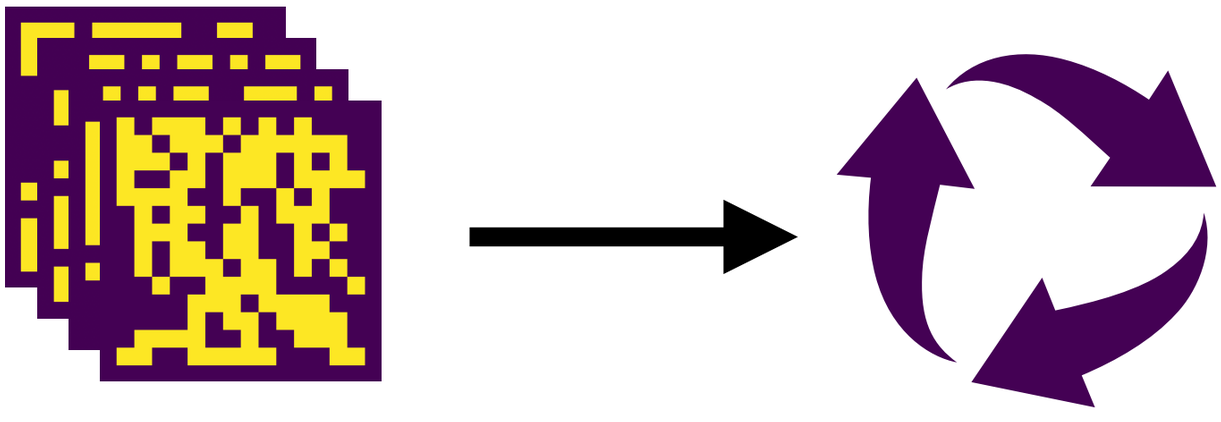
Mutation Models

Learning to Generate Levels by Imitating Evolution

Ahmed Khalifa, Michael C. Green, Julian Togelius

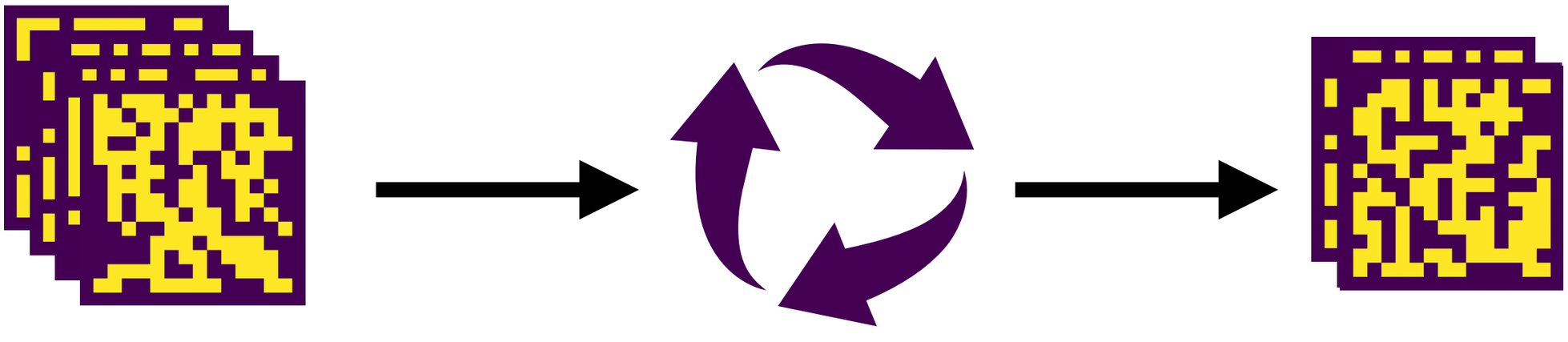
@amidos2006

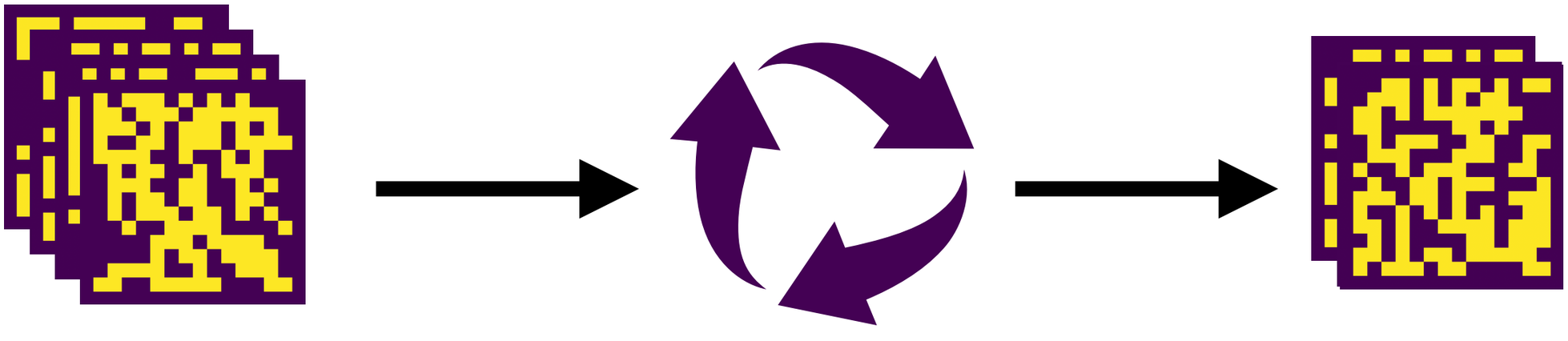
Train a Neural Network to imitate the evolutionary process in generating levels



Initial Population

Evolution

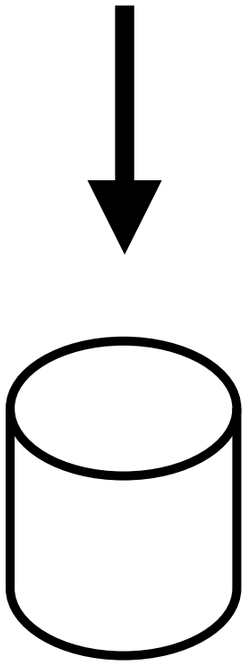

Initial Population
Evolution
Top X Levels



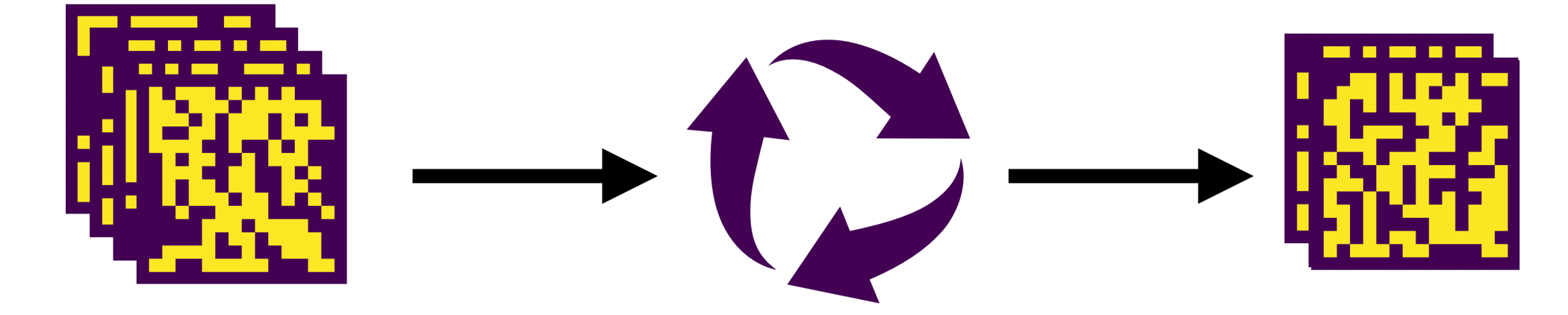
Initial Population

Evolution

Top X Levels



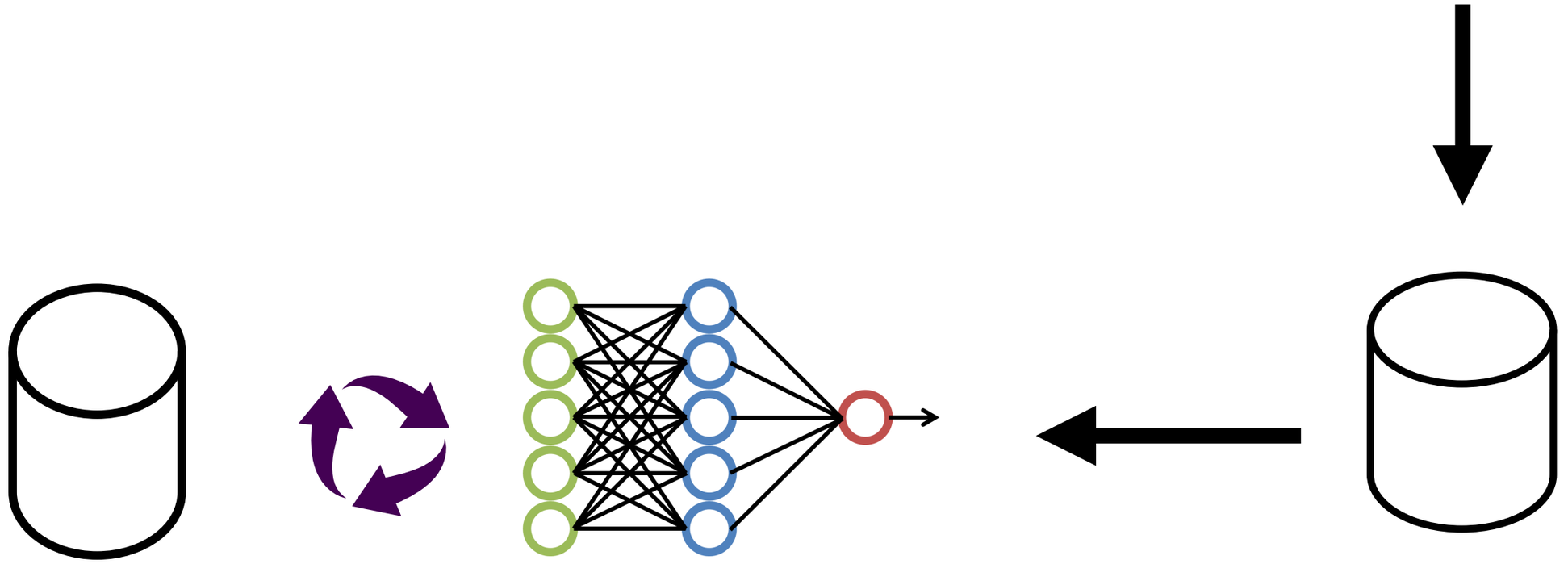
Extract Evolution Trajectories



Initial Population

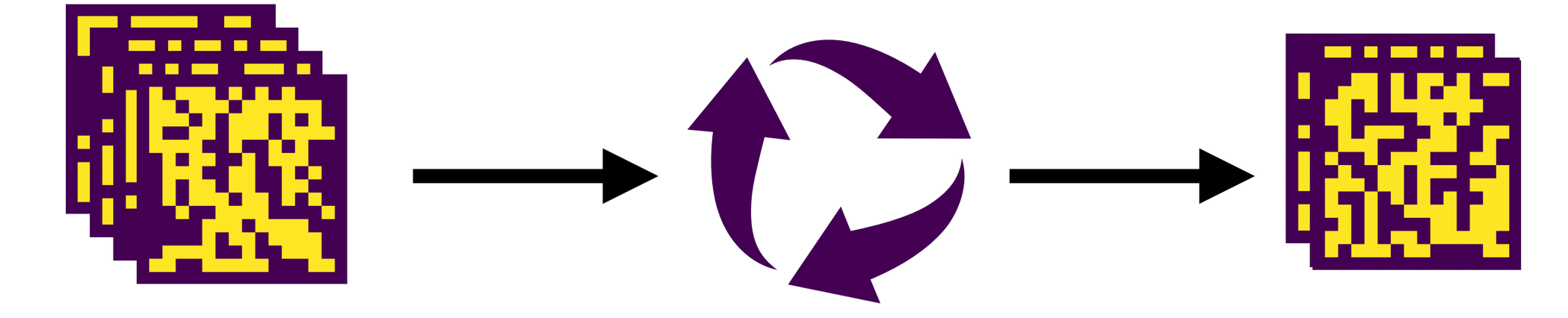
Evolution

Top X Levels



Train ML Model on
Extracted Trajectories

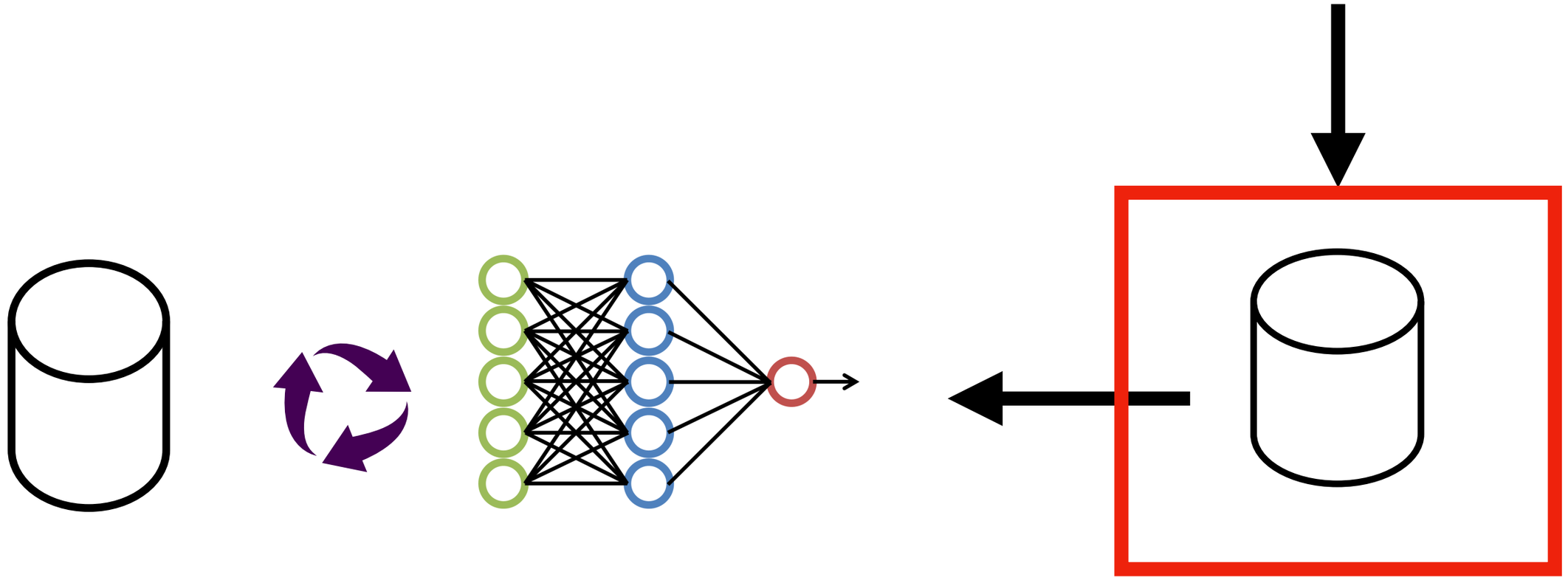
Extract Evolution
Trajectories



Initial Population

Evolution

Top X Levels



Train ML Model on
Extracted Trajectories

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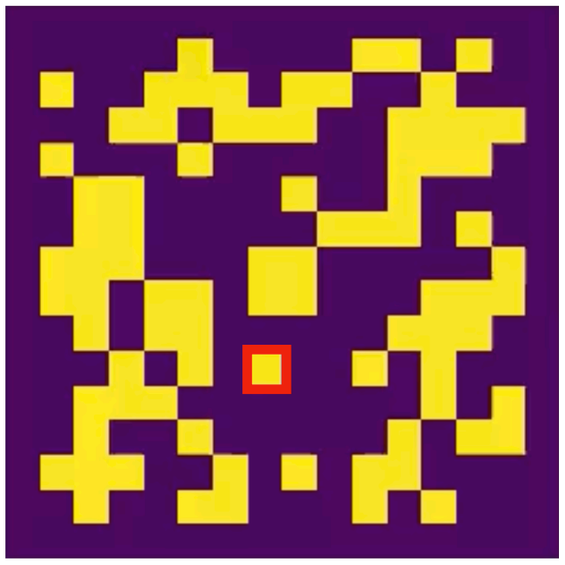
Trajectories

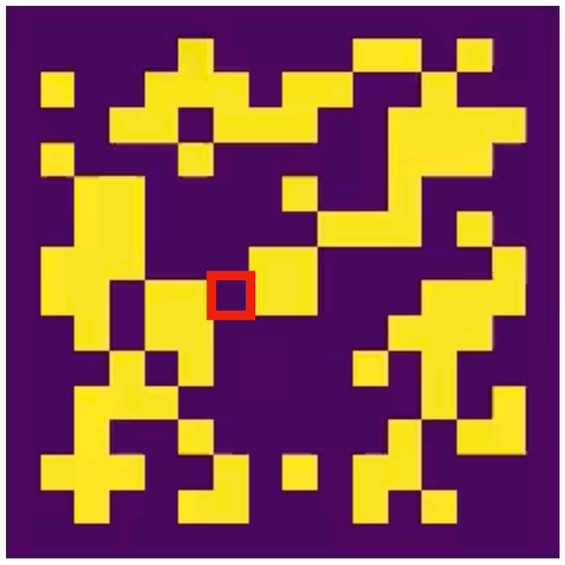
Trajectories

Initial Level



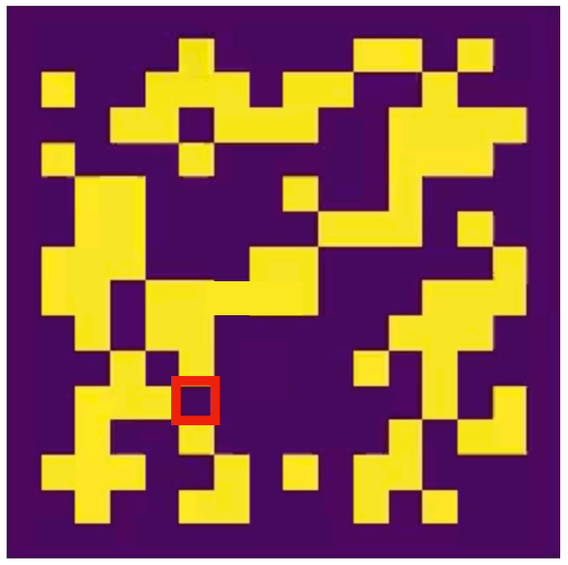
Mutation

$Level_1$



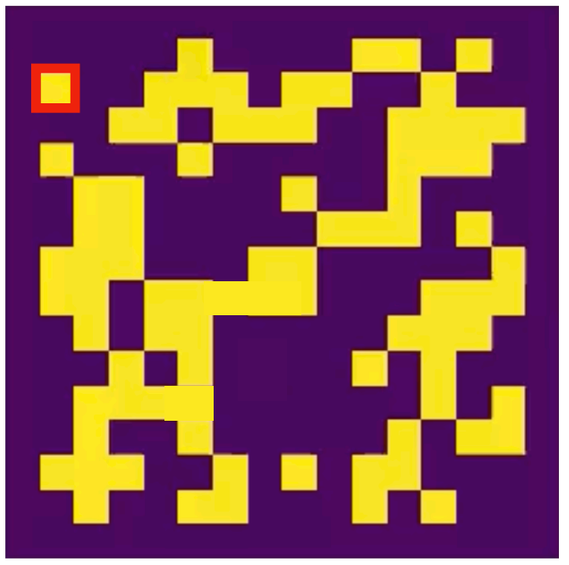
Mutation

$Level_2$



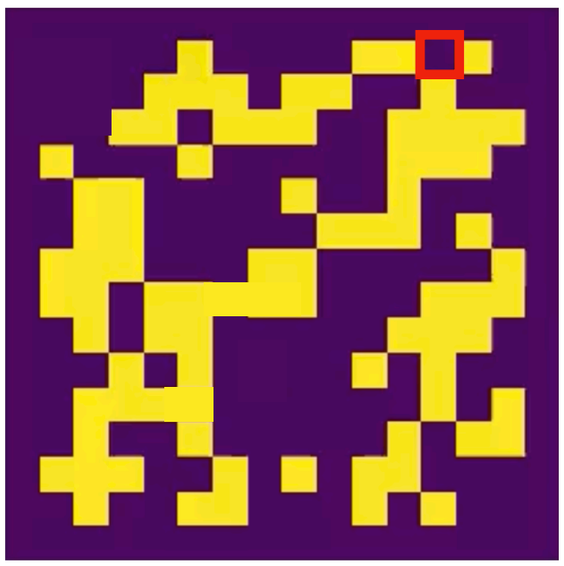
Mutation

$Level_3$



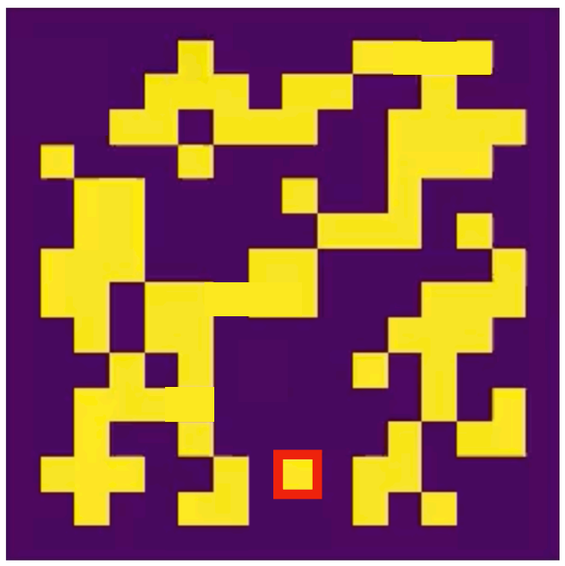
Mutation

$Level_4$



Mutation

$Level_5$



Mutation

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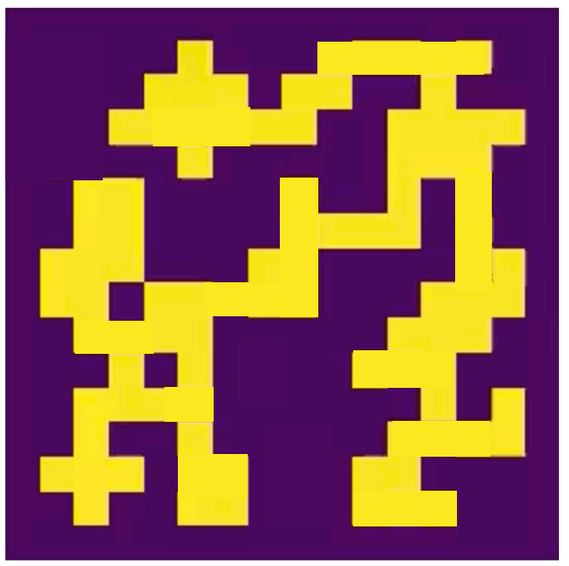
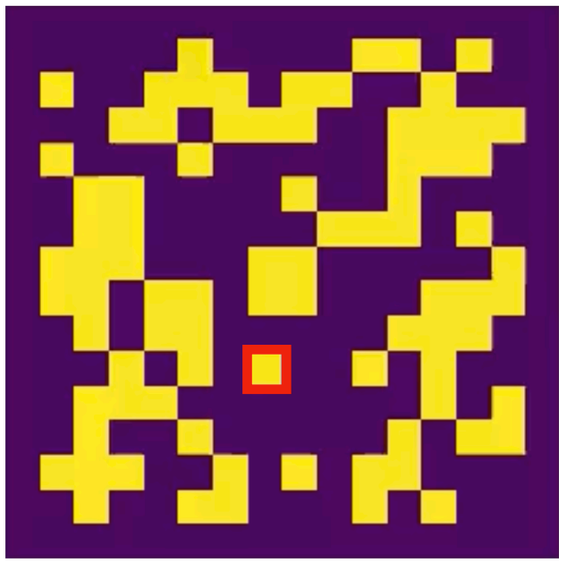
Final Level



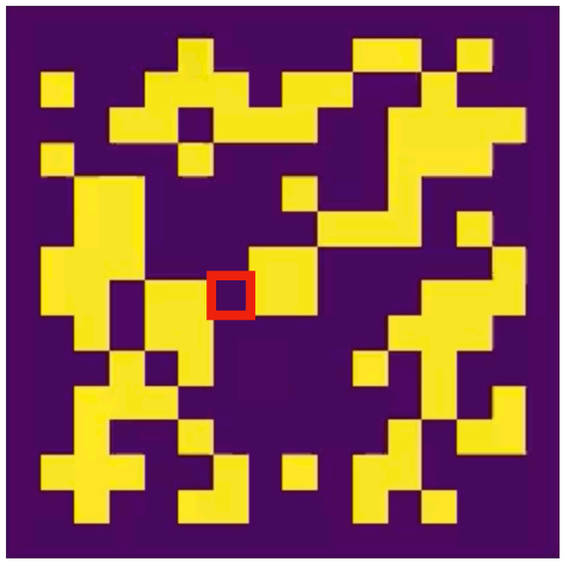
Trajectories

$State_0$



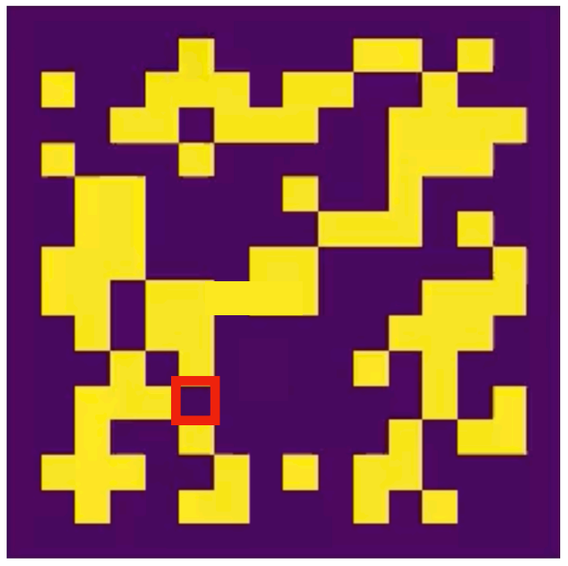
Action

$State_1$



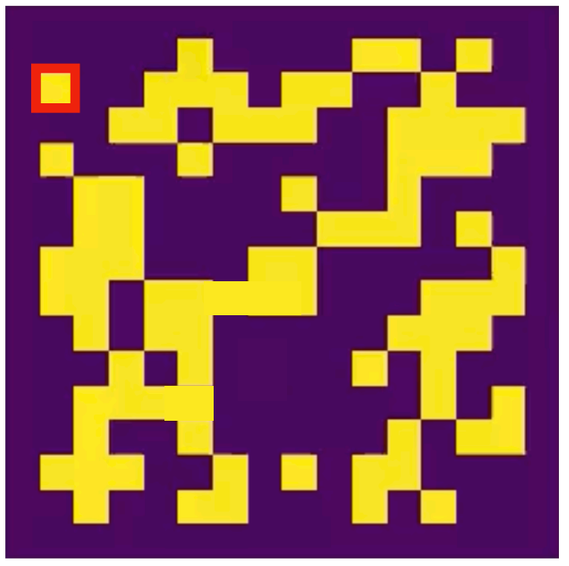
Action

$State_2$



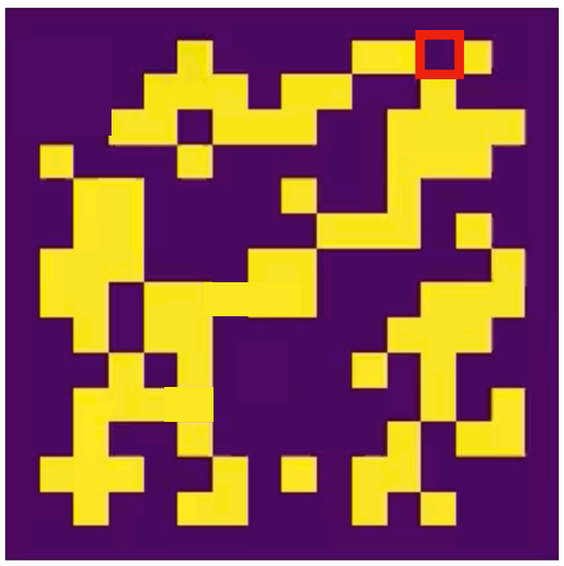
Action

$State_3$



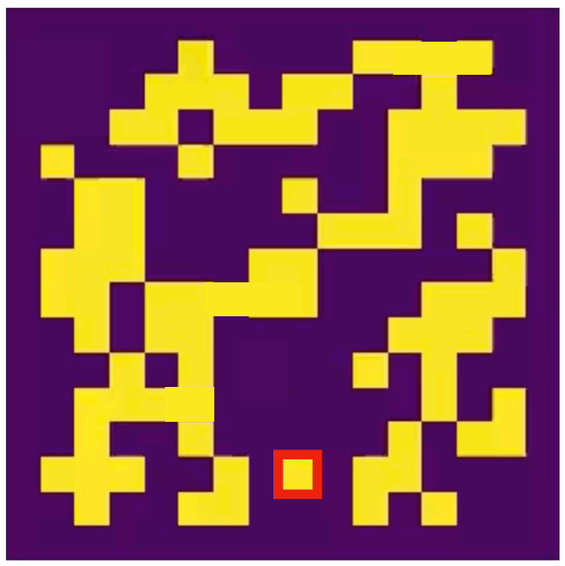
Action

$State_4$



Action

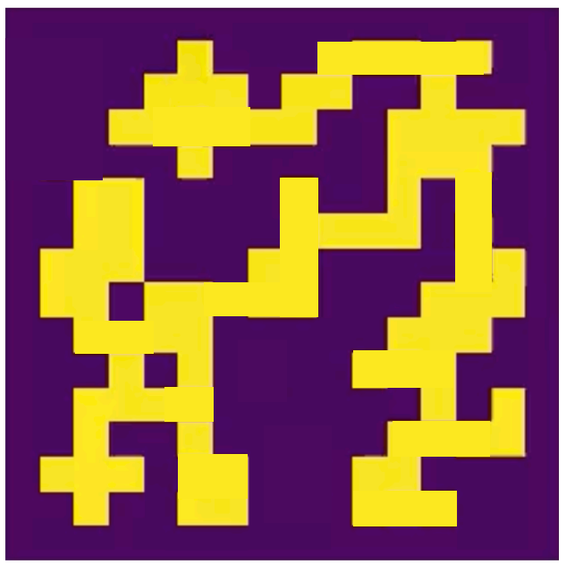
$State_5$

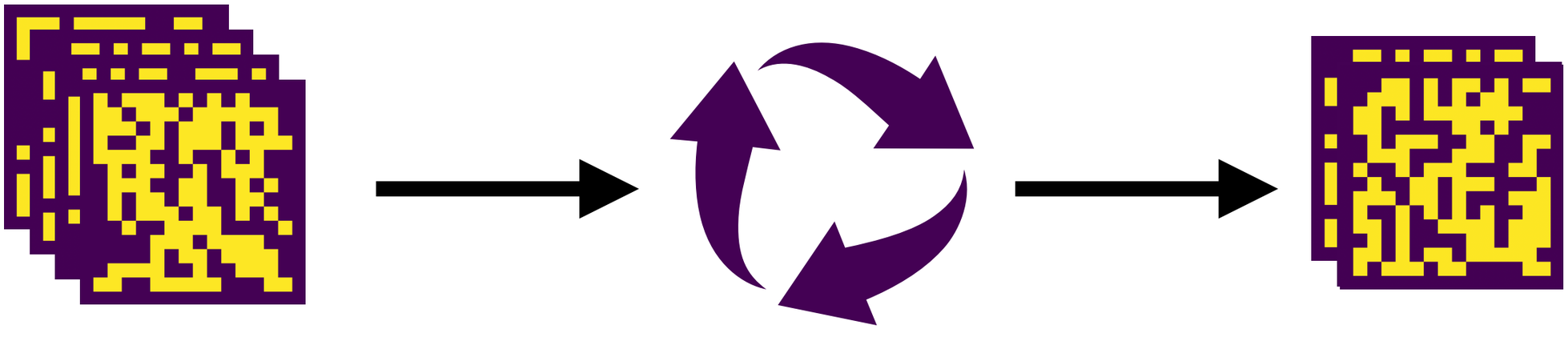


Action

.....

Final State

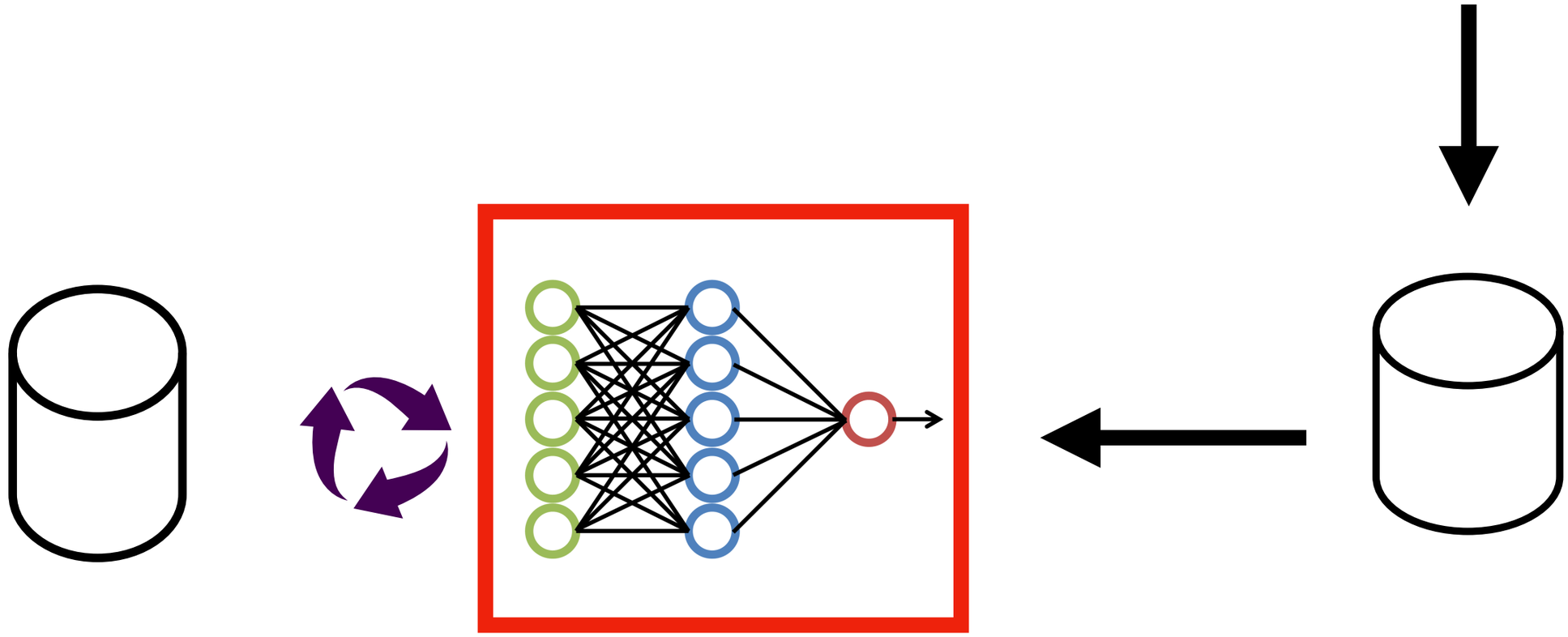




Initial Population

Evolution

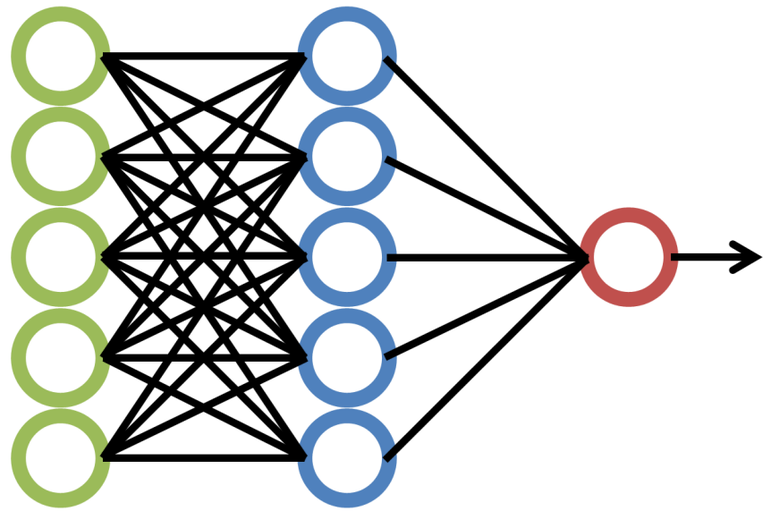
Top X Levels



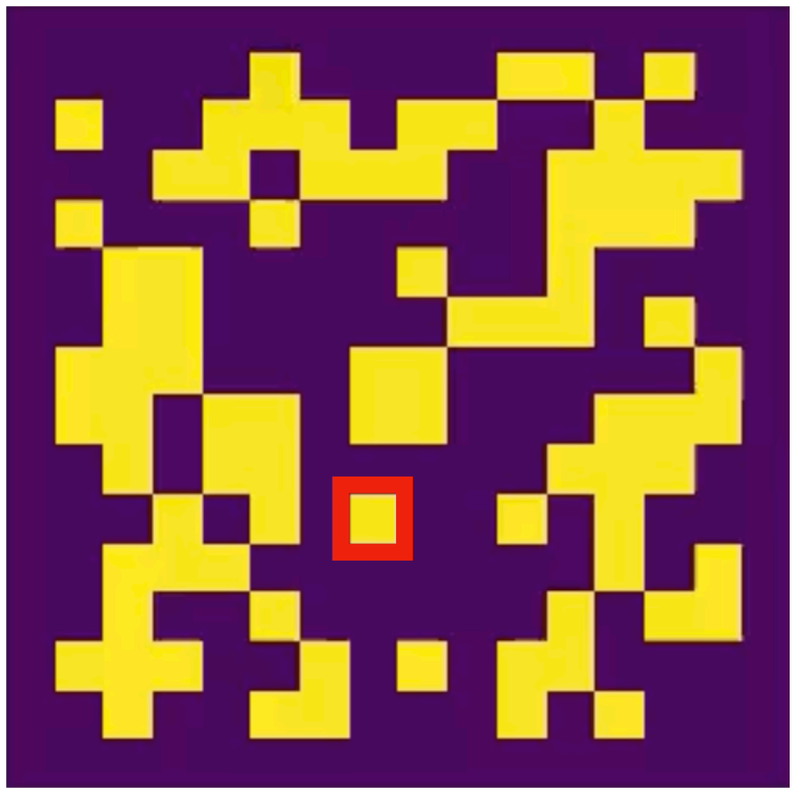
Train ML Model on
Extracted Trajectories

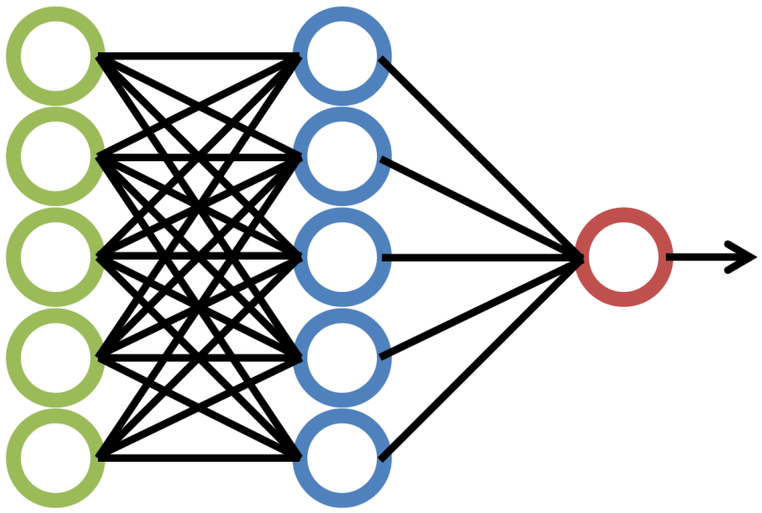
Extract Evolution
Trajectories

Generating New Levels

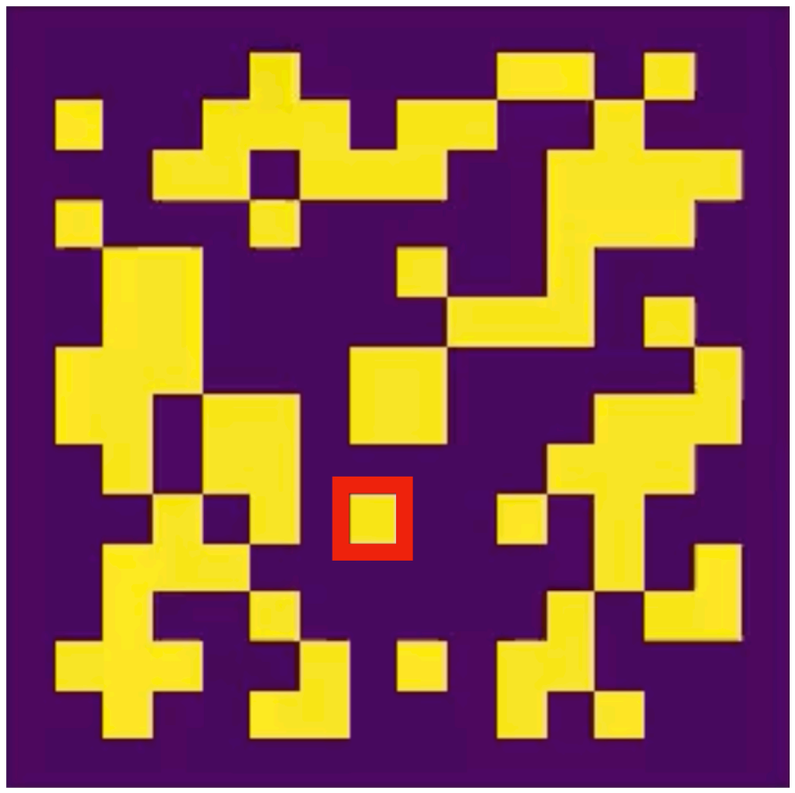


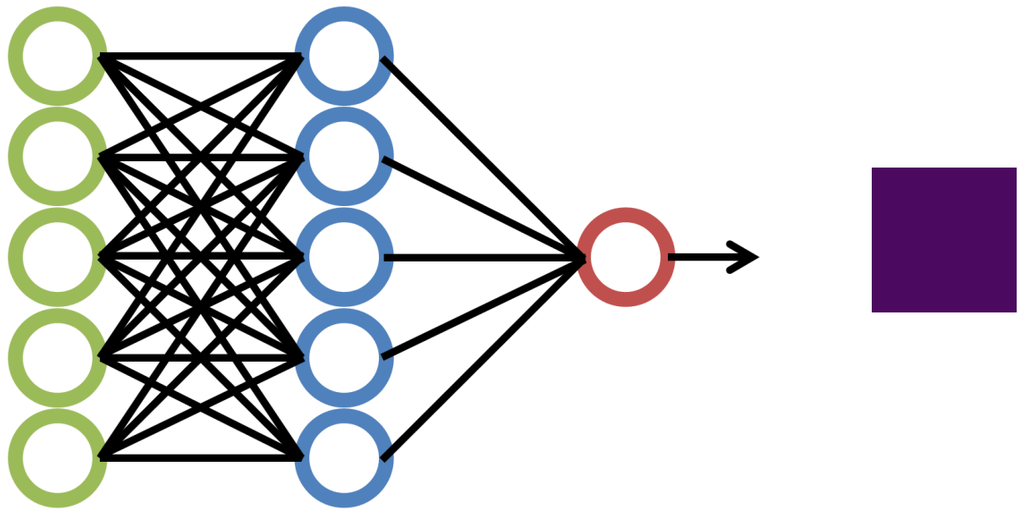
Generating New Levels



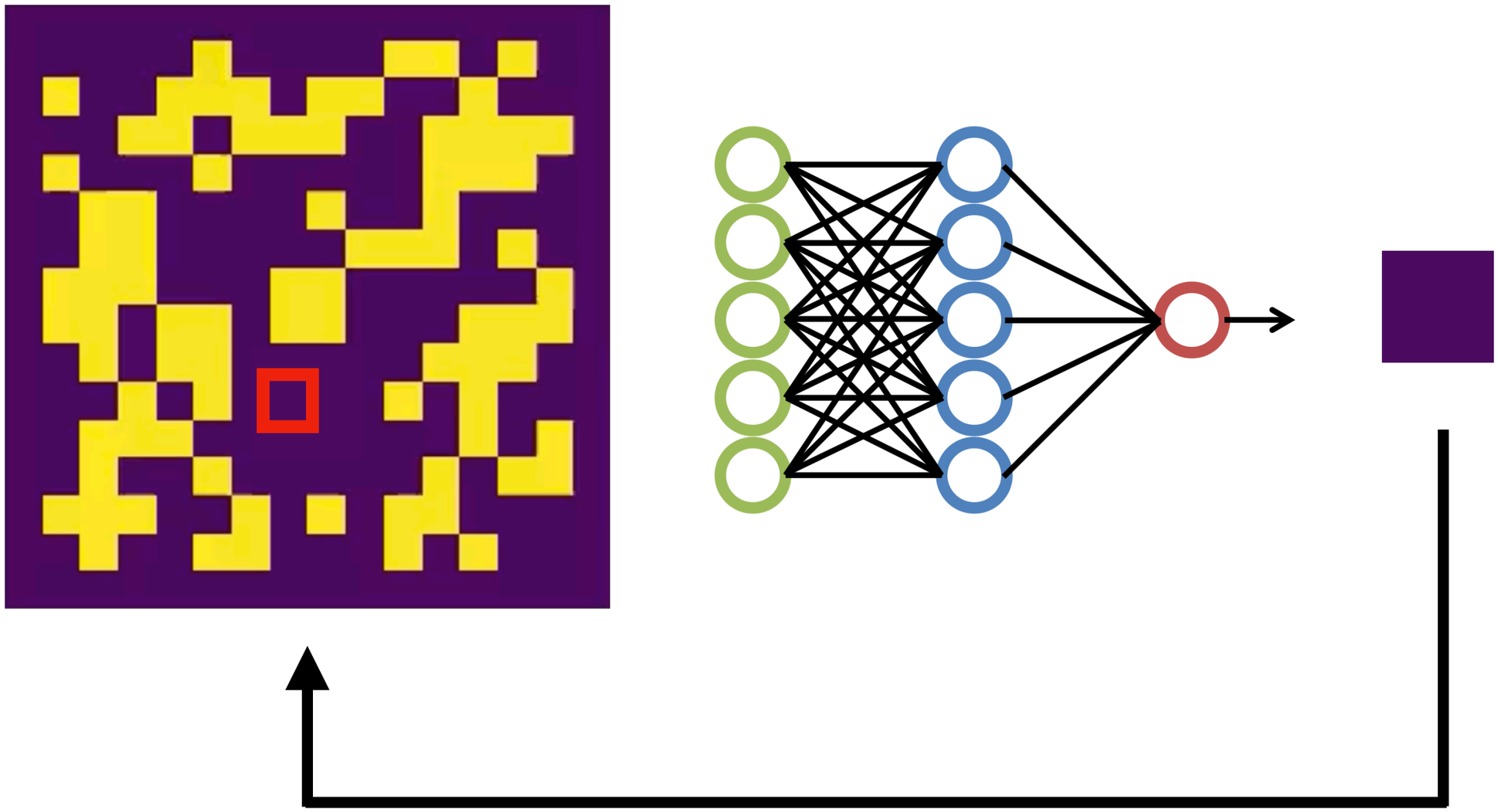


Generating New Levels

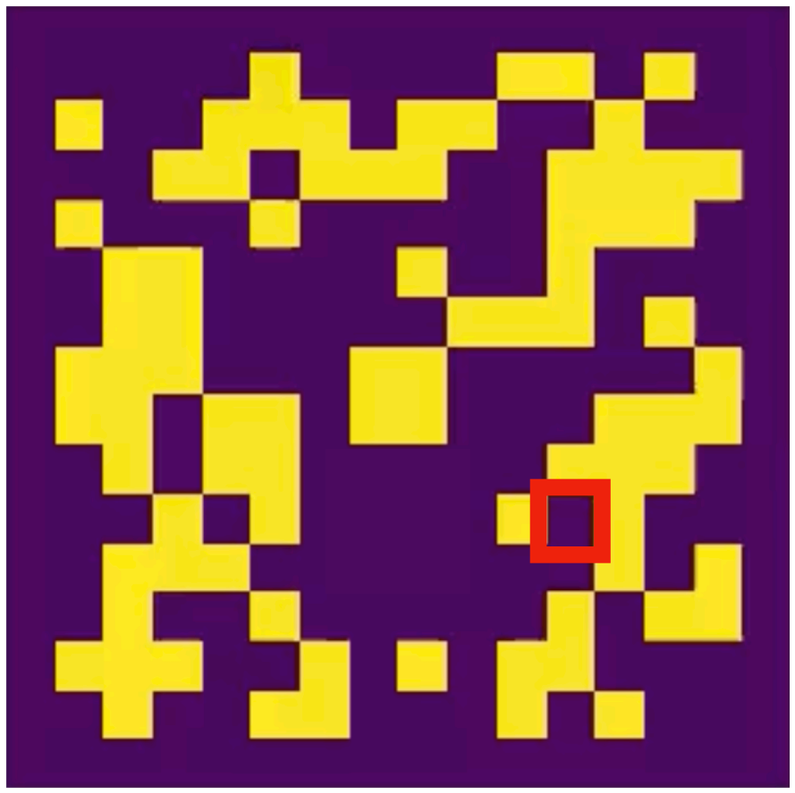


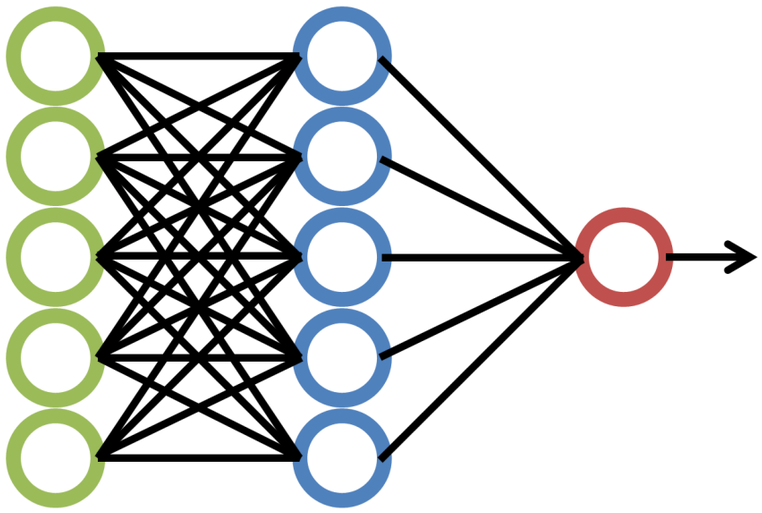


Generating New Levels

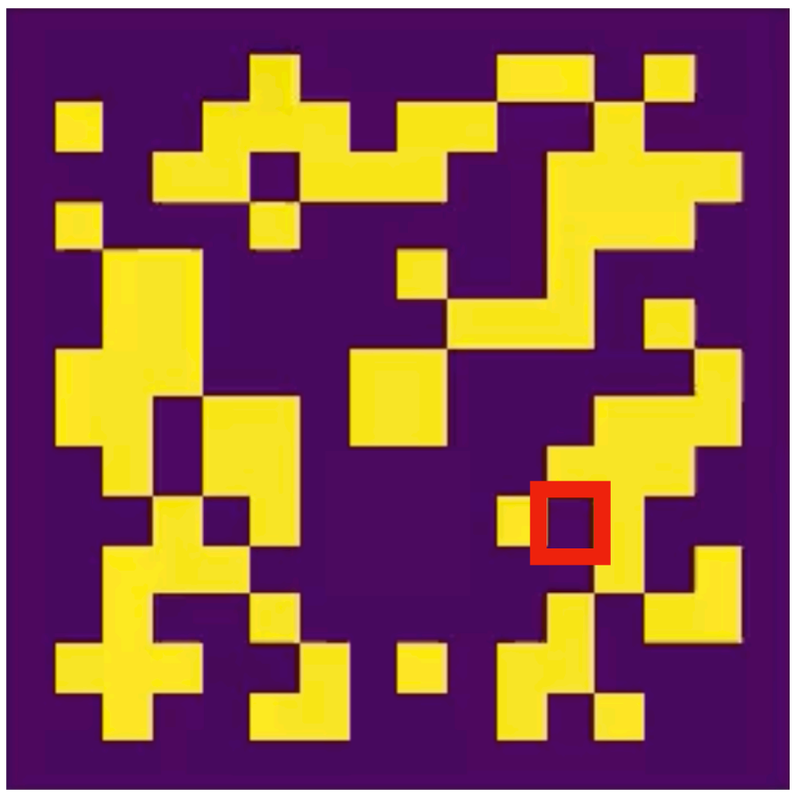


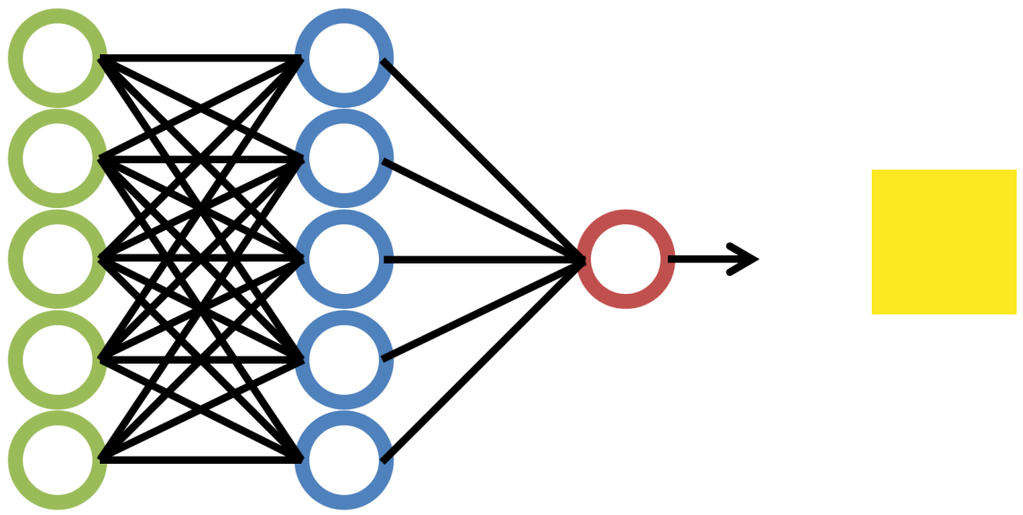
Generating New Levels



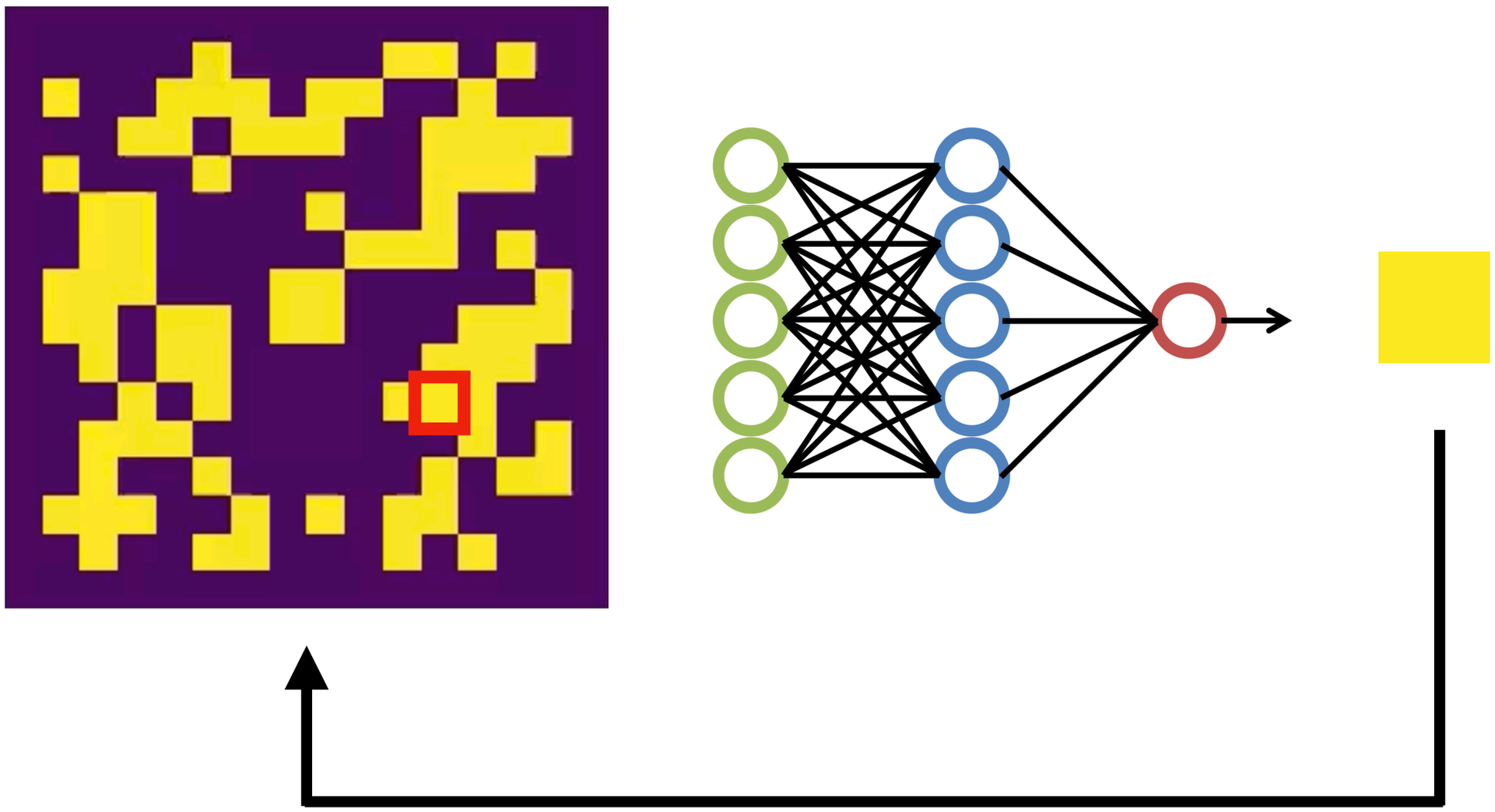


Generating New Levels

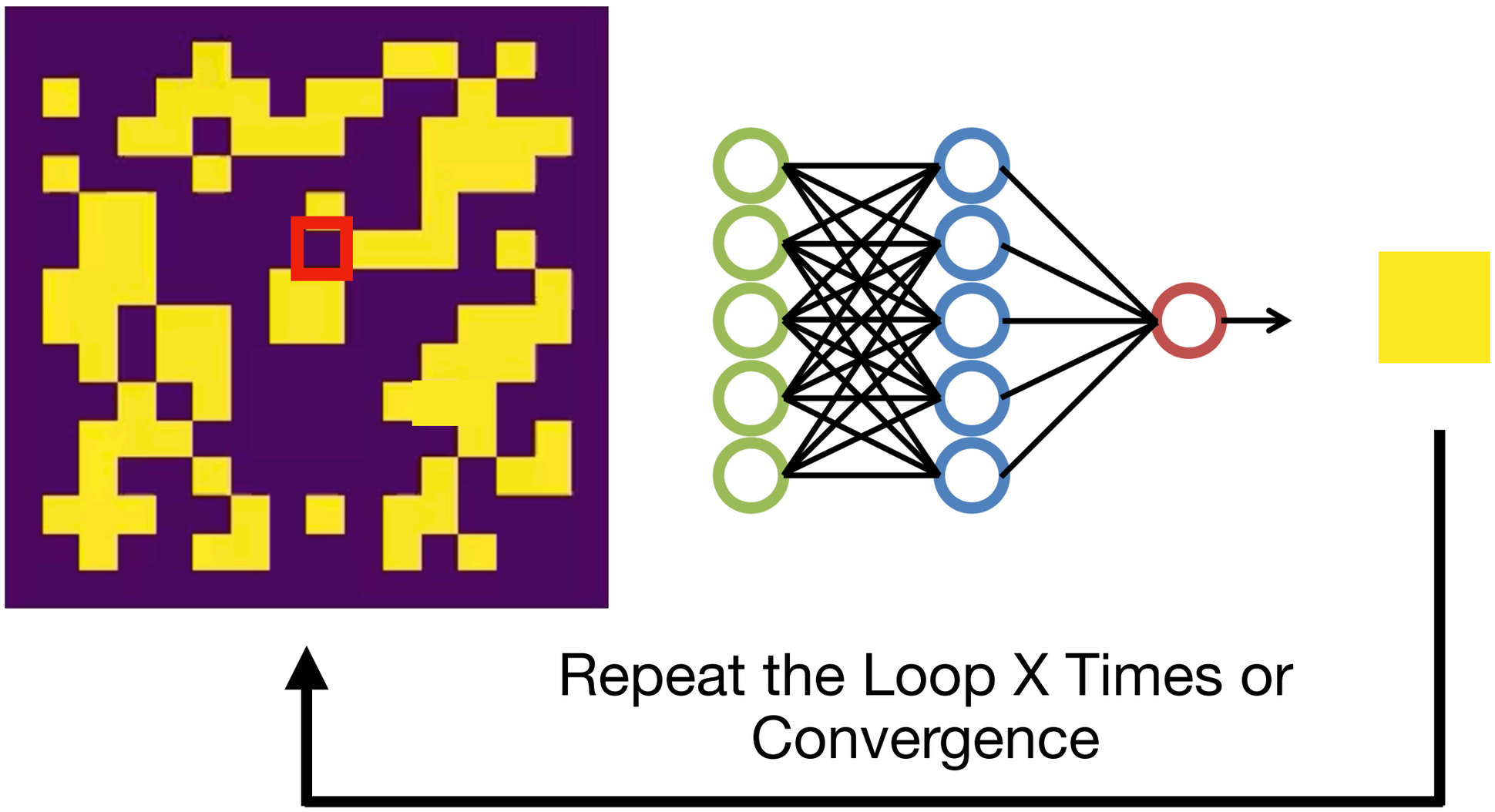




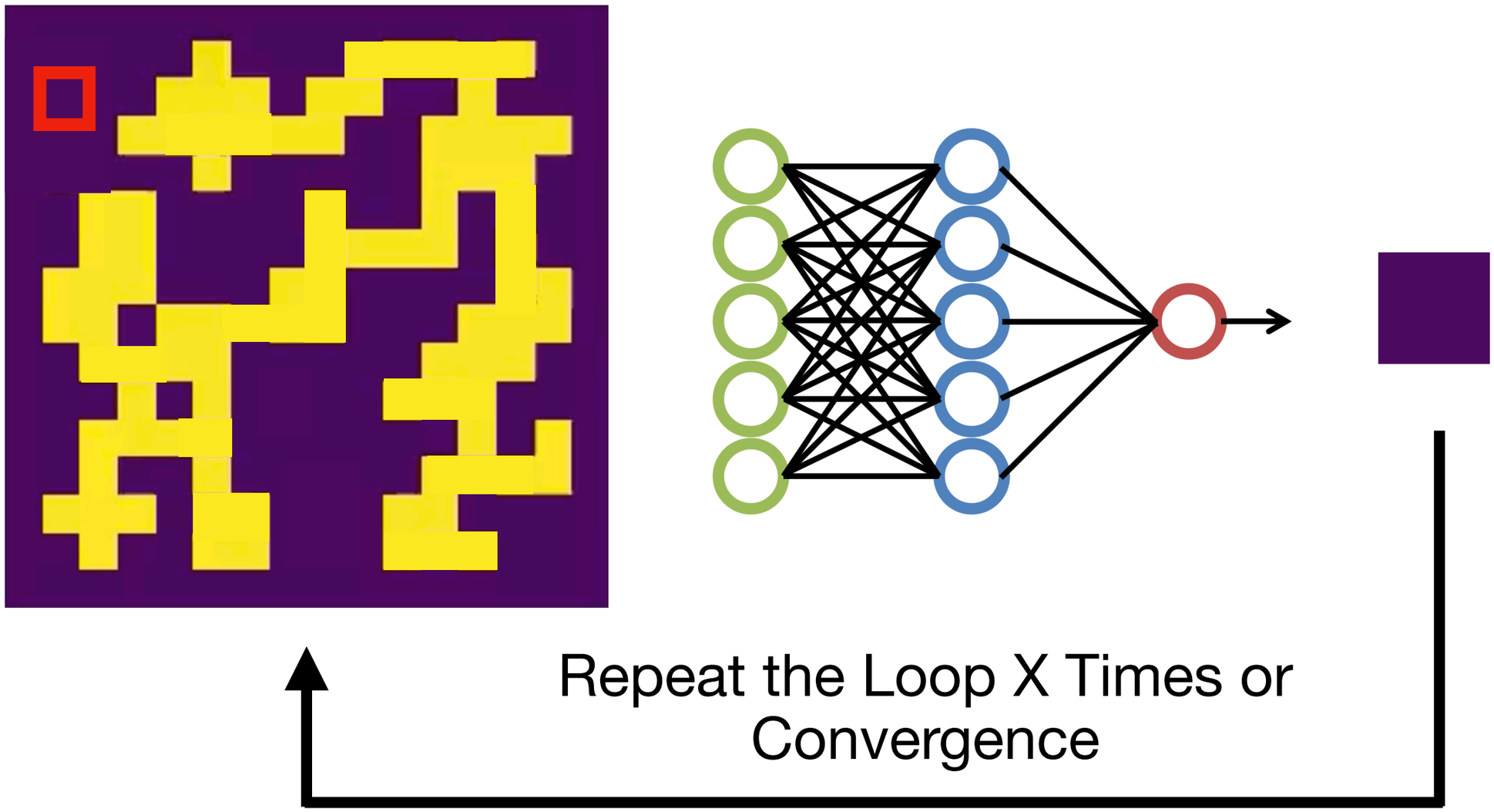
Generating New Levels



Generating New Levels



Generating New Levels



Why?

- Evolution takes long time to generate levels due to fitness function
- Defining fitness function for levels is easier than a fitness function for generators
- New games usually don’t have much levels

Training Loop

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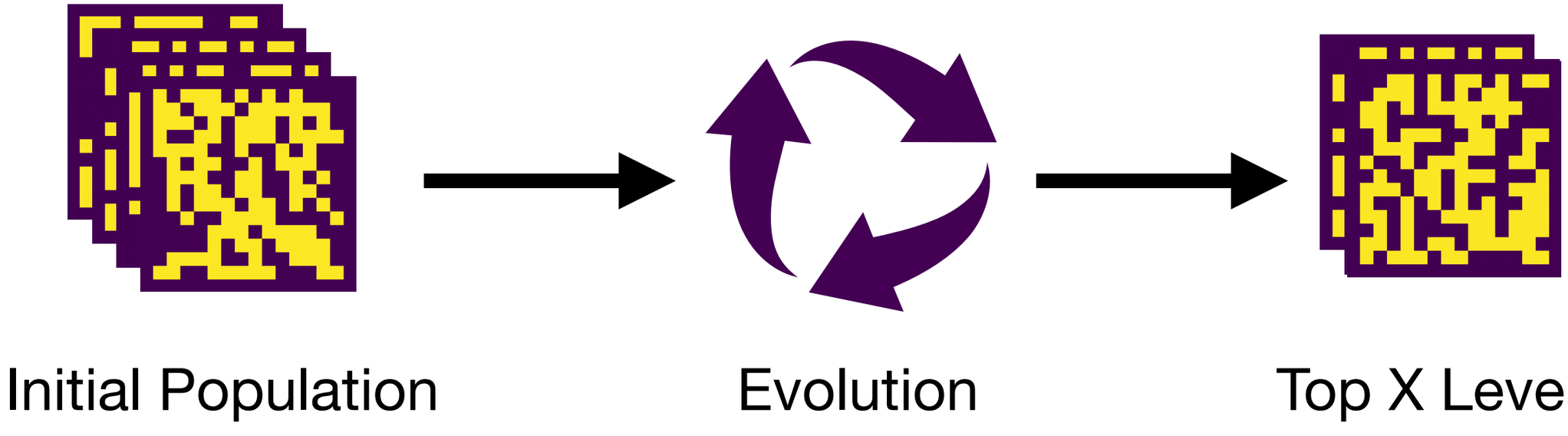
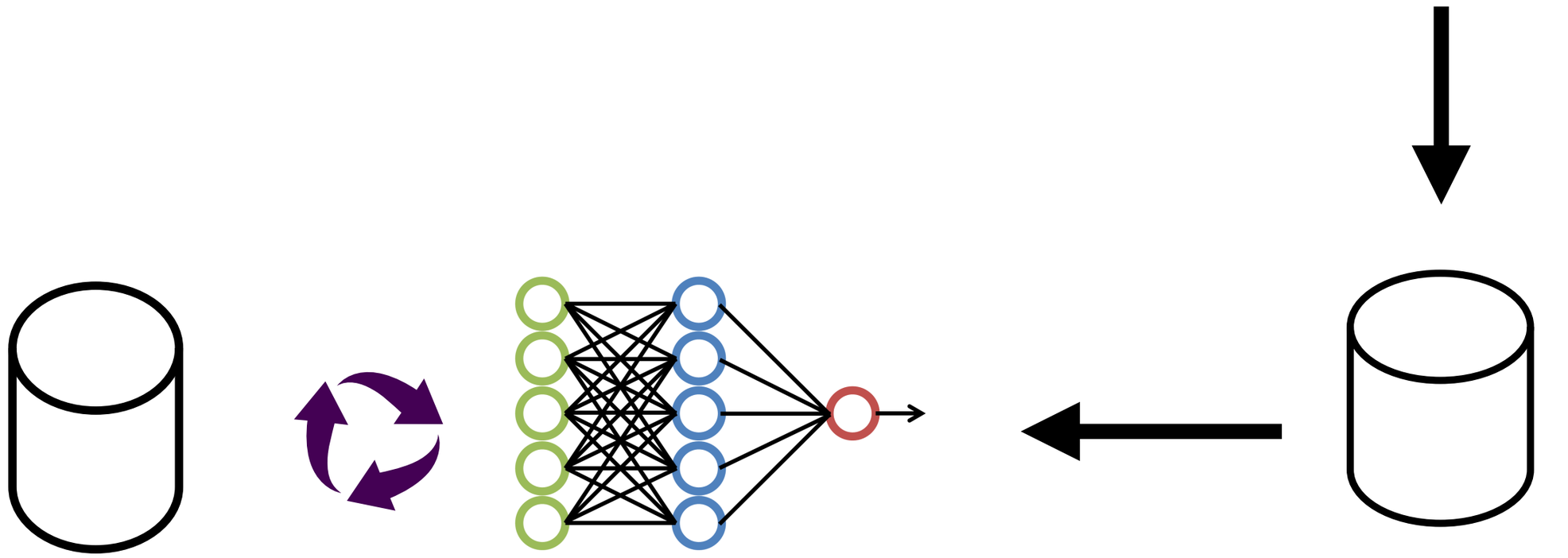
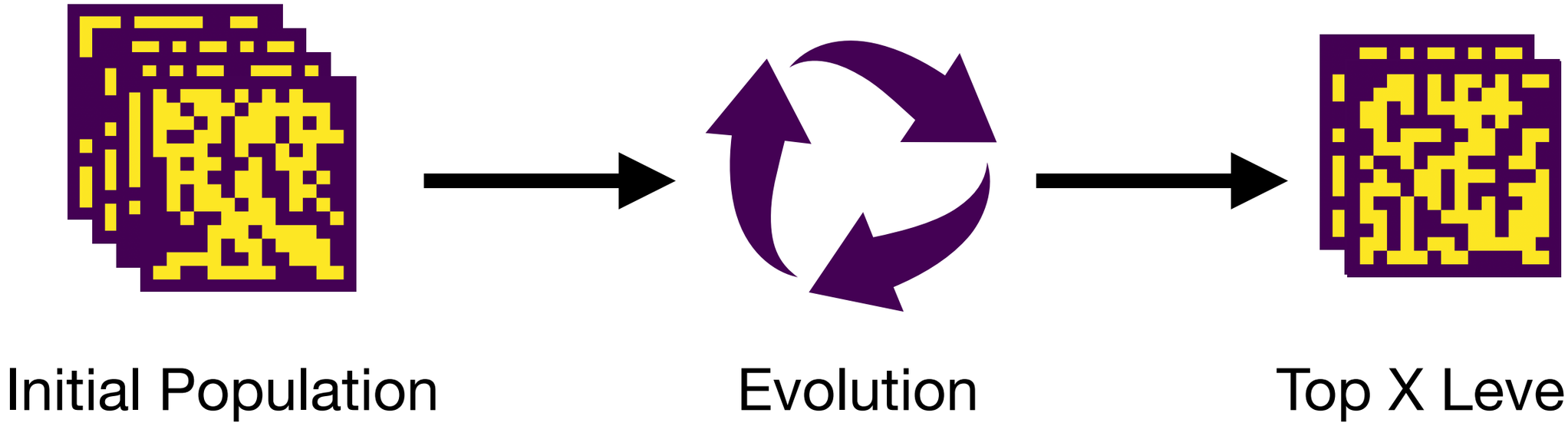
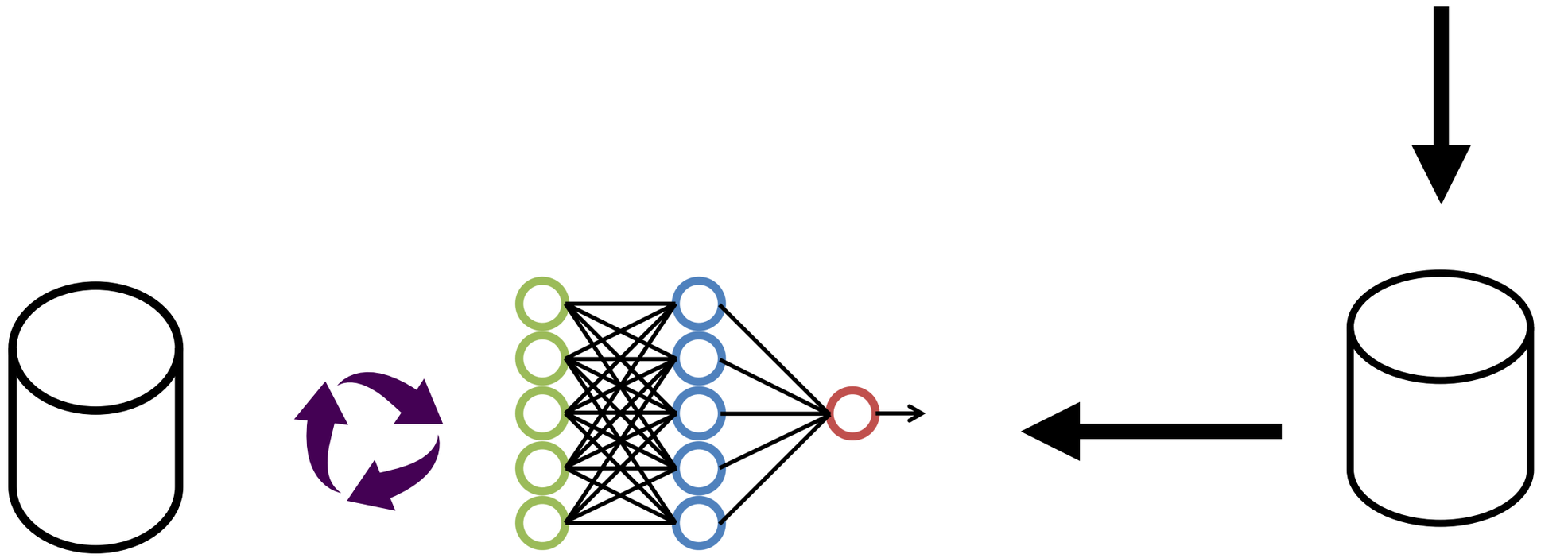
Training Loop





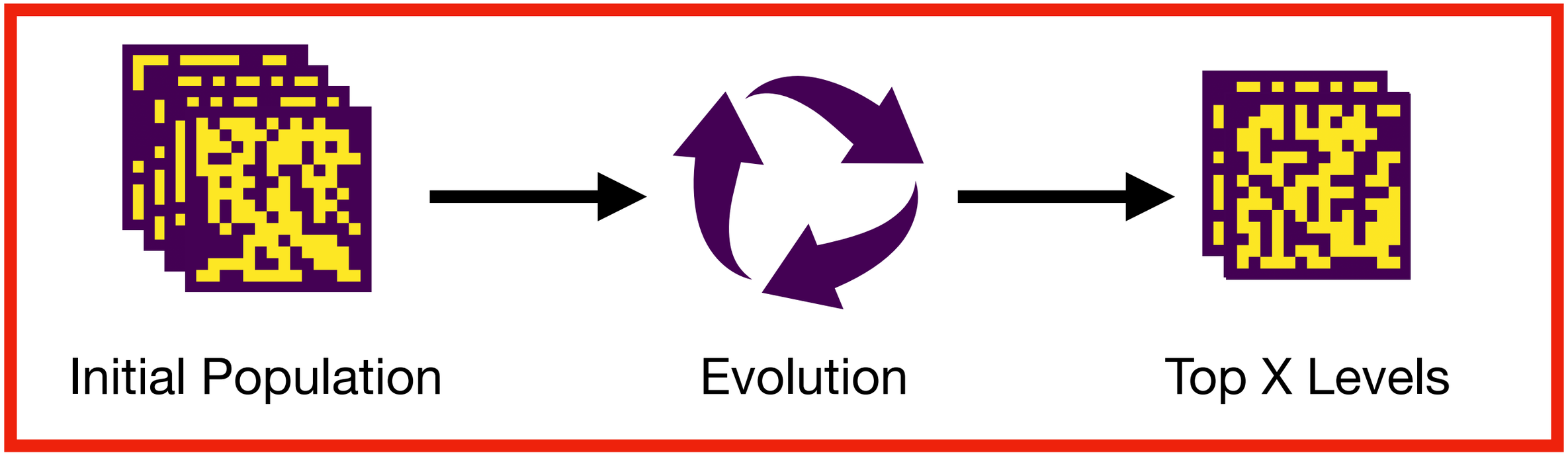
Training Loop

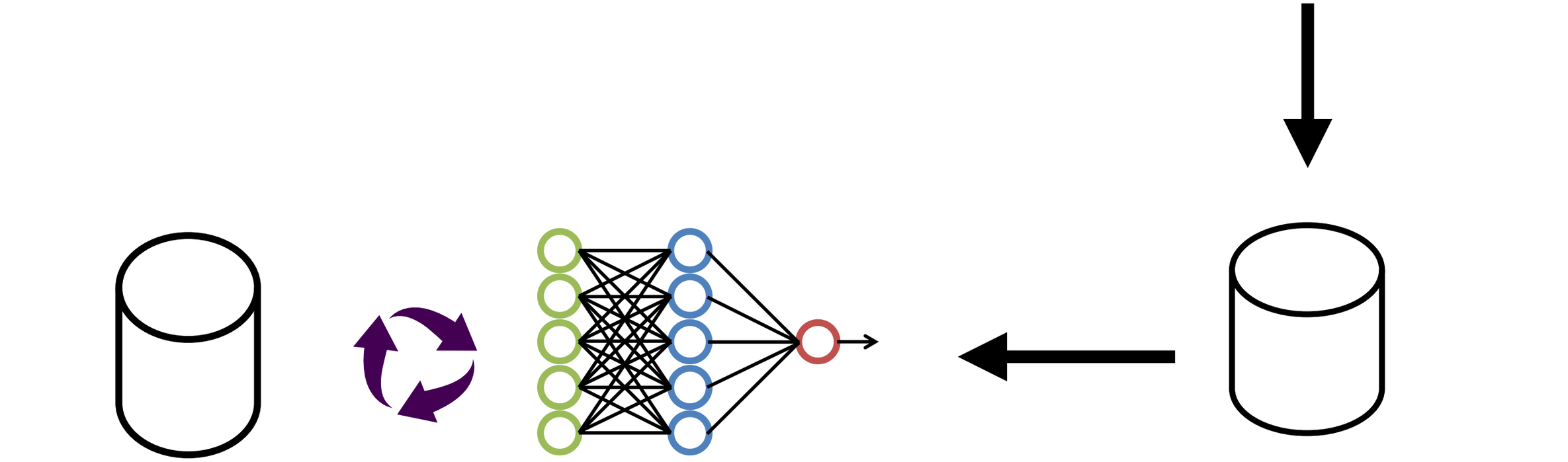




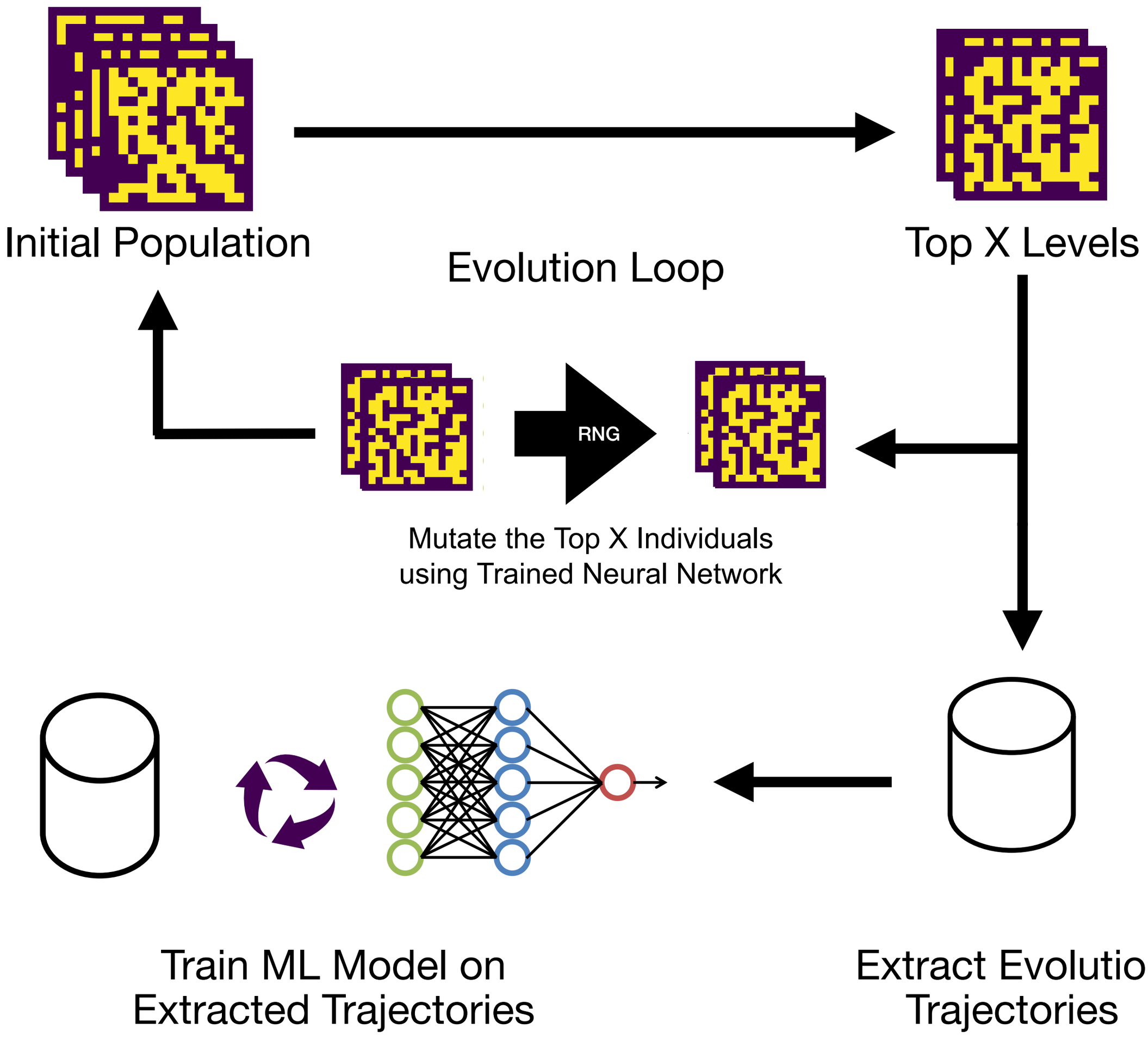
Normal Mode

Training Loop

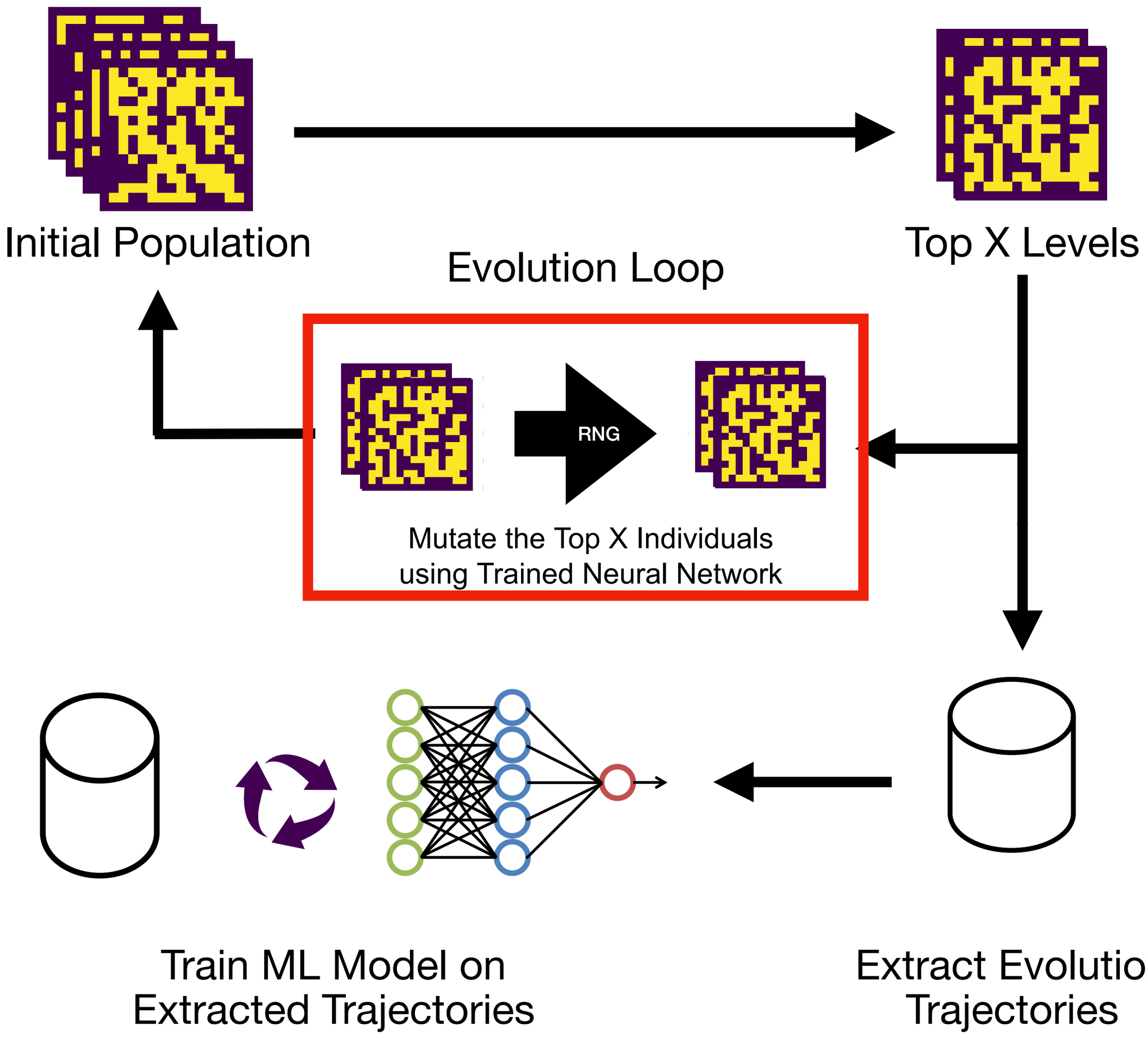




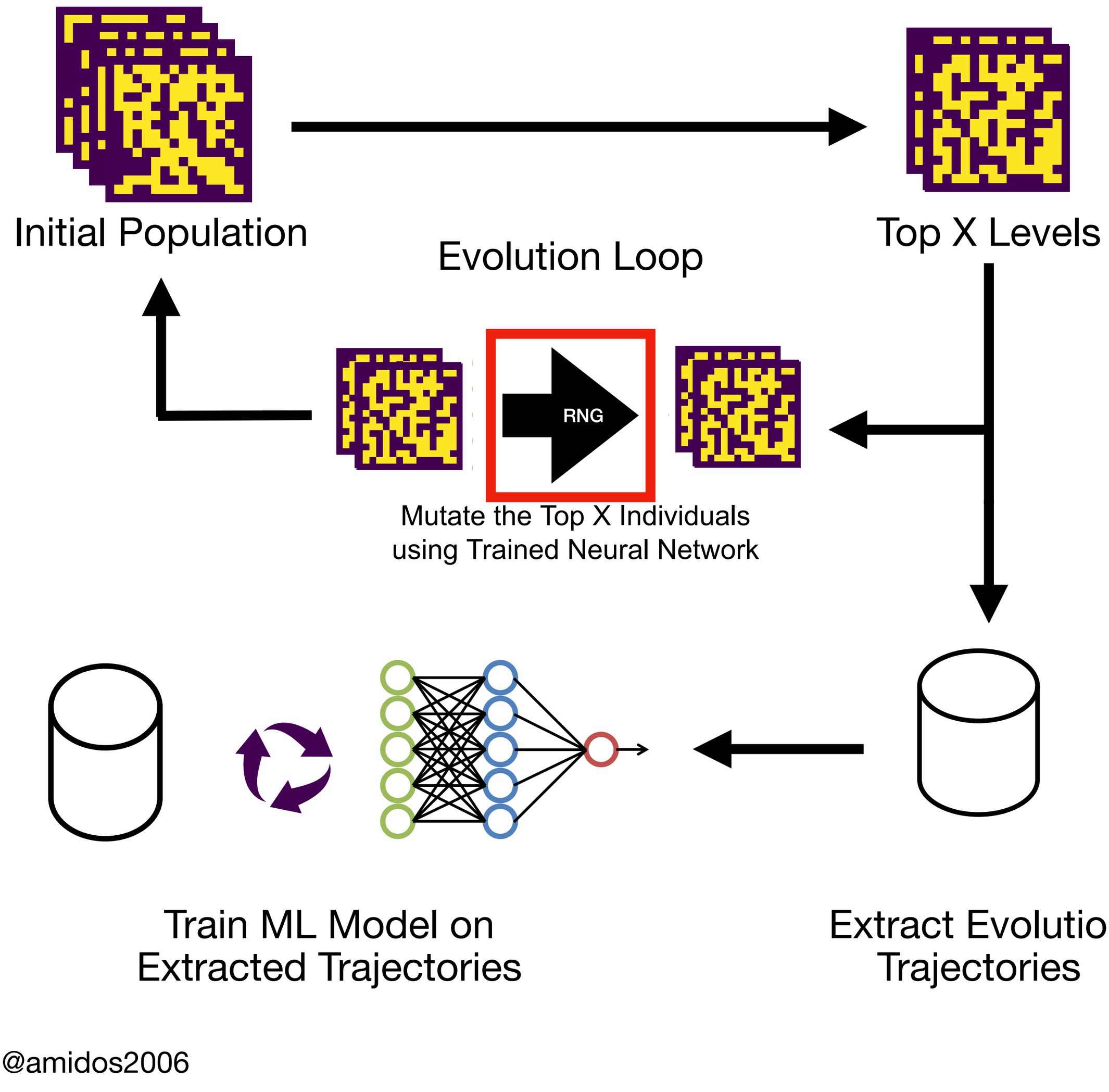
Training Loop



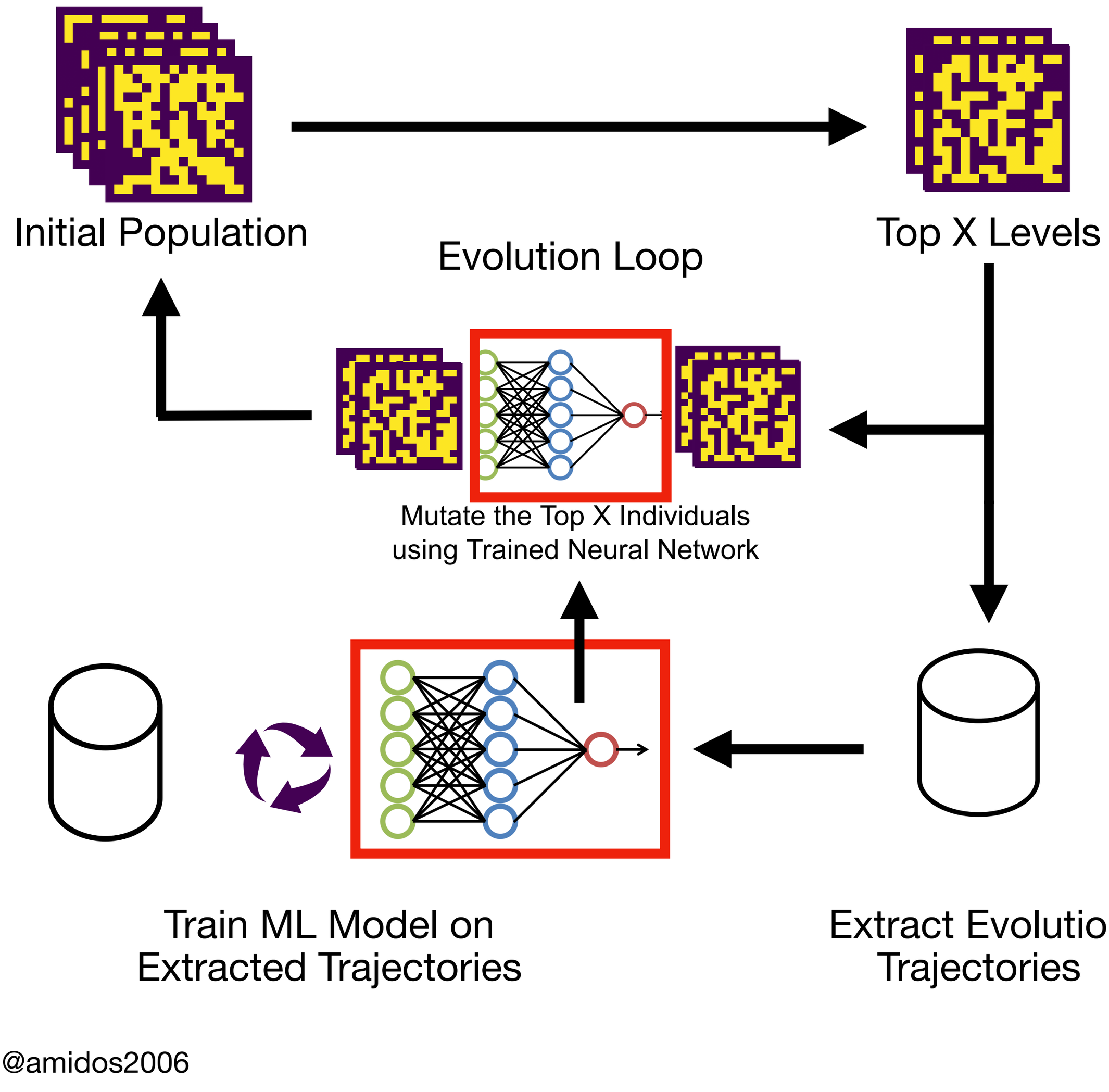
Training Loop



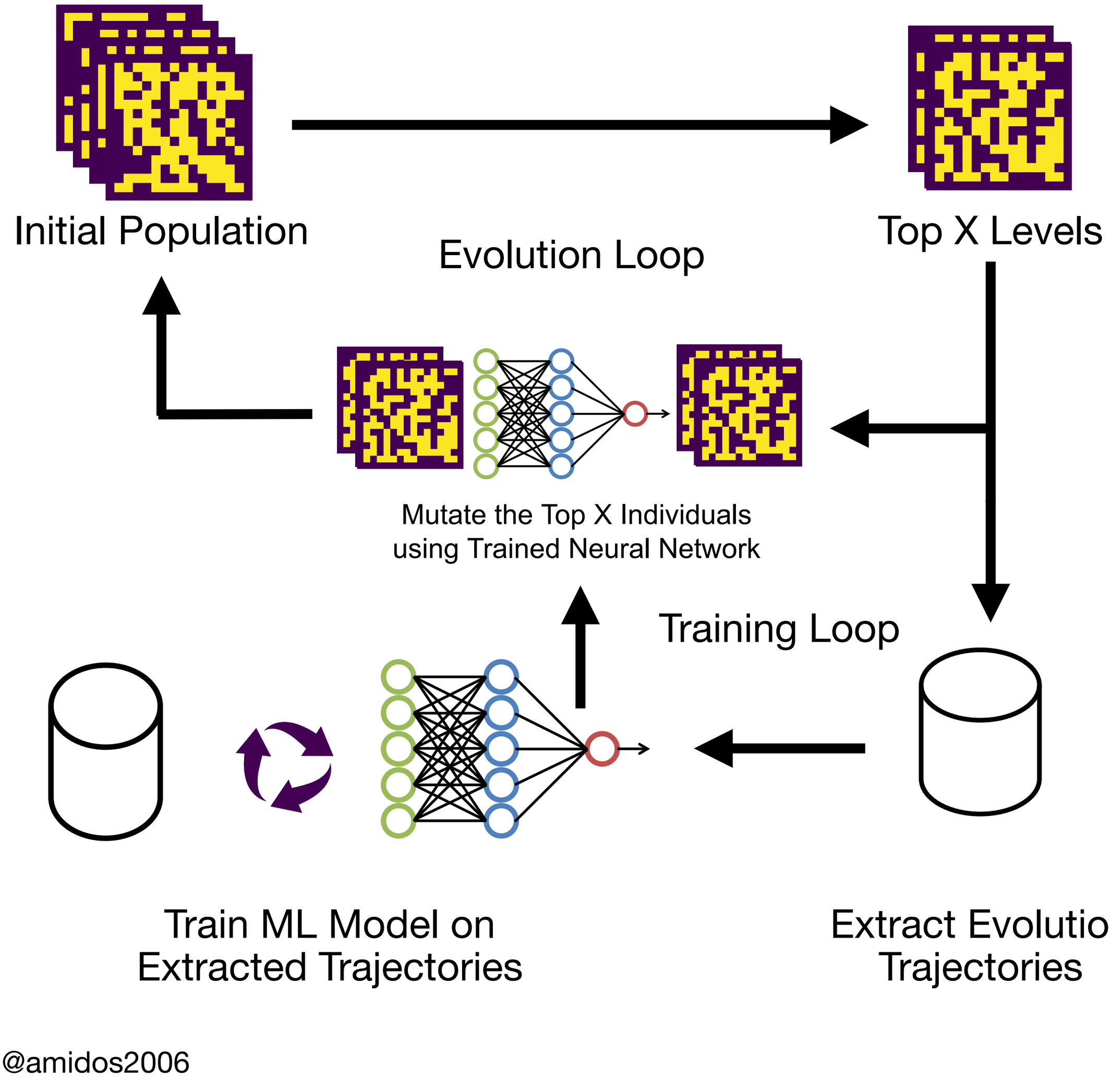
Training Loop



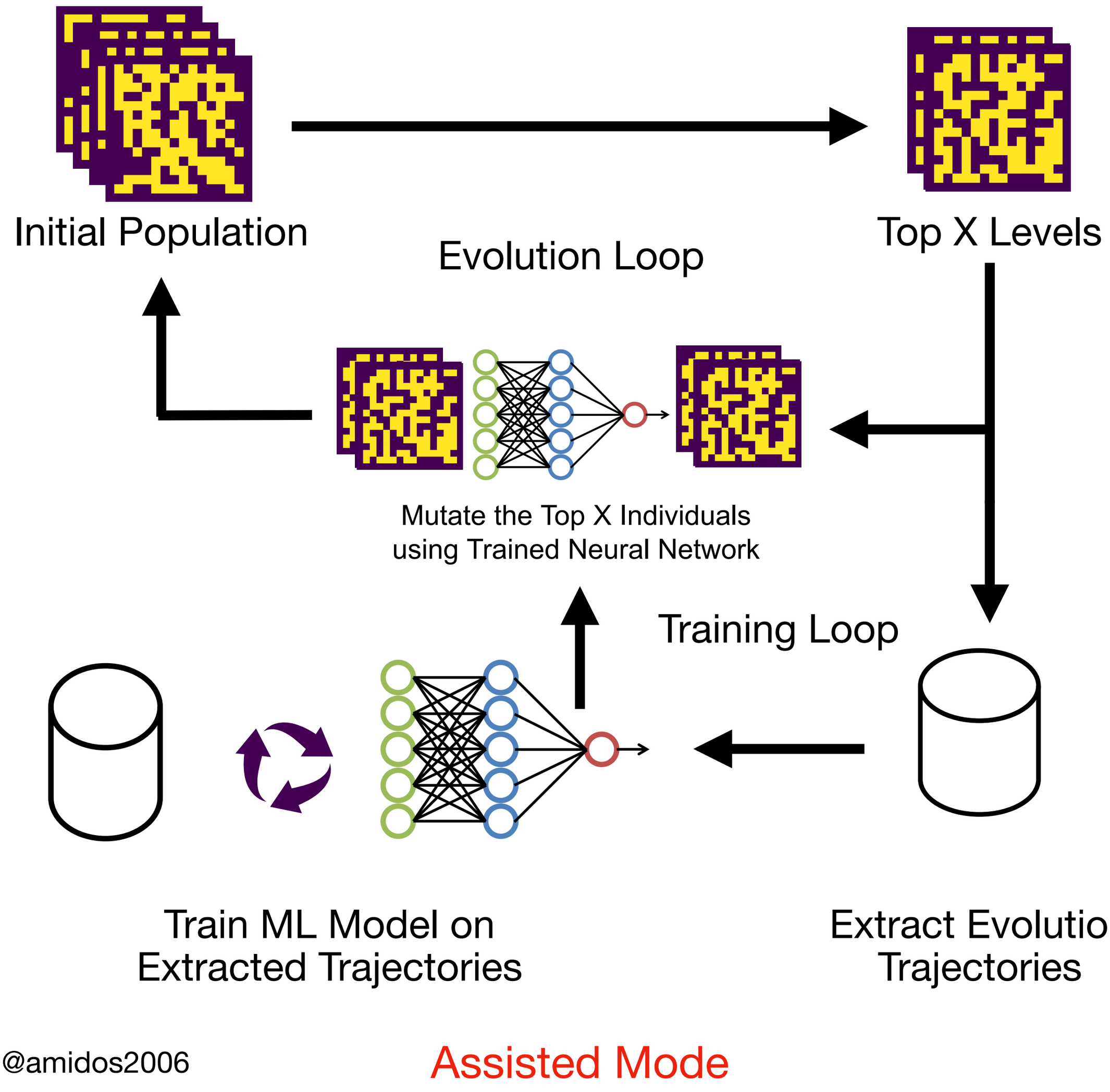
Training Loop



Training Loop



Training Loop



Experiments

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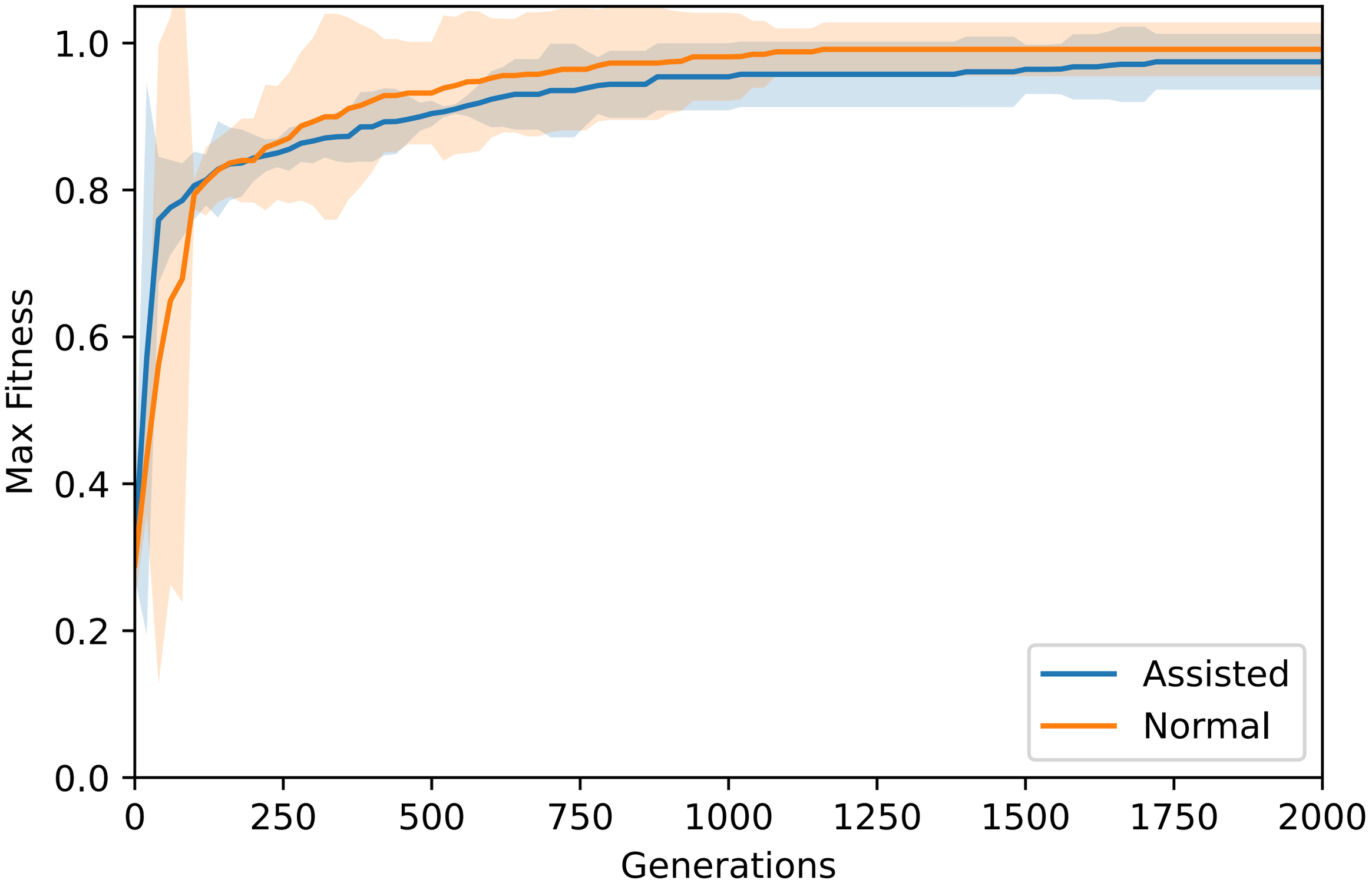
Evolution

- μ + λ evolution strategy (50 + 50)

- Fitness:
  - Connect all the level
  - Increase the shortest Path Length in the Map

Evolution Fitness



Trained Networks

- Networks are trained on top 10 levels

- Network trained for 2 epochs

- Update the whole level until:
    - Fully connected (Success)
    - Each tile get visited 196 times (Failure)

Trained Networks

	Success	Diversity	Average # visits
Assisted	**99.67% ± 0.49%**	**86.83% ± 3.8%**	**18.21 ± 18.57**
Normal	30.17% ± 32.7%	28.5% ± 30.62%	61.7 ± 47.22

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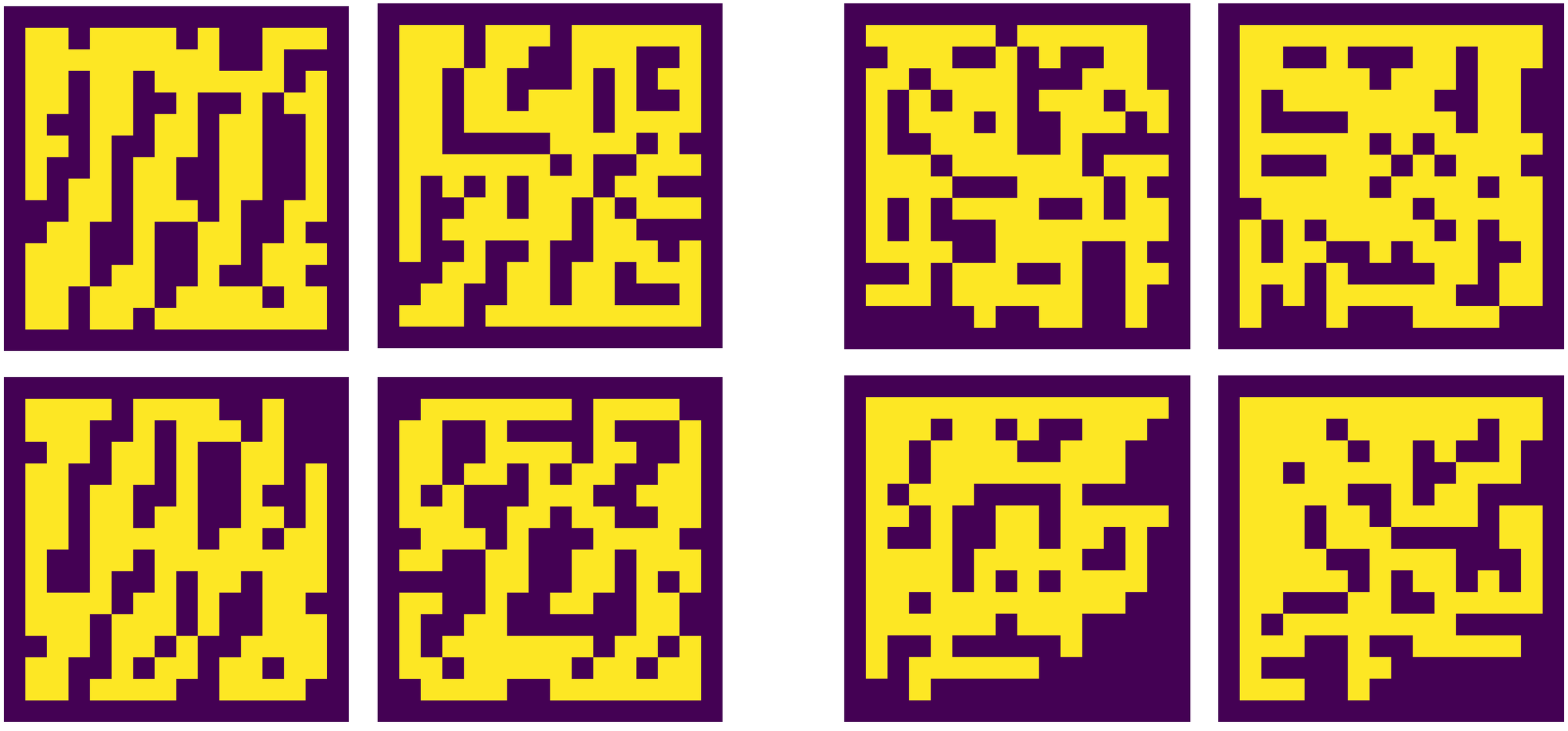

Assisted

Normal

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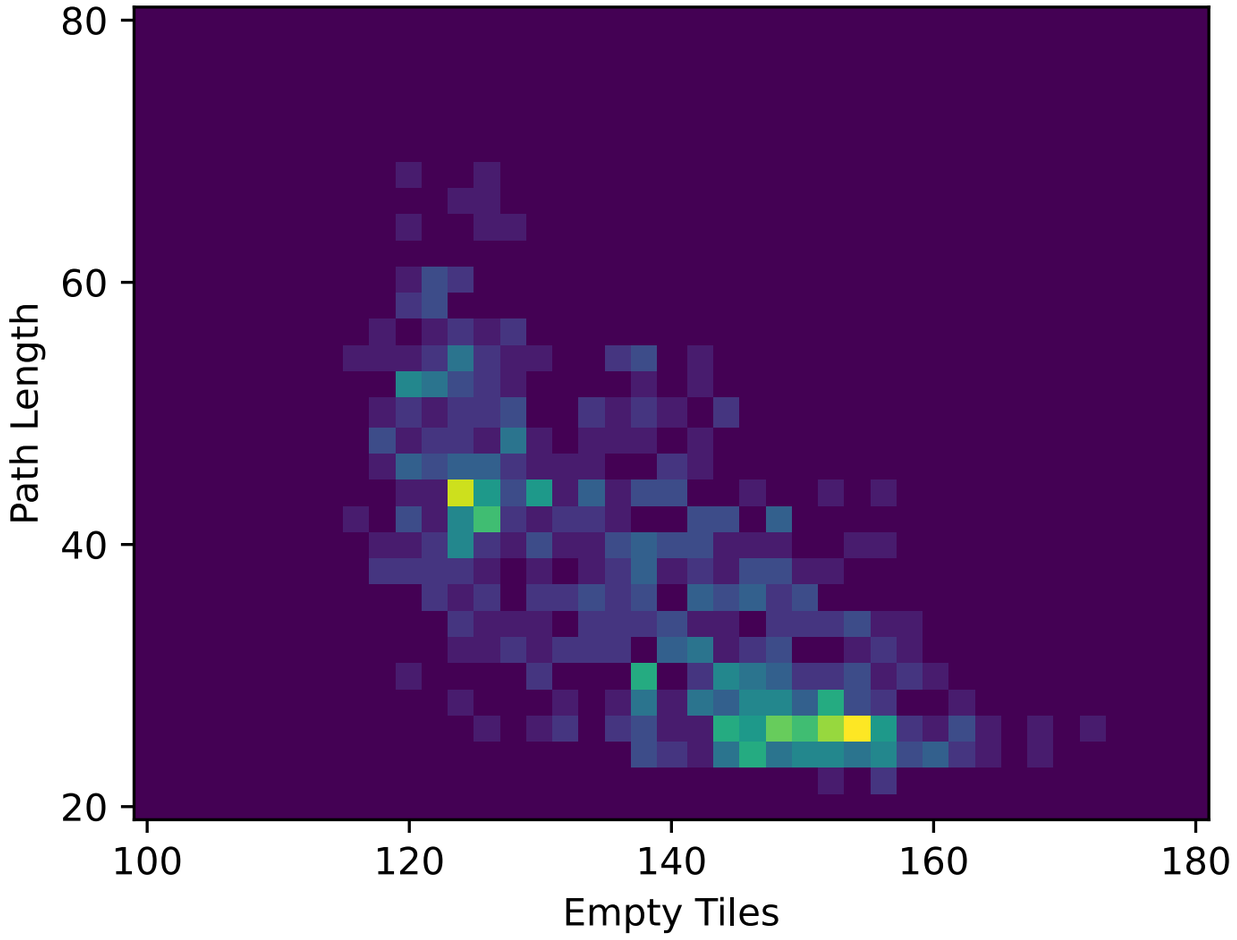
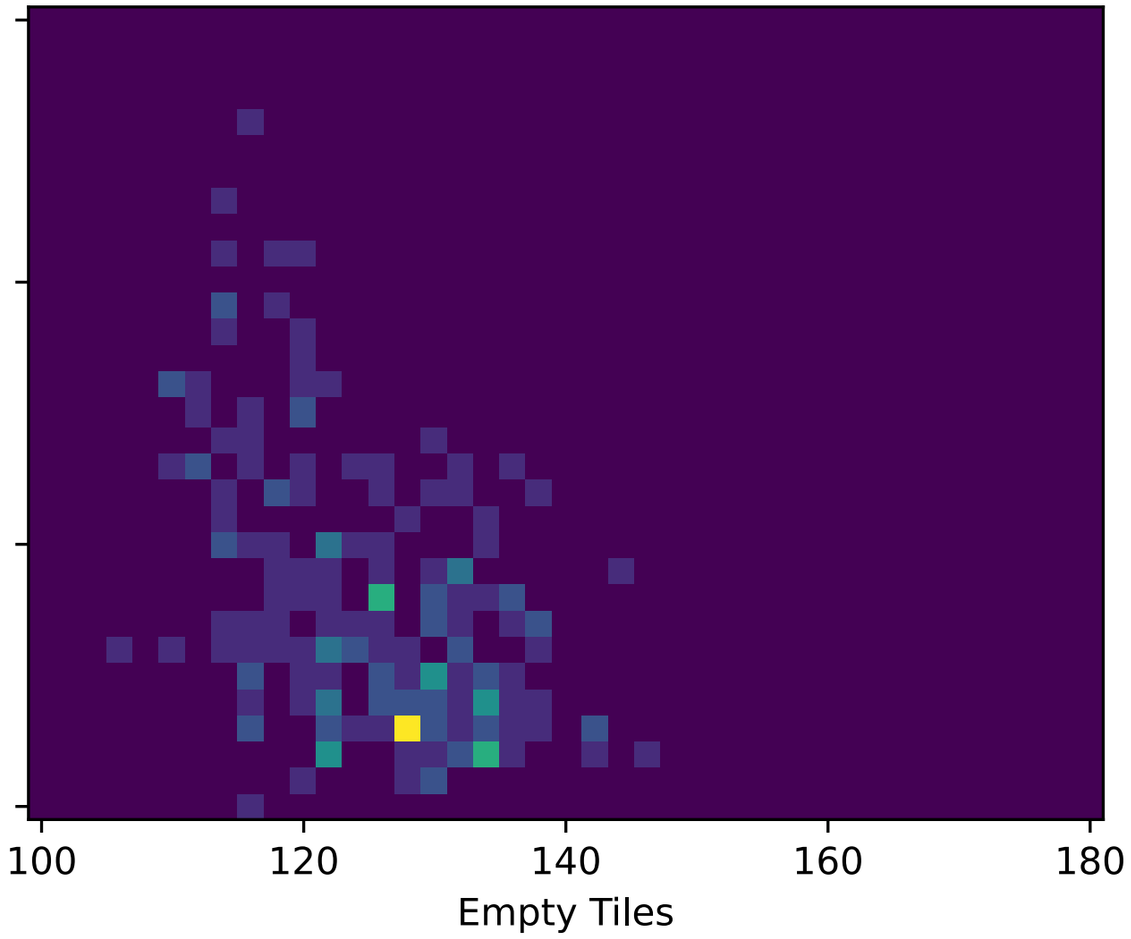


Assisted



Normal

Comparing Evolution to Trained Network

@amidos2006

Compare Evolution to Trained Networks

- Generate 100 levels by evolution
- Generate 100 levels by each trained network

- Stop evolution/updating levels:
  - Fully connected (Success)
  - Each tile get visited 196 times (Failure)

Compare Evolution to Trained Networks

	Success	Diversity	Wall Time (sec)
Assisted	99.67% ± 0.49%	86.83% ± 3.8%	**0.6612 ± 2.3874**
Evolution	**100%**	**96%**	12.6957 ± 2.2571

Future Work

- What about Evolving Diverse Levels using Quality Diversity?

- Different Games? Applications?

- What about indirect encoding?

- Different ways to create trajectories?

Thanks

@amidos2006