Exploiting graph structure in diffusion control strategies

Description: The Dynamic Resource Allocation (DRA) has been proposed as a framework on which control strategies can be developed aiming to dynamically suppress a Susceptible-Infected-Susceptible (SIS) diffusion process [1,2]. The considered SIS process is a continuous-time Markov process that allows node recoveries and (re-)infections in a stochastic setting. The DRA strategy acts at a micro-level deciding exactly which nodes should receive the treatment resources. In the related work there has been proposed to develop score-based strategies where a deterministic criticality score is computed locally for each node providing a node ranking for deciding where to allocate the treatments, like LRIE [1] and Priority-Planning [2]. Roughly speaking, the first can be seen as a local approximation of the second approach. As such, it doesn't have a long term plan but it can be more appealing for cases where the network is partially known, and also adapt to changes in the environment (e.g. network changes).

The directions of work in this project can be:

- extending the modeling side behind LRIE by considering more general SIS-like epidemic models (i.e. allowing reinfections). Examples are models with intermediate incubation states or competitive scenarios.
- designing better performing greedy strategies that may combine structural properties of the network and compare that with meta-population models from the optimal control literature (i.e. considering a k-cluster structure at the top level, and a mixing model inside each cluster).
- go beyond the deterministic local scoring by incorporating Monte Carlo approximations of network evolution that can then be used as refined criticality scores. This can also help in cases of partial knowledge of the infections states of nodes.

The work will be based on existing work, therefore the students will need to review existing material, use code repositories, etc., and will be asked to generalize theoretically the methods to the aforementioned cases, run simulations, and finally highlight insights about the problem.

Topic keywords: epidemics, social interactions and behavior, diffusion control

Indicative references:

[1] Scaman, K., Kalogeratos, A., and Vayatis, N. (2015). "A Greedy Approach for Dynamic Control of Diffusion Processes in Networks". Proceedings of International Conference on Tools with Artificial Intelligence.
[2] Scaman, K., Kalogeratos, A., and Vayatis, N. (2016). "Suppressing Epidemics in Networks using Priority Planning". IEEE Transactions on Network Science and Engineering.
[3] Fekom M., Vayatis, N., and Kalogeratos, A. (2019). "Sequential Dynamic Resource Allocation for Epidemic Control". International Conference on Decision and Control.