STEPS Students Report

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During my exchange program, I have spent one month in the research laboratory of Prof. Masaki Sano, which belongs to the Graduate School of Science, Department of Physics. My research was based on the use of neural network models for dynamics reconstruction of *Dictyostelium* cells shape and orientation.

The approach was to use Recurrent Neural Networks (RNNs) for researching the dynamics of these cells. RNNs are useful because they can approximate dynamical systems. In 2001, a fundamentally new approach to RNN design and training was proposed independently by Wolfgang Maass and Herbert Jaeger [1]. Now this approach often called as Reservoir Computer Paradigm (Fig. 1).

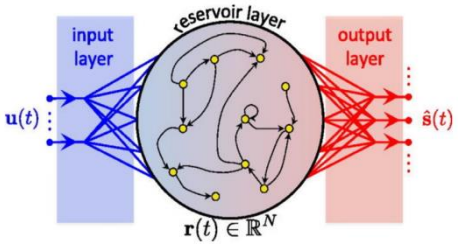

Fig. 1. A reservoir computer.

This paradigm was applied by me to research some chaotic dynamical systems. The first way, which was realized, allows me to replicate chaotic attractors using network by training it during some period, and then taking the outputs as an input (Fig. 2-3).

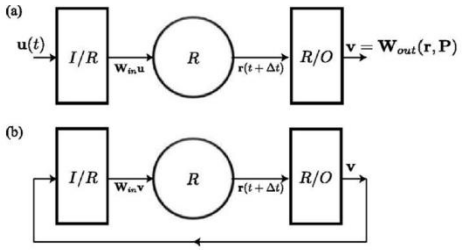

Fig. 2. Configurations in the training (a) and the prediction (b) phase.

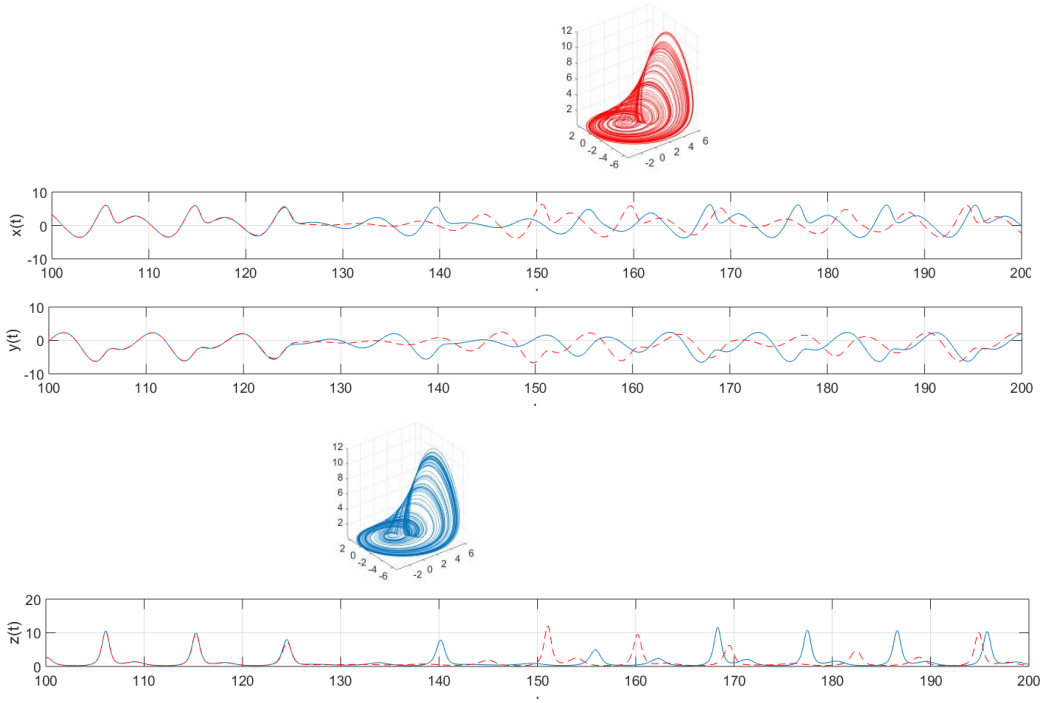

Fig.3. Rössler attractor (blue) and attractor, received from network without observers (red).

Another way allows me to deduce the state of a dynamical system from a limited number of concurrent system state measurements (Fig. 4). These two methods were used on a set of data obtained by Sano's laboratory of spontaneously migrating *Dictyostelium* cells [2].

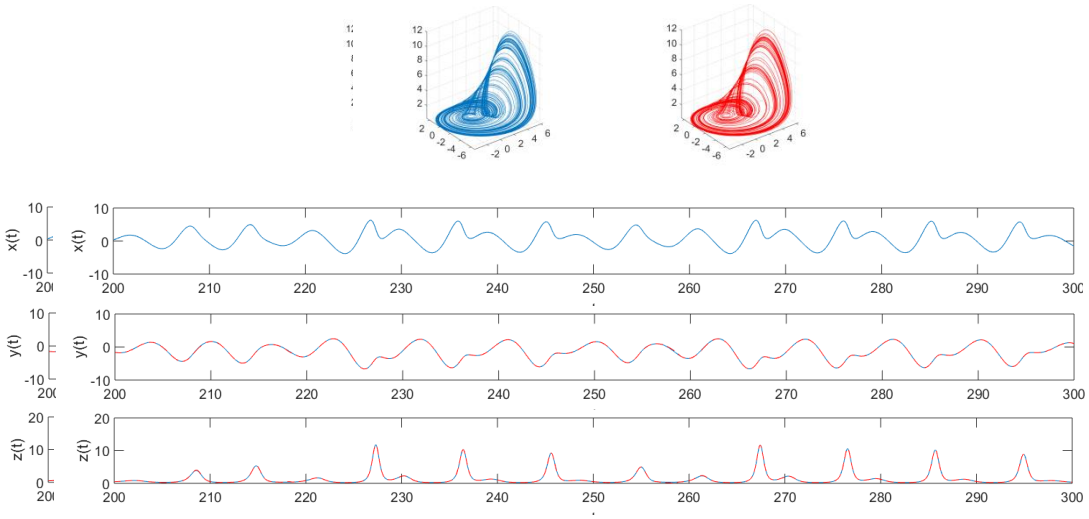

*Fig.4. Rössler attractor (blue) and attractor, received from network reconstruction with observed **x** axe (red).*

I fed this data to the network for some initial time and obtain the results with the second method, and when I increased number of observers to 36, I obtained a good approximation of the original data (Fig. 5).

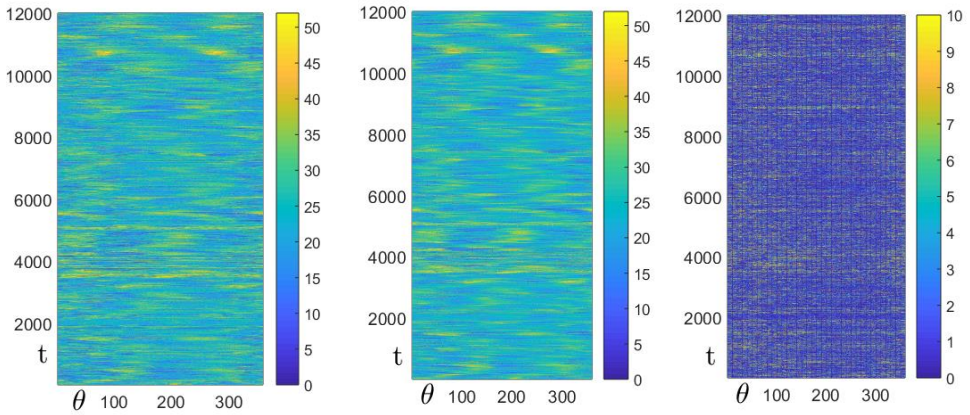

Fig.5.From left to right: original data; data, received from RNN; differences between pictures.

Thus, because of stability of second method, my future work is to apply it to find optimal parameters of the reservoir for the first prediction method. Other way is to justify such behavior of neural network mathematically.

I would like to thank Prof. Sato and all members of the laboratory and special thanks to the STEPS Office for a great experience.

References

1.H. Jaeger // The "echo state" approach to analyzing and training recurrent neural networks – with an erratum note" (2001).

2.Y.T. Maeda, J. Inose, M.Y. Matsuo, S. Iwaya, M. Sano // PloS one, 3(11) (2008).