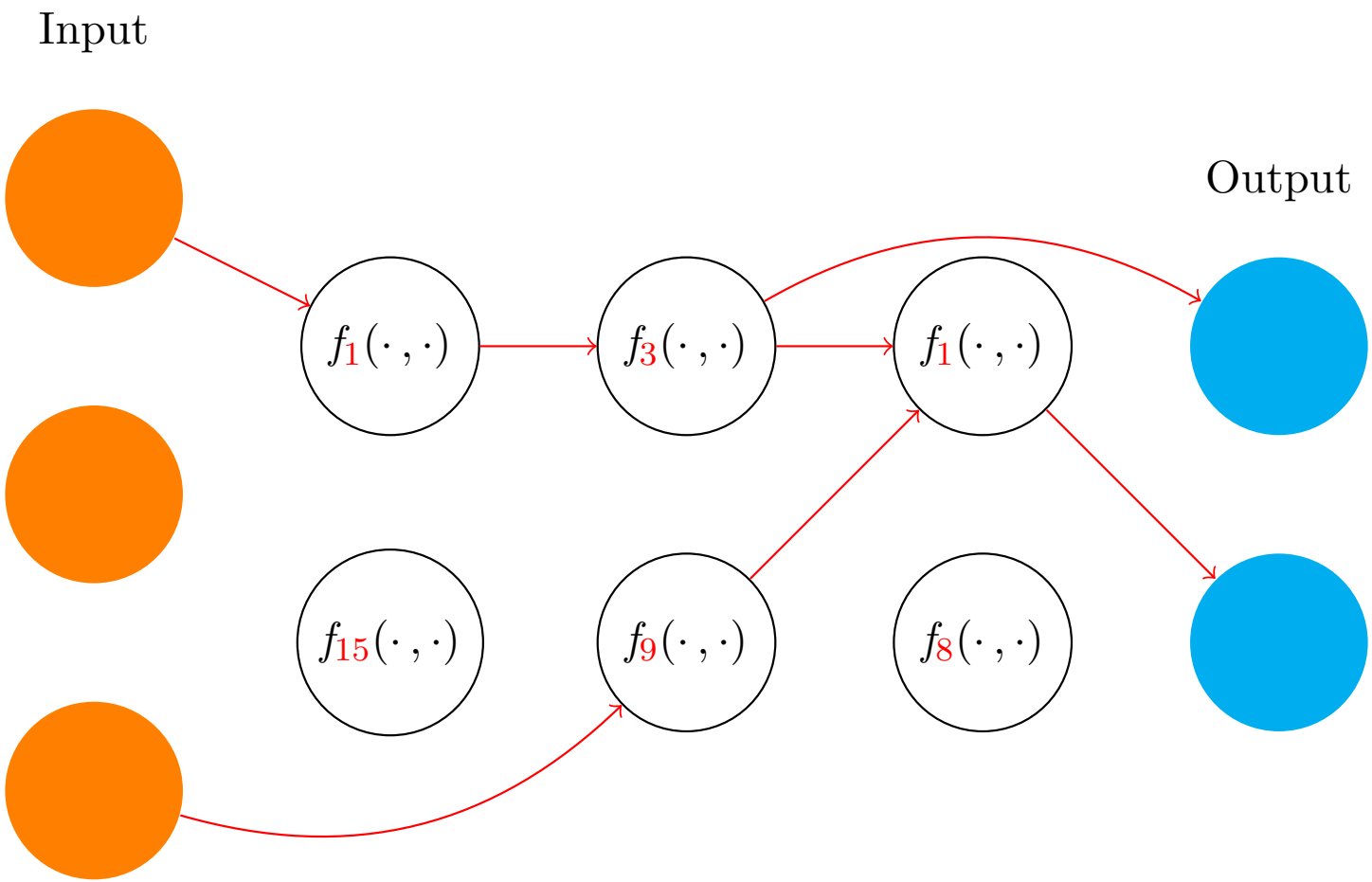
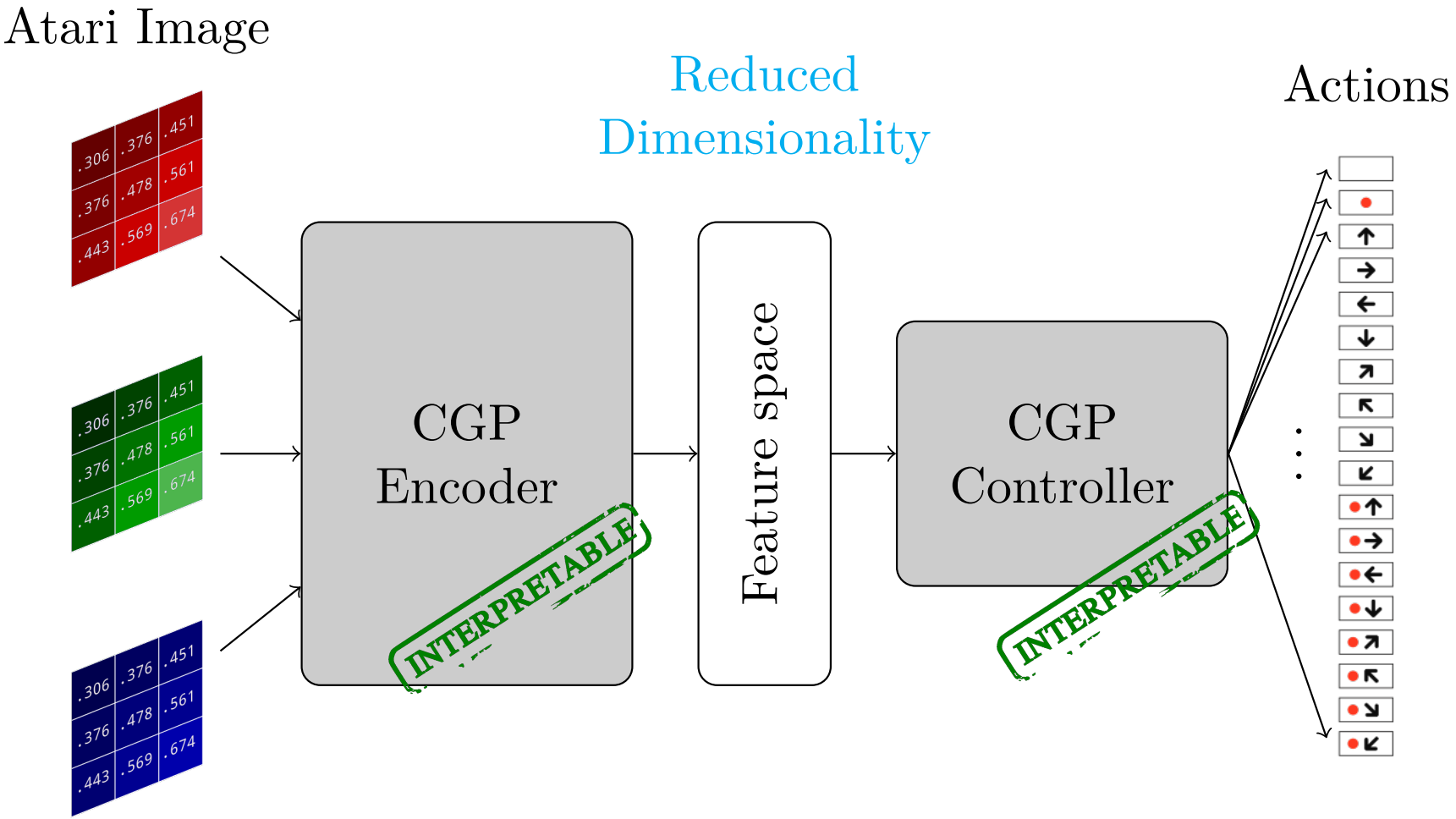


Function pool: $\{f_i : \mathcal{X}^2 \to \mathcal{X}\}_i$

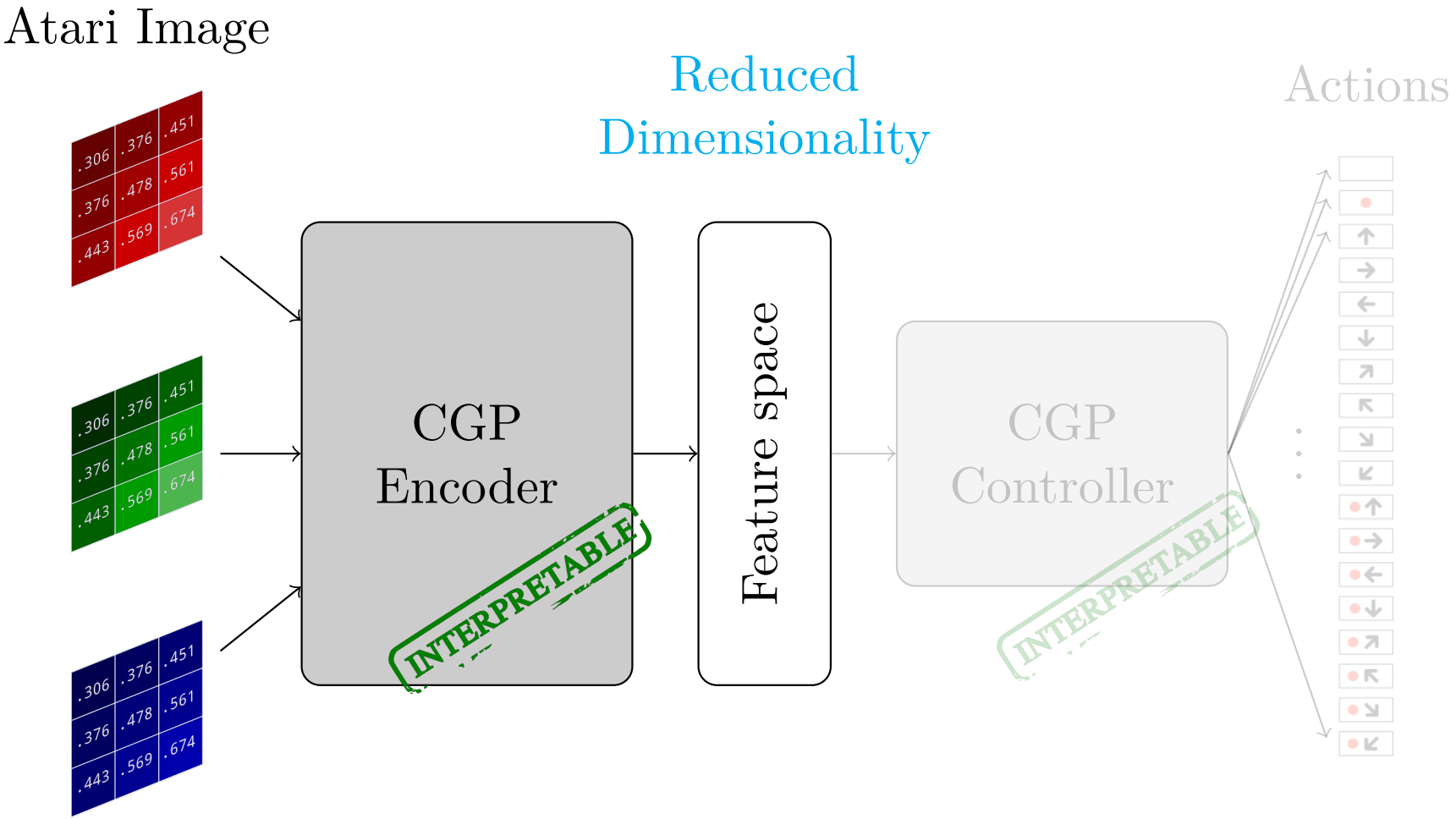
Genotype:

$[1, 1, 2, 13, 1, \ldots, 3] \in \mathbb{N}^{3\times\text{number of nodes} + \text{number of outputs}}$

Approach: Interpretable Encoder – Controller



Approach: Interpretable Encoder – Controller



Encoder's Functions

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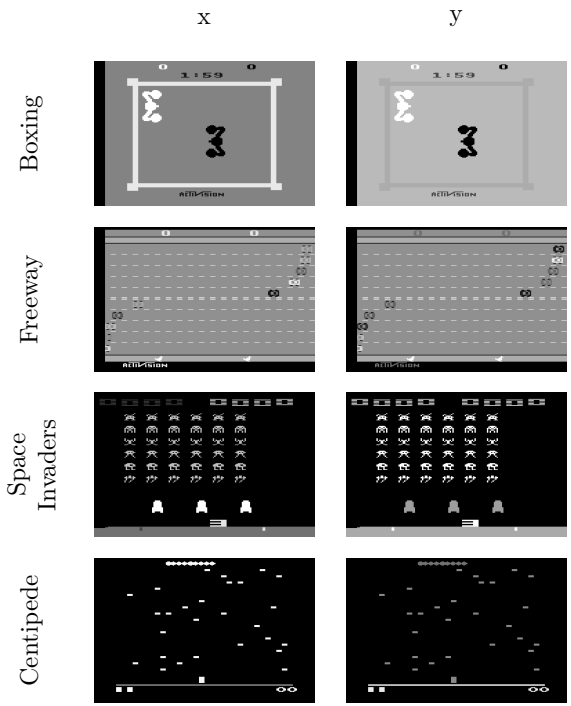

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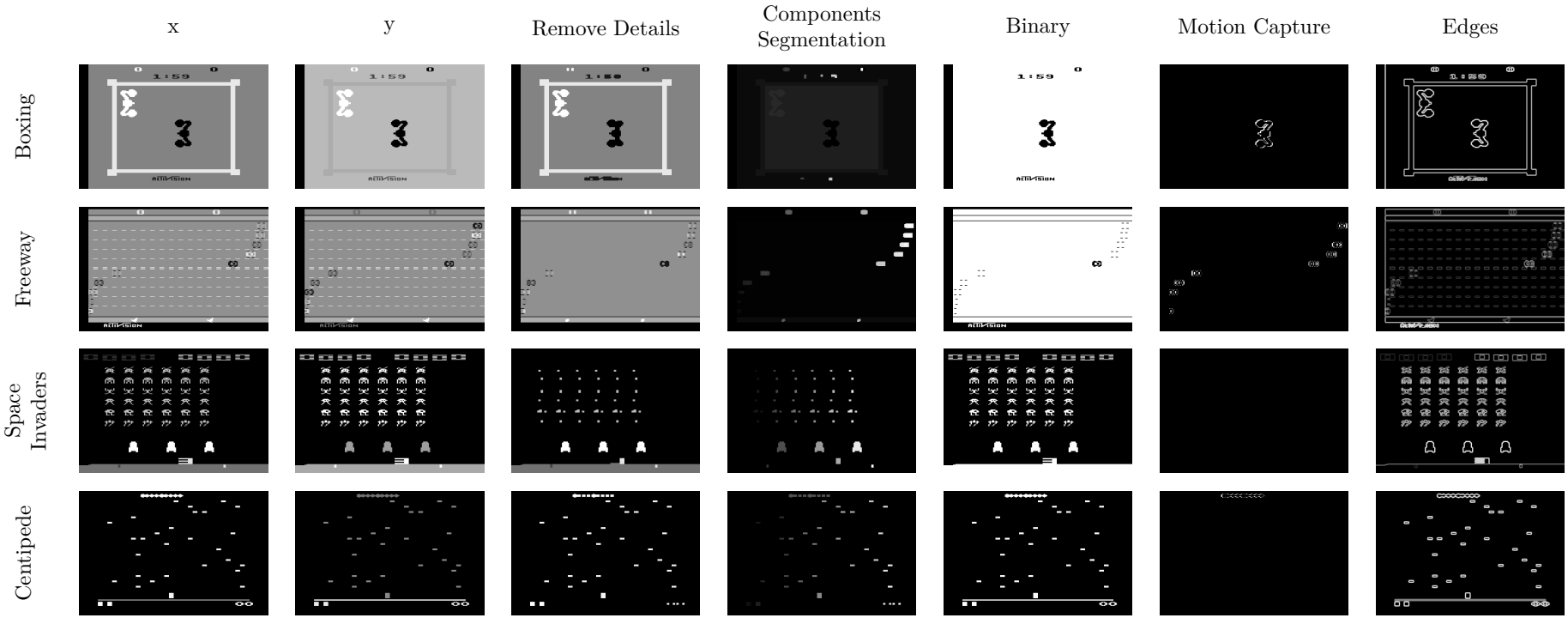

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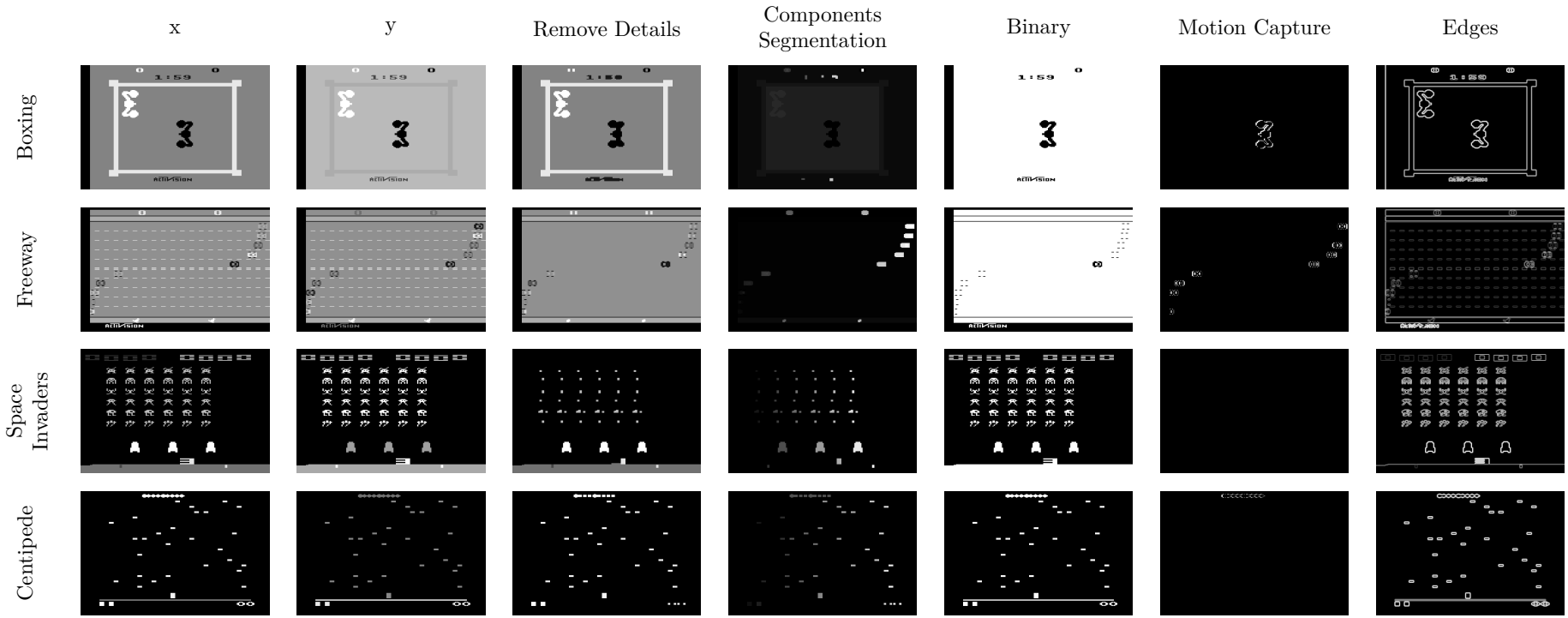
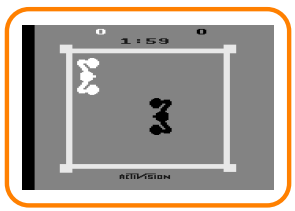


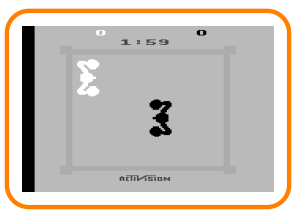
INTERPRETABLE

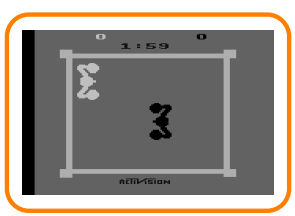
Encoder

Encoder

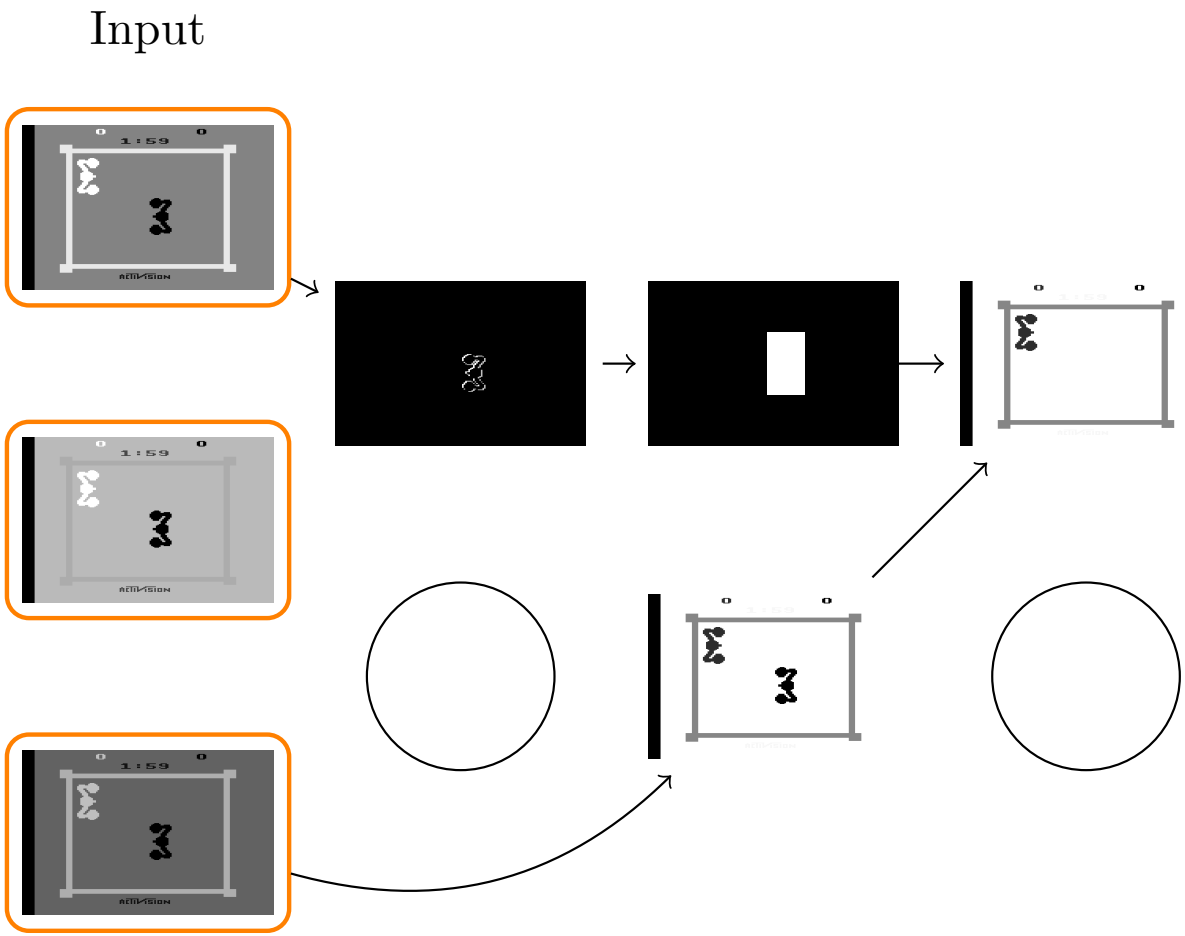
Input



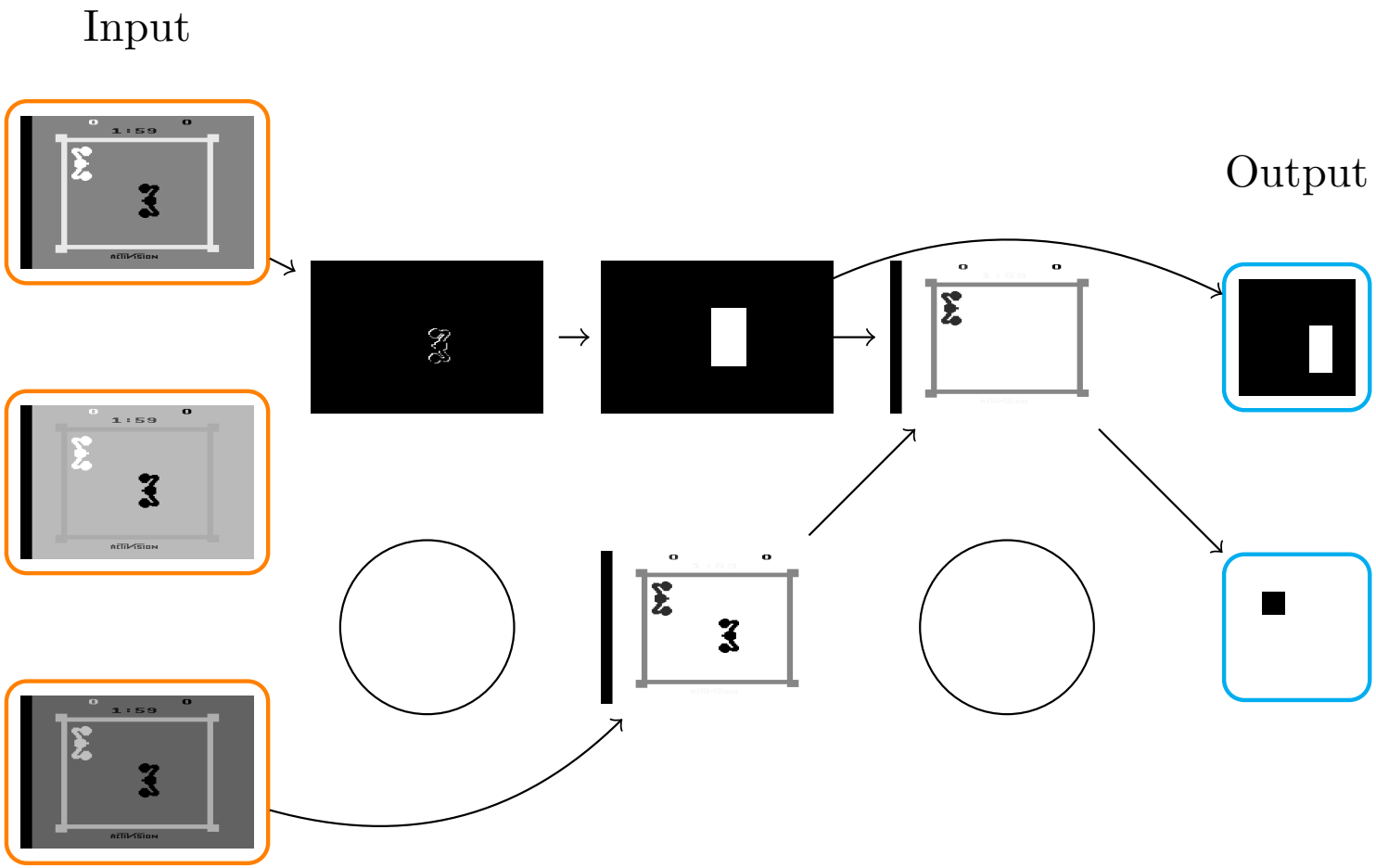




Encoder



Encoder



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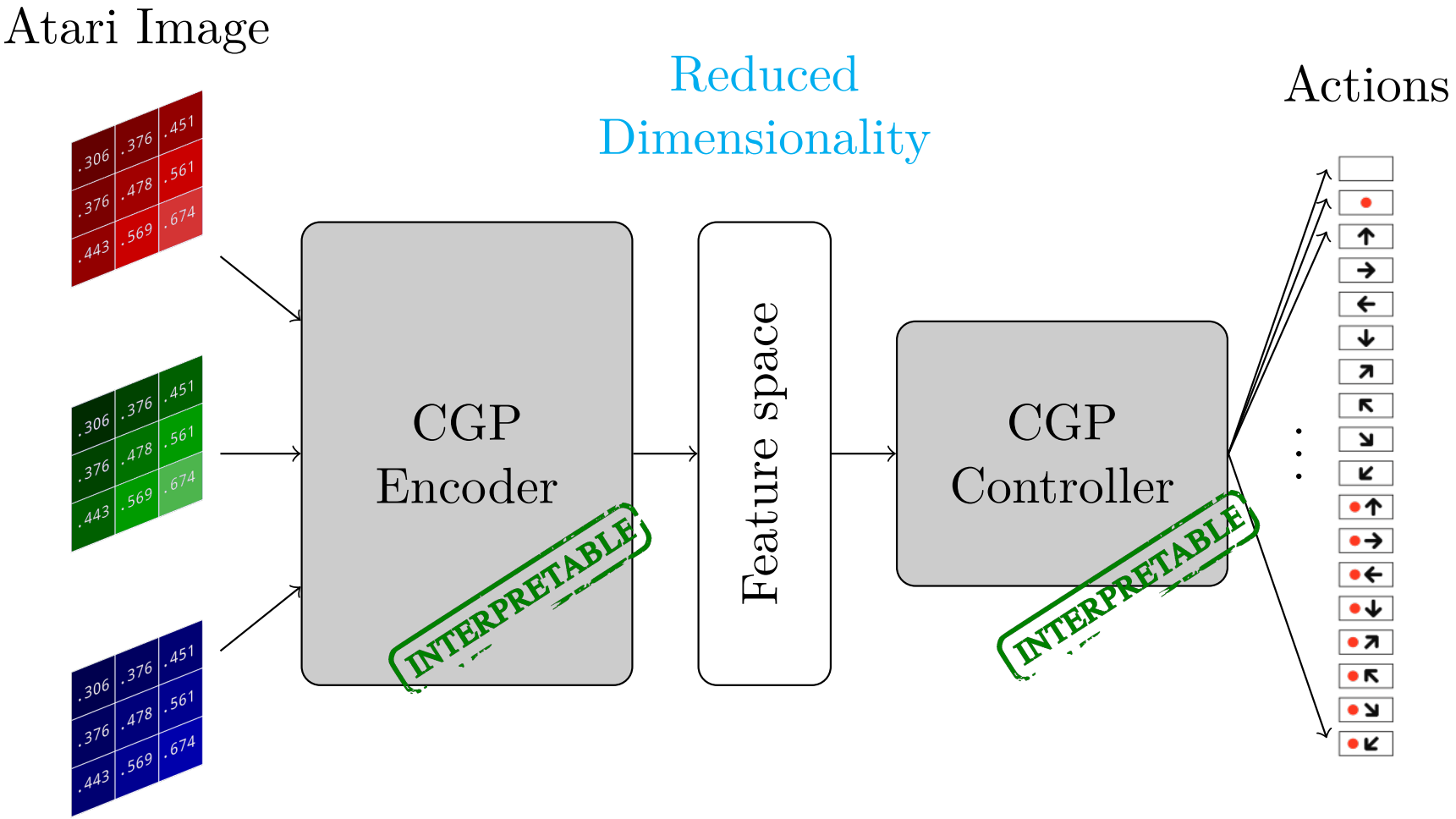

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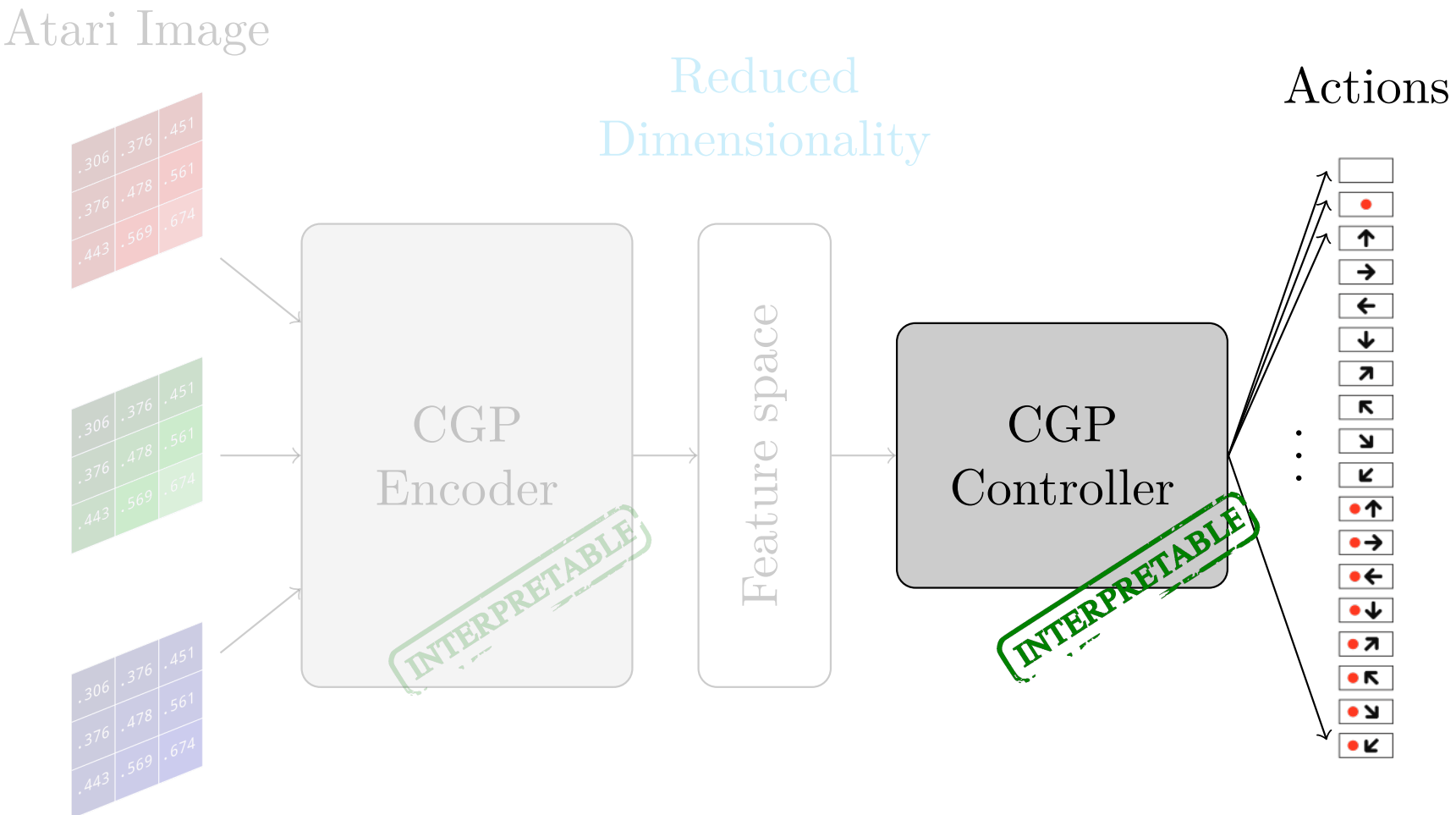
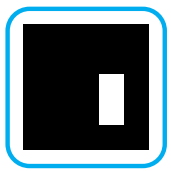
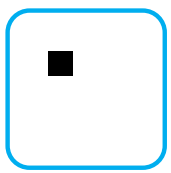


Controller

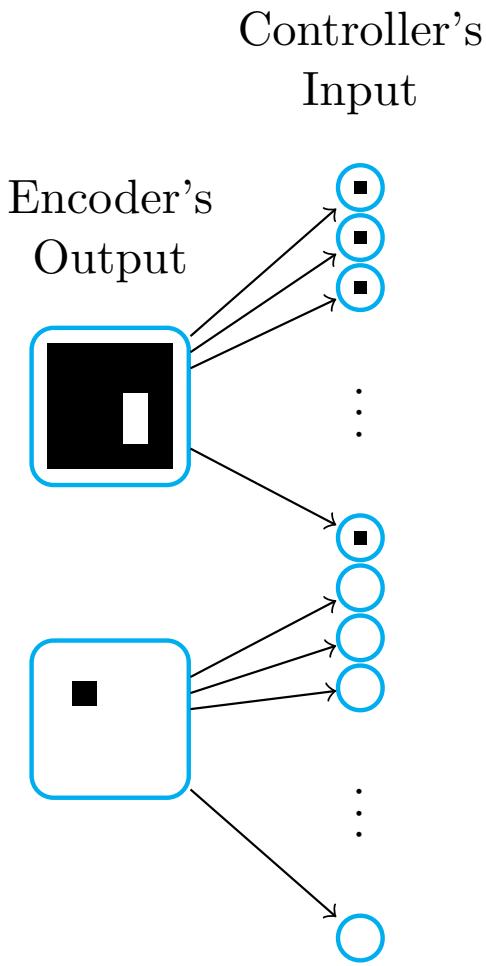
Controller

Encoder's
Output

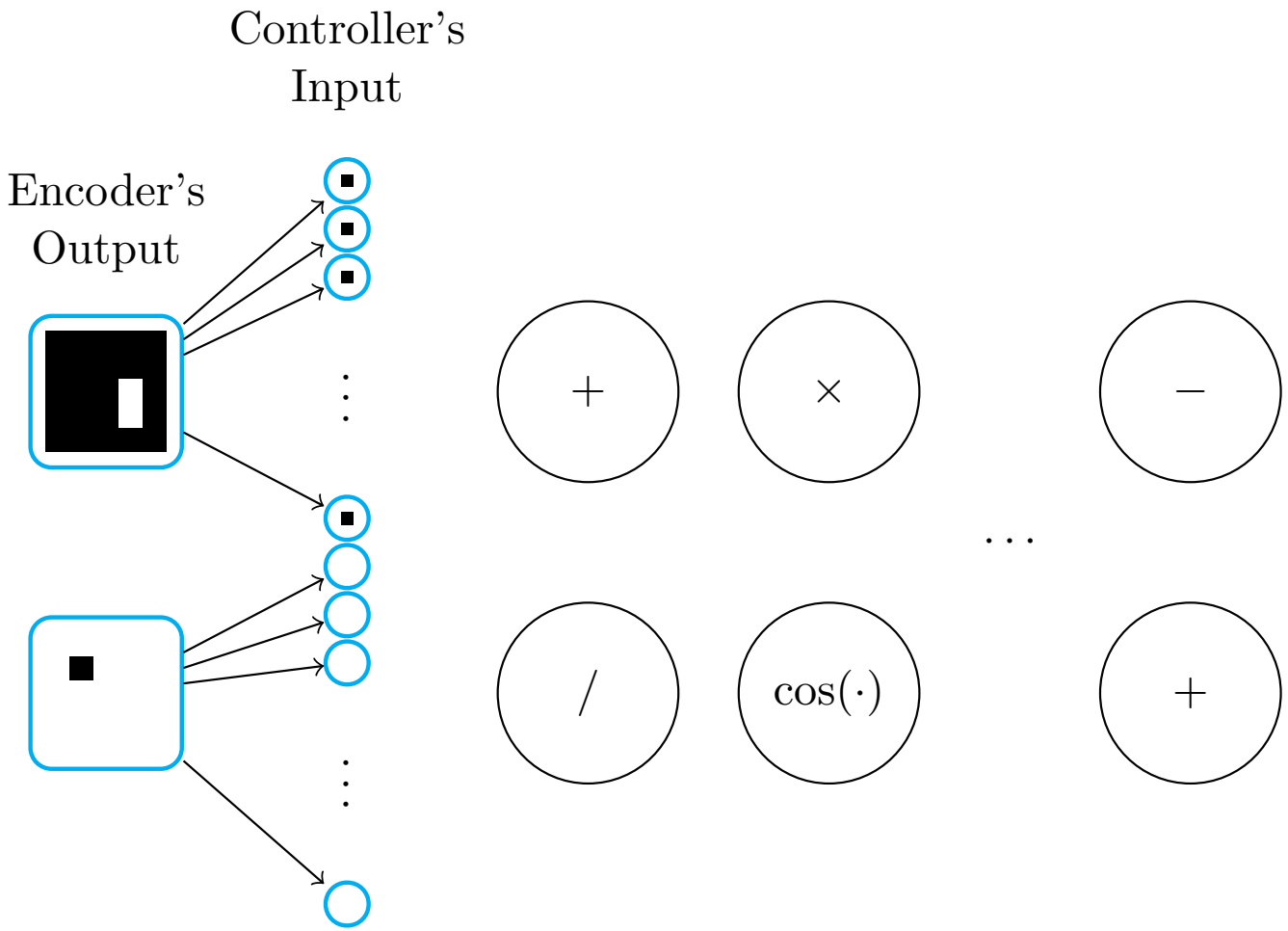




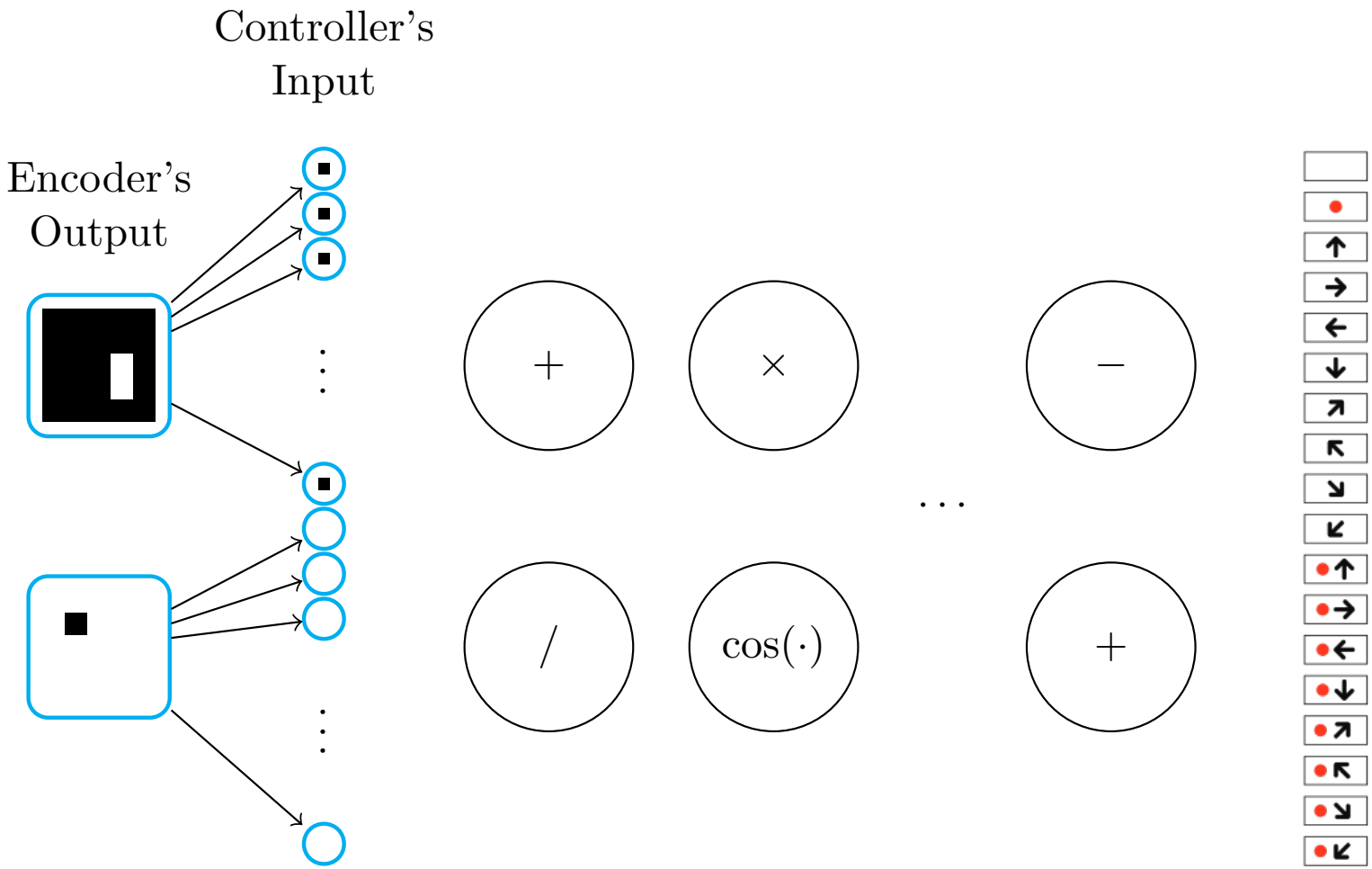
Controller



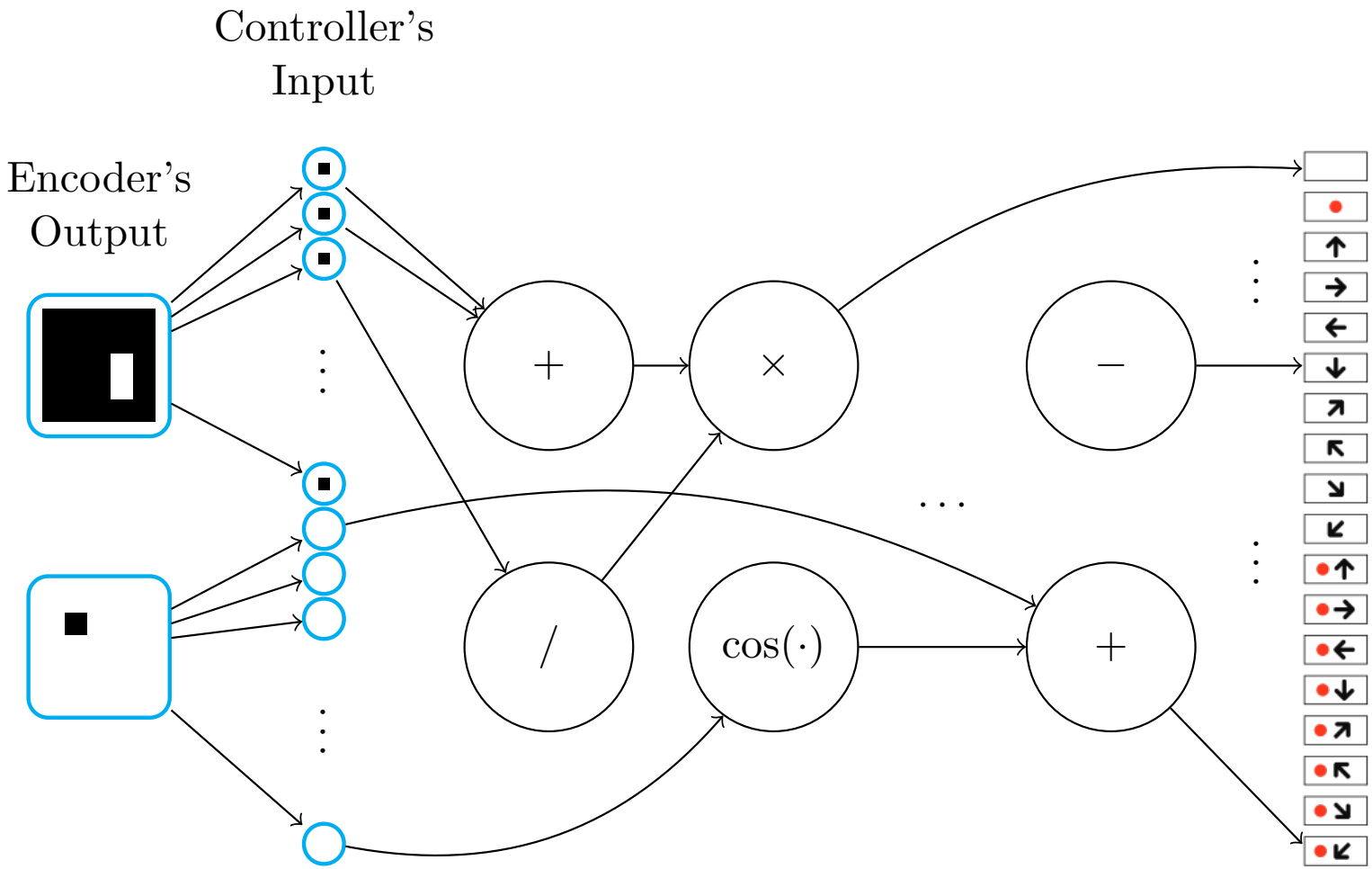
Controller



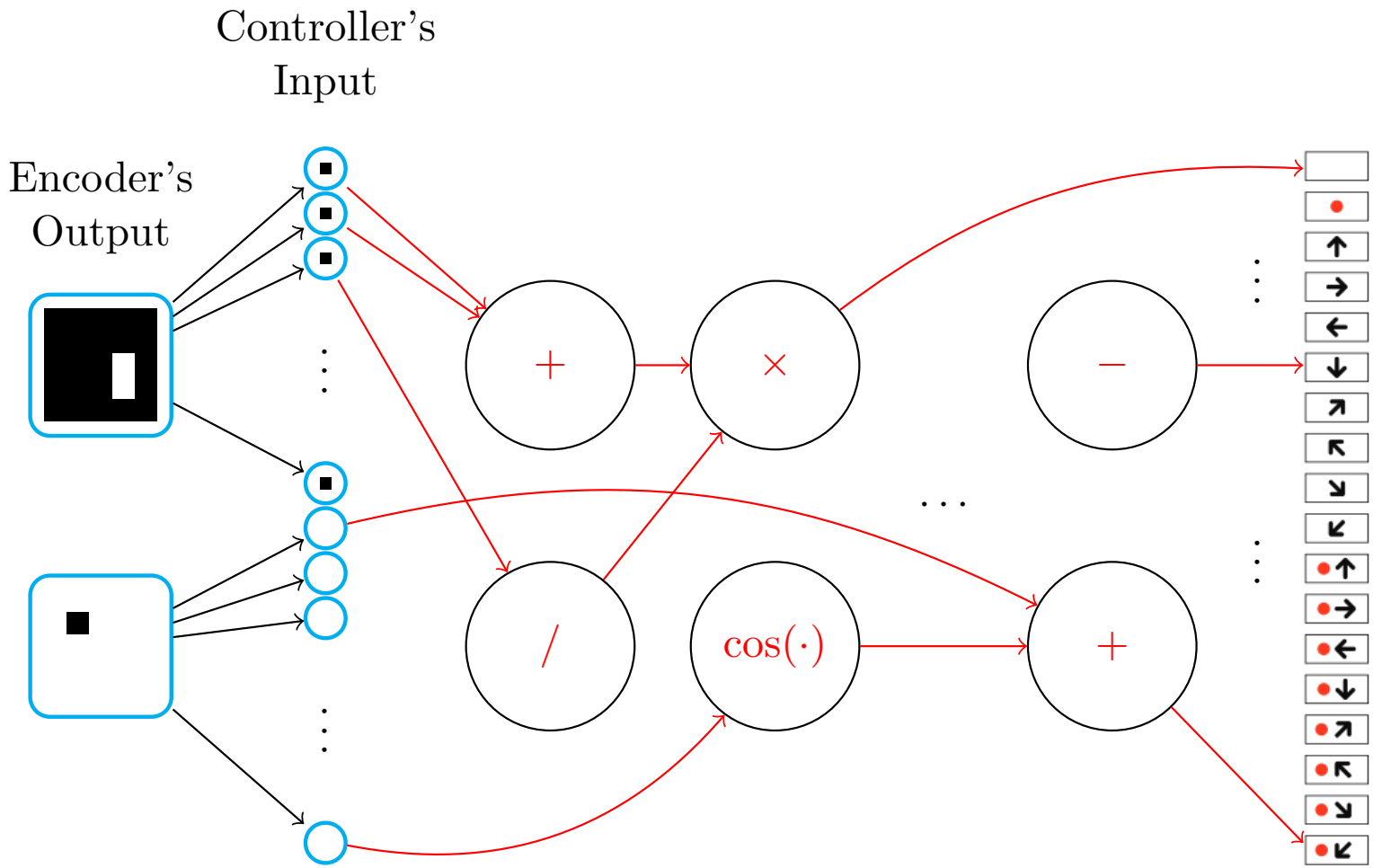
Controller



Controller



Controller

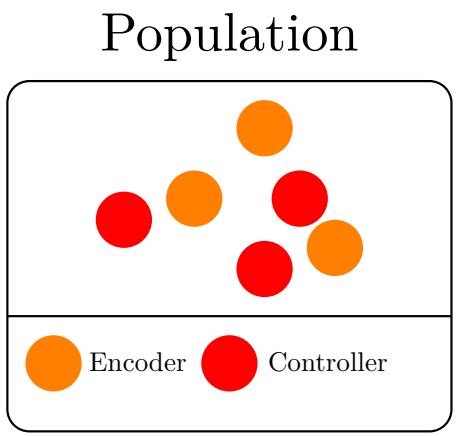


Genotype:

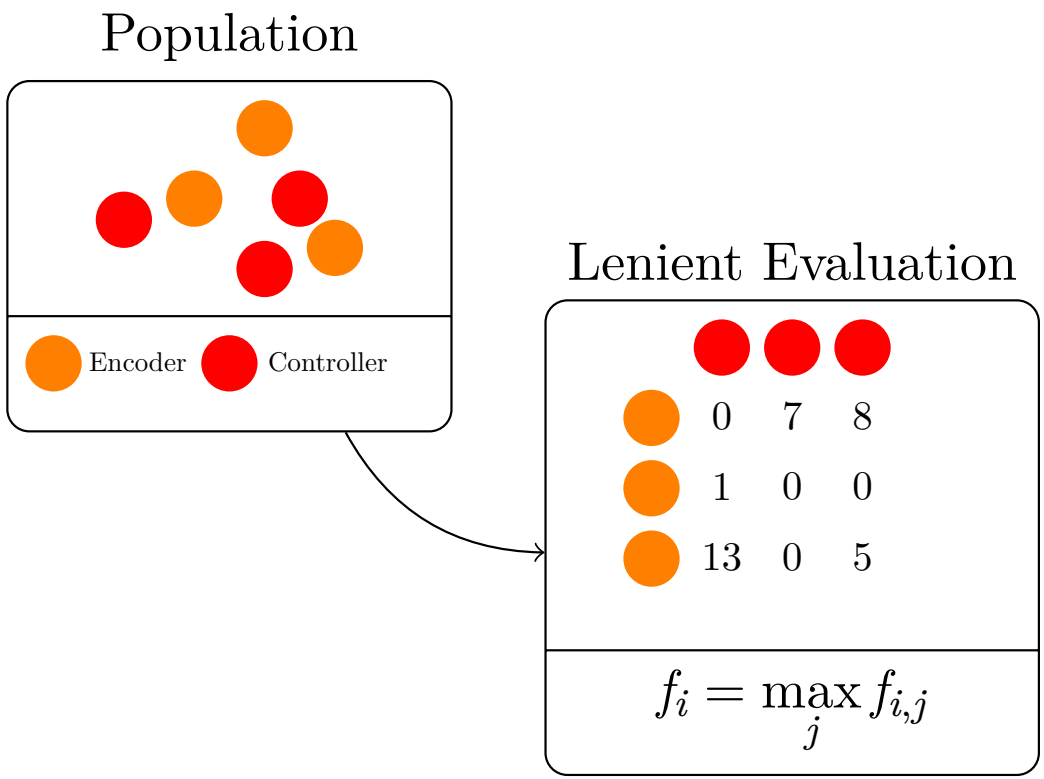
$[1, 1, 2, 13, 1, \ldots, 3] \in \mathbb{N}^{3\times\text{number of nodes} + \text{number of outputs}}$

Co-evolution

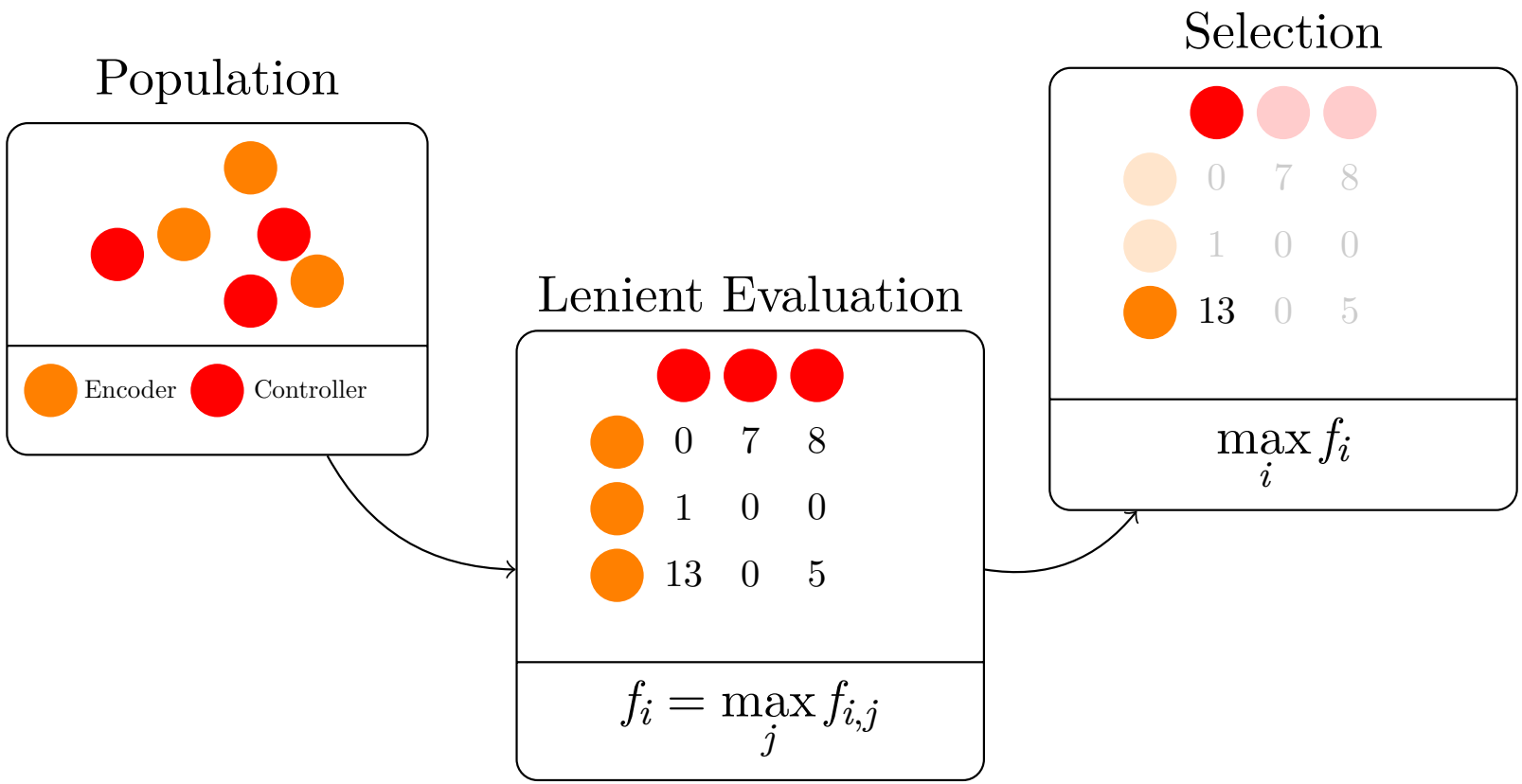
Co-evolution



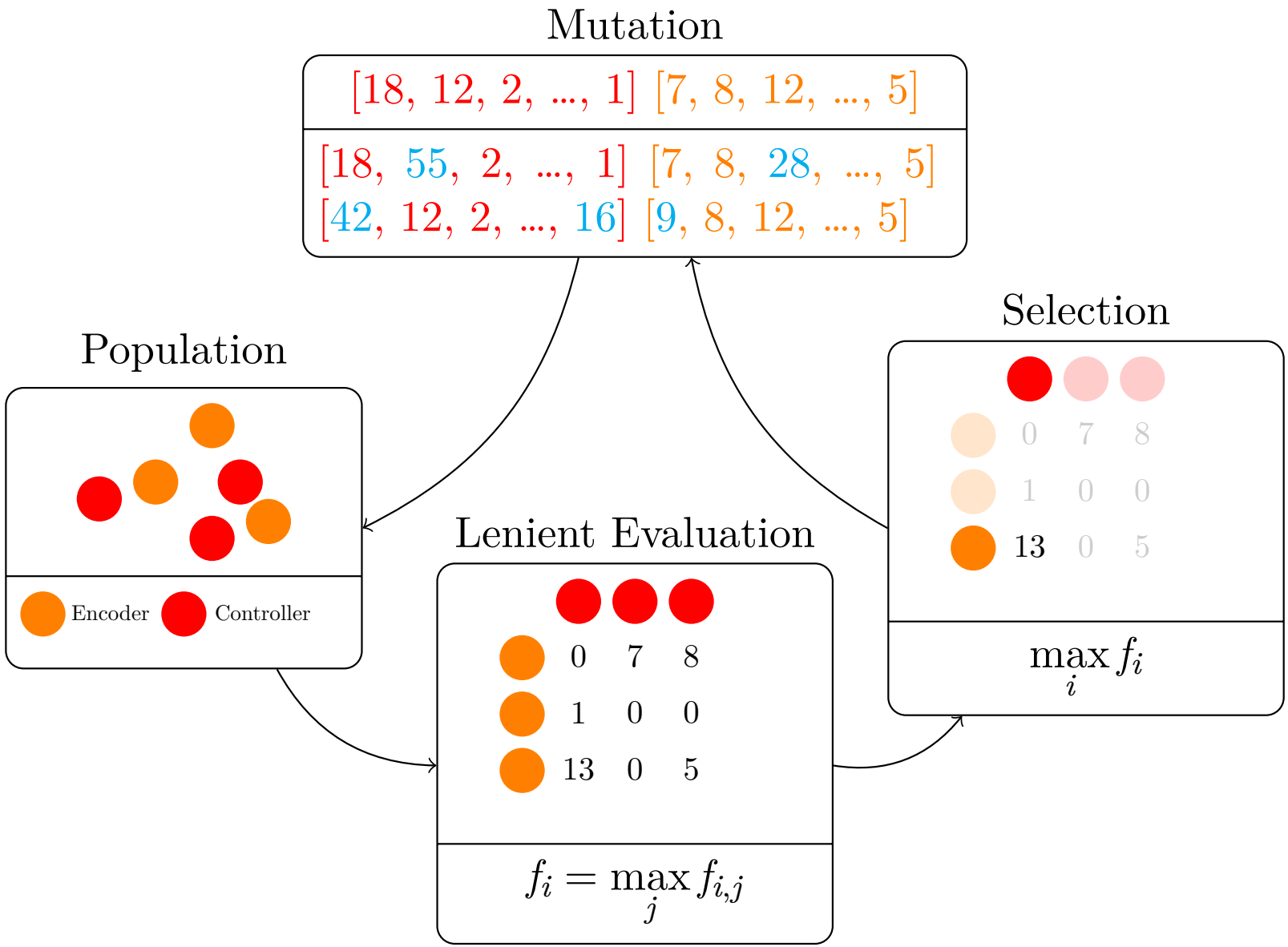
Co-evolution



Co-evolution



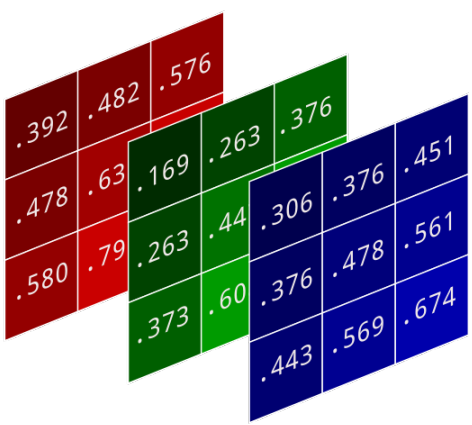
Co-evolution



Conclusion

Conclusion

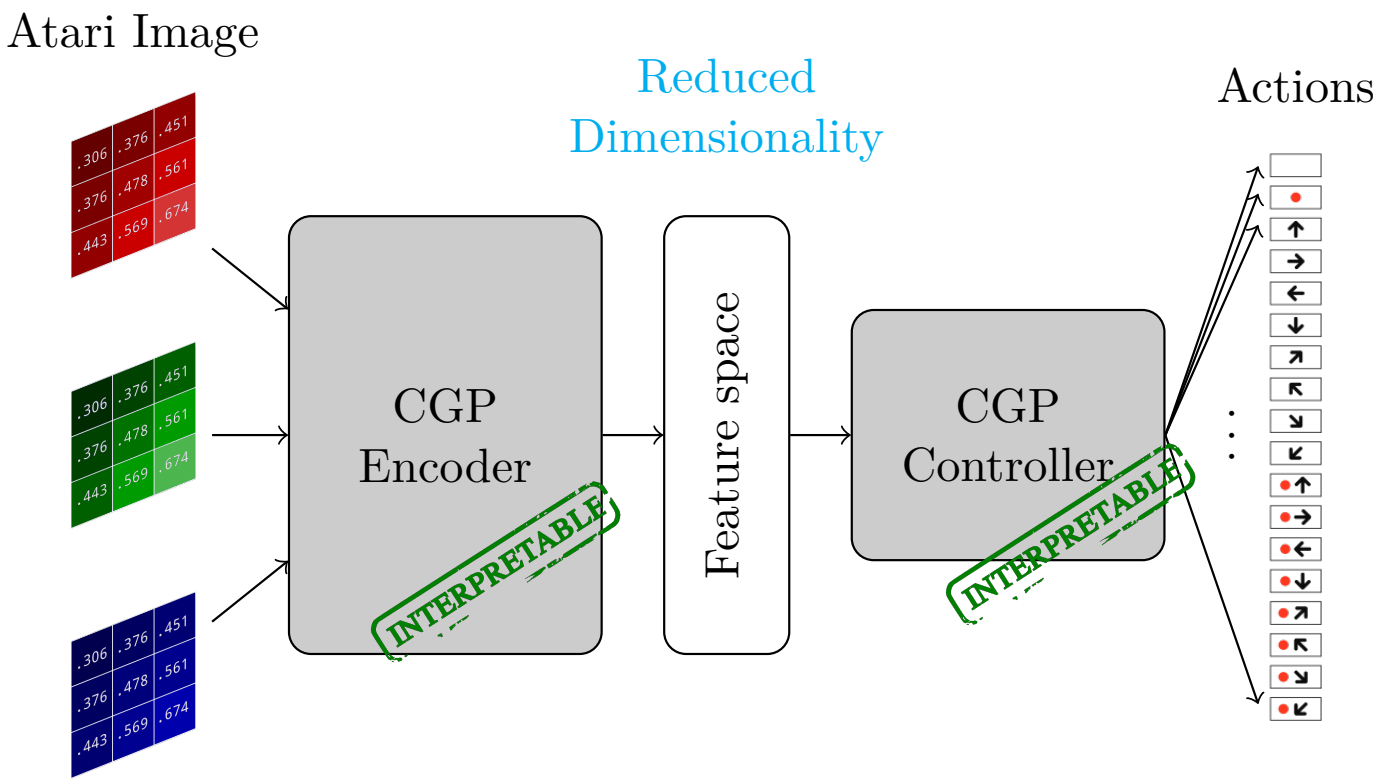
- Objective: interpretable agent in pixel-based Atari games



$$a \in \mathcal{A}$$

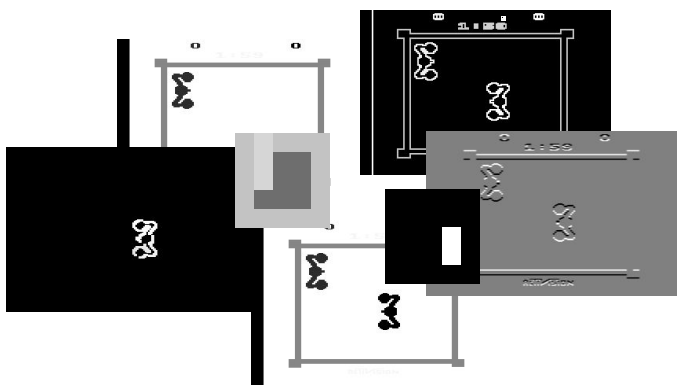
Conclusion

- Objective: interpretable agent in pixel-based Atari games
- Approach: CGP co-evolution in an encoder-controller scheme



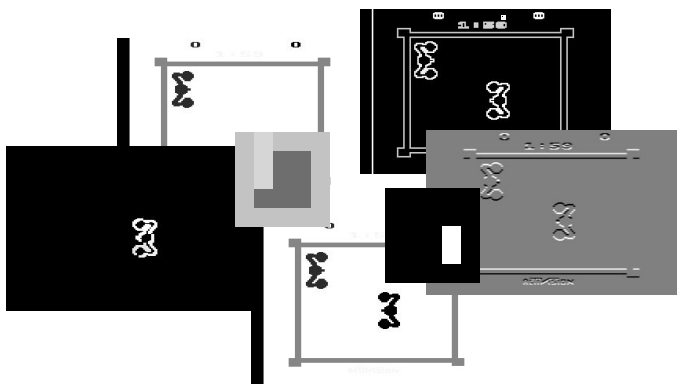
Conclusion

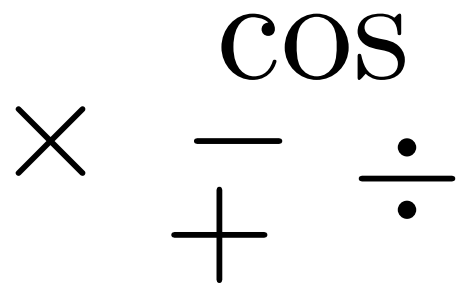
- Objective: interpretable agent in pixel-based Atari games
- Approach: CGP co-evolution in an encoder-controller scheme
- Encoder: interpretable image processing functions



Conclusion

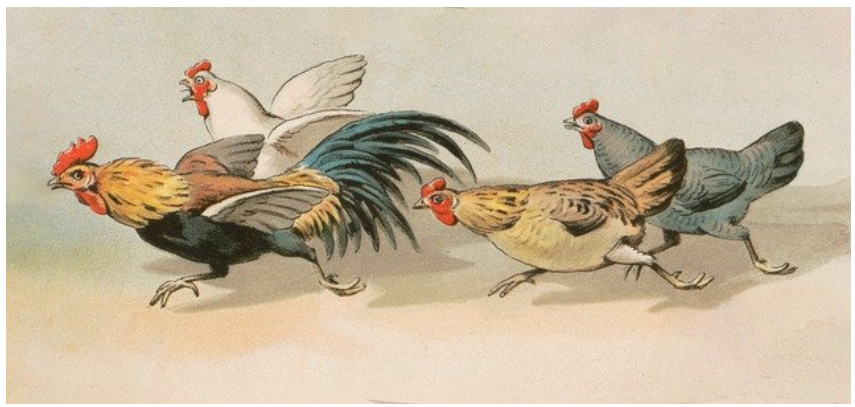
- Objective: interpretable agent in pixel-based Atari games
- Approach: CGP co-evolution in an encoder-controller scheme
- Encoder: interpretable image processing functions
- Controller: interpretable scalar functions





Conclusion

- Objective: interpretable agent in pixel-based Atari games
- Approach: CGP co-evolution in an encoder-controller scheme
- Encoder: interpretable image processing functions
- Controller: interpretable scalar functions
- Experiments: running



Images: pixabay.com and Wilson, Dennis G., et al. ”Evolving simple programs for playing Atari games.” GECCO 2018