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Power Laws and Levels of Abstraction in Understanding Legal Systems

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Abstract. This paper focuses on some misunderstandings of today's debate in network analysis and the law, resulting from a lack of clarity about the 'levels of abstraction' we are dealing with. By distinguishing three levels, *i.e.*, information *as* reality, *for* reality, and *on* reality, the paper aims to prevent some of these misunderstandings: On one hand, there is a remarkable shift in current applications of social networks to legal system-analysis, namely, from traditional researching information *as* reality to current researching information *on* reality. On the other hand, we have to pay attention to the different ways in which scholars approach 'reality' – in, *e.g.*, the realm of law – because every theory commits itself ontologically by opting for a specific level of abstraction.

1 INTRODUCTION

Last year, at the Heriot-Watt University in Edinburgh, I presented a paper on the "small world"-paradigm and the topology of complex legal systems, following up on the proposal of the AISB'09 Convention, *i.e.*, to promote the interchange of knowledge and methodologies among some of the most interesting and promising fields of current scientific research, such as social network-perspectives and multi-agent systems-analyses. Along with the paper of Jeremy Pitt, colleagues and organizers honoured us awarding our work as the best paper. Therefore, I would like to show that I took stock of what I learnt by deepening the topic in a different light: I suggest to examine today's debate on the application of social networks to legal system-analysis paying attention to the methodology of the levels of abstraction (LoA) put forward by Luciano Floridi [1].

In a nutshell, a LoA can be grasped as an 'interface' that is made of a set of features, namely, the 'observables.' Given some values, an observable of a type X is a variable whose values range over that very type. Hence, a LoA consists of a collection of observables of type X, that is defined by how we choose to describe, examine, and argue about a system and its context. For example, in the realm of 'ontologies,' Guarino and Giaretta have pointed out different kinds of analysis and, therefore, the multiple meanings related to this research [2, 3]:

i) A philosophical discipline which is concerned with being *qua* being;
ii) An informal conceptual system;
iii) A formal semantic account of that system;
iv) A specification of its possible conceptualizations;
v) The representation of a conceptual system through logical theories;
vi) The vocabulary employed by that logical theory;
vii) A meta-level specification of the logical theory.

As you can see, each LoA enables an analysis of the system, the result of which is a model of it: While a range of LoAs can describe a given system, that system can have several models as well. Going back to the application of social networks to legal system-analysis, it is therefore important to determine the "ontological commitment" of every approach in opting for a specific LoA [1]. There is, indeed, network analysis on:

i) How information is produced and distributed in legal systems;
ii) How it is feasible to harness these properties so as to obtain useful applications in the legal domain;
iii) How knowledge and concepts frame the representation and function of shared legal terminology.

This differentiation is particularly relevant because many misunderstandings of the current debate depend on the lack of clarity about the LoAs we are dealing with. By distinguishing three levels, namely, information *as* reality, *for* reality, and *on* reality, the aim of this paper is thus to prevent some of those misunderstandings via an overall picture of today's work in network thinking and its diverse "ontological commitments." More specifically, the paper is presented in five sections.

In section 2, I take into account Newman's *Power laws, Pareto distributions and Zipf's law* [4]: This article frames the theoretical premises of my work so as to understand what is going on in the field of network thinking.

In section 3, I examine how analyses on power laws-distribution of information have extended to a number of different fields like, say, the realm of music [5, 6].

In section 4, I focus on some recent work on legal networks that shed further light on the small world-paradigm [7, 8].

In section 5, I consider "problems and perspectives for knowledge discovery in the legal domain," so that "with a specific regard to legal ontologies in multicultural contexts, new advances in terms of social network analysis could be fruitful" [9].

Finally, in section 6, I stress a shift in current applications of social networks to legal system-analysis, that is, from traditional researching information *as* reality to current researching information *on* reality [10].

The conclusion is that we should pay attention to the different ways in which scholars approach 'reality' (here, the realm of law) because every theory commits itself by opting for a specific level of abstraction.

2 POWER LAWS

In his remarkable work published on *Contemporary Physics* [4], M. E. J. Newman summed up current research on the statistical distribution of quantities and, more specifically, in the so-called power-law distributions. By illustrating the mathematical foundations of the research as well as its theoretical constraints, Newman highlighted an extraordinary set of phenomena that obeys this kind of law.

All in all, the statistical measurement of quantities follows a power-law when the "vast majority of the measurements assume relatively small values," and "there is a part of the population that assumes significantly larger values than the usual measurements" [5]. In other words, power-law distribution is equivalent to both Zipf's law and Pareto distribution, the only difference consisting in the way the cumulative distribution of information is plotted. This means that, notwithstanding the model, "the data depicted in the plots are identical" [4].

Newman examined twelve examples of power-law distributions: Word frequency, citations of scientific papers, web hits, copies of books sold, telephone calls, magnitude of earthquakes, diameter of moon craters, intensity of solar flares and of wars, wealth of the richest people, and so forth. Although "few real-world distributions follow a power law over their entire range, and in particular not for smaller values of the variable being measured," what is striking is that "one can, without stretching the interpretation of the data unreasonably, claim that power-law distributions have been observed in

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language, demography, commerce, information and computer sciences, geology, physics and astronomy, and this on its own is an extraordinary statement" [4].

Of course, there are distributions that do not follow a power law. This is the case of the abundance of North American bird species, the number of entries in people's email address books, or the distribution of the sizes of forest fires. Furthermore, it is quite problematic to determine the mechanisms according to which this form of distribution arises both in natural and social systems, that is, via combinations of exponentials, inverses of quantities, random walks, the "Yule process," phase transitions and critical phenomena, self-organized criticality, etc.

Yet, it is significant that a number of extremely diverse range of phenomena can be explained in terms of power-laws of distribution. Whereas this kind of distribution means that only few nodes of the network have very high values of connectivity while most nodes present low degree, such a law has become particularly popular as the 'long tail' [11], or summed up as the 'rich gets richer'-effect [12]. Because such success entails its own risks, let me further illustrate what is at stake with the peculiar case of music.

3 A CONTEXT OF MUSIC

Research on power-laws distribution in musical data is not new at all. In 1975, Voss and Clarke claimed that both pitch and loudness fluctuation in several kinds of music as classical, jazz, or rock, obeyed Zipf's law [13]. Later, in Hsu *et al.*, it was noted that acoustic frequency in a collection of Bach changes according to a scale free distribution of musical information [14]. Following Newman's analysis on the panoply of different phenomena characterized by power-law distributions, recent work has shed further light on these laws.

For example, by considering some quantities like the "number of musical scores that a repeating pattern is contained in" (*support*), the "number of notes contained in the repeating pattern" (*length*), and the "number of occurrences of a repeating pattern in the same musical score" (*frequency*), Rafailidis and Manolopoulos argue that music belongs to the numerous phenomena in which information is distributed according to power-laws [5]. Based on the Kolmogorov-Smirnov test, they show that this is the case of some famous compositions of Bach, Corelli, and Haydn. (The musical pieces are available at http://kern.humdrum.org in the kern and midi format.) This perspective would thus allow us to further understand "the differences among diverse music collections," together with music classification and the mathematical skills for developing systems that "could compose music based on statistical properties" [5].

However, it has been stressed that music "does not possess any conventionally defined units of meaning" [6]. Thereby, in order to single out the semantic features of the subject, we should take into account the position and duration of the single notes in the light of the process of a text generation. This approach is similar to the way in which Herbert Simon updated Zipf's law by examining the probability of using a word while writing a text [15]. The analysis of the Musical Instrument Digital Interface or MIDI files available at www.geocities.com/benedetto_marcello/midi/, has proved that the probability to choose a note is proportional to that note's recurrence in a text. Since notes not yet appeared have non-zero probability of being added, the result of this process is compatible with the predictions of Simon's model: "While the extension of the notion of semantic contexts from linguistics to music holds as a metaphoric allegory only, context – whose role in language is closely related to semantics – stands for a significant feature common to linguistic and musical messages. In both domains, context denotes a property emerging from the interaction of the perceptual elements that compose the message, that makes the message intelligible as a whole. (…) [T]he combination of those elements in a hierarchically organised sequence, whose structure sustains its comprehensibility, lies at the basis of the creation of context in the two domains" [6].

For centuries, scholars abandoned the classical topic of music and the law, that is, work on their structural analogies. Without discussing the ideas of the Pythagoreans or Jean Bodin, the quantitative parallelism between musical and linguistic contexts suggests we should further analyse this connection in the light of some recent research in law, power-laws, and small world-networks. This work allows us to insist on the different levels of abstraction which are involved in the study of power-laws of distribution. As with network analysis on music, and leaving aside systems that "could compose music" by exploiting the statistical properties of the network [5], we should distinguish two different approaches of network analysis: That is, information *as* reality (*e.g.*, support, length, and frequency in music) and information *on* reality (*e.g.*, a musical context).

4 LAW, POWER-LAWS, AND SMALL-WORLD NETWORKS

Following my AISB'09 paper, two new results on the topology of complex legal systems have emerged in connection with the ways in which information is distributed through the nodes of a given network.

The first study focuses on the comparison of various network representations of the US Supreme Court Corpus from 1791 to 2005 [7]. As in previous research [16, 17], the body of US Supreme Court decisions, available at http://supreme.justia.com/, is represented as a network: Cases, or individual opinions within cases, are the nodes of the network, and citations are the links or edges of the network. The goal is to "identify the specific information captured by each representation," to "evaluate the theoretical rationale and utility of each process," and to give details "for parsing the plain text corpus into each network representation" [7].

Similarly to a citation network, the US Supreme Court jurisprudence can be represented as the network of connections between its cases. Yet, cases often include multiple (and dissenting) opinions, so that, in a number of relevant cases, we need a more detailed picture of the system by developing an opinion-to-opinion citation network. For example, in *Vieth v. Jubelirer* (541 U.S. 267 from 2005), we have Scalia's decision, Kennedy's concur opinion, and three different dissents by Stevens, Souter, and Breyer. Moreover, four of the Justices also referred to *Baker v. Carr* (269 U.S. 186 from 1962). It is clear that the five distinct units of the opinion network with its four citations would collapse into a single edge of a case-to-case network. Hence, it is necessary to increase the granularity of the analysis moving beyond citations, so as to properly distinguish the citation network from what Bommarito *et al.* call the semantic network of the US SC Corpus. The next step would be to discover how they interact: Is the web of law "seamless," so that the categorization of legal doctrine into discrete fields like torts, contracts, etc., would not capture the nature of the law?

A fruitful way to address the issue would be to look at "the set of cases that feature both semantic similarity and a direct citation linkage. In general, these are likely communities of well-defined topical domains. Of greater interest to an empirical evaluation of the law as a seamless web, is likely the magnitude and composition of the *Citation Only* and *Semantic Only* subsets. Subject to future empirical investigation, we believe the *Citation Only* components of the graph may represent the exact type of concept exportation to and from particular semantic domains that would indeed make the law a seamless web" [7].

Awaiting the results of this new research, there is another recent study in law and network analysis that may help to

clarify the different levels of abstraction involved in this kind of work. In the network analysis of the French environmental code, Boulet *et al.* show that this code presents small-world features that clearly "contrast with the architecture found in the analysis of the reference network at the scale of codes," that is, "a rich-club of ten codes very central to the whole French legal system, but with no small-world property." Consequently, this level of abstraction indicates that "changing the granularity of the analysis modifies the nature of network structure and its associated properties. The density variation is not unexpected because while increasing the granularity (that is grouping vertices), the number of vertices decreases and the probability of existence of a citation between the two any bigger verteces increases" [8].

The conclusion, however, involves not only the underlying structures and properties of the law as dependent on the scale and granularity of the analysis. According to the French scholars, the small world-approach has a semantic meaning as well for it sheds light on "hidden communities" of articles in the French environmental code [8]. Whereas Boulet *et al.* propose to deepen the comparison between different environmental codes and codes related to other legal fields, their research suggests that we should to distinguish properly between two levels of abstraction, namely, between the "underlying structure" of a given legal system and the existence of "hidden communities" of articles. In the first case, we are dealing with information *as* reality; in the second case, as with Bommarito *et al.* [7]'s research on the semantic features of the US SC network, Boulet *et al.* are focusing on information *on* reality. Let us look at why this difference is so relevant.

5 KNOWLEDGE DISCOVERY

In their work on epistemological completeness of legal ontologies and knowledge discovery in the legal domain, Ajani and Rossi examined social network analysis in order to assess whether they "may contribute to integrate currently used legal ontologies" [9]. Although this approach can be useful to establish the epistemological completeness of the ontological mapping – so as to determine the effectiveness of knowledge discovery in the legal domain – a network approach would present three difficulties. We can summarize these criticisms in the following way:

First, it is argued that the topological relations examined in a small-world or power-law perspective are "made of connections among physical systems" [9]. Hence, while ontologies can be used to represent social networks, the reverse is not necessarily true. In fact, social networks would consist in representations of social interactions, where the nodes are the social actors, rather than concepts, linked by the edges of the network. From this viewpoint, the problem would be to encompass legal concepts and relations among social actors (as in the attempt of folksonomies).

Secondly, it is stressed that social network analysis for legal ontologies "cannot correspond to a representation of the whole social reality in which a top level ontology may be grounded" [9]. It follows that it is always debatable which sets of objects lie within a given network, along with network sampling and the abovementioned degree of granularity used in the analysis. "In other words, the research focus of social network analysis is too tailored on localised objectives, while conceptualisations from legal culture require a wider research focus according to the multi-layered issues of the legal domains at the international, national and regional levels" [9].

Thirdly, when small world functions are taken into account, the problem is that the focus is mainly on structural information such as the centrality, closeness, in-betweenness, etc., of the nodes that, nonetheless, would be devoid of meaning. Links or edges of the network, in fact, would only represent the relation among nodes or subjects of the network, missing the typology of that relation. "This argument is strictly related to the rigid nature of a node-based network. Nodes are a sort of abstraction in the network and they have finite boundaries that distinguish them from their surroundings. Meaning nuances may fail to be detected when social network analysis is applied directly to semantics" [9].

At the end of the day, would not a model based on the 'family air' of such different fields like telephone calls and magnitude of earthquakes, word frequency and web hits, citations of scientific papers, law and music, be oversimplified?

Even though "empirical analysis by small world functions could be applied orthogonally to defined tasks, linguistic occurrences or instances with the purpose of bridging the different extensional semantics to a specific period of time and a specific social context," the method would be "reductionist in the axiom formalisation and static in its implementation" [9].

6 LEVELS OF ABSTRACTION

When comparing multiple small-world techniques, power-law distributions, scale-free approaches, and so forth, there are limits and problems afflicting network analysis and its applications to complex social systems (such as the law). Not only power-law distributions can result from different mechanisms [18], but the very idea of 'small' of the small world-paradigm seems highly context-dependent: "for instance, with regard to infectious diseases, the whole world could be small – but with regard to solidarity, and mutual support, six degrees might be a whole universe apart" [19].

Nonetheless, it is important to understand what network perspectives are doing in the specific context of a given research. The aforementioned studies in the realm of law [7, 8, 16, 17], *all* deal with *how* information is distributed in complex legal networks and, yet, we need to agree on *what* 'information' actually means, as well as on the kind of connection between information and reality that we are examining.

First and foremost we need to go back to the difference between 'information *as* reality' and 'information *on* reality': While the former concerns the traditional field of philosophical inquiries on ontology, the latter concerns semantic information. (I do not discuss 'information *for* reality' here, since it exploits the topological properties of a given network so as to obtain *sets of rules* or *instructions* for the determination of other informational objects.)

Once we distinguish such different levels, you may notice that network analyses and the topological approaches to complex social networks mentioned in this paper mostly deal with the level of information *on* reality. Even though network analysis is traditionally focused on the statistical distribution of quantities, it is possible to grasp the topological properties of the network so as to further understand *knowledge* and *concepts* that frame the representation and function of a shared (legal) terminology. It is thus extremely important to differentiate such levels, when discussing limits and problems of the network approach to the "semantic subset" of the US SC Corpus [7], to the "hidden communities" of the French environmental code [8], and so on.

Indeed, a method does not become "reductionist" as suggested by Ajani and Rossi [9] regarding to "the axiom formalisation" of the network approach, lest information *as* reality, namely, information defining being *qua* being, is kept indistinct or confused with information *on* reality, *i.e.*, statements that involve knowledge acquired and organized by legal experts. Such a confusion takes place if legal network analysis is depicted as implying an unspoken definition of the nature of law, whereas it does not have any such claim. Rather, what is at stake in the distribution of the information represented through network analysis is the semantic

commitment to the true (or false) conformation of the real world. Contrarily to those who believe that nodes have no intrinsic meaning and links represent simple relations without defining any kind of typology, topological descriptions of complex social networks define the meaning of that very information through different scales and granularity of the analyses, multiple mechanisms for determining the laws of distribution, etc., thus enabling a comparison of their (true or false) results with the opinion of legal experts [20].

Alas, it is arguably hard to conceive a topological description of the "entire social reality," where "meaning nuances [would] fail to be detected when social network analysis is applied directly to semantics" [9].

Let aside the description of the complete social reality, the real problem concerns the level of abstraction that is implied when comparing approaches and disciplines. Along with their multiple methodologies, there is in fact a crucial point which is common to social network-perspectives, legal ontologies, and even current research in multi-agent systems: We could imagine the preliminary assumption of every theory as a computer interface which enables both the analysis of a system and its modelling.

As I mention in the introduction, an interface is made of a collection of 'levels of abstraction' which includes a finite but non-empty set of observables. These 'observables' represent the building blocks of the theory, while defining the 'gradient of abstractions' or 'scale and granularity' of the analysis. As stressed by Floridi, an 'observable' should not be understood as an 'empirically perceivable' entity but, rather, as an 'interpreted typed variable,' that is, "a typed variable together with a statement of what feature of the system under consideration it stands for" [1]. While this method allows the analysis of systems by means that are necessarily developed at specific gradients of abstraction, it is the level of abstraction that enables the theory both to evaluate the system under analysis and to elaborate a model that identifies some properties of the system at the given LoA.

In the case of LoAs of network analysis, it is then important to distinguish the "ontological commitment" of this approach in opting for a specific LoA and the information captured *on* reality or processed *for* reality.

On one hand, you may indeed understand network analysis in terms of information as opposed to knowledge and concepts: *i.e.*, information *as* reality as a matter of statistical distribution of quantities in a given network.

On the other hand, information can also be exploited in order to develop some applications as set of rules or instructions to determine other informational objects: information *for* reality.

Nonetheless, there is also information *on* reality, namely, the semantic commitment of legal network analysis which is at stake in this paper with knowledge acquired and organized by scholars in both the development and evaluation-phases established by most ontology building methodologies nowadays. What about network analysis on case studies and jurisprudence [7, 16, 17], codes [8, 21], or general theory of law [22]?

All in all, integration between network theory and other areas of AI & Law does not hinge only on information *as* reality, that is, on the assumption that basic human concepts would be wired in our brains thus grounding cultural evolution. In fact, problems and limits of this approach involve the representation of a shared legal knowledge as well. If the latter may be tuned to reality in terms of evolution, it should not be confounded with the ontological quests of philosophers on being *qua* being in terms of information [23, 24].

7 CONCLUSIONS

We examined some recent research in complex social networks and three criticisms to this approach in order to highlight a crucial point in the interchange of knowledge and methodologies among some of the most interesting and promising fields of today's scientific research. This crucial point has been represented by the different levels of abstraction that are involved in that interchange of knowledge and methodologies proposed by the AISB meetings.

Network thinking is often represented as if it were semantically uncommitted, so that it would deal with 'information' as opposed to 'knowledge' and 'concepts.' Consequently, the level of abstraction at which, say, network theory and legal ontologies communicate is necessarily given by a standpoint such as Pinker's evolutionary psychology [25].

However, it is highly debatable that network theories are invariably "made of connections between physical systems" [9], and hence, dealing with social networks like the law, it is questionable whether nodes should only represent social actors linked in the network, without any consideration of the 'concepts' that are involved therein.

As shown by this paper, even recent studies on power law-distributions imply multiple levels of abstraction, among which the representation of the nodes as concepts of a dynamical legal system. The "conceptual hubs" and "semantic subsets" of the US SC Corpus [7], along with the "hidden communities" of the French environmental code [8], recall the specific 'interface' of this kind of research. It does not deal with information *as* reality but *on* reality, namely, semantic information which is true or false. This very difference sets the specific level of abstraction that should be always taken into account when discussing the exchange of knowledge and methodologies between different branches of AI & Law and legal theory.

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