Walking Finelines between Law and Computational Social Science

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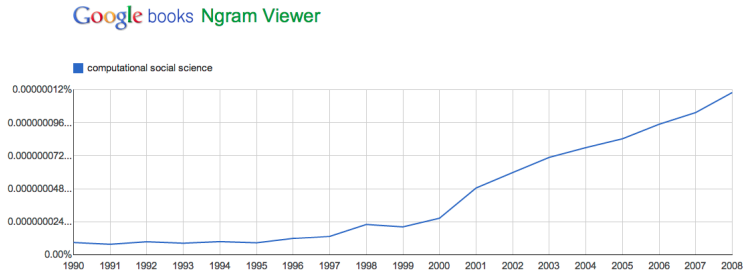

"Computational social science" entries in Google N-gram Viewer from 1985 to 2008

1. Four years ago, "Science" published a position paper on the emergence of a new research paradigm – computational social science – destined to have a profound impact on social sciences[1].

The authors, 15 leading scientists coming from strongly diversified disciplinary spheres, from physics to economics, begin with the observation of a phenomenon that is a fundamental characteristic of the information society: "we live life in the network", each transaction that occurs in the network

> "leaves digital traces that can be compiled into comprehensive pictures of both individual and group behaviour, with the potential to transform our understanding of our lives, organizations, and societies"[2].

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[1] D. LAZER, A. PENTLAND, L. ADAMIC, S. ARAL, A.-L. BARABÁSI, D. BREWER, N. CHRISTAKIS, N. CONTRACTOR, J. FOWLER, M. GUTMANN, T. JEBARA, G. KING, M. MACY, D. ROY, M. VAN ALSTYNE, *Computational Social Science*, in "Science," Vol. 323, 2009, n. 5915, pp. 721-723.

[2] *Ivi*, p. 721.

In their view, the capacity of new technologies to collect and analyse massive amounts of data is bound to play a fundamental role in the future of science.

The position of the authors demonstrates that social sciences are going through a phase of profound change due to two main factors. Firstly, there is resort to computational tools and approaches: understanding social phenomena means increasingly using statistical and analytical tools, exploiting data mining techniques, running simulation models or, in other words, exploiting the power of computation[3]. Secondly, there is integration, enabled by computational tools, among different disciplines and sciences, a process that is involving different areas of social sciences from economics to political science, from sociology to anthropology.

The scenario in which the article in "Science" is inserted is that of the ever increasing availablity of information in electronic format regarding the most varied aspects of reality[4]. The so-called "Data Deluge"[5] is at the basis of innovative scientific research practices rich in implications of an epistemological nature[6] in which scientific progress is mainly the fruit of the application of

[3] See I. AYRES, *Super Crunchers: Why Thinking-By-Numbers Is the New Way To Be Smart*, New York, Bantam Dell., 2007, and the review by E.K. CHENG, *Will Quants Rule the (Legal) World?*, in "Michigan Law Review", Vol. 107, 2009, pp. 967-978.

[4] According to a recent estimate, in 2011 only, humanity has overall produced more than 1,200 billion gigabytes of information compared to 125 billion produced in 2005.

[5] The data deluge is central to a consideration, originating in the scientific domain, that (see, among others, T. HEY, A. TREFETHEN, *The Data Deluge: An e-Science Perspective*, in Berman F., Fox G., Hey A. (eds.), "Grid Computing - Making the Global Infrastructure a Reality", Chichester, Wiley and Sons, 2003, pp. 809-824 and *Nature* of 4 September 2008, which dedicated its cover to so-called "Big data", *Big Data, Science in the petabyte era*) has come to the attention of the non specialised public, as the cover and the articles dedicated to it in the *Economist* of 27 February 2010 show.

[6] In a provocative article of 2008, American physicist and essayist Chris Anderson argues the science that is the descendant of Data Deluge, so-called "Big Data Science", is making scientific method obsolete: "Sensors everywhere. Infinite storage. Clouds of processors. Our ability to capture, warehouse, and understand massive amounts of data is changing science [...] faced with massive data, this approach to science – hypothesize, model, test – is becoming obsolete [...] There is now a better way. Petabytes allow us to say: 'Correlation is enough.' We can stop looking for models. We can analyze the data without hypotheses about what it might show. We can throw the numbers into the biggest computing clusters the world has ever seen and let statistical algorithms find patterns where science cannot" (C. ANDERSON, *The End of Theory: The Data Deluge Makes the Scientific Method Obsolete*, in "Wired Magazine", 2008, http://www.wired.com/science/discoveries/magazine/16-07/pb_theory). Particularly interesting, on this matter, see also T. HEY, S. TANSLEY, K. TOLLE,

computational heuristics to enormous data sets (Big Data[7]) made possible by the development of computer capacities. In this context, computational social science

> "leverages the capacity to collect and analyze data with an unprecedented breadth and depth and scale"[8].

Recently, *Nature*[9] and the website *Edge* have again returned to look at the matter. The latter gathered together eight conversations – spanning from "Big Data" to "Network Science"[10] – under the title "Computational Social Science".

In defining the state of evolution of computational social science, Claudio Cioffi-Revilla[11] demonstrates how this area of research already actually embraces a substantial number (and potentially growing) of methodologies,

In The Fourth Paradigm: Data-Intensive Scientific Discovery, Redmond, Microsoft Research, 2009.

[7] On Big Data see the recent work: V. MAYER-SCHÖNBERGER, K. CUKIER, *Big Data: A Revolution That Will Transform How We Live, Work, and Think*, Houghton, Mifflin Harcourt, 2013; according to the authors (p. 19) "Big data is all about seeing and understanding the relations within and among pieces of information that, until very recently, we struggled to fully grasp" and, moreover, "big data is about three major shifts of mindset that are interlinked and hence reinforce one another. The first is the ability to analyze vast amounts of data about a topic rather than be forced to settle for smaller sets. The second is a willingness to embrace data's real-world messiness rather than privilege exactitude. The third is a growing respect for correlations rather than a continuing quest for elusive causality".

See also the presentation of the book (http://goo.gl/mdPTk) that includes some examples concerning legal data like the analysis of proceedings of the House of Commons in UK and an analysis of the association between the ideology and citation practices of U.S. Supreme Court Justices.

[8] D. LAZER, A. PENTLAND, L. ADAMIC, S. ARAL, A.-L. BARABÁSI, D. BREWER, N. CHRISTAKIS, N. CONTRACTOR, J. FOWLER, M. GUTMANN, T. JEBARA, G. KING, M. MACY, D. ROY, M. VAN ALSTYNE, *Computational Social Science*, cit., p. 722.

[9] Only over the last two years, this journal has gone back five times to the matter, the last time being J. GILES, *Making the Links*, in "Nature", Vol. 488, 2012, pp. 448-450.

[10] See http://www.edge.org/events/-computational-social-science. Up to date, conversations with Dirk Helbing, Nicholas A. Christakis, J. Craig Venter, Cesar Hidalgo, Sandy Pentland, Albert-László Barabási and Tim O'Reilly have been published.

See also, in general terms: B. CASTELLANI, F.W. HAFFERTY, *Sociology and Complexity Science: A New Field of Enquiry*, Berlin-Heidelberg, Springer, 2009 and N. GILBERT, *Computational Social Science*, London, Sage, 2010, that republishes the key articles in this field, brought together within a logical and coherent framework.

[11] C. CIOFFI-REVILLA, *Computational Social Science*, in "WIREs Computational Statistics", Vol. 2, 2010, n. 3, pp. 259-271.

tools and approaches, namely: (i) automated information extraction (algorithmic methods of parsing and coding documents to extract information from data that can be used, amongst other things, for designing computational models or performing advanced statistical analyses[12]), (ii) social network analysis (graph theory applied to social groups and systems[13]), (iii) complexity theory (application of principles, concepts and models of complexity science to the study of social phenomena[14]), (iv) social simulation models (set of different simulation methods spanning from system dynamics to cellular automata and agent-based social simulations[15]), (v) geospatial

[12] This methodology represents an efficacious strategy for using information technology in all the domains of the social sciences, like the law, in which the study and comprehension of the text plays a decisive cognitive role.

[13] Networks, understood as a set of entities (nodes) and a set of relations between entities (links), each defined by a set of attributes, are a phenomenon that can be found in a wide variety of social phenomena. Social network analysis seeks to exploit this characteristic to obtain knowledge of the functional properties of the social phenomenon observed. In doing this, the analysis of the networks is developed in two phases: the construction of a graphic representation (graph) of the phenomenon under investigation and, therefore, the quantitative analysis of the structural characteristics of the graph based on standard methods and metrics. This methodology can provide interesting information regarding the properties of the systems studied, such as resilience, vulnerability, decomposability, functionality. Such information is difficult to derive through simple observation or through more traditional methods. In addition, social network analysis can be applied to design networks that are more reliable and sustainable for public policies, for example in the field of transportation, homeland security, and public health.

[14] The models of the complexity are models based on mathematical concepts and principles aimed at understanding the rules that govern the behaviour of complex phenomena. A complex phenomenon is a phenomenon composed of many elements linked by different kinds of relationships that make it difficult to predict the results produced by these relations. Often complex phenomena are characterised by non-equilibrium dynamics, which are quite often found in challenging research problems across the social sciences. Patterns and regularities of social phenomena like terrorist attacks, wealth and poverty in developing societies and political instability are instances of non-equilibrium dynamics. Complexity models aim at finding regularities of these dynamics in order to comprehend how they evolve and, possibly, predict them.

[15] Simulation models are intended to explain and predict the evolution of complex social phenomena reproducing specific aspects on the computer. The two main simulative techniques used today in the field of social research are system dynamics models and agent-based models. System dynamics models are based on the idea that the evolution of a social system is the result of complex cycles of action and feedback that can be described in mathematical terms. On this assumption, we obtain computer simulations in which the phenomenon under investigation is represented as a set consisting of variables (stocks) and the rates of change (flows) associated with them. Agent-based models are theoretical simulations based

analysis (geographic information systems allowing the spatially-referenced analysis of social phenomena[16]).

At the end of 2012 a paper titled "Manifesto of Computational Social Science"[17] was published that described computational social science as

> "a truly interdisciplinary approach, where social and behavioural scientists, cognitive scientists, agent theorists, computer scientists, mathematicians and physicists cooperate side-by-side to come up with innovative and theory-grounded models of the target phenomena"[18].

Regarding this approach,

> "ICT can provide significant help for social science. Not only ICT can help access, analyse and build upon BigData, i.e. new type of massive data, for addressing BigProblems. It can also help provide instruments for Big-Thinking"[19].

Computational social science is expected to produce effects in different directions. Among these, the impact on science and on society are of particular interest for our purpose. Concerning the impact on science, on the one hand,

on the assumption that social phenomena on the macro level (e.g., the emergence of social norms or the spread of the phenomena of racial segregation) are the result emerging from the interactions that, at micro level, are to occur between individuals and between individuals and the environment. An agent-based simulation typically includes a set of actors/agents, a set of interaction rules and an environment where the dynamic, organizational and spatial characteristics are defined.

[16] GIS - Geographic Information Systems permit the representation and display of information located in a geographically referenced context. The application of these systems to social research (social GIS) has found a place in various areas of the social sciences, also in combination with other quantitative techniques that allow us to produce new knowledge about spatial patterns and configurations that would not be otherwise identifiable with statistical or mathematical methods. This methodology is characterized, in particular, by the fact that it offers a synoptic view of different categories of social data obtained thanks to the superposition of multiple layers of information.

[17] See, R. CONTE, N. GILBERT, G. BONELLI, C. CIOFFI-REVILLA, G. DEFFUANT, J. KERTESZ, V. LORETO, S. MOAT, J.-P. NADAL, A. SANCHEZ, A. NOWAK, A. FLACHE, M. SAN MIGUEL, D. HELBING, *Manifesto of Computational Social Science*, in "The European Physical Journal Special Topics 214", 2012, pp. 325-346.

[18] *Ivi*, p. 327.

[19] *Ivi*, p. 331. Furthermore, the Authors stress that "indeed, computational social science can be characterised along two main aspects, which both take advantage, one way or the other, from ICT developments: a) Big Data, and b) the role of computation in inspiring, formalizing and implementing the core scientific concepts, principles, and ideas of computational social science".

> "the combination of the computational approach with a sensible use of experiment will bring the social sciences closer to establishing a wellground link between theory and empirical facts and research. Such links should inform all sciences in which human behaviour is the main object of research or interest"[20];

on the other hand, new tools and methods to be applicable in any instances where Big Data are, or could become, a key ingredient will be developed. Concerning society, the development of computational social science will make it possible to better understand social processes, allowing researchers to take full account of the interdependencies that characterise today's heavily interconnected world. This can support policy makers in their decision making, in order to enable them to efficiently and effectively identify optimal paths for facing the big problems of society from epidemics to financial crises and terrorism[21].

Ultimately, within the space of a very short time, computational social science has taken the form of an unprecedented intersection among social sciences, information sciences and complexity sciences that seems able to lead human sciences, also through new interpretations of the experimental method[22], to the falsifiability, rigour and cumulativeness that have always characterised the study of the physical and biological world[23],

[20] *Ivi*, p. 341.

[21] *Ivi*, p. 342.

[22] The experimental method, the cornerstone of scientific research in the physical and natural sciences, has now found a place in the social sciences through computer simulations, virtual laboratories for the study of social phenomena. Simulations, in particular, have been the starting point of a new scientific paradigm, presented with regard to the social sciences by J.M. EPSTEIN, *Generative Social Science. Studies in Agent-Based Computational Modeling*, Princeton, Princeton University Press, 2006. According to Epstein, simulations are giving birth to a new kind of science, "generative social science", which can be considered the third paradigm of science along with induction and deduction. Based on the generative approach, to explain social phenomena, you must reproduce, "generate", the phenomena themselves within a computer simulation. On the "epistemolgy of simulation", see also: H. SIMON, *The Sciences of Artificial*, Cambridge, The MIT Press, 1996; J. CASTI, *Would-Be Worlds. How Simulation is Changing the Frontiers of Science*, New York, Wiley, 1997; D. PARISI, *Simulazioni. La realtà rifatta nel computer*, Bologna, Il Mulino, 2001.

[23] In philosophy of science, falsifiability is the quality that belongs to scientific hypotheses and theories that can be tested through empirical experiments and comply, therefore, in the Popperian sense of the term, with the standards of the scientific method. Cumulativeness is the quality of scientific knowledge that increases through successive additions.

"blurring the dividing lines among disciplines and creating a truly interdisciplinary, non-compartmental science"[24].

2. Why discuss the relationship between law and computational social science? The theme seems interesting not only generically, because we are seeing a change that may involve all social sciences, but mostly because this relationship shows promise for reasons related specifically to the nature and function of law and legal science.

Legal phenomena are at the same time the outcome and the ordering factor of social life. The production, interpretation and application of legal rules conceived to regulate social life cannot ignore the scientific knowledge and methodologies illuminating social dynamics at both individual and collective level[25].

From a theoretical point of view, the scientific paradigm underlying computational social science and the nature of the phenomena investigated by it can focus greater attention by lawyers on the empirical dimension of legal phenomena and greater openness to dialogue with other disciplines, two basic conditions for finding appropriate legal responses to the complexity and dynamism of contemporary society[26].

From the methodological point of view, then, computational social science can encourage the appreciation, in the legal field, of a scientific approach (in a Galilean sense) able to offer, through empirical research[27] – the

[24] R. Conte, N. Gilbert, G. Bonelli, C. Cioffi-Revilla, G. Deffuant, J. Kertesz, V. Loreto, S. Moat, J.-P. Nadal, A. Sanchez, A. Nowak, A. Flache, M. San Miguel, D. Helbing, *Manifesto of Computational Social Science*, cit., p. 341.

[25] For example, knowledge of the conditions that lead to the emergence and evolution of social norms, obtained through the applications of the so-called "distributed artificial intelligence" (artificial societies and social simulations) can usefully be applied in the study of legal issues: see the seminal work of R. Axelrod, *An Evolutionary Approach to Norms*, in "The American Political Science Review", Vol. 80, 1986, n. 4, pp. 1095-1111. On projections of the simulative method in the legal domain, see N. Lettieri, *Ius in silico. Scienza giuridica ed epistemologia generativa*, in "Sistemi Intelligenti. Quadrimestrale di scienze cognitive e intelligenza artificiale", 2010, n. 3, pp. 419-430; Id., *Artificialia. Intorno a possibili nuovi orizzonti per la scienza giuridica*, in "Scienza&Filosofia", 2010, n. 4, pp. 41-52.

[26] Particularly striking in this perspective is the call for the rehabilitation of the factual and social dimensions aspects of legal phenomenon by Paolo Grossi: see P. Grossi, *Società, diritto, Stato. Un recupero per il diritto*, Milano, Giuffrè, 2006; Id., *Mitologie giuridiche della modernità*, Milano, Giuffrè, 2007.

[27] See R.M. Lawless, J.K. Robbennolt, T.S. Ulen, *Empirical Methods in Law*, Wolters Kluwer, 2010.

use of statistical and mathematical methods and computational techniques – new tools for understanding phenomena in relation to which the law is called upon to perform its ordering function. Computational social science provides new ways to exploit, even in the legal field, the massive data flow that characterizes the "Big Date Science", offering innovative possibilities to combine qualitative and quantitative research.

In addition, especially through simulation models, computational social science offers legal science a new experimental method by which the modelling of the structural properties of social systems and the exploration of their spatial-temporal development through computer simulations become two basic steps not only to explain complex social dynamics, but also to predict their evolution.

Also the implications of an applied nature seem to be promising: computational social science. provides lawyers with methods and tools that seem to be able to offer a new scientific basis for their activities in the various contexts of interpretation and application of the law and also to the processes of policy and rule making.

3. While, as mentioned above, other disciplines have already widely come closer to the methods and innovative approach of computational social science, the law appears to be still at the beginning of this process[28] which

[28] Purely by way of example, see: S.J. CHANDLER, *The Network Structure of Supreme Court Jurisprudence*, 2005, available at SSRN http://papers.ssrn.com/sol3/papers.cfm?abstract_id=742065; T.A. SMITH, *The Web of Law*, San Diego Legal Studies Research Paper No. 06-11, 2005, available at SSRN http://ssrn.com/abstract=642863; F.B. CROSS, T.A. SMITH, *The Reagan Revolution in the Network of Law*, 2006, available at SSRN http://ssrn.com/abstract=909217; D. BOURCIER, P. MAZZEGA, *Toward Measures of Complexity in Legal Systems*, in "Proceedings of ICAIL 2007", 2007, pp. 211-215; J.H. FOWLER, T.R. JOHNSON, J.F. SPRIGGS, S. JEON, P.J. WAHLBECK, *Network Analysis and the Law: Measuring the Legal Importance of Supreme Court Precedents*, in "Political Analysis", Vol. 15, 2007, n. 3, pp. 324-346, available at SSRN http://ssrn.com/abstract=906827; P.A. HOOK, *Visualizing the Topic Space of the United States Supreme Court*, Indiana Legal Studies Research Paper No. 68, 2007, available at SSRN http://ssrn.com/abstract=948759; U. PAGALLO, *Small World Paradigm and Empirical Research in Legal Ontologies: A Topological Approach*, in Ajani G., Peruginelli G., Sartor G., Tiscornia D. (eds.), "The Multiple Complexity of European Law: Methodologies in Comparison", Florence, EPAP, 2007, pp. 195-210; M.J. BOMMARITO II, D.M. KATZ, *Properties of the United States Code Citation Network*, 2009, available at SSRN http://ssrn.com/abstract=1502927; M.J. BOMMARITO II, D.M. KATZ, J. ZELNER, *Law as a Seamless Web? Comparison of Various Network Representations of the United States Supreme Court Corpus (1791-2005)*, in "Proceedings of the 12th International Conference on Artificial Intelligence and Law (ICAIL 2009)", available at SSRN http://ssrn.com/abstract=1419525;

certainly deserves being developed. In this vein, with this Special Issue of "Informatica e diritto", we want to promote an opportunity for discussion that, starting from experiences that seem very far apart, even because of the heterogeneous origin of the authors, introduces topics that we hope will encourage lawyers to imagine the application of computational social science methods to authentically legal problems.

In more general terms, the intention is to stimulate a reflection on whether and how the law and the way of thinking of a lawyer can be transformed by their encounter with the research paradigm of computational social science.

The first two articles in this Special Issue are introductory because they touch on the question of the relationship between law and science, which we consider preliminary compared with respect to the analysis of our theme, providing lawyers and non-lawyers with a framework within which to place the discussion.

The starting point of Orlando Roselli is his view of the difficulties that the lawyer today meets when faced with the complexity of the global and technologically advanced society. Modern legal culture is faced with an obvious difficulty in performing its principal ordering function when it encounters the plural phenomena of globalisation, the radical ever accelerating transformation of the social tissue, the invasiveness of new technologies, the changing relationship among rules, time and space. The great difficulty to acquire an historically conscious method that enables modern jurists to de-

M.J. BOMMARITO II, D.M. KATZ, *A Mathematical Approach to the Study of the United States Code*, 2010, http://arxiv.org/abs/1003.4146; U. PAGALLO, *Power Laws and Levels of Abstraction in Understanding Legal Systems*, in Andrighetto G., Boella G., Pagallo U., Villata S. (eds.), "Combined Proceedings of the International Symposium on Social Network Analysis and Social Norms in MAS", Leicester, De Montford University, 2010, pp. 41-45; P. CASANOVAS, U. PAGALLO, G. SARTOR, G. AJANI (eds.), *AI Approaches to the Complexity of Legal Systems*, LNAI, Heidelberg, Springer, 2010; D.M. KATZ, D.K. STAFFORD, *Hustle and Flow: A Social Network Analysis of the American Federal Judiciary*, in "Ohio State Law Journal", Vol. 71, 2010, n. 3, pp. 457-509; R. WINKELS, J. DE RUYTER, H. KROESE, *Determining Authority of Dutch Case Law*, in Atkinson K.M. (ed.), "Legal Knowledge and Information Systems. JURIX 2011: The 24th Annual Conference", Amsterdam, IOS Press, 2011, pp. 103-112; M. VAN OPIJNEN, *Citation Analysis and Beyond: In Search of Indicators Measuring Case Law Importance*, in Schäfer B. (ed.), "Legal Knowledge and Information Systems - JURIX 2012: The 25th Annual Conference", Amsterdam, IOS Press, 2012, pp. 95-104.

See also the *Computational Legal Studies Blog* (http://computationallegalstudies.com/) founded in 2009 by D.M Katz, M.J. Bommarito II and J. Zelner as "an attempt to disseminate legal or law related studies that employ a computational or complex systems component".

cipher the consequences of social changes means they have to be open even more so than in the past to the contribution of other sciences. Therefore, jurists must broaden the horizon of their research in the understanding that, at the basis of scientific development, there is no presumption of a final result but, rather, a healthy uneasiness that pushes them to rethink their results which they should never assume to be ontologically definitive.

Domenico Parisi examines the same question from the viewpoint of the philosophy of science, also proposing resort to the artificial[29] for legal science (in this case, robots and computer simulation) as a tool for knowledge of reality and of the phenomena under legal regulation. Computational and robotic artifacts are more and more often laboratories for the study of society[30] in which different disciplines converge that study phenomena which in a more or less direct manner influence the dynamics relevant to the law. A robotic science of legal phenomena should be able to reproduce some phenomena and should be able to answer some research questions briefly outlined by Parisi.

This initial and general framework is followed by the articles of Bruce Edmonds and Klaus Troitzsch that identify specific issues relevant to law to which the methods of computational social science may apply, in particular, social simulation which is playing an increasingly important role in the understanding of social phenomena.

In the use of simulation, Bruce Edmonds identifies an ally in understanding how and why law works and, consequently, to decide how to act legally for obtaining certain effects on society and individuals. Edmonds points out that computer simulations can be applied to different legal tasks, namely studying breakdown in norm compliance; preparing the ground for compliance to legislation; bootstrapping away from endemic corruption, and assessing efficacy of different modes of legal rule-making. In this vein, simulations have to be considered *in vitro* experiments that do not replace *in vivo* studies in any way but rather complement them, suggesting possibilities that subsequent empirical studies can investigate and producing precise but complicated models of the existing evidence.

[29] On the concept of "artificial" and its role in science see, *inter alia*, H. SIMON, *The Sciences of Artificial*, cit., *passim*.

[30] See, for example, the research carried out at the Yale Social Robotics Lab where computer science, and in particular robotics, offers a complementary perspective on the study of human behavior, http://www.scazlab.com/.

Instead, Klaus Troitzsch, shows us the possible applications of simulation approaches to legislative processes, especially in assessing the impact of alternative political strategies before new legislation would be set into force. The focus of his article is on regulatory impact assessment (RIA) that appears, without doubt, one of the most promising sectors where methods of computational social science can be applied, although it should not be underestimated the author's final comment in which he maintains that all kinds of simulation are and will be unable to make precise predictions of future states of a complex systems or to precisely predict the outcomes of planned policies. The only thing that is possible is foresight in the sense that possible futures can be sketchily described. Policy makers are responsible for the measures taken, but simulation can improve the information on which political decisions rest.

In the field of social simulation, especially agent-based social simulation in which the basic element is the individual or rather his representation as a computational model, a key issue, regardless of the phenomenon to be studied, is the availability of theoretical models that allow the mechanisms underlying the behaviour of individuals and their interactions with others and with the environment to be described in rigorous and scientifically reliable terms. The simulation study of phenomena that have to do with the law assumes an understanding of the cognitive processes that influence the emergence and evolution of social and legal norms. The articles by Castelfranchi, by Cecconi, Andrighetto and Conte, and by Terna offer different points of view on the issue by offering, on the one hand, theories on what are the norms on the level of individual and social cognition and, on the other, models and cognitive architectures to implement in the simulation agents we want to build.

Cristiano Castelfranchi addresses the issue of norm internalization: all norms, from the social and legal, can be seen as mental objects that arise out of individual cognition through processes that can be modelled in a formal way. Castelfranchi proposes an inspiring model of norms, norm adoption and "cognitive processing" of norms in cognitive agents, from the recognition of the input as a normative prescription to the formulation of the intention to conform or to violate.

The work of Federico Cecconi, Giulia Andrighetto and Rosaria Conte presents the use of multi-agent-based simulation as a tool for exploring the dynamics of norm emergence based on mental representations. In their approach, social and legal norms are treated as recognized, represented and rea-

soned upon prescriptive commands. The agent-based simulations presented aim at understanding what would happen in a world populated by normative agents, able to recognize norms and to reason upon them, compared to other, cognitively, less complex agents, following only their own individual goals.

Finally, Pietro Terna, moves the discussion onto cognitive architectures versus the application aspect, presenting a recent implementation of a software library for agent-based simulation that can be used in modelling social learning dynamics that can play a relevant role in the simulation of normative phenomena. He also dwells on the question whether agent-based simulation could help in a perspective of policy management and law creation.

Two practical examples of simulation that could interest lawyers are proposed by Lettieri and Parisi and by Bonaventura and Consoli.

Nicola Lettieri and Domenico Parisi, present a simple evolutionary agent-based model of the interplay between damaging behaviours, punishment and social mechanisms of learning and imitation. The article is an attempt to show how agent-based simulation can be used to illuminate basic mechanisms underlying social phenomena that are relevant for legal science and to reflect, in an innovative way, on how society, policy and rule makers can deal with such phenomena.

Luigi Bonaventura and Andrea Consoli present an interesting application of agent-based simulation in the field of the organization of criminal justice, demonstrating how it is possible to study "*in silico*" effects on pending cases deriving from the different application of priority criteria applied by a judge in treating procedures. The proposed simulations enable us to assess the effects that different choices have on the reduction in cases pending and on the social cost deriving from delays in dealing with the more serious cases.

Another area of interest for lawyers in which simulation seems to be particularly promising and where theoretical observations and experimentation[31] already exist is the study of the criminal phenomenon. In many respects, the methodologies of computational social science have been demonstrating a significant capacity to address the study of crime and criminal justice to support policy making, with consequences also of considerable

[31] See, for an initial view of the matter: L. LIU, J.E. ECK (eds.), *Artificial Crime Analysis Systems: Using Computer Simulations and Geographic Information Systems*, Hershey, IGI Global, 2008.

applicative impact[32]. The four articles proposed here, coming from criminologists, computational scientists and sociologists of deviance, demonstrate the interest of different disciplines to the topic and give us a glimpse of interesting future developments.

Fabrizio Caccavale offers a criminologist's brief reflection on the impact that computational social science methods can have on research in the criminology and criminal law domains focusing on the benefits that interaction with other disciplines offers criminology and presenting, in general terms, computational criminology, which involves the use of computational power to identify existent and emerging models of crime.

Federico Cecconi shows how agent-based simulation allows us to obtain reliable computational models for criminal phenomena, making it possible "to simulate the crime". According to the author, agent-based simulation is potentially a very powerful tool for crime study; it increases the empirical understanding of how society works and can help policy makers in designing more effective norms and mechanisms for fighting criminal behaviour.

Valentina Punzo discusses the role of agent-based social simulation in crime research, in particular, criminal policy making offering some suggestions about the utility of applying simulated experiments to crime research. After a review of some examples regarding such type of simulations in predicting and assessing the impact of crime-prevention interventions and policy changes, the specific tasks and purposes of agent-based social simulation along the different stages of the overall policy making process are summarized and discussed.

Finally, Nicolas Malleson, Andrew Evans, Alison Heppenstall and Linda See illustrate how agent-based simulation enables us to reach new levels of analysis to the traditional quantitative analysis of crimes accounting for the individual dimension of criminal behaviour. They present a social simulation model of burglary replicating offender drivers and decision making in a realistic geographical environment, full of potential victims and guardians. Hence, the model offers an interesting way to link aggregate-level crime patterns and individual-level offender behaviour.

[32] An interesting example of the applications of computational methods to the study and forecasting of the dynamics of crime is found in PredPol (http://www.predpol.com/) a computer-based program developed by mathematicians, an anthropologist and a criminologist, to implement "Predictive Policing," which uses advanced computation to predict where crime will occur. The environment is actually used by Los Angeles Police Department to figure out where crimes will be committed before they take place.

A final contribution in the field of simulation is by Migle Laukyte, who discusses the still too limited impact of the multi-agent system approach in the legal field. The author argues that an important reason why the simulation of legal phenomena is not making much headway is a certain language barrier between lawyers and software engineers. To overcome this barrier, the paper suggests making use of "boundary objects", a sociological concept used to describe the use of the same information or categories by different communities and in different ways. In this vein, the boundary object considered is the autonomy which can be ascribed to an agent within a multi-agent system. In the author's opinion, if we can spell out in a clear enough way what autonomous action means in the law, then we will also have a roadmap we can rely on in developing autonomous agents and building multi-agent systems that would be more effective at simulating or reproducing social interactions in areas of activity which fall within the purview of the law.

The article by Deborah De Felice, Giovanni Giuffrida, Giuseppe Giura, Vilhelm Verendel and Calogero Zarba is the first of three articles dedicated to information extraction and the subsequent processing of information using social network analysis techniques. The authors report and discuss sociological and computational approaches allowing for the characterisation of the social structure of criminal phenomena using large-scale and automated computer tools. The research project they present was based on analysing criminal sentences on organized crime activities in Sicily, pronounced from 2000 through 2006. After having collected the criminal sentences from the various courthouses and stored them into digital format, the texts were examined in order to extract information on the actors involved in the facts and the relationships between them. Finally the network of actors was investigated using social network analysis, in order to capture social network properties.

Nicola Lettieri, Delfina Malandrino and Raffaele Spinelli present an ongoing research exploring applications of computational methods in the analysis of structural and functional features of criminal organisations. Inspired by a sociological study using social network analysis techniques to compare properties of two criminal organisations belonging to the *mafia* and the *camorra*, the research aims at studying tools combining information extraction, network analysis and visualization methods to support investigation and to combat criminal organizations. The paper offers an overview of the results so far achieved from a technical and methodological viewpoint sketching future developments of research that appears to be challenging both for criminology and legal informatics.

Gugliemo Feis presents a theoretical framework called "Network Analysis Formalism" that he proposes as a third way that attempts to rejoin the formalism of legal positivists and the anti-formalism of legal realists by way of relying both on data mining and on network analysis. The article applies this theoretical framework to the concrete problem of taxation, proposing a traceability system for payments. Such a system undoubtedly poses many legal and technical problems, common to all systems that use large quantities of data, sometimes referable to the entire population of a country, on which the author begins to reflect.

Geospatial analysis methodology is also covered in this Special Issue in the contribution of Tamara Bellone, Francesco Fiermonte and Chiara Porporato. They deal with the techniques for transforming plain date, such as normal address lists, into geographic coordinates expressed in latitude and longitude. The issue of access and use of free data or free information for such purposes, also that available on line, is not only technical because the opportunities offered by information sharing and knowledge facilitate individual and collective growth, participatory processes and social justice.

The Special Issue closes with two articles that generally ponder on the possible relations between specific disciplines in the legal and economic-legal area and computational social science. Guido Migliaccio, on the one hand, with reference to business administration, accounting and legal sciences and Ernesto Fabiani, on the other, with reference to civil procedure law, identify some issues that could be studied in accordance with the research perspectives offered by computational social science methodologies. The goal for both is to promote interdisciplinary dialogue, to ask questions and to present specific problems that may be studied in greater depth or from new viewpoints thanks to the contribution offered by computational social scientists.

4. It is likely that, in the near future, as has happened in other areas of the humanities and the social sciences, the relationship between the law and the paradigm of computational social science will intensify. The contributions collected here, on the one hand, confirm this trend and, on the other, suggest pathways to deepen this relationship in various directions, both scientifically and on the level of its application.

Here we limit ourselves to a few concluding remarks. Readers who will wish to walk the finelines between law and computational social science will certainly identify other areas of interest for each one of them.

The approach and methodologies of computational social science have great potential for scientific applications that in order to best be exploited in the field of the law requires the lawyer to identify avenues for research and the appropriate questions to ask. Help in the formulation of these questions may come from the lawyer's comparison with other disciplines that may help to understand, to predict and to manage the phenomena of interest to the law. In this perspective, the ability of ICT to mediate the interaction between different knowledge makes legal informatics the research area ideal for bridging the gap between law and computational social science. The background to what has been said until now is provided by the issue of legal culture and, therefore, a lawyer's training. Albeit with significant differences between the different legal cultures, the world of law is less used to dealing with quantitative approaches and computational tools than other areas of the social sciences such as, for example, economics and sociology. The enhancement of this dimension involves law schools and, more generally, the whole world of legal education. Without giving into *a priori* enthusiasm, it is possible to imagine that many interesting developments in the way in which the law is studied and the way in which the complexity of modern society is handled legally depend on the ability to train new generations of lawyers to seize the opportunities on the horizon in the world of computational social science. The road is now wide open. At a closer look, after all, it is not a matter of inventing anything new: as stated in 1895, by the American jurist, Oliver Wendell Holmes Jr.

> "An ideal system of law should draw its postulates and its legislative justification from science"[33]

and, moreover,

> "for the rational study of the law the black-letter man may be the man of the present, but the man of the future is the man of statistics"[34].

[33] O.W. HOLMES JR., *Collected Legal Papers*, New York, Peter Smith, 2010, p. 139.

[34] O.W. HOLMES JR., *The Path of Law*, in "Harvard Law Review", Vol. 10, 1897, p. 457, http://www.gutenberg.org/files/2373/2373-h/2373-h.htm.