# Computational Concept and Architecture of Artificial Psyche

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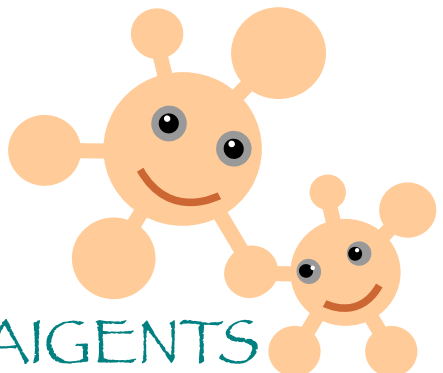
*THE REAL SCIENCE
https://www.nsu.ru



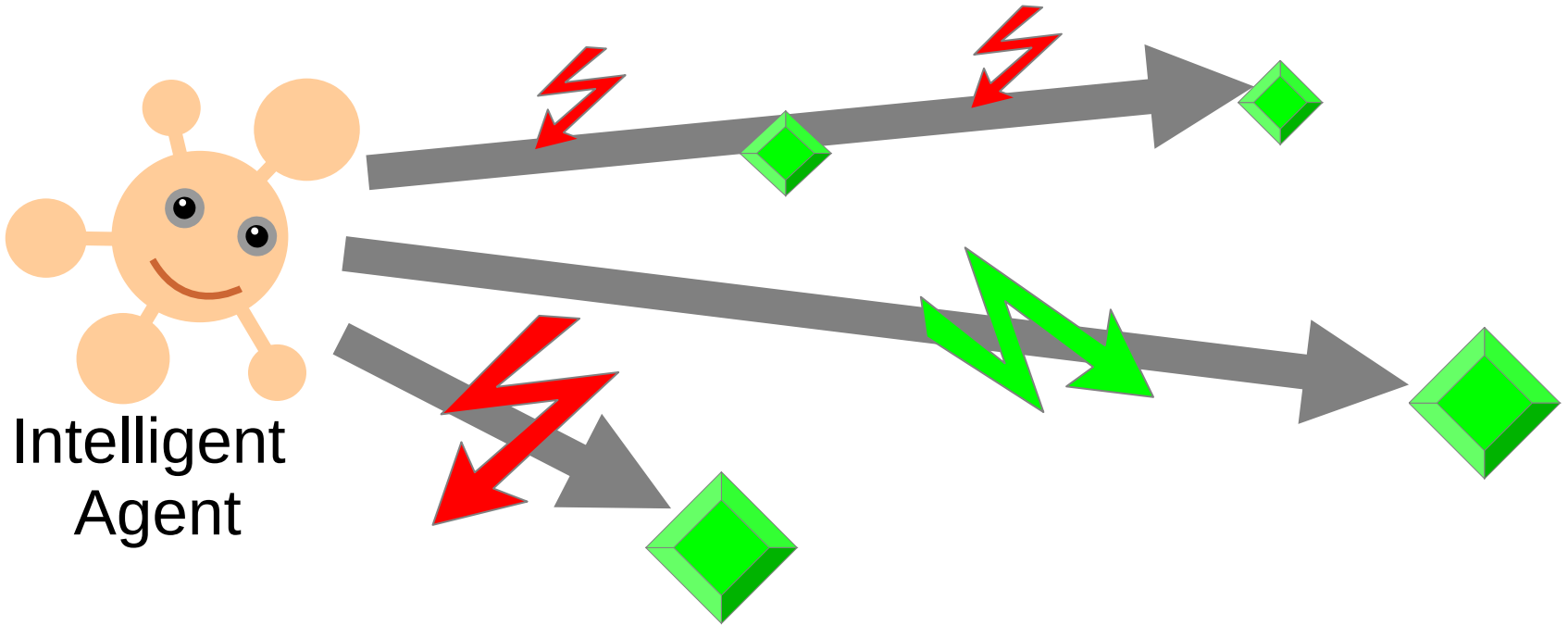
https://aigents.com

https://agirussia.org

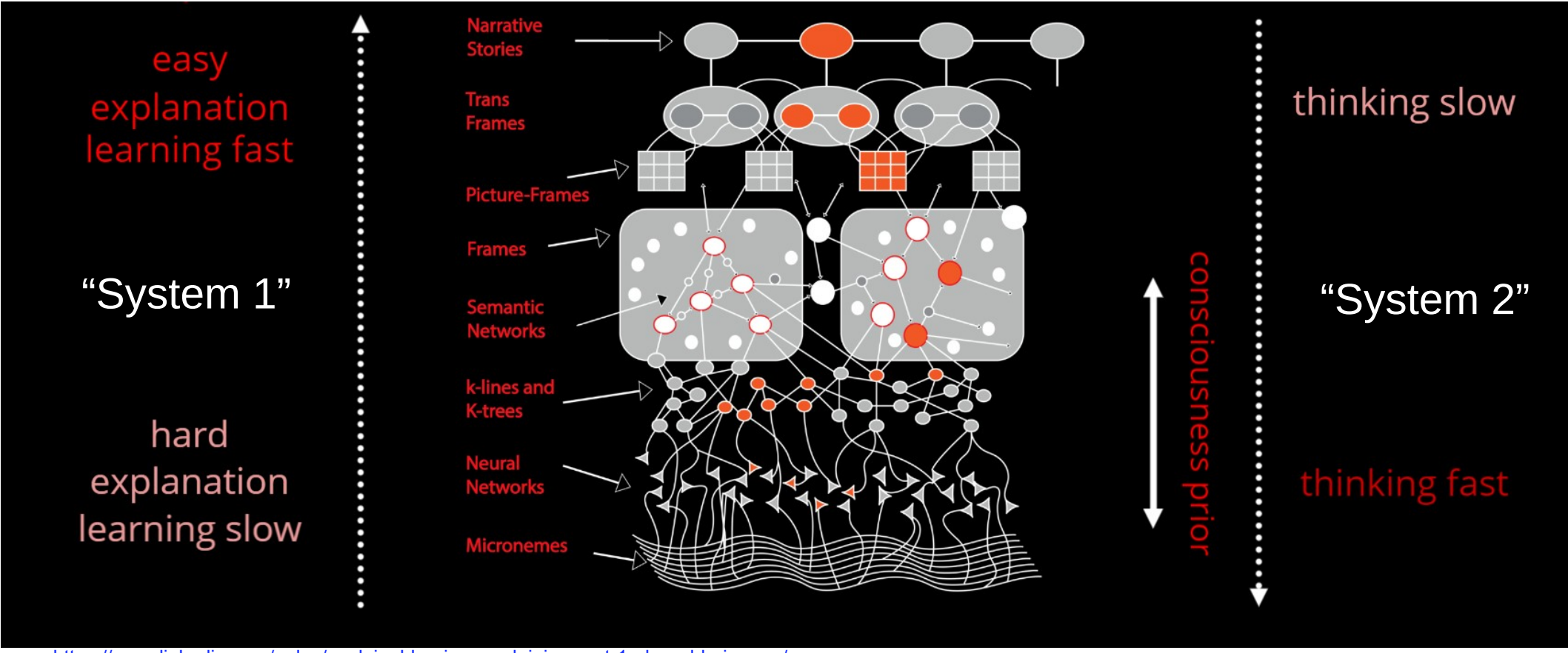
# General Intelligence:

## Reaching complex goals in different complex environments, using limited resources under uncertainty

(Ben Goertzel + Pei Wang + Shane Legg + Marcus Hutter)

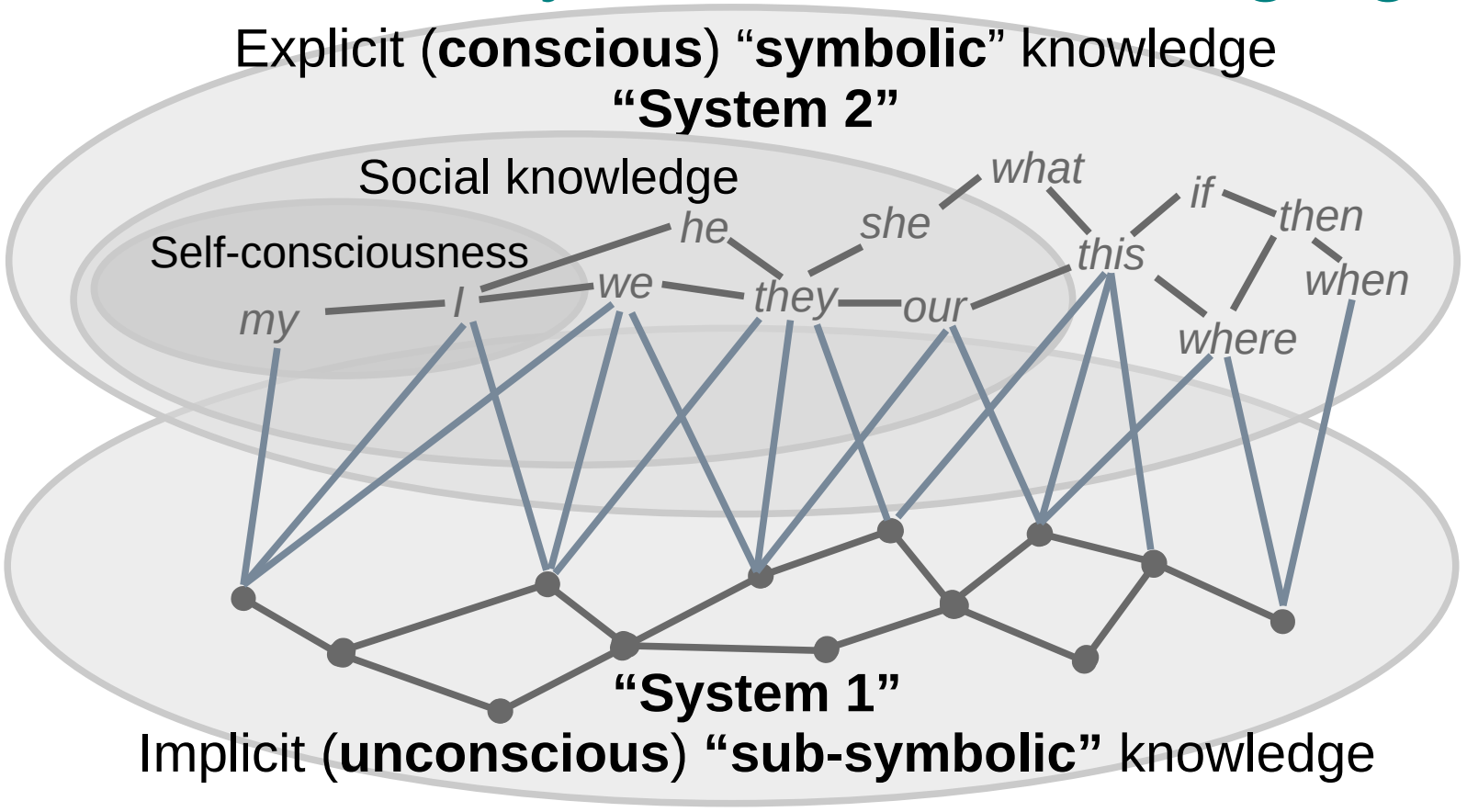


# “Fast and Slow Thinking” – Daniel Kahneman



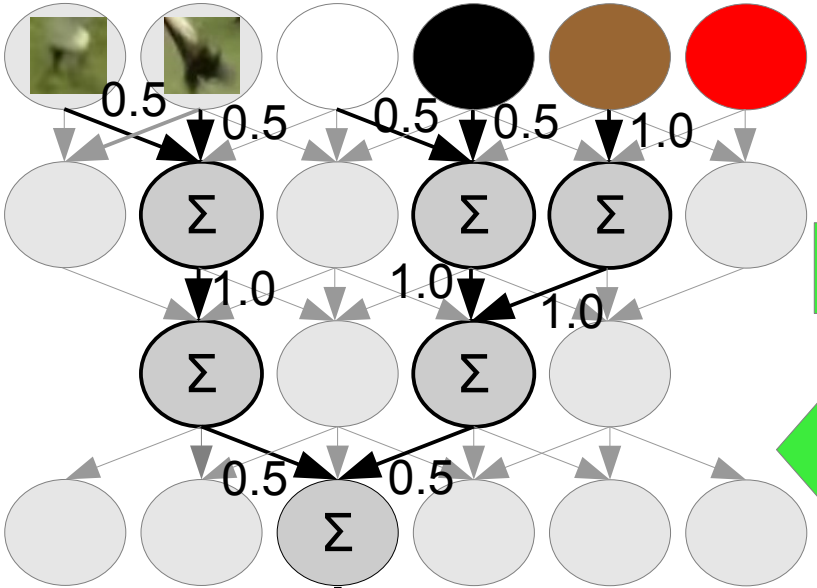

https://www.linkedin.com/pulse/explainable-ai-vs-explaining-part-1-ahmad-haj-mosa/
Xing, F., Cambria, E., Welsch, R. (2019). Theoretical Underpinnings on Text Mining. In: Intelligent Asset Management. Socio-Affective Computing, vol 9. Springer, Cham. https://doi.org/10.1007/978-3-030-30263-4_3
M. Minsky, The Emotion Machine: Commonsense Thinking, Artificial Intelligence, and the Future of the Human Mind (Simon & Schuster Paperbacks, Princeton, 2007)

# Medium: “neuro-symbolic” “knowledge graph”



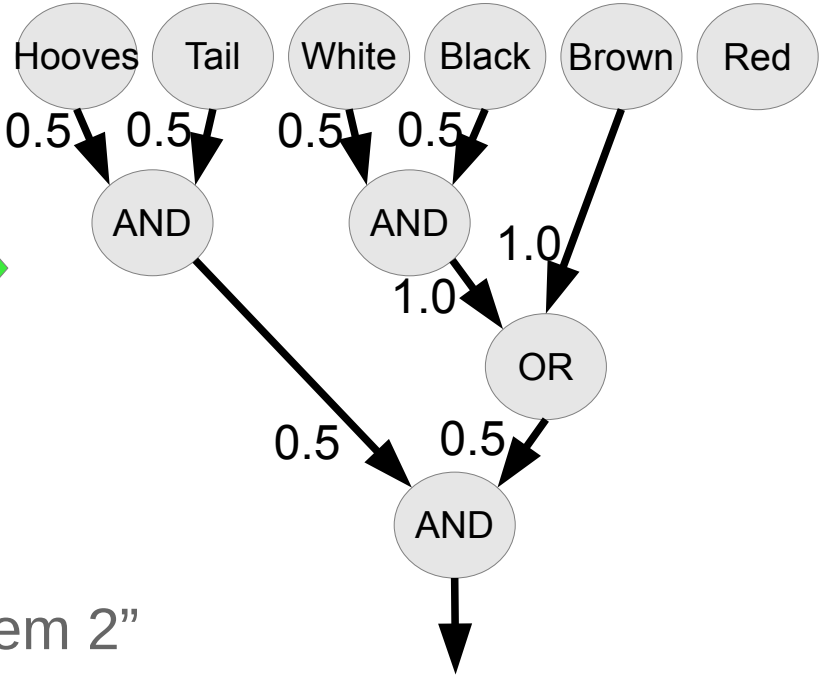

https://www.amazon.com/Thinking-Fast-Slow-Daniel-Kahneman/dp/0374533555
https://amit02093.medium.com/atomspace-hyper-graph-information-retrieval-system-450cab9d751e

# Neuro-Symbolic Integration for Interpretable AI




Explain

Transfer



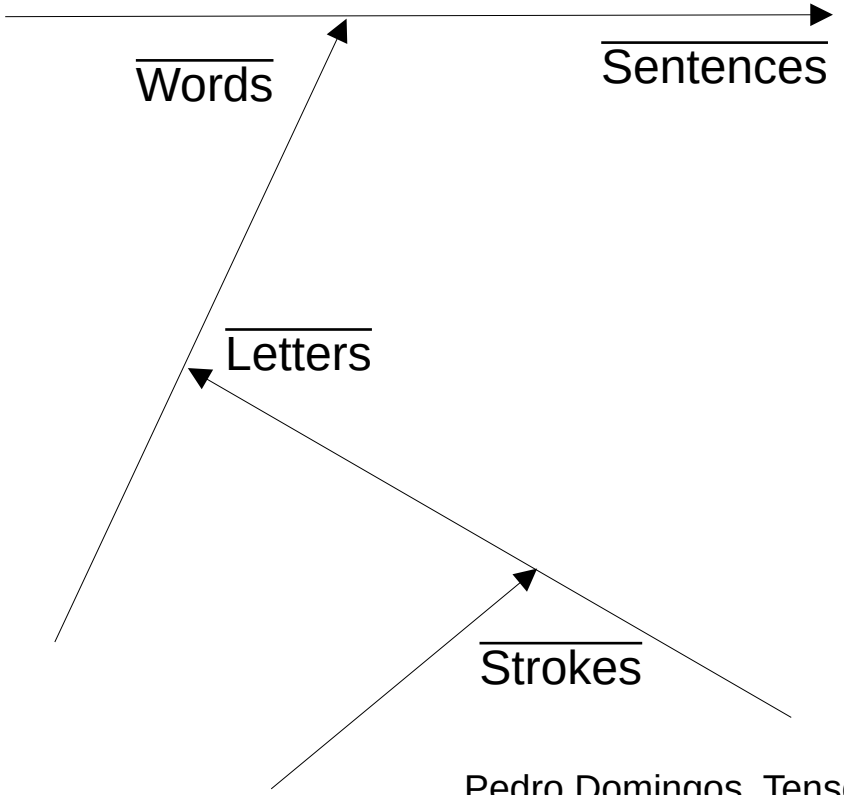

"System 1" "System 2"

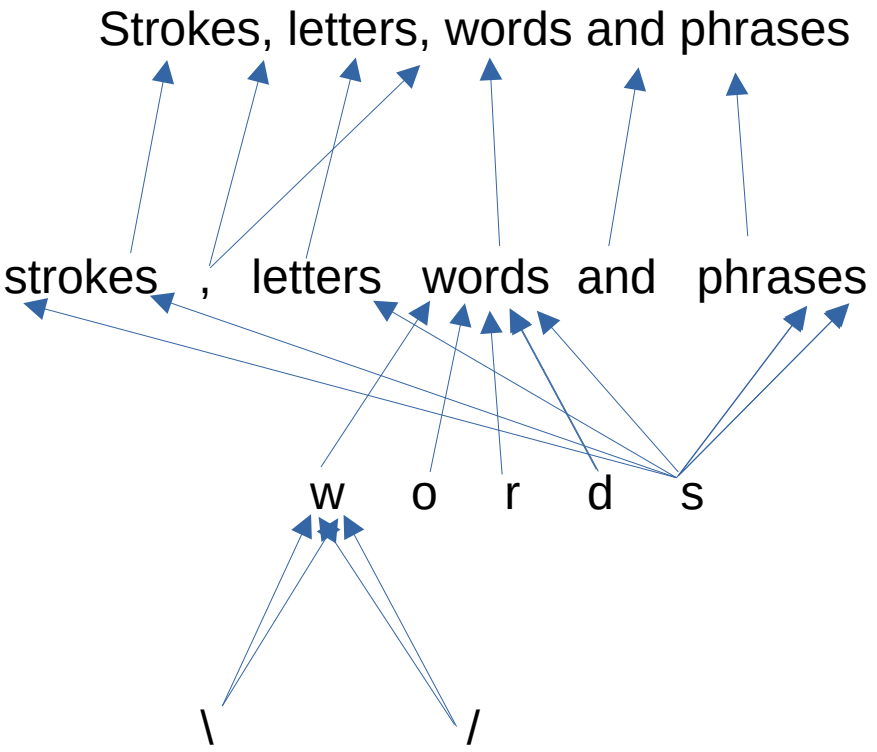
(Hooves AND Tail) AND NOT Red
((White and Black) OR Brown)

# => Horse

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

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

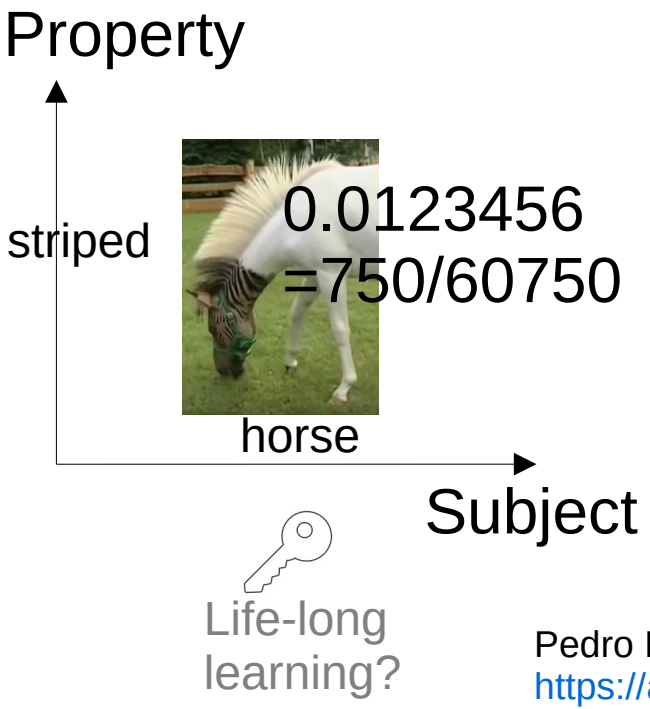


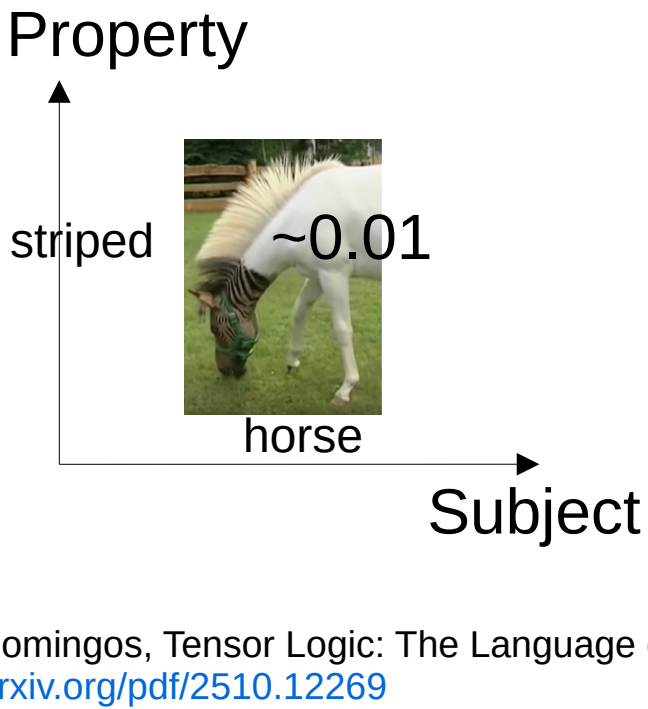

Pedro Domingos, Tensor Logic: The Language of AI
https://arxiv.org/pdf/2510.12269

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

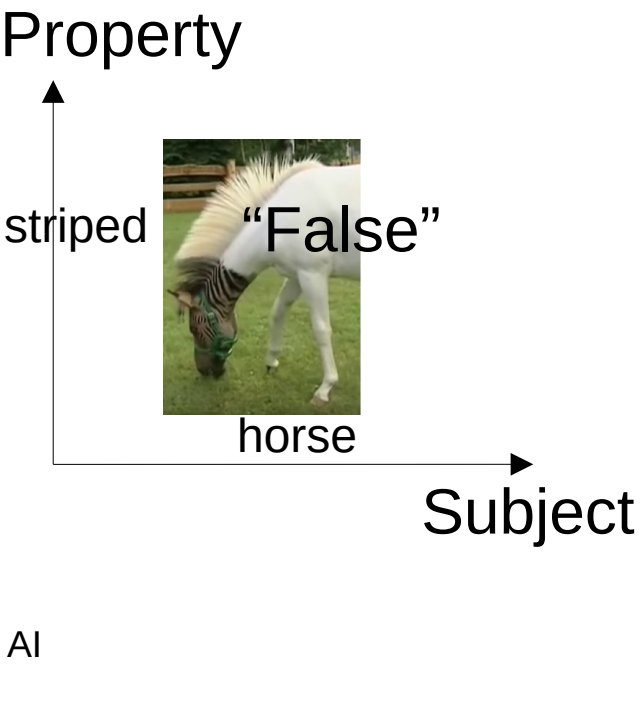
**Truth-Value Tensor**
(NARS/PLN)




**Numerical Tensor**
(ANN/Bayesian Logic)




**Boolean Tensor**
(Boolean Logic)



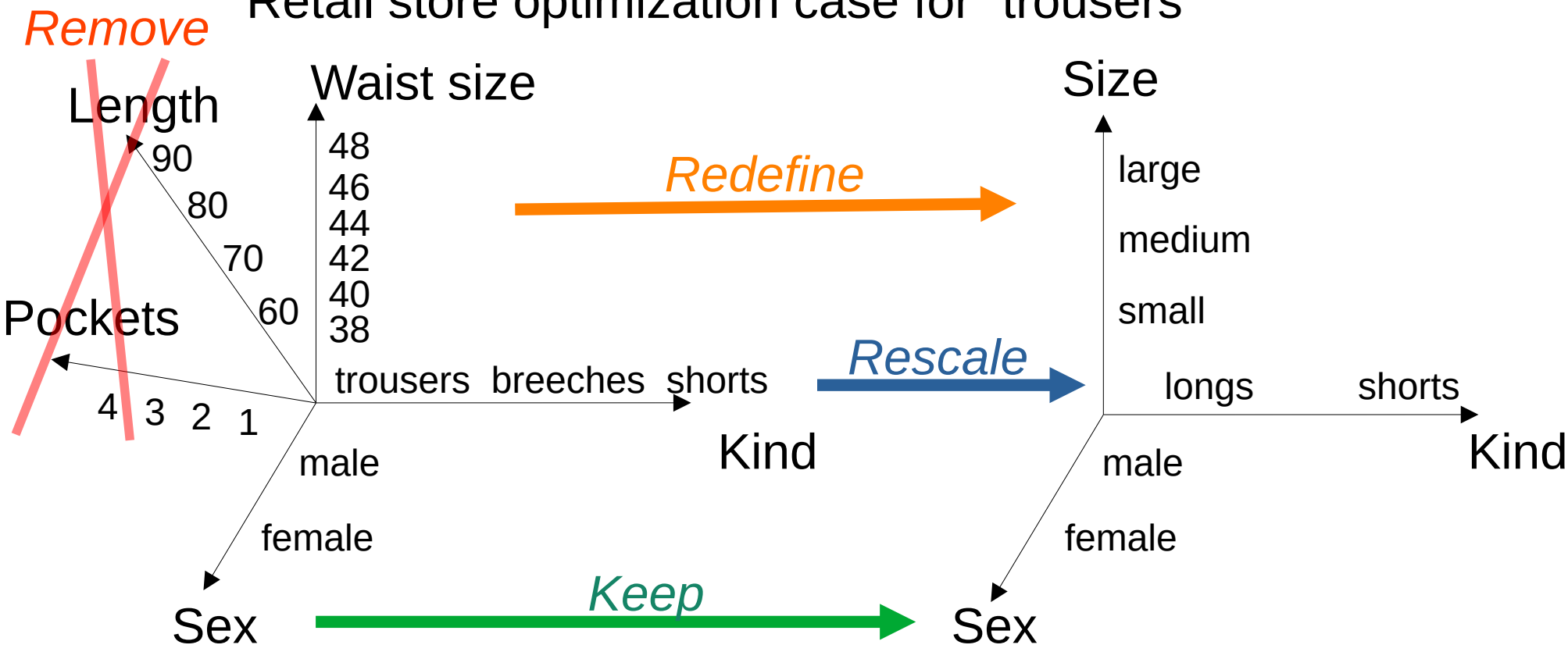




Pedro Domingos, Tensor Logic: The Language of AI
https://arxiv.org/pdf/2510.12269

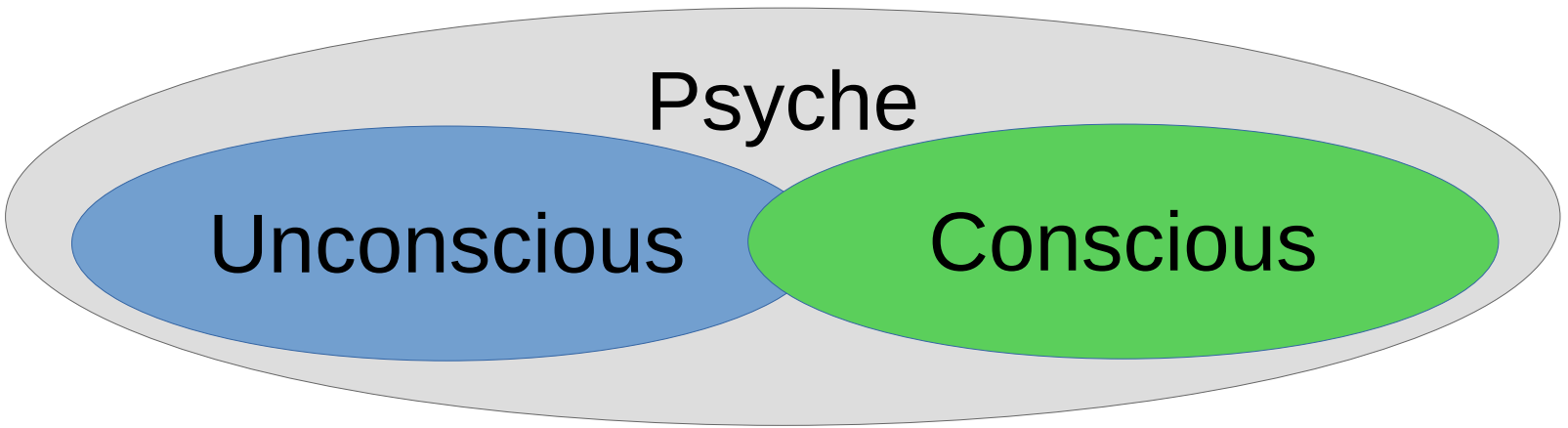
# Problem of dimensionality (reduction) and discreteness (increase)

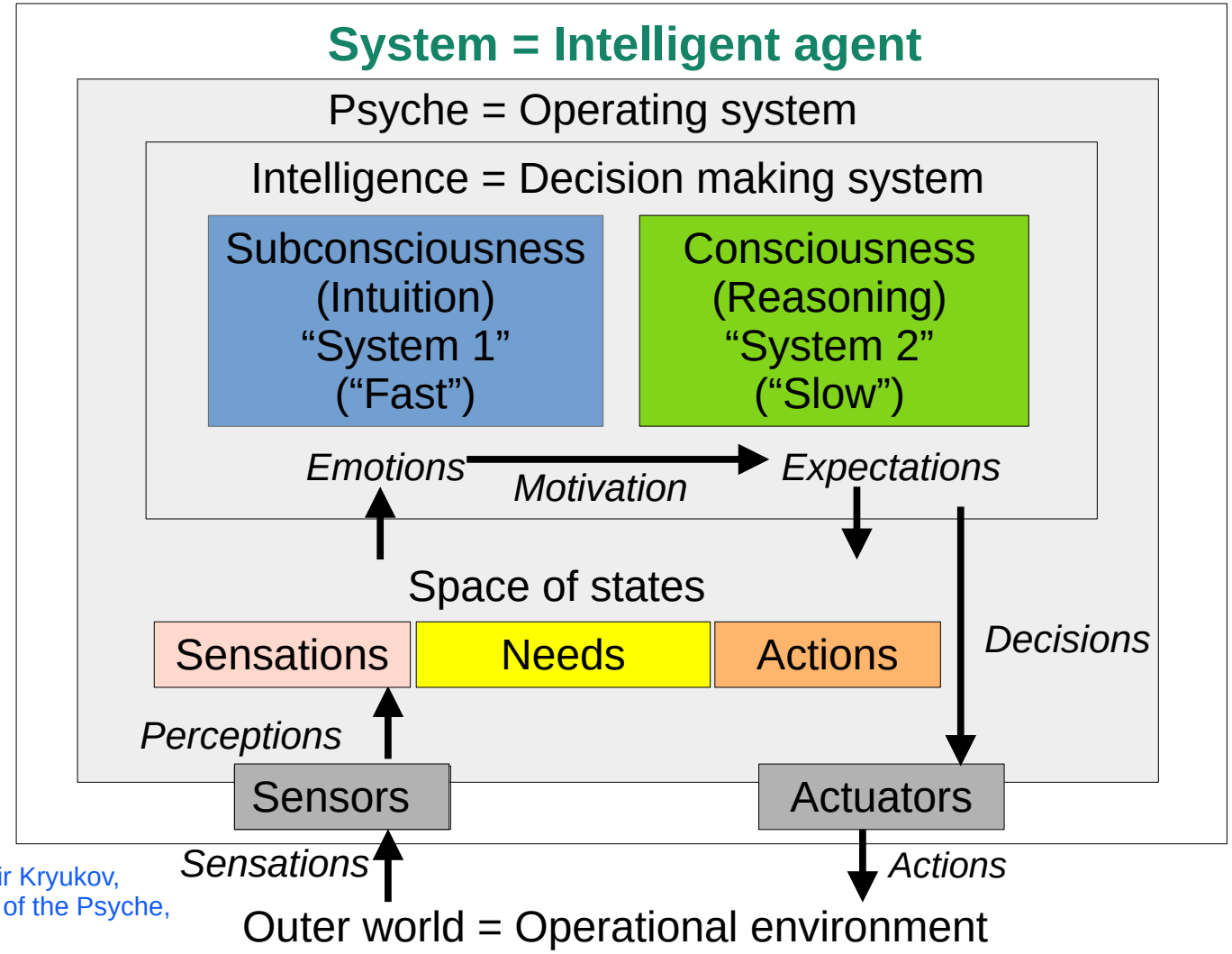
Retail store optimization case for “trousers”



The psyche /ˈsaɪki/ is currently used to describe the totality of the human mind, conscious and unconscious.

https://en.wikipedia.org/wiki/Psyche






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

# Psyche = Operating system

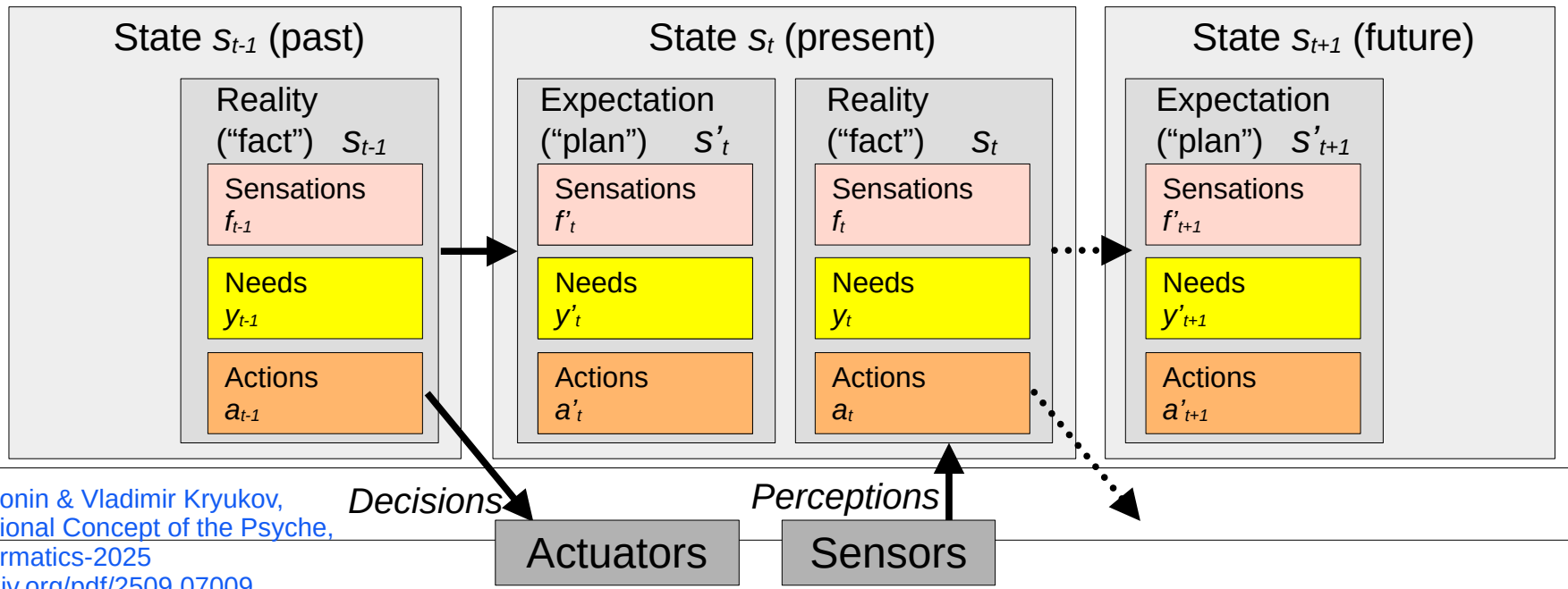
## Intelligence = Decision making system

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

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

*Experiential learning* ↑ ↓ *Decision making*

## Space of states and episodic memory ("precedents")




Anton Kolonin & Vladimir Kryukov,
Computational Concept of the Psyche,
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# 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

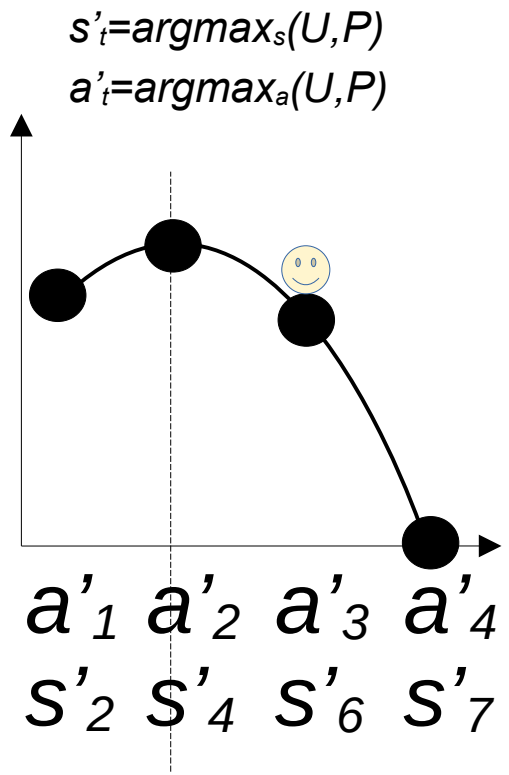
Sensors → *Perceptions*

$x\cdot y_t$ – "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)*

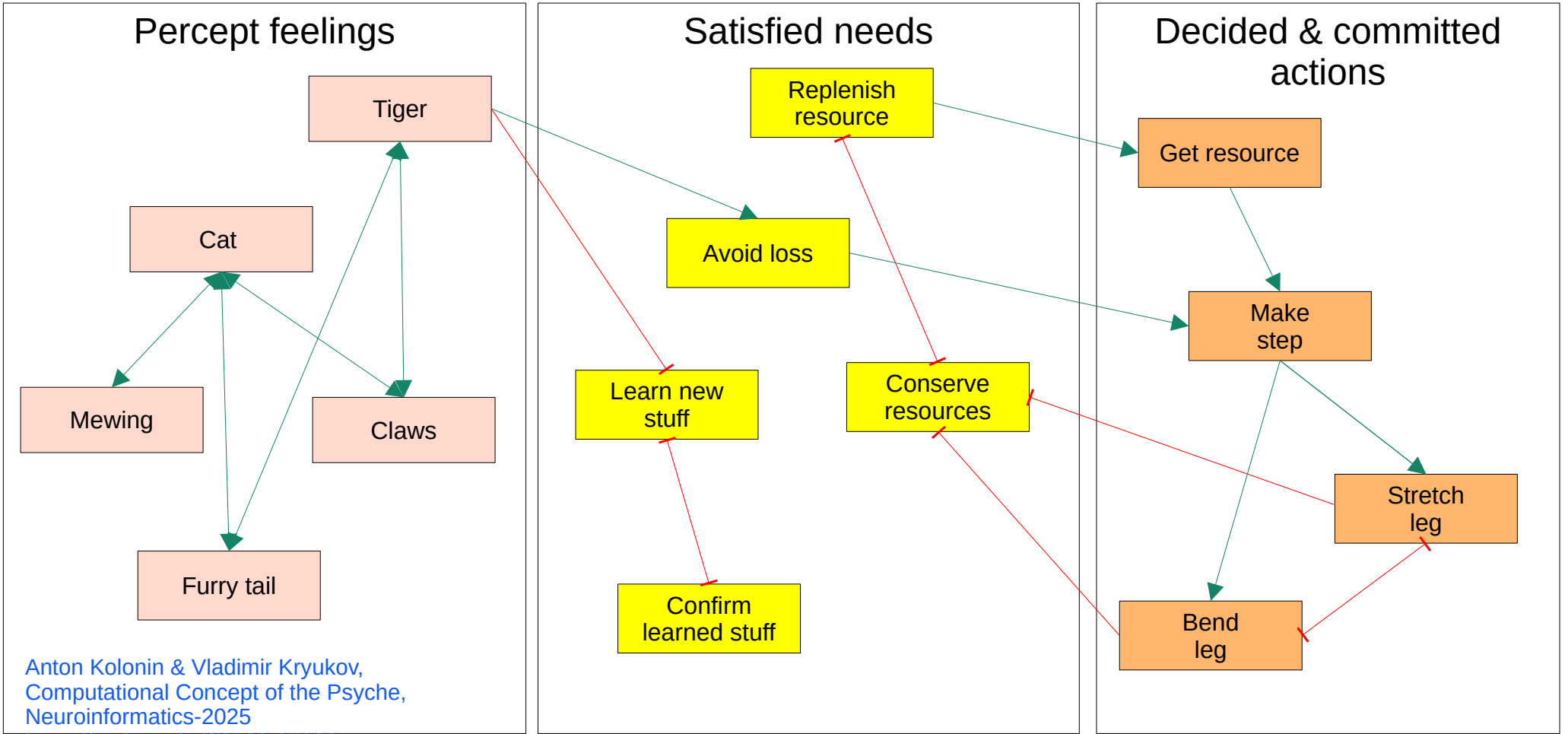
# Decision making as operational risk management

| $s_t$ | $s'_{t+1}$ | $s'_{t+1}$ | | | $U$ | $P$ | $\sum U*P$ |
|---|---|---|---|---|---|---|---|
| | | $a'$ | $y'$ | $f'$ | | | |
| $s_1$ | $s'_2$ | $a'_1$ | $y'_1$ | … | 1.0 | 0.5 | **0.7** |
| $s_1$ | $s'_3$ | $a'_1$ | $y'_2$ | … | 0.4 | 0.5 | |
| $s_1$ | $s'_4$ | $a'_2$ | $y'_3$ | … | 1.0 | 0.8 | **0.8** |
| $s_1$ | $s'_5$ | $a'_2$ | $y'_4$ | … | 0.0 | 0.2 | |
| $s_1$ | $s'_6$ | $a'_3$ | $y'_5$ | … | 0.6 | 1.0 | **0.6** |
| $s_1$ | $s'_7$ | $a'_4$ | $y'_6$ | … | 0.0 | 1.0 | **0.0** |




Tversky & Kahneman: most people choose $a'_3$ и $s'_6$ *("smaller profit with greater reliability")*

# Mutual dependency of state variable ~~subgraphs~~ tensors




Anton Kolonin & Vladimir Kryukov,
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Neuroinformatics-2025
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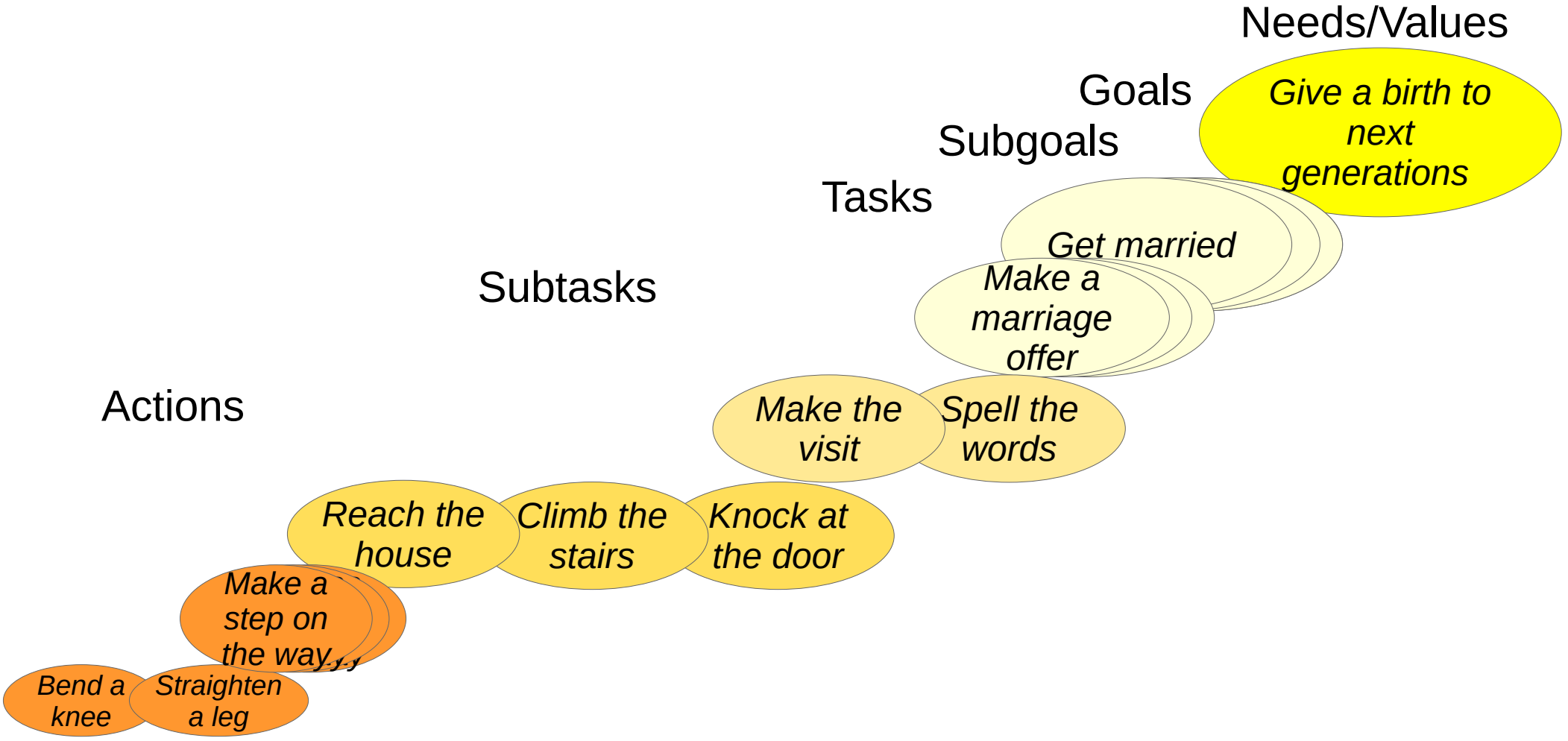
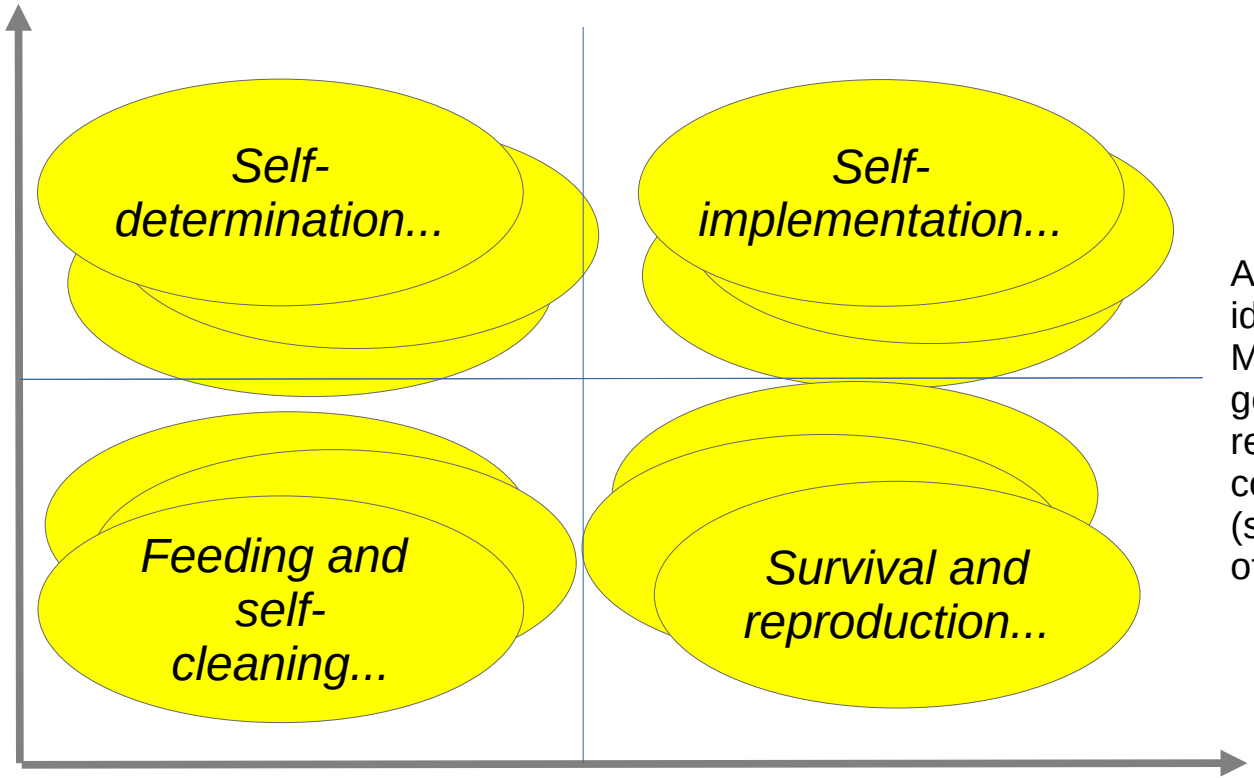
# Hierarchy of values/goals/subgoals/tasks/subtasks



# Space of needs/goals/values

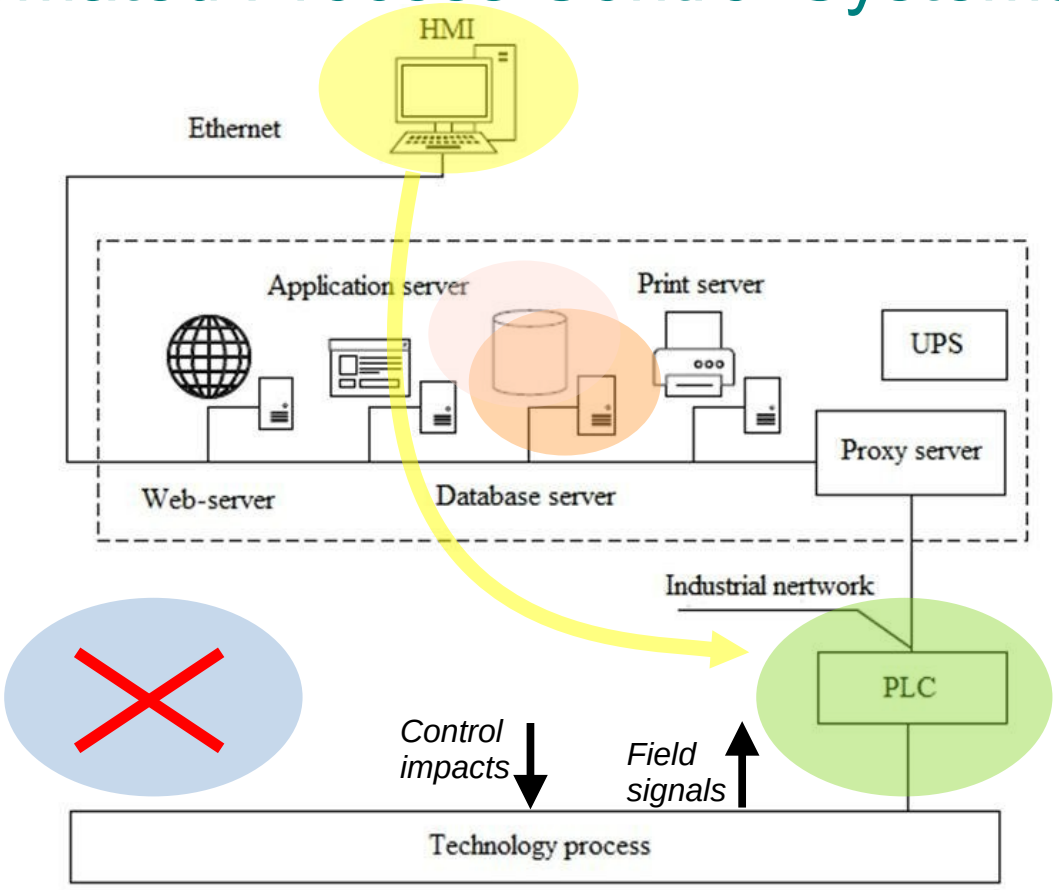



According to the ideas of A. Maslow, any goal can be represented as a combination (superposition) of basic needs

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

# Application cases

## A) Automated Process Control Systems (APCS)




Programmable logic

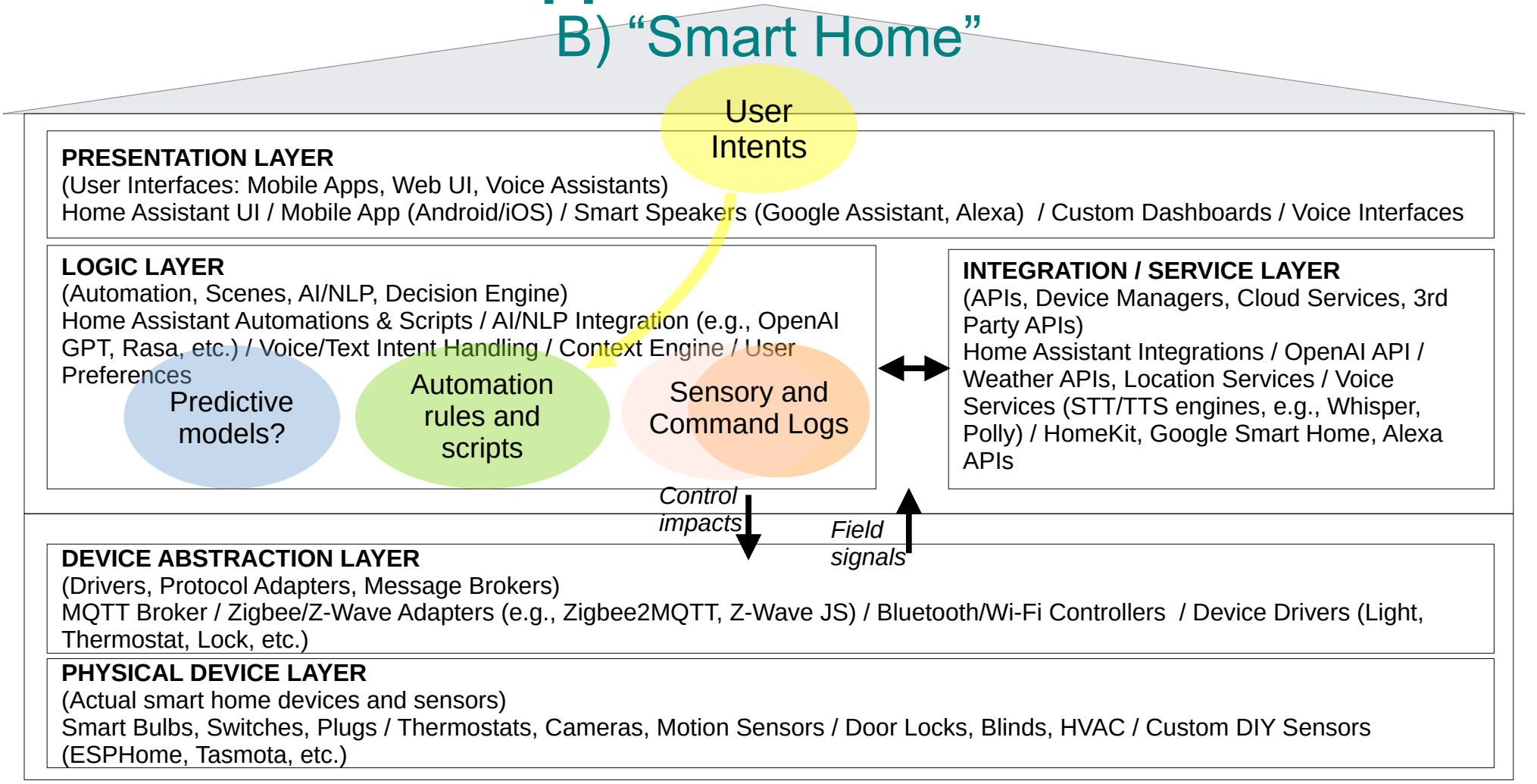
**IEC 61131** (synchronous)

**IEC 61499** (asynchronous)

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

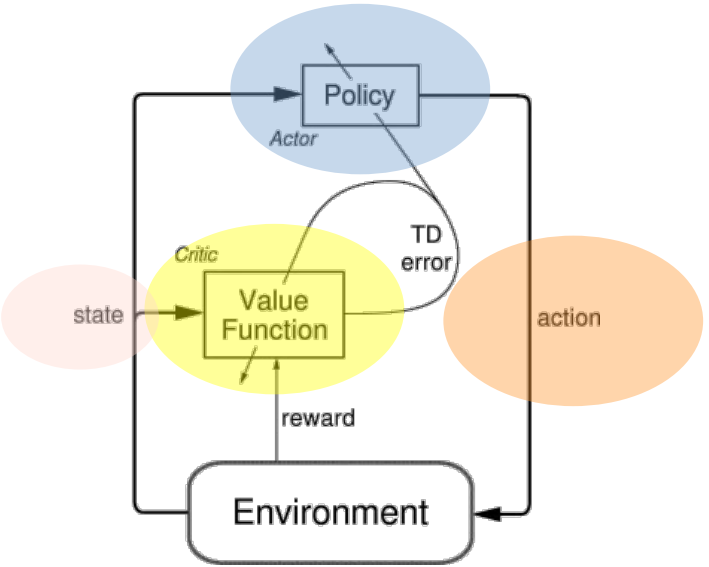
# Application cases

## B) “Smart Home”



# Implementation options

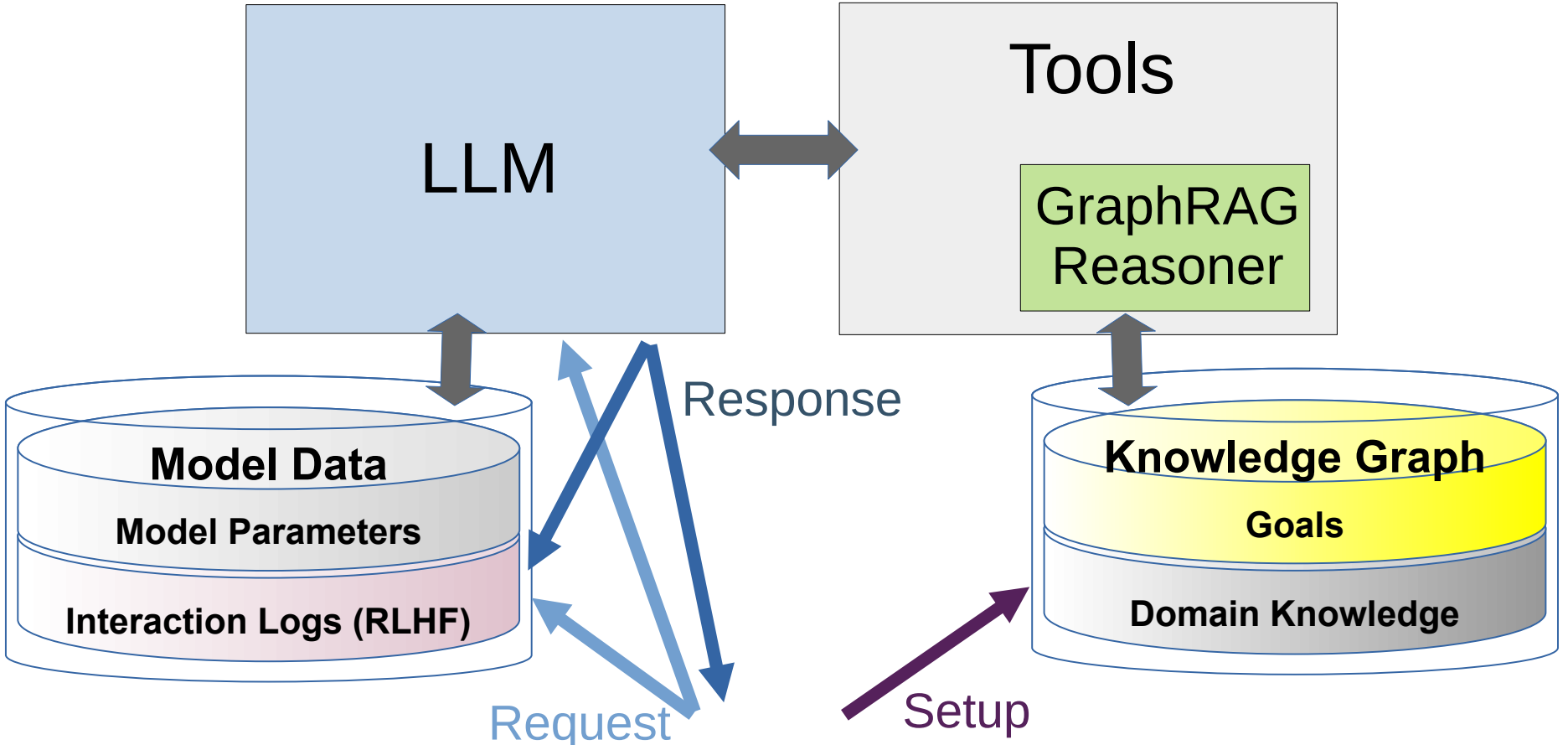
## 1) Reinforcement learning based on “actor-critic” model




https://medium.com/intro-to-artificial-intelligence/the-actor-critic-reinforcement-learning-algorithm-c8095a655c14

# Implementation options

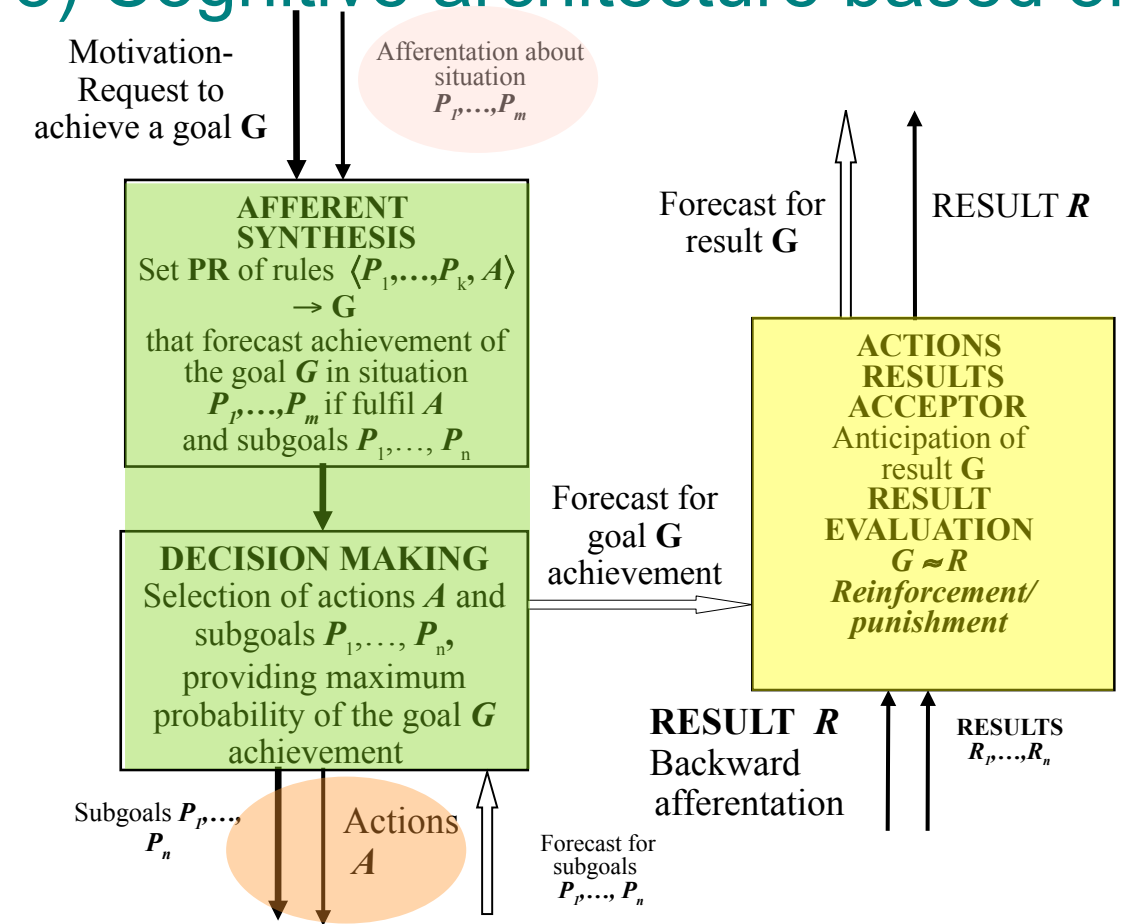
## 2) Cognitive architecture based on LLM and (active) GraphRAG




Leonie Monigatti, "The Evolution from RAG to Agentic RAG to Agent Memory", November 3, 2025
https://www.leoniemonigatti.com/blog/from-rag-to-agent-memory.html

# Implementation options

## 3) Cognitive architecture based on probabilistic logic




$$Prob(G \mid P_1,\ldots,P_k,P_1,\ldots,P_n,A) = Prob(rule)\cdot Prob(P_1)\cdot\ldots\cdot Prob(P_n)$$

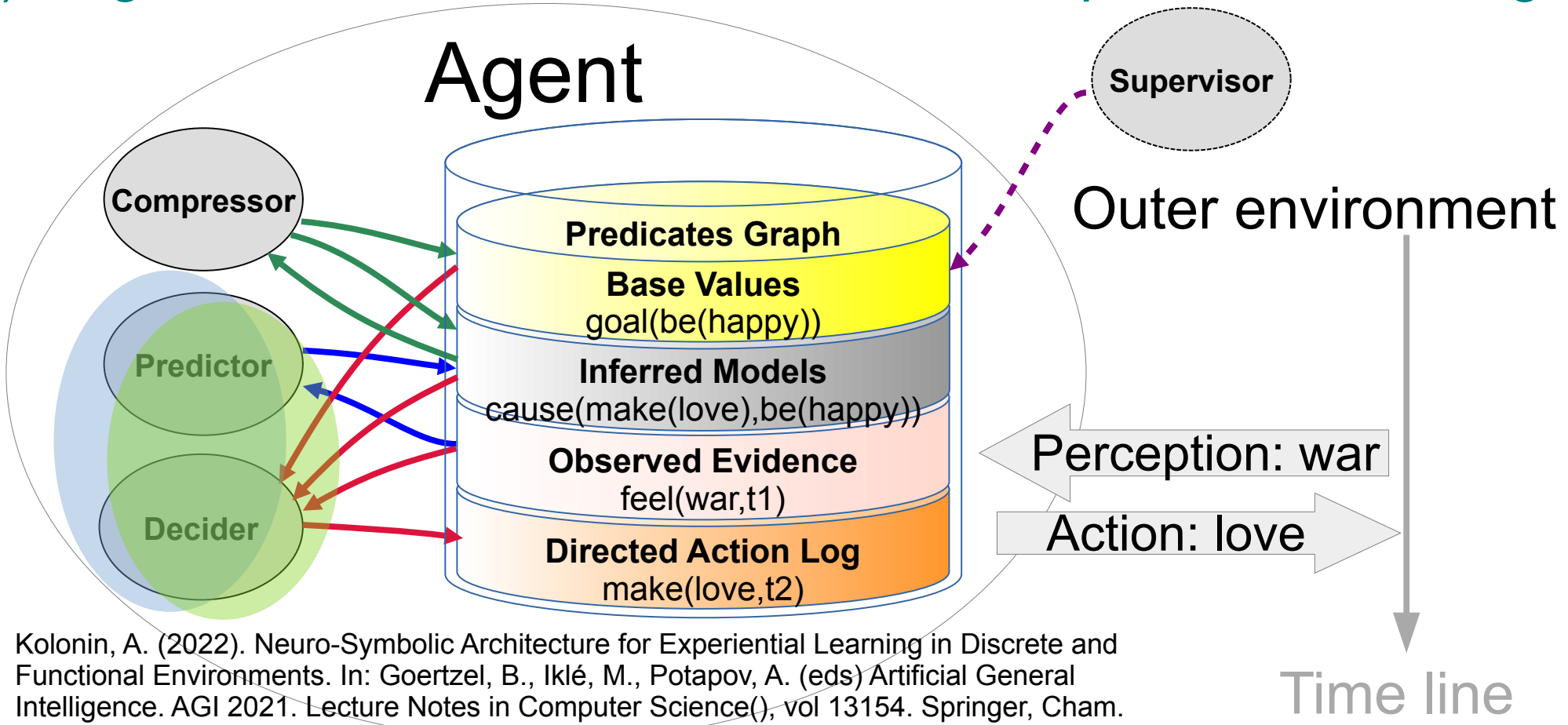
Evgenii Vityaev, Alexander Demin: Adaptive Control of Modular Robots // Conference Paper in Advances in Intelligent Systems and Computing, Conference: First International Early Research Career Enhancement School on Biologically Inspired Cognitive Architectures, Springer, August 2018

Evgenii E. Vityaev: Purposefulness as a Principle of Brain Activity // Anticipation: Learning from the Past, (ed.) M. Nadin. Cognitive Systems Monographs, V.25, Chapter No.: 13. Springer, 2015, pp. 231-254.

Витяев Е.Е. Логика работы мозга. Подходы к моделированию мышления. (сборник под ред. д.ф.-м.н. В.Г. Редько). УРСС Эдиториал, Москва, 2014г., стр. 120-153.

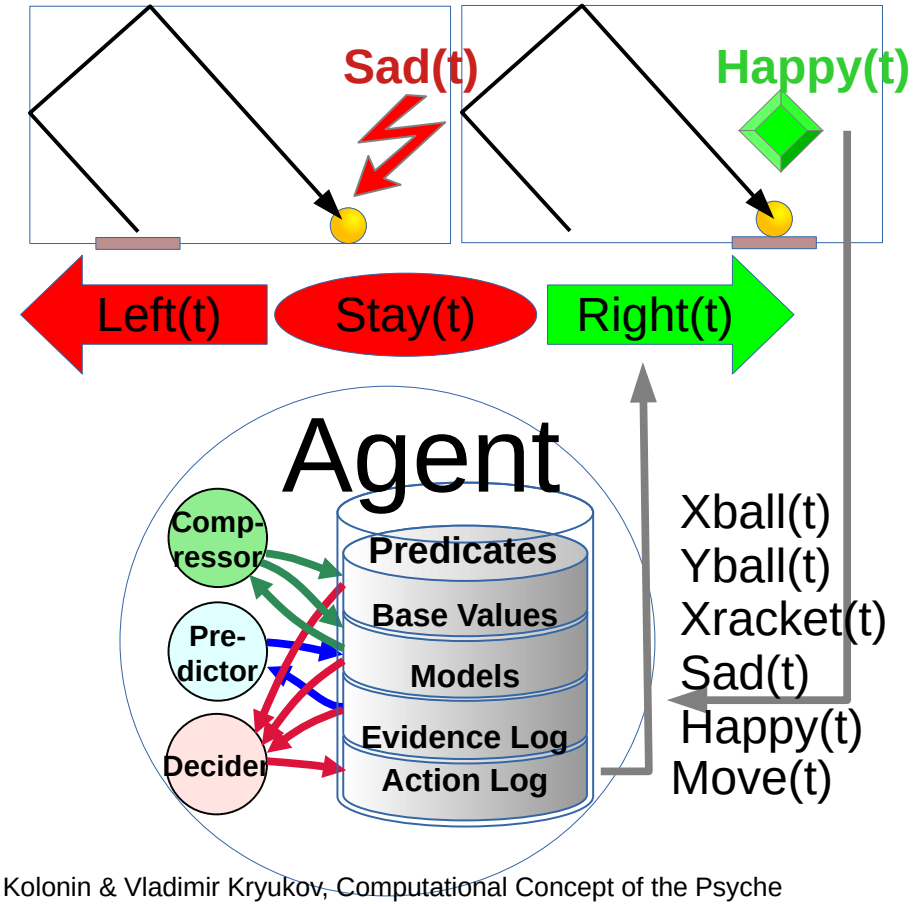
# Implementation options

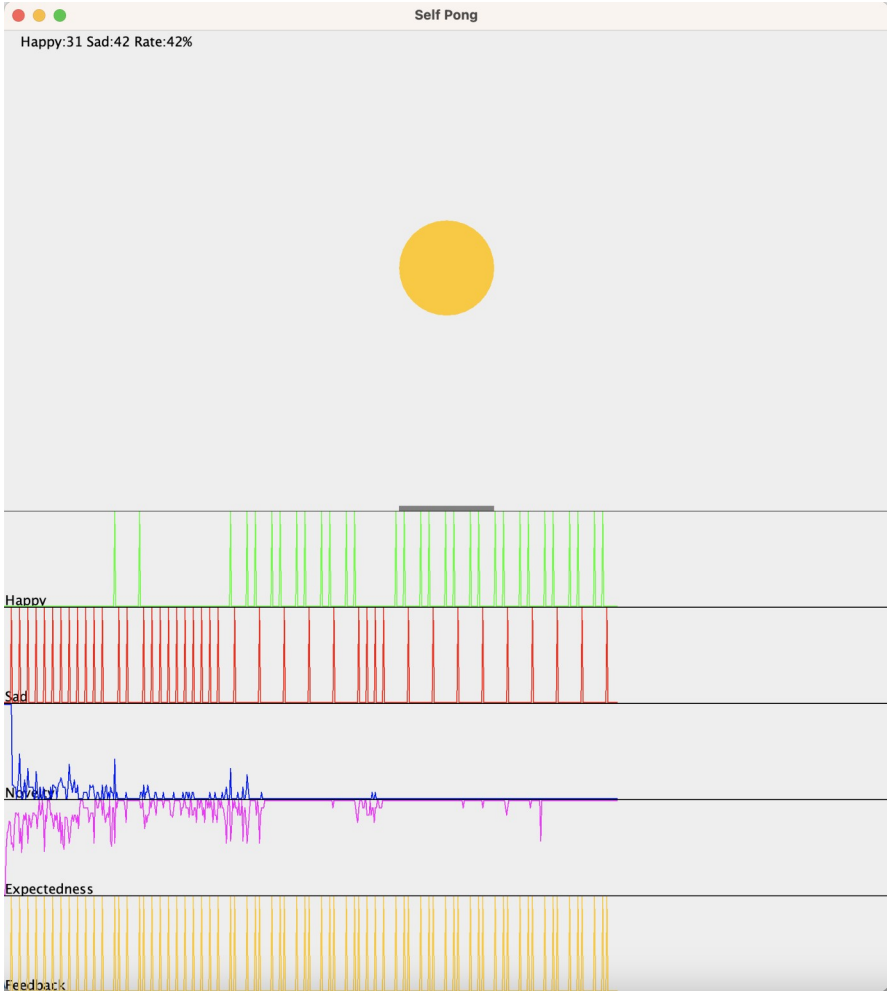
## 4) Cognitive architecture of value-based experiential learning




Kolonin, A. (2022). Neuro-Symbolic Architecture for Experiential Learning in Discrete and Functional Environments. In: Goertzel, B., Iklé, M., Potapov, A. (eds) Artificial General Intelligence. AGI 2021. Lecture Notes in Computer Science(), vol 13154. Springer, Cham. https://doi.org/10.1007/978-3-030-93758-4_12

# Cognitive architecture of value-based experiential learning

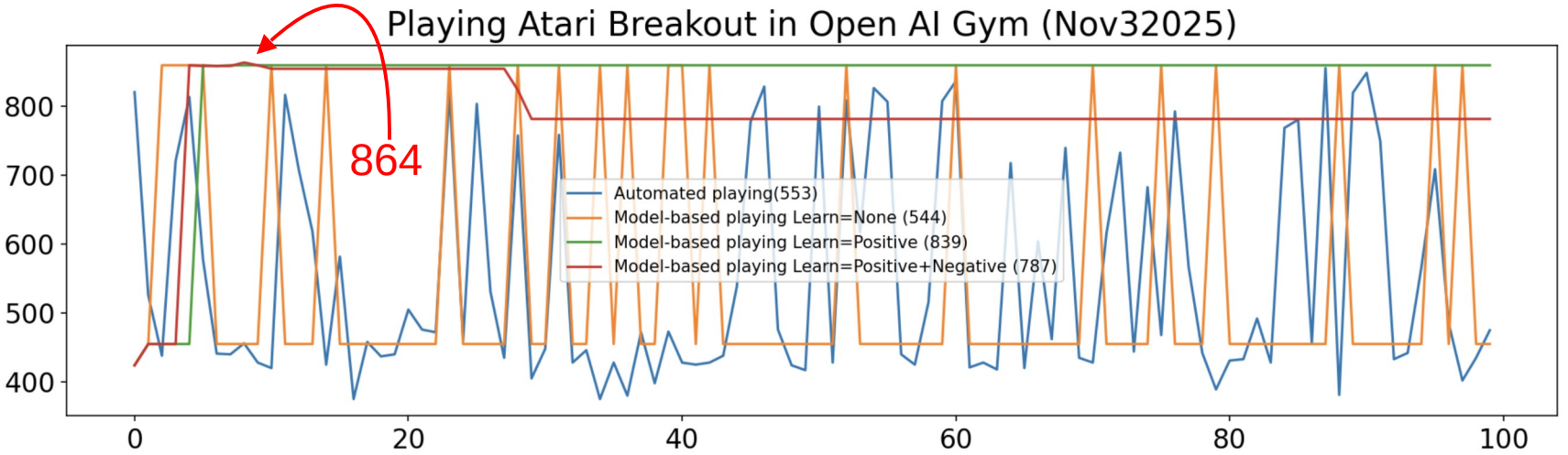


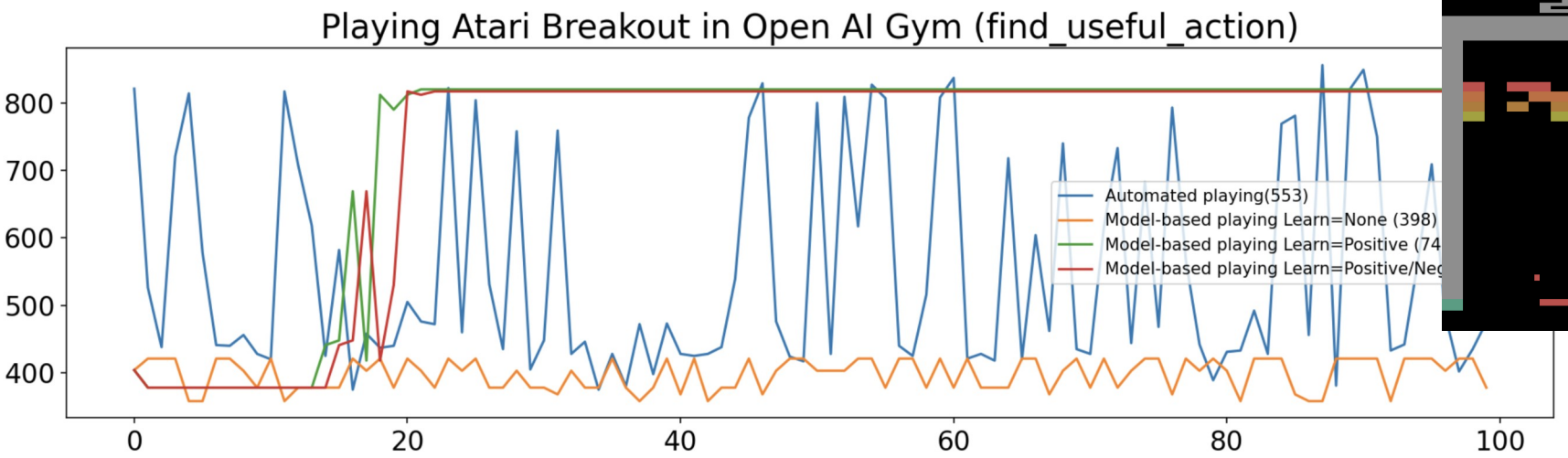



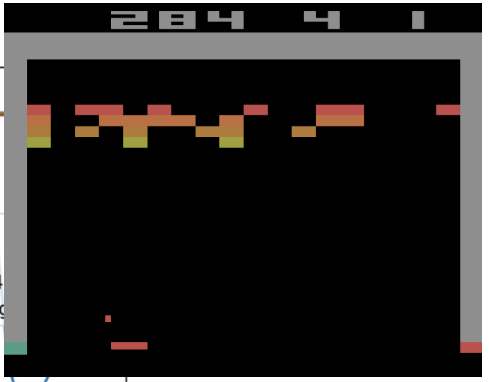


Anton Kolonin & Vladimir Kryukov, Computational Concept of the Psyche
https://arxiv.org/pdf/2509.07009
Anton Kolonin, Neuro-Symbolic Architecture for Experiential Learning in Discrete and Functional Environments
https://doi.org/10.1007/978-3-030-93758-4_12

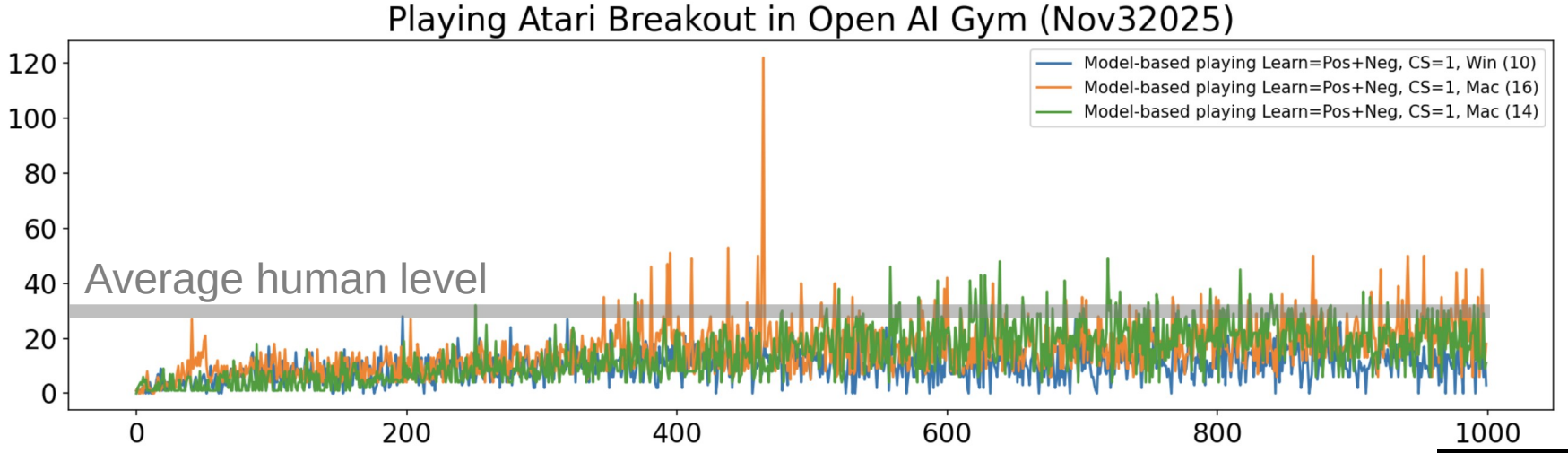
# Imitation learning – decision making on “pre-trained” model

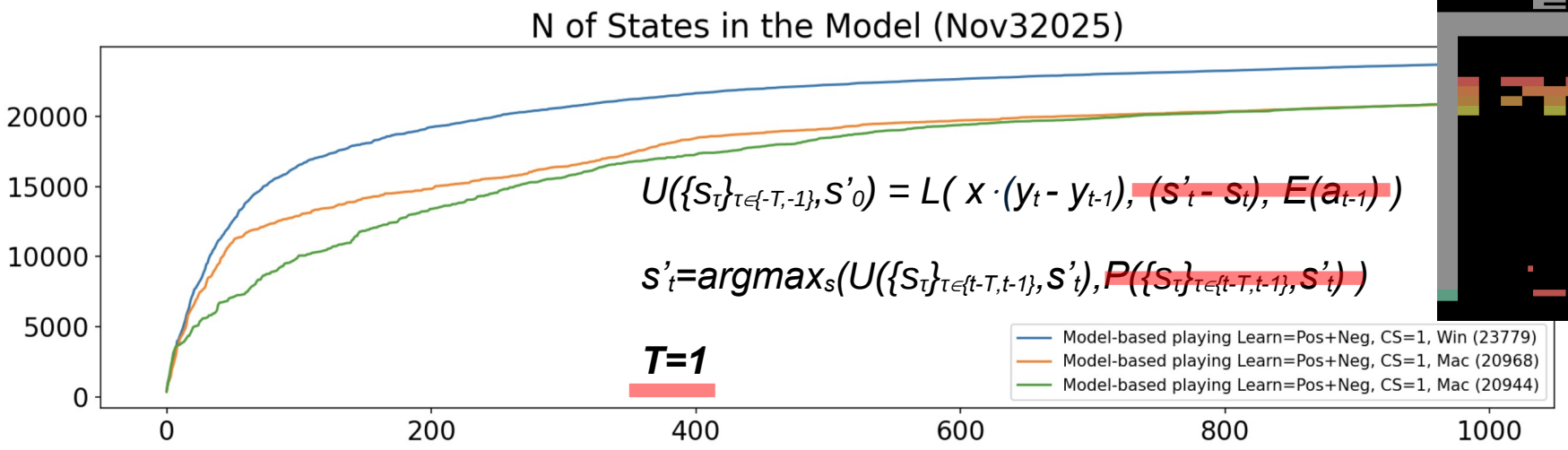


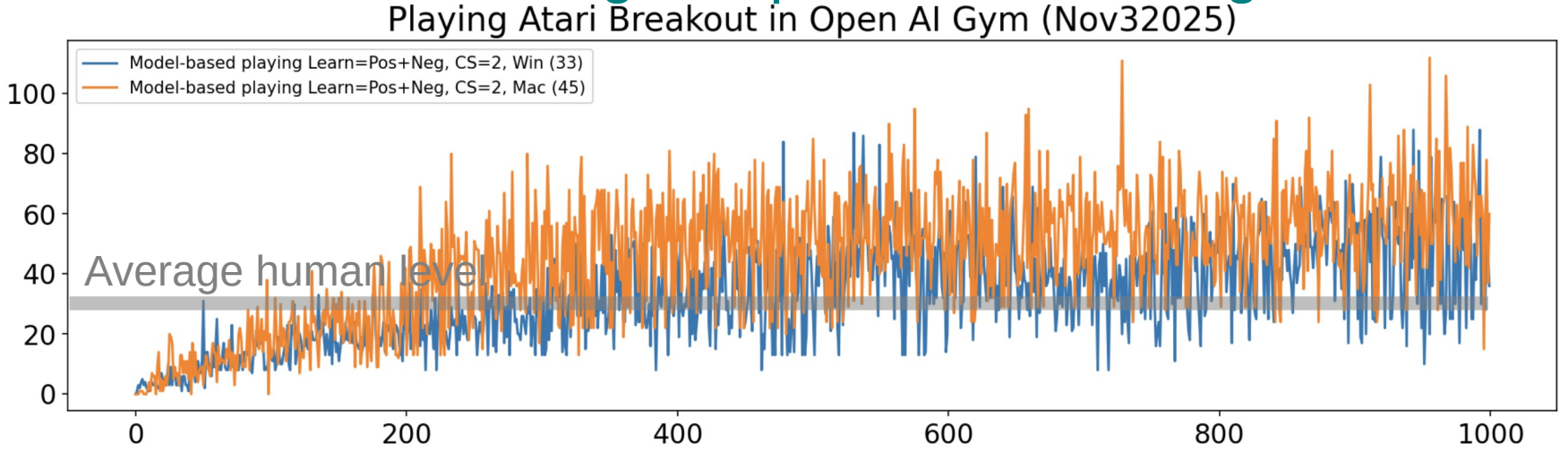



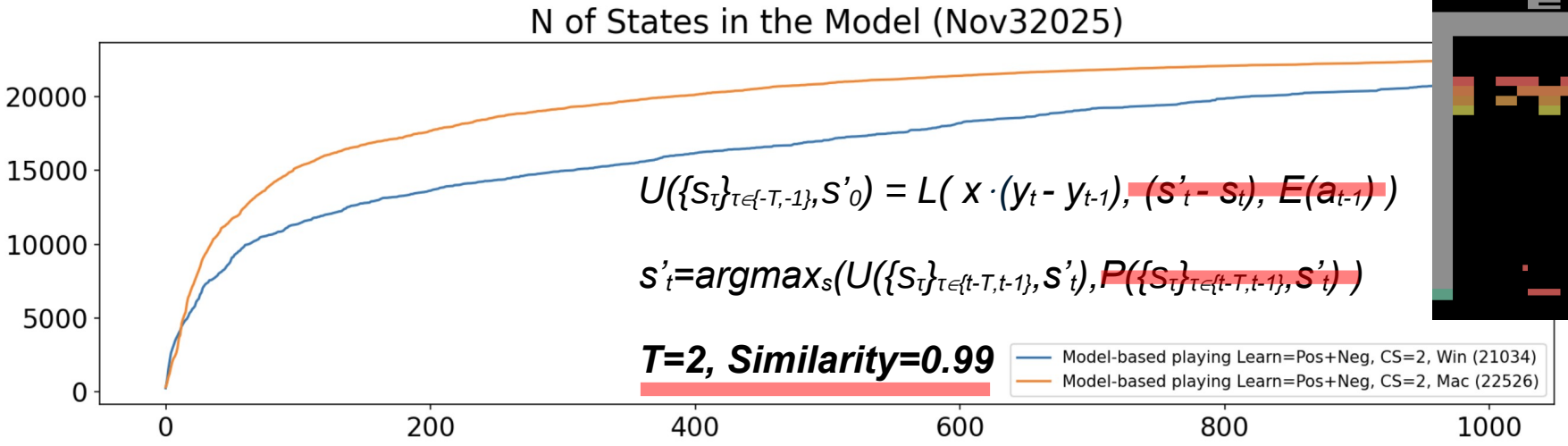
# Reinforcement learning – experiential learning and decision making

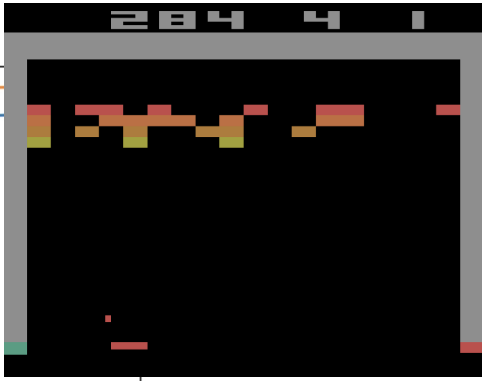


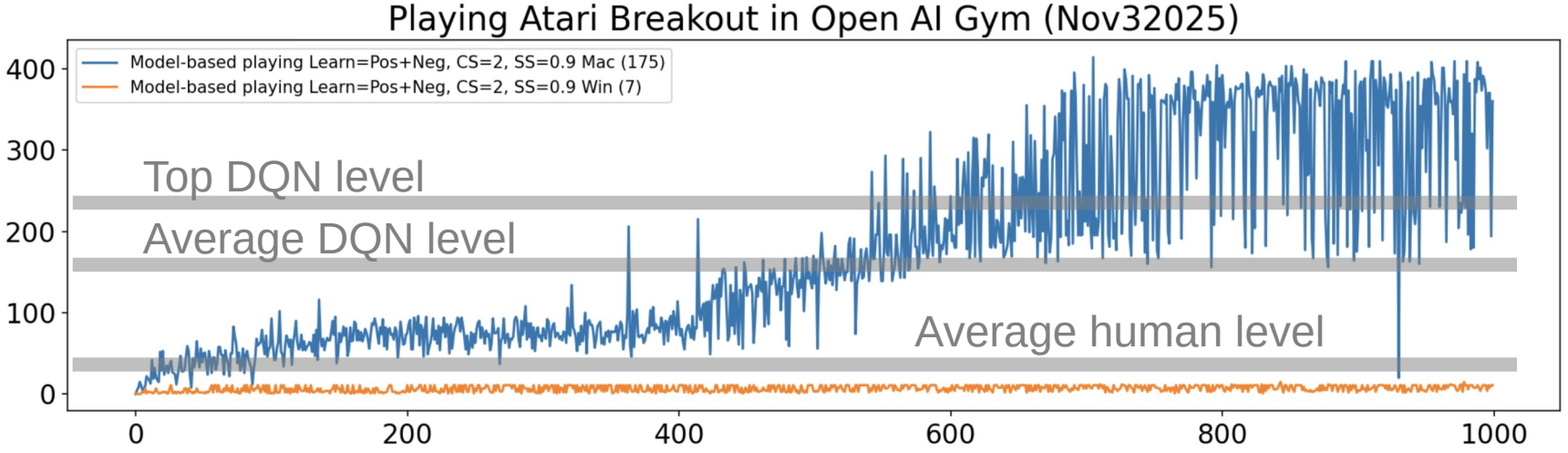

# Reinforcement learning – experiential learning and decision making

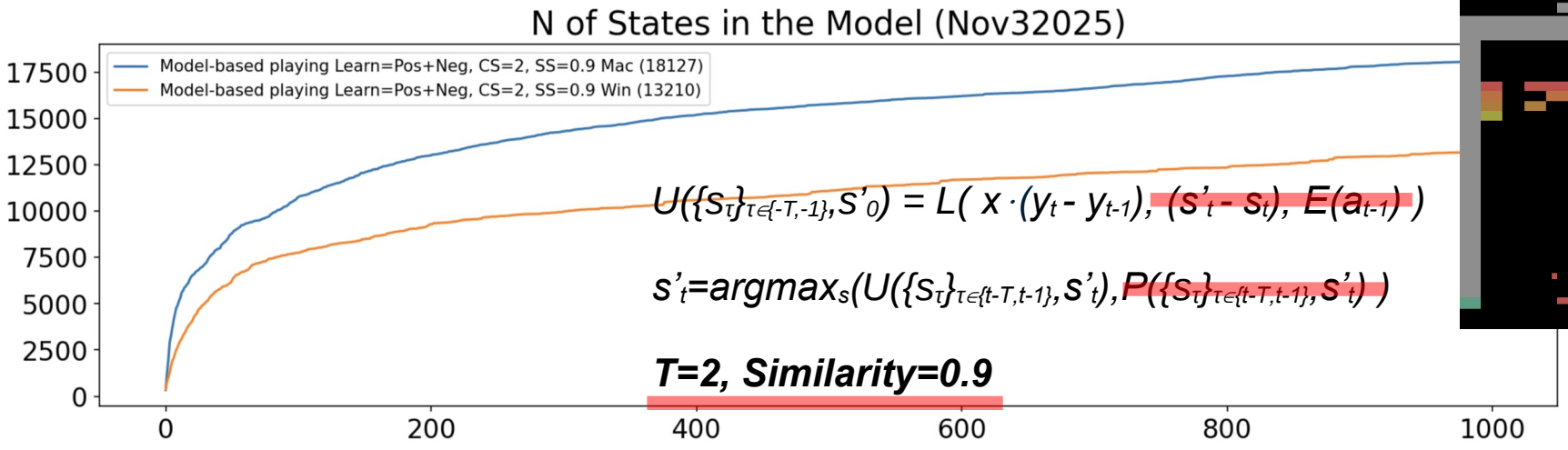


# Reinforcement learning – experiential learning and decision making

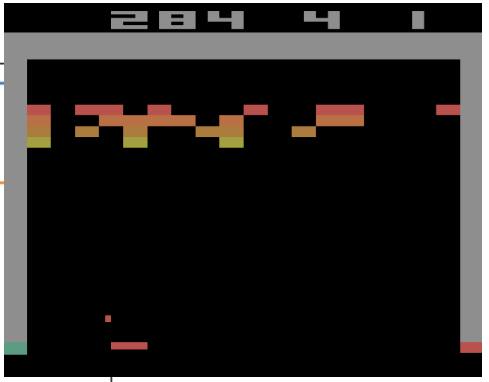



$U(\{s_\tau\}_{\tau\in\{-T,-1\}}, s'_0) = L(\ x \cdot (y_t - y_{t-1}),\ (s'_t - s_t),\ E(a_{t-1})\ )$

$s'_t = \mathrm{argmax}_s(U(\{s_\tau\}_{\tau\in\{t-T,t-1\}}, s'_t), P(\{s_\tau\}_{\tau\in\{t-T,t-1\}}, s'_t)\ )$

***T=2, Similarity=0.9***



# Thank you for attention! Questions?

Anton Kolonin
akolonin@aigents.com
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## Workshop recording on the subject

## Anton Kolonin & Vladimir Kryukov, Computational Concept of the Psyche, Neuroinformatics-2025