Understanding responses to environments for the Prisoner's Dilemma

Max Planck Institute for Evolutionary Biology

@NikoletaGlyn

CARDIFF
UNIVERSITY
PRIFYSGOL
CAERDYDD

Software
Sustainability
Institute

PLOS
Channels

rebloggy.com/post/animals-bat-black-and-white-eyes-creepy-horror-gore-halloween-animal-bats-vampir/101865318472

$$\begin{bmatrix} (3,3) & (0,5) \\ (5,0) & (1,1) \end{bmatrix}$$

✊✊

✊✊

✋✊

✊✊

✋✊

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✊✊

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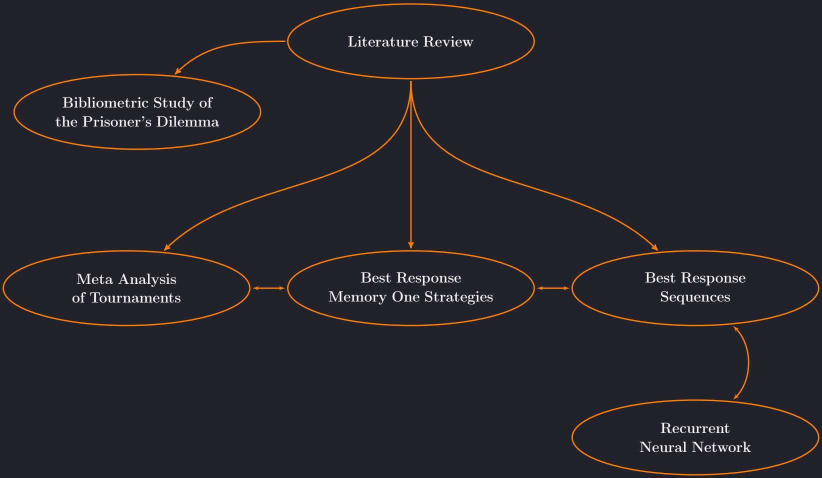
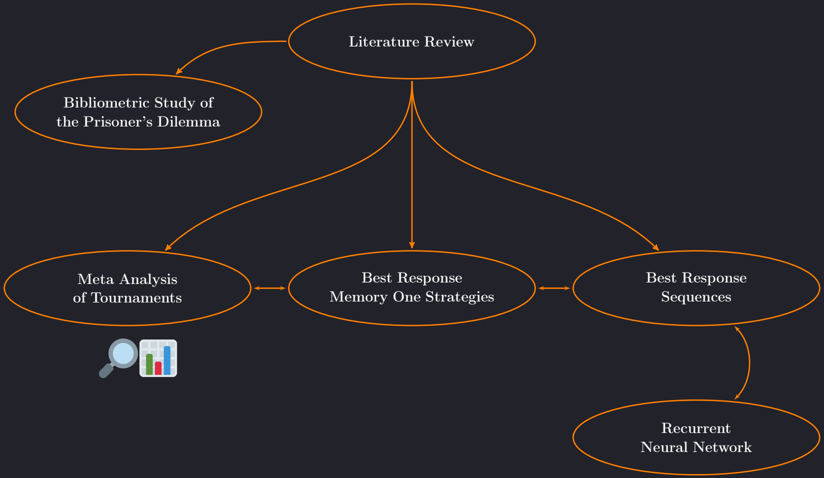
🤝


Literature Review
Bibliometric Study of the Prisoner's Dilemma
Meta Analysis of Tournaments
Best Response Memory One Strategies
Best Response Sequences
Recurrent Neural Network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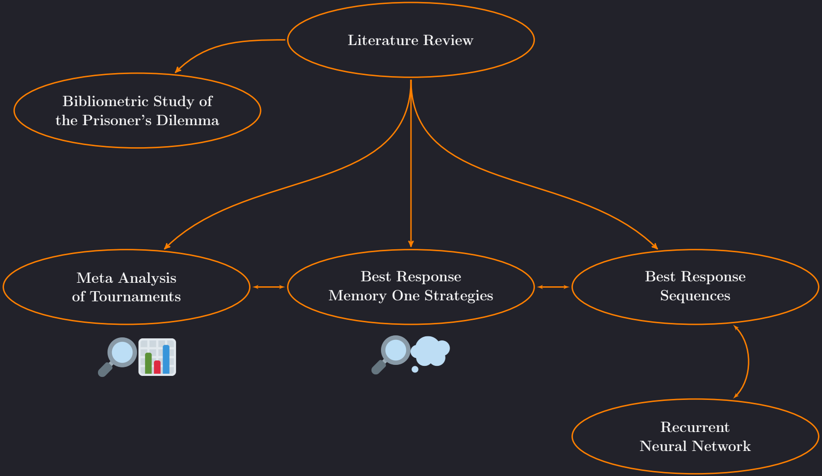
Literature Review
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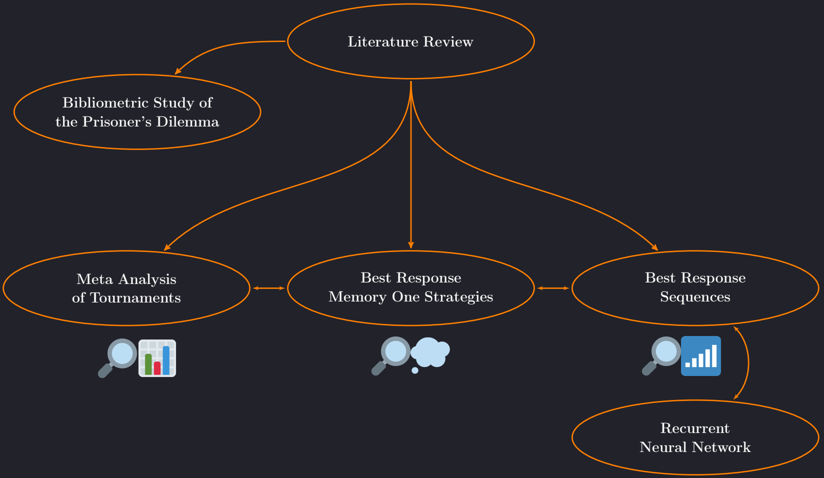
the Prisoner's Dilemma
Meta Analysis
of Tournaments
Best Response
Memory One Strategies
Best Response
Sequences
Recurrent
Neural Network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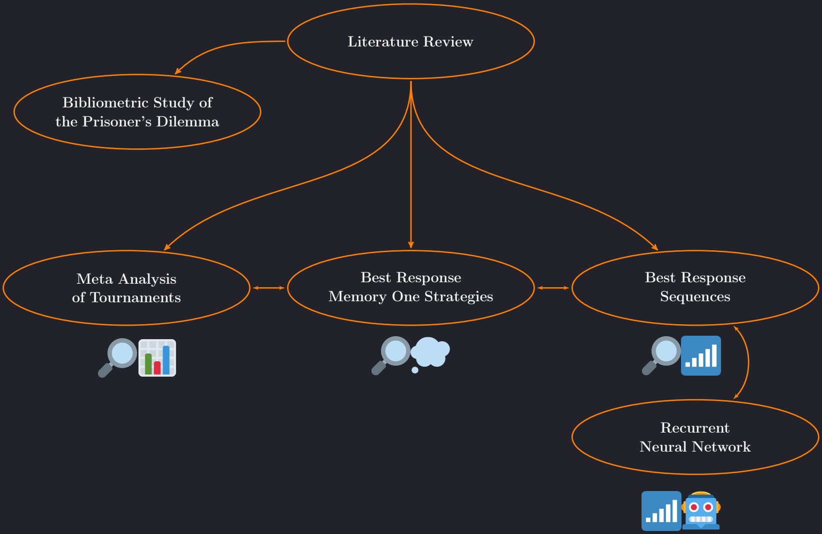

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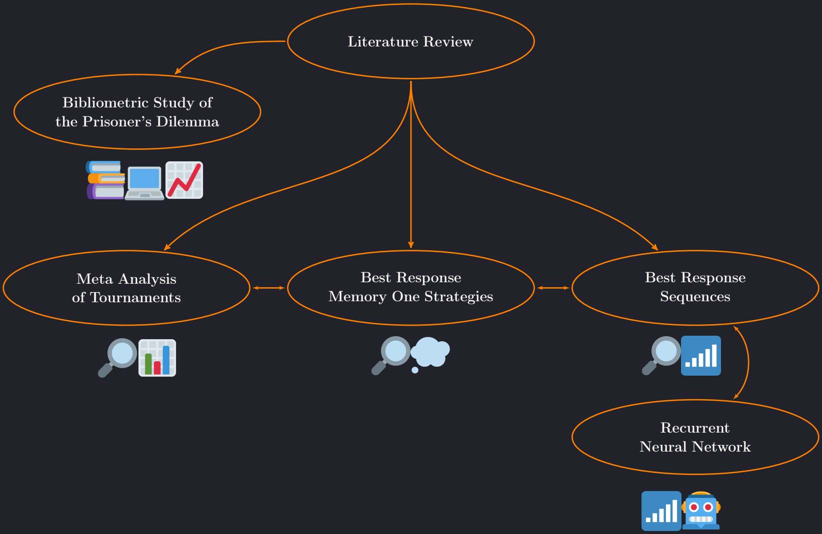

Literature Review
Bibliometric Study of the Prisoner's Dilemma
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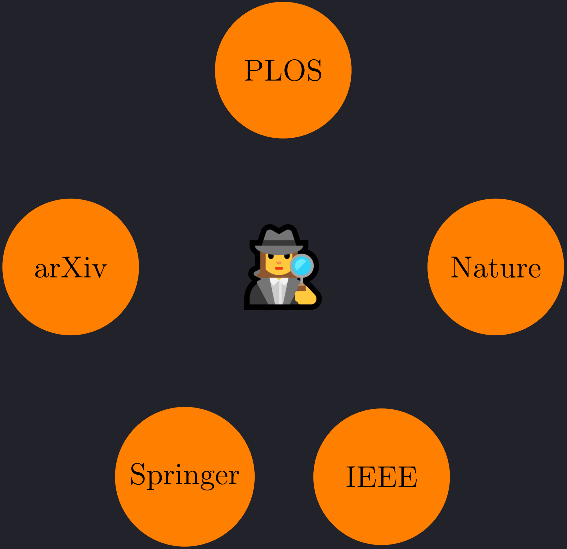
Recurrent Neural Network

Bibliometric Study of the Prisoner's Dilemma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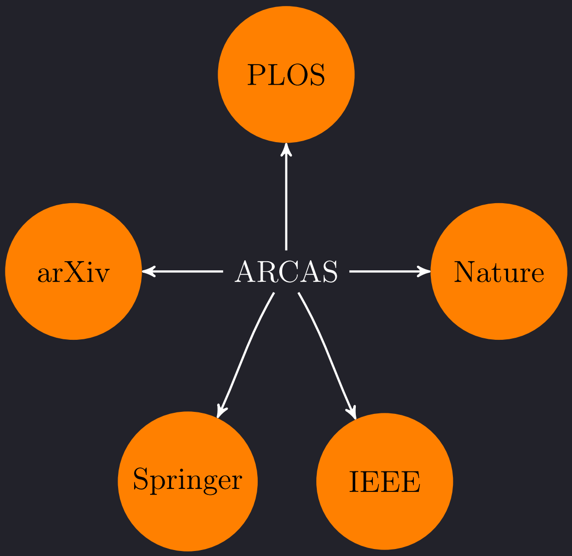
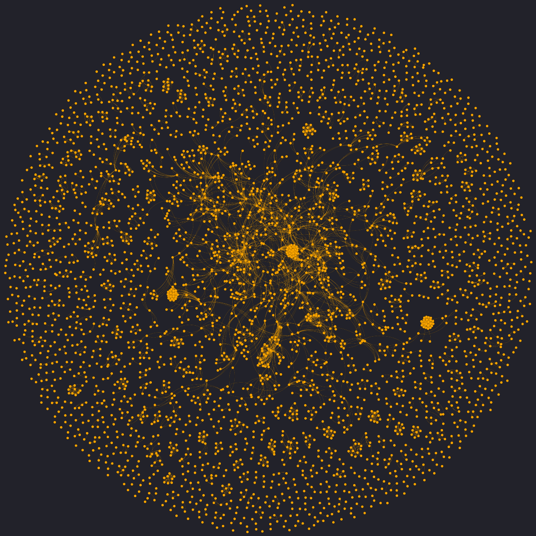
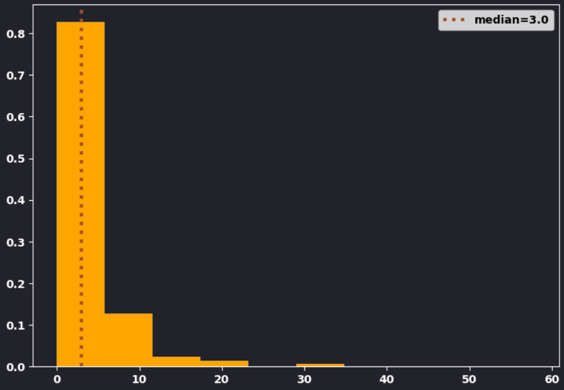
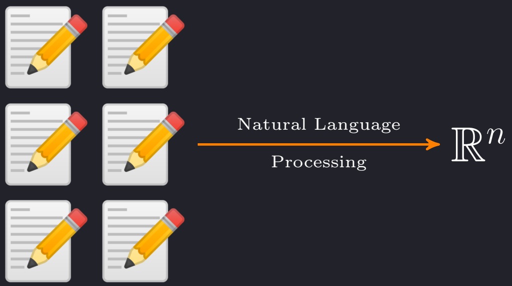
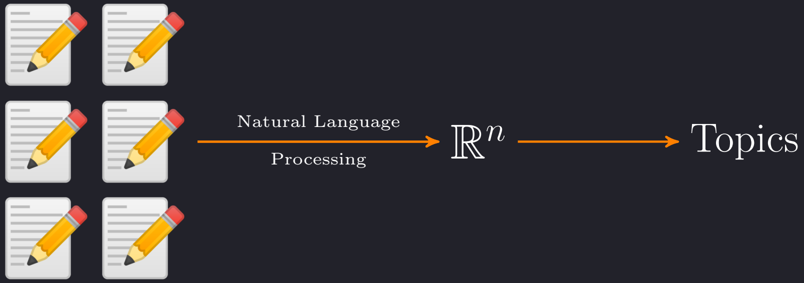
arXiv
Nature
Springer
IEEE


PLOS
arXiv
ARCAS
Nature
Springer
IEEE

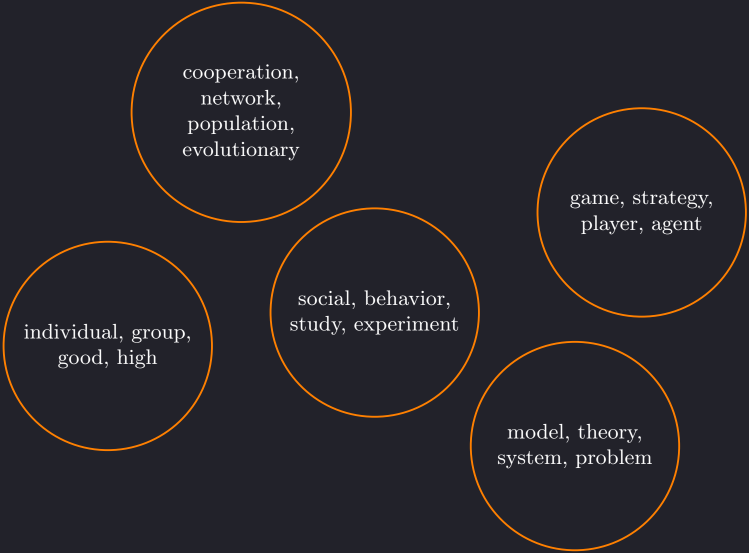


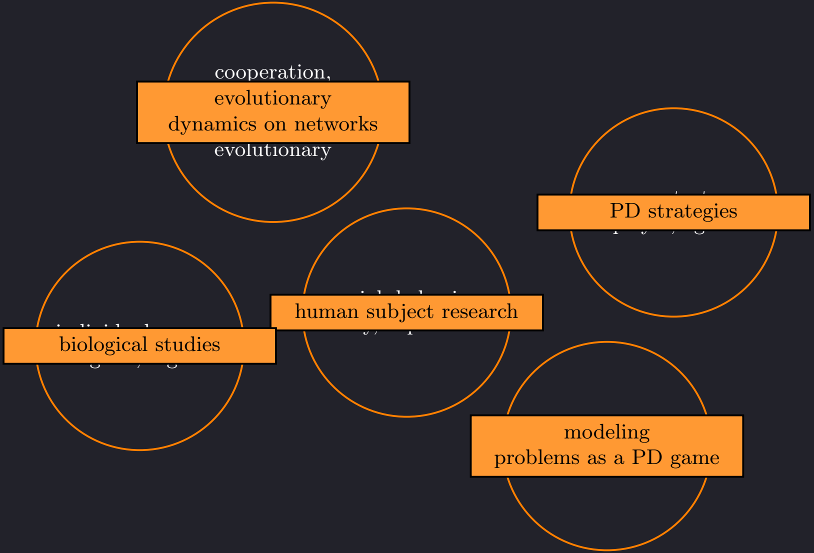

median=3.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
10
20
30
40
50
60


Natural Language
Processing
$\mathbb{R}^n$



Natural Language
Processing
$\mathbb{R}^n$
Topics


cooperation, network, population, evolutionary
game, strategy, player, agent
social, behavior, study, experiment
individual, group, good, high
model, theory, system, problem


cooperation,
evolutionary
dynamics on networks
evolutionary
PD strategies
human subject research
biological studies
modeling
problems as a PD game

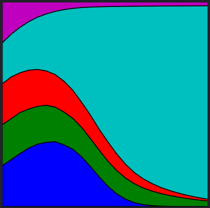
“A bibliometric study of research topics, collaboration and influence in the field of the Iterated Prisoner’s Dilemma”

Nikoleta E. Glynatsi, Vincent A. Knight

arxiv.org/abs/1911.06128

Meta Analysis of Tournaments

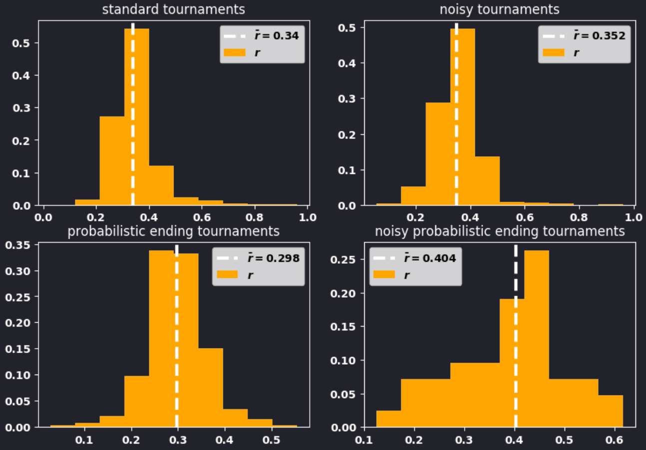
🔍📊



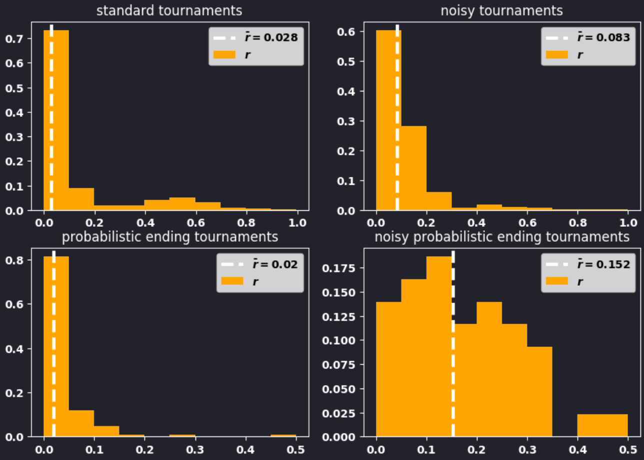
Axerlod-Python

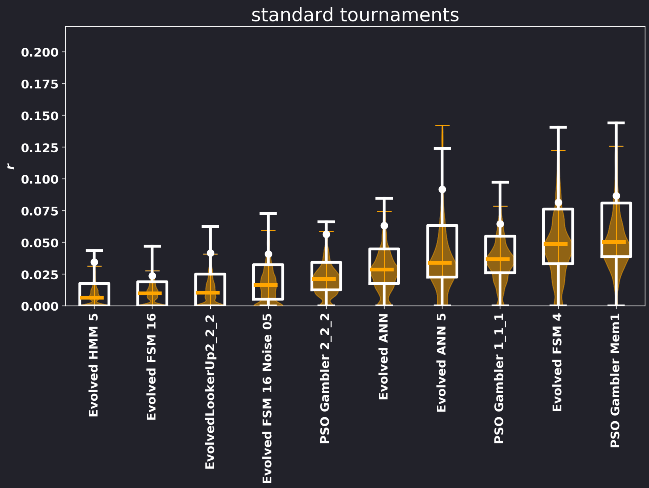
195 strategies in **45686** tournaments

Tit For Tat Normalised Rank

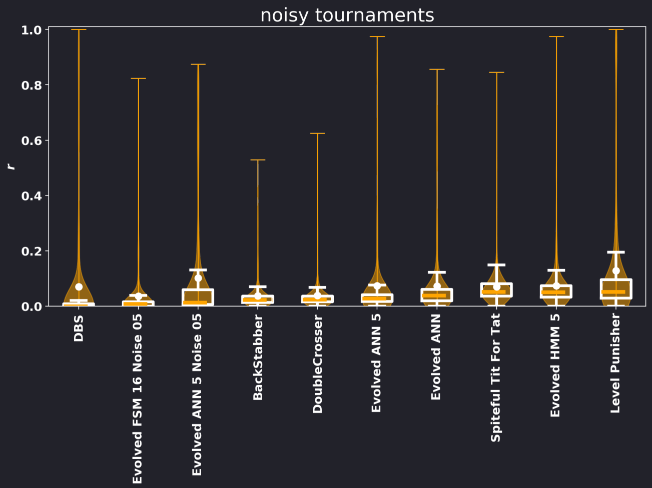


Evolved FSM 16 Normalised Rank

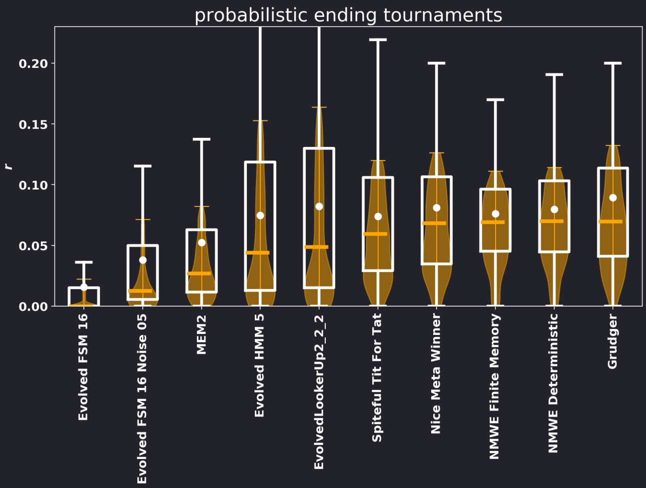


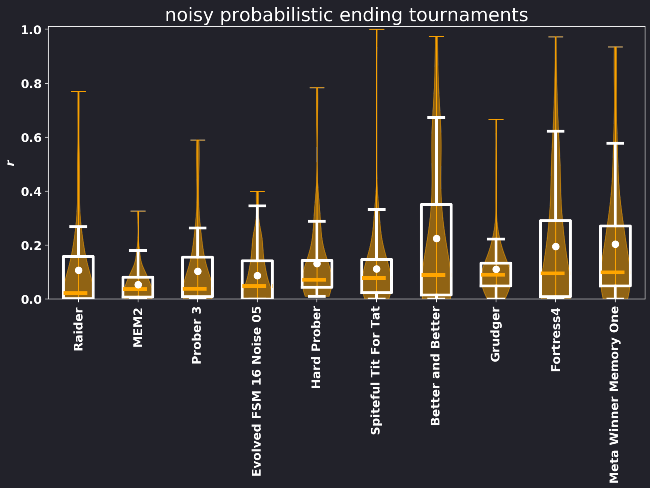


standard tournaments
r
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
Evolved HMM 5
Evolved FSM 16
EvolvedLookerUp2_2_2
Evolved FSM 16 Noise 05
PSO Gambler 2_2_2
Evolved ANN
Evolved ANN 5
PSO Gambler 1_1_1
Evolved FSM 4
PSO Gambler Mem1

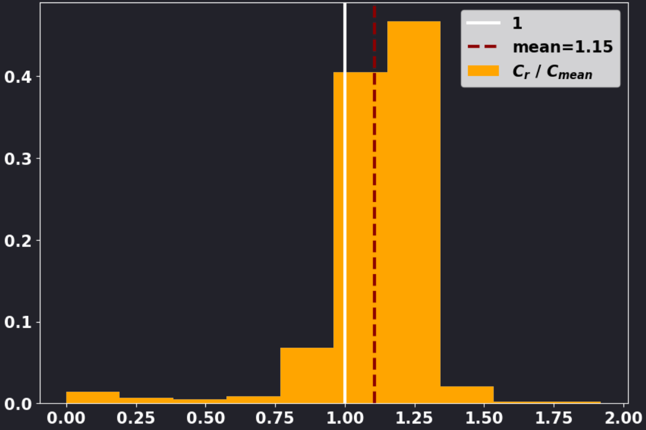


noisy tournaments
r
1.0
0.8
0.6
0.4
0.2
0.0
DBS
Evolved FSM 16 Noise 05
Evolved ANN 5 Noise 05
BackStabber
DoubleCrosser
Evolved ANN 5
Evolved ANN
Spiteful Tit For Tat
Evolved HMM 5
Level Punisher


probabilistic ending tournaments
r
0.00
0.05
0.10
0.15
0.20
Evolved FSM 16
Evolved FSM 16 Noise 05
MEM2
Evolved HMM 5
EvolvedLookerUp2_2_2
Spiteful Tit For Tat
Nice Meta Winner
NMWE Finite Memory
NMWE Deterministic
Grudger


noisy probabilistic ending tournaments
r
1.0
0.8
0.6
0.4
0.2
0.0
Raider
MEM2
Prober 3
Evolved FSM 16 Noise 05
Hard Prober
Spiteful Tit For Tat
Better and Better
Grudger
Fortress4
Meta Winner Memory One

Evolved FSM 16


1
mean=1.15
C_r / C_{mean}
0.0
0.1
0.2
0.3
0.4
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00

"A meta analysis of tournaments and an evaluation of performance in the Iterated Prisoner's Dilemma"

Nikoleta E. Glynatsi, Vincent A. Knight

arXiv:2001.05911

data: DOI:10.5281/zenodo.3516652

Best Response Memory One Strategies

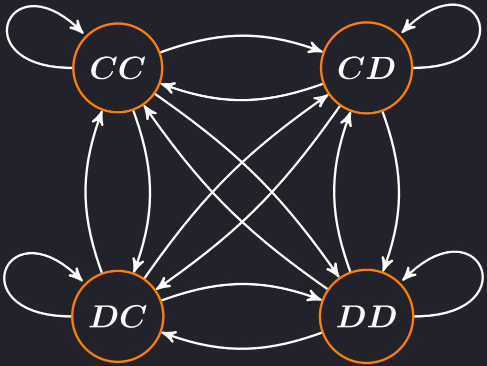

CC
CD
DC
DD

CC CD

DC DD

$$p = (p_1, p_2, p_3, p_4)$$

$$p = (p_1, p_2, p_3, p_4)$$
$$q = (q_1, q_2, q_3, q_4)$$



$$p = (p_1, p_2, p_3, p_4)$$

$$q = (q_1, q_2, q_3, q_4)$$

$$u_q(p) = v \cdot (3, 0, 5, 1)$$

$$u_q(p) = v \cdot (3, 0, 5, 1)$$

$$\downarrow$$

$$u_q(p) = \frac{\frac{1}{2} p Q p^T + c p + a}{\frac{1}{2} p \bar{Q} p^T + \bar{c} p + \bar{a}}$$

$$u_q(p) = v \cdot (3, 0, 5, 1)$$

$$\downarrow$$

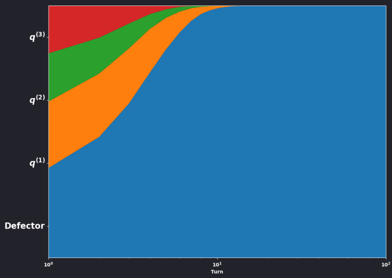
$$u_q(p) = \frac{\frac{1}{2}pQp^T + cp + a}{\frac{1}{2}p\bar{Q}p^T + \bar{c}p + \bar{a}}$$

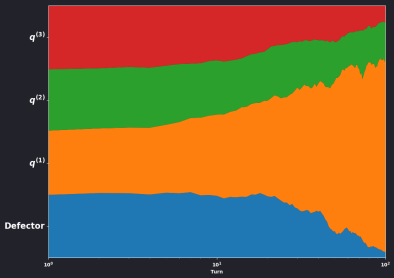
$$\downarrow$$

$$\frac{1}{N}\sum_{i=1}^{N} {u_q}^{(i)}(p)$$

$$\sum_{i=1}^{N}(c^{(i)T}\overline{a}^{(i)} - \overline{c}^{(i)T}a^{(i)}) \leq 0 \text{ if} \rightarrow \text{Defection}$$

$$\sum_{i=1}^{N}(c^{(i)T}\bar{a}^{(i)} - \bar{c}^{(i)T}a^{(i)}) \leq 0 \text{ if} \rightarrow \text{Defection}$$



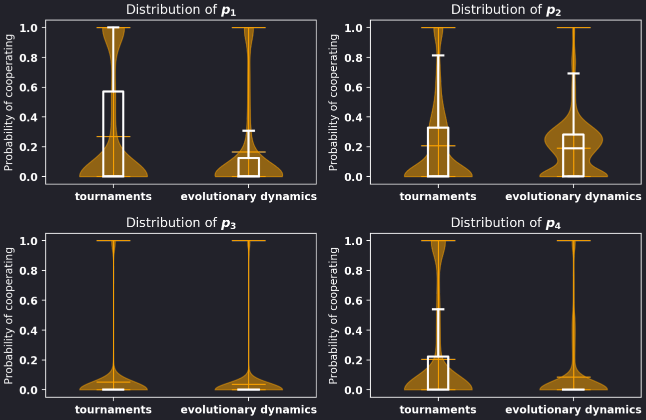


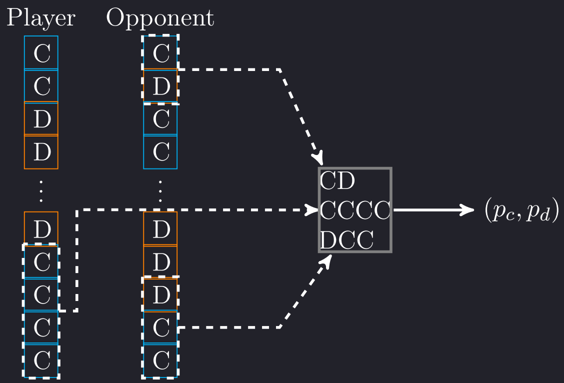
$$\sum_{i=1}^{N} u_q{}^{(i)}(p)$$

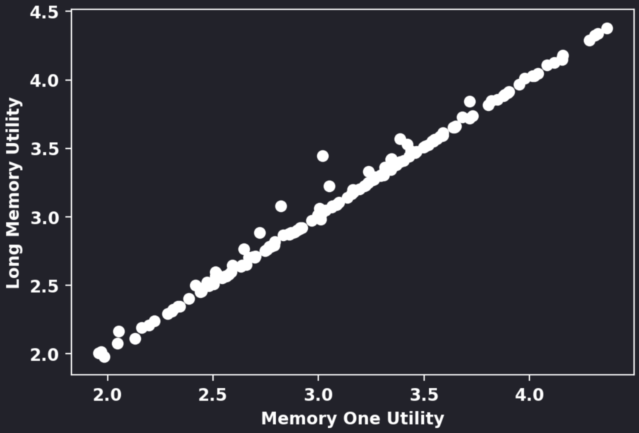
$$\sum_{i=1}^{N} u_q{}^{(i)}(p) \longrightarrow \max_p : \sum_{i=1}^{N} u_q{}^{(i)}(p)$$

$$\sum_{i=1}^{N} u_q{}^{(i)}(p) \longrightarrow \max_p : \sum_{i=1}^{N} u_q{}^{(i)}(p)$$

$$\sum_{i=1}^{N} u_q{}^{(i)}(p) + u_p(p) \longrightarrow \max_p : \sum_{i=1}^{N} u_q{}^{(i)}(p) + u_p(p)$$


Distribution of p_1
Distribution of p_2
Distribution of p_3
Distribution of p_4
Probability of cooperating
0.0
0.2
0.4
0.6
0.8
1.0
tournaments
evolutionary dynamics


Player
Opponent
C
C
D
D
D
C
C
C
C
C
D
C
C
D
D
D
C
C
CD
CCCC
DCC
(p_c, p_d)



4.5
4.0
3.5
3.0
2.5
2.0
Long Memory Utility
2.0
2.5
3.0
3.5
4.0
Memory One Utility

"Stability of defection, optimisation of strategies and the limits of memory in the Prisoner's Dilemma"

Nikoleta E. Glynatsi, Vincent A. Knight

arXiv:1911.12112

Best Response Sequences

	1	2	3	4	5	U
Tit For Tat						
S						

	1	**2**	**3**	**4**	**5**	U
Tit For Tat						
S	D	D	D	D	D	

	1	2	3	4	5	U
Tit For Tat	C	D	D	D	D	
S	D	D	D	D	D	

	1	2	3	4	5	U
Tit For Tat	C	D	D	D	D	**0.8**
S	D	D	D	D	D	**1.8**

	1	2	3	4	5	U
Tit For Tat	C	D	D	D	D	**0.8**
S	D	D	D	D	D	**1.8**

	1	2	3	4	5	U
Tit For Tat						
S						

	1	**2**	**3**	**4**	**5**	U
Tit For Tat	C	C	C	C	C	
S						

	1	**2**	**3**	**4**	**5**	U
Tit For Tat	C	C	C	C	C	
S	C	C	C	C	D	

	1	2	3	4	5	U
Tit For Tat	C	C	C	C	C	**2.5**
S	C	C	C	C	D	**3.3**

Tit For Tat

Alternator

AntiTitForTat

Random

Cooperator

Defector

SuspiciousTitForTat

WinShiftLoseStay

$\vdots$

Evolved FSM 16

197

Tit For Tat

Alternator

AntiTitForTat

Random

Cooperator

Defector

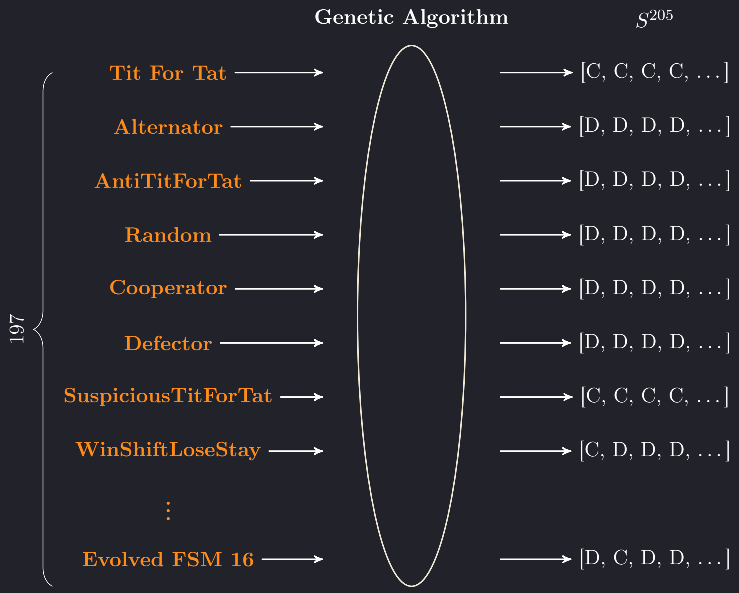
SuspiciousTitForTat

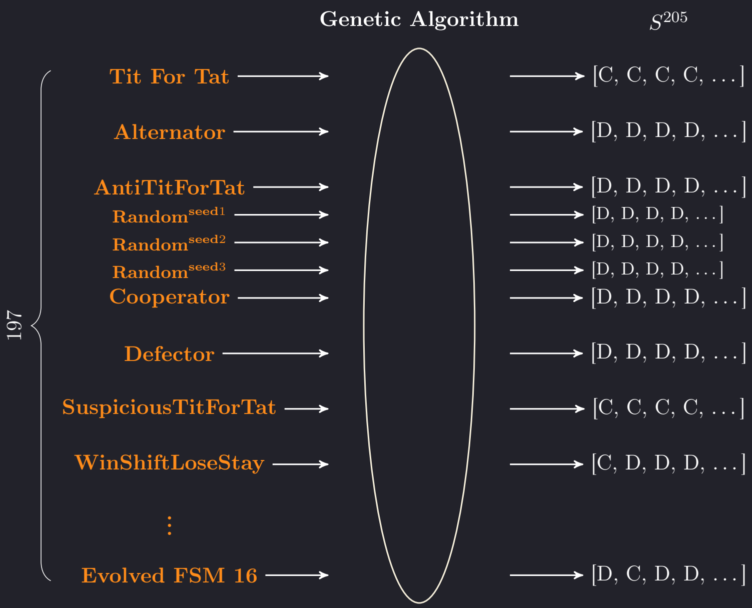
WinShiftLoseStay

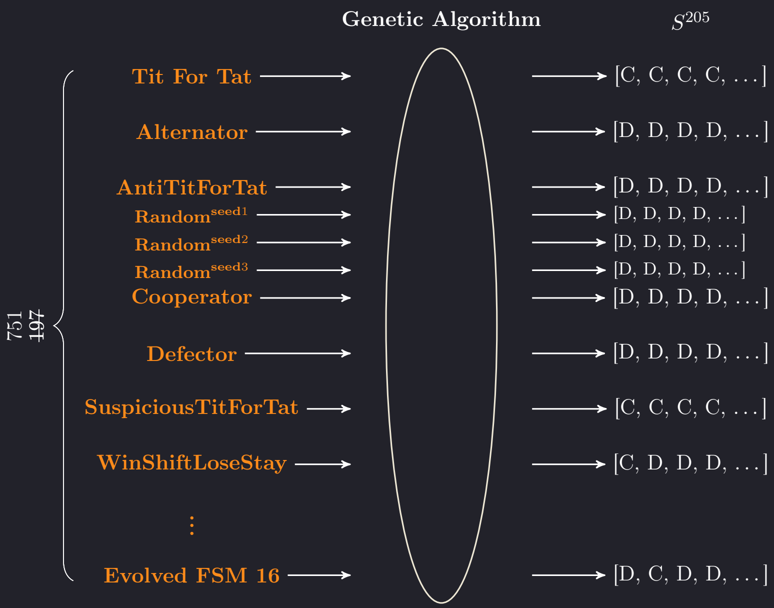
⋮

Evolved FSM 16


Genetic Algorithm
Tit For Tat
Alternator
AntiTitForTat
Random
Cooperator
Defector
SuspiciousTitForTat
WinShiftLoseStay
⋮
Evolved FSM 16
197


Genetic Algorithm
S^{205}
197
Tit For Tat
Alternator
AntiTitForTat
Random
Cooperator
Defector
SuspiciousTitForTat
WinShiftLoseStay
⋮
Evolved FSM 16
[C, C, C, C, . . .]
[D, D, D, D, . . .]
[D, D, D, D, . . .]
[D, D, D, D, . . .]
[D, D, D, D, . . .]
[D, D, D, D, . . .]
[C, C, C, C, . . .]
[C, D, D, D, . . .]
[D, C, D, D, . . .]

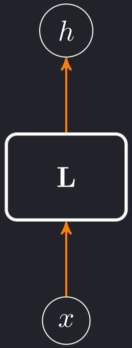

Genetic Algorithm
S^{205}
197
Tit For Tat
Alternator
AntiTitForTat
Random$^{\text{seed1}}$
Random$^{\text{seed2}}$
Random$^{\text{seed3}}$
Cooperator
Defector
SuspiciousTitForTat
WinShiftLoseStay
⋮
Evolved FSM 16
[C, C, C, C, . . .]
[D, D, D, D, . . .]
[D, D, D, D, . . .]
[D, D, D, D, . . .]
[D, D, D, D, . . .]
[D, D, D, D, . . .]
[D, D, D, D, . . .]
[D, D, D, D, . . .]
[C, C, C, C, . . .]
[C, D, D, D, . . .]
[D, C, D, D, . . .]

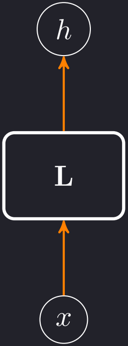


Genetic Algorithm
S^{205}
751
~~197~~
Tit For Tat
Alternator
AntiTitForTat
$\text{Random}^{\text{seed1}}$
$\text{Random}^{\text{seed2}}$
$\text{Random}^{\text{seed3}}$
Cooperator
Defector
SuspiciousTitForTat
WinShiftLoseStay
⋮
Evolved FSM 16
[C, C, C, C, ...]
[D, D, D, D, ...]
[D, D, D, D, ...]
[D, D, D, D, ...]
[D, D, D, D, ...]
[D, D, D, D, ...]
[D, D, D, D, ...]
[D, D, D, D, ...]
[C, C, C, C, ...]
[C, D, D, D, ...]
[D, C, D, D, ...]

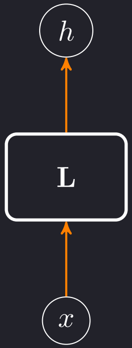
"Training Recurrent Neural Network strategies for Iterated Prisoner's Dilemma"

data: DOI:10.5281/zenodo.3685251


h
L
x

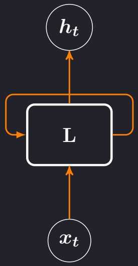


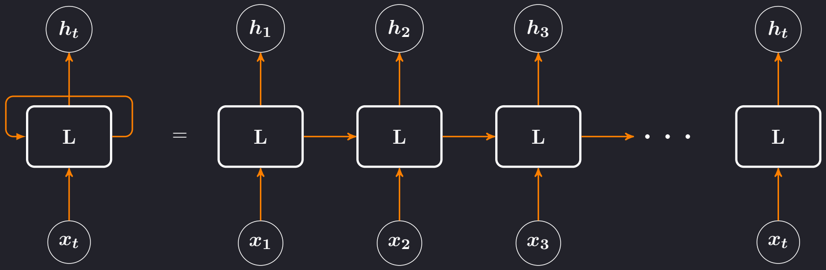
Evolution Reinforces Cooperation with the Emergence of Self-Recognition Mechanisms: doi.org/10.1371/journal.pone.0204981



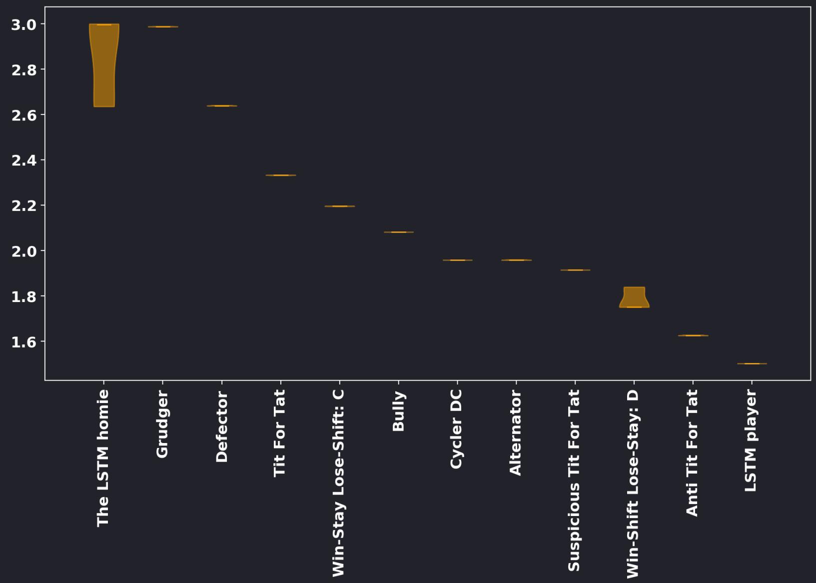
Evolution Reinforces Cooperation with the Emergence of Self-Recognition Mechanisms: doi.org/10.1371/journal.pone.0204981

Reinforcement learning produces dominant strategies for the Iterated Prisoner's Dilemma: doi.org/10.1371/journal.pone.0188046


h_t
L
x_t



h_t
L
x_t
=
h_1
h_2
h_3
h_t
L
L
L
L
x_1
x_2
x_3
x_t



3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
The LSTM homie
Grudger
Defector
Tit For Tat
Win-Stay Lose-Shift: C
Bully
Cycler DC
Alternator
Suspicious Tit For Tat
Win-Shift Lose-Stay: D
Anti Tit For Tat
LSTM player

5 TOPICS & AUTHORS ARE COLLABORATIVE

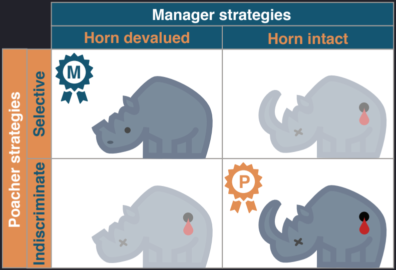
IDENTIFY THE MEAN COOPERATOR

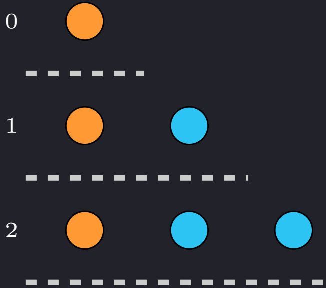
& ADJUST TO THEM

TO BE ES YOU MUST BE FORGIVING

A LONGER MEMORY IS BENEFICIAL

POSSIBLE TO TRAIN A RECURRENT NETWORK BEST RESPONSE


Manager strategies
Horn devalued
Horn intact
Poacher strategies
Selective
Indiscriminate
M
P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@NikoletaGlyn

- nikoleta-v3.github.io

`github.com/ArcasProject/Arcas`

`github.com/Nikoleta-v3/bibliometric-study-of-the-prisoners-dilemma`

`github.com/Nikoleta-v3/meta-analysis-of-prisoners-dilemma-tournaments`

`github.com/Nikoleta-v3/Memory-size-in-the-prisoners-dilemma`

- arXiv:2001.05911
- arXiv:1911.12112
- arXiv:1911.06128