Computers, Environment and Urban Systems 61 (2017) 66–80

Contents lists available at ScienceDirect

Computers, Environment and Urban Systems

journal homepage: www.elsevier.com/locate/ceus

Modeling the emergence of riots: A geosimulation approach

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ARTICLE INFO

Article history:
Received 2 August 2015
Received in revised form 17 September 2016
Accepted 17 September 2016
Available online 17 October 2016

Keywords:
Agent-based modeling
Geographic information systems
Social network analysis
Riots
Social influence
Rumor propagation

ABSTRACT

Immediately after the 2007 Kenyan election results were announced, the country erupted in protest. Riots were particularly severe in Kibera, an informal settlement located within the nation's capital, Nairobi. Through the lens of geosimulation, an agent-based model is integrated with social network analysis and geographic information systems to explore how the environment and local interactions underlying Kibera, combined with an external trigger, such as a rumor, led to the emergence of riots. We ground our model on empirical data of Kibera's geospatial landscape, heterogeneous population, and daily activities of its residents. In order to effectively construct a model of riots, however, we must have an understanding of human behavior, especially that related to an individual's need for identity and the role rumors play on a person's decision to riot. This provided the foundation to develop the agents' cognitive model, which created a feedback system between the agents' activities in physical space and interactions in social space. Results showed that youth are more susceptible to rioting. Systematically increasing education and employment opportunities, however, did not have simple linear effects on rioting, or even on quality of life with respect to income and activities. The situation is more complex. By linking agent-based modeling, social network analysis, and geographic information systems we were able to develop a cognitive framework for the agents, better represent human behavior by modeling the interactions that occur over both physical and social space, and capture the nonlinear, reinforcing nature of the emergence and dissolution of riots.

1. Introduction

Riots can take many different shapes and forms but can be broadly defined as a type of contentious collective action that emerges when individuals without regular access to institutions act out on behalf of new or unrecognized rights to highlight their grievances (Tarrow, 1994). They can be driven by a variety of social and political grievances, including inequality (Jackman, 2002), resource scarcity issues (Auyero & Moran, 2007), or the unfair treatment of civilians by authorities (Stark, 1972). While riots have been studied within several disciplines, including sociology (e.g., Tucker, Schweingruber, & McPhail, 1999), physics (e.g., Pabjan & Pekalski, 2007), and military operations (e.g., McKenzie, Garcia, Nguyen, Seevinck, & Petty, 2004), this has not been the case within urban studies, especially when explored through the lens of geosimulation. Furthermore, geographically explicit agent-based models have been used to study a wide variety of urban phenomena from the bottom up—including residential mobility (e.g., Jordan, Birkin, & Evans, 2014), the growth of informal settlements (e.g., Augustijn-Beckers, Flacke, & Retsios, 2011), pedestrian movement (e.g., Torrens, 2012), and crime (e.g., Malleson, Heppenstall, & See, 2010)—but little attention has been paid to the utilization of spatial data in creating agent-based models of riots. We would argue that this is an important but overlooked area especially given the rising urban population and youth bulge (NIC, 2012), which is playing a defining role in the increase in riots (OECD, 2011). For example, immediately after the results of the 2007 presidential election were announced, Kenya broke-out in protest. Deep-rooted grievances, perceptions of government illegitimacy, and Kenya's long history of political and economic ethnic exclusion led many to believe that election results were rigged, which quickly escalated the protests to violence. Rioting would continue for nearly two months, resulting in 1100 deaths and up to 350,000 internally displaced people (De Smedt, 2009).

Kibera, an informal settlement located in Nairobi, became the "epicenter" of the riots that hit the city (International Crisis Group, 2008). A map of Kibera, divided into its fourteen neighborhoods, is shown in Fig. 1. According to Allport and Postman (1947), a rumor is necessary to "incite, accompany, and intensify" rioting. This was no different in Kibera, where the rumor that election results were rigged, serving as the external trigger, played a significant role in the riots (Dercon & Gutiérrez-Romero, 2011). Between cell phones, text messages and radio, rumors spread quickly (De Smedt, 2009). Approximately two months after the riots began, a power-sharing agreement was reached and the violence ceased almost immediately (De Smedt, 2009).

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http://dx.doi.org/10.1016/j.compenvurbsys.2016.09.003
0198-9715/

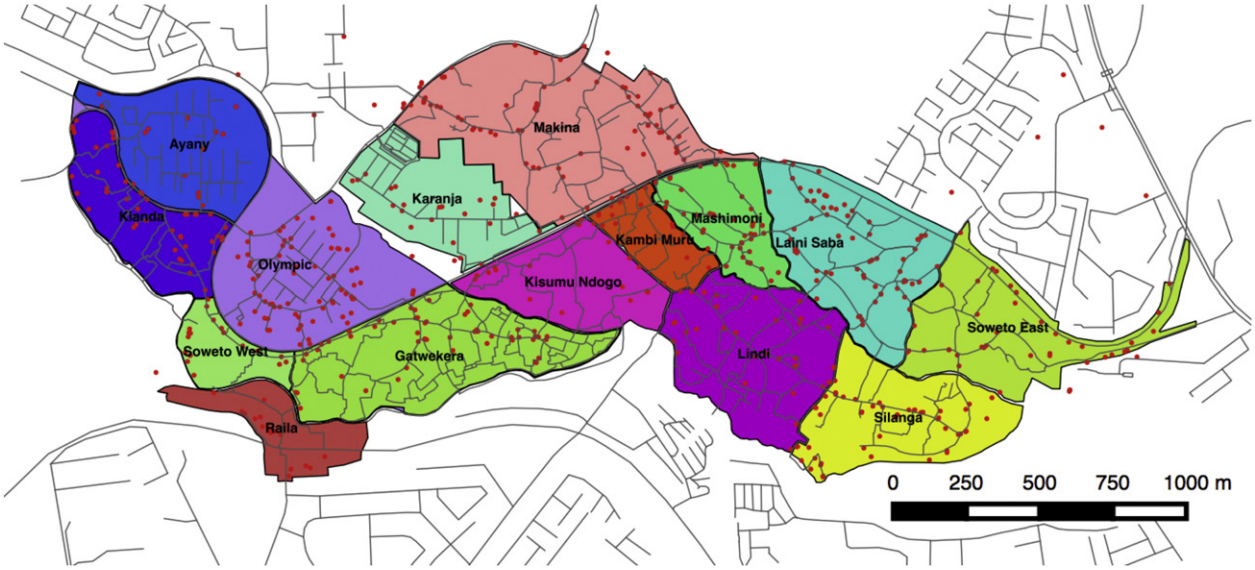

Fig. 1. A map of Kibera divided into its 14 neighborhoods. Points of interest, including schools, health facilities, and religious institutions are represented by red circles and the transportation network is represented by black lines.

The emergence of riots is a complex system; they arise from the interactions between individuals with distinct identities, interests, and needs, all within a connected social network over a physical environment (Torrens & McDaniel, 2013). In order to capture this complexity, in this paper we develop a theoretically grounded agent-based model (ABM) that integrates ABM with geographic information systems (GIS) and social network analysis (SNA) through the lens of geosimulation (Benenson & Torrens, 2004). We focus in particular on the individuals' decision to participate (or not) in collective action that may lead to riots, which incorporates the unique socioeconomic and environmental factors of Kibera, the local interactions of its residents, and an external trigger in the form of a rumor. Furthermore, as we attempt to balance complexity with parsimony, we seek to ground the model as much as possible in theory and/or empirical data (O'Sullivan et al., 2012). It should be noted that for simplification purposes, we do not incorporate additional factors introduced after the riots breakout (e.g., the role of police) as this is not the focus of the paper. While other studies have explored the use of ABM, GIS, and SNA with respect to riots, most have explored the techniques in isolation, which will be discussed in Section 2. We will argue that the integration of the techniques allows us to create models that can better capture the interconnected and nonlinear dynamics associated with the emergence of riots; allowing us to capture elements in the real world that may be missed using the techniques in isolation—our interactions are affected by both our physical distance and our social networks. The riots that took place in Kibera in 2007 are used as inspiration in the development of the simulation presented here. However, we take a "generative" approach to modeling riots, which we ground in theory, as the purpose is not to model the exact timing and outbreak of riots but to see if riots emerge through the interplay of ABM, GIS, and SNA. In the remainder of this paper, we will provide a background into theories of human behavior relevant to the riots (Section 2), discuss the details regarding development of our geosimulation model (Section 3), show the results from the model (Section 4), and summarize the paper (Section 5).

2. Background

In order to effectively construct a model of the emergence of riots, it is important to briefly review the spectrum of literature. This ranges from exploring human behavior, specifically that related to the decision to participate in collective action and riotous behavior (Section 2.1), the external triggers that influence a person's decision to riot (Section 2.2), and how researchers have attempted to incorporate such behaviors within previous models (Section 2.3).

2.1. A unified theory of identity

Modeling human behavior is not a simple task; humans neither behave randomly nor act perfectly rational (Simon, 1996). To this end, theorists have moved away from rational choice theory (e.g., Lichbach, 1995) and relative deprivation (e.g., Gurr, 1970), and have stressed group identity as the driver of internal conflict and the emergence of riots (e.g., Brubaker & Laitin, 1998). Identity theory focuses on the concept of identities as *roles* (McCall & Simmons, 1978). It is the way a person is or wishes to be known by others (Stein, 2001) and how that translates to "being and acting" in that role (McCall & Simmons, 1978). Social identity theory, on the other hand, involves the concept of social *groups*, where a group is a "collection of individuals" who identify with the same social category (Tajfel & Turner, 1979). Such identification with a social group can lead to the differentiation between "we" and "they" when faced with an opposing group (Stein, 2001), and to intragroup cohesiveness and cooperation when intergroup conflict exists (Tajfel & Turner, 1979), which can allow for group mobilization for purposes of social movements. Individuals have an array of identities (Oyserman, Elmore, & Smith, 2012) and by combining *role*-based and *group*-based identities into one theory, Stets and Burke (2000) integrate collective identity with the individual, heterogeneous identities of group members, allowing for the dynamic modeling of individual and group identities under one theory.

It has been argued that an identity has four main components: an *Input*, an *Identity Standard*, a *Comparator*, and an *Output* (Stryker & Burke, 2000). Furthermore, the identity model as shown in Fig. 2 requires aspects of both the inner and outer environments. The inner environment is the person itself (shown as the blue shaded areas) and the outer environment is the person's surrounding (shown as the green shaded area). This can be compared to Simon's (1996) view of inner and outer environments, where the inner environment is the artifact itself (in this case, the person) and the outer environment is the surroundings for which the artifact operates. The person seeks a particular goal in the outer environment, in this case, to meet the *Identity Standard*, and this in turn dictates the processes of the inner environment. The outer environment thus goes beyond geographical space to include our complete surroundings, such as meaningful feedback from others (i.e., reflected appraisals) and others perception of our