

Computational Concept and Architecture of Artificial Psyche

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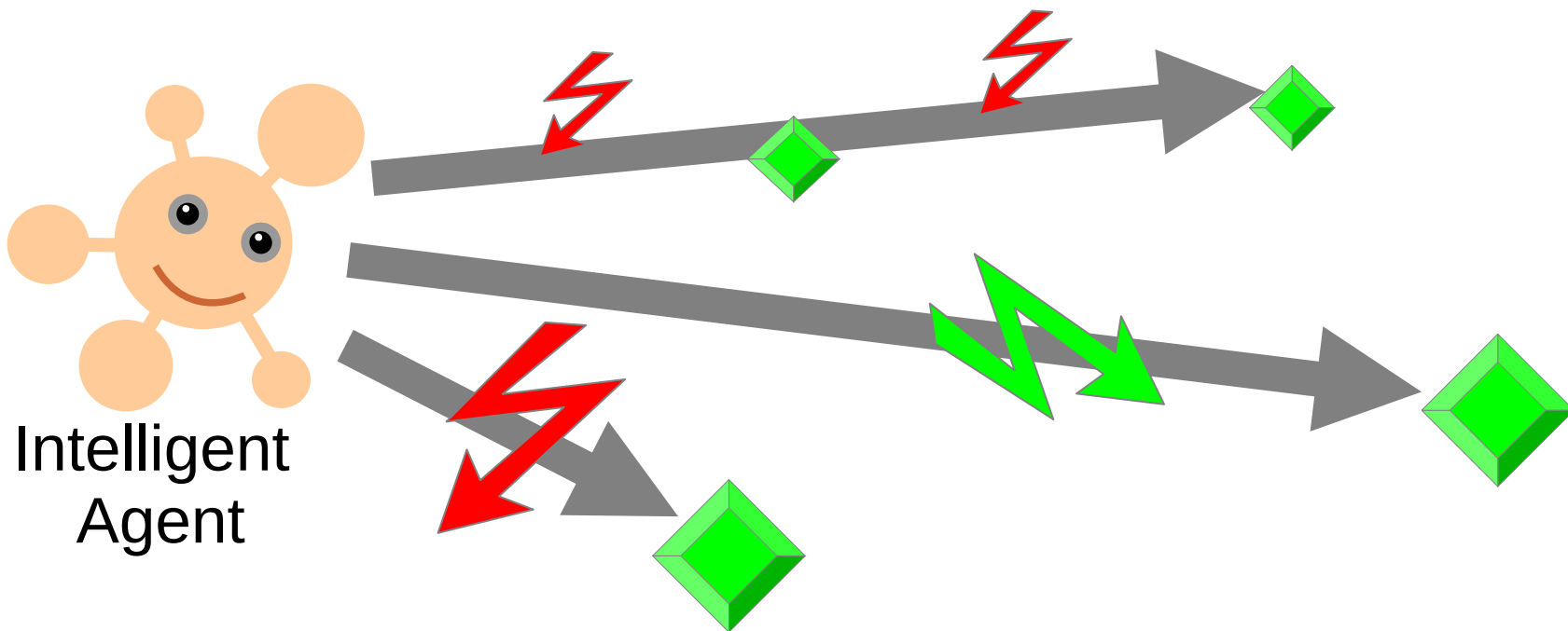
N* Novosibirsk
State
University
*THE REAL SCIENCE
<https://www.nsu.ru>



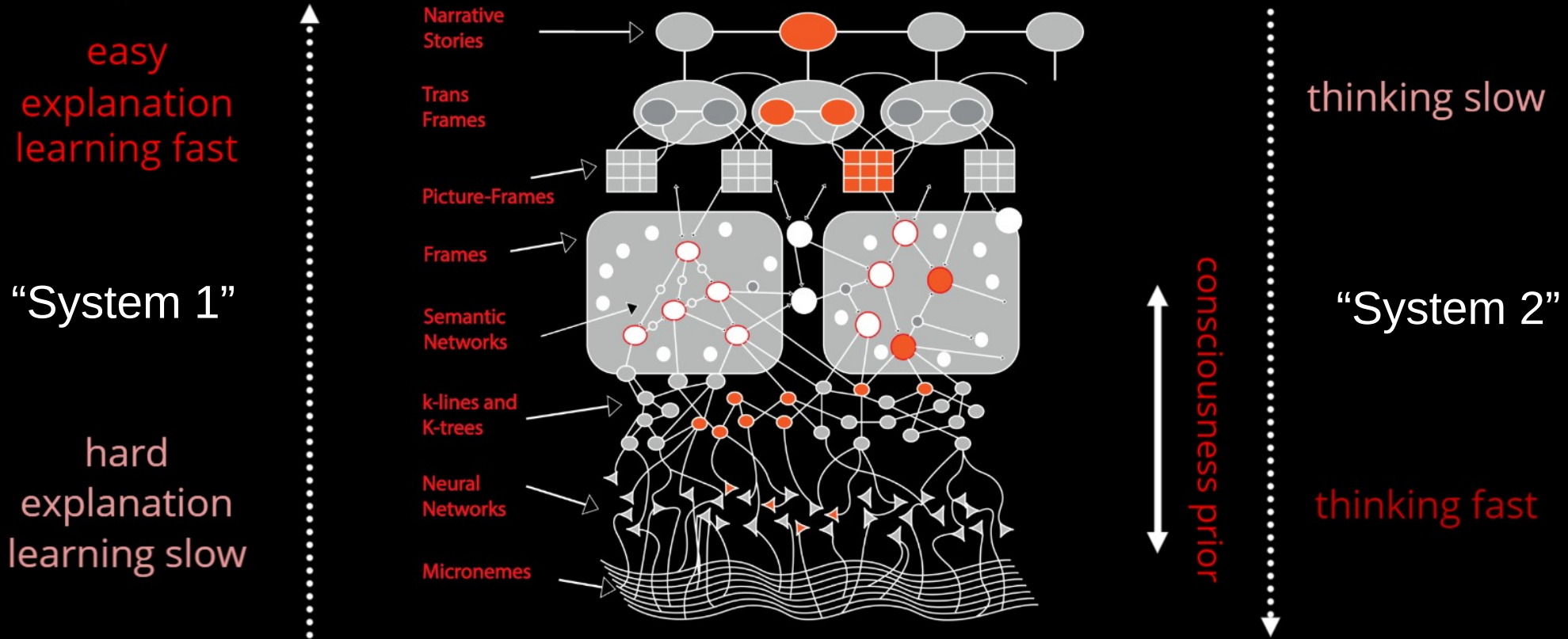
<https://agirussia.org>

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



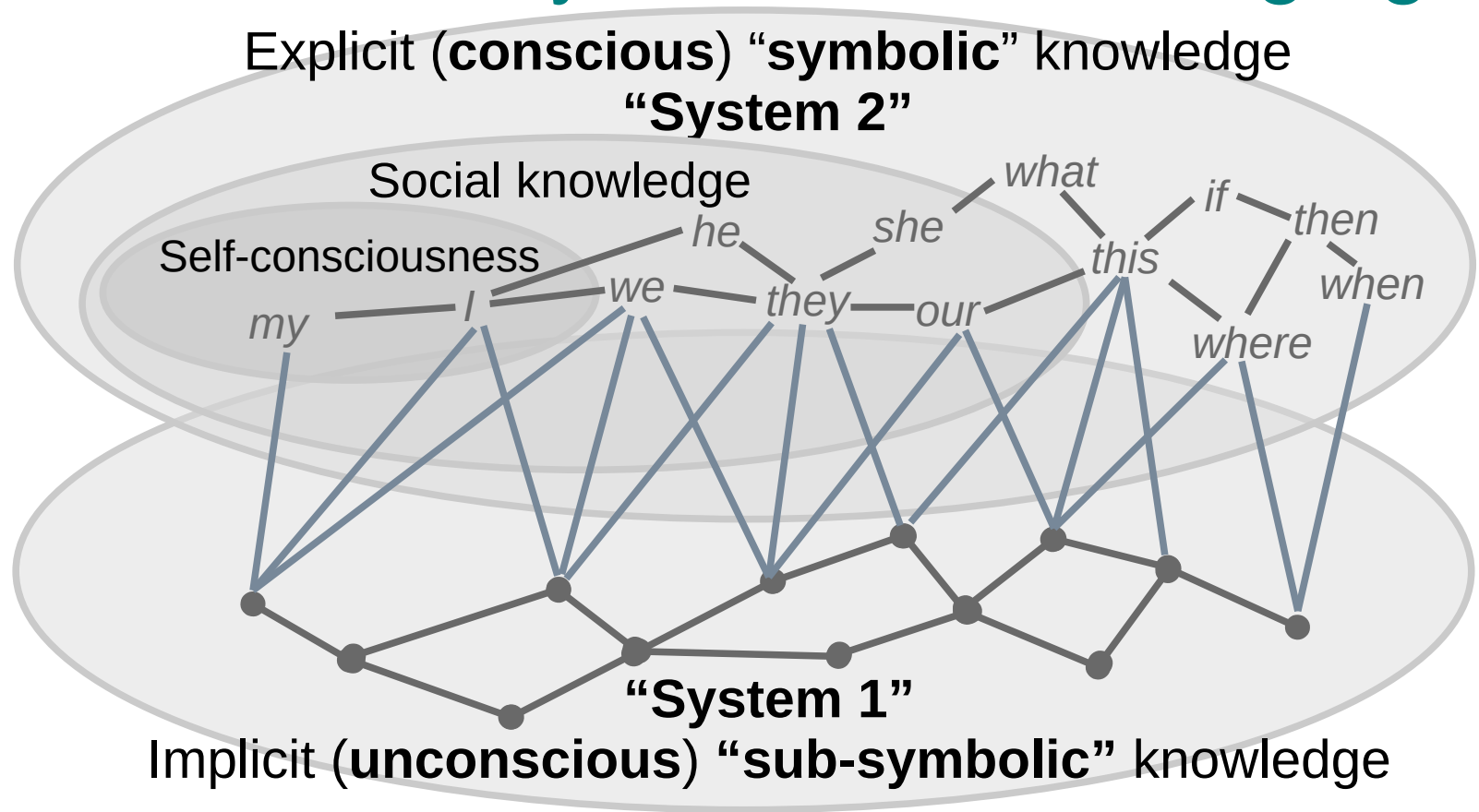
<https://www.linkedin.com/pulse/explainable-ai-vs-explaining-part-1-ahmad-haj-mosa/>

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)

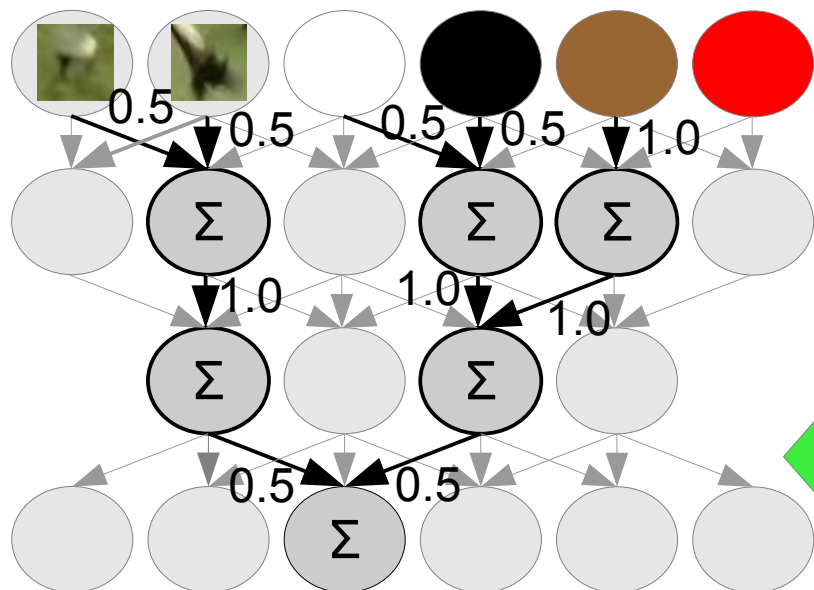
Medium: “neuro-symbolic” “knowledge graph”



<https://www.amazon.com/Thinking-Fast-Slow-Daniel-Kahneman/dp/0374533555>

<https://amit02093.medium.com/atomspace-hyper-graph-information-retrieval-system-450cab9d751e>

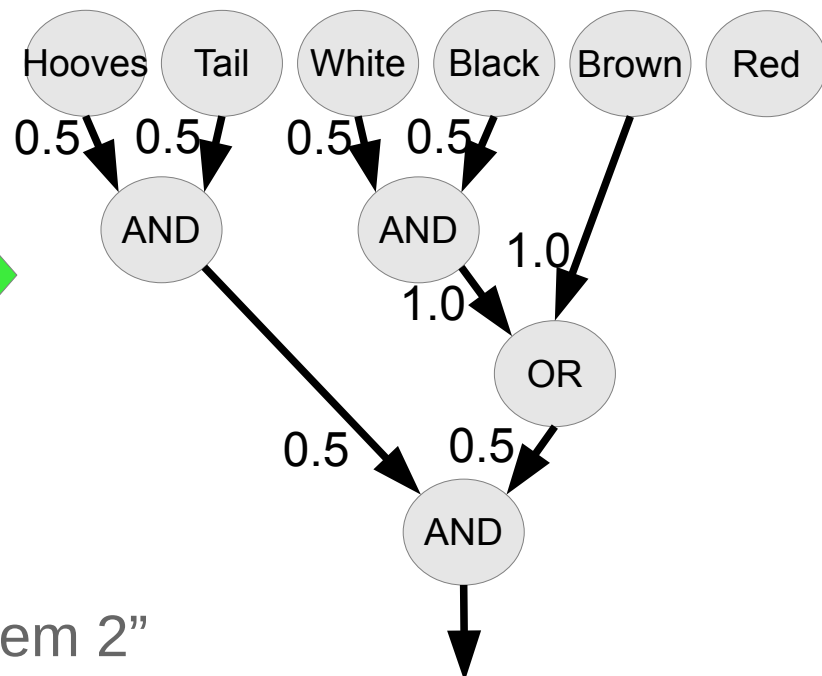
Neuro-Symbolic Integration for Interpretable AI



“System 1” “System 2”

Explain

Transfer



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

=> Horse

<https://arxiv.org/abs/2006.13155>

<https://arxiv.org/abs/2006.06465>

<https://arxiv.org/abs/1904.11694>

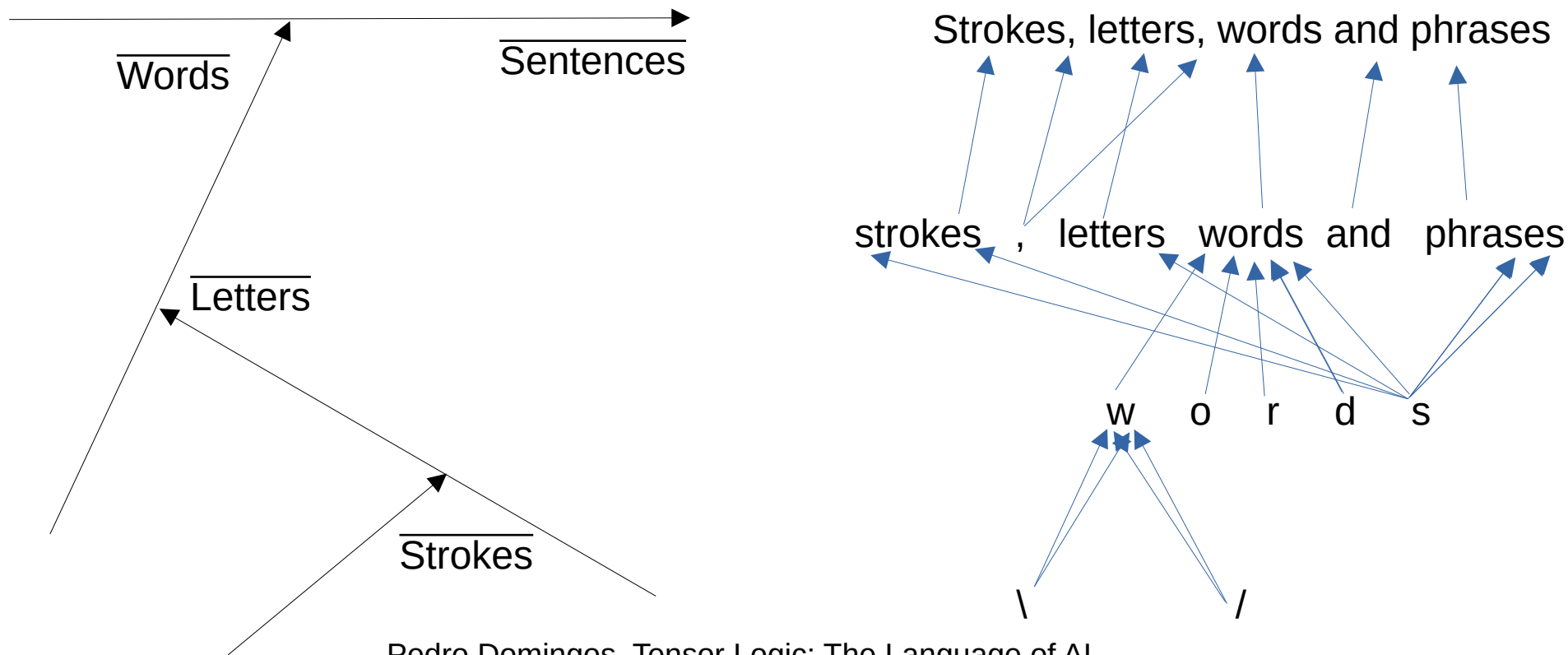
<https://arxiv.org/abs/1910.08629>

<https://www.ijcai.org/proceedings/2025/0555.pdf>

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

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

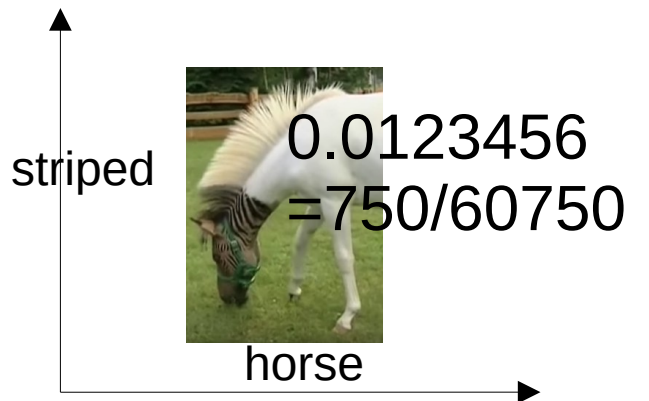


Pedro Domingos, Tensor Logic: The Language of AI
<https://arxiv.org/pdf/2510.12269>

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

Truth-Value Tensor
(NARS/PLN)

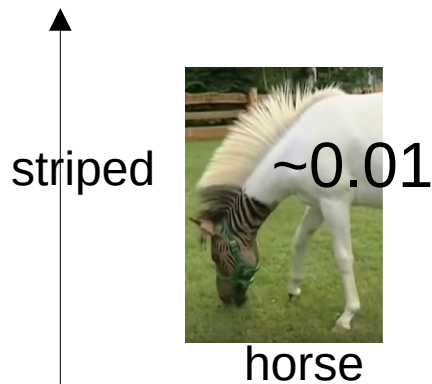
Property



Subject

Numerical Tensor
(ANN/Bayesian Logic)

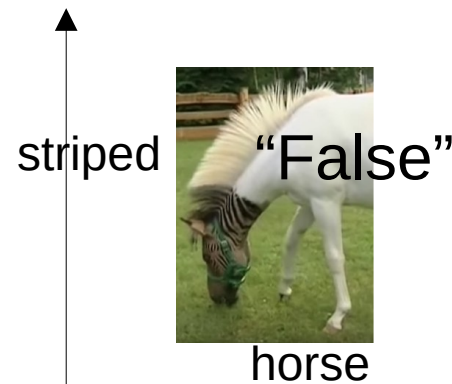
Property




Subject

Boolean Tensor
(Boolean Logic)

Property



Subject

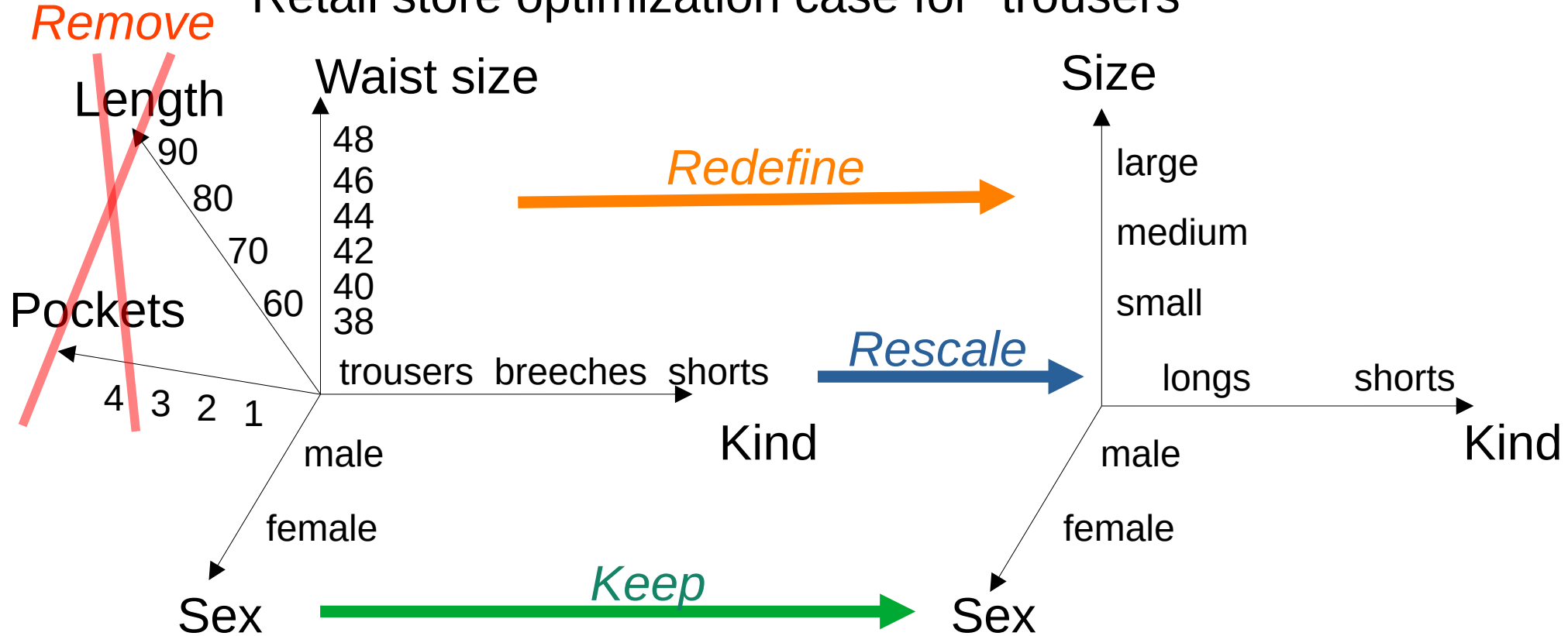

Life-long
learning?

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

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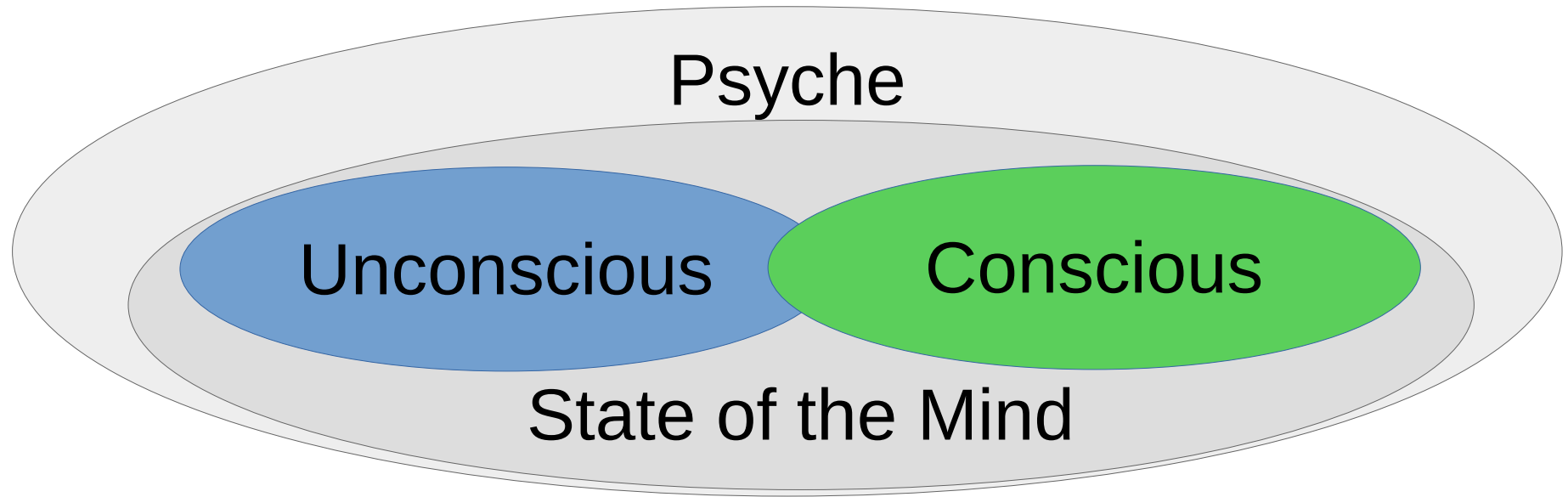
Problem of dimensionality (reduction) and discreteness (increase)

Retail store optimization case for “trousers”

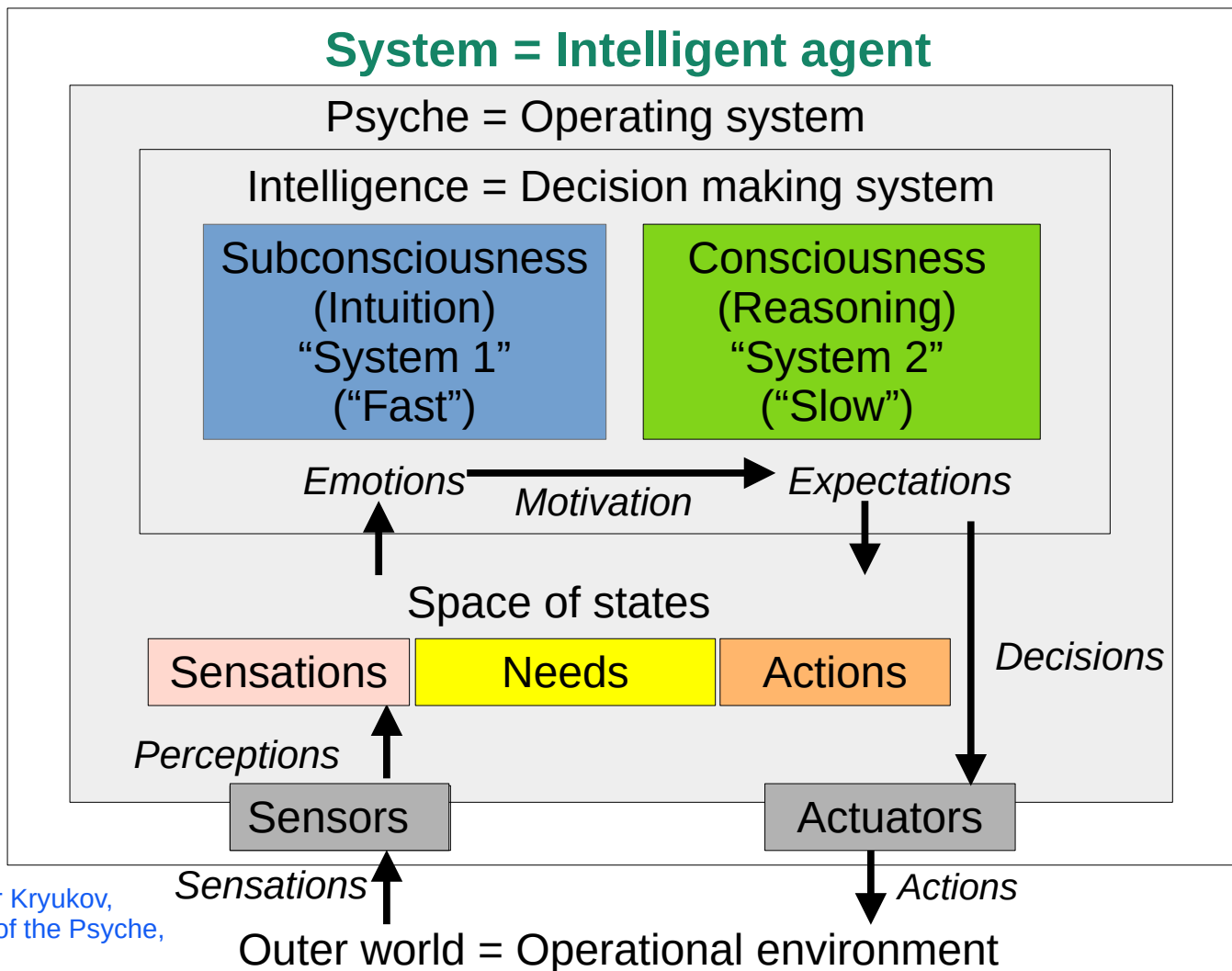


The psyche /'saɪki/ is currently used to describe the totality of the human mind, conscious and unconscious.

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



System = Intelligent agent



Psyche = Operating system

Intelligence = Decision making system

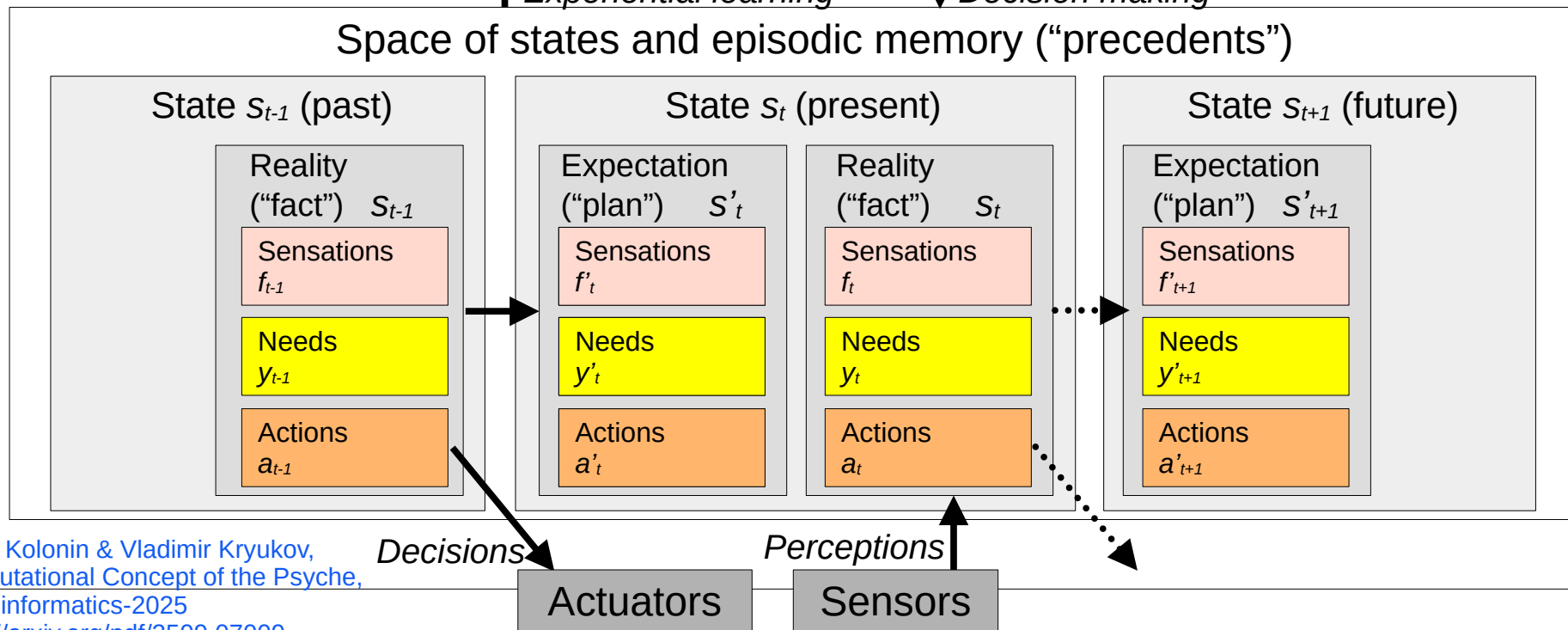
Models s (“invariants”) of states with utilities U and probabilities P of transitions

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

↑ *Experiential learning*

↓ *Decision making*

Space of states and episodic memory (“precedents”)



Psyche = Operating system

Intelligence = Decision making system

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

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

↑ Experiential learning

↓ Decision making

Space of states and episodic memory ("precedents")

State s_{t-1} (past)

Reality
("fact") s_{t-1}

Sensations
 f_{t-1}

Needs
 y_{t-1}

Actions
 a_{t-1}

State s_t (present)

Expectation
("plan") s'_t

Sensations
 f'_t

Needs
 y'_t

Actions
 a'_t

Reality
("fact") s_t

Sensations
 f_t

Needs
 y_t

Actions
 a_t

State s_{t+1} (future)

Expectation
("plan") s'_{t+1}

Sensations
 f'_{t+1}

Needs
 y'_{t+1}

Actions
 a'_{t+1}

Decisions

Perceptions

Actuators

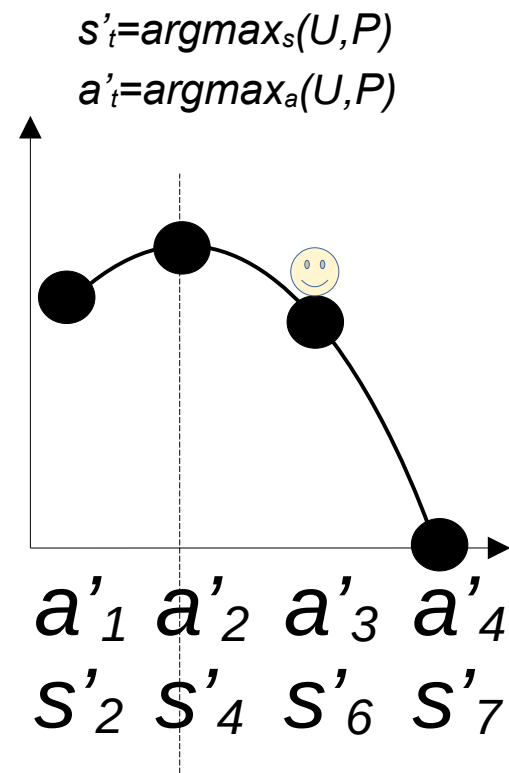
Sensors

$x \cdot y_t$ — "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

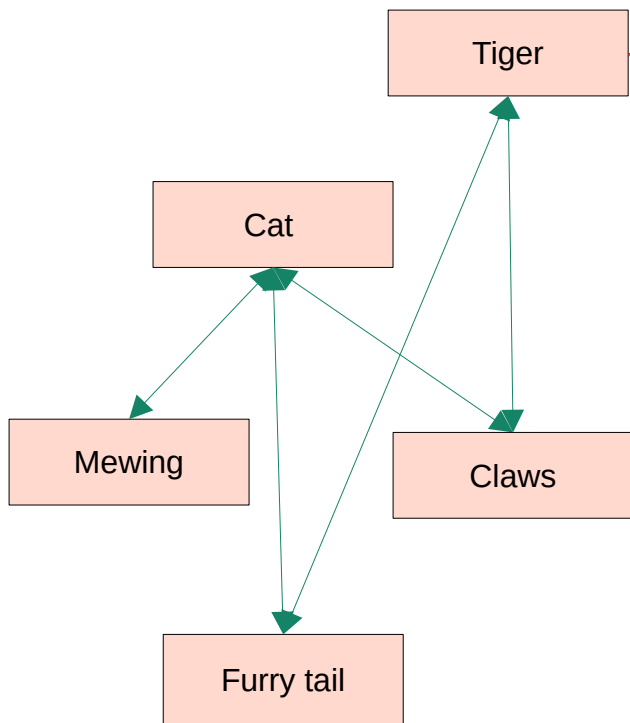
S_t	S'_{t+1}	S'_{t+1}			U	P	$\Sigma U*P$
		a'	y'	f'			
S_1	S'_2	a'_1	y'_1	...	1.0	0.5	<u>0.7</u>
S_1	S'_3	a'_1	y'_2	...	0.4	0.5	
S_1	S'_4	a'_2	y'_3	...	1.0	0.8	<u>0.8</u>
S_1	S'_5	a'_2	y'_4	...	0.0	0.2	
S_1	S'_6	a'_3	y'_5	...	0.6	1.0	<u>0.6</u>
S_1	S'_7	a'_4	y'_6	...	0.0	1.0	<u>0.0</u>



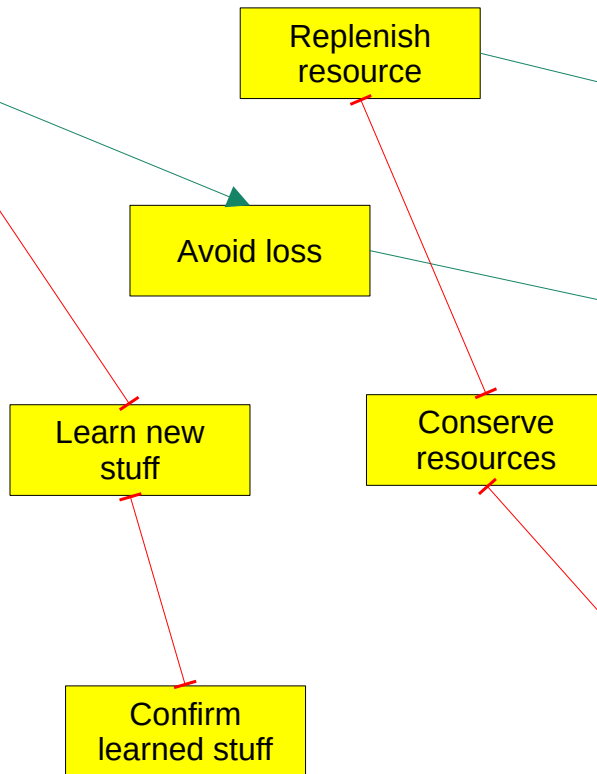
Tversky & Kahneman:
 most people choose a'_3 и S'_6
 ("smaller profit with
 greater reliability")

Mutual dependency of state variable subgraphs tensors

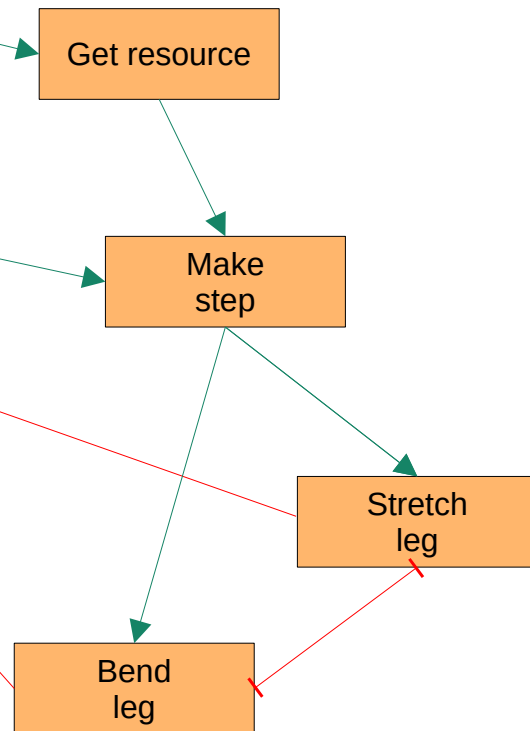
Percept feelings



Satisfied needs



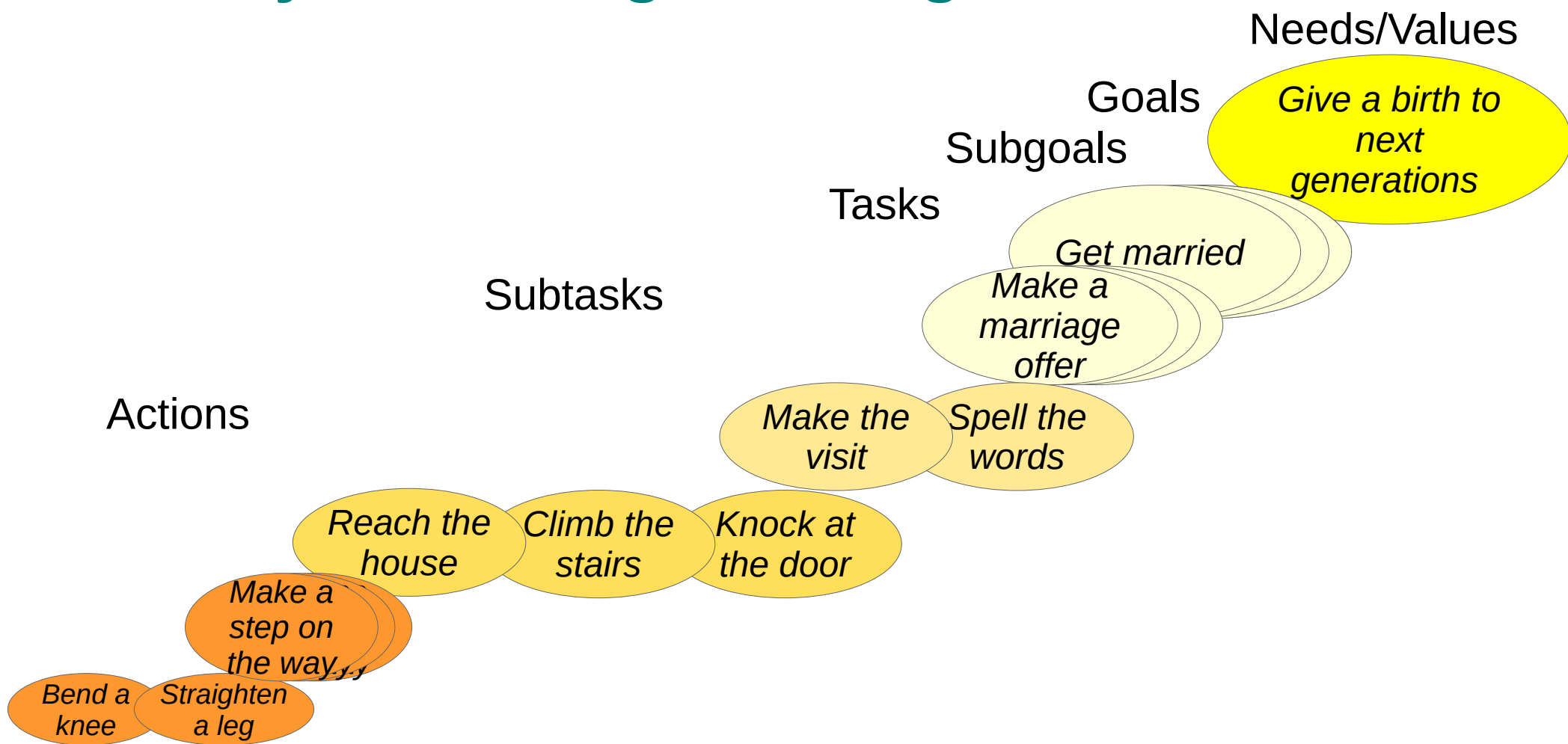
Decided & committed actions



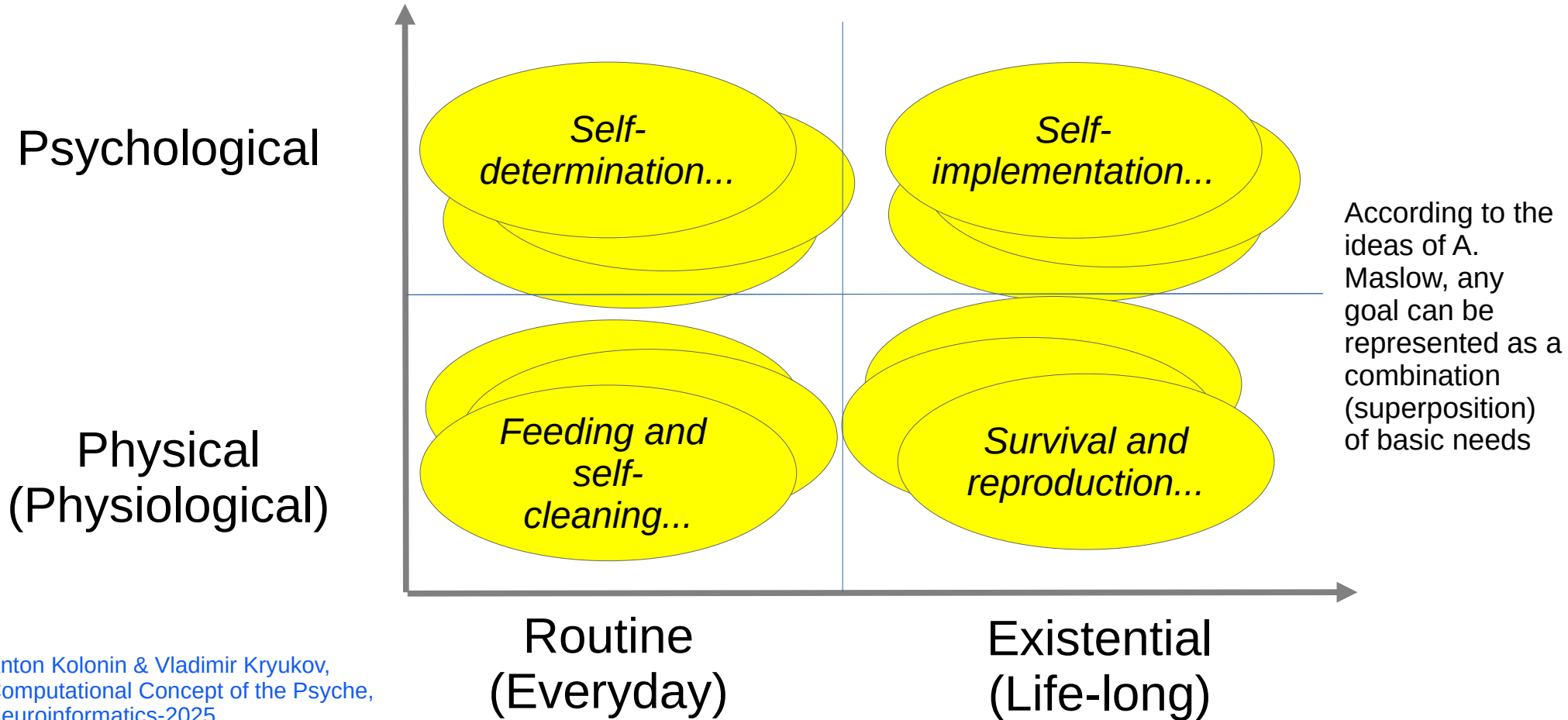
Anton Kolonin & Vladimir Kryukov,
Computational Concept of the Psyche,
Neuroinformatics-2025

<https://arxiv.org/pdf/2509.07009>

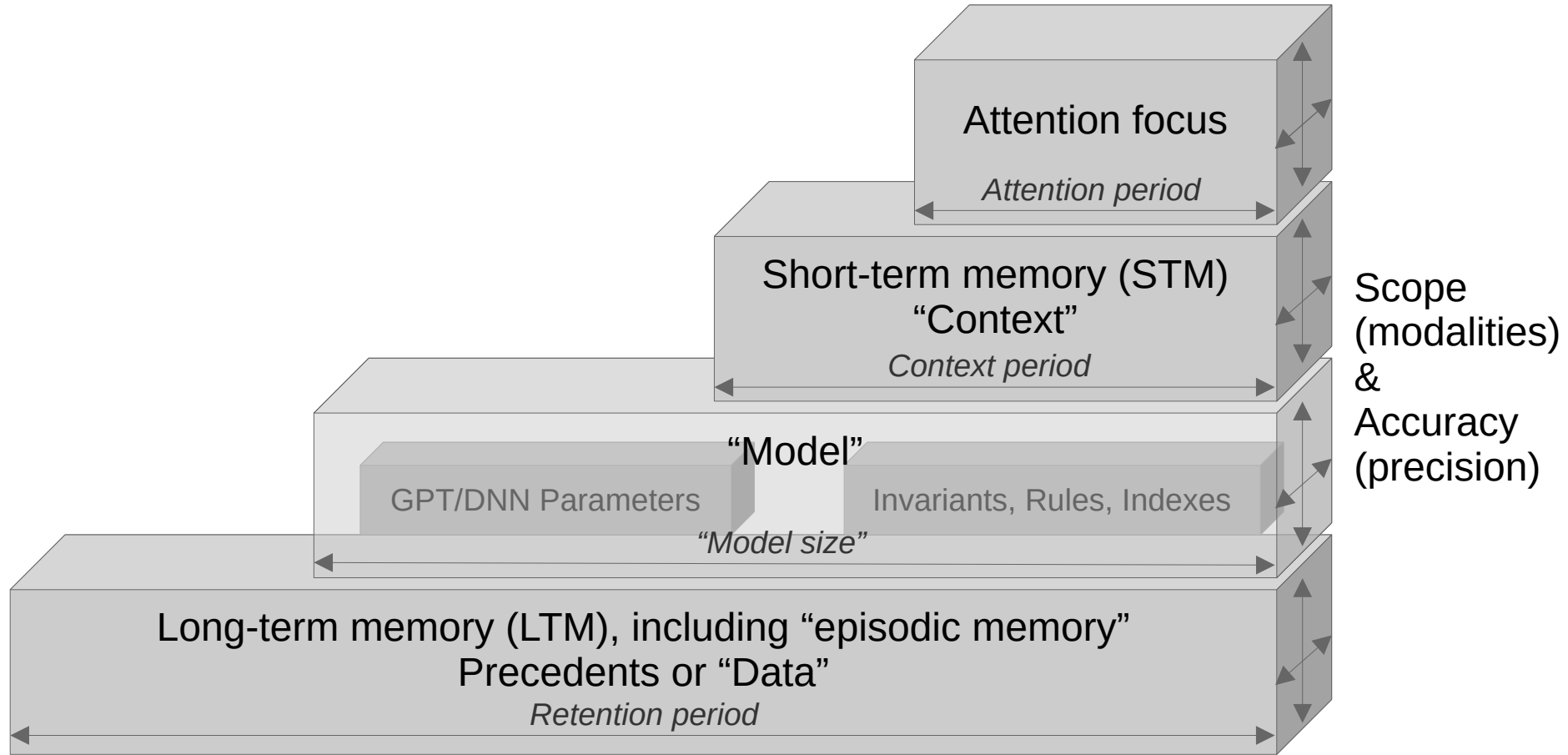
Hierarchy of values/goals/subgoals/tasks/subtasks



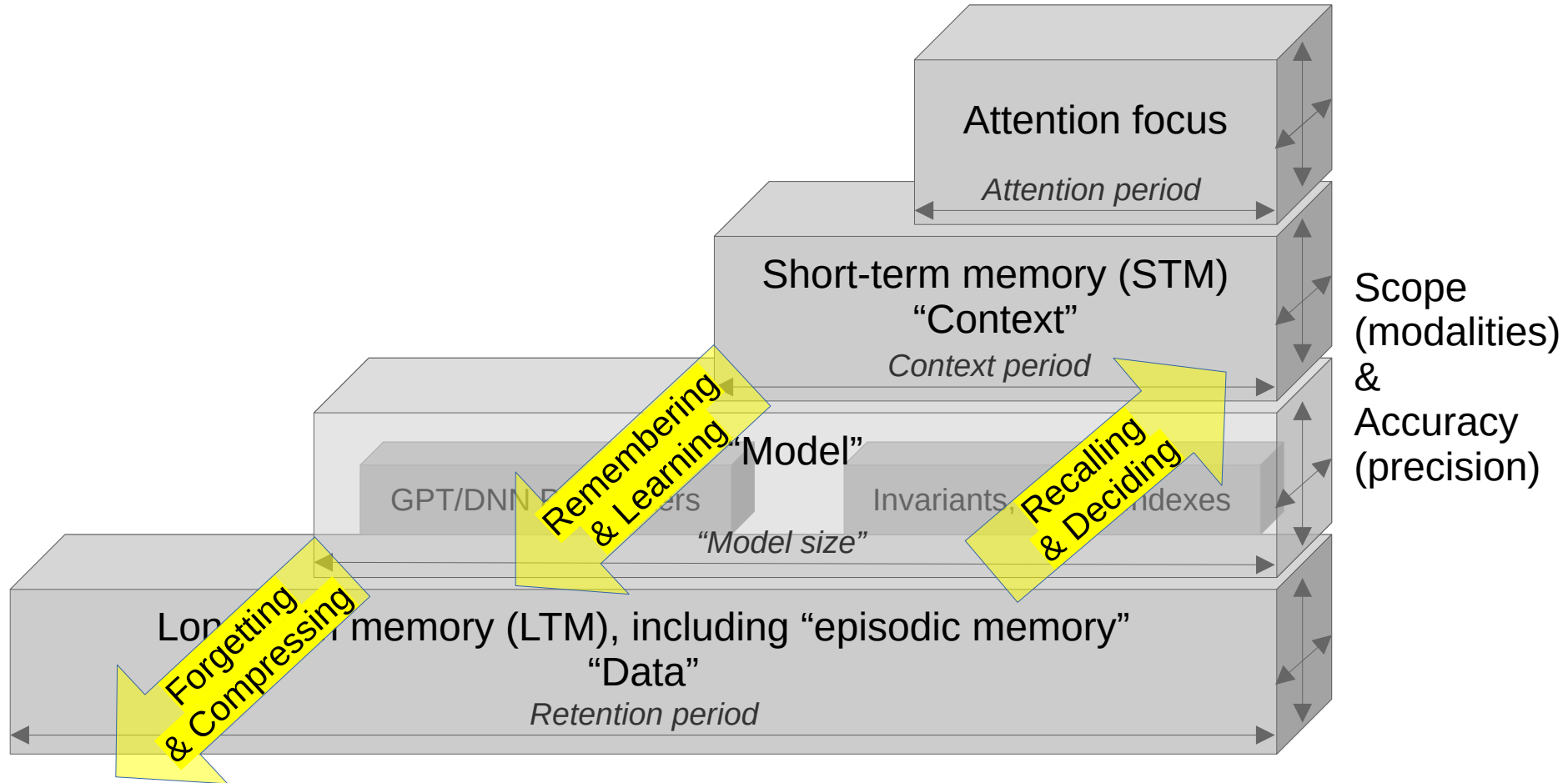
Space of needs/goals/values



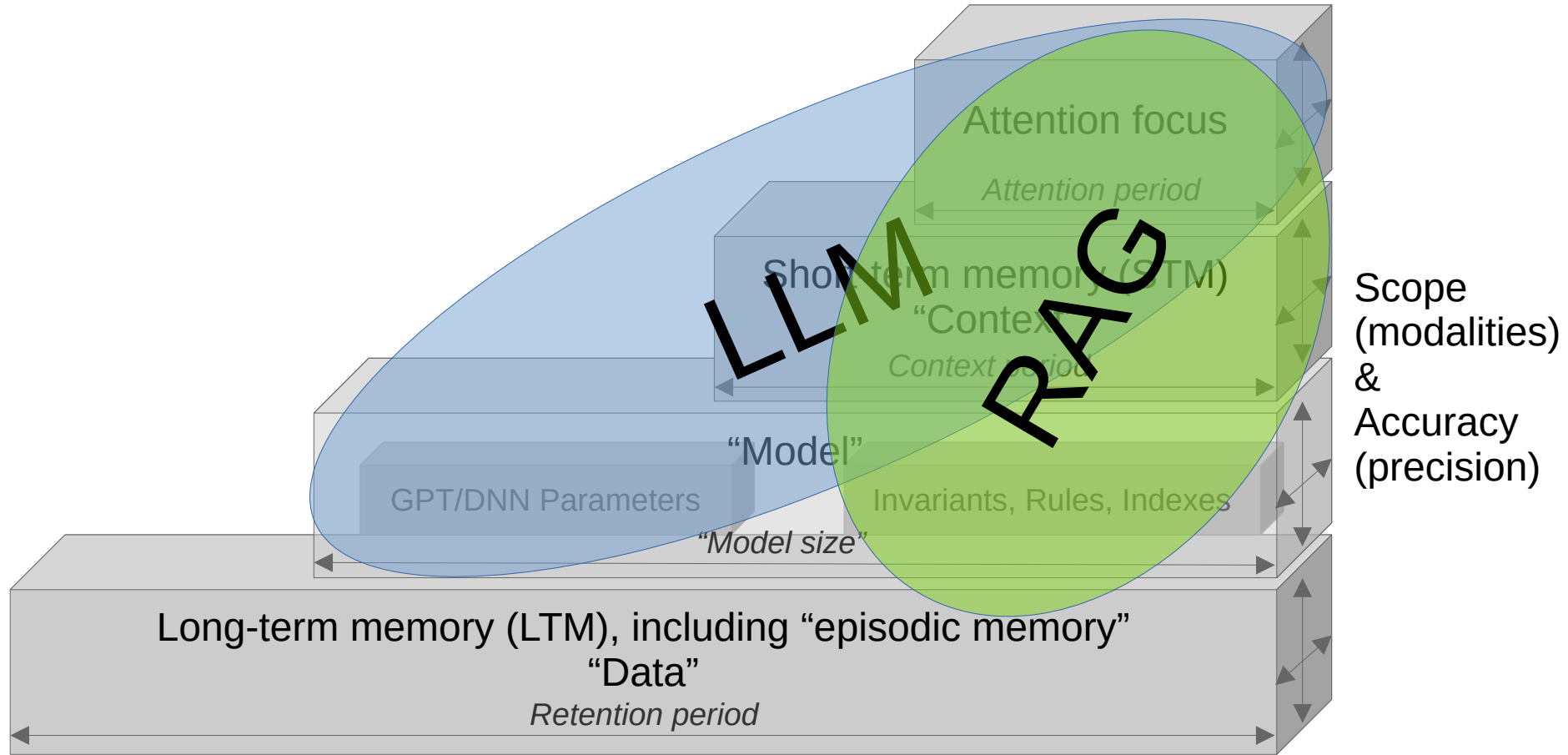
Attention, context, model and memories



Attention, context, model and memories

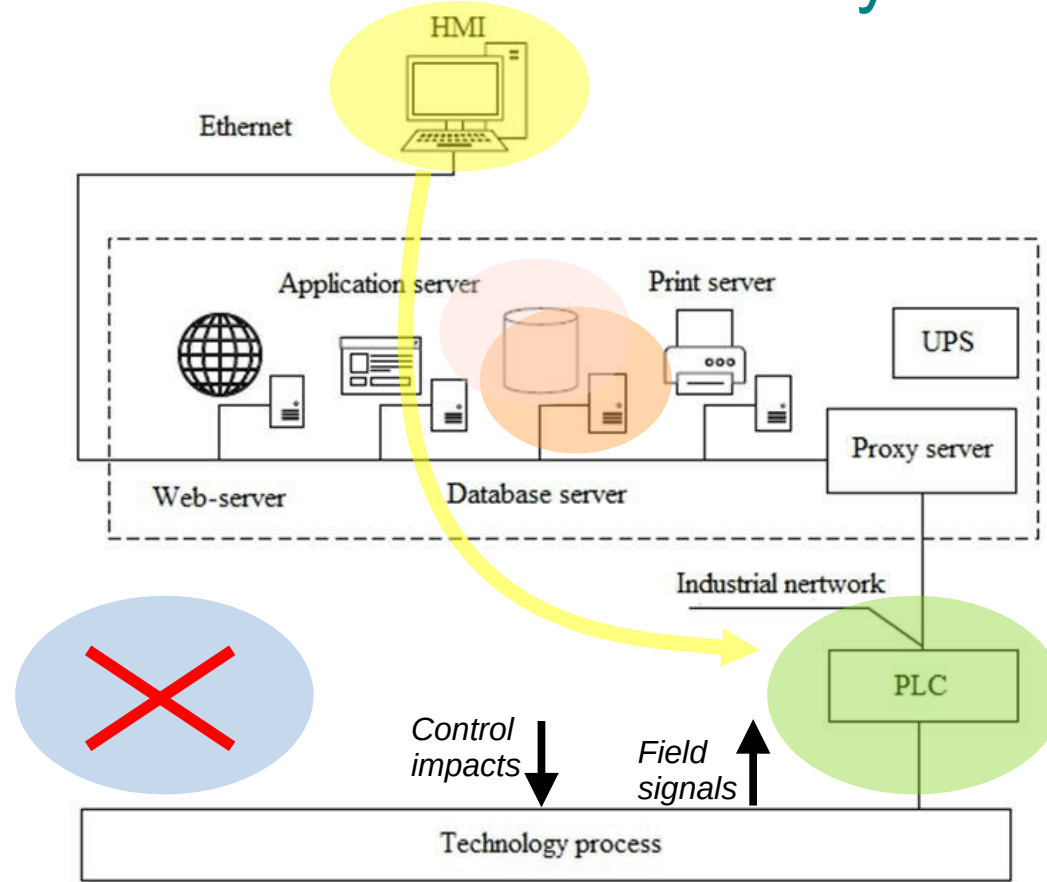


Attention, context, model and memories



Application cases

A) Automated Process Control Systems (APCS)



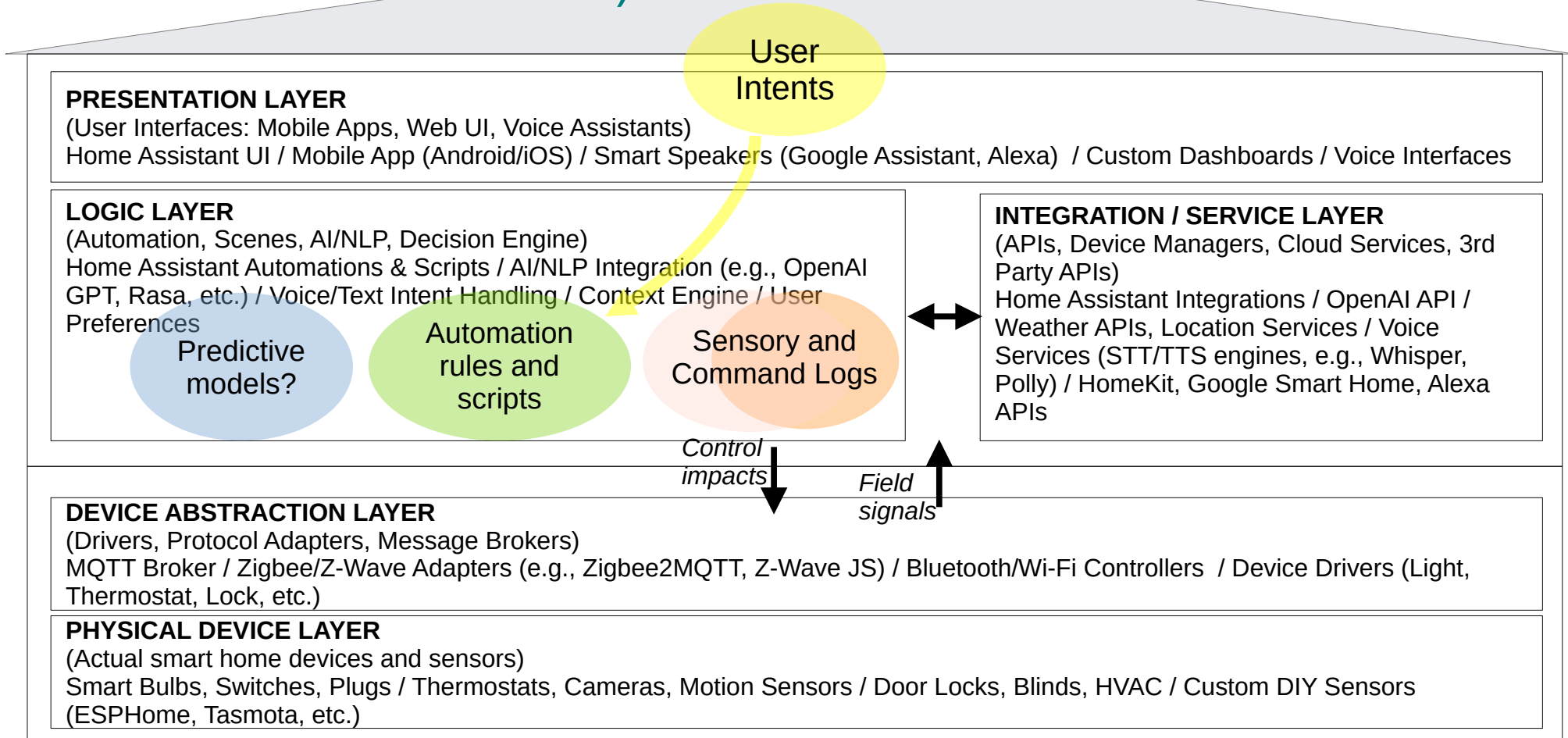
Programmable logic

IEC 61131 (synchronous)

IEC 61499 (asynchronous)

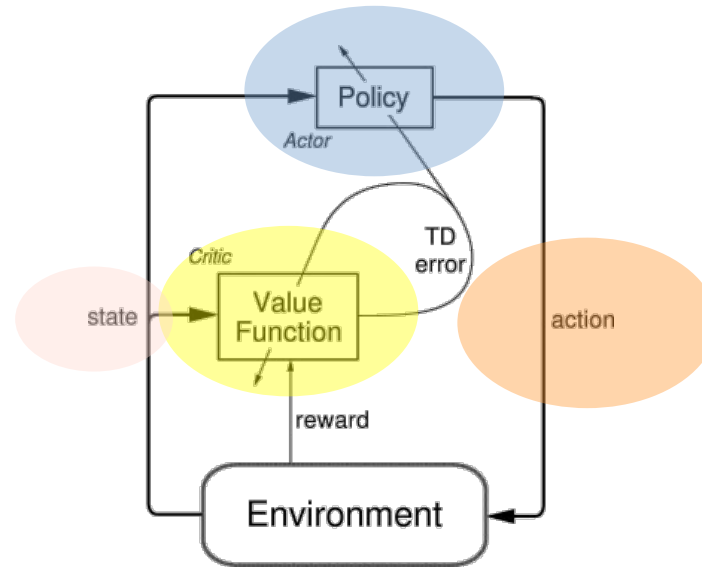
Application cases

B) “Smart Home”



Implementation options

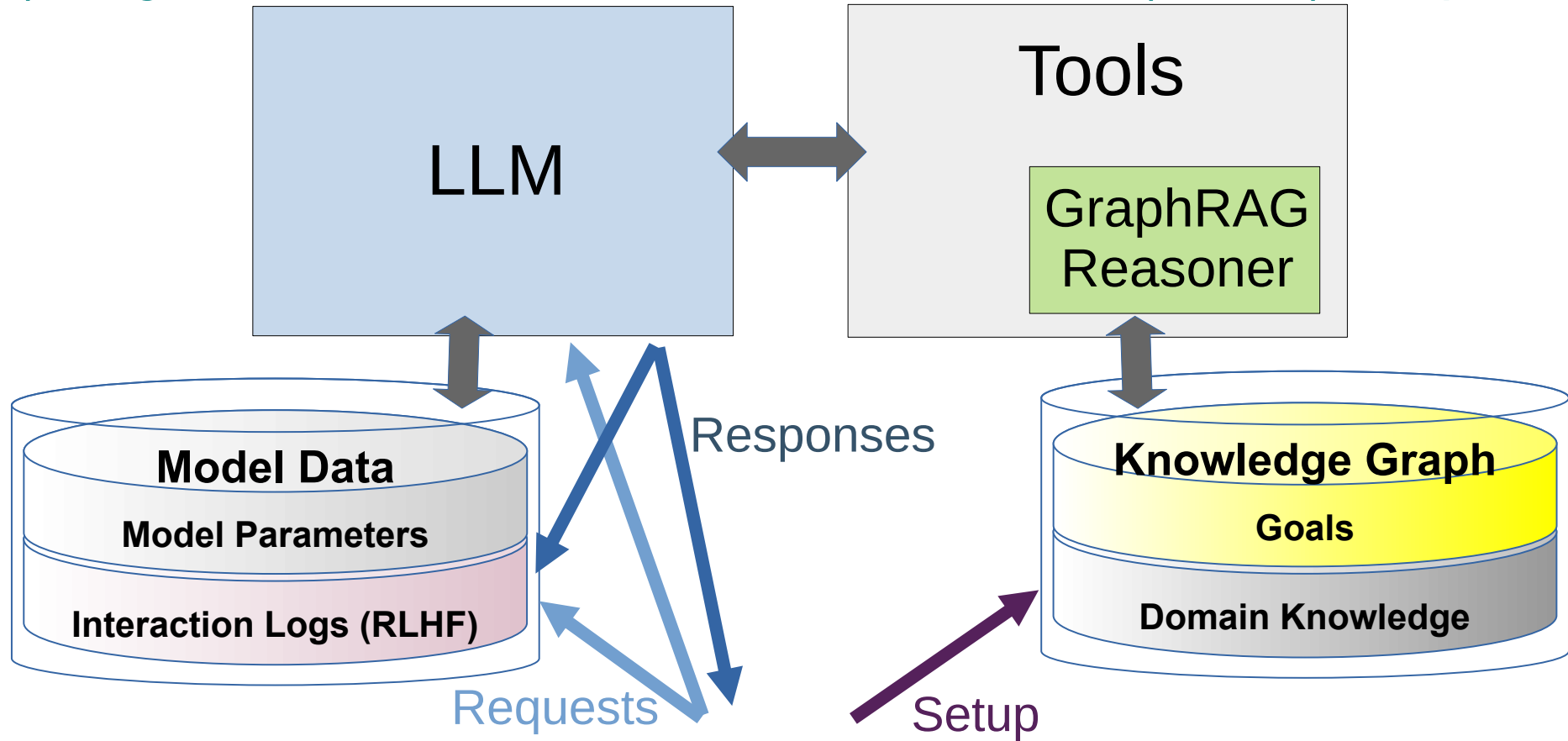
1) Reinforcement learning based on “actor-critic” model



<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

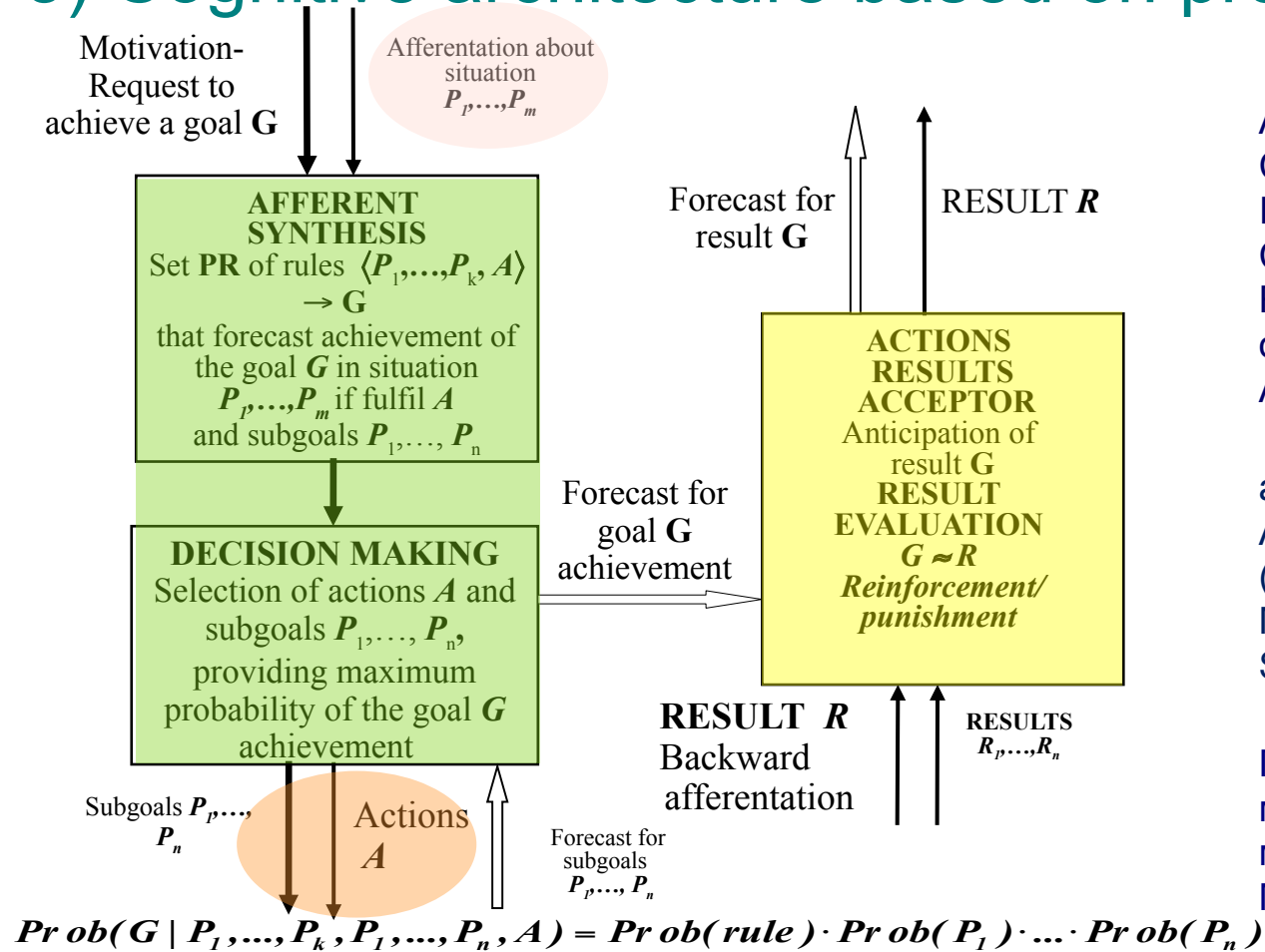


Leonie Monigatti, "The Evolution from RAG to Agentic RAG to Agent Memory", November 3, 2025
<https://www.leonimonigatti.com/blog/from-rag-to-agent-memory.html>

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Implementation options

3) Cognitive architecture based on probabilistic logic



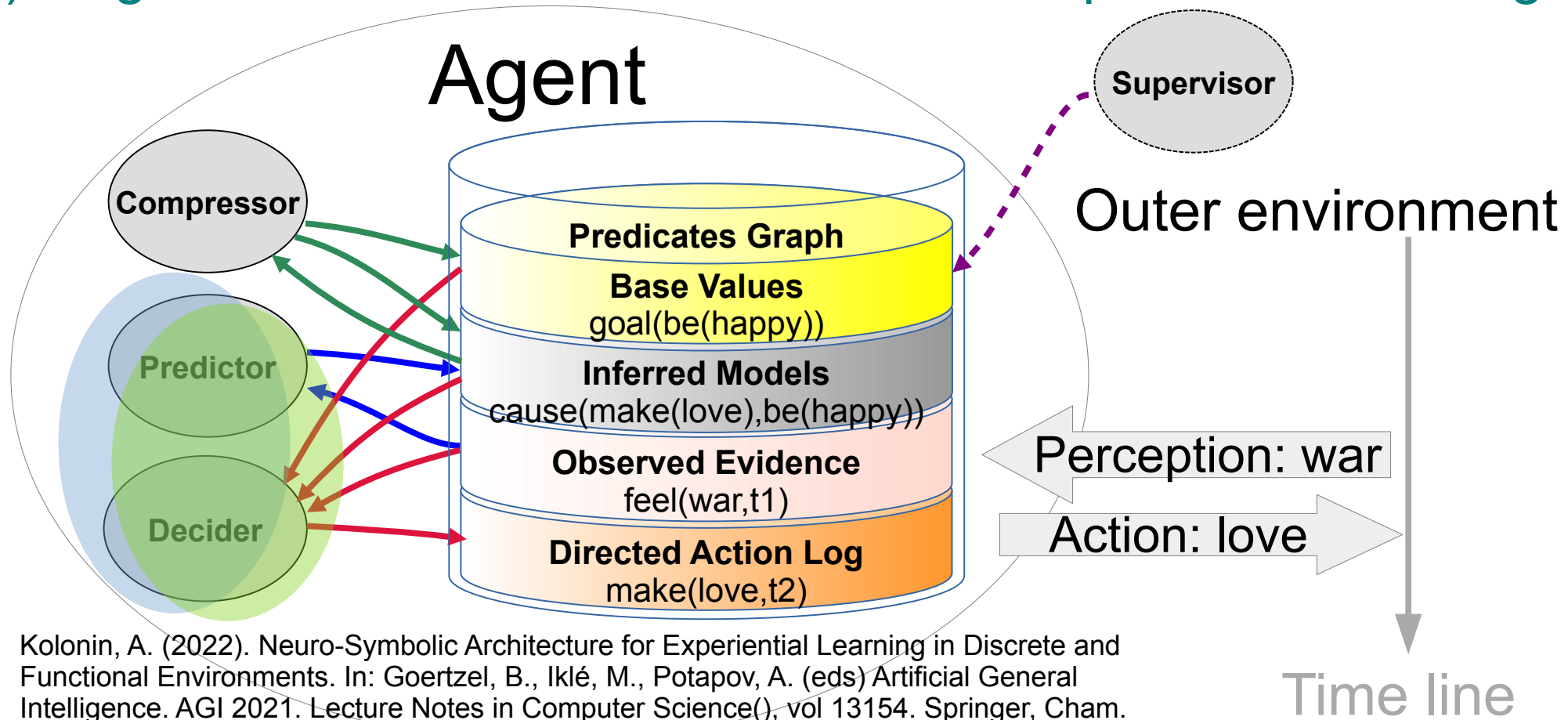
Evgenii Vityaev, Alexander Demin:
Adaptive Control of Modular Robots //
Conference Paper in Advances in
Intelligent Systems and Computing,
Conference: First International Early
Research Career Enhancement School
on Biologically Inspired Cognitive
Architectures, Springer, August 2018

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.

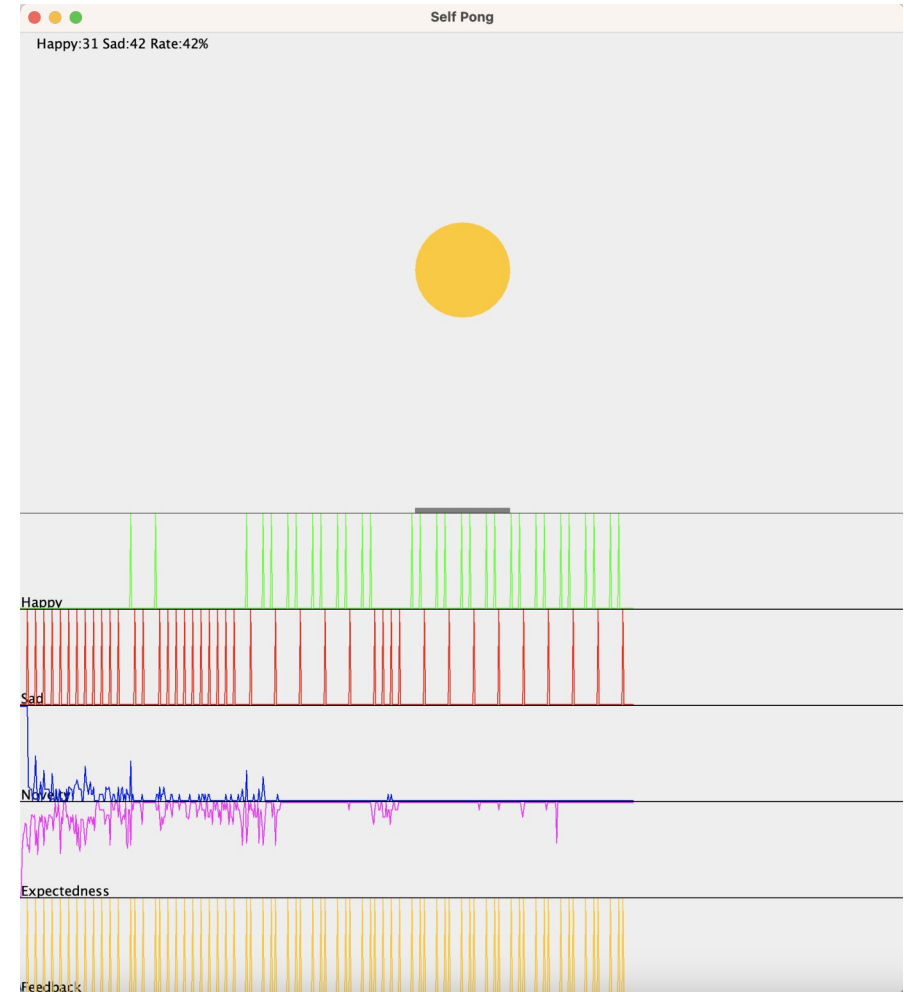
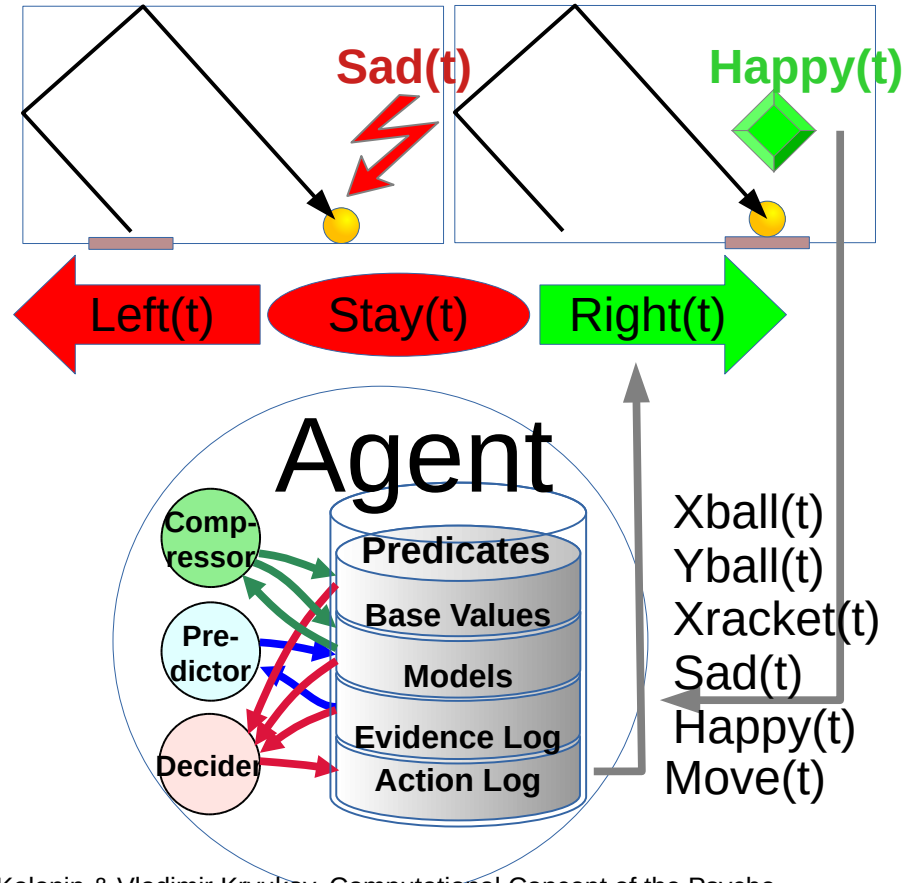
Implementation options

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>

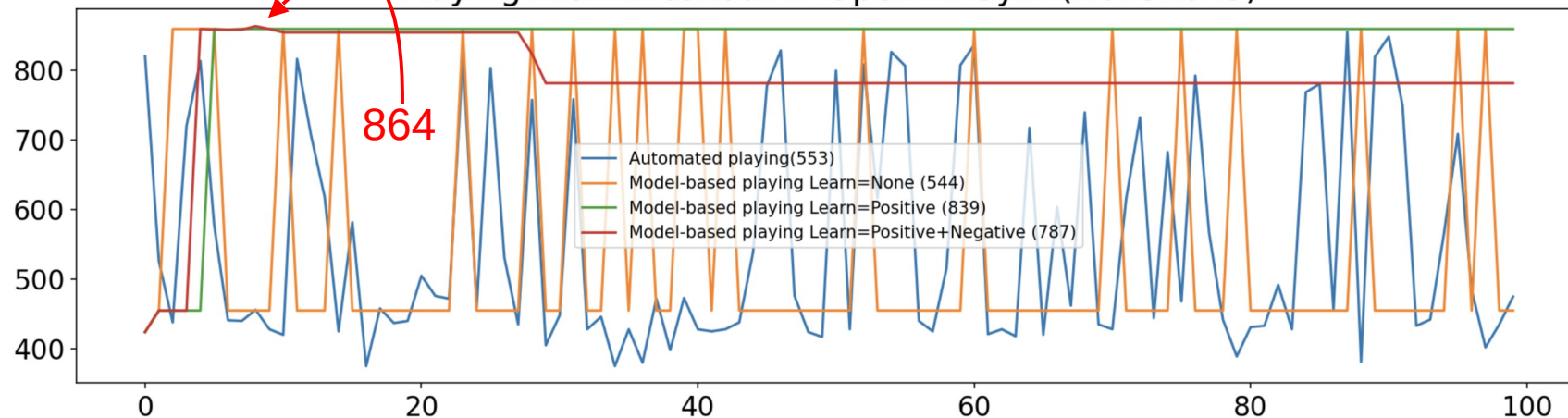
Anton Kolonin, Neuro-Symbolic Architecture for Experiential Learning in Discrete and Functional Environments

https://doi.org/10.1007/978-3-030-93758-4_12

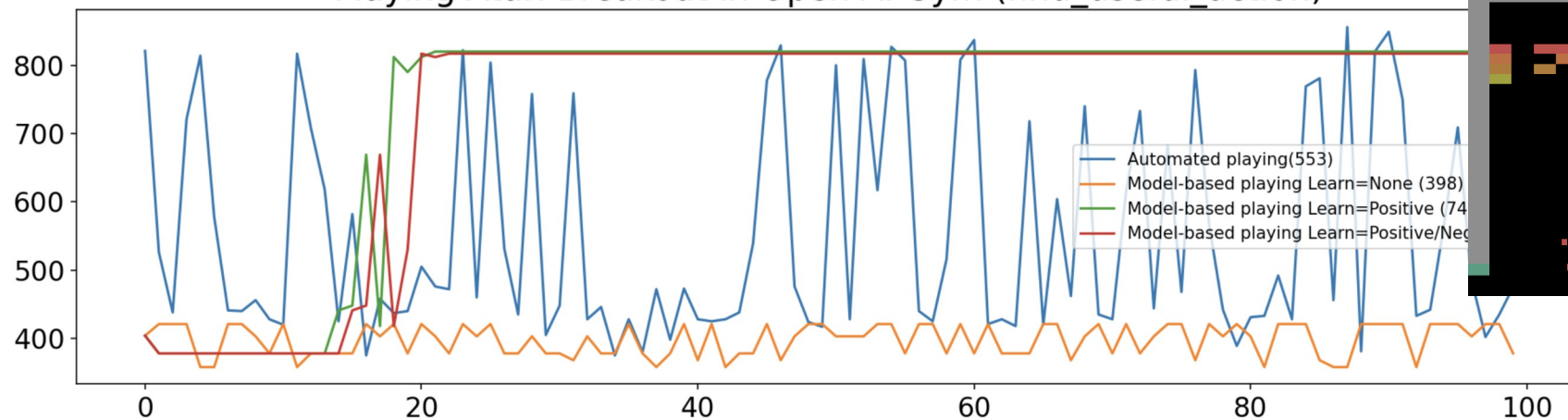
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Imitation learning – decision making on “pre-trained” model

Playing Atari Breakout in Open AI Gym (Nov32025)

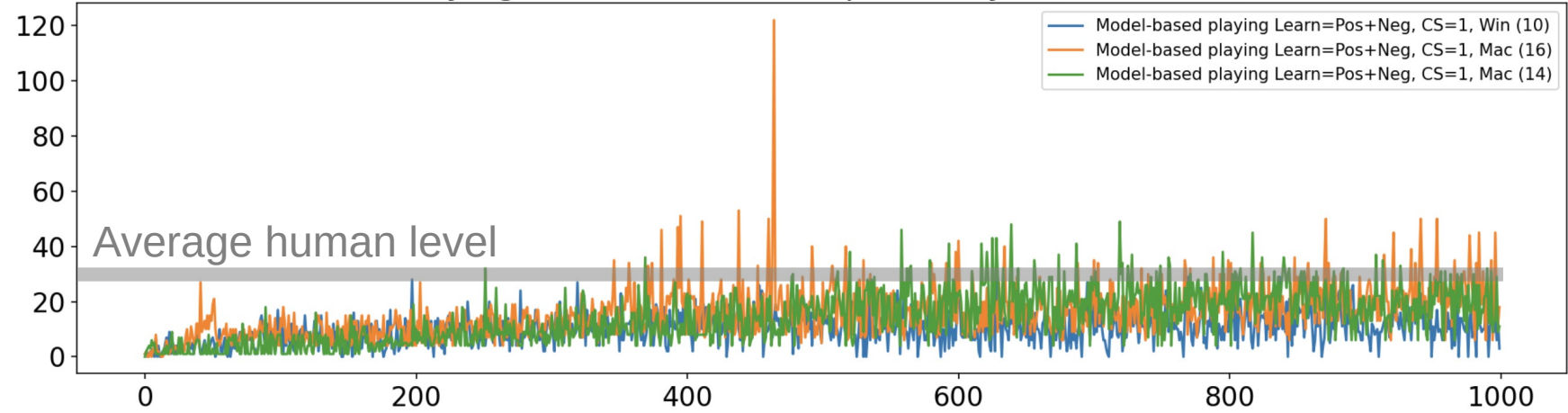


Playing Atari Breakout in Open AI Gym (find_useful_action)

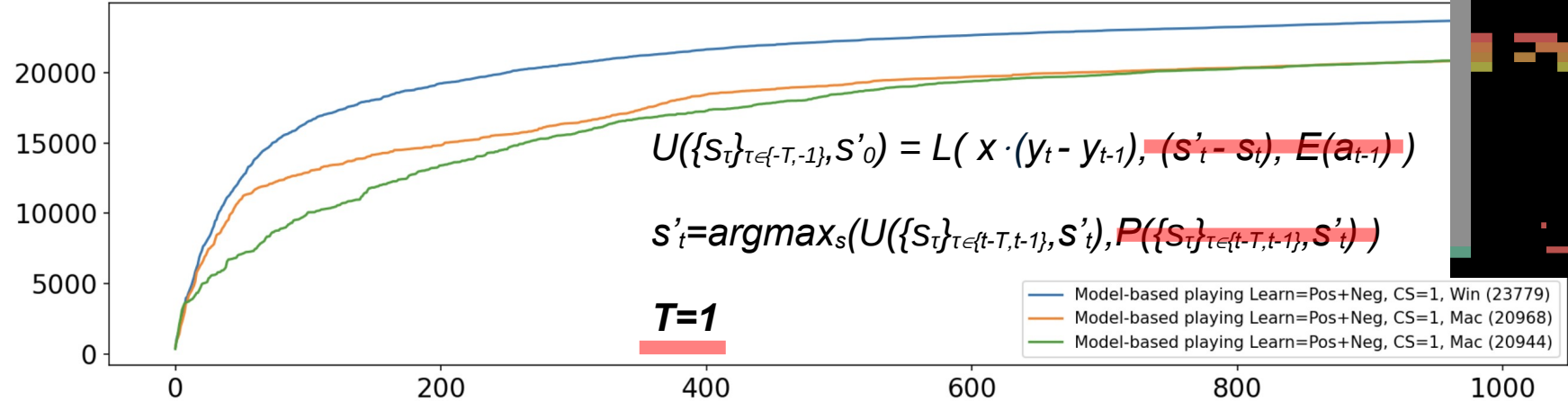


Reinforcement learning – experiential learning and decision making

Playing Atari Breakout in Open AI Gym (Nov32025)



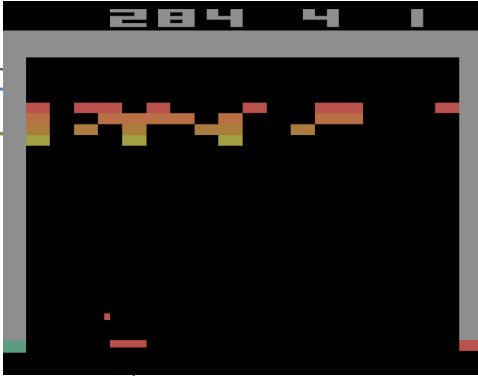
N of States in the Model (Nov32025)



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

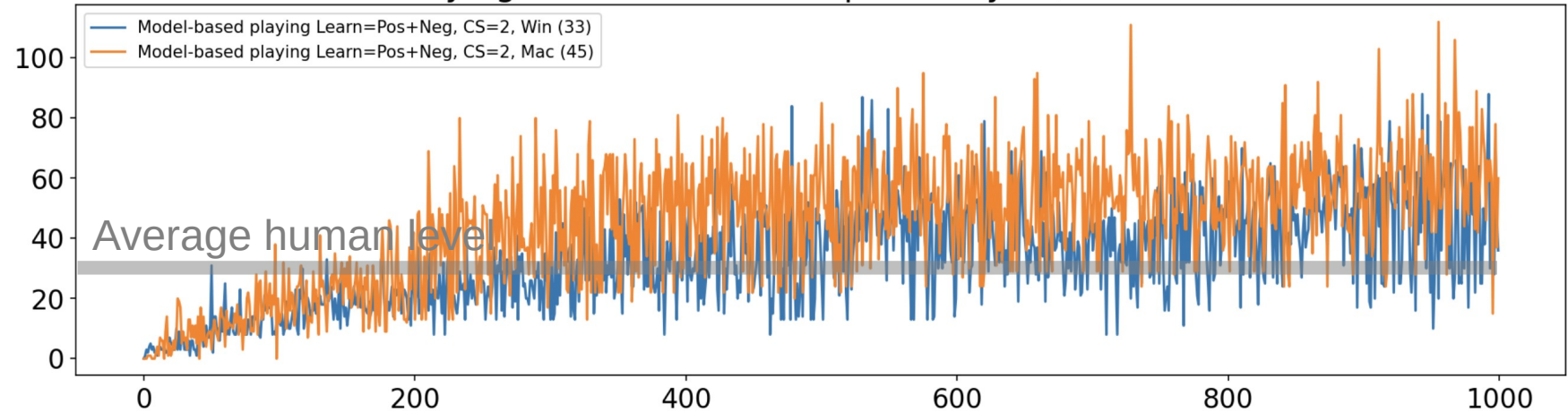
$$s'_t = \operatorname{argmax}_s (U(\{s_{t'}\}_{t' \in \{t-T, t-1\}}, s'_t), P(\{s_{t'}\}_{t' \in \{t-T, t-1\}}, s'_t))$$

T=1

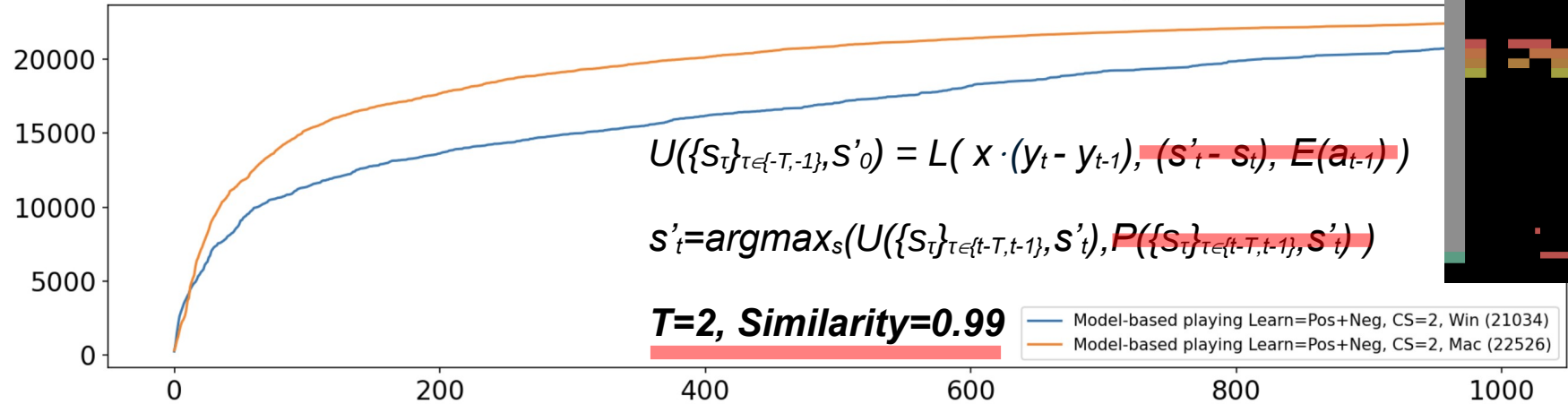


Reinforcement learning – experiential learning and decision making

Playing Atari Breakout in Open AI Gym (Nov32025)

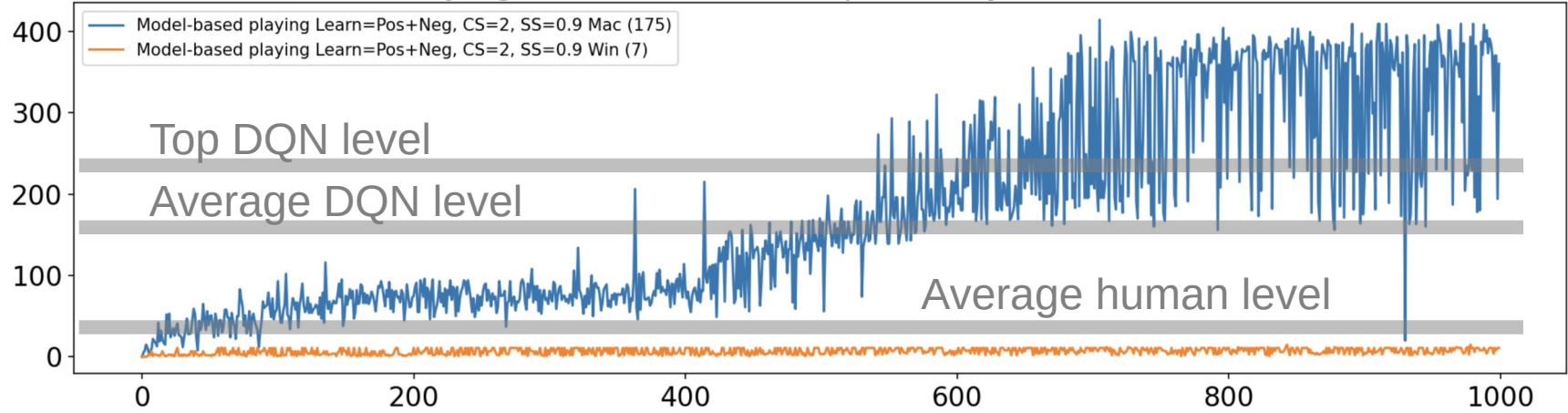


N of States in the Model (Nov32025)

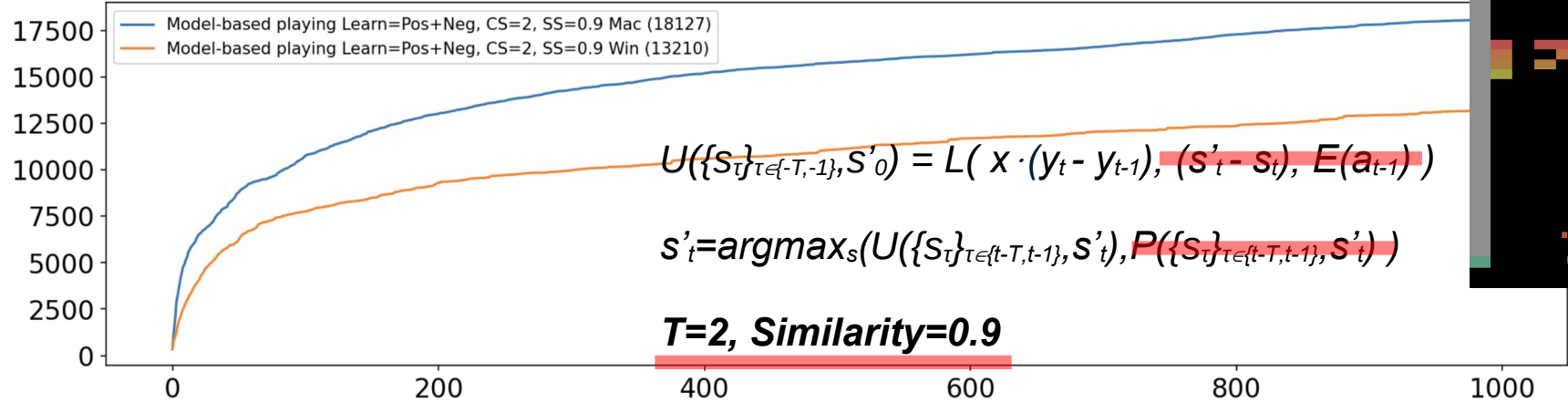


Reinforcement learning – experiential learning and decision making

Playing Atari Breakout in Open AI Gym (Nov32025)



N of States in the Model (Nov32025)



Thank you for attention! Questions?

Anton Kolonin

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Workshop recording
on the subject



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

