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Comment

The role of mathematical modelling in modern criminology Comment on "Statistical physics of crime: A review" by M.R. D'Orsogna and M. Perc

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Criminality is a big challenge at several different levels. This is particularly evident – even for microcriminality – in urban areas (in Europe and North America the percent of population living in urban areas is around 85%). It is considered by sociologists among the most important indexes affecting the (perception of the) quality of life in a given place.

Starting from the seminal paper by G. Becker [3], the study of crime and criminality from the point of view of economics has been developed in several directions. And the role of mathematical, statistical, and physical models has been steadily increasing. Thus, the paper [6] appears to be extremely timely and useful.

Generally speaking, models are often more *descriptive* than *predictive*, in the sense that it is not expected that they predict e.g. the number of burglaries or car thefts that will occur in a given district over a given period of time. Nevertheless, they can be instrumental in describing the mechanisms by which it can be foreseen that a concentration of crimes can appear in particular zones (hot spots), or the "contagion" that criminal behaviour can have on particular classes of individuals. This description can in turn suggest how to contrast the phenomena.

Therefore, modelling the diffusion of criminal (or simply unlawful) behaviour in urban areas can be a tool that administrations and police authorities can use in order to choose optimal strategies to combat crime. And this is particularly important in a horizon of budget cuts that impose the best use of the existing (scarce) resources, optimization of strategies, logistics etc.

Another feature of the models is the fact that they allow to perform simulations to mimic the response of the system to changes of parameters, of external inputs or constraints. Of course *"for complex phenomena as criminality (in its various guises), the goal is not to represent the whole reality, let alone generate precise predictions. However, the enhanced understanding of "stylized facts" that characterise a system of interest by isolating elements of a theoretical model can shed new light on the subject and contribute to new insights into the more complex global picture. With the aid of such models, one can then investigate the various effects implied by factors such as the severity of punishment, duration of imprisonment, different deterrence strategies, or the allocation of limited crime reduction resources in the most efficient way"* [4].

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The review by M.R. D'Orsogna and M. Perc [6] shows how rich is the panorama of the methods that can be of help.

A special attention is devoted to agent-based models in which the time-varying attractiveness of a given target (for instance in burglary) is modelled, biasing the movement of a burglar over a grid simulating the city; the consequent probability of occurrence of crime is evaluated, thus influencing in turn the attractiveness of the target. Possible mean-field approximations are discussed, leading to models based on population dynamics and on reaction–diffusion equations. Perhaps, from this point of view, the bibliography of the review could be successfully complemented with the one that can be found in the paper by M. Gordon [7] and by the papers published in a special issue of EJAM [11] in 2010.

Among the agent-based models, one could also include the methods based on cellular automata that can take into account the influence that "neighbours" can have in the diffusion of unlawful behaviour (e.g. tax evasion), see for instance [9].

Another important class of models is based on "space–time point processes". These are particularly relevant to the crimes that appear to be clustered in time and space, so that a methodology similar to that applied in studying earthquake swarms and clusters can be used. This is a typical example in which a technique that has proved efficient in a context that is far from sociology and criminology appears to be successful not only in describing the occurrence of an offence, but also, in some cases, to locate the home base of criminals.

It is well-known, and properly outlined in the paper, that evolutionary game theory has proved to be apt to model some basic phenomena connected with crime and criminology, including the role of social control in discouraging criminality: the category of "informants" plays a major role in the desirable transition from a criminal-controlled society to an almost crime-free situation. And this is clearly described by an evolutionary game with four possible strategies (criminal, informants, guards, and "blinds"). Inspection games are another category of techniques that are used in this context, although some counter-intuitive results could be obtained (see e.g. [1]).

An emerging line of investigation is also reviewed by the paper, with several hints of possible new areas of research: the development of networks of criminality. The increasing interconnectivity of our societies suggests that, besides of the classical cases of geographically localized networks such as street gangs, one could have to deal with organized criminal networks [8] that have a worldwide domain of action (drug dealers, money laundering [2,10] etc.); but another topic that deserves further investigation concerns the way criminal or unlawful behaviour can proliferate just because of the existence of social networks [5].

A final remark on the paper: the bibliography is so rich that it would have been desirable that the references are ordered by the alphabetical order of the first author, or by the date of publication.

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