Modeling the Effect of Propaganda in Civil Violence Simulations

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Abstract

This paper focuses on the effect of propaganda in social simulations regarding the outburst of civil violence. Given an agent-based computational model for the dynamics of civil population and central authorities during civil violence outbursts, we augment the model with agents that spread propaganda in favour of rebellion and attempt to further model the dynamics between different agents with different propaganda influences. Preliminary results showcase the effect of propaganda spreading in the systems equilibria, by gradually spawning larger (time-wise) and more massive rebellions that converge to the majority of the population suppressed by the authorities.

1 Introduction

While many articles have been written about agent-based modelling approaches and their appliances in the field of social sciences, the topic of civil violence still offers an opportunity to further improve our knowledge of agent-based systems and their capabilities of simulating complex real life scenarios. This paper describes and evaluate an implementation designed to improve on an existing model. We will elaborate on the problem, the state of the art and suggested extensions.

1.1 Problem

Civil violence has been a problem throughout history and much research has been done in an effort to better understand its causes and possible solutions. After significant increases in available computing power in the last decades, computers now offer more efficient ways of analysing complex social phenomena.

If one would be able to accurately simulate the behaviour of crowds engaging in violence against some ruling authority, it might be possible to deduce some details about the dynamics of the crowd. This could be of interest to police and state as well as protesters, along with social scientists and anthropologists studying human violence affairs. Since the phenomenon is most likely caused and influenced by many factors, models designed to simulate it should take into account as many parameters as possible in order to truly understand which of those factors are of most influence in the real world.

1.2 State of the art

To the best of our knowledge, there currently exists only one out of a family of papers [Eps07] describing an agent-based computational approach to the problem of modeling civil violence [Eps02]. In this article two forms of civil violence are considered, being a situation wherein a central authority tries to suppress the violence between two ethnic groups and a situation wherein a rebellion against a central authority is simulated. To allow for detailed expansion of the proposed model, we will consider only the latter.

The model described in this article involves two types of agents, being population and cops. Population agents are threshold based, meaning that they will become active, i.e. join the rebellion if some internal value reaches a critical level. Cop agents are continuously performing one task, as they scan their surroundings for active agents and arrest them according to some random probability.

Given these attributes, the model is driven by a set of rules. For a population agent it holds that if the sum effect of all its attributes become greater than the rebellion threshold, the agent will transition to an active (rebellious) state and otherwise stay in a inactive (quiescent) state. Parameters both intristic to each agent and heterogeneous, but also globally set and equally perceived by all agents, intertwine to determine the transition of citizens from one state to another. The dynamics of inter-citizen interaction (local) as well as the whole system's (simulated society) equilibrium points (global) are to be expressed through all these parameters.

1.3 New Idea

An effect that the model did not take into account however is propaganda. Propaganda has shown to be of significant influence in many occasions in the past, and the model described above could be used to analyse its influence on rebellious crowds. The following sections will describe how this effect could be added to the agent-based modeling approach for civil violence and discuss the results obtained using the implementation.

2 Method

In this section we will provide a detailed overview of the implemented agent-based model, the design of the developed software as well as the theoretical framework behind the experiments that are taken.

2.1 Simulation model

An analytical description of the simulated world model and the different classes of agents follows:

World Model We use the same world model that is suggested in [Eps02], where the world is simulated on a $40x40$ grid, each element representing an agent or an empty cell. Each agent has a local vision, the grid elements within which can inspect. Movement is random, unless defined otherwise by individual agents behaviour rule, meaning that in each simulation step the agent chooses a random empty cell within local vision and moves there. The grid is initialised randomly, with respect to the given densities of different agents as global parameters.

While a grid of such size might not seem large enough for simulating complex crowd dynamics, results showed that several aspects entailing civil violence and rebellion could successfully be explained using this model.

Exogenous Parameters This is a collection of model parameters that define the behaviour of agents globally or help us control the dynamics of their interaction throughout the simulation. The list of all parameters is given below:

- `citizen density`: The initial percentage of grid cells that is occupied by population agents (default = 70%).
- `cop density`: The initial percentage of grid cells that is occupied by cop agents (default = 7%).
- `propaganda density`: The initial percentage of grid cells that is occupied by propaganda agents (default = 4%).
- `citizen vision`: The local vision within which population and propaganda agents can inspect grid cells or move to (default = 7).
- `cop vision`: The local vision within which cop agents can inspect grid cells to arrest rebels or move to (default = 7).
- `government legitimacy` (L): A term that defines the global perception of the population regarding the legitimacy of the government. This is used to incorporate different sociopolitical environments, or different sample populations (e.g. analysis of historical civil violence outburst in the Middle East states during war, compared to a civil rebellion in the state Canada) (default = 82%).
- `max jail term`: The maximum number of simulation steps that arrested rebels are sentenced to jail (default = 30).
- `propaganda factor` (w): This factor decides how strong the influence of propaganda in the population agents decision of rebellion is (default = 0.1%).
- `propaganda agent exposure threshold` (T_P): How much a propaganda agent can influence citizens in rebelling, before the central authorities expose them and attempt to arrest them (default = 5000).
- `active threshold` (T_A): This is a quantitative threshold of intristic population agents properties that will decide whether they will rebel or not. More details about this parameter are given in the following section (default = 0.04).

2.2 Simulated agents

The properties of the three implemented classes of agents are described below:

Population Agent This agent realises a general citizen of the population. This citizen represents the average subject of our hypotheses, meaning that we want to model all properties that will determine when and why this citizen will manifest rebellious behaviour. The list of all attributes that define the citizens behaviour is given below:

- `agent class = 'POPULATION'`
- `agent state:` The current state of the agent. Can be either *Quiescent (Q)*, for non-rebellious, *Active (A)* for rebellious agents or *Jailed (J)* for arrested agents.
- `perceived hardhsip (H):` A metric of the agents perceived hardhsip, in terms of economic or physical privation. This parameter is modelled heterogeneously across agents and is distributed uniformly across the population on the interval $(0, 1)$.
- `citizen vision (v):` This is set by the global parameter, defining the local vision of the agent.
- `risk aversion (R):` The level of the agents risk aversion. This provides an heterogeneous distribution of agents inherent bias towards taking risks, granting the top risk averted citizens more likely to be vulnerable in joining violence outbursts. It is also distributed uniformly in $(0, 1)$.
- `probability of arrest (p):` The perceived likelihood of arrest that is calculated for each agent in each simulation step and varies depending on the agents local neighbourhood state. This is the answer to an agents question: "How likely it is to get arrested if I go active?". This factor is calculated as:

  $$p = 1 - exp(-k \cdot \left\lfloor (\frac{C}{A})_v \right\rfloor)$$

  where the $(\frac{C}{A})_v$ term denotes the ratio of cops C versus active (rebellious) agents A within local vision v. The result is floored after experimentation, in order to produce the system equillibria described in [Eps02]. The constant $k = 2.3$ is set to ensure a plausible estimate (of $p = 0.9$ when $C = 1$ and $A = 1$), as suggested in the paper. When an agent calculates this probability, it accounts herself as an active agent.

  Through the last two parameters, each agents individual *net risk (NR)* parameter is defined:

  $$NR = R \cdot p$$

- `susceptibility (s):` How vulnerable an agent is to the effect of propaganda agents. This is also uniformly distributed in $(0, 1)$. The more susceptible an agent is, the more likely it is for them to go active for the same net risk value. Likewise, the least susceptible agents will be almost immune to the influence of propaganda.
- `propaganda effect (PE):` The influence of propaganda in the agents decision of rebellion. This is calculated as:

  $$PE = s \cdot \sum_{j=1}^{P_v} \frac{P_j(I)}{P_v}$$

  where P_v denotes the number of propaganda agents P within local vision v and $P_j(I)$ denotes the j-th propaganda agents influence I. More details about I follow in the definition of propaganda agents.

- `grievance (G):` *

$$G = \frac{H \cdot (1 - L) \ + \ w \cdot PE}{1 + w}$$
$$A: \qquad G - NR > T_A \tag{1}$$

- `jail time (jt):` The amount of simulation steps that an arrested agent has to remain in jail, drawn randomly from the interval [1, `max jail time`]. During this state, the agent stays idle and no further operations are performed until she is released.

Propaganda Agent This agent aims at spreading propaganda in the general population (in any context of fake news, political bias, character assassination etc.) for the purpose of overthrowing the existing regime, by initiating other citizens to rebel against the central authorities. The list of all attributes that define the propaganda agents behaviour is given below:

- `agent class = 'PROPAGANDA'`
- `agent state:` Can be *Hidden (H)*, defined initially for all propaganda agents in work, *Exposed (E)* for propaganda agents that have severely affected the outburst of a rebellion and *Jailed (J)* for exposed propaganda agents that have been arrested by the central authority.
- `citizen vision (v):` This is set by the global parameter, defining the local vision of the agent.
- `influence (I):` This models the effectiveness of the agents propaganda spreading. It is again heterogeneously distributed amongst the propaganda agents by being randomly drawn from $U(0,1)$.
- `jail time (jt):` The amount of simulation steps that an arrested agent has to remain in jail, drawn randomly from the interval [1, `max jail time`]. During this state, the agent stays idle and no further operations are performed until she is released.
- `total influence (`ΣI`):` This parameter models the total effectiveness of the agents workings through the course of the simulation. In each simulation step, the propaganda effects PE that a propaganda agent causes within her local vision are added to the memory of the model:

  $$\Sigma I = \sum_{j=1}^{Q_v} \frac{PE_j}{Q_v} = \frac{I}{Q_v} \cdot \sum_{j=1}^{Q_v} s_j$$

  where Q_v denotes the number of inactive population agents Q within local vision v, and s_j the susceptibility of each one of the citizens that are affected by this agents propaganda.

  After the agent has exceeded the defined propaganda agent exposure threshold T_P, then the agent changes state to *Exposed (E)* and is visible to the central authorities:

  $$\Sigma I > T_P \tag{2}$$

  When an exposed propaganda agent is arrested, his total influence is greatly decreasing, using the update rule:

  $$\Sigma I := \frac{\Sigma I}{jt} \tag{3}$$

Cop Agent An agent that realises the central authorities attempting to manage civil violence outbursts by arresting rebellious citizens. This is a very basic module, implemented only by the two basic attributes:

- `agent class = 'COP'`
- `cop vision:` This is set by the global parameter, defining the local vision of the agent.

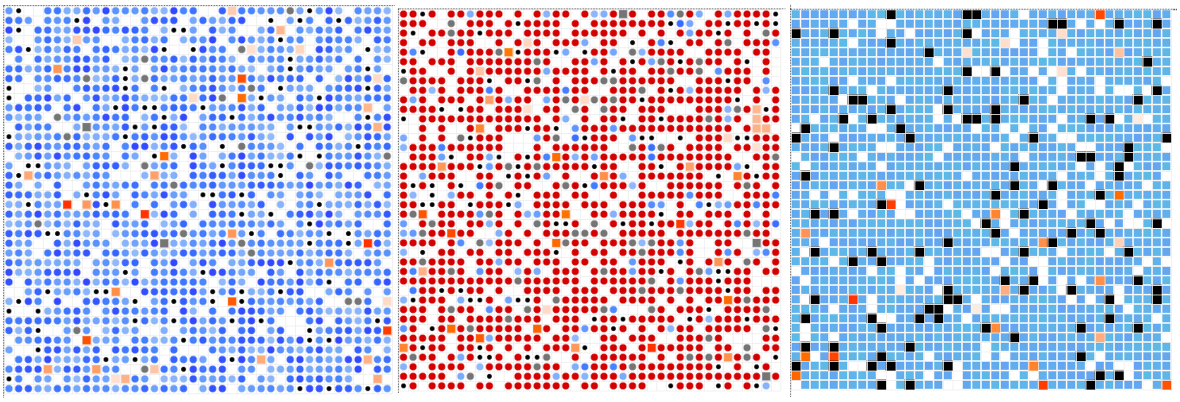
At each simulation step, a cop agent investigates the state of all agents within local vision. Priority of arrest is given to exposed propaganda agents and then to active population agents. If one of these agent classes is spotted within the neighbourhood, the cop agent arrests sem, sets a jail sentence for them and moves to their location.

2.3 Implementation details

All software has been implemented using *Python 3.6* in combination with the *MESA* agent-based framework [MK15] and is uploaded in our github repository. Through *MESA* modular server and visualisation APIs, the world grid, global parameters and plots demonstrating various aspects of the model and agents behaviour are implemented.

A detailed overview of the visualisation modules is given throughout the following sections:

Grid Maps For the visualisation of the grid, we have implemented two different maps, the *Action Map* and the *Grievance Map*, presented in Figure 1..



(a) Action Map: Initial state (b) Action Map: Rebellion state (c) Grievance Map

Figure 1: Visualization of the grid state, both with an action map describing the agent classes and states and with a grievance map, showing the grievance of all population agents.

The action map can be translated with the following rules:

- Population agents that are in the *Quiescent (Q)* state are depicted with blue dots, with the intensity of the color denoting their susceptibility parameter s. Therefore, brighter agents are influenced less by propaganda.
- Population agents that are in the *Active (A)* state are depicted with red dots.
- Black dots denote cop agents.

- Orange squares denote the position of propaganda agents within the grid. Likewise to the population class, the intensity of the color denotes the influence parameter of the agent. Therefore, brighter agents have less influence upon neighbouring citizens.
- Gray dots and squared depict jailed population and propaganda agents respectively.
- White spaces depict empty cell in the grid where agents can move to.

For the grievance map, the purpose of the visualisation is to have an insight to the true state of the agents grievance, regardless of their state in the action map. As we will discuss in the following section, population agents raise deceptive behaviour, by turning quiet when multiple cop agents move closer. However, their internal grievance state is still high, granting them a very likely target for another violence outburst. In that sense, the grievance map provides a more truthful visualisation of the population agents rebellious potential. This can be translated as:

- Black squares depict cop agents.
- Orange squares depict propaganda agents, with the same color variance as before.
- The turquoise squares depict all population agents, with the intensity denoting their grievance at the current simulation step. Darker squares are highly aggravated towards the government, and are very likely to be or become active with the absence of neighbouring cop agents.

Global Parameters All exogenous parameters defined in the previous section, along with the parameter `framerate` configuring the speed of the simulation can be set dynamically from the interface of MESA's modular server, like it is demonstrated in Figure 5

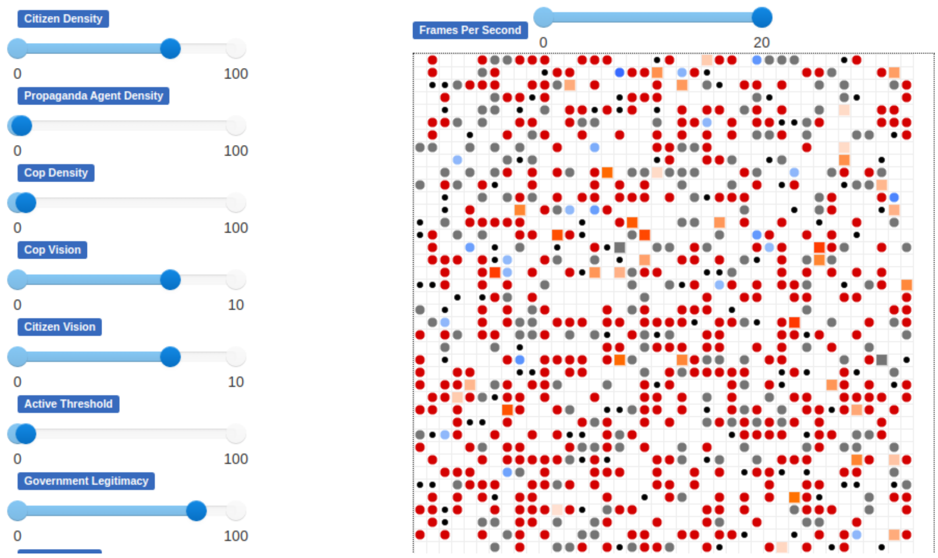


Figure 2: Dynamic parameter reconfiguration through the modular server.

Agent State Graphs Along with the grid, a figure of the number of different agent classes and states is plotted. Through this plot, the local dynamics of agent interactions can be viewed and explained (e.g. a red positive spike follows a steep blue decrease). An example of this plot for our default model settings after 1365 iterations is demonstrated in Figure 3

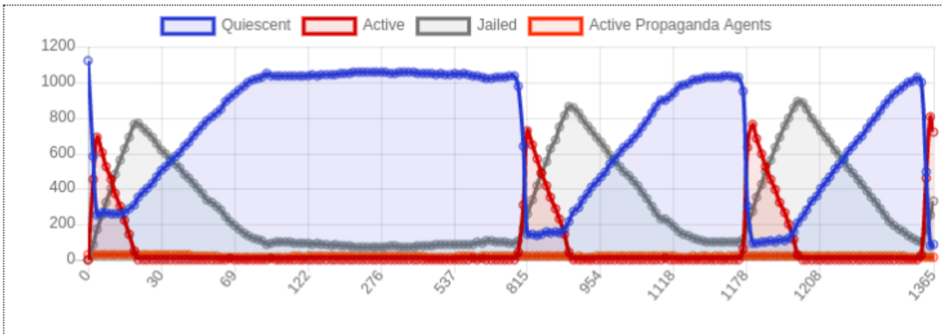


Figure 3: A line plot demonstrating total count of different agent classes and states.

Moreover, a barplot of the agent states is given for a more static view of each simulation step's dynamics. Such a barplot is shown in Figure 4

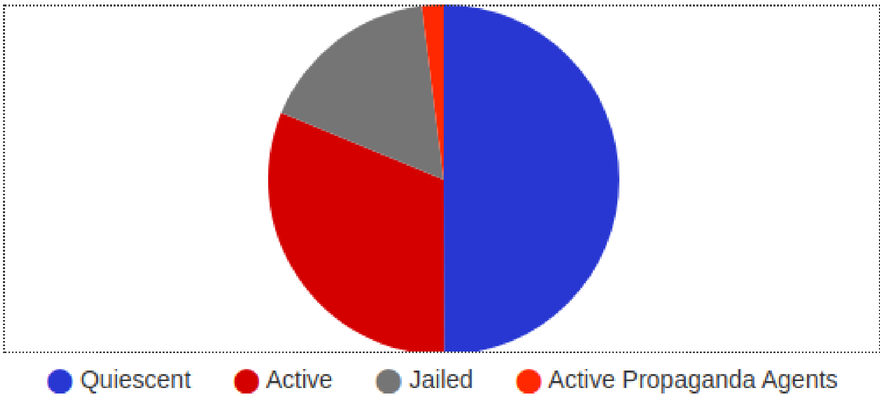


Figure 4: A barplot demonstrating the different agent classes and states in each simulation step.

Model Properties Another figuring denoting properties of the model (simulations of individual agents properties) that can prove useful when interpreting both local (interactions while-after rebellion) and global (regularities in rebellion outburst and waiting times) dynamics. An example of this plot with the default model settings is demonstrated in Figure **??**. The depicted properties can be defined as follows:

$$\sum G = \sum_{j=1}^{Q_*} G_j, ; \quad \sum \Sigma I = \sum_{j=1}^{P_*} \Sigma I_j, \quad \sum NR = \sum_{j=1}^{Q_*} NR_j$$

where Q_* and P_* denote the total number of Q state population agents and propaganda agents in the entire grid.

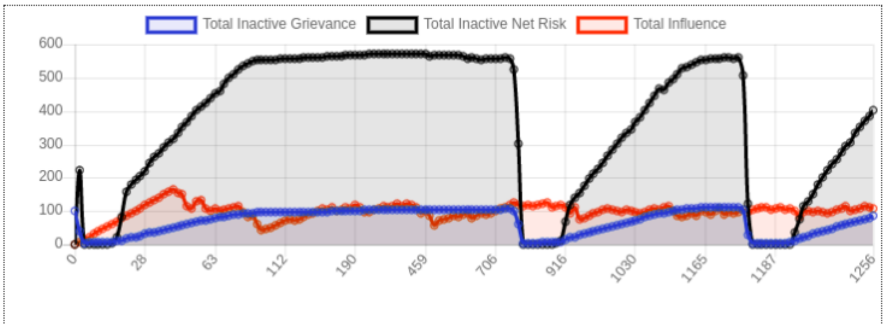


Figure 5: A line plot demonstrating total sum of different model properties.

2.4 Experiment design

In order to research the effect of propaganda in local and global agent dynamics we perform the following experiments.

1. Zero out the effect of propaganda and verify that the system presents the same equilibrium as of this discussed in [Eps02]. These parameter settings comprise the baseline model.
2. Gradually add the effect of propaganda, and investigate the effect of propaganda agents in the system's local dynamics, by comparing the spike shape in this model setting with the baseline.
3. Investigate the effect of different propaganda global parameter setttings, namely: a) initial spawn density, b) exposure threshold
4. Investigate the effect of the propaganda agents exposure - jailing scheme in the global dynamics of the system (#TODO).

3 Results

3.1 Experiment findings

For each one of the experimental goals presented in the previous section,a specific parameter setting has been found to reproduce the desired results.

Baseline After removing the effect of propaganda agents entirely and properly adjusting the active threshold parameter T_A, the model is able to reproduce the punctuated equillibria effects that are described thoroughly in Epstein's conclusion section. The system converges at an alternating state between rebellions, with the waitimg times between expressing some regularities, as shown in the agent state plot of Figure 6, where the red spikes represent the rebellious outbursts.

Propaganda effect After gradually increasing the effectiveness of propaganda agents in the population agents activeness decision through increasing their grievance, we inspect the action plot of the two model settings in Figure 7.

After viewing the red spikes at both plots, we can clearly see the effect that propaganda has in the local dynamics of the system. This is demonstrated in the plot but the smoother

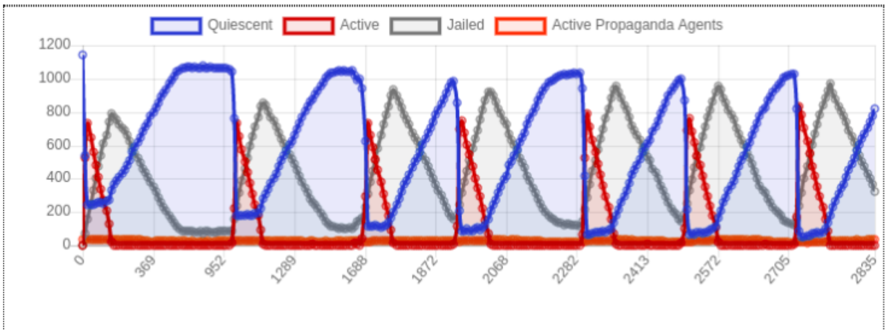
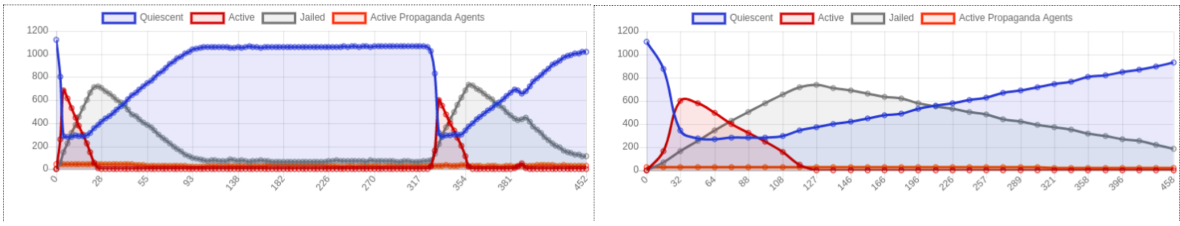


Figure 6: Baseline model demonstrating Epstein's system equillibria.

and larger (in terms of time duration) rebellions, as we see the slope of the red curve in the right plot ending up at simulation step 128, whereas the baseline model ends at about 30.

Additionally, we observe that the propaganda factor has in general shifted all agent state counts to larger and smoother transitions (gray and blue curves also) moving the average waiting time of the system compared to the baseline model. We characteristically observe that in the same time frame the baseline model has completed a full cycle of states, whereas the propaganda model has not even reached the maximum number of quiet agents that bounds the system.



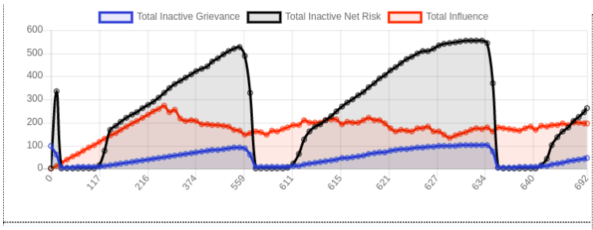
(a) Baseline Model: $w = 0$

(b) Propaganda Model: $w = 40\%$

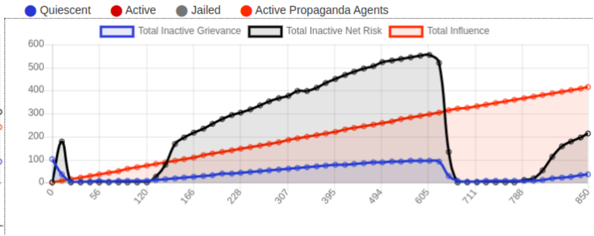
Figure 7: Baseline versus propaganda models. Rebellions in propaganda societies last longer and smooth out instead of ending suddenly.

Lastly, by also observing the *Grievance Map* of the model, like the grid *(c)* of Figure 1, we can again witness the effect of propaganda, as we see darker turquoise (highly aggreviated) agents being gathered mostly in regions around propaganda agents than in regions without them.

Further adjusting the propaganda density will shade out the rebellion effects, as occupying more and more spaces inside the grid leaves no space for random movement and therefore it is highly unlikely that a group of aggreviated citizens will gather up at the same region without the presence of central authorities. The exposure threshold will affect the distribution of propaganda agents within the simulation, ranging from them become exposed and jailed simultaneously to widely spread within the course of the simulation, as shown in the model properties plot of Figure 8.



(a) $T_H = 0.1$



(b) Propaganda Model: $T_H = 0.5$

Figure 8: Propaganda agent exposure threshold affects the distribution of propaganda agents within the simulation. In (a) the model holds a small threshold and thus presenting an slightly varied distribution. In (b) the threshold becomes larger and therefore agents stay hidden for longer periods.

4 Conclusion

4.1 Discussion

#TODO

4.2 Relevance

#TODO

4.3 Team Work

#TODO

References

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