Modeling Civil Violence

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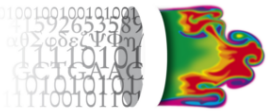
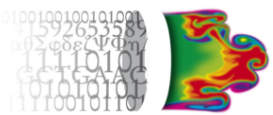


Paper

Modifications based on a paper by Epstein.

Modeling Civil Violence, A Computational Agent-Based Approach.

2002, PNAS, Vol. 99, No. 3, 7243-7250.



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Progress

Results from the paper:

- Simple interaction rules between civilians and cops on a grid produces outbursts of civilian activity (rebeling).
- Results produced by the system are very sensitive to parameter changes, but only a few are considered in the paper.

Further work:

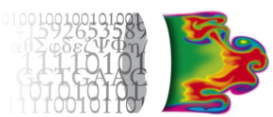
- Much effort has been made to make the agents intelligent and let them evolve.
- Based on Epsteins model the military developed MANA, a simple interface for battlefield tactics.

H. Queck, *Evolutionary Game Theoretic Approach for Modeling Civil Violence.*, 2009, Evolutionary Computation, Vol. 13, No. 4, 780-800

B. Klemens et al., *Empirical Performance of a Decentralized Civil Violence Model.*, 2010, Center on Social and Economics Dynamics Working Paper No. 56

Research Questions

- What is the effect of the agents vision range on outburst behavior?
- What is the effect of different movement strategies on outburst behavior?



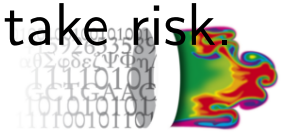
Agent Behaviour

Two types of agents:

- Cops, serving an unspecified regime, can arrest civilians.
- Civilians, oppressed by an unspecified regime, can be active (rebels) or inactive.

Each civilians has the properties:

- Hardship H: measure for the amount of 'suffering' civilians go through. Initially uniform randomly drawn for each agent.
- Legitimacy L: measure for the amount of central authority. Initially fixed for all civilians.
- Grievance G: $G = H(1 - L)$, the amount of grievance each civilian experiences.
- Risk Aversion R: the inclination of the civilian to take risk. Initially uniform randomly drawn for each civilian.



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Agent Behaviour

All agents have a vision range v, a square block of size $2v+1$ with the agent position as center.

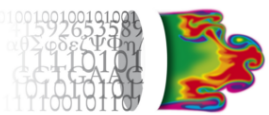
Each civilian estimates its probability of getting arrested by:

$$P = 1 - \exp(-k\lfloor (C/A)_v \rfloor)$$

where $(C/A)_v$ is the ratio of cops to agents in the vision range, k is a constant.

Use P to define the net risk $N = RP$.

Civilian Rule: If $G - N > T$, become active, otherwise, be inactive.
T is some threshold value.



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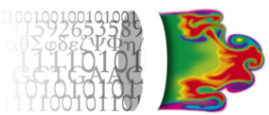
Agent Behaviour

Cop Rule: Inspect all sites within v and arrest a random active civilian.

Cops move to position of active civilian and jail them for a uniform random number between 1 and *maxJail*.
During this period the civilian cannot perform any actions.

Movement Rule: Move to a random unoccupied spot in v.



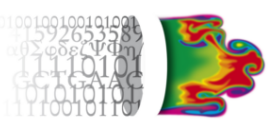
Algorithm

Start with 2D grid of size NxN with continuous boundary conditions. Place agents randomly on the grid, number of agents defined by density ρ_{civ} and ρ_{cop}.
Every iteration up to *maxIter*:

- Create a shuffled list of all agents.
- Go through the list one by one, apply the movement rule to each agent and then the cop or civilian rule.
  (Do not do anything when the civilian is jailed.)

A large number of parameters is fixed.

Parameter	Value
N	40
ρ_{civ}	0.70
ρ_{cop}	0.04
L	0.8
T	0.1
maxJail	15
k	2.3



Modifications

- Vision Range v: (Epstein: $v = 7$)
  $3 \leq v \leq 9$

- Movement Rules: (Epstein: Random movement)

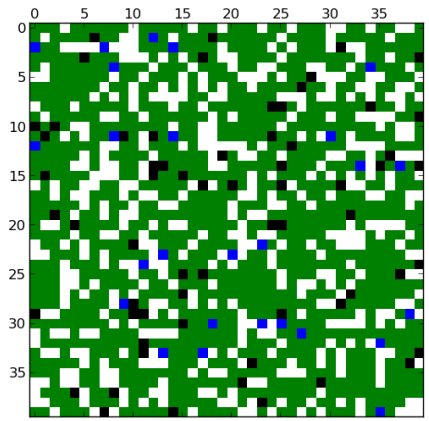
  Cop:
  If an active civilian is in v, arrest it directly instead of moving randomly first.

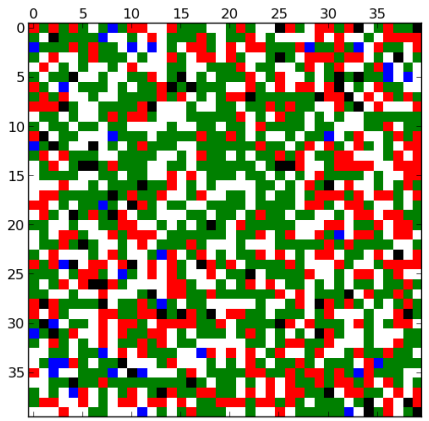
  Civilian:
  If active, move to the quadrant in v with the largest number of active civilians.

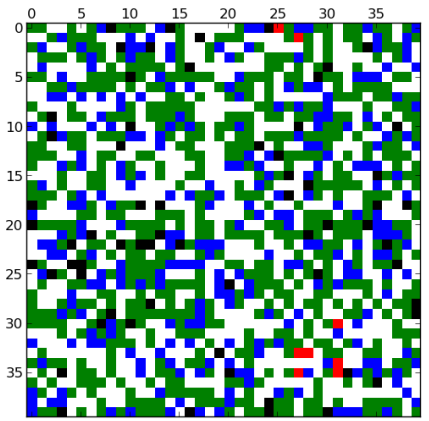
Original

Results for $v = 6$ and random movement (i.e. Epsteins model.).
Three possible macroscopic states (and mixed forms) occur.

MOVIE

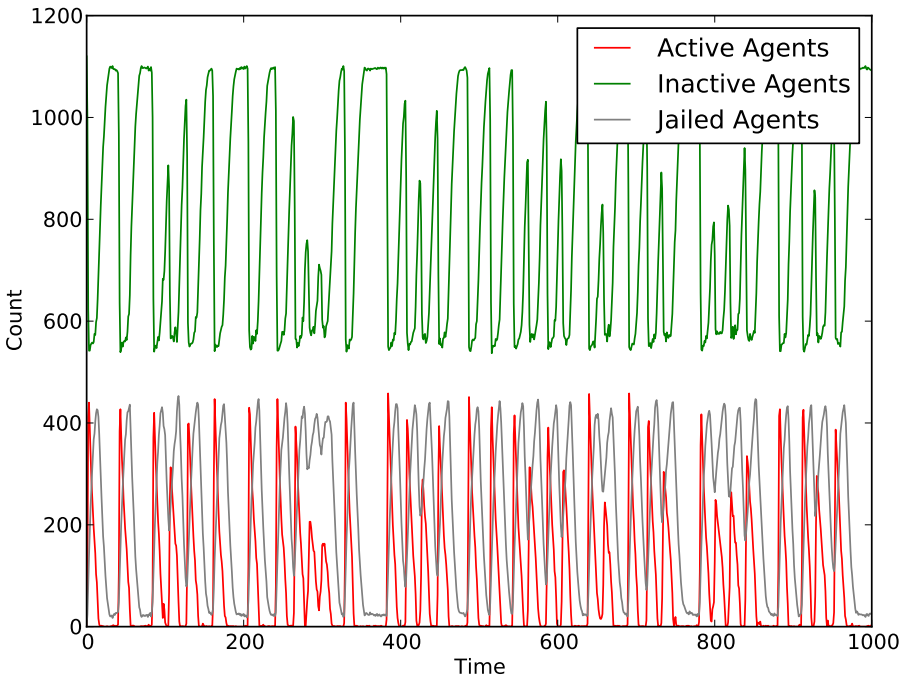






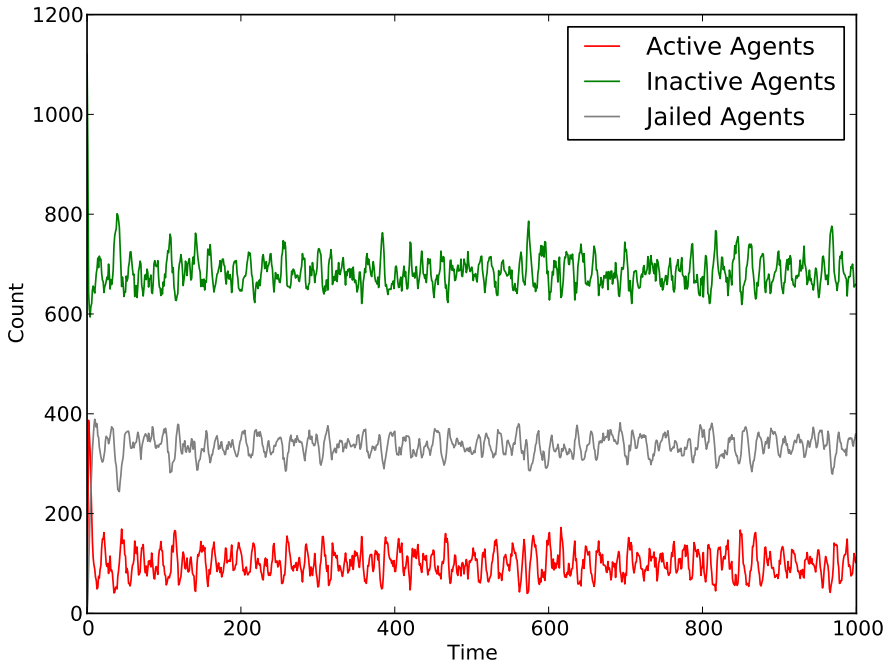
Original

- Outburst behavior is clearly visible.
- Peak in active civilians followed by peak in jailed civilians.
- Activity almost 0 between bursts, jailed agents on steady level.
- Maximum number of active agents around 400, caused by specific model parameters.



Vision Range

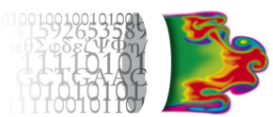
Outburst behavior disappears, fluctuations around equilibrium value.
Active regions cannot expand through the grid before they are 'killed' by cops due to low civilian vision range.
Cops cannot see enough of the grid to be present in all places, constant number of small uprisings out of cop range.



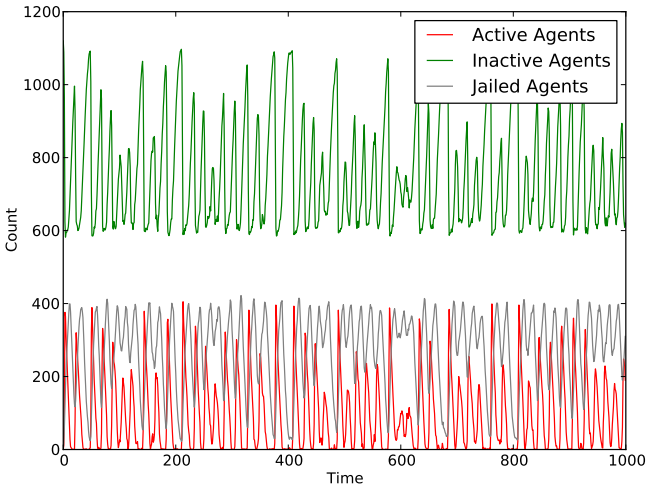
Vision Range

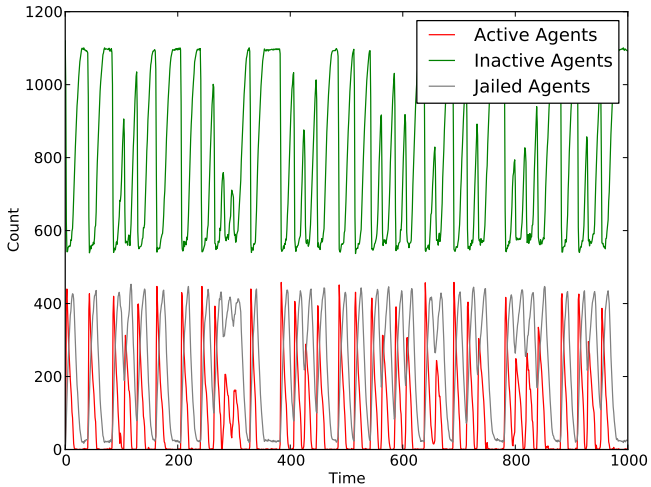
Vision Range	Number of outbursts
5	5316
6	2935
7	376

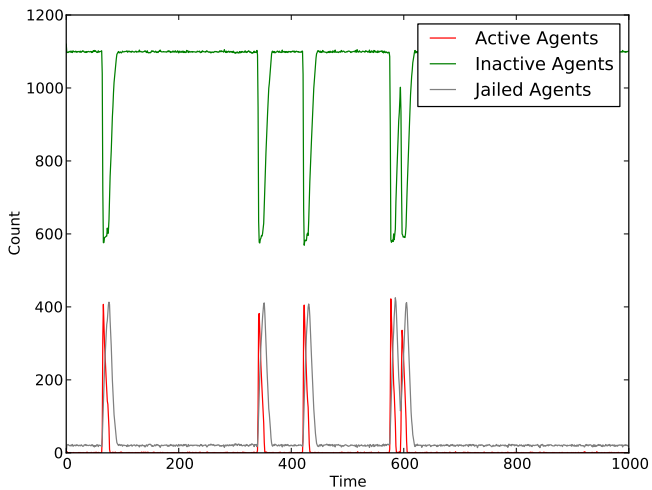
- If we set $v = 9$, we obtain 0 outbursts and almost 0 activity at all times, not very interesting.
- For intermediate values of v, i.e. 5, 6, 7 we observe a decrease in number of outbursts if v increases.
- Note that the peak height does not depend on v.



Vision Range

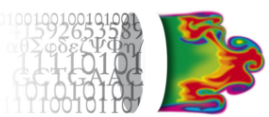






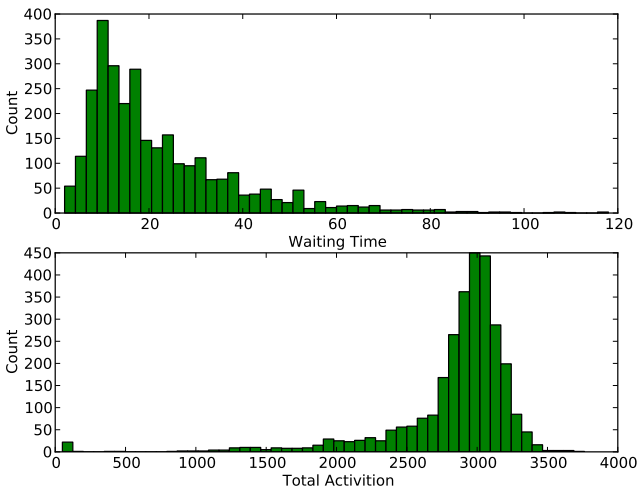
Movement Strategies

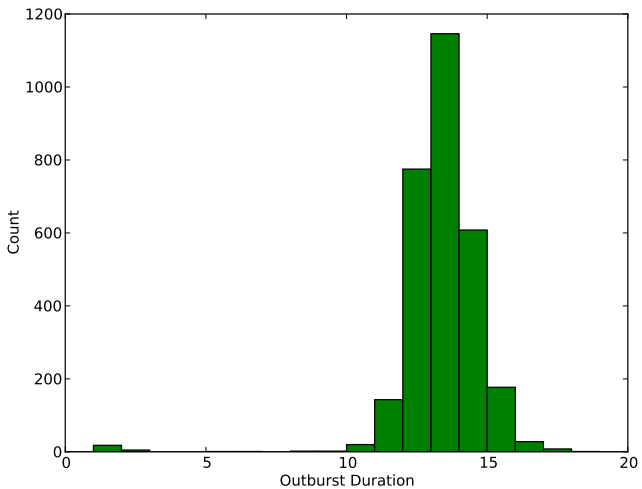
- Strategy I: The original random movements as implemented by Epstein.
- Strategy II: Active civilians move to the most 'active' quadrant.
- Strategy III: Cops can directly arrest an active civilian.
- Strategy IV: Strategy II + Strategy III



Movement Strategies

We introduce some additional statistics, example for strategy I ($v = 6$, 10^5 iterations):





Log-normal and normal distributions with outliers, use median for comparison.

Movement Strategies

Strategy	# Outbursts	Med. Wait. Time	Med. Total Act.	Med. Outb. Dur.
I	2935	17	2958	13
II	3256	14	2559	12
III	2629	30	2543	11
IV	2057	30	1933	10

Focus on Strategy I, II and III:

- Number of outbursts and waiting time behaves as expected.
- In strategy III total activation and outburst duration also behave as expected.
- Results are statistically different for waiting time (Mann-Whitney U test).

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H.B. Mann, D.R. Whitney *On a Test of Whether one of Two Random Variables is Stochastically Larger than the Other.*, 1947, Annals of Mathematical Statistics, Vol. 18 No. 1, 50–60

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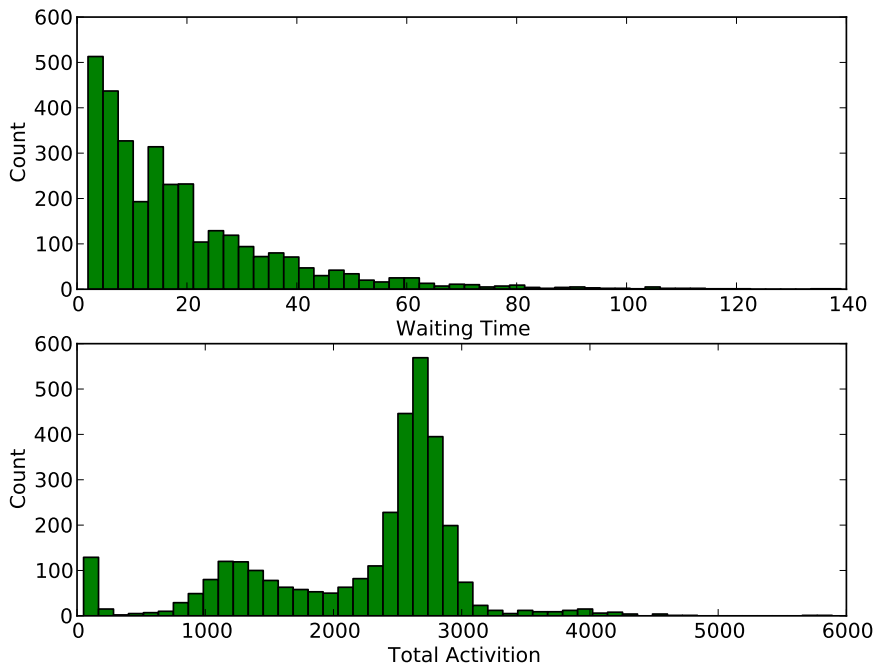
- In strategy II behavior of total activation and outburst duration is unexpected.
- Caused by the addition of a lot of small outbursts.
- Distributions look similar between strategy I and III.



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- Strategy IV shows that adding the two effects leads to increased suppression.
- Small number of outbursts, high waiting time (strategy III), small total and small outburst duration.
- Caused by herding of active civilians (strategy II) and the ability of cops to stay in the same area (strategy III).
- Cops move to area of high activity and stay there, while more actives are moving to that area because of high activity.

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Conclusion

- Different vision ranges produce different behavior, low values produce equilibrium values of activity, medium values produce outbursts and high values produce no activity.
- A slightly more intelligent movement strategy for the cops leads to decreased activity, for the civilians it leads to increased activity. Combined together it decreases activity, due to herding behaviour and the cops being able to stay in one area.

Questions?