Behaviour Dynamics in Social Networks - Assignment 1

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Abstract

After Jenny has entered Mark's door, her presence clearly makes that Mark becomes happy. Liking Mark a lot, his happiness makes her nervous, which makes that she breaks one of the two nice vases near the door. Seeing this, Mark becomes angry on her. This makes Jenny sad. Jenny's sadness makes Mark's anger disappear, and he gives Jenny a hug. Seeing this, Mark's partner Dion becomes jealous, upon which she breaks the other vase.
Use the concepts and formats introduced in Chapter 2 to analyse and model this scenario by a temporal-causal network by the following steps.

1 Graphical conceptual representation

States describing the scenario:

1. Jenny's presence (X_1);
2. Mark becomes happy (X_2);
3. Jenny likes Mark (X_3);
4. Jenny becomes nervous (X_4);
5. Jenny breaks a vase (X_5);
6. Mark becomes angry (X_6);
7. Jenny becomes sad (X_7);
8. Mark gives Jenny a hug (X_8);
9. Dion become jealous (X_9);
10. Dion breaks a vase (X_10).

In Figure 1, we can observe a connection that models a negative impact in order to make the level of the affected state lower - the one going from X_7 to X_6 (i.e. Mark anger decreases due to Jenny sadness). There is also a loop that contains two states: X_6 and X_7.

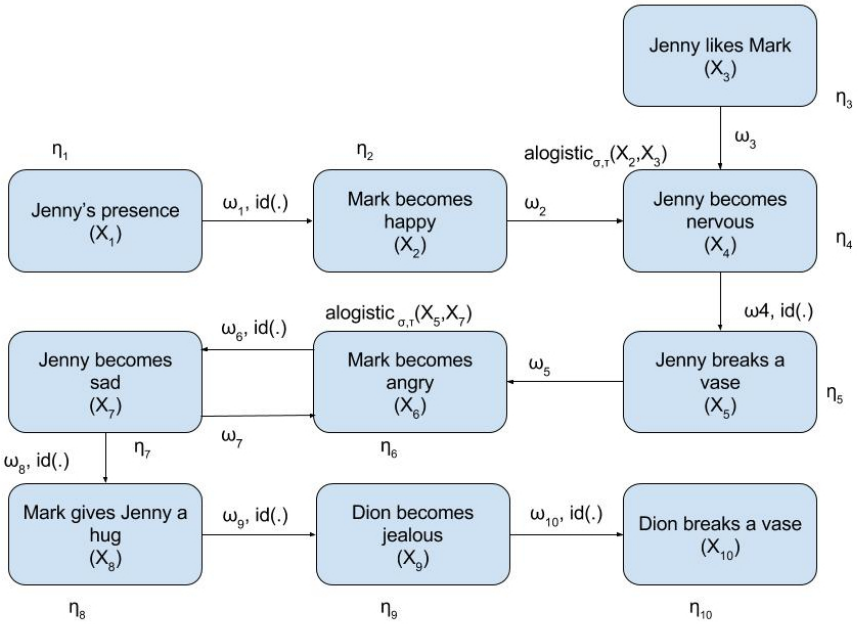

Figure 1: Conceptual representation of the scenario.

2 Conceptual representation in matrix format

We now move to the matrix representation of the graph in Figure 1. Rows represent nodes from which edges are starting, while columns represent nodes in which edges are ending.

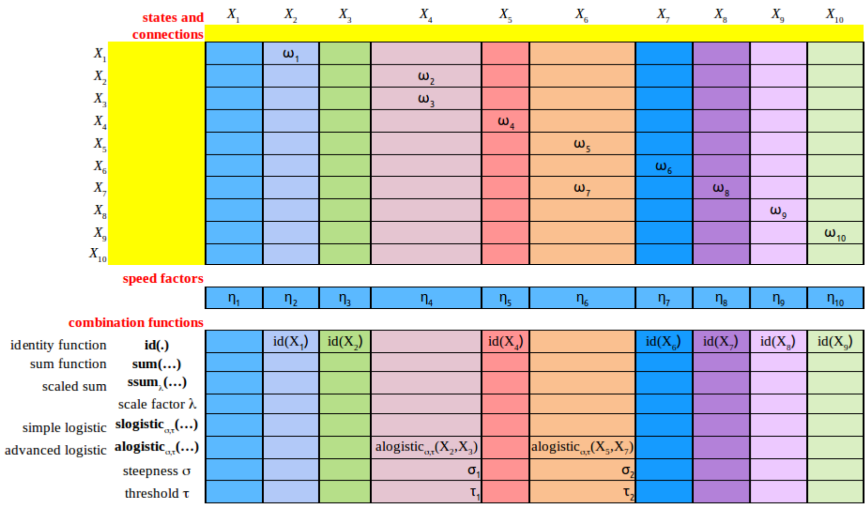

Figure 2: Matrix format of the conceptual representation

3 Numerical representation

Numerical representation for the scenario represented in Figure 2.

3.1 Difference equation

Initial states:

$$X_1(t + \Delta t) = X_1(t) + \eta_1(id(X_1(t)) - X_1(t))\Delta t = X_1(t) \tag{1}$$

$$X_3(t + \Delta t) = X_3(t) + \eta_3(id(X_3(t)) - X_3(t))\Delta t = X_3(t) \tag{2}$$

Intermediate states:

$$X_2(t + \Delta t) = X_2(t) + \eta_2(id(\omega_2 X_1(t)) - X_2(t))\Delta t \tag{3}$$

$$X_4(t + \Delta t) = X_4(t) + \eta_4(alogistic_{\sigma,\tau}(\omega_2 X_2(t), \omega_3 X_3(t)) - X_4(t))\Delta t \tag{4}$$

$$X_5(t + \Delta t) = X_5(t) + \eta_5(id(\omega_4 X_4(t)) - X_5(t))\Delta t \tag{5}$$

$$X_6(t + \Delta t) = X_6(t) + \eta_6(alogistic_{\sigma,\tau}(\omega_5 X_5(t), \omega_7 X_7(t)) - X_6(t))\Delta t \tag{6}$$

$$X_7(t + \Delta t) = X_7(t) + \eta_7(id(\omega_6 X_6(t)) - X_7(t))\Delta t \tag{7}$$

$$X_8(t + \Delta t) = X_8(t) + \eta_8(id(\omega_8 X_7(t)) - X_8(t))\Delta t \tag{8}$$

$$X_9(t + \Delta t) = X_9(t) + \eta_9(id(\omega_9 X_8(t)) - X_9(t))\Delta t \tag{9}$$

Final state:

$$X_{10}(t + \Delta t) = X_{10}(t) + \eta_{10}(id(\omega_{10} X_9(t)) - X_{10}(t))\Delta t \tag{10}$$

3.2 Differential equation

Initial states:

$$\frac{\delta X_1(t)}{\delta t} = X_1(t) + \eta_1 \cdot (id(X_1(t)) - X_1(t)) \tag{11}$$

$$\frac{\delta X_3(t)}{\delta t} = X_3(t) + \eta_3 \cdot (id(X_3(t)) - X_3(t)) \tag{12}$$

Intermediate states:

$$\frac{\delta X_2(t)}{\delta t} = X_2(t) + \eta_2 \cdot (id(X_1(t)) - X_2(t)) \tag{13}$$

$$\frac{\delta X_4(t)}{\delta t} = X_4(t) + \eta_4 \cdot (alogistic_{\sigma,\tau}(\omega_2 X_2(t), \omega_3 X_3(t)) - X_4(t)) \tag{14}$$

$$\frac{\delta X_5(t)}{\delta t} = X_5(t) + \eta_5 \cdot (id(X_4(t)) - X_5(t)) \tag{15}$$

$$\frac{\delta X_6(t)}{\delta t} = X_6(t) + \eta_6 \cdot (alogistic_{\sigma,\tau}(\omega_5 X_5(t), \omega_7 X_7(t)) - X_6(t)) \tag{16}$$

$$\frac{\delta X_7(t)}{\delta t} = X_7(t) + \eta_7 \cdot (id(X_6(t)) - X_7(t)) \tag{17}$$

$$\frac{\delta X_8(t)}{\delta t} = X_8(t) + \eta_8 \cdot (id(X_7(t)) - X_8(t)) \tag{18}$$

$$\frac{\delta X_9(t)}{\delta t} = X_9(t) + \eta_9 \cdot (id(X_8(t)) - X_9(t)) \tag{19}$$

Final state:

$$\frac{\delta X_{10}(t)}{\delta t} = X_{10}(t) + \eta_{10} \cdot (id(X_9(t)) - X_{10}(t)) \tag{20}$$

4 Expected behaviour

There are two constant and non-zero states at $t = 0$: Jenny's presence (X_1) and Jenny liking of Mark (X_3). All the others states (X_2, X_4, X_5, ..., X_{10}) are starting at 0. We expect the behaviour of the network as follows: it starts with Jenny's presence as non-zero, which makes Mark's happiness go from low to high. This change, together with the constant factor of Jenny liking Mark, make Jenny's nervousness go from low to high, which makes her break a vase (Jenny's vase breaking goes from low to high). As a consequence of the breaking, Mark's anger goes from low to high, which makes Jenny's sadness also go from low to high. This change in Jenny's sadness makes Mark's anger go from high back to low and it also makes Mark's hugging of Jenny go from low to high. The change in the hugging state makes Dion's jealousy go from low to high and as a consequence she breaks a vase (Dion's vase breaking goes from low to high). During all these processes, we can observe temporal-causal relationships between nodes connected by edges.

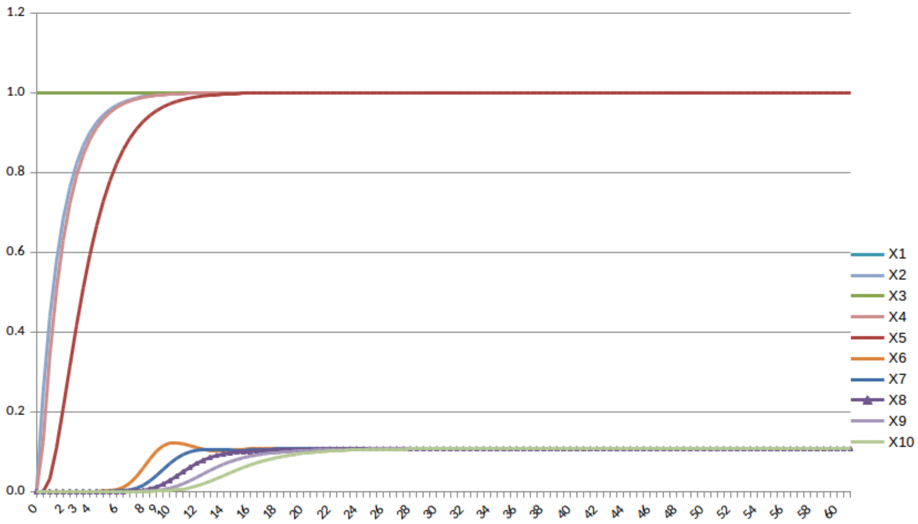

Figure 3: Results obtained from the simulation of the scenario. All the edges are weighted the same ($\omega_i = 1$), except for $\omega_7 = -1$. They also share the same speed factor: $\eta_i = 0.5, i = 1 \ldots 10$. The *alogistic* function is set with $\sigma = 10$ and $\tau = 1$

5 Simulation

In this section, we analyze the experimental results too check if they are coherents with the expected behaviour described in Section 4. As we can see in Figure 3, the two costant states - X_1 and X_3 - are set to 1. The states connected to them (X_2 and X_4) are activated due to a *causal relationship*. Moreover, we can see how the connection that models the negative impact (i.e. the edge from X_7 to X_6) lowers the value of X_6 around $t = 10$. Finally, we observe how the loop lead to a convergence of values of all the involved nodes - X_6 and X_7, and consequently X_8, X_9 and X_{10}.

References

[1] Treur, J., *Network-Oriented Modeling: Addressing Complexity of Cognitive, Affective and Social Interactions*. Series on Understanding Complex Systems, Springer Publishers, October 2016.