Extended Hierarchical Temporal Memory for Motion Anomaly Detection

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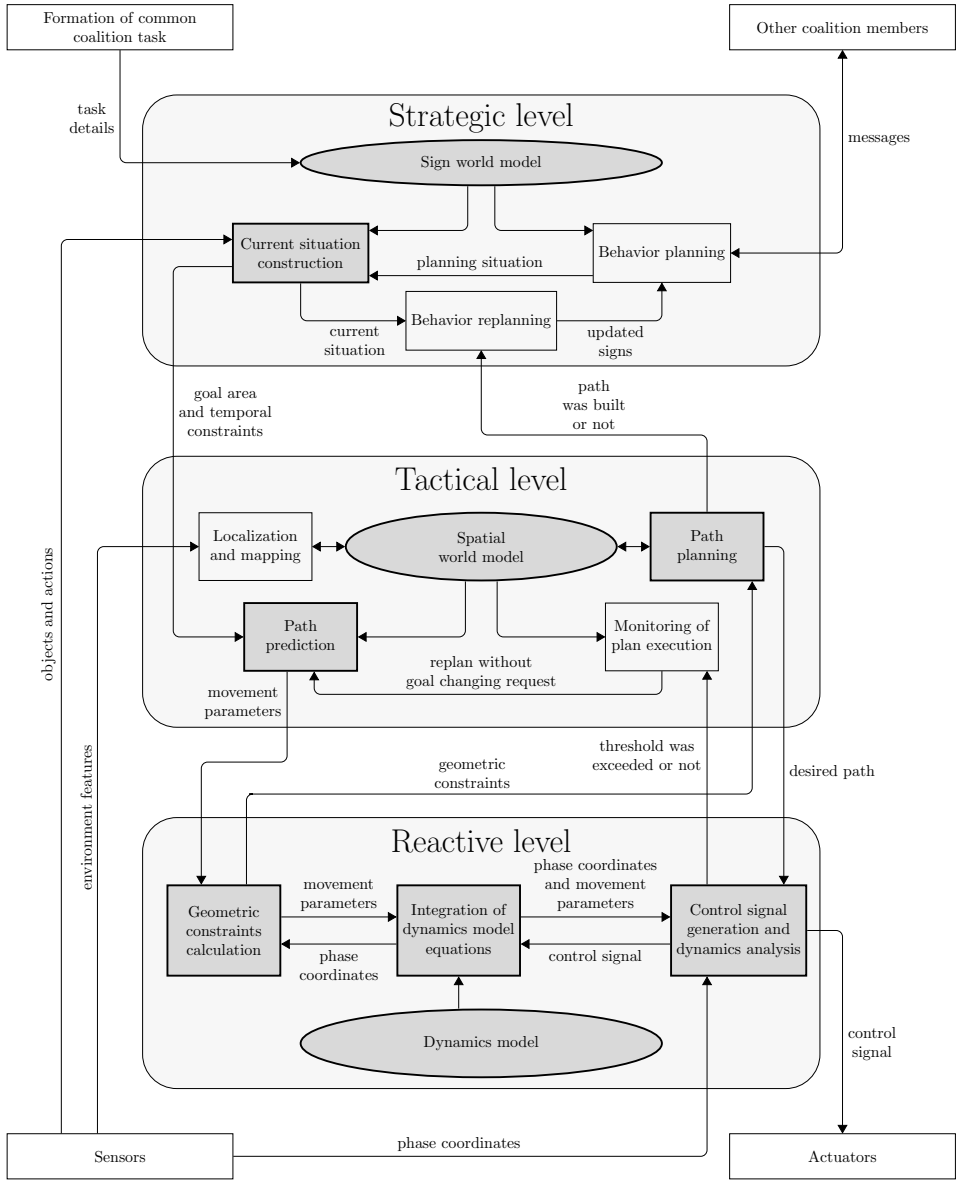
August 24 – BICA 2018

STRL Architecture

- Cognitive functions modeling and construction of models that explain psychological phenomena.
- Algorithm of synthesizing the plan of behavior (algorithms MAP, MultiMAP, GoalMAP).
- Solving symbol grounding and symbol anchoring problems.
- Reconstruction of sign based world model of the actor based on texts.
- Text generation based on specific world models (virtual assistants).
- Multi-level architectures of control (robotic systems).



Sign based world model

A component of knowledge representation is a sign:

- in sense of cultural-historical approach by L. Vygotsky,
- in sense of activity theory by A. Leontiev.

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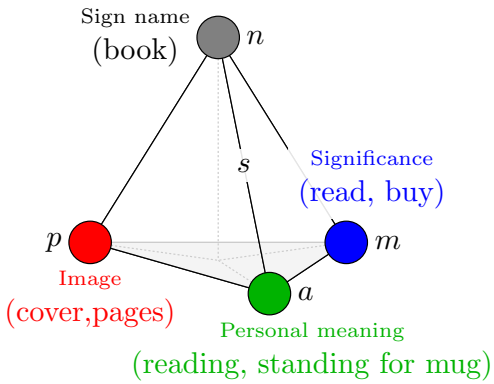

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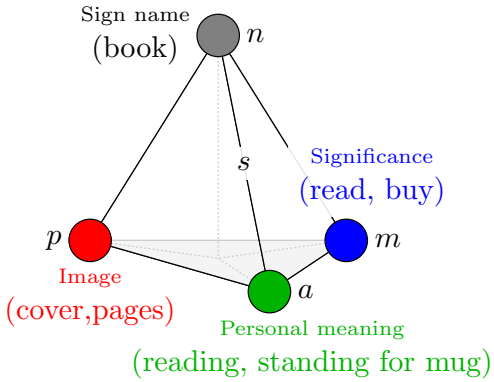
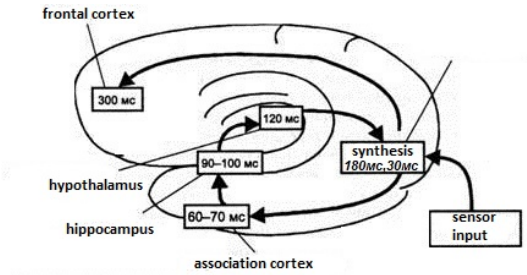
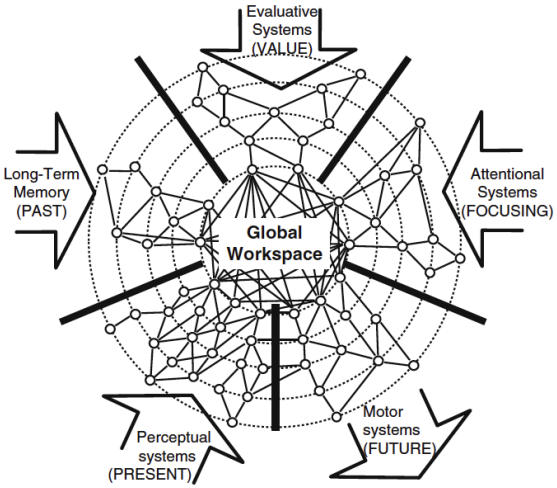






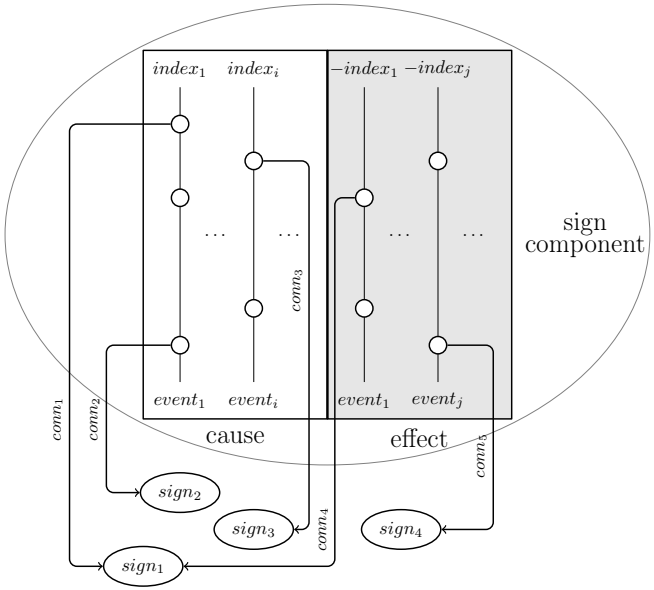
Supported ideas in psychology and biology:

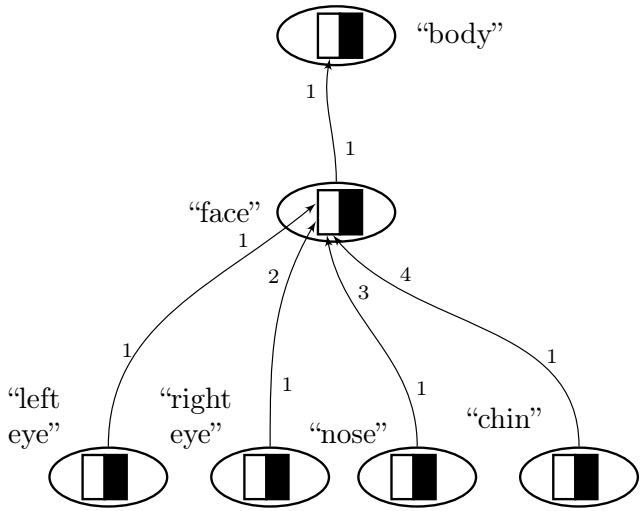
- neurophysiological data (Edelman, Ivanitsky, Mountcastle etc.),
- two and three levels psychological theories (Stanovich, Kahneman).

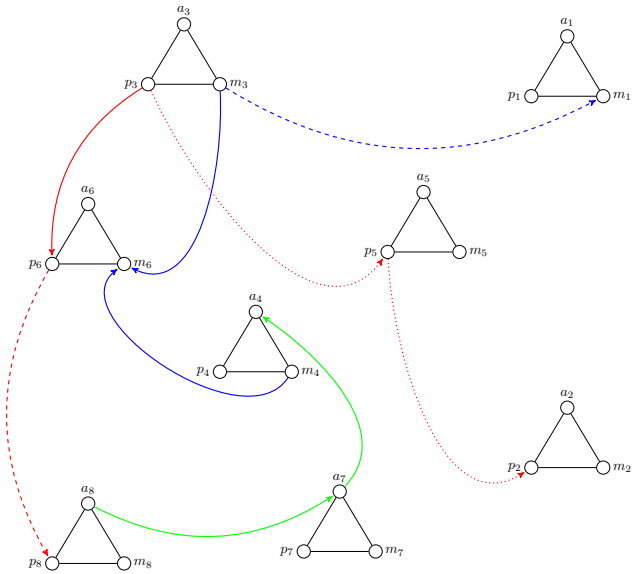
Osipov, G. S., A. I. Panov, and N. V. Chudova. "Behavior Control as a Function of Consciousness. II. Synthesis of a Behavior Plan". *Journal of Computer and Systems Sciences International*. 2015.

— ."Behavior control as a function of consciousness. I. World model and goal setting". *Journal of Computer and Systems Sciences International*. 2014.

Modeling of world model







Heterarchical causal network:

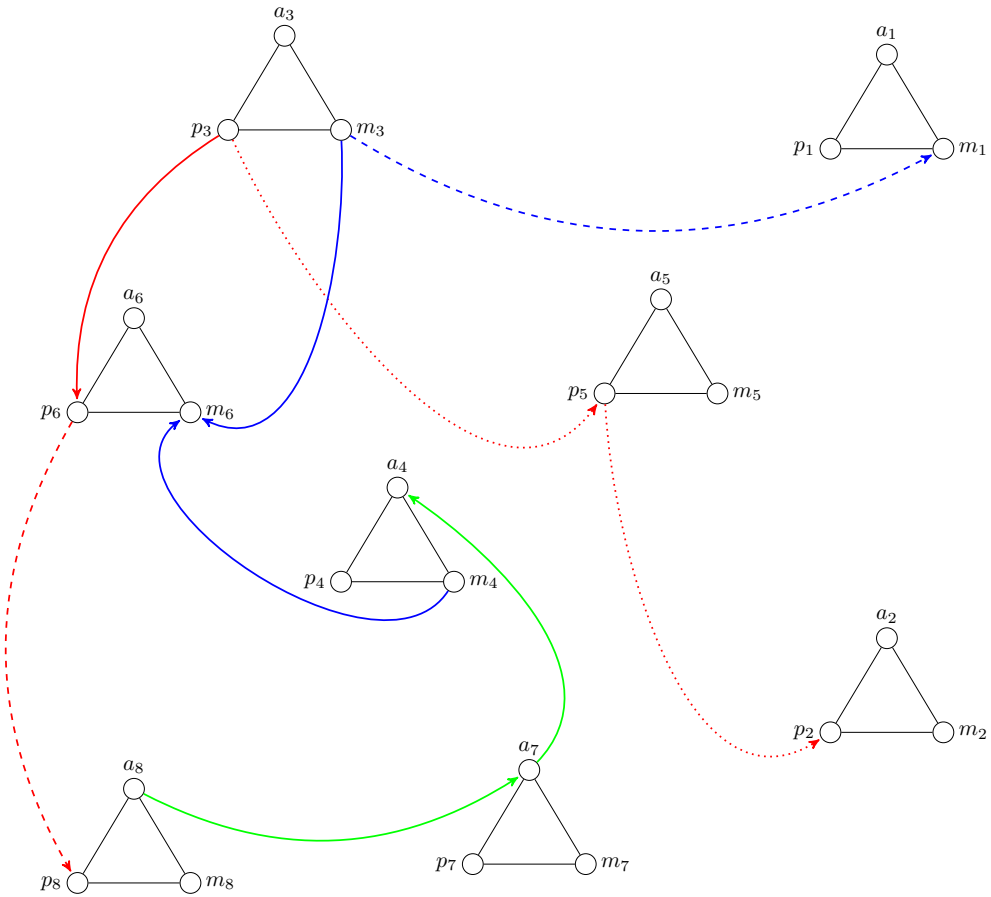
$$W_x = \langle V_x, E_x \rangle$$

$$v \to Z^x(s), x \in \{p, m, a\}$$

Panov, Aleksandr I. "Behavior Planning of Intelligent Agent with Sign World Model". *Biologically Inspired Cognitive Architectures*. 2017.

Osipov, Gennady S. "Signs-Based vs. Symbolic Models". *Advances in Artificial Intelligence and Soft Computing*.

Sign world model



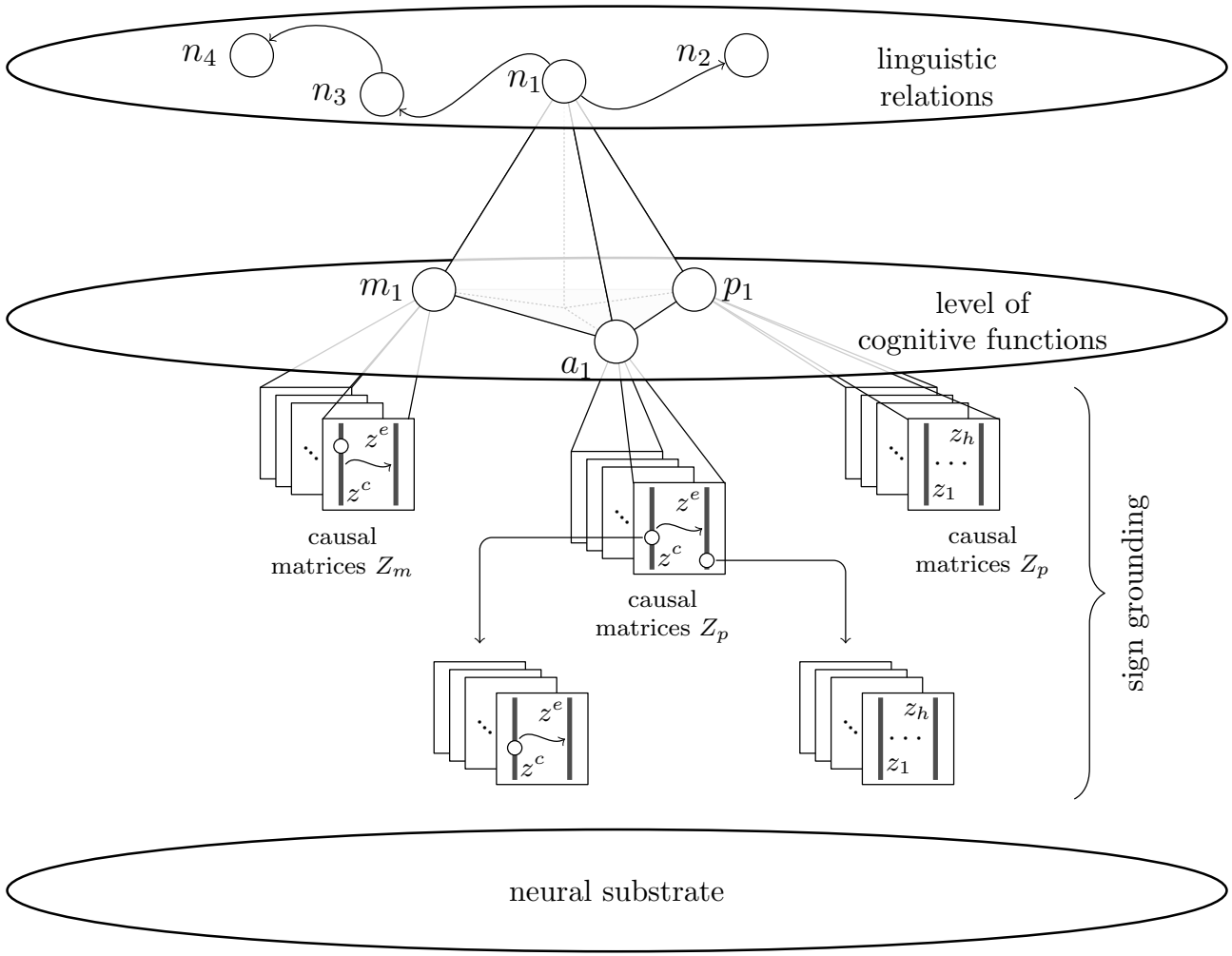
Semiotic network

$$\Omega = \langle W_p, W_m, W_a, R_n, \Theta \rangle$$

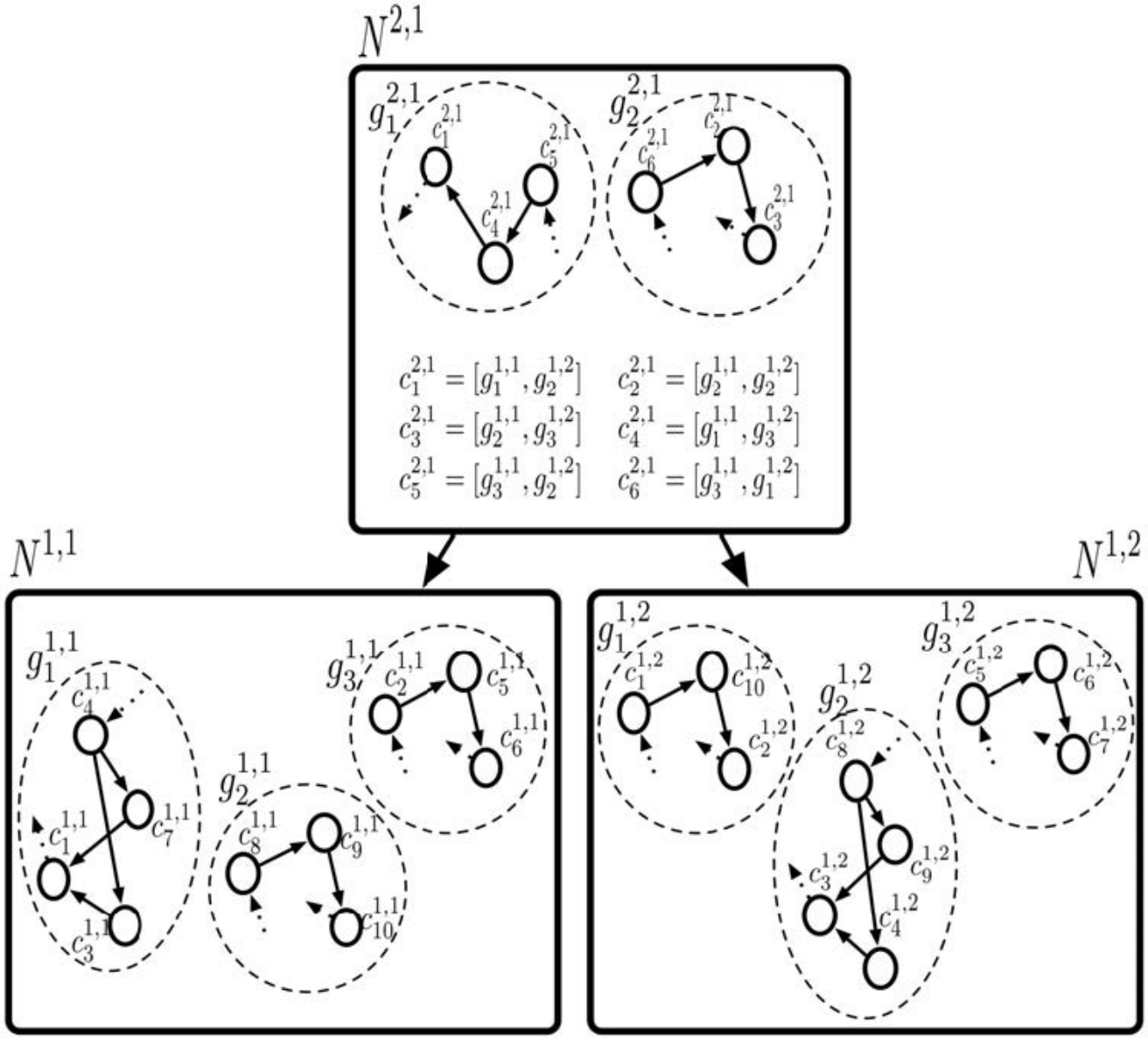
consisting of three causal network:

- $W_p = \langle 2^P, \mathfrak{R}_P \rangle$ – causal network on the set of sign images,
- $W_a = \langle 2^A, \mathfrak{R}_A \rangle$ – causal network on the set of sign meanings,
- $W_m = \langle 2^M, \mathfrak{R}_M \rangle$ – causal network on the set of sign significances.

Sign world model



Formation of causal matrices



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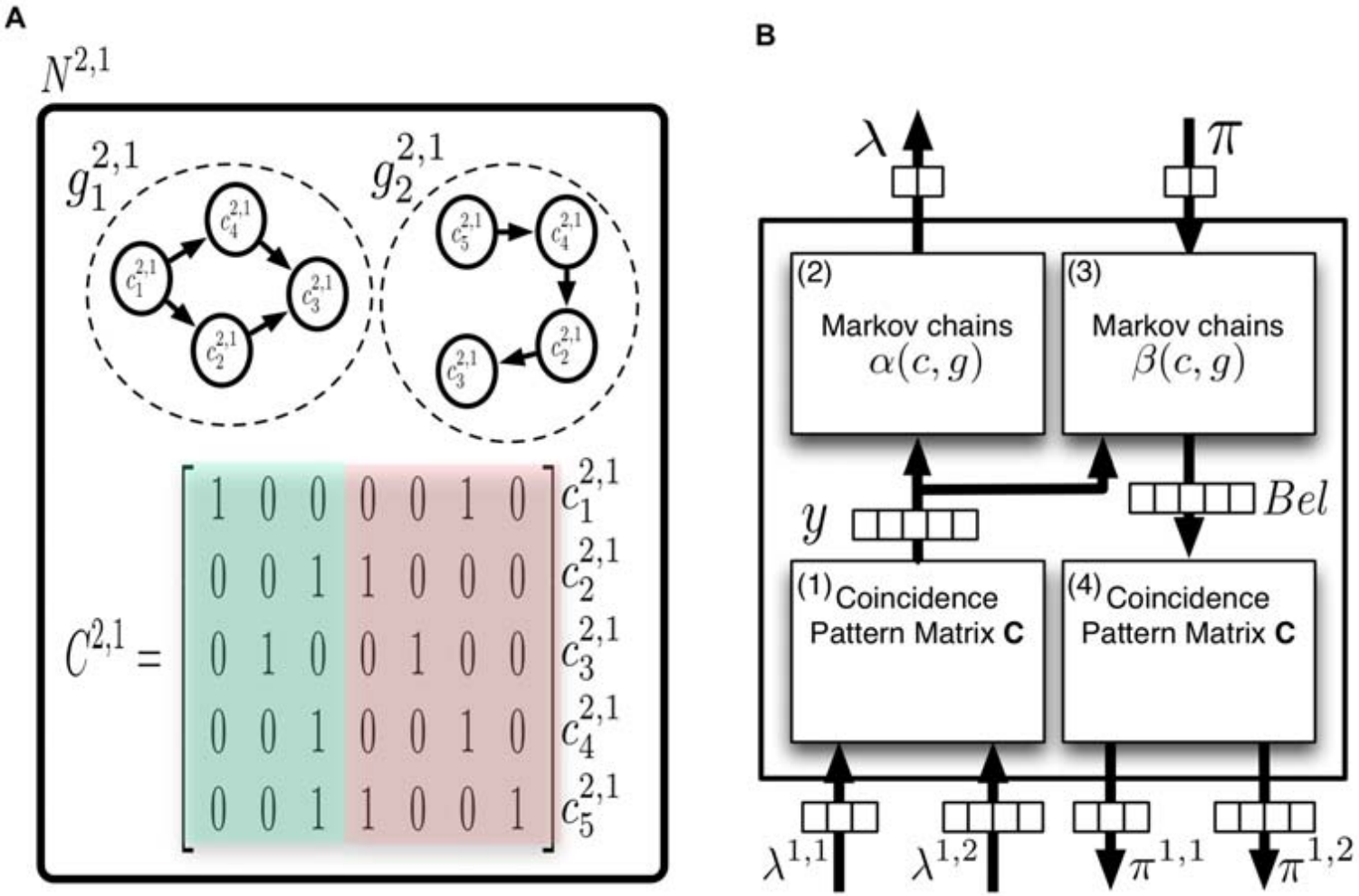
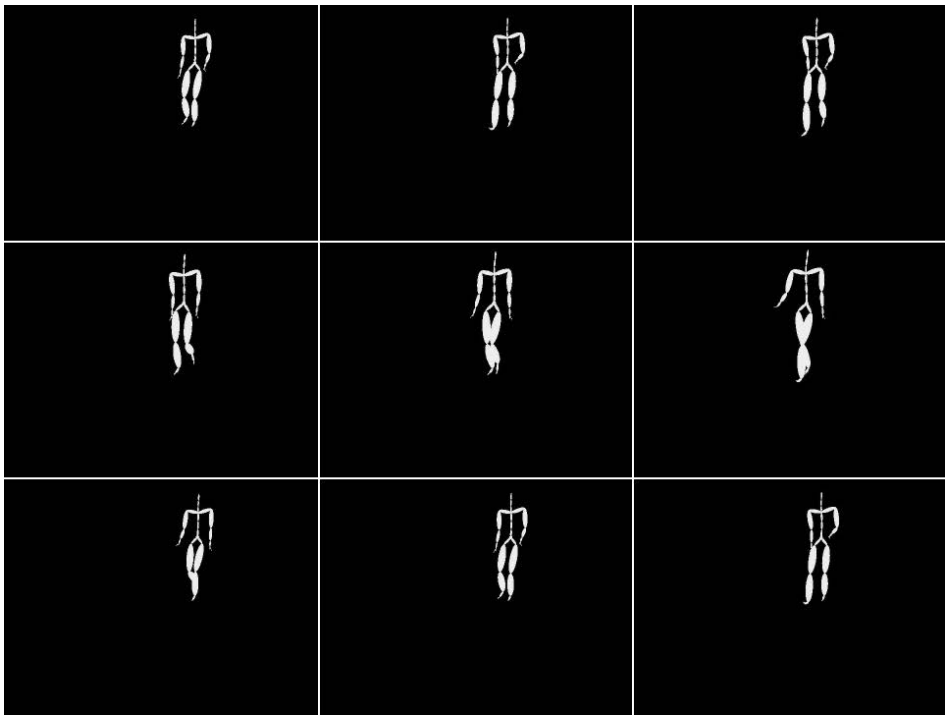


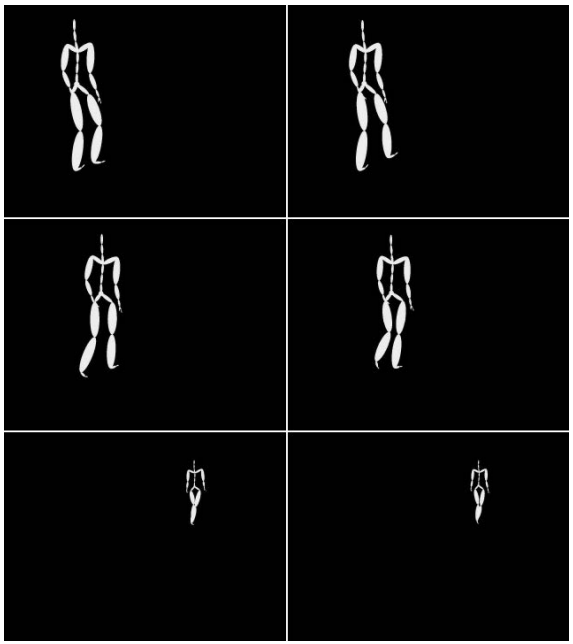
Anomaly Detection: Dataset

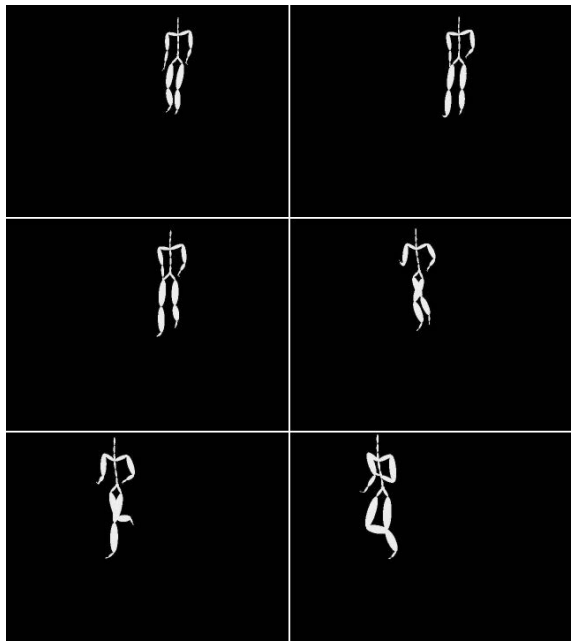
- Carnegie Mellon University Motion Capture Database.
- 2235 videos of 144 people performing different actions: walking, running, jumping and so on.
- 41 markers were positioned on a different actors' body parts and their positions were recorded during the action performance.



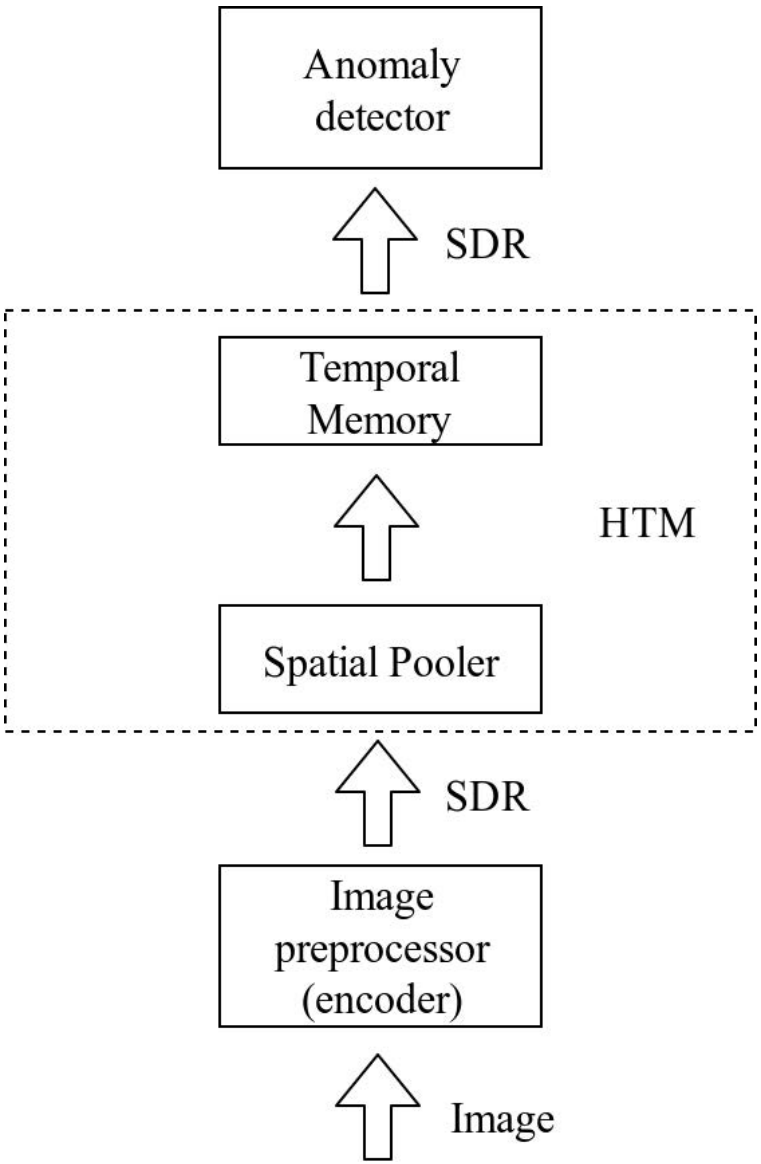
Anomaly Detection: Types

- Frames from other videos were inserted to produce an anomaly.
- Type 1: the object quickly changed the position.
- Type 2: the movements were similar, but different actions were performed.





Schema of the processing



Preprocessing:

- Image loading.
- Algorithms which control the sensor's movement around the image.

Score computing:

$$score = \frac{\sum_{i=0}^{n} \left(ac_{expected}^{(i)} - ac_{real}^{(i)} \right)^2}{n}$$

Experimental results

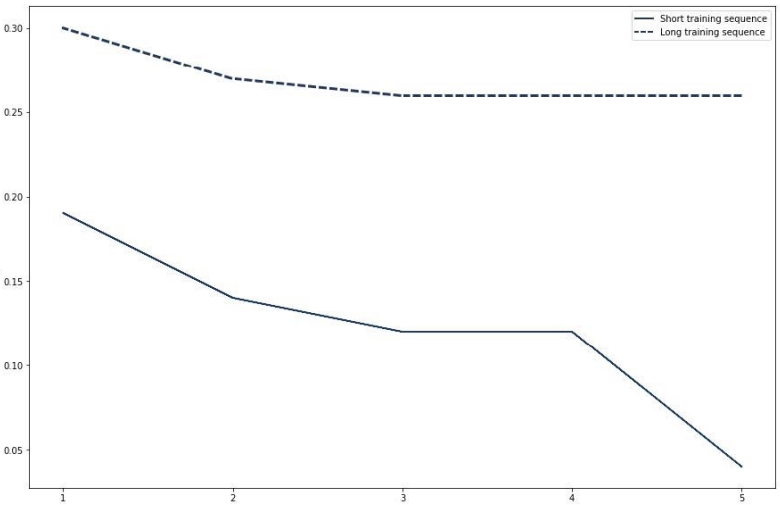
#	Original motion	# of frames	Anomaly motion	# of anomalous frames	# of detected anomalous frames	Score	Comments
1	walk	21	run	5	2	0.19	
2	walk	21	walk and turn right	12	5	0.19	
3	walk	21	jump	17	15	0.08	
4	walk	21	gorilla	12	2	0.40	wrong frames marked as anomaly
5	walk back and forth	136	scared walk	41	2	0.28	
6	walk back and forth	136	dance	31	2*	0.24	
7	walk back and forth	136	bad leg walk	22	2*	0.14	anomaly starts near the beginning
8	jump	30	walk back and forth	15	16	0.03	motion and location change
9	walk back and forth	136	walk back and forth	-	2*	-	test for sudden location change

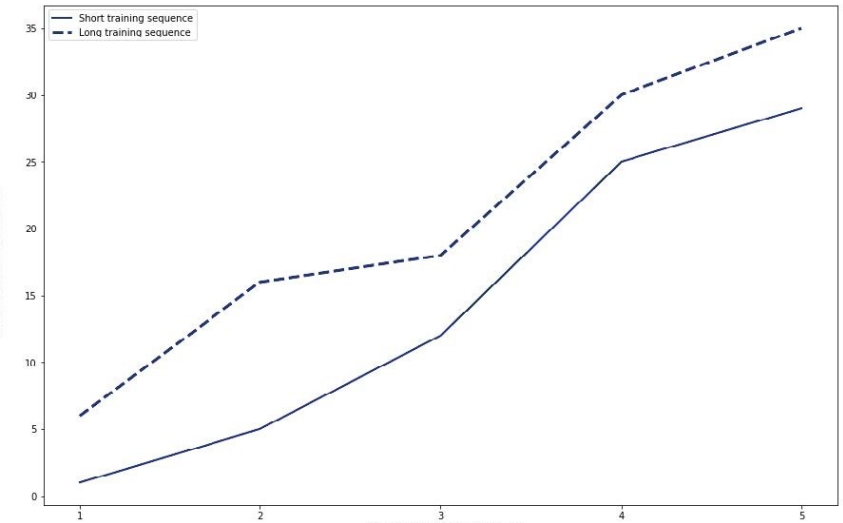
* Only first and last frames of anomaly were detected

Experimental results

Extensions:

- A preprocessing step between layers: performing a convolution of temporal memory region's output with some function (kernel).
- Feedback: producing commands to a sensor's view which will move it accordingly, therefore focusing on different parts of the image. It will have an SDR of combined information as input: the output of higher level's temporal memory, the current frame of the video and reward.





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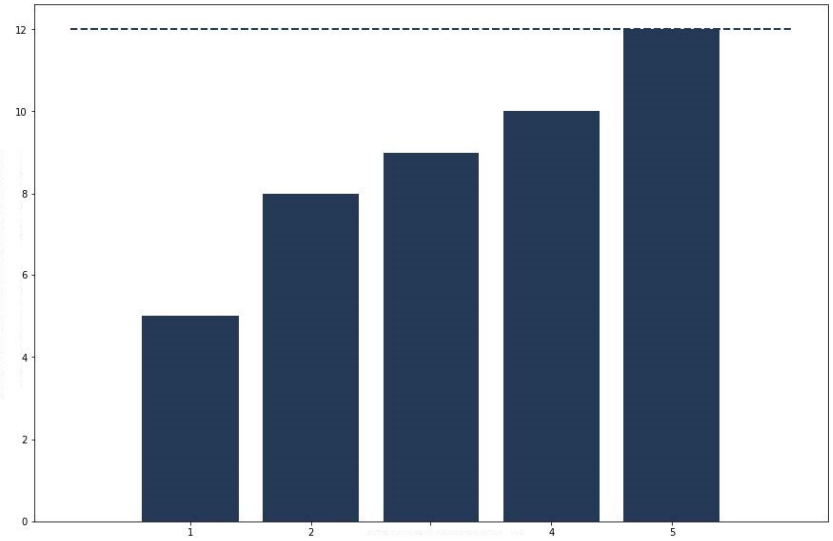

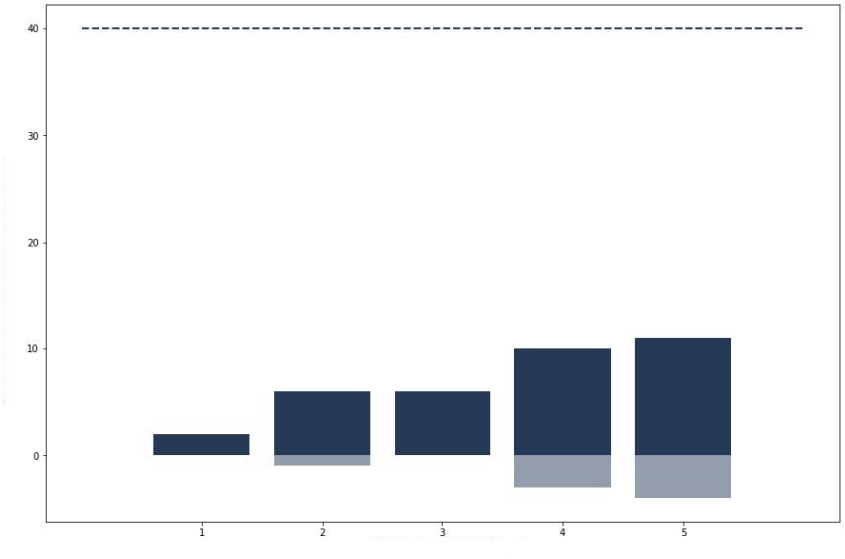

Thank you for your attention!

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