Towards an Agent-Based Model for Civil Revolution: Modeling Emergence of Protesters, Military Decisions, and Resulting State of the Institution

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ABTRACT

The recent string of events in the Middle East, dubbed as Arab Spring transcended their national systems rapidly. There was no existing mechanism to predict them or their outcome. While there are a few models that forecast rebellion, most of them do not take into account the effect of the combination of different factors, such as emotional threshold, of both the citizens and military and their the ability to be influenced by their vision of what is going on around the agent geographically, along with the influence of media/communication channels to form a realm of influence and affect the actions of the agents simultaneously. This paper explores an agent-based model whose agents react based on economic and emotional levels and a revolution ensues. Once the revolution has begun, there are several other factors in this agent-based model that decide the outcome of the rebellion including agents being killed, their geographic vision, their inclination towards news/media, being influenced by current events, and also their personality type of A or B; all these factors combined together affect the dynamics of the unanticipated revolution. The results of the model are rendered in a short duration of time, as one would expect of revolutions, except for those that plunder into a state of civil war. The model introduces more complexity and combination of attributes that can be used to study and forecast revolutions, thereby filling a niche in this area, which has been empty as so far none of the existing studies use a combination of factors that this model deploys to forecast revolutions.

KEYWORDS: Agent-Based Model, ABM, Civil War, Revolution, Protests, Military.

1. INTRODUCTION

The Arab Spring and its continued resurgence have elevated concerns in policy-making, militaristic, and academic circles. Asongu and Nwachukwu (2015) mention several qualitative studies that have been examined after and during the Arab Spring events focusing on causes, consequences, trends, and circumstances leading to the Arab Spring. However, the focus of these studies remains on the aftermath and other qualitative causes. The Integrated Conflict Early Warning System (ICEWS) developed by Defense Advanced Research Projects Agency (DARPA) in the United States has developed a system that includes models that monitor and forecast crisis, including rebellions and wars, but the four components that feed into the system (history, trends, events, attitudes) take a very different approach than the model developed for this study as each component of the ICEWS system is a highly powerful and efficient process in its own bearing and all four components need to be combined together to do a more sophisticated forecasting. But they are each stand-alone and not interrelated in the ICEWS system. And hence, the extent of predictability of Arab Spring-like events is still elusive and there is very scarce quantitative literature about it. Could policies and measures have been adopted or applied, had the phenomena been predictable? While Asongu and Nwachukwu (2015) reference several mathematical and empirical models that examine "causes, consequences, trends, and circumstances leading to the Arab Spring", these models are either lacking in representing the varied roles in the population or do not account for the various factors in one comprehensive model. Different models use different factors – emotions, hardships, communication/media, but none take into account the effect of the presence of some combination of all the factors together.

In this paper, using qualitative variables associated with various factors, the emergence of civil uprising is examined and modeled so that the results of the model can be used to analyze whether anything can be done to mitigate the uprising or any policy changes should be instituted based on the results of the model. The model hopes to introduce a quantitative solution, which could be used alongside other mechanisms to predict if the phenomenon is foreseeable, something that has remained an empirical challenge and debate in militaristic, foreign affairs, and policy-making domains (Gause III, 2011). Academics and policy-makers had long known that several Arab regimes were unpopular with their citizens, yet the focus was mostly on the persistence of the undemocratic rulers. The interplay of the military (which was largely pro-government) with the citizens has generally not been used in studying the outcomes of these rebellions, though more recent analyses have indicated that the civil-military relations (CRMs) were the ultimate determinant of the final outcome of the rebellions in most of the Arab countries (Segell, 2013). This paper hopes to use those factors as the main agents and determinants of any uprising and hence paint a picture of what variables factor in and what can be forecasted and hence prevented to some extent possible. The remainder of the paper provides a detailed background along with existing studies (section 2), followed by the conceptual model in an overview design concepts and detail (ODD) protocol (section 3). A detailed narrative on the sensitivity analysis (section 4) and verification and validation concepts and methodologies (section 5) is presented followed by the results of the model (section 6). The findings and analysis of the results is presented in the penultimate section (section 7), followed by a brief conclusion to the paper (section 8).

2. BACKGROUND

Arab countries had long held regimes with the largest string of self-elected or even democratically-elected dictators, and many still continue to do so. Egypt until 2011 had been ruled under the same power since 1981, while Yemen had been under the helm of the same President since 1978. In Syria, the Assad family coagulated power since 1970s and still continues to do so, while in Jordan the Hashemites have been ruling since the 1920s. Saudi Arabia and Bahrain have also held ruling power very closely since the 1930s and Libya's dictator had taken charge since 1969, until he was deposed of in 2011.

The understanding of Arab Spring unrest, that has been extended to us so far, is largely based on empirical studies, economic, or mathematical models (e.g. Epstein 2002; Makowsky and Rubin, 2013; Acemogh and Robinson, 2011; Ellis and Fender, 2011). These models have unilaterally used factors such as grievances, information communication technology (ICT), or conditions for a peaceful post-war democracy. While there are several formal theoretical models that explain the cross-country income inconsistencies documented in the context of the neoclassical growth models and recently extended to the fields of economic development (see Bruno et al., 2012 for a review), these models stop short of quantifying it in way it could be forecasted using information that has been available empirically or through literature.

Epstein's work in model of rebellion (2002), which is one of the most important inspirations for the study of any rebellion, uses grievance as the basis for the start of a rebellion. Most models of civil unrest extend from Epstein's basic research. For example, one of the interpretations of the model in Netlogo modeling environment, uses grievance and spatial vision to model the emergence of rebellion. The mathematical model proposed by Makowsky and Rubin (2013) focuses on two features – extremely centralized power and widespread information and communication technology (ICT), which are highly instrumental in determining the outcome of the revolution, but grievance or economic hardship as a cause are not factored in. While such designs of models are extremely useful and their underlying assumptions have been used in the model developed for this paper, these studies fall short of a cohesive analysis of the interaction of various factors that actually lead to the emergence of revolution. The factors used in these studies do not exist in a vacuum, and the interaction amongst the different factors is what leads to different results, given a similar set of conditions in different countries. However, revolutions and civil unrests are a complex phenomenon. They involve parties that collude and collide based on several attributes. And most of the mainstream mathematical, political science and even international relations (IR) based models and studies of revolution and unrest, reduce the complexity that give rise to conflicts (Masad, 2017).

As Masad (2017) states "Game theory provides a basis that can formally describe and analyze strategic interactions, and yielded powerful concepts such as the notion of a Nash equilibrium, and stylized, insight-generating models such as the Prisoners' Dilemma." However, these lines of research are often somewhat disconnected from one another. An agent-based model (ABM) would not only provide a better way of studying this complex phenomenon as ABMs are particularly suitable to apply to the study of international relations (Cederman, 1997) because by their very definition, they study agents that interacts with each other using a varied set of attributes/behaviors. As an ABM inherently allows for the study of complex factors combined with other behaviors, interactions among agents, and the agents within the model can be endowed with a variety of internal decision making models, they inherently offer a better alternative than mathematical, political science, or other IR based models that have traditionally been used to study revolutions and conflicts.

A few of the recent papers that have deployed agent-based computation include works by Moro (2014) on violent political revolutions and Masad's (2017) research on agent-based modeling of international crises and conflicts. Moro's paper deploys three classes of agents, where rebels are an agent class and always existent, along with citizens and cops. However, the cops are designated to always be loyal and suppress the revolution, which in case of Arab Spring, has not proved to be accurate. The military turnover in uprisings in Egypt, Tunisia and Syria was very instrumental in determining the final outcome of the Institution (country/region/state) (Barany, 2011). The different stances taken by the military can largely explain the different outcomes for the similar kinds of protests in countries governed by the same types of dictatorial powers. And Masad's research focusses more on how ABMs can be used in a different way to serve as a bridge between several of the other methodologies and paradigms (Axelrod, 2006).

This paper builds on a basic ABM for a revolution and adds a combination of complex behaviors to its agents such as military benefits, citizen's grievances and other factors such as geographic vision, empathy, personality type A or B, and media impact and tendency. Though Kuran (1991 and 1995) criticizes the idea of automatic relationship between social grievance and revolution, arguing that most historical revolutions were unanticipated, as people who dislike the government tend to conceal their political preferences as long as the opposition seems weak. And that is what this paper builds on, which is also supported by Makowsky and Rubin (2013) in their centralization hypothesis that people conceal their preferences unless there is a chance of success. While agents with grievances do not rebel, until their emotional threshold is reached or until they see active rebellion around them and then they join in. This paper blends in neatly with the varied ideas proposed by different models above to form a cohesive model that also takes into consideration the different agents' personalities, ability to bear income hardships, and a choice in the face of futility.

3. CONCEPTUAL MODEL

In this section, the model is described based on the Overview, Design concepts, and Details (ODD) protocol by Grimm et al. (2006). The purpose of the ODD protocol is to "standardize the published descriptions of individual-based and agent-based models (ABMs)." The model used for this paper is designed in a Netlogo modeling environment and the model description and code can be found in and downloaded from the OpenABM models library. In this section the purpose of the model is examined (section 3.1), the variables and scales assessed and described (section 3.2) along with the overview and scheduling of the processes involved (section 3.3). This is followed by a detailed description of the model inputs (section 3.4) and details about the requirements for their initializations (section 3.5), and finally a description of the outputs of the model (section 3.6).

3.1 Purpose

The purpose of the model is to analyze the interplay between citizens who rebel, and those who don't and the consequences their actions have with the military's various behaviors. To accomplish this, the model is intended to forecast three different states of outcome for an Institution. One of the states is when the government wins, the second when the citizens win, and finally the third state is when the model goes over 150 runs (each run is equivalent of 2 weeks hence equating to ~5 years) the model stops running and outputs that civil war has ensued. During these runs the model also outputs the number of total citizens along with those in different states: happy, rebelling, unhappy, neutral, and killed. The same is true of the military whose state is counted as happy, defected, or unhappy.

In order to analyze the interaction component of the model, a number of calculated assumptions are made and factored into the model with regard to behavior, input variables, and scale, which are described in the sections below.

3.2 Input Variables and Scale

The model used for this paper has two types of agents with various states, behaviors, and attributes. The citizen agents have an income that is drawn from a non-linear distribution (power law distribution) (Clementi and Gallegati, 2005). And based on the income, their income-level is stated as poor, middle, or rich. Emotions are also a variable associated with citizens and emotions are drawn from an exponential distribution. Emotions were drawn from an exponential distribution based on a study by Garas et al. (2012), where studying over 2.5

million user posts online and analyzing them using an ABM, it was concluded that user emotion patterns exhibited a stretched exponential distribution. However, this probability distribution can be changed from exponential to another distribution based on data for a particular set populace being studied. Another input variable is the state of the agent which could be happy, dissatisfied or neutral (do-not-care), that is based on various factors as the model gets executed. Deriving an estimated probability distribution from various psychological studies (e.g. Riggio, 2012), of the total number of agents that get initiated, 30% are initiated with personality A-type (alpha) and the remaining 70% with personality B-type (passive). In general among populations, more number of people tend to have personality type B over personality type A. Citizens can also get killed, jailed, and have vision around them to see others get killed, jailed or revolt. The agents also have memory to remember how many times they get jailed and their income.

The military has comparable input variables as citizens. Military's income is defined as benefits they receive from the government. The income benefits for the military agents are user defined in the model's interface and can be selected from low, middle, or high. Military agents too have emotions which are drawn from an exponential distribution. They have a status of happy or sad and can be active as in loyal or defected from the military. They too have a vision, which is a user defined feature in the model interface and can see citizens revolting or getting killed or could kill citizens themselves.

Using the interface, the user can select the probability with which military agents can kill revolting citizens. There is a switch for Information, Communication and Technology (ICT) which can be turned ON or OFF by the user in the model interface, to determine if agents are getting news (defined in the model by having the vision to see how far it can extend around them and see if other agents are revolting or getting killed and in case of the military to have the vision to see the same – rebels or citizens getting killed). There is also a slider in the model's interface for the user to choose the probability for the citizens and military to hear the news. This determines the probability whether agents will get the news or not. The threshold-killed is also a user defined attribute that is used to determine (along with other factors) the number of agents an agent can watch being killed around it before it changes state from happy and loyal to another state depending on how other factors align. Figure 1 below shows the model interface, which has all the user inputs and switches that have been described above.

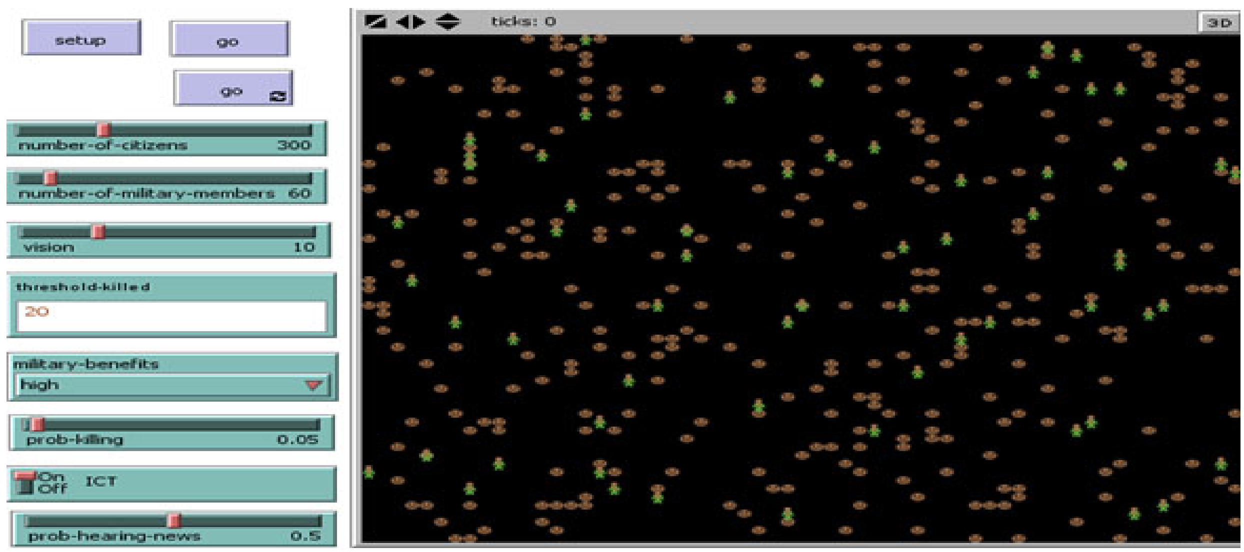

Figure 1: Interface of the model with the user inputs, switches, and slides for selecting variables

3.3 *Process Overview and Scheduling*

At each time step, both types of agents go through several steps of processing to determine their next state. It starts with the citizen agents checking their income which has been exponentially distributed. If its income is greater than 105.24399, which is the mean and standard deviation, the agent is rich in income-level, if the income is greater than 94.75601 the agent has middle income-level and the agent is poor in income-level for income after that This results in fewer agents being extremely rich or poor and most agents in the middle income bracket. (*The above two assumptions were made under the presumption that anyone earning between 105.24 and 94.75 (which would be few due to an exponential distribution) would have a happy status as* *they would be rich in income and hence would have no reason to revolt against the Institution*). After checking its income-level, each agent could result in being happy, unhappy or neutral. If it is unhappy, then based on its personality type it can revolt. If it is a personality A, the agent revolts if anyone around it is revolting as personality-type As are generally known to be quick to react (McLeod, 2008). However if it is a personality B, and in an unhappy state, it revolts based on the percentage of revolting population, if that percentage is greater than 20%. This is because personality-type Bs are usually not motivated to react unless there is considerable momentum around them (Janjhua and Chandrakanta, 2012) If the status of the agent is neutral or happy, it then checks to see if anyone around it is being killed for revolting, and if that has reached its emotional threshold. That state check can lead an agent to be happy or unhappy or neutral again, and the decision making based on being personality A or B resumes again. This loop circulates until a final state for the Institution has been reached. Figure 2 maps the decision making process that determines the state of the civilian agent at each step.

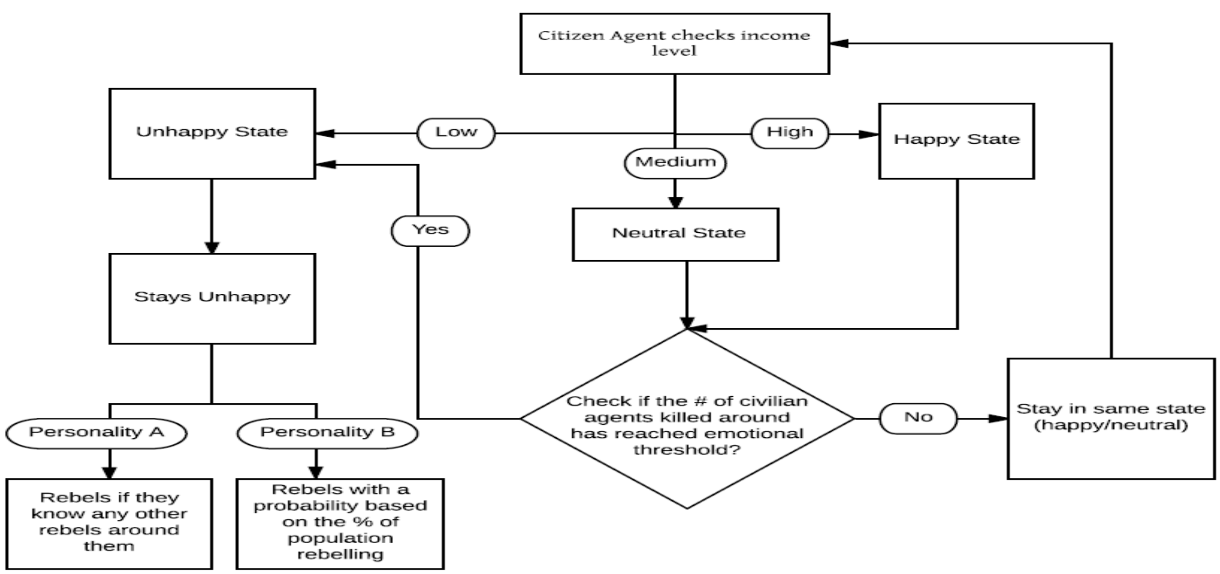

Figure 2: Decision Making State for Citizen-Agent

The military agents undergo a similar process of decision making which decides their next state. The military agents start by checking their benefits which could range from low, medium, to high. If the agent's benefits are low, and it sees citizens revolting the agent defect, if members around it have defected, with a probability of greater than 20%. This is based on the assumption and news history (Ohl et al., 2015) that if military members have low income, they wouldn't be as motivated to fire on or kill their own citizens to protect the Institution and would be easily demoralized as there is no financial incentive. However, if its benefits are medium, the agent also checks to see if the number of citizen agents being killed around it has reached its emotional threshold. This is based on presumption that if income is mid-level, then there needs to be another motivation for the military agents to defect as financial incentive might not be the only factor that plays a role and hence combined with their emotional threshold for seeing the number of civilians killed could be the trigger for the status change. If its emotional threshold is reached along with medium income then its state turns unhappy and it defects too in keeping with the same probability as defined above. However, if the number of citizen agents killed has not reached their emotional threshold, it continues to stay in the state of being happy. All happy military agents check to see if there are any rebelling citizen agents in their vision, if there are, the military agents can jail or kill them based killing probability user defined parameter and then go back to checking their benefit level. Figure 3 demonstrates in a flowchart, the process overview for the military agents.

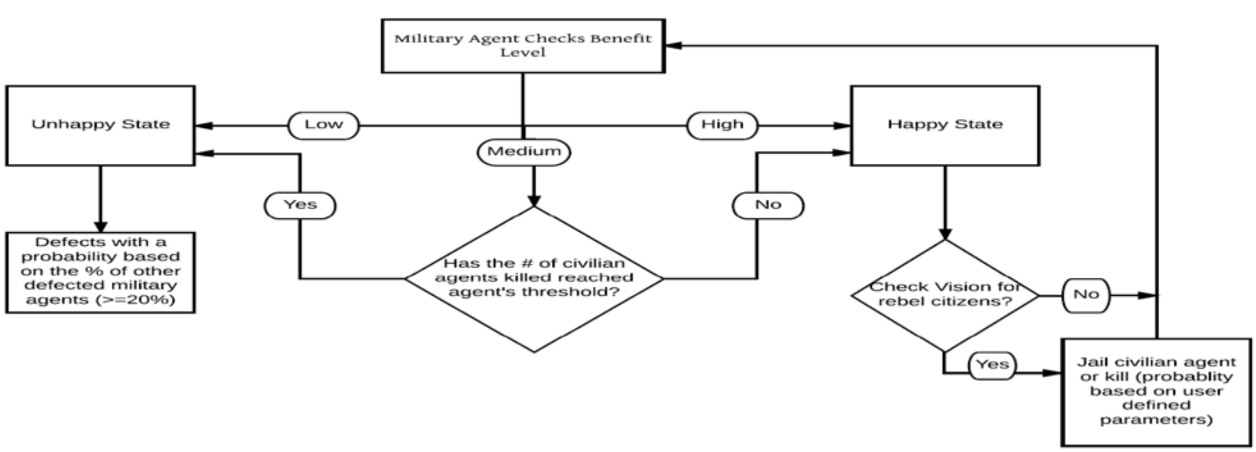

Figure 3: Process Overview for the Military Agents

An important assumption that the model makes is that each tick (period/cycle) is calculated as 2 weeks, and based on that after 150 periods, it is assumed that the model has simulated 300 weeks which is about 5 years, and the model stops running and presumes that the Institution has descended into a civil war, which is the resulting state of the Institution. However based on the combination of other factors and parameters, the number of periods/ticks will vary for each of the model run thereby simulating real-life situations, where revolutions take different amount of time to result in a final outcome based on other factors such as number of people rebelling, number of people killed, influence of media, etc.

3.4 Model Inputs

The model relies on user inputs for certain behaviors for the agents. The population of the agents can be varied by the user on a slider scale from 0 to 1000 and the military is set to half the population varying from 0 to 500. The choice of the military to citizen ratio was decided based on the empirical data available for military force population in the Arab state nations where the ration is approximately at 1:2 or 1:3 (Reuters, 2012). Other inputs include physical vision of the agents, which is the number of lattices/blocks around it that it can see. The threshold-killed is a manual user defined number. The benefits of the military can be set using the chooser scale and there is a slider for the probability with which the military will kill a rebelling citizen agent. The ICT switch (defined in detail in section 3.2) can be turned ON or OFF by the user and the user can also decide the probability with which the news will be known by the citizen and military agent based on a slider scale, if the ICT is ON.

The jailed agents are depicted by a bar icon, the neutral agents are brown neutral faces and the angry agents are red faces. Military is depicted by a military uniform. Figure 4 shows the different agent visualizations.

Figure 4: Visualizations of the Different States of Agents from left to right: jailed citizen agent, military agent, neutral citizen agent, unhappy agent.

3.5 Initializations

The model for the purposes of the paper is initialized with 300 citizens with 60 military members, setting the citizen to military ratio at 5:1. The model is initialized at a higher rate for citizens to military to better understand if States with fewer military members change their output based on the ratio of the citizens to military. The vision is set to 10 lattices around the agent, where the model world wraps around at 30 to 30 coordinates. The threshold for seeing other citizens killed is set to 20, which is between low to medium. The probability to kill for a military member is set to 0.05, as most militaries resist the instinct to kill initially, unless explicitly instructed to do so. And the probability of hearing the news is set to 50% if the ICT is ON. Figure 5 shows the basic initializations of the model for this paper which were: Number of citizen agent: 300; number of military agents: 60. The model, for the initial run, also kept the vision at 10, keeping ICT at ON. The probability of killing was selected at 5% when the emotional threshold had reached 20. The military benefits were selected as High for the initial run.

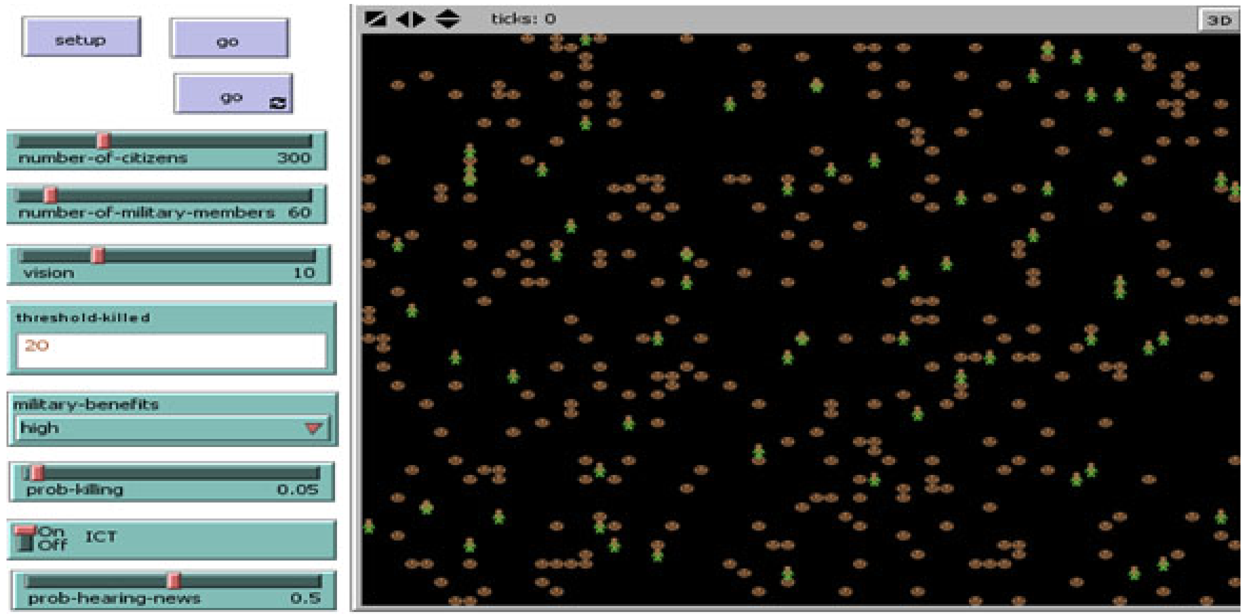

Figure 5: Basic Model Initialization Input Values

3.6 Model Outputs

The major output from the model is the resulting state of the Institution, which is displayed in the Command Center in the Netlogo interface. However other outputs are also displayed. For the citizen agents the citizen count along with happy, unhappy, killed, and rebelling citizens is displayed. The numbers are also plotted on a graph for visual comparison. For the military agents, the defected and unhappy count is displayed. A final graphical output is a plot that charts the count of the citizens to the rebels and the defected military.

4. SENSITIVITY ANALYSIS

Thiele et al. (2014) state that sensitivity analysis is an important part of the development and analysis of any simulation model. By exploring the sensitivity of model output to changes in parameters, we learn about the relative importance of the various mechanisms represented in the model and how robust the model output is to parameter uncertainty. These insights helped in fostering the understanding of this model and its use for theory development and applications to policy making and militaristic diplomacy. Vision is one of the most sensitive parameter in this model. When vision is turned off, the chances of the government winning are much higher than when it is not. This can also be evidenced by observational data where regimes often turn off the communication channels and news when there are rebellions and revolts in order to contain the revolution (Yang, 2013).

Another parameter that is quickly affected when altered is the probability of killing. When military members have a high probability of killing, even with middle benefits, the model takes significant amount of time to reach a state of completion and the government always wins and very few military members defect, and this is while ICT is ON or OFF. This was an interesting observation because when the probability was set to a lower scale there was an equal chance of a civil war and more chance of a civil war with ICT being turned ON.

A final parameter tested in the sensitivity analysis was the emotional threshold of citizens, which when lowered always produced a civil war whether benefits of the military were middle. This helps attest to the fact that more citizens were rebelling, whether personality A or B as their threshold of emotions was so low in seeing how many of their fellow citizens were being killed.

5. VERIFICATION AND VALIDATION

Verification of the model, to ensure that the model matched its design and the logic tested positive against computer logic as stated by North and Macal (2007) and Heppenstall et al. (2012), was performed by conducting code walkthroughs, profiling and parameter testing to ensure the model was working as intended. Checking that the model behaves as expected is also referred to as the 'inner validity' of the model (Brown, 2006; Axelrod, 2006). For this model, this was performed by testing the model at various stages of the code to ensure that the model was working and there were no logical errors made in the translation of the model into code, and that there were no programming errors. After carrying out these tests, it can be confidently stated that the model behaved as it was intended and matched its design.

Validation was also performed on this model to ensure that this model was designed as sufficiently as accurate to solve the research problem on hand (Casti, 1997). Three kinds of validations were performed on this model based on Robinsons' (1997) discussions on verification and validation: Conceptual validation, black box validation and white box validation. Furthermore empirical research was also aligned with the results of the model to ensure its validity.

Conceptual Validation: This method was used to determine that the details of the model and assumptions were correct. All of this was verified using empirical, historical, or news data from reputable or reviewed books, websites, journal articles etc. discussing Arab Spring. It was ensured that model contained all the necessary details required to meet the objectives of the simulation study such as the assumptions, probability distribution, and placement of agents.

White Box Validation: This method was used to ensure that the contents of this model were true to the real world. The code was checked to ensure that correct data had been entered. And the code was also expressed in a non-technical format, as a written concept and explained to a graduate class of computational social science students with different areas of social science expertise, where non-experts were provided with an overview of the data and the logic. Output from different parts of the model was compared and tested, and the results were traced through progression over the 100 runs with different parameter initializations to ensure the model was validating appropriately.

Black Box Validation: Black Box validation for this model was split up into two categories. Validation was performed by comparing the relationship between the inputs and outputs of the model, this latter was used as an alternative for validating in comparison with the real system. Two other validation approaches were used to validate the model further. Empirical validity (face validity) (Xiang et al, 2005) was used based on the news stories and other factual data from the Arab Spring revolutions. This model's outcomes pair very close to the actual outcomes in real life. In countries like Bahrain and Saudi Arabia, where the military is very well encumbered financially and through other means (Reuters, 2017), the rebellions and protests were quelled rather quickly. But in countries such as Egypt, Tunisia, Yemen and Libya, where military members were in the same economic status of low income as the citizens, the government was disposed of rather soon as the military turned an eye or even supported the citizens. And in countries such as Syria and Lebanon, where the military is paid between middle to high income, some members have defected as their emotional threshold of seeing others getting killed was reached and others have not (Sayigh, 2014; Reuters, 2010).

Another form of validation was Model-to-Model Validation (Xiang et al., 2005), where the results were compared against four other models:

1. Willenksy's Rebellion Model (2002), based on Epstein's Civil Violence Model (NetLogo Model)
2. Moro's (2014) Understanding the Dynamics of Violent Political Revolutions in an Agent-Based Framework (NetLogo Model)
3. Makowsky and Rubin's (2013) An Agent-Based Model of Centralized Institutions, Social Network Technology, and Revolution (MASON simulation, JAVA library)
4. Lawson and Oak's (2014) Apparent Strength Conceals Instability in a Model for the Collapse of Historical States (Mathematical Model)

Based on these several methods of verification and validation, the model lends enough credibility in its outcomes and results that the users of this model should gain sufficient confidence in the results output by this simulation.

4. RESULTS

The model's default inputs before any user changes are military benefits set at high and ICT is ON with a probability of 0.5. This basic settings for this paper resulted in some very unpredictable, yet applicable results. When tried with different settings, different outcomes were realized as expected and each will be described later in this section. As mentioned in section 3.3, the ticks' column which shows the number of cycles/periods that each model run goes through, changes each time the model is run, hence different model runs have different number of ticks. When a final outcome of the model is reached: democracy, civil war or status-quo (no change in government), the model stops running. Therefore for each of the result sets below, the ticks are different because it takes different amounts of times for the Institution to reach its final state. This is representative of the real world phenomenon, where each of the countries that had Arab Spring revolts depending on their various input factors took varying amount of time to declare democracy or continue with status quo and some fell into the anarchy of civil war. The model was run several times with parameter values changed to understand how the outcome changes and what the results were. With the default parameters, Table 1 lists the results for a representative model run with 10 trials.

Inputs:
Benefits – High; ICT on @ 50%

Runs	Resulting State of Institution	Ticks	Citizen Count	Unhappy Citizens	Citizens Killed	Defected Military	Unhappy Military
1	Civil War	150	46	53	254	0	0
2	Civil War	150	58	40	242	0	0
3	Civil War	150	61	37	239	0	0
4	Civil War	150	39	28	261	0	0
5	Civil War	150	161	8	139	0	0
6	Government Wins	60	212	15	88	0	0
7	Civil War	150	123	49	177	0	0
8	Government Wins	99	182	9	118	0	0
9	Government Wins	105	207	14	93	0	0
10	Government Wins	69	229	8	71	0	0

Table 1: Resulting State of the Institution after 10 runs (20 weeks) with "ICT at ON at 50%" and Military Benefits at "LOW"

Simulating the model with the same input for most parameters but changing ICT to OFF, results in a different set of results. Table 2 lists the results for a 10 trial representative model run.

Inputs:
Benefits – High; ICT -- OFF

Runs	Resulting State of the Institution	Ticks	Citizen Count	Unhappy Citizens	Citizens Killed	Defected Military	Unhappy Military
1	Government Wins	50	18	4	282	0	0
2	Government Wins	39	23	10	277	0	0
3	Government Wins	50	22	9	278	0	0
4	Government Wins	40	24	7	276	0	0
5	Government Wins	66	9	4	291	0	0
6	Civil War	150	70	2	230	0	0
7	Government Wins	41	95	13	205	0	0
8	Government Wins	51	93	7	207	0	0
9	Civil War	150	51	4	249	0	0
10	Government Wins	116	56	3	244	0	0

Table 2: Resulting State of the Institution after 10 trial runs (20 weeks) with "ICT at OFF" and Military Benefits at "HIGH"

For the next set of results, the model was simulated under military benefits set to middle and ICT set to ON at 50% probability of hearing the news. Table 3 shows the compiled result set, while Figure 6 captures a single representation of when the model was running with the specified inputs.

Inputs:
Benefits – Middle; ICT - On @50%

Runs	Resulting State of Institution	Ticks	Citizen Count	Unhappy Citizens	Citizens Killed	Defected Military	Unhappy Military
1	Government Wins	123	2	1	298	25	25
2	Civil War	150	3	2	297	24	24
3	Civil War	150	7	6	293	17	17
4	Government Wins	57	9	6	291	17	17
5	Government Wins	59	7	4	293	20	20
6	Government Wins	95	3	0	297	23	18
7	Government Wins	49	9	7	291	21	26
8	Civil War	150	7	6	293	29	25
9	Government Wins	70	7	3	293	24	25
10	Government Wins	81	3	2	297	28	28

Table 3: Resulting State of Institution after 10 runs (20 weeks) with "ICT at ON at 50%" and Military Benefits set to "MIDDLE"

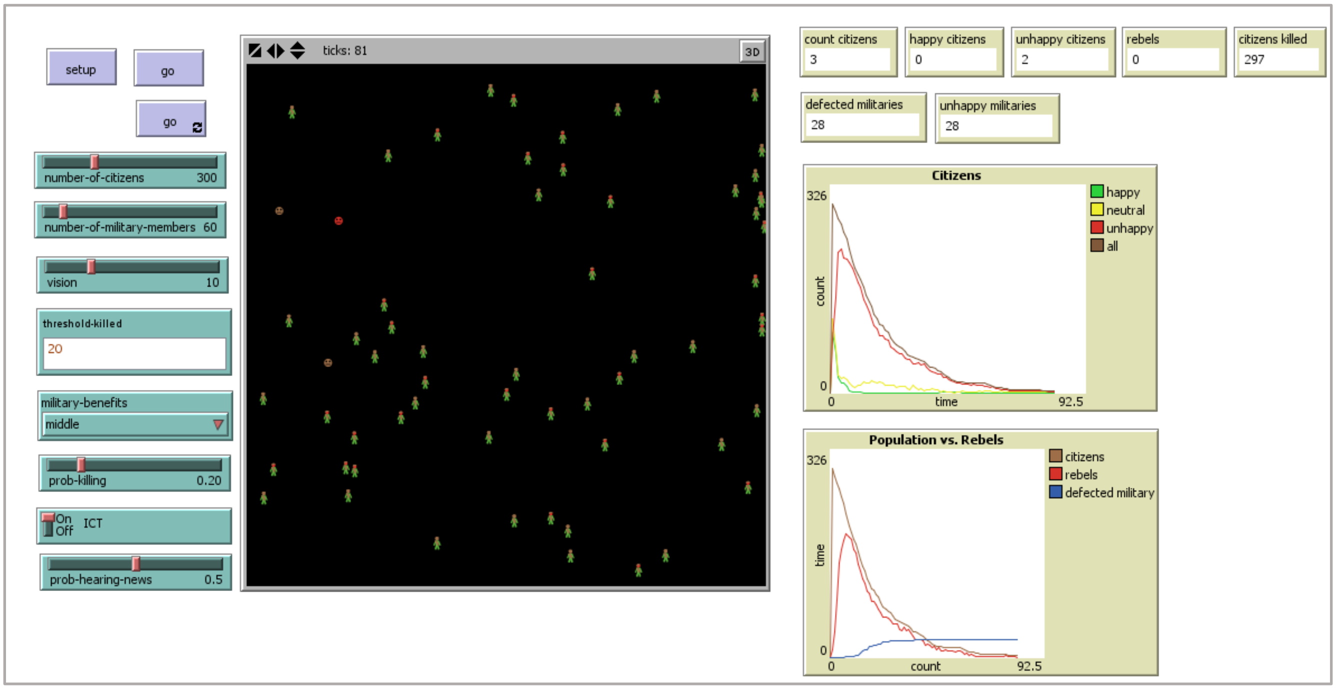

Figure 6: Representative Model Run Showing the Resulting State of the Institution with ICT at "ON @50%" and Military Benefits set to "MIDDLE"

For the same set of parameters, the model was simulated under military benefits at middle while ICT was set to OFF so there was no probability of hearing the news. Table 4 below shows the compiled result set, while Figure 7 captures a single representation of when the model was running with the specified inputs.

Inputs: Benefits – Middle; ICT - Off

Runs	Resulting State of Institution	Ticks	Citizen Count	Unhappy Citizens	Citizens Killed	Defected Military	Unhappy Military
1	Government Win	54	89	7	211	11	11
2	Government Win	41	125	14	175	12	12
3	Government Win	57	94	9	206	17	17
4	Government Win	83	72	3	228	20	20
5	Government Win	40	112	7	188	16	16
6	Government Win	117	59	2	241	18	18
7	Government Win	128	63	0	237	24	24
8	Government Win	68	83	25	217	14	14
9	Government Win	62	89	3	211	14	15
10	Civil War	150	43	2	257	22	22

Table 4: Resulting State of the Institution after 10 runs (20 weeks) with "ICT at OFF" and Military Benefits set to "MIDDLE"

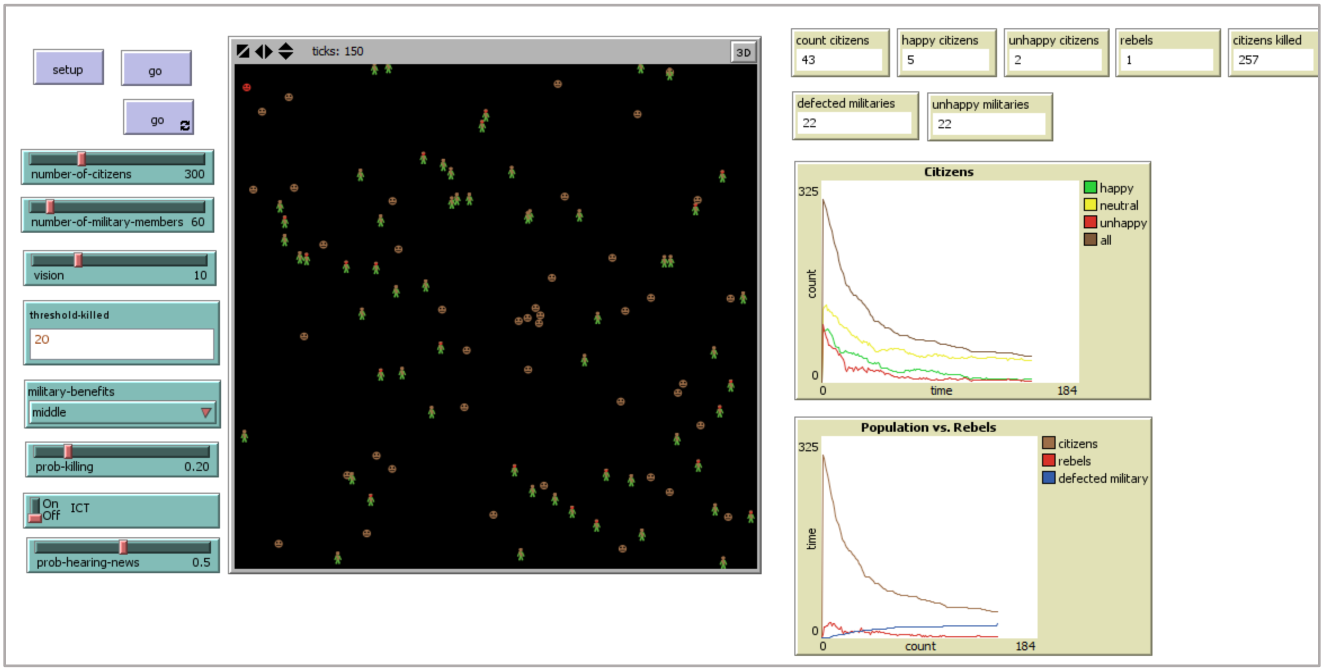

Figure 7: Representative Model Run Showing the Resulting State of Institution) with "ICT at OFF" and Military Benefits set to "MIDDLE"

For the final set of results, the model was simulated under military benefits at low while ICT was set to ON at 50% probability of hearing the news. Table 5 shows the compiled result set, while Figure 8 captures a single representation of when the model was running with the specified inputs.

Inputs:
Benefits – Low; ICT – ON @50%

Runs	Resulting State of Institution	Ticks	Citizen Count	Unhappy Citizens	Citizens Killed	Defected Military	Unhappy Military
1	Citizens Win	5	279	160	21	61	60
2	Citizens Win	6	289	78	11	60	60
3	Citizens Win	5	276	182	24	60	60
4	Citizens Win	5	290	125	10	60	60
5	Citizens Win	5	284	112	16	60	60
6	Citizens Win	5	279	225	21	60	60
7	Citizens Win	5	284	165	16	60	60
8	Citizens Win	5	289	79	11	60	60
9	Citizens Win	4	290	74	10	60	60
10	Citizens Win	5	284	166	16	60	60

Table 5: Resulting State of the Institution after 10 runs (20 weeks) with "ICT at ON at 50%" and Military Benefits set to "LOW"

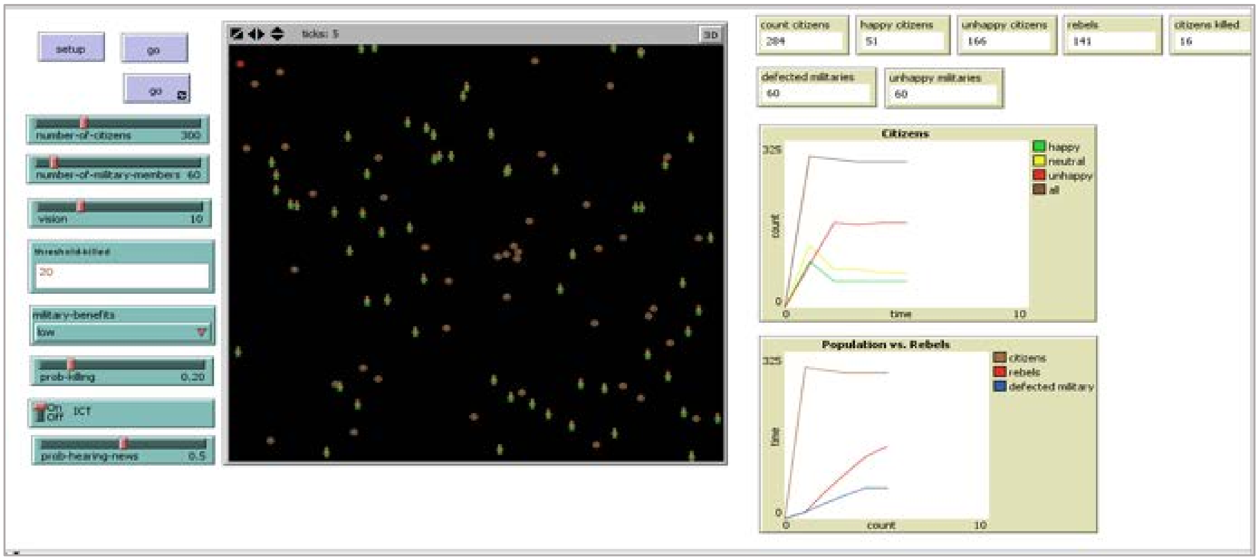

Figure 8: Representative Model Run Showing the Resulting State of the Institution after 10 runs (20 weeks) with "ICT at ON at 50%" and Military Benefits set to "LOW"

For the same set of parameters, the model was simulated under military benefits at low while ICT was set to OFF so there was no probability of hearing the news. Table 6 shows the compiled result set, while Figure 9 captures a single representation of when the model was running with the specified inputs.

Inputs:
Benefits – Low; ICT – ON @50%

Runs	Resulting State of Institution	Ticks	Citizen Count	Unhappy Citizens	Citizens Killed	Defected Military	Unhappy Military
1	Citizens Win	4	292	80	8	60	60
2	Citizens Win	4	290	98	10	60	60
3	Citizens Win	5	290	82	10	60	60
4	Citizens Win	6	280	76	20	60	60
5	Citizens Win	5	283	79	17	60	60
6	Citizens Win	5	290	71	10	60	60
7	Citizens Win	5	280	72	20	60	60
8	Citizens Win	5	286	71	14	60	60
9	Citizens Win	5	288	88	12	60	60
10	Citizens Win	4	288	72	12	60	60

Table 6: Resulting State of the Institution after 10 runs (20 weeks) with "ICT at OFF" and Military Benefits set to "LOW"

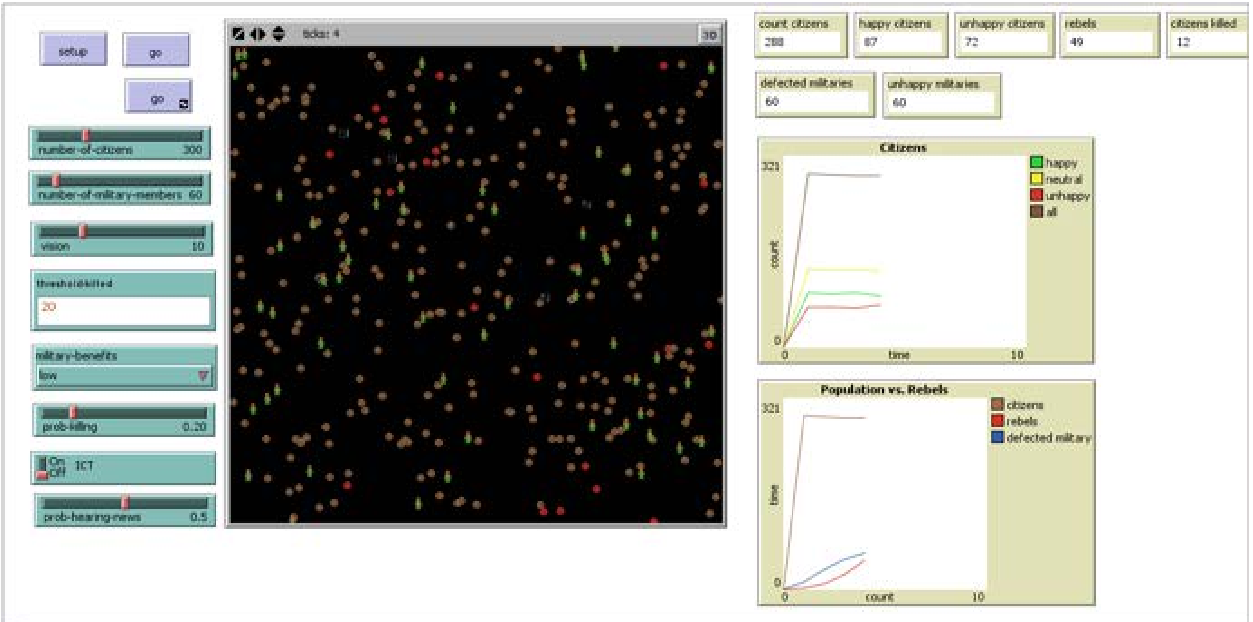

Figure 9: Representative Model Run Showing the Resulting State of the Institution after 10 runs (20 weeks) with "ICT at OFF" and Military Benefits set to "LOW"

Overall, it can be concluded that when the benefits for the military are low, the chances of defection are high resulting in a win for the citizens as no military members are left to prevent the revolution. The result does not change whether ICT is ON or OFF. When the ICT if turned OFF, there are better chances of the government winning over a civil war occurring and with middle level benefits, there is an approximately equal chance that the government could win or a civil war could ensue. However, when ICT is switched ON at a probability of 50%, then even with military benefits being high, the chances of a civil war are at the same proportion as that of the government winning, hence crushing the revolution. And when the military benefits are low, there is a higher chance of a civil war raging over the government winning. Figure 10 summarizes the results compendiously.

Figure 10: Summary of the Results and the Resulting State of the Institution

7. DISCUSSION

Political conflicts and rebellions are a complex phenomenon and they are composed of connected, heterogeneous behaviors (parameters) in individuals and military that come together to cause rebellions and civil unrest. This model strives to connect those different behaviors and factors that play a role in the start of a revolution and pave its direction. The model that was developed for this paper explores how emotions, income, media (ICT), personalities together decide how and when a rebellions can start, how long it will last, and what the outcome would be. The way in which the model forecasts the results based on a set of input parameters has implications for governments to realize where their Institution is leaning toward if a revolution were to occur and make economic and diplomatic changes in accordance with it. The model also paves way to better forecast the outcomes of a revolution and the role ICT plays in channeling its direction.

The model for purposes of this paper has been simulated only for a few, limited runs but it holds tremendous potential to be enhanced. Future work using spatially explicit ABM techniques to better aim military and citizen placement are merited. This paper's model does not include variation among agents based on demographic groups including inter-ethnic warring among different rebel groups, which in Arab countries can play a critical role. The model also needs to be enhanced for inclusion of other factors when military benefits are low.

8. CONCLUSION

This model, despite the existence of other mathematical, economic and international relations models and even one agent-based model that have tried to study Arab Spring revolutions, has a niche in the study of how revolutions can shape the outcome of an Institution especially in the context of the countries in the Middle East as it focusses on combining several factors including ICT and the personality of the citizens. While there are several potential enhancements that the model could benefit from such as exploring the role of inter-factional rebel in-fighting, the model in its current state is still very robust and could inform economic, policy making, and military decisions for a Institution. As the model has been designed to show several outputs, it is easier for non-modelers to understand and form decision making policies based on the outcome and results that this model reveals, and thereby intervene through policies, politics, international affairs, or another form of diplomacy to prevent rebellions and civil unrest before it surfaces and can become violent and thereby ultimately, besides other things, save human lives, prevent massive refugee crisis, and ensure protection of property and infrastructure.

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