Influencer-Follower Dynamics for Advertising Campaign Goal Statement

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1 Goal

To create an agent based model to simulate the propagation of advertising campaigns in a population of influencers and followers, and analyse the effects of influence on the consumption patterns of the population. In addition, study the efficacy of different advertising strategies under budget and time constraints.

2 Literature Review

Agent based models have previously been used to simulate the spread of influence in a population. An agent based model simulation of the propagation of a viral marketing campaign by word-of-mouth, along with spatial strategies for choosing 'viral' (influential) agents has been attempted [1].

In this model, a consumer agent is in one of three states: Susceptible, Latent and Infected. Every agent is equal regarding their influence on others. However, this is certainly not the case in a real population of influencers and followers. An influencer will have varying levels of influence on its followers. Three broad classes of social influence namely, assimilative influence, similarity-biased influence and repulsive influence are described in [2]. These classes have been used to study the consensus of opinion in automated information campaigns [3]. The usefulness and challenges of agent based modelling for consumer behaviour in media markets have been evaluated in [4]. The authors also create a retail customer model to analyze the apparel market. The application of agent based models and simulations is getting increasing attention from the research community.

Although simple models of social influence have been studied, they do not account for the subjective nature of influence. This makes them less practicable for real world scenarios. The effects of advertising strategies under budget and time constraints seems to be unaddressed. Such analysis would greatly help in designing optimal advertising strategies.

Social networks are known to show the *small world phenomenon* - the idea that the world looks "small" when you think of how short a path it takes to get from you to almost anyone else. It's also know as the *six degrees of separation*[5]. The first experiment of this notion was performed by Stanley Milgram[6]. This is the source of our motivation to model our network as a small world graph.

3 Architecture

We propose an agent based network model to effectively model the subjective nature of an influencer on different followers. This can be achieved by representing a network as a directed graph with each agent a node in the graph.

3.1 The Graph Based Network

Social networks are known to show the small world phenomenon. Thus, our network of influencers and followers is represented as a small world directed graph. A small world graph can be created using the Watts–Strogatz model [7]. The subjective influence is captured in the directed graph by representing the influence level of one node on another as the edge-weights. This also incorporates the notion that every agent is an influencer with varying levels of influence. The graph G is defined as follows:

$G = (V, E)$ where:
- V, a set of nodes (agents)
- $E \subseteq \{(x, y) \mid x, y \in V \text{and } x \neq y\}$, representing the influence of node x on node y
- $W = \{w(e) \mid e \in E\}$, the edge weights representing the influence level

3.2 The Agent

An agent possesses the following attributes:
- ID: A unique identity used to represent an agent in the model.
- DOI: Degree of Influence which is the out degree of the agent-node in the graph.

$$DOI = deg^{+}(v), v \in V$$

- Interest (γ): The interest the agent has in a particular advertised campaign, where:

$$0 \leq \gamma \leq 1$$

3.2.1 Agent's Decision Rule

An agent i's decision for or against a particular advertisement campaign in response to the influence of another agent j is defined as:

$$d_i = \begin{cases} True, & \text{if } f(\gamma, w(e_{ji})) > threshold \\ False, & \text{otherwise} \end{cases} \tag{1}$$

Where $w(e_{ji})$ is the influence of agent j on agent i (edge weight). Three arbitrary agents are shown in Figure 2.

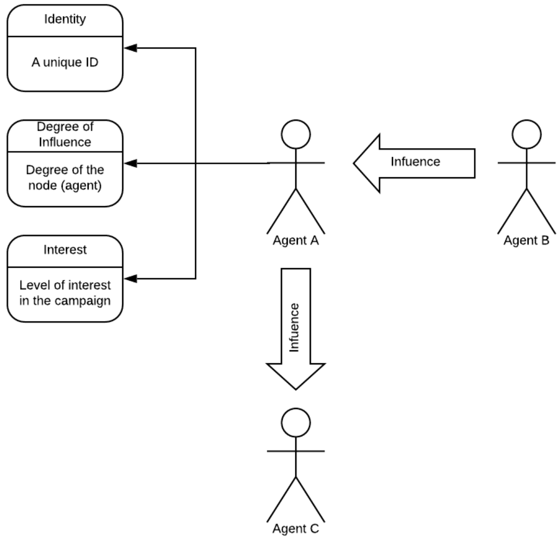

Figure 1: Attributes of an agent

3.3 Initialization

The first crucial step in this architecture is to initialize the agent based graph network, and all the attributes of an agent.

1. We create a directed small world graph where each node is an agent.
2. Once we have created the graph network, the out degree of each agent is determined. This helps interpret who is a big and small influencer.
3. The edge weights coming out of an agent are then assigned with some sort of probability distribution depending on the agent's DOI.
4. The interest values are assigned for each agent using a random distribution.

The network is now ready to propagate an advertisement campaign!

3.4 Influence Propagation

The propagation of influence begins with a selected set of agents. It is propagated in a breadth first manner, the intuition being that the directly connected agents of the source will first be aware of the campaign followed by their neighbours and so on. In other words, the propagation starts from the source, visits all the children of the source in the first time step, and these children take respective decisions and perform their updates. Then the children's children are visited and so on.
Here are the equations displaying the BFS propagation. Set A_l is the set of agents whose decision changed to true in l th iteration.

1. First Iteration ($l = 1$): Starting BFS from source agent:

$$d_i, \ \{\forall i \mid v(i) \in N(source)\} \tag{2}$$

$$A_l = \{v(i) \mid \forall i \ st. \ d_i = True\} - A_{l-1}, \ l = iteration \ number \tag{3}$$

$$Update: \ \gamma_{i,l}, \ \{\forall i \mid v(i) \in N(v(j)) \forall j, \ st. \ v(j) \in A_l\} \tag{4}$$

2. Following iterations:

$$d_{i,l}, \ \{\forall i \mid v(i) \in N(v(j)) \forall j \ st. \ v(j) \in A_{l-1}\} \tag{5}$$

3.5 Attribute Updates

In every iteration, the interest (γ) attribute of an agent i in response to a neighbour agent j's decision at l th iteration is updated as:

$$\gamma_{i,l} = \psi(d_j, w(e_{ji})), \ \{\forall j \mid v(i) \in N(v(j)) \ and \ v(j) \in A_l\} \tag{6}$$

3.6 Workflow

The workflow of the proposed system is shown below. The agents are initialized as nodes of the graph and the propagation of the advertisement begins from select agents. The initialisation can be done with basic intuition or based on empirical evidence. As the advertisement campaign propagates, each agent makes a decision for or against the campaign based on a set of defined rules. The agents then update their attributes and the system proceeds to the next iteration.

4 Experimental Strategies

The following strategies will be experimented with, and evaluated based on the number of people that have positively adopted the campaign:

4.1 Budget and Time Management

We define the cost of a Big Influencer as C_{big} and a Small Influencer as C_{small}, where $C_{big} >> C_{small}$. Given a finite budget, and a target number of consumers to reach, we shall evaluate four different advertising strategies:

1. Employ only Big influencers for the campaign.
2. Rather than a Big influencer, employ more than 1 Small Influencers for the campaign.
3. Employ Small Influencer which has 1 or more Big Influencer as a follower
4. Employ a combination of Big and Small Influencers for the campaign.

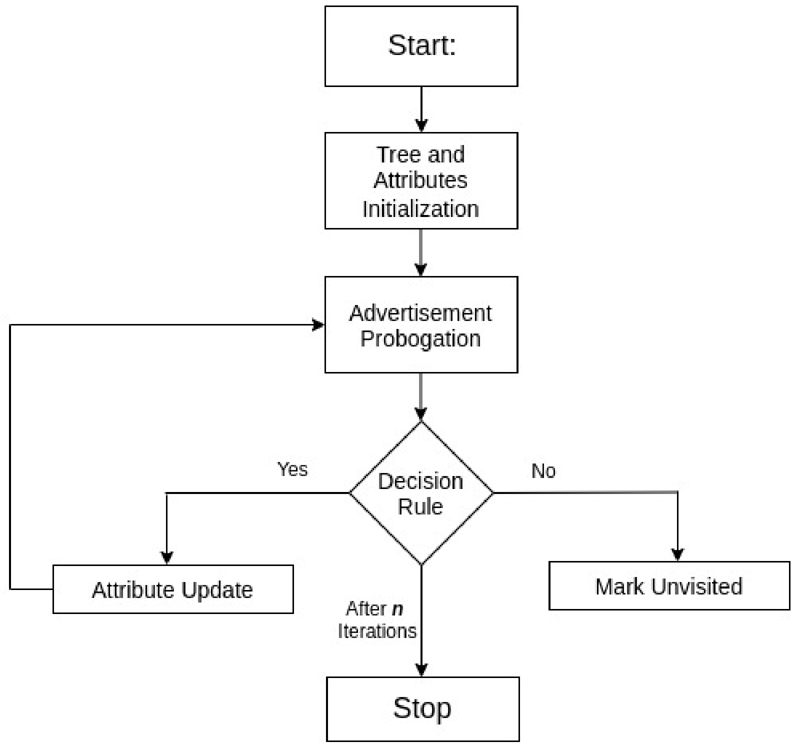

Figure 2: Agent Based System Workflow

4.2 Spatial Arrangement of Influencers

We shall analyze the results of different spatial arrangements of the potential advertisers. The closeness is simply the geodisic distance between two nodes. Two simple spatial arrangements shall be addressed in the case of both big and small influencers:

- Scattered
- Clustered

Tools and packages: Python: Mesa, NetworkX

5 Milestones

Serial Number	Date of Completion	Objective
1	22th August	Define the graph and agents: attributes, actions.
2	7th September	Implement the agent based model.
3	16th September	Simulate the model, analyze and interpret the influence propagation. Modify attributes and behaviour as necessary.
4	27th September	Simulate and experiment using the mentioned experiments.
5	23th October	Refine the model and begin documentation
6	25th November	Complete the documentation

References

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