BrainVation

Simulating the brain’s motivational mechanism

Project Number - 22804
Moderator - Dr. Cohen Sarel
Moderator - Mr. George Kour
Snir Dobo | Ido Kahlon | Romi Erez

Introduction

Goal

Help the researcher understands how the brain works

How

Find the most similar artificial Brain to a rat in a motivational experiment

Implementation

Simulating number of brains, train and compare by the likelihood of action

Deep Learning method

Reinforcement learning

Outcomes

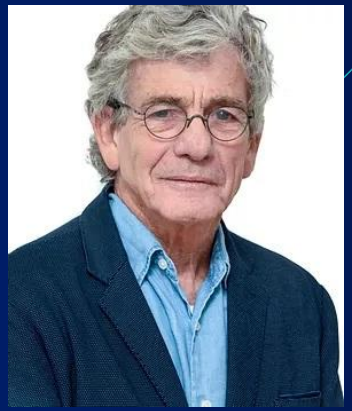
Artificial brain parameters that represent the rat physical brain

The research team

George Kour

Dr. Genela Morris

Dr. Sarel Cohen



Prof. Eilon Vaadia

01

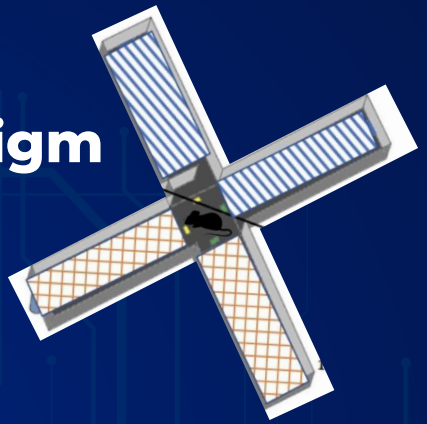
The research

Research Questions

How motivation affects learning?

How do rules learned under one motivation transferred under two different motivation?

The Experimental Paradigm



Food motivation + Odor 1

1

Interdimensional shift

Food motivation + Odor 2

2

Motivational shift

Water motivation + Odor 2

3

Interdimensional & Motivational shift

Food motivation + Odor 1

4

extra Interdimensional shift

Spatial Food motivation

5

02

The Project

01

Data Preparation & brain exploration

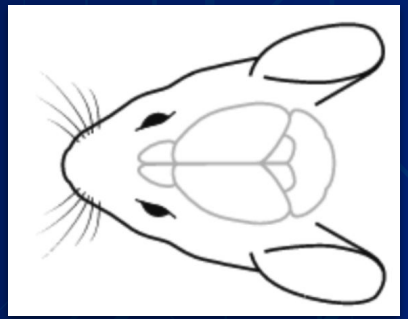
02

Implementation
fitting the simulation on real animal data

03

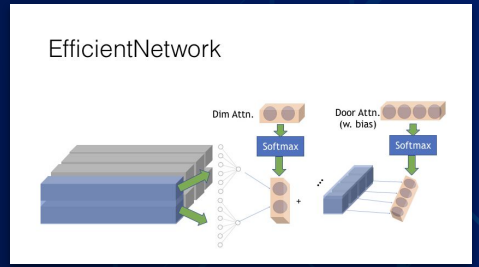
Investigation
Calculating the goodness-of-fit of artificial brain model

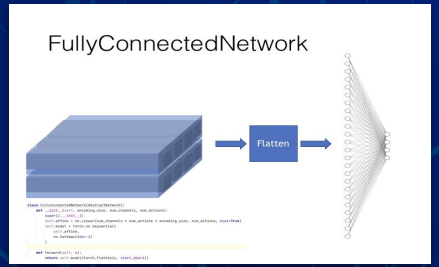
Data Preparation & brain exploration



Explore the artificial brain and its parameters.

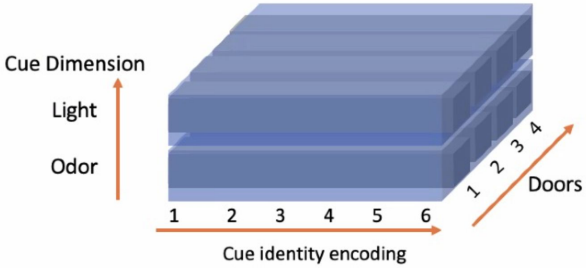
Generate the meaningful parameters to simulate the artificial brains.

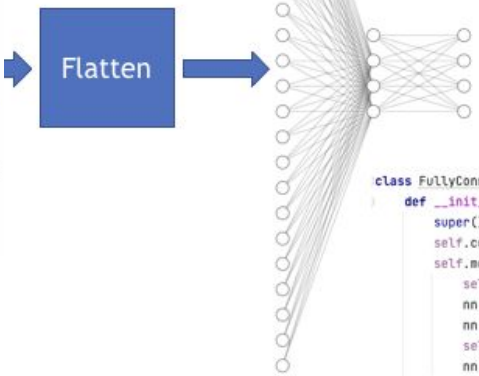




Used Networks

FullyConnectedNetwork2Layers



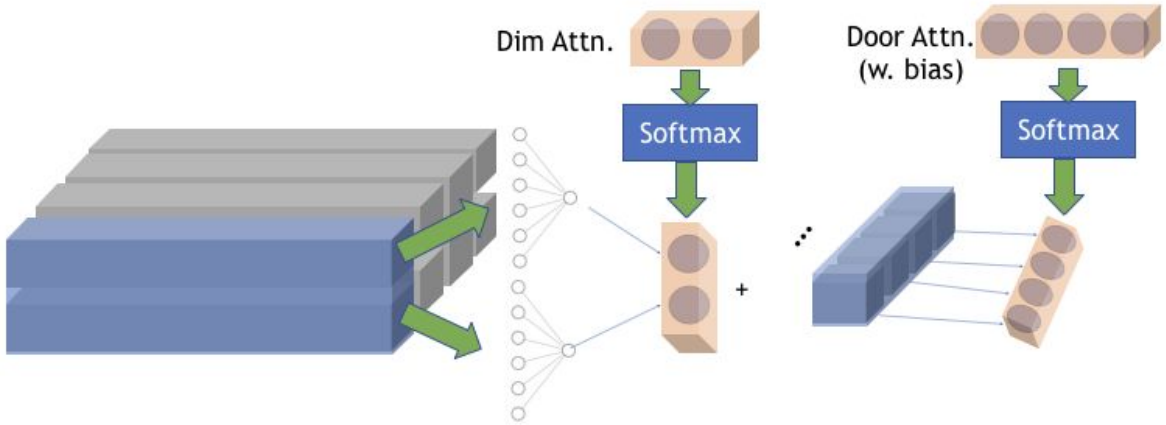



```python
class FullyConnectedNetwork2Layers(FullyConnectedNetwork):
    def __init__(self, encoding_size, num_channels, num_actions):
        super().__init__(encoding_size, num_channels, num_actions)
        self.controller = nn.Linear(num_actions, num_actions, bias=True)
        self.model = torch.nn.Sequential(
            self.affine,
            nn.Dropout(p=0.6),
            nn.Sigmoid(),
            self.controller,
            nn.Softmax(dim=-1)
        )

    def forward(self, x):
        return self.model(torch.flatten(x, start_dim=1))
```

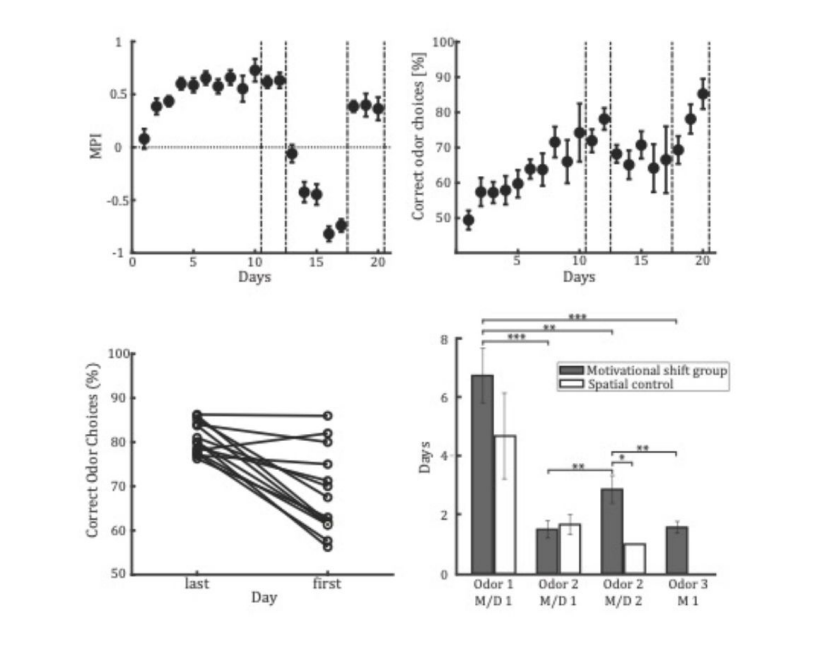
Used Networks

EfficientNetwork



Implementation - Fitting the simulation on real animal data

Implement the off-policy reinforcement learning method by force the artificial brain to learn from the real animal data instead of learning by himself.



Investigation - comparing the goodness-of-fit of artificial brain

Calculating the goodness-of-fit of each artificial brain **on trial by trial basis, by calculating the likelihood (probability) of the action of the** artificial to do the same action as the animal did.

Row Labels	likelihood mean	likelihood std	network paramaters
EfficientNetwork	2.280	0.369	22.000
BrainDQN	2.113	0.392	22.000
0	2.241	0.427	22.000
0.3	**1.985**	0.310	22.000
BrainDQNFixedDoorAttention	2.448	0.252	22.000
0	2.566	0.237	22.000
0.3	2.330	0.211	22.000
FullyConnectedNetwork	3.067	0.441	196.000
BrainDQN	3.063	0.447	196.000
0	3.442	0.207	196.000
0.3	2.684	0.261	196.000
DQN	3.076	0.435	196.000
0	3.441	0.191	196.000
0.3	2.712	0.270	196.000
FullyConnectedNetwork2Layers	2.400	0.287	216.000
BrainDQN	2.400	0.287	216.000
0	2.654	0.167	216.000
0.3	2.146	0.083	216.000
SeparateMotivationAreasNetwork	2.077	0.480	44.000
MotivationDependantBrainDQN	2.007	0.498	44.000
0	2.159	0.555	44.000
0.3	**1.855**	0.385	44.000
MotivationDependantBrainDQNLateOutcomeEvaluation	2.148	0.454	44.000
0	2.183	0.499	44.000
0.3	2.112	0.407	44.000

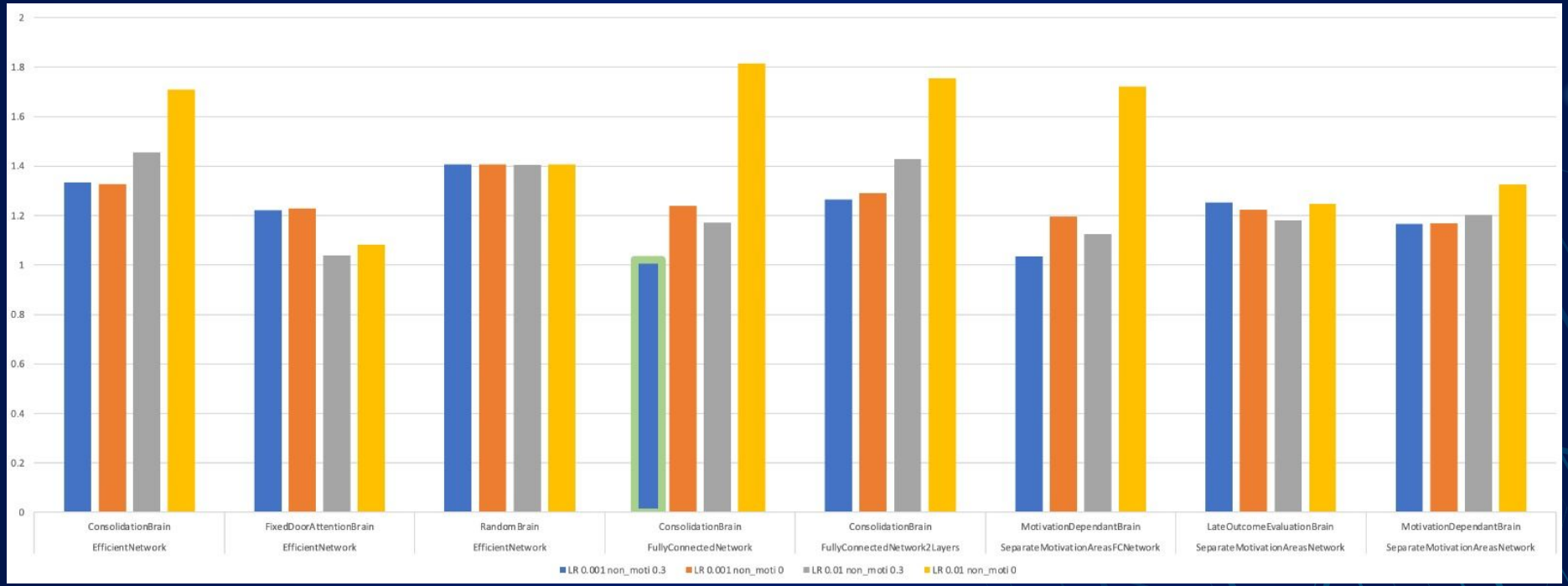
$$\ell(M) = -\frac{1}{T}\sum_{t=1}^{T} \log P\left(a_t \middle| s_t; M, \theta_t\right)$$

Results

learning_rate	0.001
non_motivated_reward	0.3

Row Labels	Average of average_likelihood_s1	Average of average_likelihood_s2	Average of average_likelihood_s3	Average of average_likelihood_s4	Average of average_likelihood_s5	Average of all stages likelihood
EfficientNetwork	**1.374853317**	**1.170238347**	**1.378966477**	**1.412489689**	**1.267197226**	1.320749011
ConsolidationBrain	1.343787763	1.06394274	1.487759612	1.550333306	1.225795682	1.334323821
FixedDoorAttentionBrain	1.375676617	1.040068577	1.234341638	1.284646958	1.169423043	1.220831367
RandomBrain	1.40509557	1.406703724	1.414798182	1.402488802	1.406372954	1.407091846
FullyConnectedNetwork	**1.542460205**	**0.822371333**	**0.72886051**	**0.855133728**	**1.160396699**	1.021844495
ConsolidationBrain	1.542460205	0.822371333	0.72886051	0.855133728	1.160396699	1.021844495
FullyConnectedNetwork2Layers	**1.161704704**	**0.832488617**	**1.470747833**	**1.51796708**	**1.346379135**	1.265857474
ConsolidationBrain	1.161704704	0.832488617	1.470747833	1.51796708	1.346379135	1.265857474
SeparateMotivationAreasFCNetwork	**1.529929358**	**0.836133934**	**0.668367386**	**1.074973701**	**1.06498323**	1.034877522
MotivationDependantBrain	1.529929358	0.836133934	0.668367386	1.074973701	1.06498323	1.034877522
SeparateMotivationAreasNetwork	**1.380324561**	**1.077177117**	**1.145137032**	**1.229751656**	**1.215334595**	1.209544992
LateOutcomeEvaluationBrain	1.465877172	1.13940512	1.212840305	1.232472773	1.215970699	1.253313214
MotivationDependantBrain	1.29477195	1.014949113	1.07743376	1.22703054	1.214698491	1.165776771

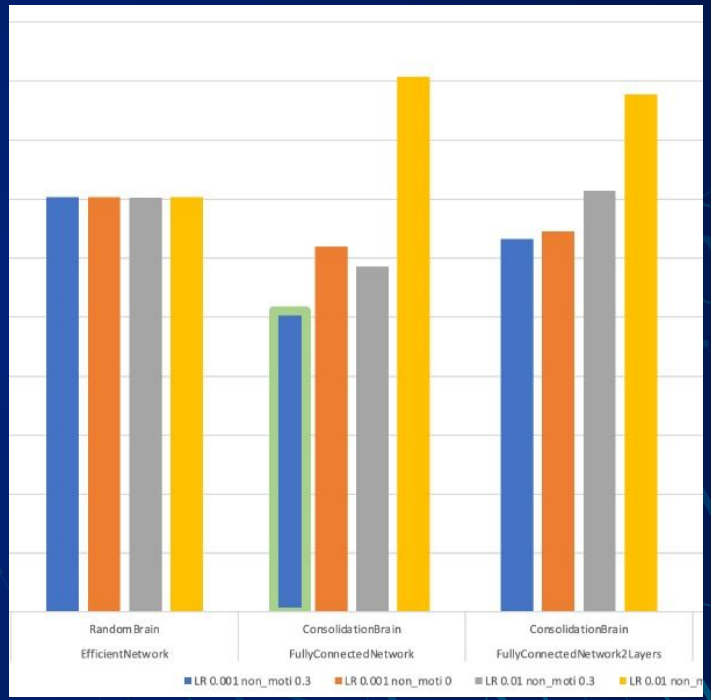
Results


2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
ConsolidationBrain EfficientNetwork
FixedDoorAttentionBrain EfficientNetwork
RandomBrain EfficientNetwork
ConsolidationBrain FullyConnectedNetwork
ConsolidationBrain FullyConnectedNetwork2Layers
MotivationDependantBrain SeparateMotivationAreasFCNetwork
LateOutcomeEvaluationBrain SeparateMotivationAreasNetwork
MotivationDependantBrain SeparateMotivationAreasNetwork
LR 0.001 non_moti 0.3
LR 0.001 non_moti 0
LR 0.01 non_moti 0.3
LR 0.01 non_moti 0

Conclusions

The most similar artificial Brain to a rat in a motivational experiment

- Learning Rate - 0.001
- Non-motivated reward - 0.3
- Network - FullyConnectedNetwork
- Brain Type - Consolidation Brain



Project Summary

Review the project code

Simulating Different brains by looping different parameters

Building DB for each animal in the Laboratory

Train the network by the animal actual actions

Evaluating each brain by their goodness of fit to the animal data

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The team was an important part of the research, their contribution was the first and massive data analysis which is one of the most massive part of the research

George Kour, research scientist, project moderator

Thank You!