Make experiential learning interpretable life-long!

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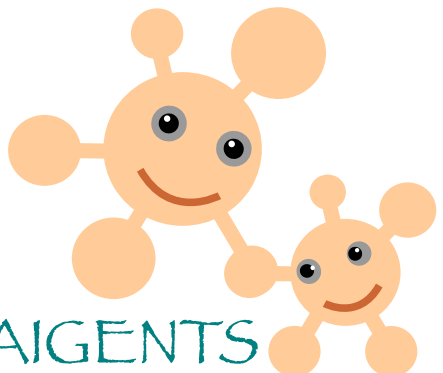
https://www.nsu.ru



https://aigents.com

https://agirussia.org

What are the problems?

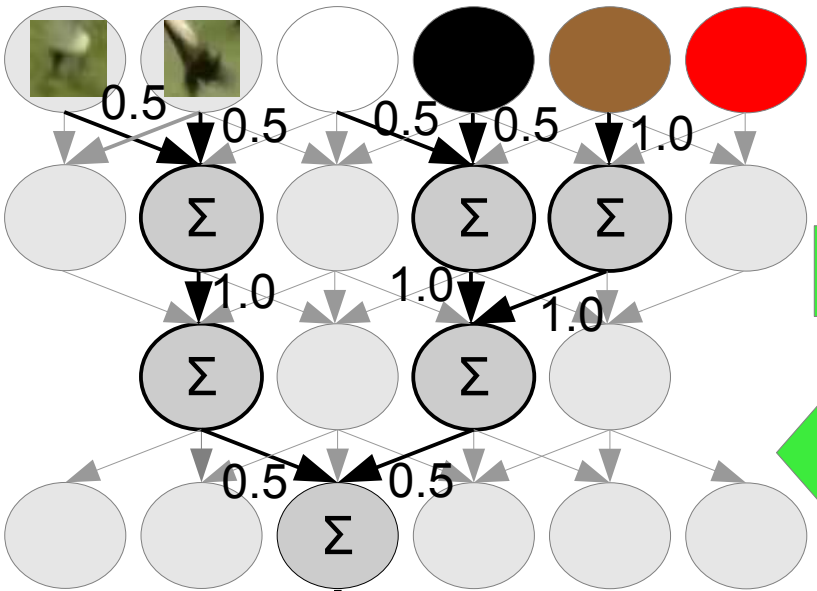
Slow learning

Uninterpretable models

Catastrophic forgetting

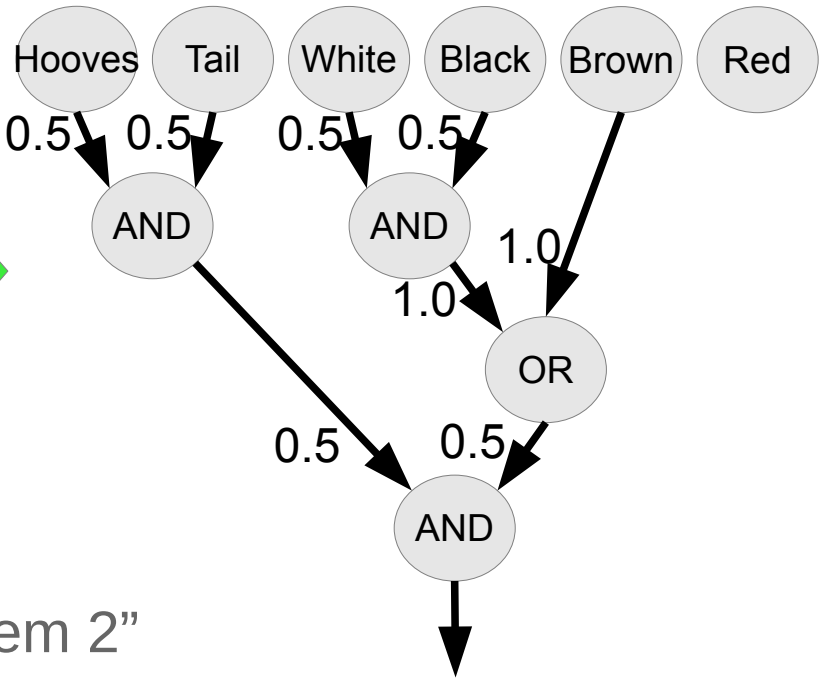
Expensive, resource-consuming training

Neuro-Symbolic integration for interpretable AI



Explain

Transfer



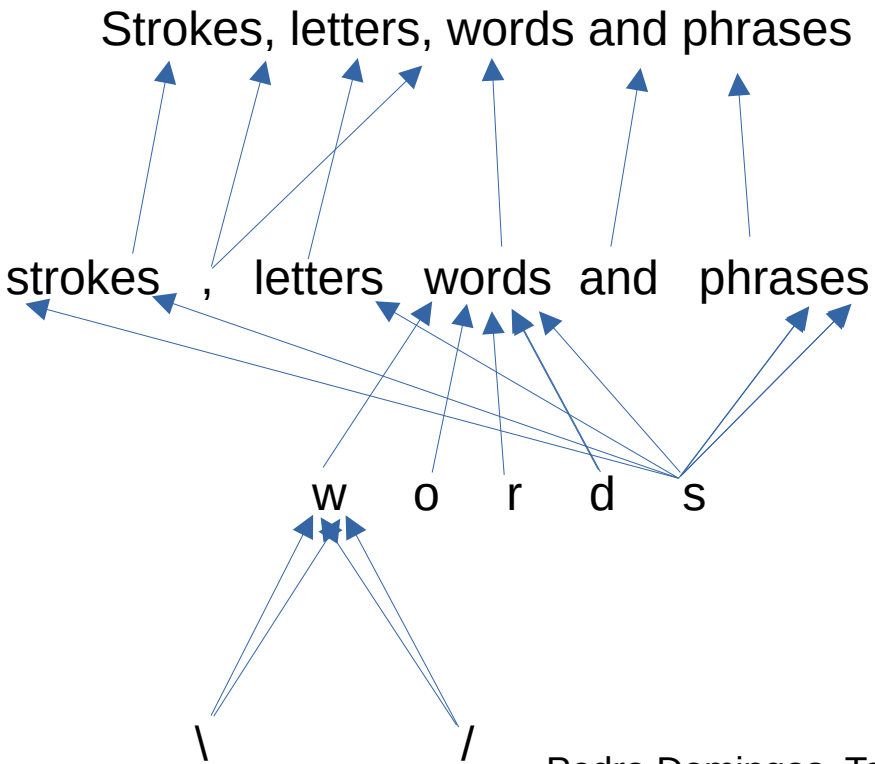
"System 1" "System 2"

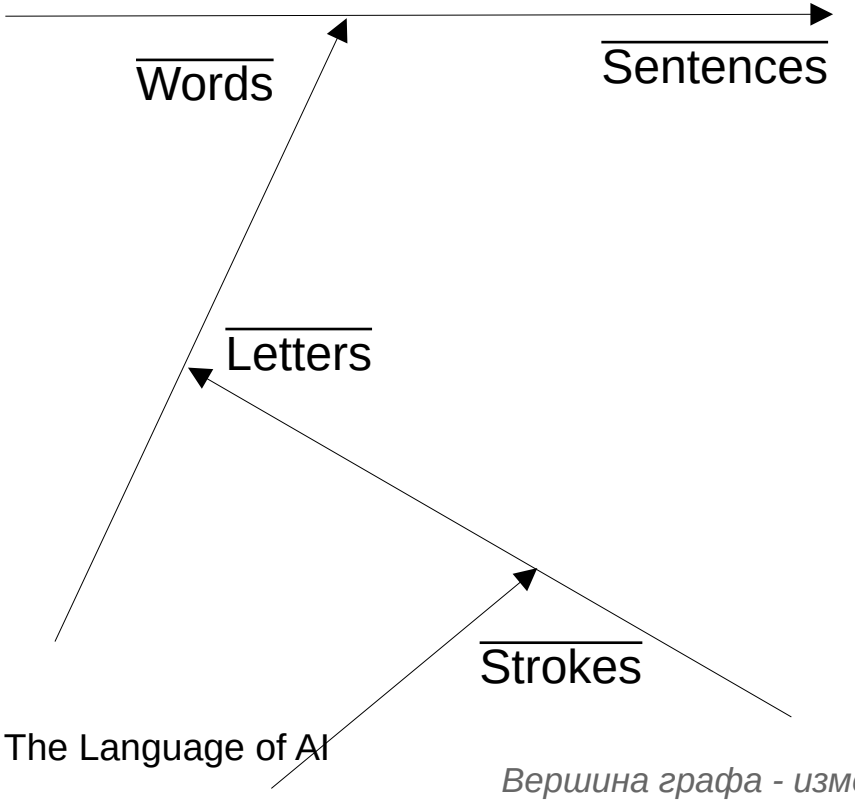
(Hooves AND Tail) AND NOT Red
((White and Black) OR Brown)

=> Horse

https://www.springerprofessional.de/neuro-symbolic-architecture-for-experiential-learning-in-discret/20008336

Functional equivalence of graph (symbolic) and ~~neural network~~ tensor models



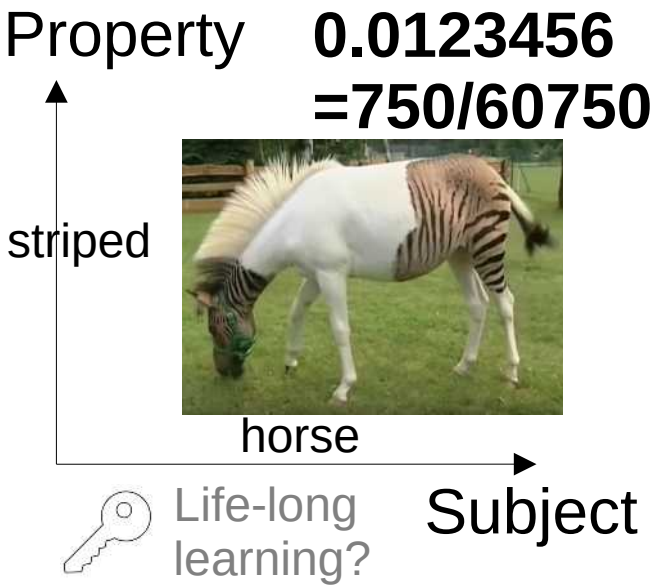


Pedro Domingos, Tensor Logic: The Language of AI
https://arxiv.org/pdf/2510.12269

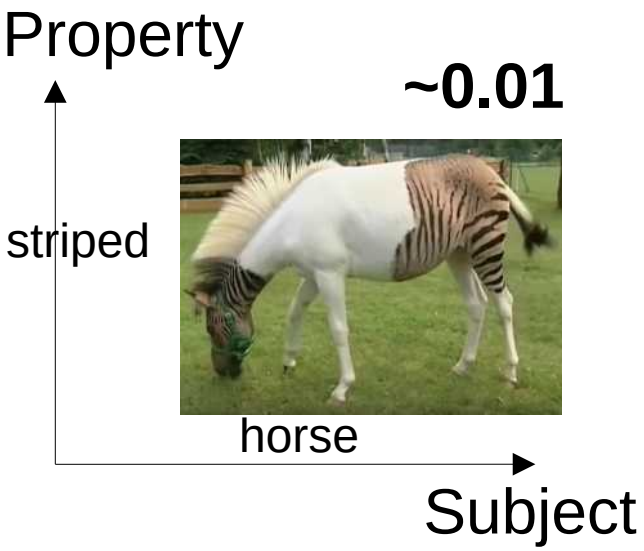
Вершина графа - измерение
Ребро графа - вектор
Гиперграф - тензор

Typed tensor logic for different kinds of AI-s (logical, sub-symbolic, probabilistic/non-axiomatic)

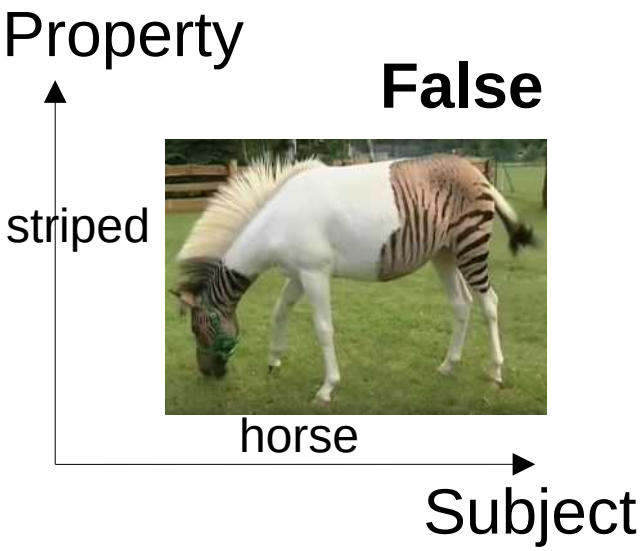
Truth-Value Tensor
(NARS/PLN/...)



Numerical Tensor
(ANN/Bayesian Logic)

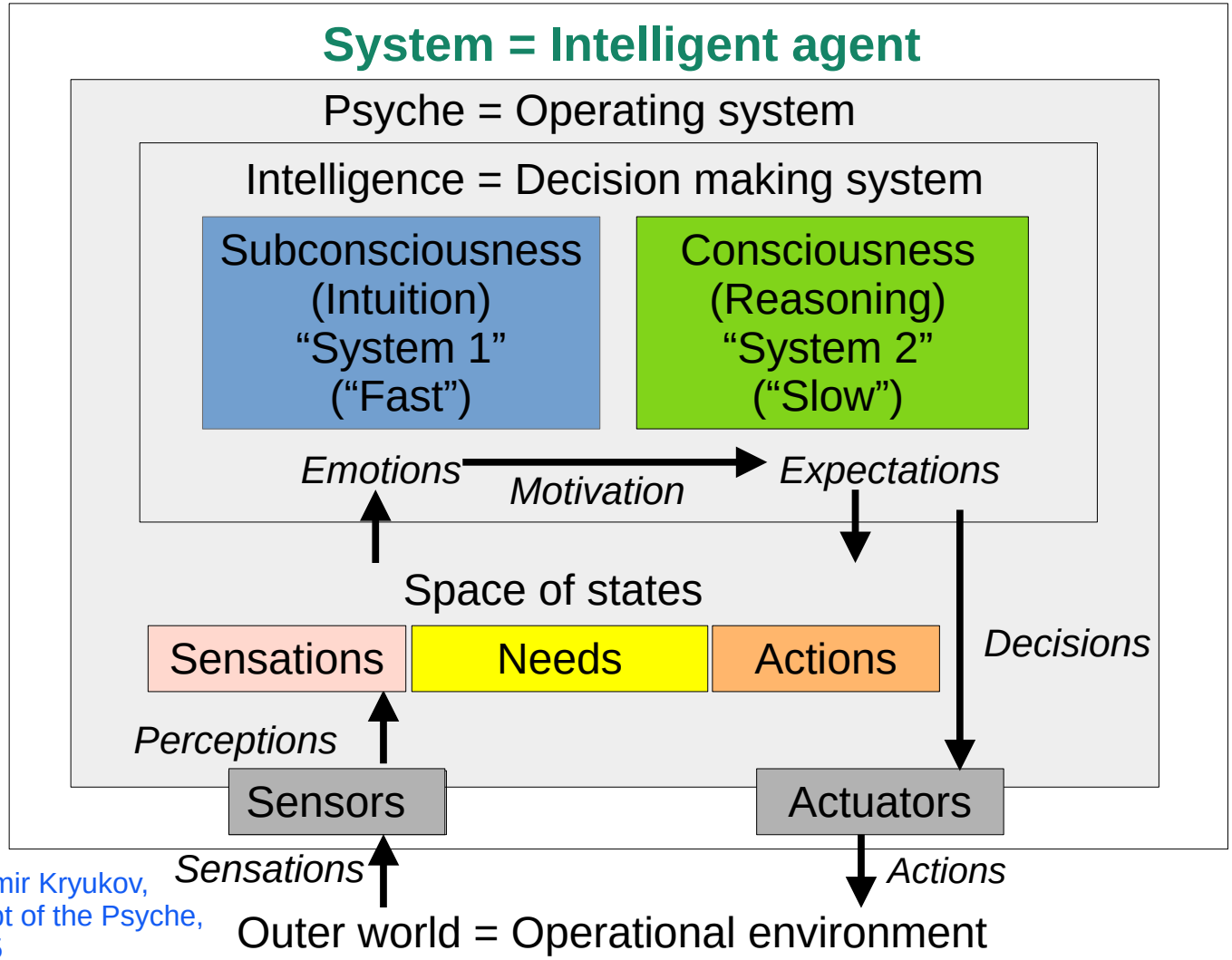


Boolean Tensor
(Boolean Logic)



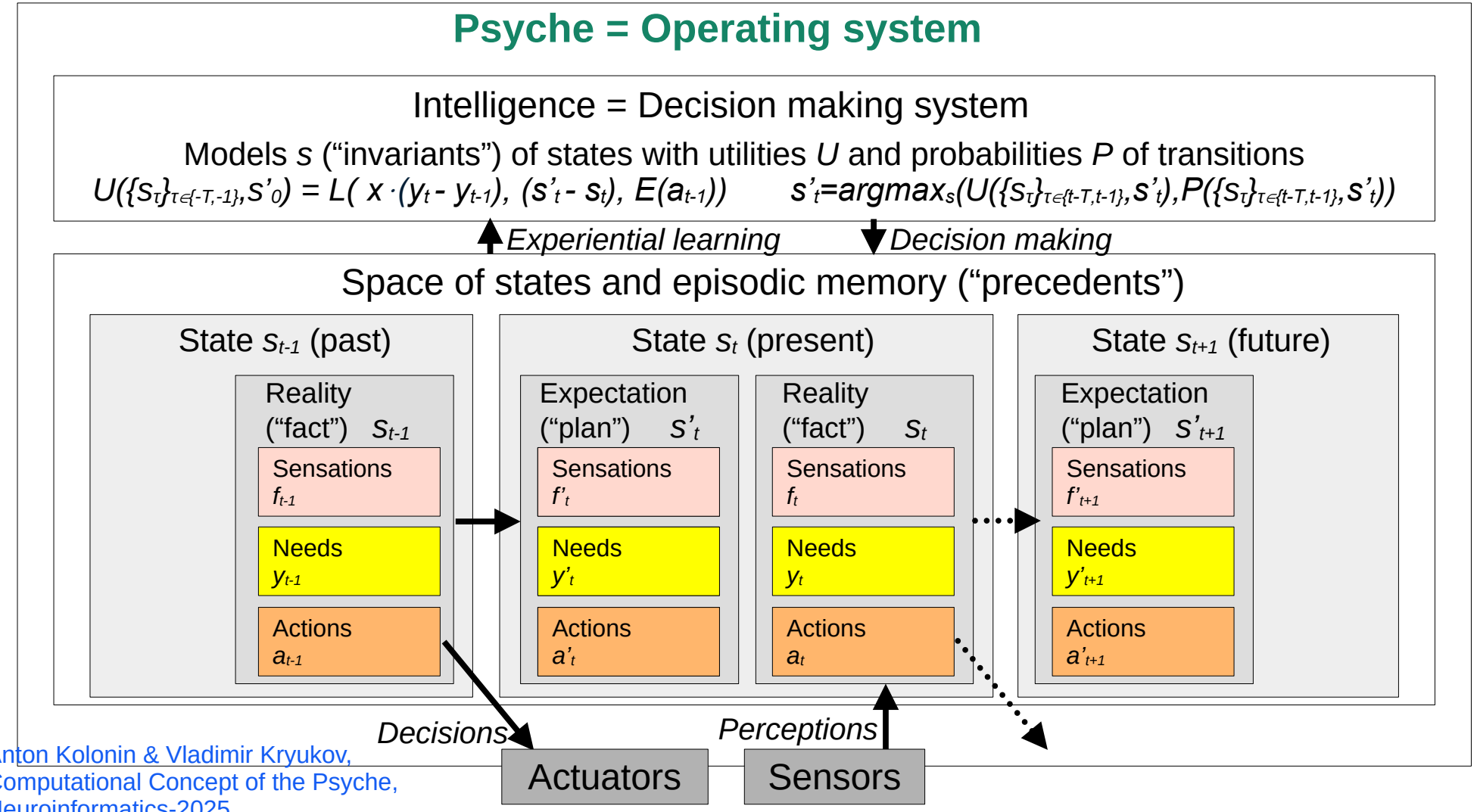
Pei Wang: Non-Axiomatic Logic
https://www.worldscientific.com/worldscibooks/10.1142/14486

Pedro Domingos, Tensor Logic: The Language of AI
https://arxiv.org/pdf/2510.12269



Anton Kolonin & Vladimir Kryukov,
Computational Concept of the Psyche,
Neuroinformatics-2025
https://arxiv.org/pdf/2509.07009

Psyche = Operating system



Anton Kolonin & Vladimir Kryukov,
Computational Concept of the Psyche,
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https://arxiv.org/pdf/2509.07009

Psyche = Operating system

Energy-efficiency *of a*

Optimal decision and expectation of *s*

Predictability *of s*

Expected utility of *s*

Intelligence = Decision making system

Models *s* ("invariants") of states with utilities *U* and probabilities *P* of transitions

$U(\{s_\tau\}_{\tau\in\{-T,-1\}},s'_0) = L(x\cdot(y_t - y_{t-1}), (s'_t - s_t), E(a_{t-1}))$ $\quad s'_t=\mathrm{argmax}_s(U(\{s_\tau\}_{\tau\in\{t-T,t-1\}},s'_t),P(\{s_\tau\}_{\tau\in\{t-T,t-1\}},s'_t))$

Expected probability of *s*

Satisfaction *of y*

Experiential learning ↑ ↓ *Decision making*

Space of states and episodic memory ("precedents")

State s_{t-1} (past)	State s_t (present)		State s_{t+1} (future)
Reality ("fact") s_{t-1}	Expectation ("plan") s'_t	Reality ("fact") s_t	Expectation ("plan") s'_{t+1}
Sensations f_{t-1}	Sensations f'_t	Sensations f_t	Sensations f'_{t+1}
Needs y_{t-1}	Needs y'_t	Needs y_t	Needs y'_{t+1}
Actions a_{t-1}	Actions a'_t	Actions a_t	Actions a'_{t+1}

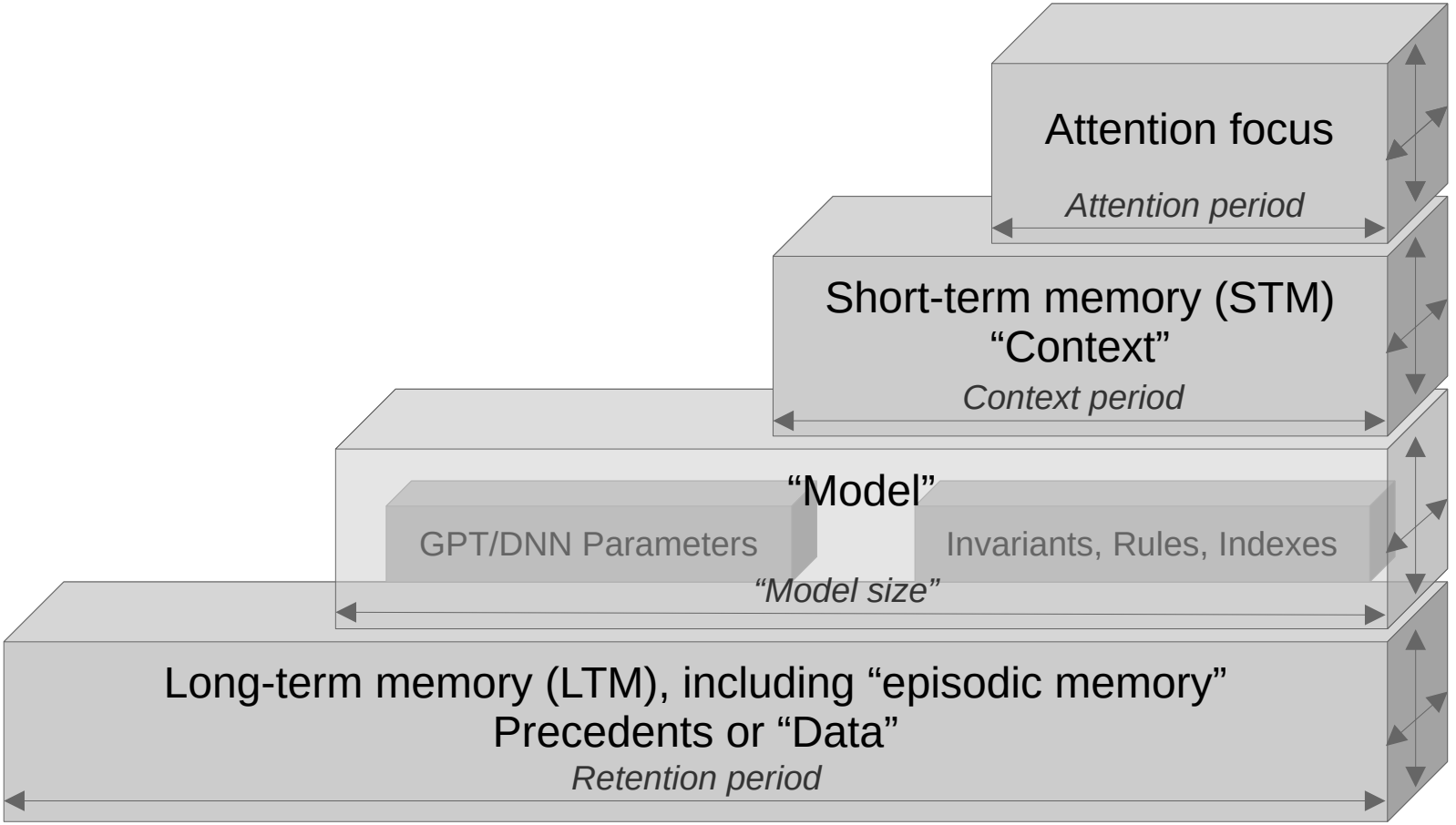
Decisions → Actuators

Sensors → *Perceptions*

$x\cdot y_t$ – "motivation vector"

V. F. Petrenko and A. P. Suprun, "Goal oriented systems, evolution, and the subjective aspect in systemology," Tr. Inst. Sistem. Analiza RAN 62 (1) (2012)

Attention, context, model and memories

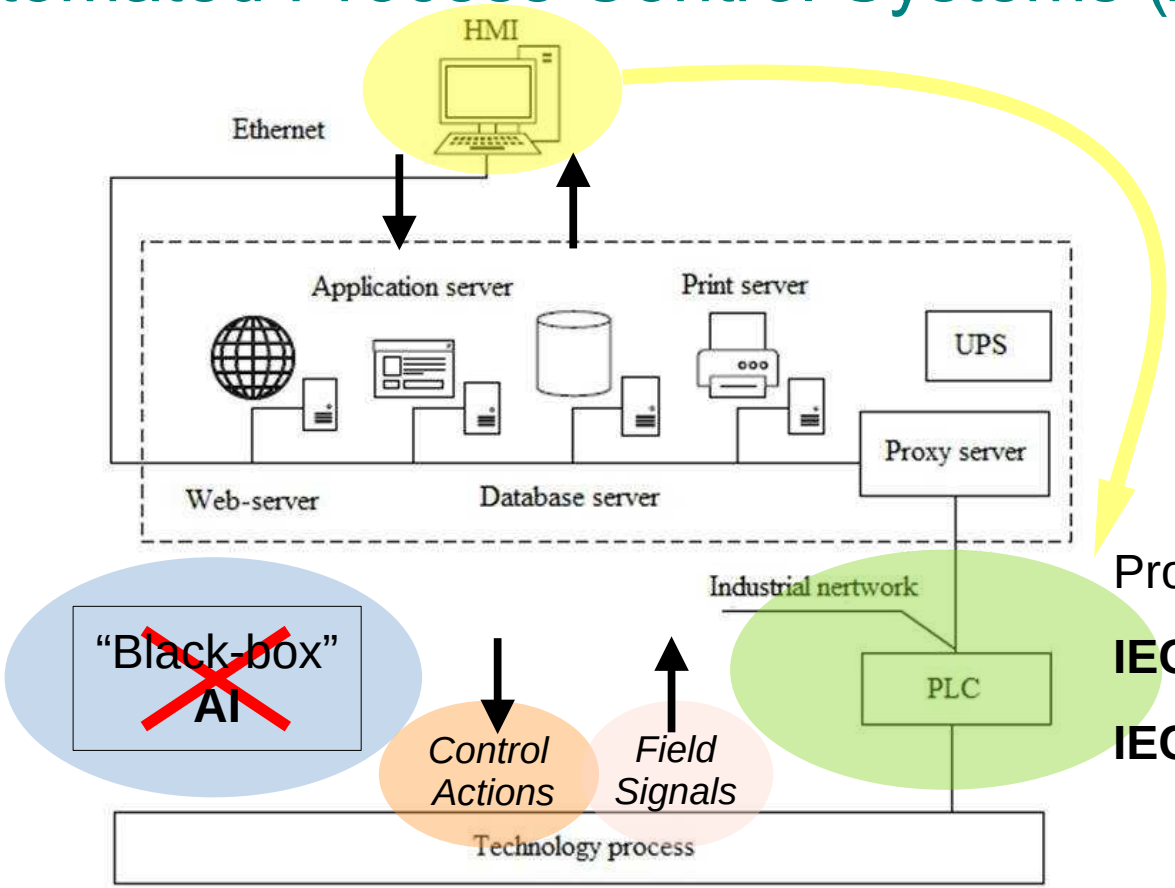


Application cases

A) Automated Process Control Systems (APCS)

Upper layer

Lower layer



Programmable logic

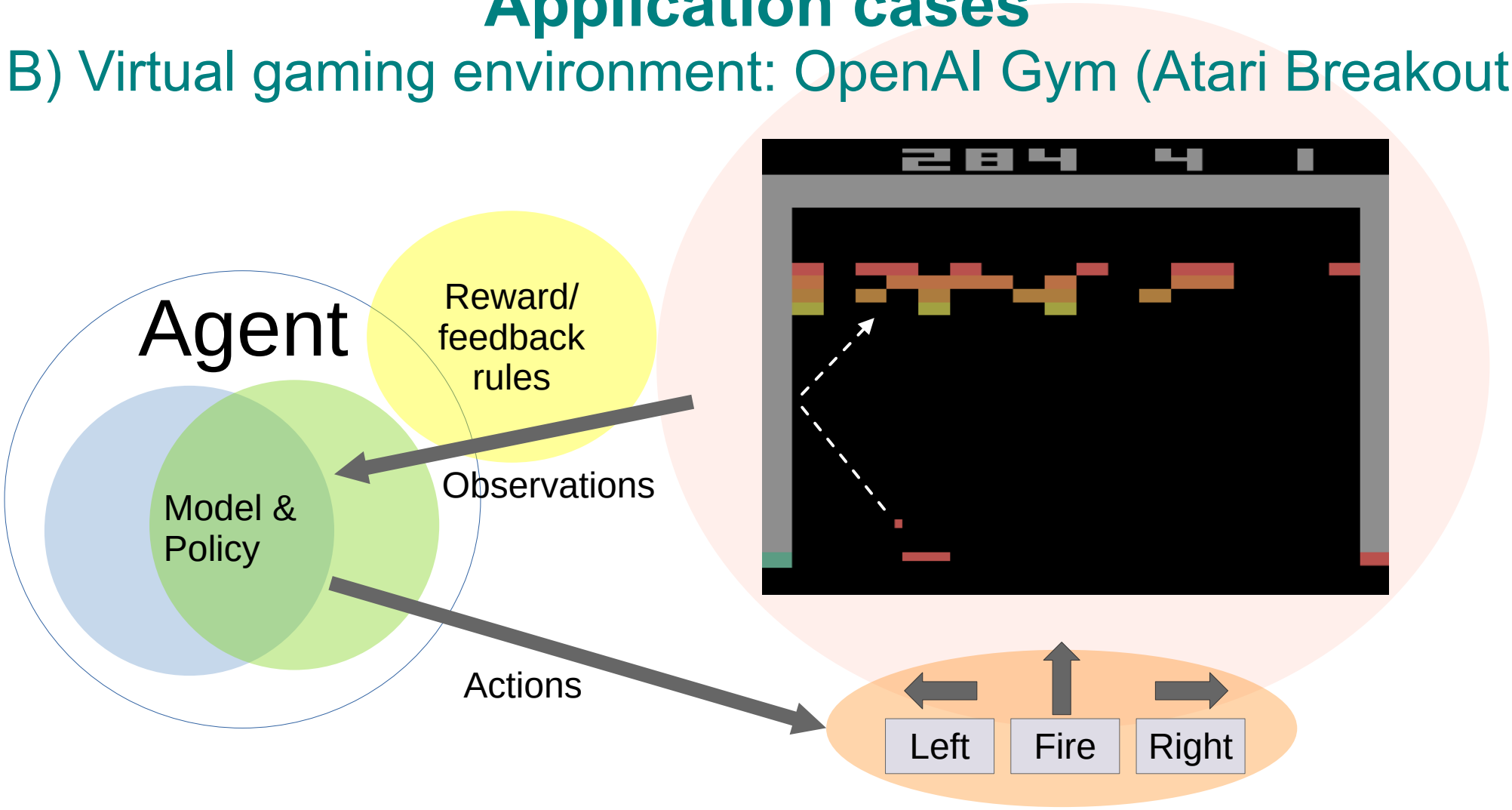
IEC 61131 (synchronous)

IEC 61499 (asynchronous)

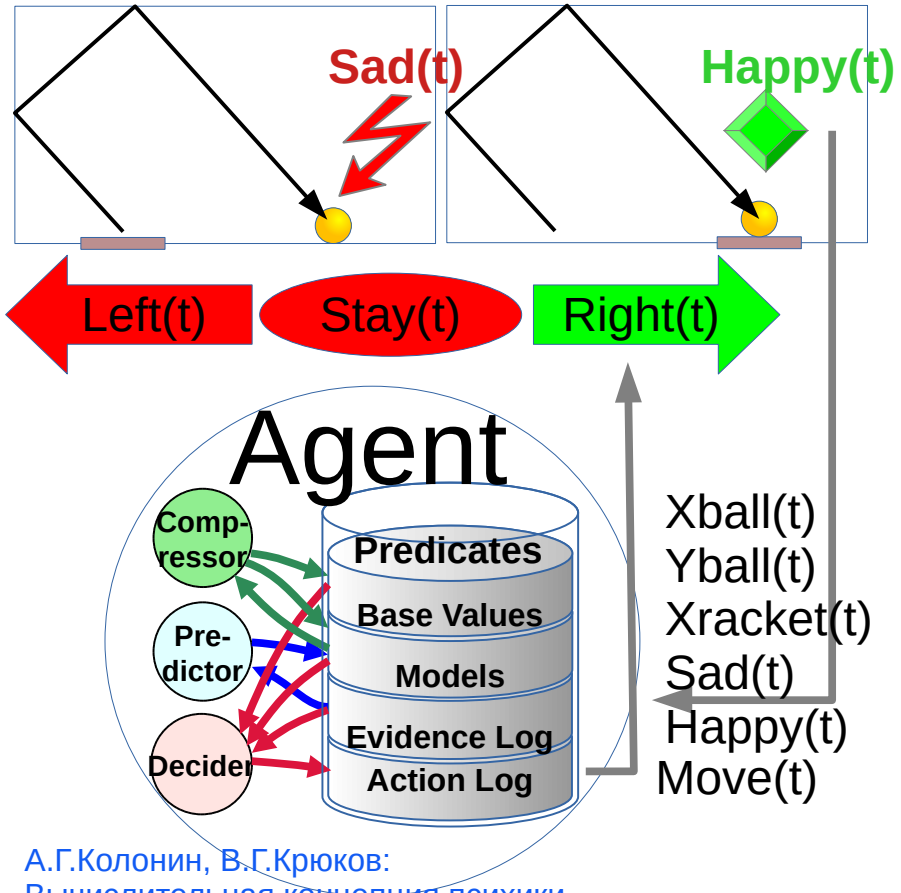
https://www.researchgate.net/publication/311662442_Adaptive_Intelligent_Manufacturing_Control_Systems

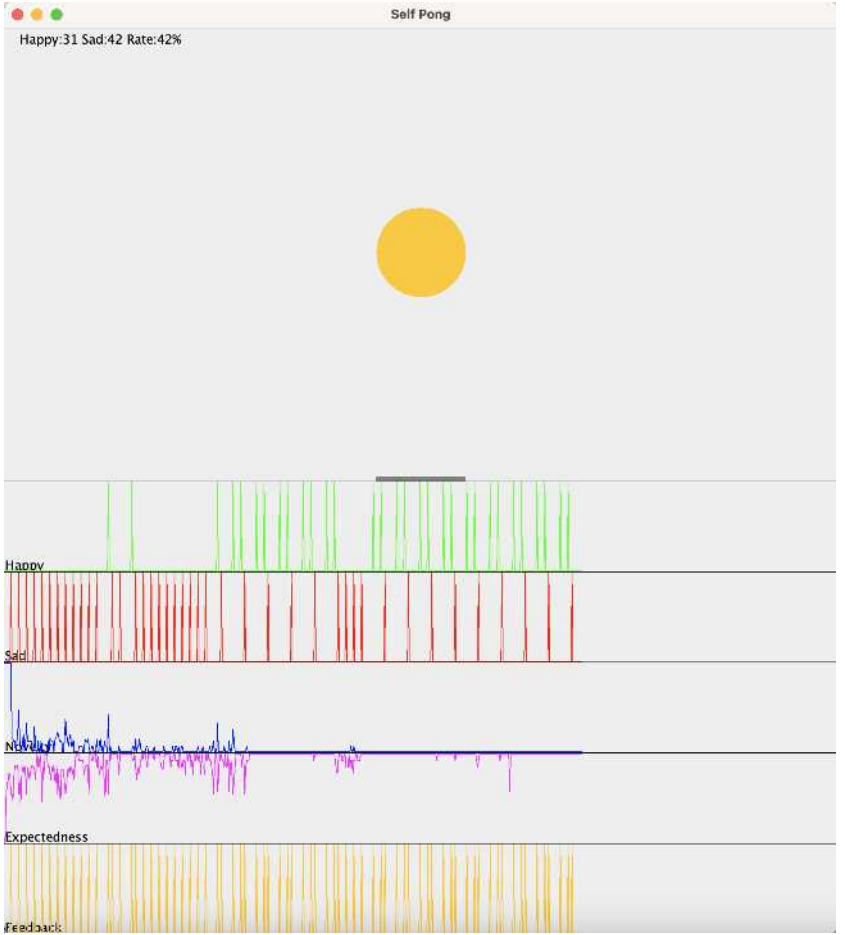
Application cases

B) Virtual gaming environment: OpenAI Gym (Atari Breakout)



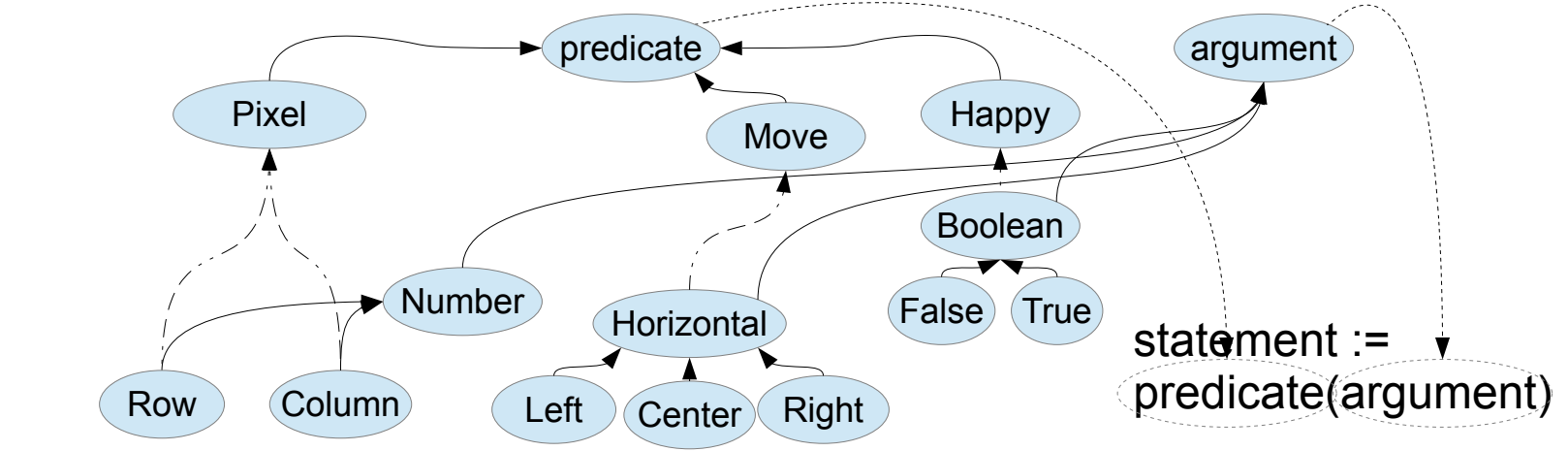
State-based History-aware Artificial Reinforcement Intelligence Kernel (**Sharik**)

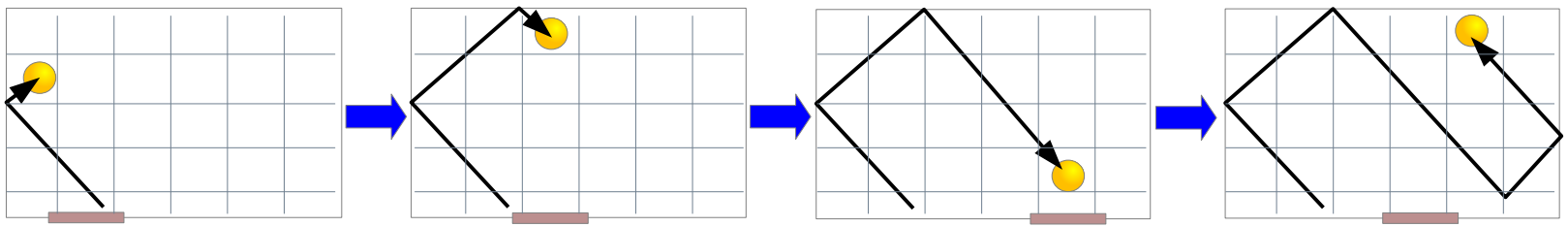




А.Г.Колонин, В.Г.Крюков:
Вычислительная концепция психики,
Статья подана на конференцию
Нейроинформатика-25

Playing “Single-player Ping-Pong” at pixel level





Pixel(1,0)
Pixel(4,1)
Happy(False)
=>
Move(Left)

Pixel(0,2)
Pixel(4,2)
Happy(False)
=>
Move(Right)

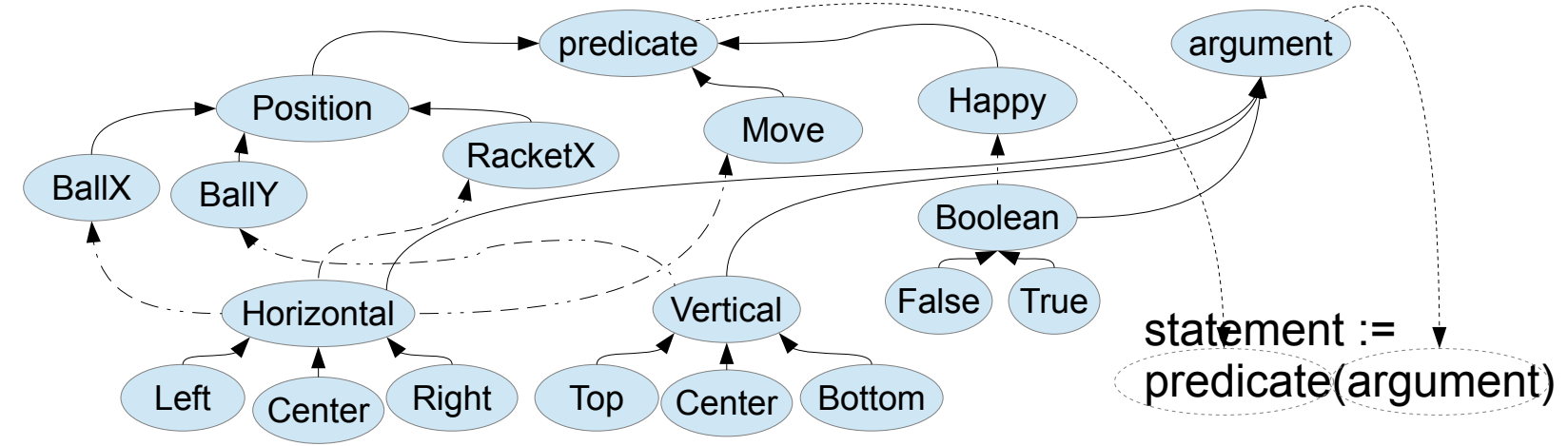
Pixel(3,4)
Pixel(4,4)
Happy(False)
=>
Move(Left)

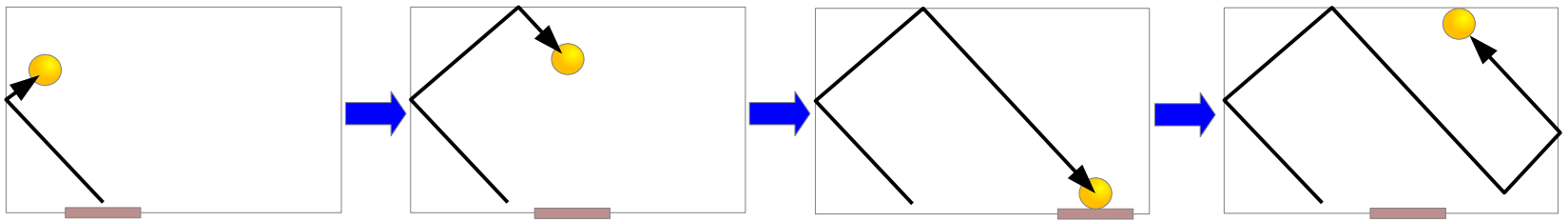
Pixel(0,4)
Pixel(4,3)
Happy(True)
=>
Move(Left)

Global Feedback

https://www.youtube.com/watch?v=2LPLhJKh95g

Playing “Single-player Ping-Pong” at object level





BallY(Top)
BallX(Left)
RacketX(Left)
Happy(False)
=> **Move(Left)**

BallY(Top)
BallX(Center)
RacketX(Center)
Happy(False)
=> **Move(Right)**

BallY(Bottom)
BallX(Right)
RacketX(Right)
Happy(False)
=> **Move(Right)**

BallY(Bottom)
BallX(Right)
RacketX(Right)
Happy(True)
=> **Move(Left)**

Global Feedback

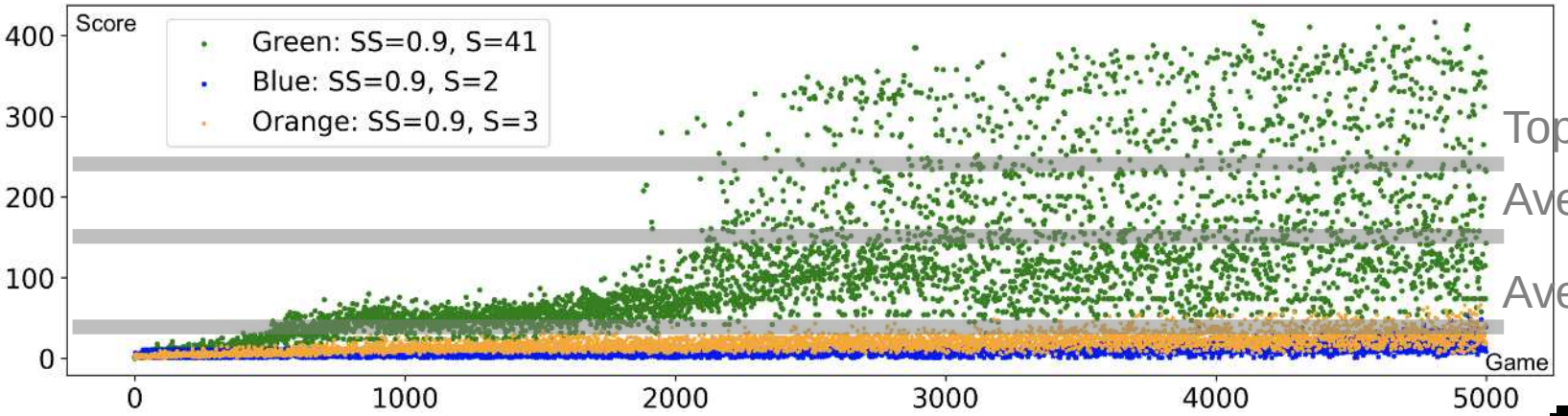
https://www.youtube.com/watch?v=2LPLhJKh95g

Problem of dimensionality (reduction) and discreteness (increase)

Re-defining environment in Atari Breakout

Interpretable representation learning for 3D multi-piece intracellular structures using point clouds
https://www.nature.com/articles/s41592-025-02729-9

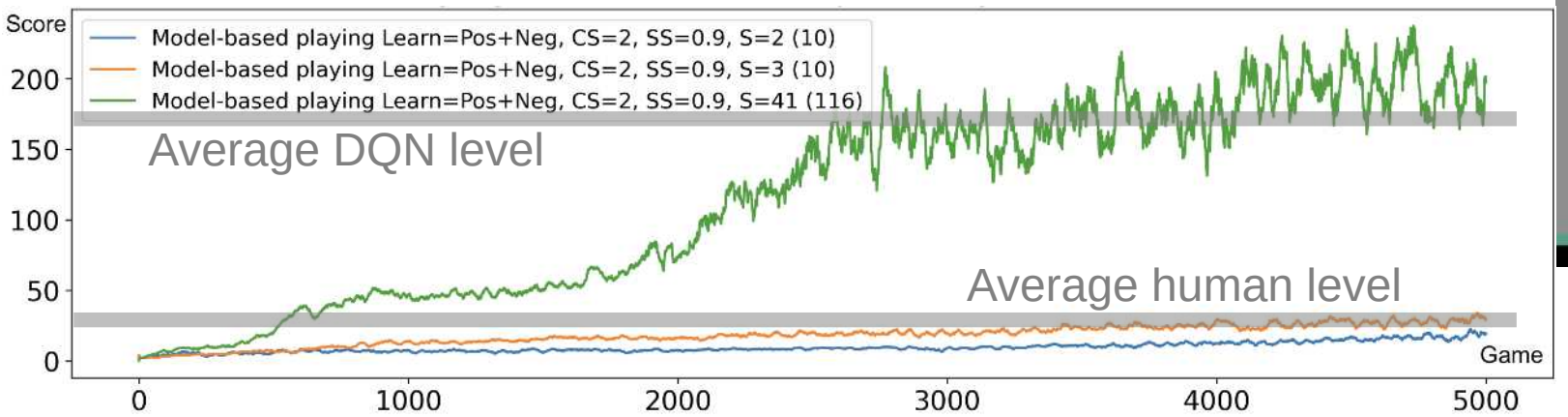
Reinforcement learning – experiential learning and decision making based and transitions between state series and “global feedback”



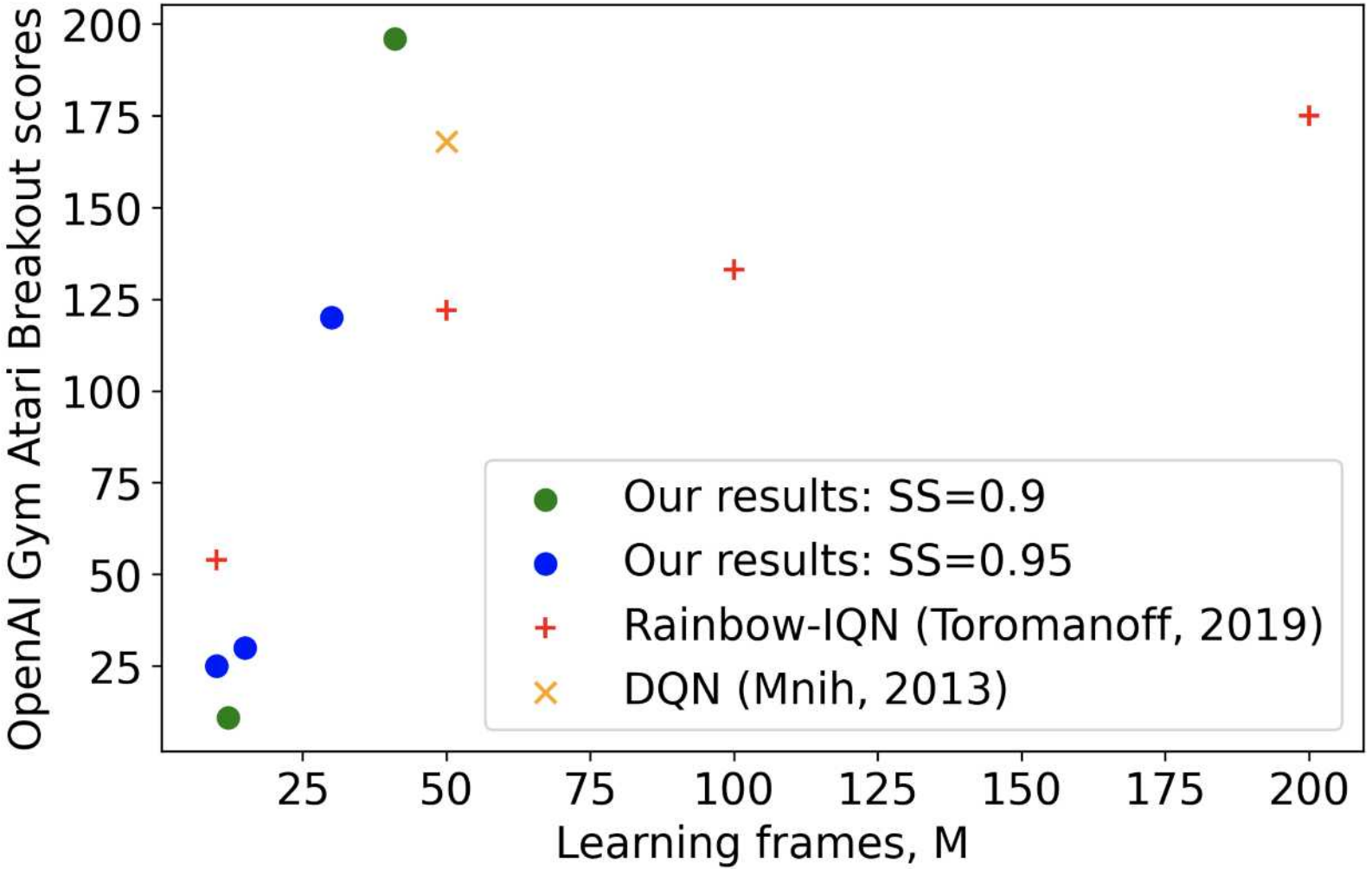
Top DQN level

Average DQN level

Average human level



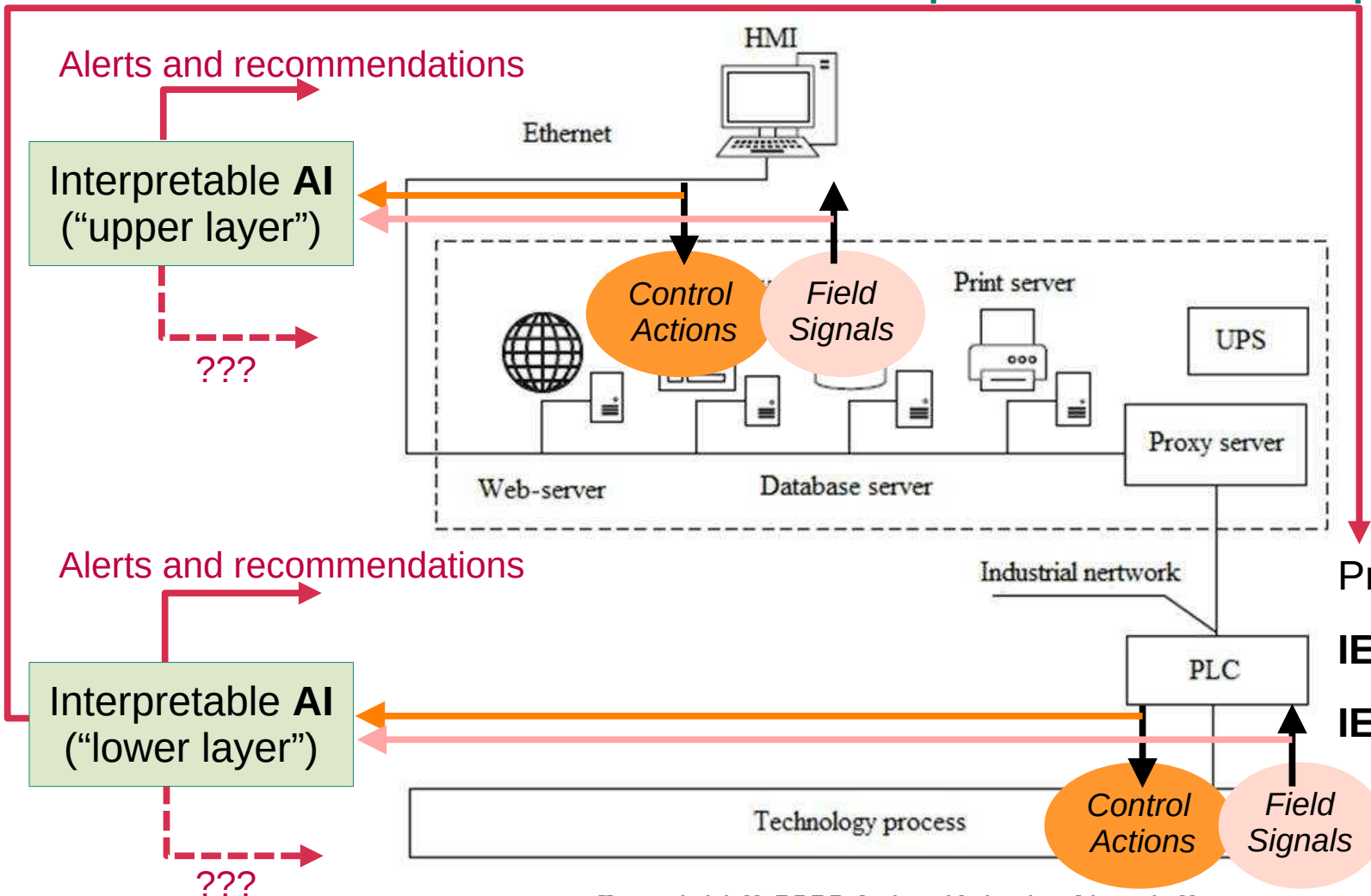
Reinforcement/experiential learning – comparing to “baselines”



What's next?

1. Make learning stable!
2. Reduce dimensionality in interpretable way!
3. More different environments!
4. Cluster/segment state of space and concurrent execution of the segments *("two-handed pong with two balls")*?
5. Applied cases – industrial automation?
6. Heterarchies of spaces of states and state series?*
7. Formal translation of transition graphs to programmable logic languages ("supercompilation")?**

Industrial Automation – Interpretable AI Setup Options



"Super compilation"
- adjustment, optimization and extension of programmable logic based on learned models (sequential state transition graphs)

Programmable logic

IEC 61131 (synchronous)

IEC 61499 (asynchronous)

Thank you for attention! Questions?

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Recording from workshop on the subject

Paper preprint from Neuroinformatics-2025 conference