Effect of mobility on violence in a bi-communal population (Extended Abstract)

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ABSTRACT
We develop a multi-agent based model to simulate a population which comprises of two adversarial groups and a peacekeeping force. We compare the effect of random and ingroup migration strategies for civilian movement on the resulting violence in this bi-communal population. Ingroup migration leads the formation of clusters. Furthermore, we show that in settings where only one of the two groups adopts ingroup migration it is a winning strategy in violently predisposed populations. On the other hand, in relatively peaceful settings clustering is a restricting factor.

Categories and Subject Descriptors I.6.5 [**Simulation and Modeling**]: Model Development, Modeling methodologies J.4. [**Social and Behavioral Sciences**]: Sociology.

General Terms Experimentation, Human Factors.

Keywords Description level: experimental/empirical: simulations. Inspiration source: social sciences. Focus: Comprehensive/Cross-cutting (multi-agent based simulation), Social/Organizational (groups and teams, emergent behavior), Environment (environment modeling & simulation)

1. INTRODUCTION
Agent-based models have long been used to simulate social phenomena: inter-group tension is one such example. The model described in this paper is based on an integration of the agent behaviour in Schelling's seminal segregation model [1] into the inter-group violence model detailed in Epstein's *Modeling Civil Violence* [2]. Several attempts at expanding upon Epstein's work in this area have been made, including Goh et. al's [3] game theoretic approach to agent decision making, while Jager et. al [4] examine the effect of clustering during civil violence.

This paper will compare the relative effects of random movement and ingroup migration on levels of violence within a civil violence simulation. We will also aim to identify the movement strategy that provides the highest chance of survival given more or less violently disposed populations.

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2. MODEL
The model comprises a grid containing two sets of agents: civilians and peacekeepers. Agents act once per simulation step. We improve upon Epstein's definitions of hardship, legitimacy and calculation of arrest probability by implementing a simpler utility-maximisation approach. Additionally, the utilities in our model are drawn from a Gaussian distribution whose mean elegantly represents the violent predisposition of the population.

2.1 Civilians
Civilians represent members of the population and are split into two groups, nominally "blue" and "green". The groups are roughly equal in number and possess identical attributes and behaviors. Civilians may either "go active" and kill a member of the opposing group or migrate to another grid location.

Civilians make this decision by comparing of two utilities, U_I and U_A, and choosing the action which carries the highest value. U_I is a uniform constant representing the utility of being non-violent (inactive). U_A is the civilian's utility of going active and is a composite variable, given by equation 1:

Equation 1: $U_A = P_{AR} U_{AR} + P_{NAR} U_{NAR}$

U_{AR} is a constant, exogenous and uniform value representing the utility of being arrested. U_{NAR} is the perceived benefit of killing another civilian without being arrested, and is drawn from a Gaussian distribution of the values $(0,1)$. P_{AR} is the estimated probability of being arrested while P_{NAR} is the estimated probability of going active and escaping arrest.

Equation 2: $P_{AR} = 1 - P_{NAR}$

Equation 3: $P_{NAR} = \left(\frac{\alpha - 1}{\alpha}\right)^{\Pi}$

Π represents the number of peacekeepers in the civilian's radius of vision (V_C), and α represents the number of active civilians within the civilian's V_C.

There are two types of migration allowed for in this model: random migration and ingroup migration. In random migration, civilians move randomly to an empty cell within their V_C. Ingroup migration involves an check of the free cells within the civilian's V_C. The civilian moves to the location neighboured by the greatest number of members of its ingroup. If several locations have the same amount, one is chosen at random.

2.2 Peacekeepers

At each step, peacekeepers compile a list of active civilians within their radius of vision (V_p). The peacekeeper then chooses randomly from that list and arrests the civilian, temporarily removing it from the grid. If none are found, the peacekeeper moves to a random free location within their V_p.

3. EXPERIMENTS

Three sets of experiments were conducted. Ten runs of 1000 steps for U_{NAR} values from 0 to 1 in increments of 0.1 were conducted. At the end of each run, a count of the number of remaining members of each group is made – the final population. Each data point in the graphs represents an average value for each set of runs.

4. RESULTS

In this section we analyse the findings from our experiments. For each of the three experiments, we present a graph showing the average final population of each group for each U_{NAR} value.

4.1 Random only

To establish a baseline, this experiment presents the finishing states of runs in which both groups migrate randomly. As expected, final populations decrease as violence increases, with both groups following the same trend.

4.2 Ingroup only

In this experiment ingroup-based migration was enabled for both civilian groups. Violence is significantly lower than in experiment 4.1. Civilians quickly cluster into segregated groups. When the "buffer zones" of empty cells between the clusters become sufficiently large, the two groups cease to meet and we observe peaceful co-existence even at high U_{NAR} values. As above, when both groups adhere to the same migration method, average final populations at each U_{NAR} value are random.

4.3 Random vs. Ingroup

In this experiment, ingroup migration is enabled for green civilians, while blue civilians move randomly. In conducting this test, we demonstrate the difference a civilian's migratory decision-making makes to its chances of survival.

Figure 3 shows a trend towards increased survivability using random migration in less violent populations, with ingroup migration faring better under increased violence. At lower U_{NAR} levels, less fighting occurs before the green group forms clusters, leading to a densely populated grid and larger targets for the blue group to attack. At higher U_{NAR} values however, the clustering of the greens becomes an advantage. Because higher violence levels at the steps prior to clustering leads to a lower population density, peacekeepers are given fewer violent civilians to cover, increasing their effectiveness.

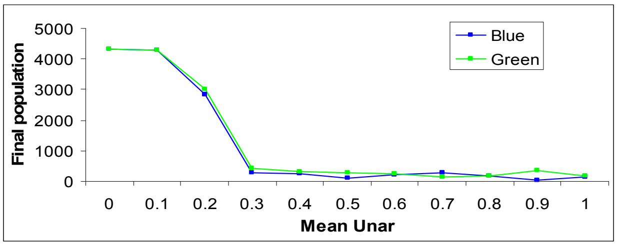

Fig 1. Random migration for both groups: final populations.

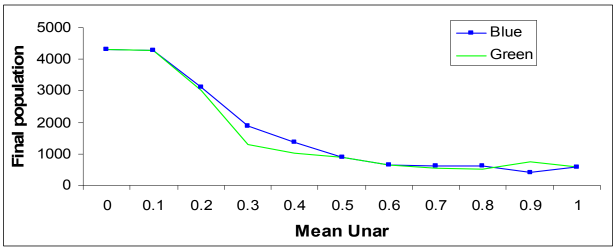

Fig 2. Ingroup migration for both groups: final populations

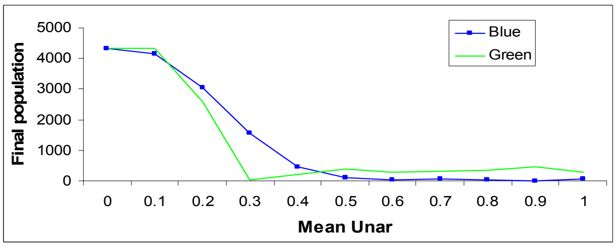

Fig 3. Ingroup migration for greens vs. random migration for blues: final populations

5. CONCLUSIONS

In this study, we presented an agent-based model of civil violence based upon previous work by Epstein. We enhanced the decision-making abilities of Epstein's agents using a utility-maximising approach, and introduced Schelling-esque migratory behaviour. We were able to establish a link between the relative success of random and ingroup-based migration in peacefully or violently predisposed populations. Ingroup-based migration was found to be the optimal strategy when civilians are more inclined towards violence, while random migration gave a better chance of survival in more peaceful populations.

6. REFERENCES

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