Project specification - Computational Modeling

MEi:CogSci 1st year semester project

General Project Information

Project Title	Computational model of high level multimodal representations
Author	Timotej Jurášek
Supervisor	Kristína Malinovská

Summary of Topic/Phenomenon

Specify which topic or (cognitive) phenomenon you are going to study, why you want to study it and emphasize the interdisciplinarity of your approach to the topic/phenomenon ()
Grounding of meaning
Perceptual symbols
High Level Representations
Linguistics, Psychology, Philosophy

Learning Outcomes[1]

Knowledge and transferable skills gained during the work on the project; some general expected outcomes outlined below, task to do – customise, add specific skills arranged in categories, all kinds of skills, including software, soft-skills, etc.

Subject specific

• Advanced knowledge and understanding of a phenomenon from the perspective of at least two disciplines
Understanding the phenomenon of multimodal representations from an interdisciplinary perspective.

Methodological

• Ability to approach a phenomenon in an interdisciplinary manner

Generic/Instrumental

• Ability to write and follow a project plan
Using Numpy library for the implementation of the algorithm.

[1] as defined in the MEi:CogSci curriculum

Systemic

• Interdisciplinary work/thinking
• Project-oriented work and organisational skill
• Critical evaluation of approaches & methods
• Quick orientation & navigation in mother and/or novel complex field
• Change of viewpoint/perspectives (intellectual mobility)
• Phenomenon-oriented thinking
• Problem-solving abilities

Short Project Description

(300-500 characters)
We will approach the phenomenon using computational modelling. We will use a novel biologically plausible learning algorithm for artificial neural networks created by the project supervisor.

Project Plan

Project Steps

1. Literature Research				**Total Working Hours (WH)/ECTS: 20/ __**	
Working-package (WP)	**Start – End**	**WH / ECTS**	**Activities**	**Resources required**	**Mile-stones (M)**
WP11	15-31.3.	5	Barsalou 1999, Perceptual symbols		M11
WP12	15.3.-15.4.	15	Cognitive robotics modelling papers (Farkaš, Marroco, …)		M12

2. Conceptualisation				**Total Working Hours (WH)/ECTS: 20 / __**	
Working-package (WP)	**Start – End**	**WH / ECTS**	**Activities**	**Resources required**	**Mile-stones (M)**
WP21		10	Consultations with supervisor		M21
WP22		10	Analysis of the topic		M22

3. Programming/Implementing the Model				**Total Working Hours (WH)/ECTS: 40 / __**	
Working-package (WP)	**Start – End**	**WH / ECTS**	**Activities**	**Resources required**	**Mile-stones (M)**
WP31		40	Programming and implementation of the model		M31

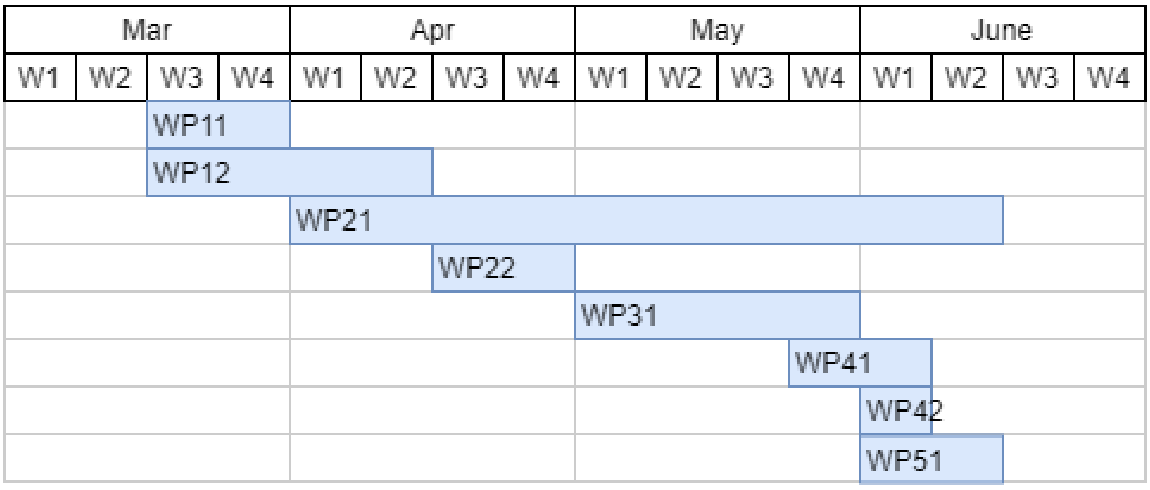
4. Running and Analysing the Model				**Total Working Hours (WH)/ECTS: 15 / __**	
Working-package (WP)	**Start – End**	**WH / ECTS**	**Activities**	**Resources required**	**Mile-stones (M)**
WP41		10	Creating tests for the model		M41
WP42		5	Gathering data from testing		M42

5. Project Documentation				**Total Working Hours (WH)/ECTS: 10 / __**	
Working-package (WP)	**Start – End**	**WH / ECTS**	**Activities**	**Resources required**	**Mile-stones (M)**
WP51	1.6.-1.6.	10	Documenting the progress on project		M51
WP52	1.6.-10.6.	10	Creating poster for the project		M52

Project Milestones

Milestone	**Result/"Product" and/or Deliverables**
M11	Basic information about perceptual symbols

Project Schedule[2]



Short Project Report [Conference Abstract]

(~1 page, 3000-5000 characters)

Grounding meaning in sensorimotor cognition

One of the perennial problems of cognitive science is the process of understanding language. There are multiple theories proposing different ways to process language. Many of those are subject to the symbol grounding problem. This problem focuses on the connection between symbolic representation(word) and meaning. However, one of the theories states that all meaning is grounded in sensorimotor cognition avoiding the symbol grounding problem.[1]
Children have a period of time during which they explore the environment around them via their sensorimotor systems, commonly linked with linguistic input from their parents. This provides an opportunity to learn associations between sensorimotor perception, interaction and linguistic input. Linguistics provides evidence that most languages use verbs and nouns. Nouns are linked to objects in the environment, whereas verbs are linked to the actions in the environment. This is the basis of linguistic repertoire and enables to express meaningful information via language. This was well demonstrated by Marocco et. al.[1], who used a fully connected recurrent neural network trained via standard Backpropagation-through-time learning algorithm to demonstrate how simple a cognitive system can be to learn these associations effectively. Input of the network was linguistic input, proprioceptive information, tactile information and preprocessed visual information.

Our model is based on a learning algorithm called UBAL - universal Bidirectional Activation-based Neural Network Learning Algorithm that is an extension of BAL algorithm proposed by Farkaš & Malinovská.[2] This algorithm is able to train a neural network with similar properties as a network trained by backpropagation, using a model that has higher biological relevance. Depending on setup, this type of neural network can perform association tasks. Linking perceptual inputs, proprioception or motor properties and associating them with linguistic labels gives us a model that grounds meaning of language

[2] voluntary

in sensorimotor cognition. This is tested on a canonical 4-2-4 encoder task used by O'Reilly[3], that auto-associates 4 different bit patterns through 2 hidden neurons. We also tried heteroassociative tasks with satisfying results. This demonstrates that our model can associate inputs from different domains. Whether this is a sufficient model for demonstrating neurologically plausible model of learning language needs further testing.

References:

[1] D. Marocco, A. Cangelosi, K. Fischer, & T. Belpaeme. (2010). Grounding action words in the sensorimotor interaction with the world: experiments with a simulated iCub humanoid robot. Frontiers in neurorobotics, 4, 7.

[2] I. Farkaš, & K. Rebrová. (2013, September). Bidirectional activation-based neural network learning algorithm. In International Conference on Artificial Neural Networks (pp. 154-161). Springer, Berlin, Heidelberg.

[3] R. C. O'Reilly, "Biologically Plausible Error-Driven Learning Using Local Activation Differences: The Generalized Recirculation Algorithm," in Neural Computation, vol. 8, no. 5, pp. 895-938, July 1996.