Modeling Urban Mobility for E-Governance with Low Energy Complexity

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Abstract

In this paper we design some characteristics of a possible E-governance system for the urban mobility. In particular we shortly present the complex city features and the background automata gas paradigm for a microscopic modeling. Moreover we show some statistical laws based on long time series of traffic dynamics data, fundamental for the now-casting and the private vehicles mobility control. We study also the crowd dynamics, specifying a stochastic equation founded on a cognitive decisional dynamics, with a threshold changing the evolution from a cooperative behavior to a selfish one, which we identify with the emergence of 'panic states'. Concluding, essentially our E-governance system is composed of a large data base, of one or more centers that can collect real time microscopic data, elaborate models based on the individual mobility demand, find the optimal self-organized mobility states and diffuse the relative information (best path dynamical map) along the mobility network performing a bidirectional continuous interaction with the citizens. Moreover we underline that the complex interactions via information diffusion, i.e. cognitive based dynamics and mobility governance are low energy consuming

Keywords: urban mobility, low energy complex systems, E-governance.

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1 Introduction

Cities are the nodes of the human civilization network from Neolithic until today, when more than half of the whole world-wide population is composed by individuals that live in urban systems, from towns to metropolis. But in the last three, four decades the discover and development of complexity changed the landscape, in the double sense both that many phenomena must be investigated with a multidisciplinary approach if we want really to understand them, and that also in the physics domain a complex paradigm allows us a deeper knowledge of the richness and variety of nature at our human scales [27]. As matter of fact, from one hand many natural events do not respect the deterministic laws not even in the physics dominion, from the other one the behavior and the evolution of human beings are in part governed by free will, intrinsically non deterministic. A completely ordered world appears too much inert and lifeless, and the completely disordered one would make the life and the human culture development impossible. From any point of view the order disorder duality risks to wear us in a blind alley. Complexity can be conceived as the exit strategy invented by nature to escape from this duality, discovering that many natural phenomena are organized but not deterministic, that is also a characteristic of the social systems (almost the democratic ones) [5]. Complexity science faces the problem studying systems whose dynamics cannot be reduced to physical fundamental principles. Moreover in complexity science the role of models is modified becoming not a specific realization of a general theory, but rather an instrument of knowledge to perform in silico experiments that allows one to verify the consistency of the assumptions with the considered phenomenon [22]. In other words the models realize a virtual reality where the simulations point out the relevance of different hypotheses on the appearance and evolution of emergent properties identifying the control parameters [6]. This approach allows to face the control and governance of urban mobility with a sort of minimal energy principle, because it takes advantage of the dynamical properties of the system itself to avoid the transition to congested states. This means that the control strategy is not achieved by an external forcing of the system, but by a suitable change of the control parameters to drive the system through natural quasi-stationary states. The external forcing like for example a reduction of the incoming fluxes at the boundary are clearly more energy consuming since its result is to move the congestion from the urban area to the surrounding areas. The understanding of the individual strategies and of the cognitive behavior [13] is a key point for designing of the mobility governance to minimize the energy costs by optimizing the travel times and the global state of the road network. Indeed, as suggested by the idea of complexity, the optimal states for a system are nearby the critical thresholds, that means an instability character in the dynamics, and the E-governance strategy should allow a continuous control of the system state to avoid the instability rising. Under this point of view the E-governance system based on the construction of a virtual reality in silico permits a consistent energy saving to prevent the congestion formation up to the threshold of the system capacity. Of course, when one reaches such a threshold, only a strong external forcing can be efficace.

2 Physics of the City

> Aggregate of beings that hold their biological history into its borders and model it within all their intentions proper to thinking creatures, the city results at the same time by the biological generation, the organic evolution, and the aesthetics creativity. The city is contemporary a natural object and a subject of culture. (Translated from French by the authors)

From these words of Claude Levi Strauss clearly emerges the complex nature of every urban system, that today it is generally accepted and considered in order to study the city, its development and evolution [8]. Let us stop for a moment to consider the city as an extremely intertwined set of flows, information and forms. The city shows itself to be polymorphous, polysemic and polyglot, stratified in time and crossed by actors and objects whose dynamics are extremely different and can be conflictive, often engendering a feeling of chaos, i.e. we can say that cities live at the edge of chaos, and the problem is exactly to govern the system emerging complexity and not chaos, specifically in citizens mobility which is crucial for a good social quality of life [7]. If we want to try to express the quality of this complexity in quantitative terms, using the instruments of the exact sciences, without losing its texture, we must reduce the semantic, logical, syntactic and phenomenological field in which to articulate the possibilities of constructing models able to be descriptive, explanatory and, at least to some extent, predictive. A simple consideration can help us in the reduction process: regardless of the variety and complexity of flows, forms and information, an urban system exists insofar as it is inhabited. A city is not even definable without citizens, elementary components common to any urban system, from the Neolithic *Catal Hoyuk* to the modern *New York*, only changing over the time the complexity degree. Therefore our physics of the city will be essentially physics of the inhabited city, and given the large number of elementary components, this means non-equilibrium statistical physics, because the town is an open system. Moreover, given that the elementary components move in urban space-time, this also means the physics of dynamic systems and since the individuals in the system have free will, we are also talking about probabilistic physics. Finally, since the elementary components have memory and are capable to draw information from the environment, in order to process it according to intentions, choices and decisions, the physics of the city must also be intentional, cognitive and decisional [2]. Another basic ingredient of physics, besides the elementary components, is a space-time where the dynamics can evolve. So we can ask if it is possible to identify a space-time structure proper to a generic urban system. Obviously we can describe the streets network, and the different morphologies with a spatial metric that usually it is not Euclidean, but this it is not sufficient to develop an urban dynamics. We need also of a clock, a time structure scale invariant. This structure can be modeled by the chronotopoi (literally, places of time), the primal agents of urban temporal dynamics able to generate time correlations that would not exist without them. In the planning language, the chronotopoi are defined as areas where are implanted temporal scheduled activities, for example an hospital, the university, a shopping center and so on, that generate/attract mobility [14]. Urban topology thus becomes chronotopic and the interaction between the individual's agenda and the chronotopoi pulsations produces complex urban mobility. Finally for us a possible paradigm of complex system is an automata gas, i.e. a gas of individuals that can process information and perform a cognitive dynamics [23], the automaton being a sort of 'intelligent' atom [26], more precisely a particle, with mass, size, velocity and so on, i.e. the typical physical properties, but also with a cognitive internal state.

3 Mobility and Social Dynamics

Understanding human mobility is significant for problems related to urban planning, design of transportation systems and forecasting the diffusion of infectious diseases [16]. Moreover mobility and transportation is a common need in many and different natural systems, where individuals interact with each other by cooperation or by competing for the same resources. Usually for the human social systems (but it is true also for other natural systems) we found that the features of mobility and transportation systems are closely related to the community structure, and to liveability of city and/or the quality of life. For example in the Western city of nineteenth and twentieth centuries, the organization of industrial working in big factories, with its rigid entry and exit times (the famous eight-hour factory day) controllably, predictably and almost deterministically systematized the citizens mobility, but when the great capitalistic factory empties and declines, the labor organization is transformed, becoming more complex: spatially scattered across the territory and time based on flexible schedules [8]. This new spatiotemporal and virtual displacement of labor, distinctive of post-industrial metropolis, induces a widespread mobility unpredictable and asystematic, which is strongly relevant in urban systems. Furthermore a new culture of planning was arising, where the free decisions and behaviors of the citizen become significant and cannot, in general, be reduced to simple statistical averages or organized by an external authoritarian form. A culture where planning and design emerge from the bottom up, where the singles citizens are in touch with the urban problems, and where the individuals contribute to drawing up the plane. So the science of city must face the problem of a new understanding in terms of how the individuals behave, and the strategies/actions that they develop in order to know and modify their environment. This means that we must focus the attention at small spatial and temporal scales observing and modeling the microscopic urban dynamics. In this context, for example, we studied the car mobility in many different Italian cities from Roma to Bologna, from Torino to Senigallia, analyzing a large set of GPS individual car data and discovering three statistical laws, which are in our opinion valid for every European city, from towns to metropolis [1, 4]. Moreover we studied the pedestrian dynamics, especially in the Venetian Carnival context in order to understand the crowding phenomena and the existence of self-organized states in a automata gas.

4 Traffic Modeling

Traffic on an urban network is the consequence of individuals mobility demand driven by the chronotopic temporal dynamics. From one side the microscopic traffic dynamics is forced on a one-dimensional space (the street), from the other side its spatial scale is extended to the whole city. For this various researchers have proposed to simplify the microscopic dynamics, focusing the attention to the fluxes optimization in the road network. Nevertheless the microscopic drivers' behavior is responsible of local congestions that may propagate on the network, producing a macroscopic phase transition. In the literature we can find two main types of models: the cellular automata which discretize the road dynamics and the continuous models based on stochastic differential equations [17]. Our *Auto-Mobilis* model is built up with a simple microscopic continuous dynamics, but able to describe different driving styles and behaviors at the crossing points (traffic lights, roundabouts and stop signals at insertions). The microscopic physical dynamics is defined by a differential equations of the form

$$\begin{aligned} \dot{s}_j &= v_j, \\ \dot{v}_j &= a(s_{j-1} - s_j, v_j, v_{j-1}(t-\tau); \Theta), \end{aligned} \tag{1}$$

where (s_j, v_j) are the position and the velocity of the j-automaton on a road, which the follows the $j-1$ driver, Θ is the parameters set that characterizes the individual behavior and τ is a reaction time to the velocity changes of the successive vehicle. More precisely the parameters Θ are individual characters and have a random distribution among the individuals' populations. Indeed the driver behavior can be related to citizens social characters (sex, age, birth place, etc.), so several social mesoscopic aggregates can be identified. In the real situations often the presence of different drivers' types is crucial for understanding urban vehicles mobility. Moreover the model can simulate different traffic regimes: at low density the free flow, and when the density increase the model performs a synchronized flow, which becomes unstable when the local density overcomes a threshold and we can see the emergence of congestions [9]. Finally as matter of fact the emergent global properties of traffic cannot understood, described, and eventually predicted only using microscopic dynamics, a global cognitive time-dependent field interacting with individuals is needed [12, 10]. The chronotopoi are the agents constituting a cognitive map to the individuals by means of cognitive field. In other words the chronotopoi are the adaptive agents generating the individual mobility demand, and introducing timing correlations between the city macroscopic level (social time) and the microscopic dynamics based on the individual time agenda.

5 Traffic Empirical Laws

The new information technologies allow direct measures of individual mobility behavior in the city, opening the concrete possibility to build up a new class of models able in principle to predict, at least statistically, the traffic dynamics, so that the governance could be more effective, especially to prevent congestions. As is well known, the congestion phenomena are

Figure 1 Torino, September 2007, 5 million GPS data corresponding to 800 thousands trajectories and 16 thousands vehicles on an area of 27 $\times$ 23 km. Data provided by Octotelematics Spa.

strongly impacting on energy consumption in terms of time and fuel lost and on pollution, moreover also on expended nervous energy. In Italy 2% of vehicles population has a GPS system, for insurance reasons, that gives information on position and velocity sampling the trajectories at a spatial scale of $\simeq$ 2 km, plus the initial and end point of each path. This means a direct time-dependent measure of the individual mobility demand on a significant population sample. Analyzing this large data set, we had extracted time dependent data series sufficiently long in order to study the statistical mobility car features, as for instance the path length distribution, the downtime in the different activities related to mobility, the average flux in the road network and the degree distribution for the destinations. But firstly we show in Figure 1 the picture of the GPS data in Torino for the whole month of September 2007. Each single datum has been drawn as a square of 4 by 4 meters, the dot darkness codes the velocity (light grey from 0 to 30, grey from 30 to 60, and black $>$ 60 km/h). This picture gives an immediate perception of the mean traffic situation, giving prominence to the hierarchy and the critical arcs of the road network.

Before giving the empirical results, we briefly discuss the data set main features. When the GPS signal is good, the time precision of the recorded data is 'perfect', whereas the space uncertainty is of about 10 meters, usually sufficient to localize the car on the road. The data suffer when the GPS looses the satellite signal. This type of problem is particularly relevant for the exact

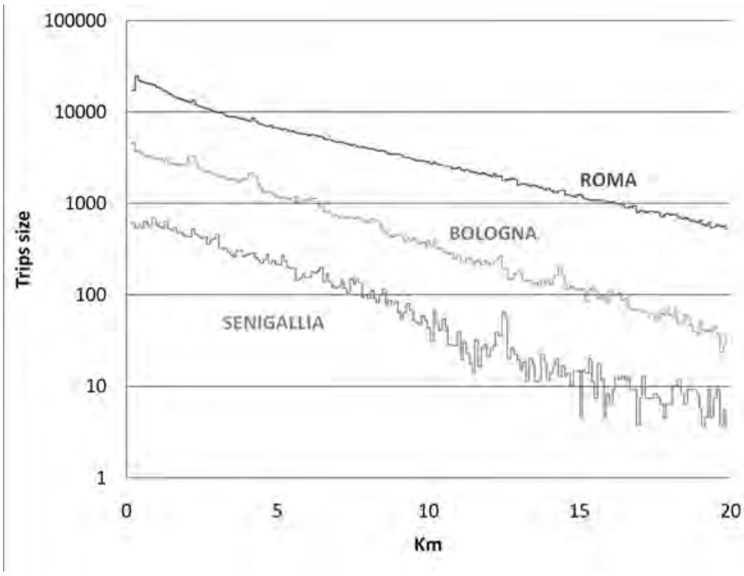

Figure 2 Trip lengths distribution for Roma (a large metropolis), Bologna (a mid size city) and Senigallia (a maritime uncongested small town). Data have been recorded during February 2007 (Roma) and during June 2006 (Bologna and Senigallia). The total number of trajectories is 1,176,763 for Roma, 79,154 for Bologna and 13,838 for Senigallia.

reconstruction of short paths, where it can be possible to have a trip with no internal data and a filtering procedure has been applied to our data base to avoid systematic errors. At this point we shortly review three empirical macroscopic laws concerning the car mobility we deduced from the GPS data time series. These laws do not depend on the specific urban topology neither on the citizen's number or on the car density and traffic conditions, i.e. they look completely general at least for the Italian urban systems, and we think also for the Europeans ones.

The first law says that the lengths distribution of the trajectories looks as an exponential with a mean distance of about 5 km as shown in Figure 2. This law suggests that urban traffic is a local phenomenon with a 5 km exponential decaying scale, a characteristic length common to the citizens cars of all Italian urban systems we analyzed (Roma, Bologna, Senigallia, Torino, Firenze, Genova and Milano). This result agrees with the existence of a mobility energy proposed in [18].

In Figure 3 we show a second empirical law: the car stops distribution as function of the downtime duration, which is a typical t^{-1} power law (Ben-

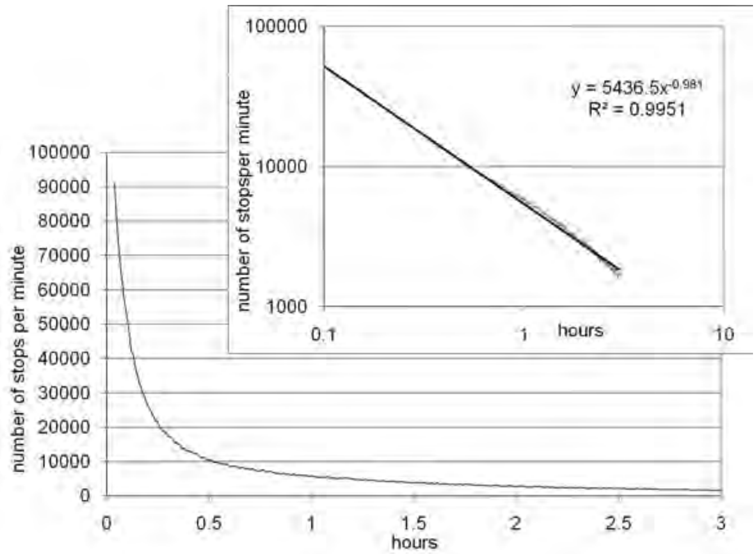

Figure 3 Stop time distribution for Firenze (March 2008) with in a bi-logarithmic scale (inset figure). For short stops (< 3 hours) we get a t^{-1} power law (Benford's law). The stop time density is computed with time intervals of one minute.

ford's law) [19]. This law may suggest the existence of a log-time perception for individual as proposed by psychologists [24].

In order to find significant signal hidden in the statistical noise, we look the phenomenon for a longer time. In Figure 4 the peaks at 4 and 12 hours point out a structure which can be related with the circadian and/or working rhythms.

Thirdly we studied the trips distribution for each of the $15,000$ monitored vehicles in Firenze for one month. More precisely (see Figure 5) we computed for each vehicle the number of times (rank) of its parking in the same spot (a square with 500 meters of size). The data analysis suggests the existence of a power law (n^{-2}) for the rank distribution that could be related to the stop time distribution (see Figure 3).

Concluding this part, we have discovered three empirical statistical laws, for the lengths, the time stops and the node rank valid for the car mobility in a generic Italian urban system. In our philosophy these laws are the basis for the traffic now-casting and for the real time prediction of the car dynamics.

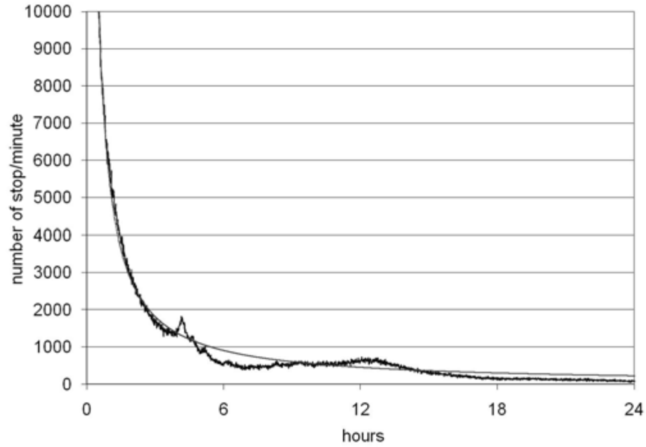

Figure 4 Time stops distribution for Firenze (March 2008) for stops up to 24 hours, in grey the t^{-1} power law.

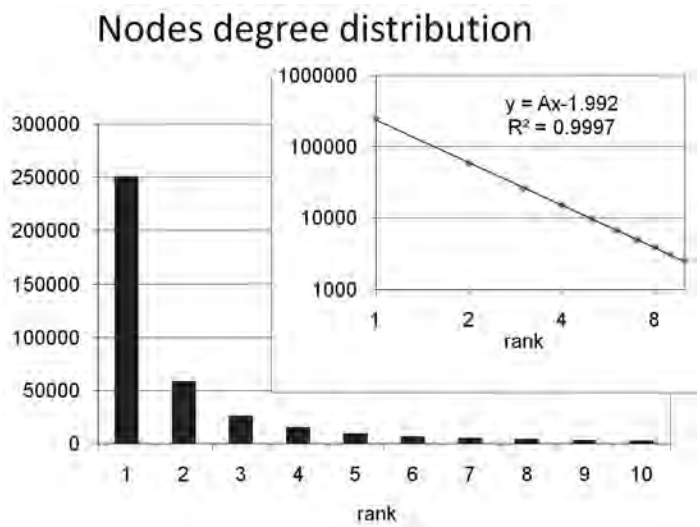

Figure 5 The nodes degree distribution, where it is evident that the repetitive travels are almost negligible, moreover in the bi-log scale the n^{-2} power law is shown.

6 Low Energy Complexity

Complexity is a very wide concept. In urban mobility we study phenomena whose complex dynamics can be modeled by physical and cognitive processes. Our claim is that the cognitive dynamics is the key to solve the criticalities. For the short distance microscopic dynamics we model an individual interaction theory based on local information acquisition to avoid collisions. We can assume this high energy consuming dynamics as the zero ground level. Above this level, the cognitive dynamics based on information exchanging, has a fundamental role in the process of choosing the long distance paths. This information type interaction is low energy consuming and can be used to choose the best path strategy reducing the energy consuming of the ground level (time, fuel and so on). Now the main idea is constructing the E-governance system using the new information-communication technologies (GPS, smart cellular phones, etc.) to collect long time series of data to understand the individual behavior and the mobility demand, and then complex models to perform virtual experiments on critical situations management (think for example to extreme events). The final E-governance system will be able to elaborate real time information diffusing it in the whole system in order to give to individuals the possibility of improving their strategies. This also implies a system for the now casting and for the short term prediction, preventing or weakening for congested critical states. A quantitative evaluation of the hours lost in the Provincia of Florence is shown in Figure 6 giving a perception of traffic congestion importance. Figure 6 is based on the difference between the actual measured speeds and the free speed on each road. In the full month of March 2008 the total number of lost hours due to traffic congestion added up to two millions. Preliminary studies suggest that optimal control strategies tend to keep the system just under the transition point [15]. The individual strategies are decisive at this purpose up to the maximal boundary inflow; then only a inflow control can avoid the congestion transition. Indeed the irreversible characters of such transitions requires a big effort and energy expense to recover the non-congested states since one has to reduce drastically the fluxes at the boundaries [20].

7 Modeling Crowd Dynamics and Panic Transitions

The statistical approach based on the GPS data does not allow to enroll the complexity of human mobility due to the individual cognitive behavior and free will. To deal with this problem, we have studied the pedestrian mobility,

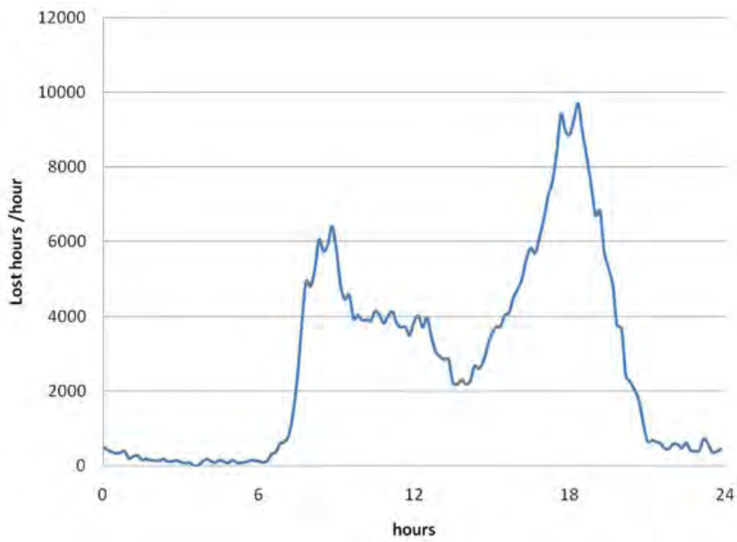

Figure 6 The number of lost hours every hour in an average day of March 2008. It is pointed out that every day between the six and seven in the afternoon almost ten thousand hours are lost due to congestion. In the full month the total number of lost hours adds up to two millions.

that is basic human activity strictly linked with the detailed structure of urban environment and the social life. Indeed due to the human being social nature, the pedestrian mobility will continue to play a fundamental role for the life quality of metropolis. The development of fast and comfortable transportation means has reduced the spatial scale of walking activity to an average dimension of 500 m. The direct observations on video turns out to be the most useful tool to extract detailed information on pedestrian dynamics. Various research group have pointed out the following items [17]:

- pedestrians tend to walk at a desired velocity toward a local destination;
- the desired walking speed depends both on social characters (for example age, sex, job) and on the cognitive internal state;
- individuals develop strategies in order to walk in the more comfortable way (for example avoiding collisions and at least energy consuming), and following a best path according to their propensities and knowledge of the urban topology;
- pedestrians like to keep a certain distance from other pedestrians and borders as walls or obstacles;

- individuals who know each other, tend to form clusters that move as single entities performing a flocking dynamics;
- to avoid physical contacts individuals reduce the walking velocity and take local detours;
- the best pedestrian paths usually are not the minimal time or space geodetic, so a minimal action principle cannot model the dynamics.

In this context one of the most difficult governance problems is facing the crowding and the possible insurgence of panic [11]. From one hand the panic is a typical phenomenon where the irrational behaviour has a strong relevance; from the other we cannot set up real experiments for evident ethical reasons. So we must build up a model including irrational and at the same time able to simulate the crowding dynamics with the transition to the possible panic situations [21]. Elias Canetti described the crowd formation:

> There is a type of slow crowd which can be better compared with a network of streams. It starts with small rivulets gradually running together. Into the stream thus formed other streams flow, and these, if enough land lies ahead, will in time become a river whose goal is the sea. The pilgrimage to Mecca is perhaps the most impressive example of this slow crowd. (Translated from Italian by the authors)

But also the Venetian Carnival or a Rolling Stones concert show similar crowding effect, and the microscopic dynamics play a key role to explain this type of events and the emergent phenomena as, for instance, herding effect, stream formation, and panic states. In these situations the prediction, even if partial or probabilistic, is relevant not only for the pleasure's knowledge but also for the governance in order:

1. to minimize the impact of provisional city users on the town, and in particular on the mobility of local populations;
2. to avoid critical and potentially dangerous crowding phenomena;
3. to prefigure and plan security saving trajectories.

Generally if we want our models being useful for the E-governance, they need not only to reproduce some aspects of the factual reality but also they must be able to explore all the possible paths of the potential reality, via simulations in the corresponding virtual system. Crowd dynamics investigates the emergent self-organized states from the individual behavior, which results from many decision mechanisms, processing information assumed from external. Obviously an accurate description of the decisions chain risks to be too much complex in order to realize a mathematical model. So we have chosen to simplify the problem assuming essentially two classes of models. From one side we consider pedestrian mobility strategies avoiding collisions and/or preserving the 'individual social space', i.e. the space where the human beings accept that another person can approach only if he is a friend. From the other side the individual dynamics is directly related to cognitive processes which depend from the available information. In such a case an individual may perform different choices to reach his destination, and moreover for the free will property he may change strategy at every time step. A significant result has been the discovering of the existence of critical conditions for the transition from self-organized dynamics to chaotic (turbulent) states, where real physical interactions could be dangerous for the people safety. In short we formulate a dynamical cognitive model assuming that:

- there exists an individual cognitive state X that represents the brain activity;
- the cognitive state evolves according to a stochastic n-dimensional dynamical system;
- the stochastic term simulates the effect of unpredictable perturbations that influence the individual cognitive state;
- there is a nonlinear subjective relation between the utility of a decision and the probability of taking that decision;
- the decision utility introduces a potential landscape whose shape depends on external information;
- the potential landscape introduces a partition of the cognitive space according to the possible choices $E(n) = 1, 2, 3, \ldots, n$;
- there exists a decision mechanism which is a function of the cognitive states $X(t)$.

Before the following, we would underscore that the cognitive dynamical hypothesis assumed in our model, is strongly discussed in neuroscience literature [25], i.e. many people do not agree with the assumption that we can consider the brain as a complex dynamical system. According to the previous assumptions we can introduce a stochastic process $X(t)$, which models a cognitive dynamics in a dichotomic decision

$$dX = -\frac{\partial V}{\partial X}(X; I)dt + \sqrt{2T}dw(t) \qquad (2)$$

where $V(X; I)$ is a double well utility potential, I the information related to the considered decision and T is a *social temperature*. The two wells represent the two possible decisions, whose utility is measured by their depth. The

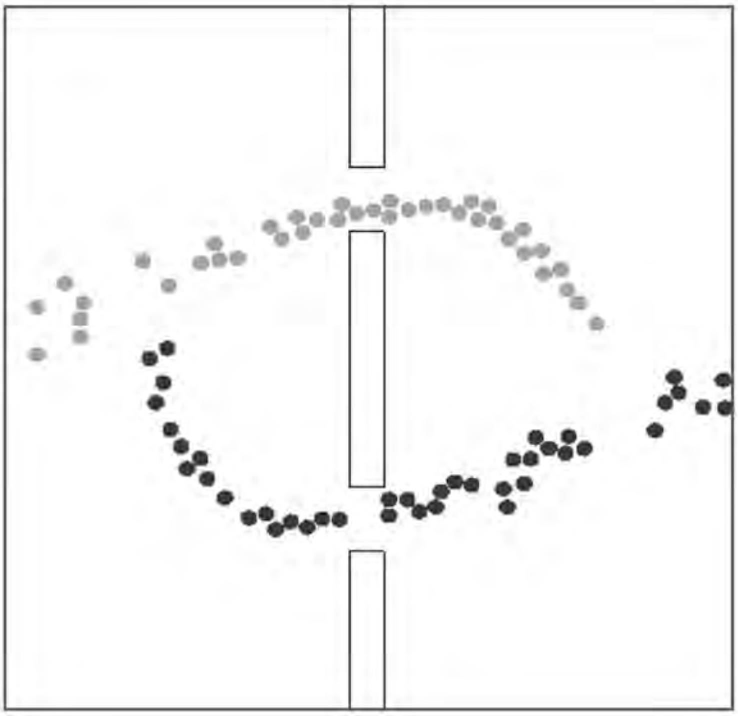

Figure 7 Snapshot of two counteracting populations moving across two narrow doors. The cooperative strategy that the individuals perform at moderate crowding allows the appearance of a self-organized state if the cooperation degree C overcomes a critical threshold.

information I changes the decision utility by varying the depth of both wells. The social temperature measures the individual free will level and the attitude of people to change their decision in an unpredictable way. To consider a realistic situation we simulate two counteracting populations that have to move from one front to the other (see Figure 7) choosing between two narrow doors. Each individual get information on the flux and the crowding at the chosen door, and modifies the utility potential to perform a cooperative strategy in case of moderate crowding and a selfish strategy in case of high crowding. We have introduced a parameter C which measures the ratio between the cooperation degree and the selfish attitude [3]. When C overcomes a critical threshold for a fixed value of the social temperature T, a self-organized state appears as shown in Figure 7. However as the crowding level increases, we observe a sudden transition from the ordered regimes to chaos, due to the

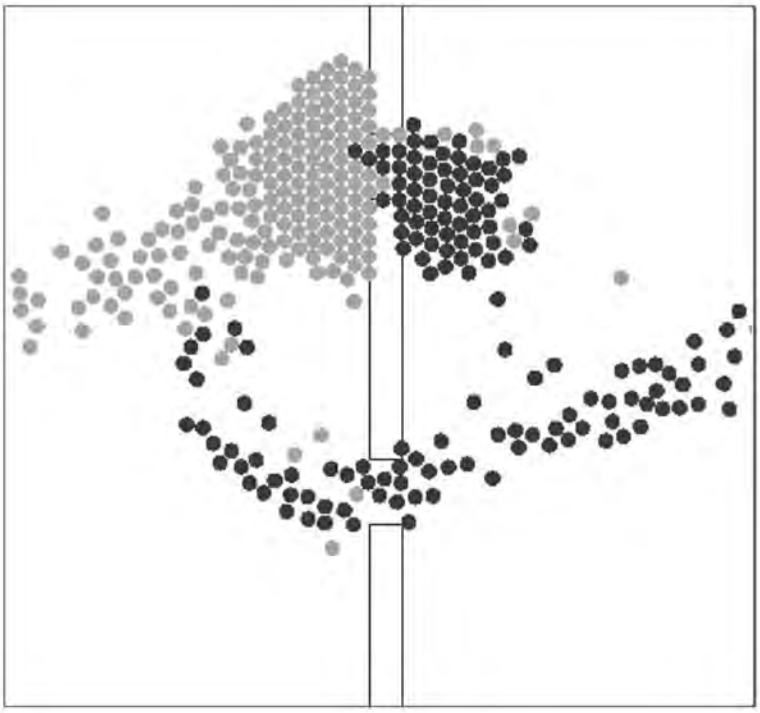

Figure 8 Snapshot of two counteracting populations moving across two narrow doors when the crowding level induces selfish behavior of few individuals and after a chaotic regime a congested state appears.

selfish behavior of few individuals and rapidly to a critical congested state (see Figure 8). Roughly speaking, when the crowd is broken and/or we have a breakdown of the utility function (collective cooperating behavior), the social temperature (the individual free will strategy) becomes dominant, generating a transition to chaotic dynamics, which we interpret as panic. More precisely the transition from a cooperative self-organized state to a chaotic one triggered by few individuals, suggests a possible dynamical mechanism explaining the panic insurgence in crowding. Moreover in principle we could predict, obviously in a statistical sense, the approach of the system to the critical threshold measuring the utility function and the social temperature. A prediction of the possible panic incoming would be a powerful input for an E-governance system, above all for big events as international rock concerts, European football matches, famous carnivals, and so on. Unfortunately at present we do not have sufficient long time series of data for pedestrians and crowding, and so it is impossible to inject in the model a substantial real data set. But at least the GPS and video data collected by our laboratory, during the Venetian Carnival in 2007–2008, give a modeling indication in the previous sense.

8 Conclusions

The models and the empirical traffic laws described in this paper can be useful from different points of view:

1. they represent a set of tools to describe, understand and simulate mobility in a generic urban/metropolitan topology with different transportation systems;
2. they can be used in designing mobility networks in order to evaluate their effectiveness and territorial impact through the simulations;
3. they make it possible to study critical configurations and critical points, and seek potential architectural, communication and other types of solutions and/or alternative trajectories, which could simplify the mobility paths;
4. they highlight conditions in order to have emerging phenomena of self-organization and/or chaotic situation;
5. they can be applied to research into safety routes in the event of accidents or disasters, simulating these extreme situations and their effects on the mobility network;
6. they can contribute to establishing a shared rationality among the different social, economic and institutional actors in the mobility scenario;
7. and last but not least, they can constitute the architrave of an effective E-governance system.

In order to explain the importance of an E-governance system for mobility, we can refer by analogy to the train and railways. The railroad development was based on heavy hardware (tracks, steam, wheels, cars, bridge, and so on) but could not have achieved without the software provided by the telegraph, as macro system of governance, essential to overall railways network. With train a new mobility space was created: the road of iron. But this space quickly became dangerous due to the high speed which the cars were launched on the rails. The invention of telegraph permitted the solution of this problem, because it put in place a new type of control which is now generalized: regulation and control at a distance. Obviously there is a big difference between the train mobility, strictly deterministic, and traffic or pedestrian dynamics largely asystematic because the individual free will, but in our opinion the problem today is the same: to construct a software, an E-governance system, able to control in real time the urban mobility via a widespread information network, based on understanding, intelligence and learning, a system that moreover is low energy consuming.

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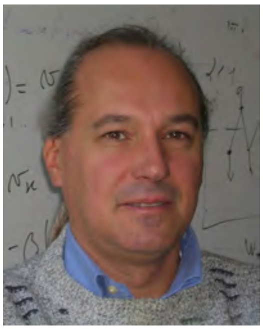
Biographies



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