Local dynamics identification in a network

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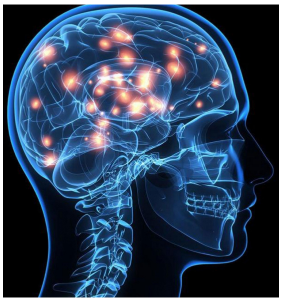
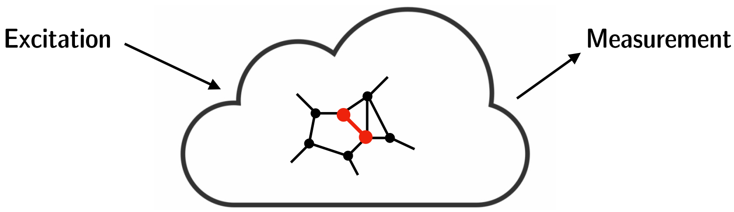
Nowadays, more and more dynamical systems are connected to form what is denoted in the litterature by networked systems. Examples of such systems include indeed power networks (smart grids), biochemical networks, neurobiology, transportation networks, multi-agent robotics, social networks, economic systems, telecommunication systems, or distributed control systems, to name a few. Many of these systems play a crucial role in our modern society and their harmonious operation is thus essential. Models of these networks are necessary for simulation, prediction or advanced controller design. Very often though the interconnection structure or a set of possible connections of the network is known, but the specific dynamics are not, or only imprecisely known, spurring the need for identifying local components of the dynamics.



Let us consider the example of neurobiology: a brain is a network of neurons communicating via electrical signal. In order to study the relation between two regions of the brain, it is not ethically plausible to isolate the two regions of interest and perform experiments on them. Instead, one could show a person different visuals and, through RMI, observe which parts of the brain are active. This example illustrates properly the approach followed in this research: from external excitation and measurement, we aim at recovering local dynamics of the network.



In order to get an insight of this work, we address the simple network depicted in Figure 1. The four nodes can be seen as neurons, connected by directed edges which model the dynamics governing their relative behaviour. In the first setup, nodes 1 and 3 are excited, while nodes 2 and 4 are measured. With no more than the four edges of the cycle, we can recover the dynamics of the four edges from data collected by the inputs and outputs, the network is said to be *identifiable*. If node 4 directly influences node 2 though, two edges can not be identified anymore. Measuring node 3 does not bring new useful information, whereas adding a measure at node 1 allows to recover the identifiability of the whole network.

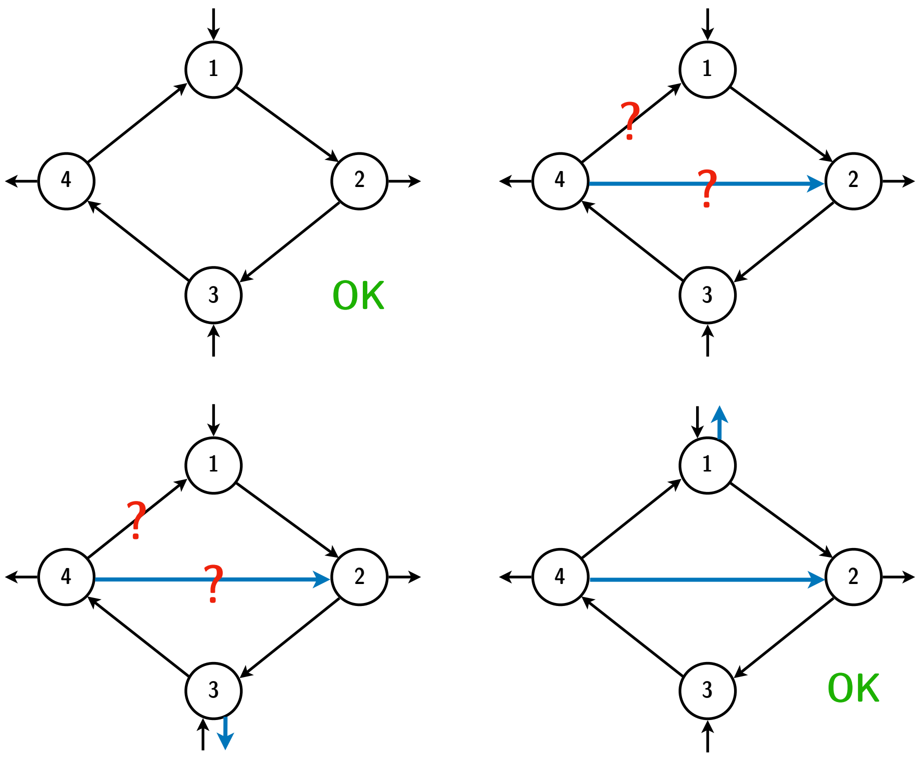


Figure 1: Simple network example

In this example, we assume the network topology to be known, i.e. we know the inter-connection structure of the nodes. From the topology and the input/output data collected, the aim is to recover the dynamics, modeled by the edges. This example illustrates the issue addressed in this research: given a known topology, a set of excited and measured nodes, which edges can be identified? This work answers this question by providing conditions on the network topology (i.e. the presence of paths between certain nodes), which ensure identifiability or not.