Project proposal "Diffusion of Innovation"

Summary

In general we would like to understand how the characteristics of the first nodes in a network that accept an innovation, also known as seeds, influence the diffusion of the very same innovation. We decided to use the paper "Multiparameter Models of Innovation Diffusion on Complex Networks" (McCullen et al. 2013) as the basis for our project and extend their model to find the relationship between seed characteristics and the success of an innovation. The success of an innovation is given by a) the time it needs to reach the maximum acceptance within a given network and b) the proportion of nodes that accepted the innovation at equilibrium. In particular we would to know whether including a variable for the node's *i* influenceability in the model of McCullen et al. will allow us replicate the finding of Watts and Doods (Watts and Dodds 2007), who showed that the success of an innovation primarily depends on to what the extent easily influenced individuals with a large node degree have accepted the innovation.

Detailed Overview

The model that McCullen et al. propose is applicable to a range of innovation diffusion models with a strong peer-to-peer component. The model represents these individuals as nodes in a network, each with a variable representing their current state of adoption of the innovation. The motivation to adopt is composed of three terms, representing personal preference, an average of each individual's network neighbors' states, and a system average, which is a measure of the current social trend. The adoption state of a node changes if a weighted linear combination of these factors exceeds some threshold. For extending their model we argue that every node can have different rate for getting influence from other nodes. The intuition for this parameter *influence* comes from paper entitled "Influentials, Networks, and Public Opinion Formation"(Watts and Dodds 2007). This paper shows that under most conditions that they consider, large cascades of influence are driven not by Influentials but by a critical mass of easily influenced individuals.

Our proposed model tries to explain the diffusion of innovation using a threshold model. In a threshold model a node i accepts an innovation if the utility gain u from accepting exceeds a certain threshold θ.

The total utility is given by $u(t) = (\alpha p_i + \beta s(t) + \gamma m(t)) * I_i$ where p_i is the personal benefit, s_i is the community benefit, $m(t)$ is the mainstream social norm and w_i is the degree determining how easy this node can be influenced by others. Here $\alpha + \beta + \gamma = 1$ and we choose w_i randomly between 0.5-2.

Then we look at the number of neighbors needed to induce uptake of an innovation. As u_i needs to be at least θ in order for an innovation to spread to node i, one obtains the critical community benefit s^*

$$s^* = \frac{\theta - \alpha p_i - \gamma m(t)}{\beta}$$

From here one gets the required number of active contacts Y_i^*. If $Y_i^* = 0$, the innovation is adopted immediately by all nodes.

In this paper, both random networks (ER network) and small-world networks (Watts-Strogatz network) are studied. For us the Watts-Strogatz model is more interesting since we are concerned about the spreading of innovation between communities. Yet, we intend to study our system also on other common networks models, if necessary.

Eventually, we will observe the network at steady-state and will analyse how seed characteristics relate to parameters of our model in a highly clustered network.

References

McCullen, N J, A M Rucklidge, C S E Bale, T J Foxon, and W F Gale. 2013. "Multiparameter Models of Innovation Diffusion on Complex Networks." *SIAM Journal on Applied Dynamical Systems* 12 (1): 515–32. doi:10.1137/120885371.

Watts, Duncan J, and Peter Sheridan Dodds. 2007. "Influentials, Networks, and Public Opinion Formation." *Journal of Consumer Research* 34 (4): 441–58. doi:10.1086/518527.