Curriculum Vitae

Luca Pappalardo

Qualifications

- M.Sc. in Computer Science
  Date: 22/07/2010
  Given by: University of Salerno
  Final Grade: 110/110 *cum laude*
  Advisor: Roberto De Prisco (Department of Computer Science and applications)
- Diploma in Piano
  Date: 17/07/2010
  Given by: Conservatory of Salerno

Studies and current positions

- October 2012 - December 2012:
  Visiting scholar at Barabasi Lab, Northeastern University, Boston
  `http://www.barabasilab.com/`.
- January 1st, 2011 - now:
  PhD student in Computer Science, Computer Science Department, University of Pisa, Italy.
  Supervisor: Dino Pedreschi.
  `http://www.di.unipi.it/`
- January 1st, 2011 - now:
  associate researcher at KDDLab, ISTI-CNR, for the study of new mobility models and interactions between mobility and social networks.
  Supervisor: Fosca Giannotti.
  `http://www-kdd.isti.cnr.it/`
- January 1st, 2011 - now:
  associate researcher at UILab, IIT-CNR, for the study and developing of new mobility models for opportunistic routing.
  Supervisor: Marco Conti.
  `http://www.iit.cnr.it/`
- June 2010:
  student at Lifelong Learning Programme Erasmus Intensive Programme (IP), "Interdisciplinary Approaches to Microarray Data Analysis", Marina di Ascea, Italy.
  `http://www.neuronelab.dmi.unisa.it/`
- March 2011:
  student at Bertinoro International Spring School on Computer Science, Bertinoro, Italy.
  `http://www.bici.eu/biss2011/`
- July 2011:
  student at Lipari Summer School on Computational Social Science, island of Lipari, Italy.
  `http://lipari.cs.unict.it/LipariSchool/ComputationalSocialScience/`

- July 2012:
  student at MODAP Summer School on Privacy-Aware Social Mining, Leysin, Switzerland.
  `http://mss2012.modap.org/`
- September 2002 - July 2010:
  M.Sc. (Laurea) in Computer Science at University of Salerno.
- September 2008 - February 2009:
  Erasmus Student at University Rey Juan Carlos of Madrid, Spain.

Research statement

The Big Data revolution offers us a giant laboratory of human dynamics. If, in the past decade, network theory has revolutionized our understanding of systems of interacting objects, now in the area of complex systems another seismic shift is taking place: the mathematical modeling of human behavior. In this context, social networks and human mobility are central issues, due their wide range of application, from the study of epidemics, to new paradigm of computation.

In my PhD thesis, I am investigating the modeling of human mobility behavior and complex networks evolution, both from an analytical perspective and a pattern discovery point of view. The combination of network science with data mining could represent a breakthrough for understanding human mobility behavior, giving their complementary approach to taming complexity: while the former has unveiled the general statistical laws governing some relevant quantities about human motion, the latter has developed methods for discovering the statistically significant subpopulations where complexity disappears and regular behavior appears. A goal of my research proposal is to investigate how the combination of the two approaches has the potential to develop macro-micro models of human mobility and achieve an unprecedented explanatory and predictive power. The current macro-laws of human mobility focus on asymptotic properties: to achieve a better short-range temporal fidelity, we need to incorporate the periodic modulations that are known to characterize human mobility, as well potential correlations in spatial mobility, and the semantics related to the logical day view. The motion of an individual can be described by a simple model that depends only on a small number of parameters; however, to turn this knowledge into actionable recommendations, we need to gain a better understanding of the factors that affect the parameters that pertain to an individual's mobility pattern. To this end, mobility data mining may characterize sub-groups where the macro-laws specialize, specific parameters are fitted, and a better fidelity achieved. The investigation of human mobility behavior involves the attempt to answer interesting questions: How do the mobility patterns and parameters, such as a user's radius of gyration or a commuting profile, depend on demographic factors and social network characteristics? Do these parameters and patterns correlate with population density? Are there dependencies on age, gender, or other demographic factors and mobility? Would the level of income, poverty, crime and other social factors of the region that a user frequently visits correlate with the user's travel patterns? How communities and homophily are correlated with proximity and mobility? Another interesting aspect is the emergence and increasing popularity of location-based Mobile Social Networks (e.g., Foursquare), geographic social networks (e.g., Flickr), or simply social networks with geographic features such as Twitter and Facebook in which the content can be associated to a geographic location. Users in the social web leave footprints of their movements, their visits on real and virtual places and their movements can be recorded and analyzed. These data allow to begin studying the interplay between mobility patterns and the structure of social ties, and call for challenging extensions of existing mining and querying framework. In addition, there are other two key issues for research. Can we use the same methodologies developed for moving objects for the virtual moving users to analyze their trajectories? If the methodologies are the same, it is also the same for the semantic and for the interpretation of the movement?

Results obtained in such research process, will be applied in two main contexts. The first one regards epidemics and social contagion, id est the diffusion of biological and mobile phone viruses and ideas in complex networks characterized by mobility. Nowadays handheld devices are becoming the dominant mean of communication, increasingly replacing desktops and laptops. This makes mobile technologies susceptible to a new generation of threats, that could imply, in addition to usual malware techniques, novel attack strategies taking advantage of the complex network nature of the interplay between human interactions, mobility, wired and wireless technologies. For these reasons, a new paradigm shift is needed in the development of a theoretical framework for the modeling and anticipation of the malware spreading in and security threats to smart mobile communication systems. This breakthrough require a deep understanding and characterization of the multi-scale mobility and social networks emerging from the coupling of human mobility, social interactions, mobile devices and infrastructures. The predictive power of mobile and social behavior in forecasting future mobility and social ties at the individual level, using data mining techniques applied to historical data, can be exploited to reach these goals. Such understanding of mobility and social networks at the global scale together with the mobility and social prediction models at a local scale can be then used to define data-driven models with high predictive power and to provide algorithmic and computational tools for designing optimized countermeasures and defense against possible attacks. The methods addressing above problems need to be privacy-preserving to achieve the desired anonymity of the individuals whose data was collected in the process. A major challenge for modeling epidemics and cascades arises from the fact that most real world networks are not isolated but interconnected and interdependent with other networks. Indeed, modern complex systems are coupled, communicate with each other or may depend on each other for their proper operation. Think about the several large-scale blackouts in the USA and Europe, result of a cascade of failures in mutually-dependent networks. Or think about mobile phones, that may communicate directly with other mobile phones in its proximity using Bluetooth technology, or with other devices on the Internet through Wi-Fi technology. This combination defines a set of connected networks, that may display, in certain cases, dependence between them. For example, a virus transferred through Bluetooth technology may cause phones to overload the cellular network or Wi-Fi networks, rendering them unusable and vice versa. Furthermore, the Internet connection of nearby Wi-Fi stations may itself be provided using the cellular communication infrastructure. Thus, a failing link in one network may lead to a cascade of failures in other networks. Some recent work on the robustness of coupled networks showed that coupled networks are extremely vulnerable due to cascading failures and that they behave very differently from single networks. This problem is closely related to the spreading of epidemics in coupled networks, as the SIR and SIS epidemic models can be mapped to a percolation problem.

The second applicative context is opportunistic networking, one of the most important engineering application of principle from network and mobility sciences. Opportunistic networks exploit the underlying social structure, the contact network and the mobility of nodes (mobile devices carried by users) to deliver messages, and connect, asynchronously in time, otherwise disconnected subnetworks. One of the most important open research challenge in this field is mobility. Human movements have a threedimensional nature - spatial, temporal, and social - to which are associated three corresponding dominating techniques: *maps of preferred locations*, *personal agendas*, and *social graphs*. Each of these approaches reproduces only a subset of patterns. In order to construct more realistic opportunistic protocols, a combination of different techniques is required. An interesting and promising approach is that of time-varying social graphs: they account both temporal and social dimensions, and results from complex networks research community could be exploited. My research efforts are now concentrating on how to incorporate the spatial dimension into a model based on time-varying social graphs. A different direction of research is to incorporate knowledge about social relationships and design better protocols that are able to learn the social network of users. Such inferred social graph can be exploited in several ways. For example, social hubs could be exploited to speed the dissemination process, placing content on them. Furthermore, the social network of users is a strong predictor of future meetings among them, and predicting contact opportunities between nodes is clearly a fundamental piece of information. An interesting open question concerns the understanding of the level of trust between users, related for instance to trust and reliability of communications. Results in social anthropology show that social links of a person are organized according to shells of increasing size and decreasing average tightness. Relationships in inner shells are more frequent and tighter, and have a higher level of trust. The size of these shell increase approximately according to a factor 3 up to the *Dunbar number* (equals to 150), a sort of cognitive capacity limit for humans. An opportunistic protocol could identify such shells and the 150 tigher friends, and exploit them to improve reliability of communications involving their nodes.

Participation to Research Projects

- (2011-present) *DATASIM*. European project.
  Objective: DATASIM aims at providing a new and detailed spatial-temporal microsimulation

methodology for human mobility, grounded on massive amounts of Big data of various types and from various sources (GPS, mobile phones and social networking sites), with the goal to forecast the nation-wide consequences of a massive switch to electric vehicles, given the intertwined nature of mobility and power distribution networks.
`http://www.datasim-fp7.eu/`.

Teaching

- September 2011 - February 2012:
  Teaching assistant for the course "Data Mining" of the M.Sc. in Computer Science at University of Pisa, teacher Dino Pedreschi.
  `http://didawiki.cli.di.unipi.it/doku.php/dm/start`

Publications

L. Pappalardo, G. Rossetti, D. Pedreschi, "How well do we know each other?" Detecting tie strength in multidimensional social networks, ASONAM CSNA workshop 2012.

L. Pappalardo, S. Rinzivillo, Z. Qu, D. Pedreschi, F. Giannotti, Understanding the patterns of car travel, European Physics Journal Special Topics 215, 61-73 (2013) (to appear).

F. Giannotti, L. Pappalardo, D. Pedreschi, D. Wang, A complexity science perspective on human mobility, to appear on Cambridge press book.

L. Spinsanti, M. Berlingerio, L. Pappalardo, Mobility and geosocial networks, to appear on Cambridge press book.

Computer Science skills

- Programming languages: Fluent in C, C++, Java, Python, GNUplot. Knowledge of Pascal, Matlab.
- Web: Experience of HTML, XML, CSS, Javascript.
- Databases: Mysql.
- Operating Systems: Windows (up to 7), Linux (major distributions). Knowledge of Unix.

Languages

- Italian: mother-tongue.
- English: very good.
- Spanish: very good.
- French: basic.