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DESIGN OF MULTI-AGENT SYSTEMS

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# Violence FTW

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# 1 Problem

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The civil war in Bosnia and Herzegovina from 1992 to 1995, the Ferguson unrest in 2014, and more recently the civil war in the Ukraine; Civil violence has been an issue in many countries for many years. There is no single cause for these riots and wars. Some were the result of cultural differences, some because of the feeling of being treated unjustly, and others came about due to political reasons. "Each war is as different as the society producing it", and understanding the reasons for these riots to come about is of utmost importance (Ref5Goh), but also how the authorities respond to these situations should be the focus for investigation.

Much research has been done to understand how these riots emerge, including simulations of riots using a game theoretic approach (Ref8Goh) and social networks (Ref10Goh) among others. These investigations have shown that the behavior at a macroscopic level, that is the behavior of an entire group, is the result of the microscopic level, that is the behavior of the individual. In a more recent study, Goh and colleagues (Goh, Quek, Tan & Abbass, 2006) also studied how macroscopic behavior emerged using a game theoretic approach in a simulation. The most important issue the authors addressed was how experiences changed the behavior of the individual and how this learning affected macroscopic behavior.

Goh included many different interactions in his simulation, such as a probability that civilians turned to active protesters, how jail time affected rehabilitation of arrested protesters, and how the amount and types of people affected individual decisions. The focus was thus mainly on the civilian and the protesters. What the authors failed to focus on was how experience affected the learning rate. In many reinforcement learning algorithms, such as Q-learning or Temporal Difference learning acknowledge that many previous experiences ensure a stability in behavior, resulting in a decreased influence of newer experiences, (Watkins & Dayan, 1992: Q-Learning, technical notes; REF TD). Many argue that this decrease in learning rate also occurs in humans (REF, REF). In other words, more experienced humans are less affected by new experiences compared to less experienced people. It is very well possible that the 'correct' choice may result in a negative outcome in a particular situation. The experienced person will be resilient to such an 'accidental' outcome, whereas a less experienced person may be affected more severely by that negative outcome. The latter person may therefore change to a less favourable course of action in a future occurrence of said situation. This may result in frailty of the group's dynamics, ultimately leading to a drop in performance or even a loss. On the other hand, if a less experienced person had some accidental successes

with an ‘incorrect’ action, it is easier to learn that ‘correct’ actions are more profitable. Individual experience may thus have a great impact on group performance, but so far, this has not received much attention.

The current paper focusses on how experience will influence cop behavior. By using a simulation, we were able to compare how experienced cop agents, not experienced cop agents and a mix thereof perform against a group of trained hostile agents. In the followings sections, the simulation and, in turn, data acquisition will be descibed in more detail. Following the results of the different simulation will be presented. The paper concludes with a discussion of the implications of the results, and some shortcomings to this paper.

## 2 Method

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Q-learning implements a decrease in learning rate by adjusting the learning rate variable  $\lambda$  over time (REF). In temporal difference learning this is achieved by storing memories (of actions and results) in time (REF). Over time these memories will decay (less often experienced ones quicker than more experienced ones) allowing a flexible learning of the best actions/strategies. For this simulation, the learning rate variable will be implemented.

### 3 Reflection

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