The use of Keras to model flow control mechanisms with recurrent neural networks

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There are some recent advances in algorithms, software, and technology which are related to dynamical systems and machine learning that has not yet been applied in the field of Computational Neurosciences, especially regarding computing. The main goal of present work is to present a simple model and a framework to perform a set of tasks related to flow control and discuss the obtained results using this new framework. We proposed a network topology, constraints on the parameters and a training method in order to archive those tasks and we discussed the scope of the results obtained. Trained networks serve as a source of mechanistic hypotheses and as a testing ground for data analyses that link neural computation to behavior. RNN are a convenient proxy for biological circuits and a valuable platform for theoretical investigation. We focus on the study of the following list of tasks regarding the processing of stimulus as temporal input.

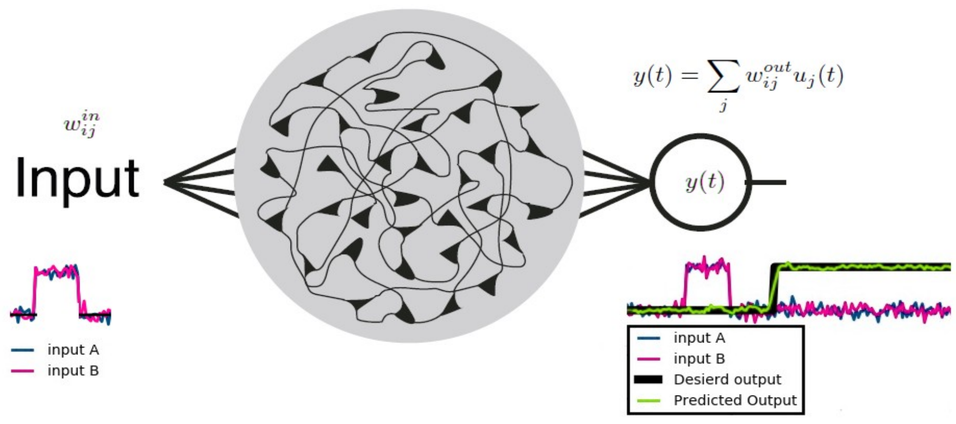
Idea:

Consider a recurrent neural network N units → to train it to perform bio-inspired tasks → To study the properties threw population analysis techniques → further statistical studies on weights matrices and damage on trained networks

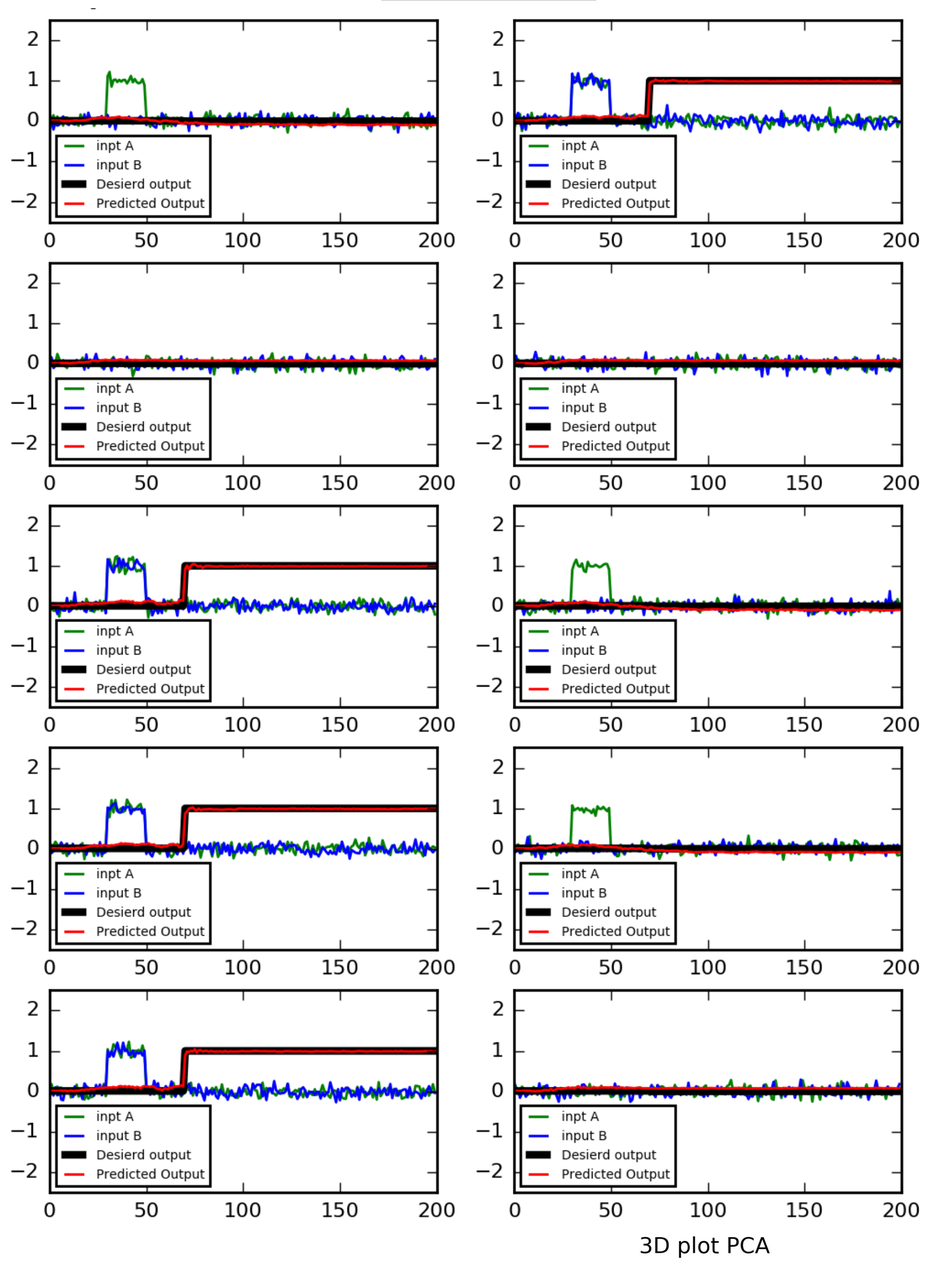
A description of the model

- The dynamic is translate in the connectivity of an RNN.
- Every value of the variable $_f$ corresponds to a certain point in the N-dimensional state space.
- Different task gives rise to different dynamical objects in the space state.

$$\frac{du_i(t)}{dt} = -\frac{u_i(t)}{\tau} + \sigma(\sum_j w_{ij}^{Rec} u_j(t) + \sum_j w_{ij}^{in} x_j)$$



Training task "And" between neural stimulus



Motivation I: A problem of interest

- To model the dynamics of the Cerebral Cortex and how does it process the flow of information.

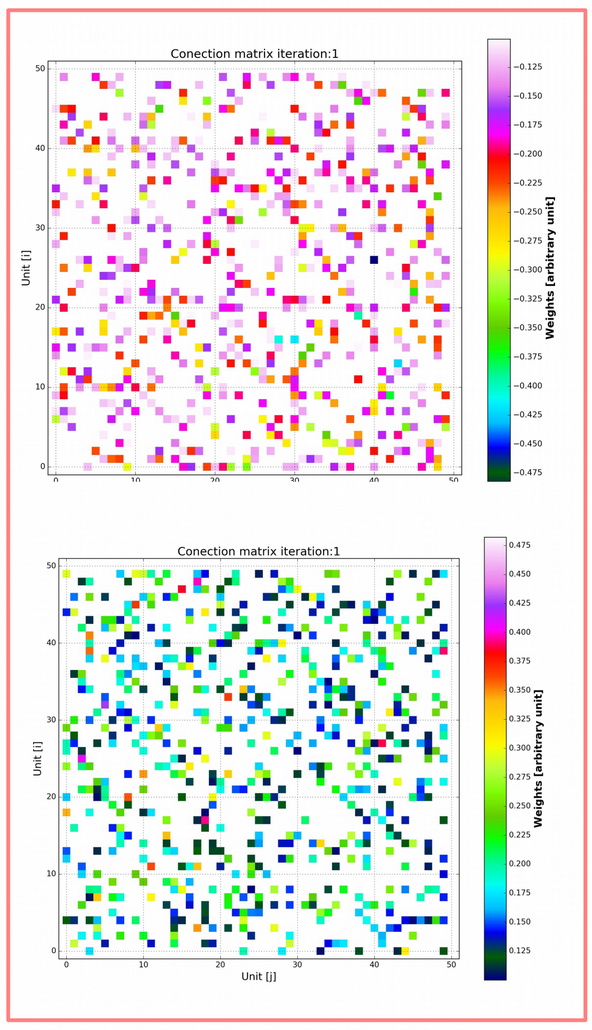
- We chose tasks :

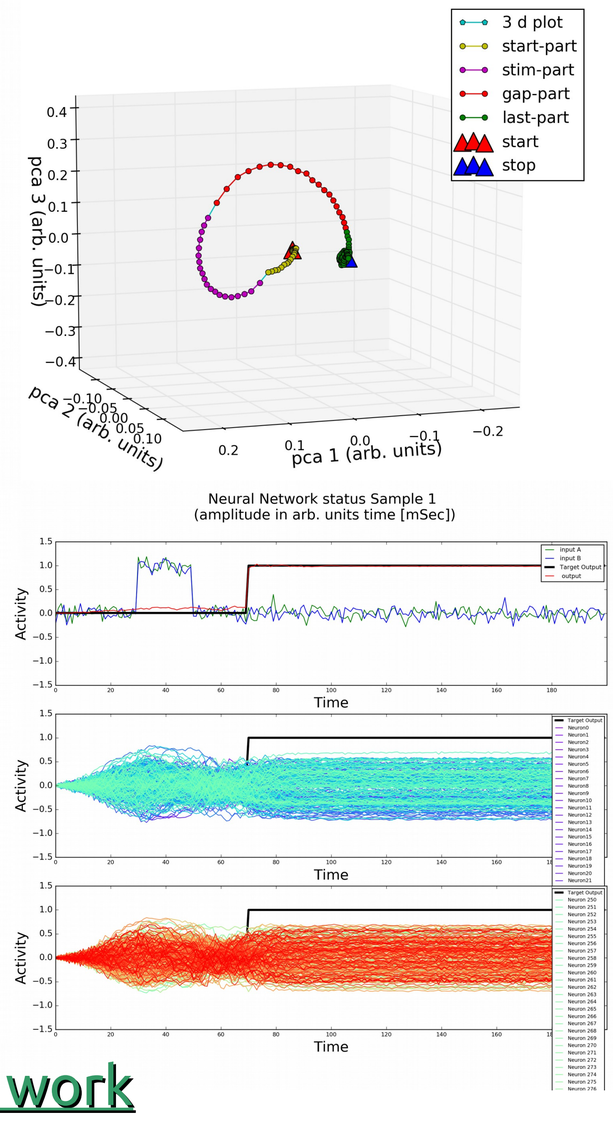
*Relevant in processing information and flow control.

*That traditionally were used in previous works to model the behavior of different brain areas, particularly cortex

Processing of stimulus as temporal inputs:

1. Memorizing and reproducing a stimulus with a time delay.
2. Binary basic operations between input stimulus (AND, OR, NOT, XOR)
3. Flip-Flop task. i. e. memorizing and forgetting a stimulus.
4. A stimulus that causes an oscillation output during a certain time.

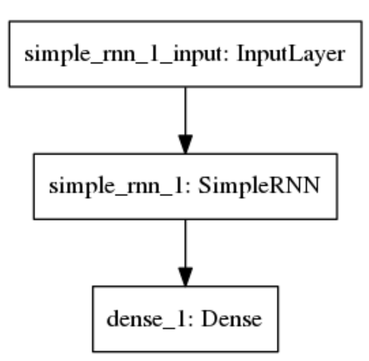




Motivation II: a new tool Tensor flow and Keras

- We propose to use Keras and Tensorow as frameworks, where traditionally Matlab is used or Theano.

- These new scientific libraries are open source and its use is rapidly growing.



Training the network

- Supervised learning
- Adaptive SGD training method.
- Noisy input with several training samples.
- An output with simulated time delay answer.

Further work

-Further statistical studies on weights matrices.
-Studies on damage on trained networks.
-Scaling the network size.
-Comparison between different tasks.

References

[1] C. Thompson, L. Shure, Image Processing Toolbox: For Use with MATLAB;[user's Guide], MathWorks, 1995 **[2]** Theano Development Team, Theano: A Python framework for fast computation of mathematical expressions, arXiv e-prints abs/1605.02688 **.[3]** S. Kuroki, T. Isomura, , Frontiers in Computational Neuroscience 12 (2018) 83. doi:10.3389/fncom.2018.00083 **[4}** https://www.tensorflow.org