Logic Goes Viral: dynamic modalities for social networks (Extended Abstract)

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We "know" more as a group than each of us knows individually. In an increasingly complex world, it becomes impossible for any individual to have a complete understanding of all the relevant information. We tend to rely more and more on sophisticated "knowledge technologies" (libraries, databases, mass-media), on modern democratic mechanisms for judgment-aggregation (voting, polls, surveys, markets) and on Internet-based algorithms for aggregating socially-distributed information (search-engines, Wikipedia). All these highly increase our *informational interdependence*. Social knowledge, mediated by information technologies and aggregated by collective decision-making procedures, is what holds together the complex interactions that form modern society.

While generally beneficial, this informational interdependence has a dangerous side: it often leads to various distortions (phenomena such as "group-think" or herd behavior etc). Such "irrational" mass phenomena are not new. But they are now tremendously multiplied by knowledge technology: from the ubiquity of social network websites, to the widespread use of automatic information-gathering tools and of sophisticated risk-assessment algorithms; from the amazing speed with which rumors and sound-bites spread at the click of a mouse, to the resulting instant bubbles and crashes, collective manias and panic waves.

In this context, the study of *group beliefs* and *group knowledge* acquires a new urgency. The first problem we are interested in is the *logical study of information flow and group belief dynamics in "social networks"* (i.e. communities of inter-connected agents capable of reasoning, communicating, learning etc). In particular, we want to study belief *formation* and belief *diffusion* across social networks. Another, related problem is (the logical-computational characterization of) *the epistemic potential of a group* or community of agents (from the Greek *episteme*, meaning "knowledge"). The phenomenon called "wisdom of the crowds" illustrates the increased epistemic power of large communities over single agents. However, the epistemic potential of a group depends on various features of the network: the

agents level of interconnectedness, their degree of mutual trust, their different interests etc. This may prevent a community from realizing its full potential, leading instead to apparently irrational mass phenomena illustrating "the madness of the crowds": e.g. group polarization, pluralistic ignorance and *informational cascades*. The third problem of interest in this respect is the *logical investigation of these social-informational distortions*: although in these situations all individual opinions and reasoning seem justified, they are influenced by the social network in such a way that eventually the groups collective belief goes completely astray. In such cases, individual rationality seems to lead to collective "irrationality".

In the talk, I survey the results and ideas in a number of recent papers (joint with other members of my research group) and Master theses done under my supervision. I look at several logical formalisms that make explicit various factors affecting the epistemic potential of a group: the agents' degree of interconnectedness, their degree of mutual trust, their different epistemic interests, their different attitudes towards the available evidence and its sources etc. I particular, I look at logics developed for reasoning about belief diffusion across social networks and about the long term-informational evolution of such networks: probabilistic dynamic-epistemic logics, versions of "Facebook logic", "friendship logic", epistemic access logic etc. I use these logical formalisms, in combination with tools from Game Theory, Learning Theory and dynamical systems, to analyze collective knowledge, as well as informational cascades. In particular, I show how the fixed-point version of one of these logics (a non-normal version of mu-calculus) can be used to characterize the maximal extent of a cascade.

One of the long-term goals of this work is to develop formalisms that can be used for the *"verification" of social-epistemic software* (checking for possible epistemic failures and informational distortions of a social network), as well as for *social-mechanism synthesis* (creating computerized pilot versions of institutional improvements and social-informational interventions meant to improve the functioning of social networks).

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