Case for Support. GALE: Global Accessibility to Local Experience

Part 1: Previous Research Track Record

Investigators' Track Record

Dr. Cecilia Mascolo is a Reader in Mobile Systems in the Computer Laboratory, University of Cambridge. Her research interests are in human mobility modeling. She has published in the areas of mobile computing, mobility and social modeling and sensor networking. She is and has been PI and co-PI of EPSRC projects on mobile and sensor networks (SATIN, CREAM, FRESNEL, UBhave, UBiVal and WILDSENSING) and on EPSRC project MOLTEN, investigating time varying complex networks. Cecilia is also involved in the Cambridge based EPSRC Infrastructure Knowledge Centre on Smart Construction. She has also been PI of a Knowledge Transfer Programme on mobile middleware for health care. Cecilia received direct industrial funding from Google, Intel and Samsung. Dr Mascolo has served as an organizing and programme committee member of many mobile, sensor systems and networking conferences and workshops. She sits on the editorial boards of IEEE Internet Computing, IEEE Pervasive Computing and IEEE Transactions on Mobile Computing. She has taught courses on mobile and sensor systems and an MPhil course on social and technological network analysis. More details are available at http://www.cl.cam.ac.uk/users/cm542.

Dr. Vito Latora is Professor in Applied Mathematics, Chair of Complex Systems, at the School of Mathematical Sciences of Queen Mary University of London. He is also the Scientific Director of the Laboratory of Complex Systems at Scuola Superiore di Catania (Italy). After his PhD in theoretical physics at the University of Catania (1996), he held postdoctoral positions at MIT, Harvard and Paris XI (1996-2001), and a position as assistant professor in Theoretical Physics at the University of Catania (2002-2011). Vito's research interests include a wide range of subjects in statistical physics and dynamical systems. Recently, he has contributed with a series of empirical studies and mathematical models to understanding the structure and dynamics of complex systems. In particular, he has pioneered works on the efficient behavior of weighted networks, on cascading failures, spatial networks and, more recently, on random walks on networks, and on time-varying graphs. He has proposed applications of complex networks theory to brain imaging, social sciences, and to study urban systems. He has authored 3 edited volumes, 7 book chapters and more than 100 scientific publications, including a review paper on complex networks (today considered a classic in the field) and papers in Science, Phys. Rev. Lett. and PNAS, with a total of more than 5000 citations (h-index from ISI=33). More details are available at http://www.maths.qmul.ac.uk/~latora.

Dr. Sergio Porta is Professor of Urban Design, Head of Department and Director of the Urban Design Studies Unit - UDSU (www.udsu-strath.com) at the Department of Architecture, University of Strathclyde (UoS), Glasgow, UK. Together with Dr. Ombretta Romice, he holds the MSc in Urban Design Programme to Y5 students at and teaches various classes including "Urban Design 1" at Y4 and "Urban Theory" at Y5. He is member of the Environmental Structure Research Group and the Academy of Urbanism and sits in the editorial boards of leading international journals like "Environment and Planning B" and "Urban Design International". Dr. Porta's research is on sustainable community design, space analysis and community engagement in decision-making. Dr. Porta presented his research internationally on many occasions. In 2011 he has organized the international seminar *"Evolution in complex transportation networks"* (August 2011) and sits in the scientific committee of IAPS 2012 (June 2012, http://www.iaps2012.org.uk/). His publications include papers on Urban Studies, Urban Design International, Journal of Transport Geography, Environment and Planning B, Nature SR, Chaos, Physica A, Physical Review E, The European Physical Journal B, the edited volume Urban Sustainability through Environmental Design, Routledge, 2007, and contributions to edited volumes like Haas T, ed. (2008), New Urbanism and Beyond: the future of urban design, and Estrada et al, eds. (2010), Network science complexity in nature and technology. More details are available at: www.udsu-strath.com.

Previous Related Results and Investigator Complementarity

GALE partners have a strong record in developing metrics are able to analyze the fine-grained data outputted by geo-social networks both temporally and spatially. We have been very active in the area of mobile sensing through mobile phones, studying how phone applications using a variety of sensors could be made power efficient. We combine this knowledge with world-class expertise in the sciences of complex

networks as well as urban policy and design to create a unique interdisciplinary team capable of approaching the development of a novel efficient mobile phone application for recommendation. The framework will be based on a notion of neighborhood, redefined according to new evidence, and to explore the impact of that in terms of urban transport and community identity. GALE partners not only show a number of key publications in the respective areas, but also a long record of successful scientific partnerships that guarantee the reliability of the collaborative team. The team is in fact well trained to work together, which will significantly ease the achievement of cutting edge results.

Geographical analysis of social systems Dr. Mascolo and her team have studied geographical features of data collected from geo-social networks, by combining them with the social aspects. In particular, new metrics, including geo-aware node degree and geographical clustering coefficient have been devised and more general studies of the influence of distance on ties and communities have been conducted [Bro12]. The work has been cited nationally and internationally in the media. Empirical studies of human movements and models of mobility in urban areas have also been proposed by Dr Mascolo [Nou12], and by Dr. Latora [Sze12]. Dr Mascolo received a Google Research Award for work in modelling geographical social networks. This research and expertise will be the building blocks for the work proposed here, as they will inform the new neighborhood definitions.

Time-varying Social Networks Dr. Mascolo and Dr. Latora are part of EPSRC project MOLTEN, which concentrates on models for time aware complex networks. As part of this project, they have devised metrics that exhibit time-awareness for analysis of shortest paths, centrality, and components in large-scale complex networks [Tan10]. The metrics have been applied to large datasets to highlight important aspects: e.g., we have studied influence and centrality of people in the Enron scandal through the public email data set of the company. The experience with fine grained data analysis in terms of time will be essential for the development of the run-time recommendation system planned in this project.

Mobile phone sensing and applications Dr. Mascolo has been involved in a number of projects dealing with attaching sensors to moving entities. In particular, in project EPSRC WILDSENSING, we have monitored badgers in collaboration with zoologists in Oxford. EPSRC FRESNEL is studying federation of sensor networks for the monitoring of places and people in an efficient and privacy preserving manner. EPSRC UBHAVE in collaboration with psychologists, plans to design phone based intervention and monitoring tools. Seminal work EmotionSense [Rac10] has been published prominently and has received the attention of major newspapers in England and abroad. Dr. Mascolo is a Co-I in an EPSRC University of Cambridge Infrastructure and Knowledge Centre on Smart Infrastructure and Construction, a multi-disciplinary project with civil engineers and architects aiming at using sensing and mobile technology to improve the construction industry. This experience with mobile phone applications will inform the development of the recommendation system application planned in this project.

Analysis of Urban Networks Dr. Latora and Dr. Porta have a long-standing collaboration in the development of ideas and tools for the analysis of urban systems, and in particular of urban street patterns [Car06]. One of the proposed methods, named the Multiple Centrality Assessment (MCA), allows for mapping centrality in urban spaces, and establishing correlations with relevant dynamics such as location of shops and services and land-use [Por12], vehicular or pedestrian flows and crime rates. The latest research is mainly orientated evolution in street networks [Str12] and sustainable/human/adaptive urban analysis and design. The research has been extensively applied to urban design in education and in a number of professional cases and research programmes, such as the EPSRC “City Form” project (2006) and the KTA/EPSRC “Multiple Centrality Assessment (MCA) as a strategic modeling tool for use in urban regeneration” (ongoing) with Robert Adam Architects Ltd. The latest study on the elementary processes governing urbanization [Str12], has received press coverage in Nature, Scientific American, and wide diffusion in forums on urban design.

Part 2: Description of the Proposed Research and its Context

1. Background and Motivation

Recommender Systems have been generated in the past 15 years with the aim to suggest to individual users opportunities arising in the virtual space of the Internet on the basis of the individual profile of the user, her/his past history as a customer/web-user. Popular examples of such systems are the Amazon book recommendation and the Netflix personalized movie recommendation engines. Both systems use machine-learning techniques to learn from the purchase histories of millions of users and generate unique recommendations for each individual. Interestingly, Netflix has popularized recommendation systems development in the field of computer science through the Netflix Prize competition. The competition, which involved the publication of a large dataset of customer movie ratings, led to considerable research output. This included a number of novel modeling algorithms that improved the quality of recommendations in commercial services that span numerous web activities. Further, the rise of online social networks, such as Facebook, has allowed for a new source of information to be exploited by recommendation systems: *the user social network*. Indeed, numerous recommendation algorithms lie behind every feature in the Facebook system. Those include the personalized news list commonly known as 'news feed', the recommendation of new friends, or even tuning advertising content to its users. Other examples where the social network of users plays a pivotal role in recommendations is that of music website LastFm that targets audio content to its users or the StumbleUpon website which recommends Web content.

Internet access is now becoming increasingly mobile and smart phones are changing the way people interact with places and with each other in an increasingly complex manner. Morgan Stanley Research estimates sales of smartphones will exceed those of PCs in 2012. Smart phones are starting to impact the way users access information on the go and receive suggestions. More specifically, innovative recommender systems are currently being developed to exploit GPS-based or other location-sensitive information, associated on-the-go to individual users through smart-phones. Google Latitude and Google Places are examples of systems offering location-aware travel guides to users, and related research projects have appeared in ubiquitous computing conferences in recent years. This *second generation of recommender systems*, by being location-based, pose an entirely different set of problems that not only have to do with the knowledge of the user (her or his "profile"), but also with that of the places. *Knowledge of places* can be achieved by means of guides, textbooks and journey reports, or by direct experience. These mechanisms are quite different in nature. The former is globally accessible (everybody can get it from afar) and relatively fast to obtain, especially in the age of the Internet. The latter is only locally accessible (one needs to be in the place to access it) and, being generated by those living in the place through personal local interaction, it becomes accessible only after long-term interactions and the construction of personal relationship of mutual trust. When visiting a new place, you would necessarily rely only on global information to navigate the place and access its resources. Conversely, if you are a local, your knowledge of the place is mostly constructed through your personal long-term exchange with what all your neighbors are doing every day and with their favorite places in the neighborhood; as a result, you not only would rely on local knowledge, but you would also contribute – by interacting locally – to the formation and continuous re-shaping of the information used by your neighbors too in *their* interaction. If we name the long-term, locally generated knowledge of the place "*neighborhood knowledge*", we can say that what people locally do in places is in one way or another dependent on the extent to which they have access to the neighborhood knowledge.

The second generation of recommender systems allows people visiting a place who are not experienced with the place itself to access "globally" available information, i.e. information on the place available to anybody through worldwide repositories such as Wikipedia, Google Map etc. It is important to highlight that these systems are place-specific (geographic) in that they convey to individual users information that is specific to the place indicated by the user, for example the list of bars and restaurants within 400mts from the user current location, and are also user-specific (social), in that it is the user who specifies the particular place about which that information is requested and the user's profile and network of friends can be surveyed in order to personalize the service. However, a good deal of information is still not exploited in these systems, as the geographic and the social only "meet" in a superficial way: in other words, the system does not take advantage of any information about the particular use of the place that local communities

have done in the past and do at the moment. In short, the system is oblivious of the place's *neighborhoods* and the *neighborhood knowledge*.

As neighborhood knowledge information is now becoming increasingly available through the viral expansion of location-based social networks such as foursquare or Gowalla, it is now possible to explore *a third generation of recommender systems*, where knowledge about how the place had been used in the past (historical use) or is used at the moment of the inquiry (real-time use) by communities of users is the key element of the system. While foursquare is already starting to offer basic recommendation systems for places based on user history and social connections, we take this problem one step further. *The main motivation behind the GALE (Global Accessibility to Local Experience) project is to pioneer such third generation recommender systems which would make it possible for the rapidly growing population of "global" city users to access, in real time, a level of information, that of the neighborhoods knowledge, which is inherently inaccessible to global repositories.*

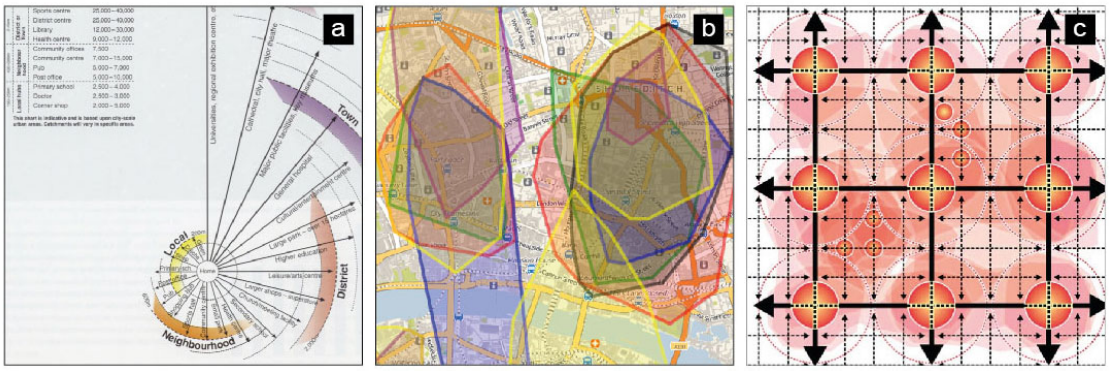

Fig.1 a) The urban designer's conventional static geographic neighbourhood as identified by catchment areas of different levels of services [UTF99]. **b)** A representation of the dynamic fluid neighbourhood proposed by GALE, as can be generated by geo-social networks datasets, such as the ones collected through Foursquare and Twitter [Nou11]. The figure shows a preliminary example of user's activities in London: each boundary represents how the local community of users utilizes different public and private services, such libraries, schools, bars and restaurant (different colors), at a particular time of the day. **c)** A conceptual model of how fluid urban neighbourhoods would inform new relationships between land use, transport and sustainable communities relevant to urban planning [Meh10]: GALE will contribute to the generation of the 21st Century smart city.

In order to do this, GALE aims at redefining the very same notion of neighborhood. The conventional definition of neighbourhood in urban planning is eminently *static-geographic*, i.e. it has to do with the notion of "catchment area" referred to services like churches, schools etc (Fig.1,a). The one most influential theory in modern urbanism, the *"Neighbourhood Unit"* [Per29], has been grounded on a notion of neighbourhoods identified by fixed distance from services, on the assumption that people would always rationally use the closest services to their home and develop community social relationships on that basis. As a result, theories of urban planning up to our days have identified neighbourhoods as communities of inhabitants of a fixed size served by a certain set of services accessible at fixed distances [UTF99]. Decision making in relevant areas of urban policy such as public transport and community health and identity has always been driven by this static-geographic notion of neighbourhood which still informs the most recent reference models in the urban design profession [Far08].

However, that *static-geographic* interpretation of the urban neighbourhood has hardly been validated empirically: studies in environmental psychology, urban geography, urban sociology have come to a different notion, grounded not on "catchment" (metric distance to service) but on resident's interaction with neighbours and psychological patterns of cognition, satisfaction, influence and place-attachment [Gif02]. Neighborhoods can be conceived as dynamic social entities, a product of the people-place local interaction and, as such, extremely variable constructs that continuously change in scale (from the personal to the collective), in time (depending on what people do in different moments of the day-week-month-year) and in space (as a result of the former two variations). The GALE project brings forward the comprehension of neighborhoods as social entities by exploring their changing spatial manifestation, that is, by providing an operative definition of what we name *"fluid neighborhoods"*, i.e. the "fluid" geography of social neighborhoods. As such, fluid neighborhoods are based on similarities in the demographic, social and cultural profile of the people. The mass diffusion of personal mobile IT devices associated with geo-social networks makes now available for the first time the geographic evidence of what fluid neighbourhoods are, and how they

change in scale, space and time, at unprecedented levels (Fig.1, b), allowing the development of new conceptual urban models (Fig.1, c).

2. Research Hypothesis and Objectives

The research hypothesis behind GALE is that, with a scientific definition of fluid neighborhoods and the use of geo-social network metrics on data harvested from mobile phones and online social networks, it is possible to build recommender systems which are more like a local human guide than a book guide, and can therefore deliver better integrated socio-geographic recommendations, offering the local experience of places in real-time to everyday city-users as well as to the growing cohort of external visitors. To support our research hypothesis we will explore a notion of fluid neighborhood that is constructed in society (socially and culturally, individually and collectively) like the one used by environmental psychologists and urban sociologists, but still identified in space (geographically), like the one used by urban designers. Secondarily, we will envision how the evidence generated about fluid neighborhoods' nature and behavior may change the way we understand the life of urban communities, the way they interact with space, the way we can govern and plan them, and how these dynamics may be shaped by the future evolution of technology.

The tangible output of the GALE project will be a next generation recommender system at the interface between the social and geographic dimensions of people activity in space. The recommender system will be accessible by personal mobile computing devices, and will allow people to orient themselves in local neighborhoods and benefit of local neighborhood-specific information in real-time. Side-outputs of the GALE project will be: *i)* a study of the nature and the behavior of fluid neighborhoods in practice, and *ii)* a study of the implications of the fluid neighborhood for: a) public transport, community identity and other matters related to collective behaviors and planning at the neighborhood scale, and b) technology-intensive people-environment interactions in the "smart cities" of the future. We are therefore proposing an interdisciplinary project involving Computer Science, Complex Systems and Urban Design.

Objective 1: Definition of Fluid Neighborhoods: the GALE Observatory. Based on the exploration of the concept of "neighborhood" in urbanism, environmental psychology and urban sociology literature, we will introduce an operational definition of *"fluid neighborhood"*. Geo-social network datasets, such as the ones collected through Foursquare and Twitter provide geographical and social profiles of the users, as well as category and visit frequency of the places. We will take advantage of this information to understand the geographic constituency of neighborhoods, defined socially and temporally. A fluid neighborhood will be identified in space by a set of boundaries, each of which is defined by the use of the place relative to a particular community of people. We will investigate the factor of scale of such communities (from individual persons to socio-demographic groups) and the factor of time (the different shapes that each boundary takes, for each community, in different moments of the day/month/year). Fluids neighborhoods will then be mapped and made available *in real time* by the construction of the GALE Observatory (*GALE-O*), an online repository of geo-social data that stores historical as well as real-time anonymized people-place information. Evidence stored in the GALE Observatory will be used to construct an operational atlas of fluid neighborhoods that will grow in time as the system expands its data reach. Evidence from the GALE Observatory will inform the continuous redefinition of fluid neighborhoods.

Objective 2: Realization of a New-Generation Real-Time Recommendation Systems: the GALE Recommendation Service. The Gale Observatory will deliver information in real-time to the end-users through the construction of an open platform of on-line recommendations accessible from the smart-phone: the GALE Recommendation System (*GALE-RS*). Knowledge about the user location, the time of the day and the user social network, as well as the user profile and history will be exploited to select the fluid neighborhoods produced by the spatial patterns of communities characterized by similar profiles and local to the area, and to tune the recommendations given. Example applications of this system are recommendations to newcomers about where they would probably like to live (buy or rent a house), or to shop, drink, eat, on the basis of the geographic boundaries of neighbourhoods of matching communities of "local" users and the places they mostly visited. Such recommendations will be delivered "on the go" as the user moves around in the urban space, therefore traversing a continuously varying geography of neighbourhoods that s/he also may contribute to shape *in time*. This real-time interactive environment "existing" on mobile personal IT devices is what makes the combination of GALE-O and GALE-RS much more than an advanced mapping system.

Objective 3: Deployment and Validation of the framework. We will validate GALE-O and GALE-RS in two ways: on one hand, through a series of experiments on geo-social datasets we hold; on the other hand, we will deploy our system on a population of students at University of Strathclyde in Glasgow as a part of the Glasgow Economic Leadership Board's strategic plan over six months time, comparing the impact of GALE-RS on the formation of neighborhoods as a result of the use of urban places by particular social groups. As a final output, we plan to deploy the produced GALE-RS software on the app markets of mobile phones. Outcomes of this validation phase will constitute feedback for the refinement and extension of both the GALE Observatory and the GALE-RS with new information, tools and applications.

Objective 4: Exploration of GALE-O potential: the GALE Urban Vision. The project will engage IBM, our industrial partner, the Glasgow City Marketing Bureau, the public sector and NGOs in a chain of creative events named GALE Urban Vision (GALE-UV). The full potential of the information stored in GALE-O will be explored creatively and collectively with an eye at delivering industrial and social impact out of the GALE innovative products and information. Ideas in the areas of urban governance and design, technology intensive urban experience will be hunted and generated towards a practical, product-orientated redefinition of the "smart cities" of the future, leading to further Research and Development initiatives.

3. Timeliness, Novelty, Academic Impact and National Importance

The novelty of the proposal is to take the exploitation of geo-social information one step further, by working out products of impact both for the industry and for the society at large. GALE will in fact explore how new kinds of real-time, bottom-up information about neighborhoods can be exploited for developing novel recommendation systems, and also, more in general, for improving the way we understand, plan and govern the cities where we live. The impact of the new knowledge produced by GALE on our understanding of cities at the scale of the neighbourhood, how they work for communities and shape collective behaviours, is profound. The academic impact of our work will likely be high. We are well placed in our respective disciplines and we expect, as a result of the project, high-impact publications in very distinct areas such as ubiquitous computing, social networks, complex systems, and urban design. In computer science, the novelty of the use of complex network theory and urban planning case studies, as well as the real deployments planned in WP3, will be pivotal to generate large interest and academic impact. In complex network theory, the possibility to develop the mathematics (metrics and models) of social networks embedded at once, both in space and in time, and to test the results on real observation, will produce a large interests, since spatial networks and temporal networks are two hot topics at the forefront of actual research. Finally in urban planning, the use of very large and novel datasets, which allows the real time analysis of neighbourhoods, will contribute to the design of sustainable communities. We plan to organize events and workshops to foster interaction of these disciplines. We have also put together a scientific advisory board of confirmed prominent experts: Prof Yvonne Rogers (UCL and PI of the Intel funded Institute for Sustainable Connected Cities), Prof Marc Barthelemy (Institut de Physique Theorique, CEA, Paris and author of a recent review paper on spatial networks) and Massimo Marchiori (University of Padua, MIT Lab for Computer Science and W3Consortium, ideator and creator of new search engine Volunia) to which we plan to expose our findings in meetings. This will help the dissemination of our ideas further. This proposal tackles issues of primary importance to the development of the UK research, and it is key to the issues identified in the EPSRC portfolio, in particular in areas related to complexity science and in social mobile and ubiquitous computing. With the combination of the three disciplines involved (Computer Science, Complex Systems and Urban Design) the work has the potential of both putting the UK at the leading place in the analysis of geographical social systems, as well as fostering the innovation of potential businesses related to the construction of novel recommendation systems. A second aspect of national importance touches urban design and the "smart city". Recent research has shown that between 7 and 9% of household in England are likely to be affected by housing needs of various kind in the next decade [Bra10], while the Government has set a target of 2 million new homes by 2016 and 3 million by 2020.

4 Programme and methodology

WP0: Management and Dissemination (WP Leader: Mascolo) As the team is distributed over three institutions we plan to organize monthly teleconferences to monitor with progress. Quarterly meetings will also be scheduled. Yearly meetings with IBM and our advisory board will be organized to keep them involved with the progress of the project. As the project is highly interdisciplinary, we will organize work-

shops aimed at integrating urban designers, computer scientists and complex network experts. In particular, one workshop will be organized in Cambridge after the first year, to build a community around the early results of the project. The workshop will include 50 invited international participants. We will further organize one workshop collocated with CUPUM 2013 and/or IAPS 2014, and one with Ubicomp 2013/14 or RecSys 2013/14. In terms of dissemination we have a good record in keeping in touch with the Media Office of the three Universities involved, and we have been fairly successful in being blogged and cited by journalists: we will make sure our results are publicized to the general public. We will submit papers and participate to conferences in the relevant areas. The project will have a web site, a blog and a Twitter presence.

WP1: Fluid Neighbourhoods and Observatory: GALE-O (WP Leader: Latora). In this WP we will first explore the literature on neighbourhoods and their various definitions in urbanism, environmental psychology and urban sociology, with an eye on the features that have been used from various perspectives to identify neighbourhoods. Then, we will focus on a selection of those features that better match the nature and the scale of our project, and the information currently available in real geo-social networks such as the ones available to our consortium. These (i.e.,foursquare and Gowalla) contain fine-grained data about the places visited by hundred thousands of users, including the exact time of the visits, the location (with GPS precision) and the category of each place. Users' profiles (such as age, gender, occupation, ethnicity, hobbies) and their social ties (the social network of the users) are also included in the dataset. By means of mathematical methods and tools such as complex network theory, clustering techniques, and machine learning we will identify sets of user communities based on three different kinds of features. Namely, we will group together users: 1) "gravitating" within a specific geographical area, as derived by the spatial distribution of their visits, 2) with high profile similarity, and 3) users belonging to the same social network communities, as defined through techniques of network community detection. Three different types of fluid neighbourhoods will be constructed accordingly, by considering the places visited by the communities of users belonging to one of the three previous categories. The results will be mapped geographically in the GALE Observatory, and each neighbourhood will be characterized by means of GIS-based spatial analysis techniques. In this way, we will get a spatial profile of how: 1) people living or working in the given area, i.e. local people, use the local resources, 2) how similar people, i.e. youngsters, or people of the same class, people with similar hobbies, use the city, 3) how friends share patterns of use of places. By taking into account data on the time of visits to places for every user, the evolution of the fluid-neighbourhoods over time will then be studied and visualized in a sequence of temporal maps at different time scales, ranging from hourly to daily, weekly and monthly. In addition, IBM will offer their expertise with the use of Dublin City Council and with their help we will use these additional datasets for the city of Dublin to further refine our views of neighbourhood with respect to the use of public transport (e.g., flows at different times, different use by different age groups).

WP2: Real Time Recommendation: GALE-RS (WP Leader: Mascolo). The fluid-neighbourhood repository stored in the GALE-O will inform a new recommender system able to disclose the local information extracted from the communities to users in the form of suggestions (GALE-RS). The suggestion recipient's profile (namely her/his pattern of visits and that of her/his social network), together with her/his location at a given time, will be taken into account in the computation of the recommendation. We will adopt techniques used in item recommendation systems, such as collaborative filtering, joint matrix factorization and random walks on bipartite graphs, but we will also extend them with domain-specific knowledge related to the spatial properties, devising new ways of building similarity measures between places and between users and places. The longitudinal nature of our dataset allows us to explore supervised learning algorithms by training and testing classifiers on different temporal periods, making approaches such as regression analysis suitable to build predictive models. We will implement our recommendation system for mobile phones (both Android and Apple). Depending on the categories selected by the user, her/his specific location and the time of the day or the day of the week, the application will in real-time display patterns of use by locals belonging to communities with similar profile that define fluid neighbourhoods. The transport data analysis over the city of Dublin, done with the help of IBM, will also provide an additional layer of recommendation related to public transport suggestions which will again be personalized based on person's profile and time of day.

WP3: Deployment and Evaluation (WP Leader: Porta). The methods developed will be evaluated at various levels and with various approaches. The *first* evaluation will be based on the Foursquare/Twitter data we hold. In order to prove that the recommendation method we have devised is effective, we will divide our dataset temporally in two parts, a training set and a testing set, and study our GALE-RS system performance in recommending places based on the history of users in the dataset and on the visits of users. We will use data about users moving to new cities or visiting new neighbourhoods (as this happens quite often in our data). *Secondly*, we will deploy our tool on phones of a set of Univ. of Strathclyde students

followed over six months time of their "use" of the city of Glasgow. This experiment will be run in partnership with the Glasgow City Marketing Bureau in the context of the Glasgow Economic Leadership Board's definition of strategic lines for the economic development of Glasgow, which specifically targets the large students population as a primal resource for the city's growth. We will articulate the testing population in subsets according to their personal profile, comparing groups with and without local knowledge, at different level of local experience, with different backgrounds, and those using or not our GALE-RS tool. This experiment will be held in Glasgow in 2014 and links with special events of very different nature, like large scientific congresses, Celtic Connections or the Commonwealth Games, will be built and observed, and questionnaires will be used for evaluation. *Finally,* we will deploy our mobile phone application to the Android Market and App Store, so to make it available for users to. A questionnaire will be given to users to get their feedbacks to evaluate the performance and usability of the recommender tool.

WP4: Exploring implications for future urban life: GALE-UV (WP Leader: Porta). In this WP we will deliver a creative product-orientated process of visioning based on the structured engagement with relevant industry and public sector stakeholders. The process, named GALE Urban Vision (GALE-UV) will develop through a triple phasing of information, brainstorming and constructive delivery, aimed at identifying the manifold impacts that new real-time as much as "historical" information of fluid neighbourhood stored in GALE-O, associated with new mobile locational technologies, may generate towards a practical, product-oriented redefinition of our future smart cities. The process will take the form of a brain storming organized in a chain of structured and facilitated events: stakeholders will be selected representing not only academic knowledge, but also industry leaders in advanced IT as well as local communities, and immerse them in a creative environment for a series of intensive exercises followed by more conventional reflective communication and dissemination events. New technologically intensive ideas in areas like place navigation and transport, marketing and manufacture as associated with local communities opportunities to grow and flourish will be explored, helping to identify more broadly the GALE-O potential.

Risk and Ethics Management

The main risk for this project is related to the evaluation: the release of the recommender system on the market might not lead to data for analysis as the take up from users might not be good. However we already have data from geo-social networks, which we can use to evaluate extensively the approach. The PI has considerable experience in the management of extensive teams and projects, including multi-disciplinary ones (see Track Record): this will help making sure thing run smoothly and on time. In terms of ethics, the PI has experience in requesting and being granted University and Departmental Ethics approval for her experiments and the University has in place considerable support in terms of committee in this sense. We are very aware of the risks and implications of the collection of data of this granularity: we have in place secure storage for these datasets and access and support from experts in privacy and security in the Computer Laboratory to ensure that collection is done in respect of users' rights.

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