Unifying information propagation models on networks and their influence maximisation

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Information propagation is a central theme in social, behavioural, and economic sciences, with important theoretical and practical implications, such as the influence maximisation problem for viral marketing. There are two widely adopted models in this context: the independent cascade model where nodes adopt their behaviour from each neighbour independently, and the linear threshold model where collective effort from the whole neighbourhood is needed to influence a node. However, both models suffer from certain drawbacks, including a binary state space, where nodes are either active or not, and the absence of feedback, as nodes can not be influenced after having been activated previously. To address these issues, we consider a model with continuous variables that has the additional advantage of unifying the mechanisms underlying these two classic models. For the associated influence maximisation problem, the objective function encoding the sum of the overall influence on each node is no longer submodular, a feature that most approximation algorithms are based on but could be strict in practice. Hence, we develop a framework, where we formulate the influence maximisation problem as a mixed integer nonlinear programming and adopt derivative-free methods as general solutions. Furthermore, we show that the problem can be exactly solved in the special case of linear dynamics, and propose a customised direct search method accordingly, with local convergence. We demonstrate the rich behaviour of the newly proposed information propagation model and the close-to-optimal performance of the customised direct search method numerically on both synthetic and real networks.

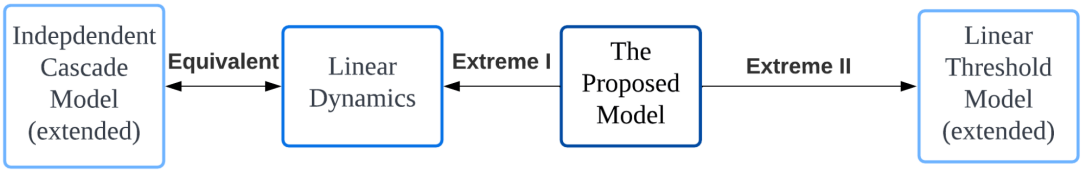

Figure 1: An illustration of the proposed general class of information propagation model, where the classic independent cascade model and linear threshold model after extended for continuous variables and deterministic dynamics can be recovered by setting appropriate model parameters.

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References

[1] Y. Tian, R. Lambiotte, *arXiv:2112.01465* (2021).