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Urban Monitoring Laboratory: New Benefits and Potential for Urban Planning through the Use of Urban Sensing, Geo- and Mobile-Web

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1 ABSTRACT

Continuous observation and monitoring of developments and changes in quality of spatial phenomena has always been a central task in the urban, spatial and environmental planning at various scales. Similar to the discussion about “Web 2.0", “monitoring” will be used in a very intense discussion of innovative planning methods. It means observation of a phenomenon over a longer period, with the result of using the knowledge gained on forecasts for a reactive or constructive control. As mentioned in the conference topic, cities, regions and spatial phenomenas do have changes and lifecycles. Though, what are changes and how could they be identified and measured? Monitoring of these issues could be the key to that and will gain more importance in the future of planning. Observation processes and furthermore, issues like smart cities and energy efficiency gains incremental importance in the context of urban planning. The amount of potential useable data for planners is growing and there will the question how to make use of it. Especially the upcoming presence and rise of sensor data will contribute to that. In times of the GeoWeb, the use of mobile based planning methods for communication and collecting data, GPS, tracking, the analysis of time in spatial planning and “smart sensoring” will gain importance: How humans can be used as an “intelligent sensor” for a better planning through the use of smartphones for example. Issues like inductive monitoring and crowdsourcing in this context with the potentials of social communities together with location based services (social geography) will be observed as well. The task for planners will be to identify what kind of data is important and how to deal with heterogeneous data in general and how to interpret it. However, there will be a lot of research for the question, what role planners could play on this interface between real and digital world. This study will give an overview about new fields of research for planners and how monitoring in this spatial and urban planning context could be used wisely.

2 INTRODUCTION

In 1998, Al Gore predicted a “digital representation of the planet that would make it possible to find, visualize and make sense of vast amounts of geo-referenced information in physical and social environment”. These predictions became true with the development of the GeoWeb with application like Google Earth. Consequentially, it is necessary to make use of this vast amount of data in order to improve planning. Monitoring of spatial relevant data could be an approach to do this. In order to develop suitable approaches, it will be necessary to define requirements referred to planning and linking to information technologies as well as for integration approaches in formal and especially informal planning process. The Geoweb for example provides the ability, to use mobile devices like smartphones and notebooks in the sense of pervasive ubiquitous computing to realize an interaction between reality and virtuality.

In addition to influential approaches like top-down initiated program U-Cities (Ubiquitous Cities) in South Korea (Jang, Shu 2010), whose technical scope is exemplary, the object of the „Urban Monitoring Laboratory“ is more to be seen in its bottom-up and participatory process context. This research paper aims to elucidate the complex correlations between the monitoring approach, technological development and participative citizen involvement and their potential influence on the planning process. Ongoing and planned research activity will be shown with the foundation of the “Laboratory for Monitoring and Spatial Sensing”.

3 MONITORING

3.1 Monitoring in the context of planning

The concept of monitoring has its origins in the English language and is described as a "permanent observation of a particular system” (Eickhoff et al 2006). This continuous observation of developments and changes in quality of spatial phenomena has always been a central task in the urban, spatial and environmental planning at various scales and will remain in the future. Only by using this data collection, it

is possible to generate time series, which are the basis for forecasts. The gained knowledge could be used for forecasts for a reactive or constructive control and could be considered as a preliminary stage to controlling. Especially in the working field of spatial planning, and the accompanying time series analysis were emphasized (Streich 2005:211). Monitoring methods should ensure an implemented protocol with exact timestamps for a continuous recording of the observation object. Regarding the data used, monitoring needs a systematic collection, analysis and documentation of these data in order to do an analysis via time of quantitative and qualitative entities. This research reflects a holistic approach and is more complex than other comprehensive spatial planning. Contents, which have to be deliberated, in order to create an additional value for the planning process, should have an emphasis not just on the technical perspective as described below.

3.2 Inductive Monitoring

With the appearance of Web 2.0 and associated opportunities, many new developments could influence the approach of monitoring. Millions of non-expert users are empowered to not only to consume but also to publish geo-information. Developments like 'Volunteered Geographic Information' or wikification of GIS will take place (Goodchild 2007; Elwood 2008). In addition, pervasive sensing is the empowerment of non-experts to create, analyze, visualize and publish geospatial information, will evolve in the next years. Therefore, new possibilities for monitoring will emerge and monitoring could be distinguished in forms of "deductive and inductive monitoring":

Deductive monitoring is mainly top-down-oriented and composed of data generated by defaults, like time series analysis: People collect data sets, with or without the awareness that they wear a sensor device and collect data, or unconsciously, like the connection dataset of cell phones. Regardless of the fact, how these monitoring technologies deal with personal data and data security, the continuous recording of these kind of data has a large potential, not only for spatial planning. Inductive monitoring approaches, especially in spatial planning have to be considered in a different way and could be described as a concluding approach from the entirety.

Inductive monitoring describes the process, when individual users unknowingly are observing the same phenomenon and this is going to be combined in self-organized channels. It is considered as bottom-up-approach. These (spatio-temporal) processes can be done in analogous form or as a distribution of information in digital form like a twitter message or like a submission in a (georeferenced) forum. Campell and Lane (2008) are characterizing an inductive spatial monitoring system as "Urban Sensing Systems": They allow users to collect, analyze and simultaneously share information from the surrounding environment. In contrast to static sensor networks, the continuous mobility and the constant mobile data availability by every human user is utilized and is concluded from particular cases on the entirety. In contrast to static sensor networks, the continuous mobility and the constant mobile data availability by every human user is going to be utilized and mobile phones or other devices like vehicles for example are involved in a system of sensor nodes. Thus, the sensors are "on site ", there, where at the point of focus in the urban cohabitation.

The deployment of sensors in urban environment and in research will be more ubiquitous in the future. From the complex and heterogeneous data sets and new technologies arise new requirements for its use, administration, organization and management. Basic research for the handling of these data sets is essential in this regard. Some experiments in the field of citywide, sensing monitoring systems have been made already made in the city of Santander in Spain (smartsantander.eu). Focus in this case was particularly sensory data, management and visualization, which will be one of the essential research fields in the planning future. The focus in our study lies more on the integration in the planning discourse and the combination with crowdsourcing data for monitoring by participating users. The ability to measure a wide field of sensors data goes along with emerging sensor technologies and mobile devices in particular. Though, it will be important, to have the research focus not only on technical realization and as well on planning relevant cause-effect-chains with the qualification through planning expertise.

In addition, participatory Sensing is gaining importance. According to Burke et al. (2006), it is a unique, user-oriented equivalent of the deductive monitoring. "Interactive, participatory sensor networks that enable public and professional users to gather, analyze and share local knowledge (Burke et al. 2006)". Focus of the Participatory Sensing can be personal, social, and also urban issues. This is possible because of the

development of ubiquitous computing. Unlike traditional sensor networks, where the sensors are made up for the task, Participatory Sensing uses crowdsourcing approaches, which combines the "wisdom of crowds" (O'Reilly 2003). Thus, human could act as sensor. The main difficulty with this approach is the is little scientific knowledge and a lack of sensors concerning the behavior of “human as a sensors” and who he act and react in his every day’s life while he is using the Smartphone for sensing (Burke et al 2006). The particular difference to deductive monitoring is that in Participatory Sensing an active involvement (participation) is included in the process of recording data. This can be compared with the phenomenon of so-called “Grassroot Journalism and Reporting” (Bowman and Willis 2003), whereby a group of dedicated journalists publish a particular topic out of the local area through a blog on the pulse of the time. Participatory Sensing uses this form of "Joining and Participation", and can refer to as “Grassroot Sensing”, in a figurative sense (Coburn 2004, Burke et al. 2006). Data gathering using "Opportunistic Sensing” includes the technology, that a person is unconsciously surveyed by a running application on his Smartphone. This may be that the mobile device continuously logged data of user’s location, as for example in Google Latitude, unless the user disables the continuous tracking of the location.

3.3 Technological development

Particularly worth noting trends are as well: the growing amount of interest in the usage of the Internet in combination with georeferenced data and the ubiquitous mobile computer systems. The term “GeoWeb” used in the British magazine “The Economist” (2007) is mentioned as well as it is metaphorically referred to “Web 3.0” or “GeoWeb” (Batty et al. 2010). In particular, the GeoWeb phenomenon refers to “the development and changing nature of map-based, data mash-ups. It will explain the basic concepts behind map mash-ups; how geospatial data gathering and analysis has changed and how new technologies and standards are impacting on this” (Batty et al. 2010). During the last years, a drastic increase in available GIS-data source and this applies especially to rapid developments and price reduction in sensing technologies. To make use of this immense amount of data within monitoring systems, real-time data integration mechanism and approaches have to be developed (Resch et al. 2010). The subsequent sections will give a brief overview about the classes’ sorts of sensors.

3.3.1 (Smart) Sensors

A general overview and classification in sensor types could be distinguished in: sensors for state variables and material properties (temperature, density, viscosity, content of dust, humidity, smoke / fire gases, pH-value), sensors for geometrical and mechanical parameters (length, position, angle, speed, acceleration, pressure, vibration, acoustic / ultrasound, but also recognition of 3D shapes) and electromagnetic and optical sensors (magnetic field, current, ionizing radiation, visible light, infrared, image capture using CCD sensors, color sensors, but also special in this area for the code recognition (OCR or barcode) and other possibilities for image processing (Schanz 2007). If planners take serious attention with utilization of sensors for spatial planning, there are in general only a few sensor required, who are useful for applying in spatial planning. The so-called “base-sensors” for spatial planning are sensors for detection the location and the direction of an object. These sensors can be subdivided in sensors for self-location (for example a GPS-Tracker) or position detecting, how it is used for radar equipment or the detection of Cell-ID in mobile phone networks. With the help of GPS and a compass, it is possible to detect the moving direction. Other available technologies are data collecting processes with the assistance of visual sensors (like digital cameras) or audio sensors. In addition, for special spatial issues, like the measurement the degree of pollution - as shown in the Copenhagen Wheel project (Outram et al. 2010), in which environmental conditions like CO2-, NOx-concentration, temperature, noise (dB) and humidity were directly measured by sensors during a bicycle rider’s tour through the city. Besides this, it is important to involve humans into a “sensing process”, because they function through their body impressions as a synchronized multi-sensor. With the development of mobile devices, a new kind of sensor is emerging, because it is a small tool equipped with GPS and Internet connection which will be omnipresent in people’s future. The chances given by this technology and the available, creative software solution will emerge a huge potential of obtainable sensor data which has to be used. In the future, these sensors will be connected in mutual and corresponding (smart) sensor networks.

3.3.2 Human as Sensors

This specific ability of humans as sensors has to be considered in terms of monitoring of spatial phenomena: People are the smartest and most intelligent sensors because they are benchmark for human-related planning issues. By the development in mobile communication technologies and the rise of Smartphones, basically equipped with sensors like GPS, accelerometers etc., and humans could act as indicators. Sensors usually are equipped with GPS, accelerometers and other measuring systems. The development of the technology nowadays yields Smartphones with these technologies. Hence, humans are equipped with those technologies and could act as sense and on a further step as indicators.

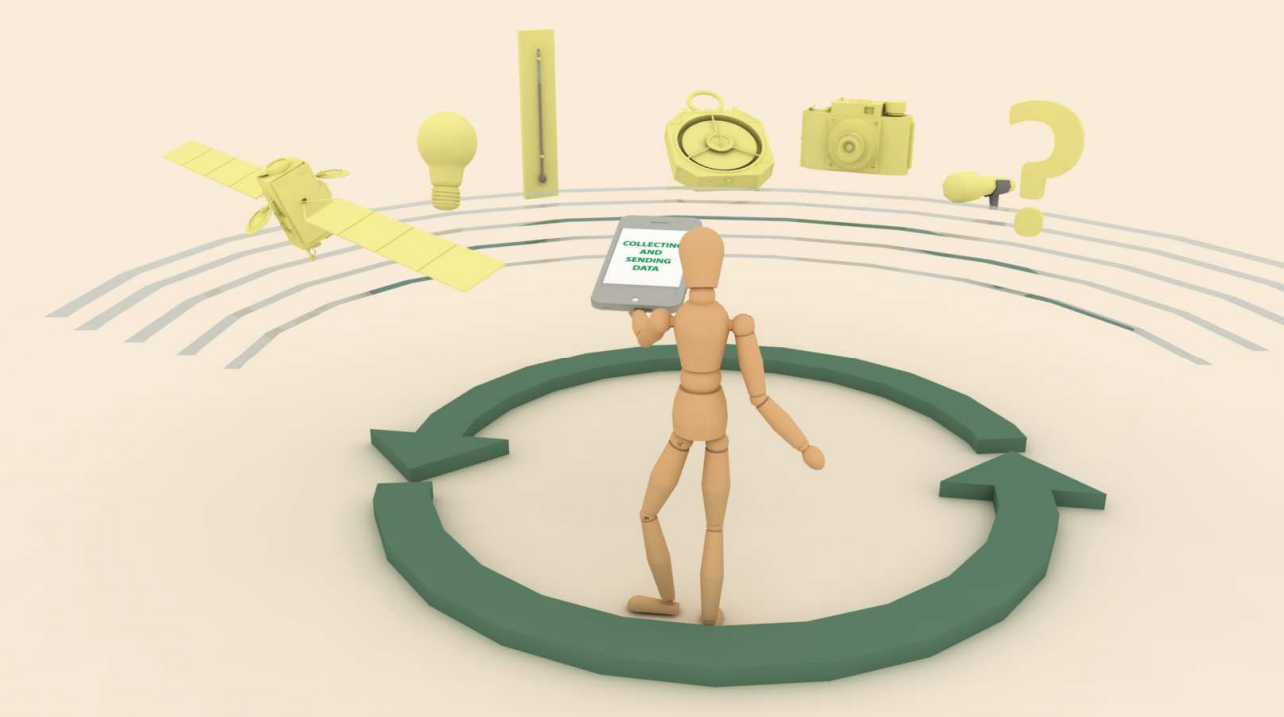

Figure 1: Humans and mobile devices as sensors with continuous interactions (Own source)

Considered form a technical perspective, mobile phones are on the threshold from “telephones” to be the instrument for participation and collaboration. Their abilities of these sensors together through interaction with the user itself will induce a vast amount of new planning relevant sensor data. However, it is just a small step from the technical level to the social perspective. Hence, a human sensor could be a mobile phone or a vehicle, equipped with a sensor. Furthermore, humans itself should rather be considered as sensors, because they can even active express themselves. Martino, et al. (2010) in this context stated, that urban citizens are evolving from actors to indicators. This describes the phenomenon of crowdsourcing, which is an evolving approach of the continuous data collection and represent individual subjects with people as the central instance of the inductive approach. It integrates an entirely new mode of participation in processes of urban discussion. Regarding this point, humans should be considered as implicit (passive) and explicit (active) sensors. Humans equipped with Smartphones act as implicit sensor, if there is a passive data transmission, like for example from a GPS-signal, with a more or less constant information flow. In contrast, the explicit approach is characterized with inconstant and deliberated information where people are transmitting their data (a localized Facebook-like-it- or googleplus1-annotation or for example) and express subjective feelings. Hence, this way of sensing effects may aim to identify problems and requirements for actions whereas they could be verified by n deductive survey. Ongoing research on this topic is needed in order to apprehend the relation between the population with the urban actor and how it can produce a rich understanding of the social system” (Martino et al. 2010). This research will also aim to understand the process from a single decision to an urban process and how to make use of the collective intelligence – and of course to understand as well as to promote it. In this context, it is important to understand, that there will be a constant flow of information and a mutual fusion and to apprehend, how this development could evolve. A Monitoring Hub could be established, which could be an interface between the single human, the crowd and the city itself and provide the chance for many linkages.

Figure 2: Interactions between users, (human) sensors and the city with the Monitoring Hub as interface in the focus (Own Source)

4 LABORATORY FOR MONITORING AND SPATIAL SENSING

The Working Group of this laboratory consists of the departments spatial and environmental planning at the University of Kaiserslautern under the supervision of the Department of CAD & Planning Methods in Urban Planning and Architecture (CPE). Scientific goal is the installation of a laboratory for monitoring and spatial sensing to create the basis for new basic research projects and to enhance existing joint research activities to make planning relevant monitoring on various scales. Based on this, further aim is to gain technical and methological expertise in this field. The developments mentioned before should also be one part of the reasearch of the laboratory. Another aim is a deeper integration of the matter of monitoring and sensing as well as pervasive monitoring in the planning context in research and education in the spatial planning faculty at the University of Kaiserslautern. Furthermore, methods and technology expertise for departments, also particularly for those facilities with no strong technological background like sociology, ecological design for example are considered. This laboratory gives the chance to make basic research with partly expensive and extraordinary monitoring devices like weather stations, laser scanners, thermography cameras, wearable sensors and many more. The laboratory comprises equipment for monitoring of spatial phenomena as 3D-phenomena and spatial structures and observing the change of phenomena of geographical featuresas well as instruments for the focus on equipment for monitoring of environmental media and building energy parameters with focus on climatic issues, thermography, water, soil, noise and ecosystems. In addition, it deals with research for monitoring of social-economic phenomena in terms of abstract spatial structures and spatial use and contains additional software for mutual connections between different projects and departments.

4.1 Case study: “Cross-border commercial Zone Monitoring Eurodistrict SaarMoselle”

One project in the laboratory with a small sensorial influence was the monitoring of commercial zones. The cross-border commercial zone monitoring project for the territorial unit of the Eurodistrict SaarMoselle was planned to give both German and French neighboring communities including the agglomeration of Saarbrücken in the southwest of Germany a tool to monitor their commercial zones. It had its focus on monitoring of land use by commercial zones in a cross-border context. Special approach at this project was a crowdsourcing approach, which enables all participating communities to insert their own data what make them responsible for them. It is a monitoring approach without technical sensing in focus, however to monitor abstract spatial structures according to the third main group. This approach focuses rather on planning relevant content than on technical realization. It is the first cross-border tool for both countries in this region to give them a common tool to monitor their commercial zones together and for cooperation in further planning issues. This portal is locally managed and accessible for potential investors with search masks and further increments are under consideration.

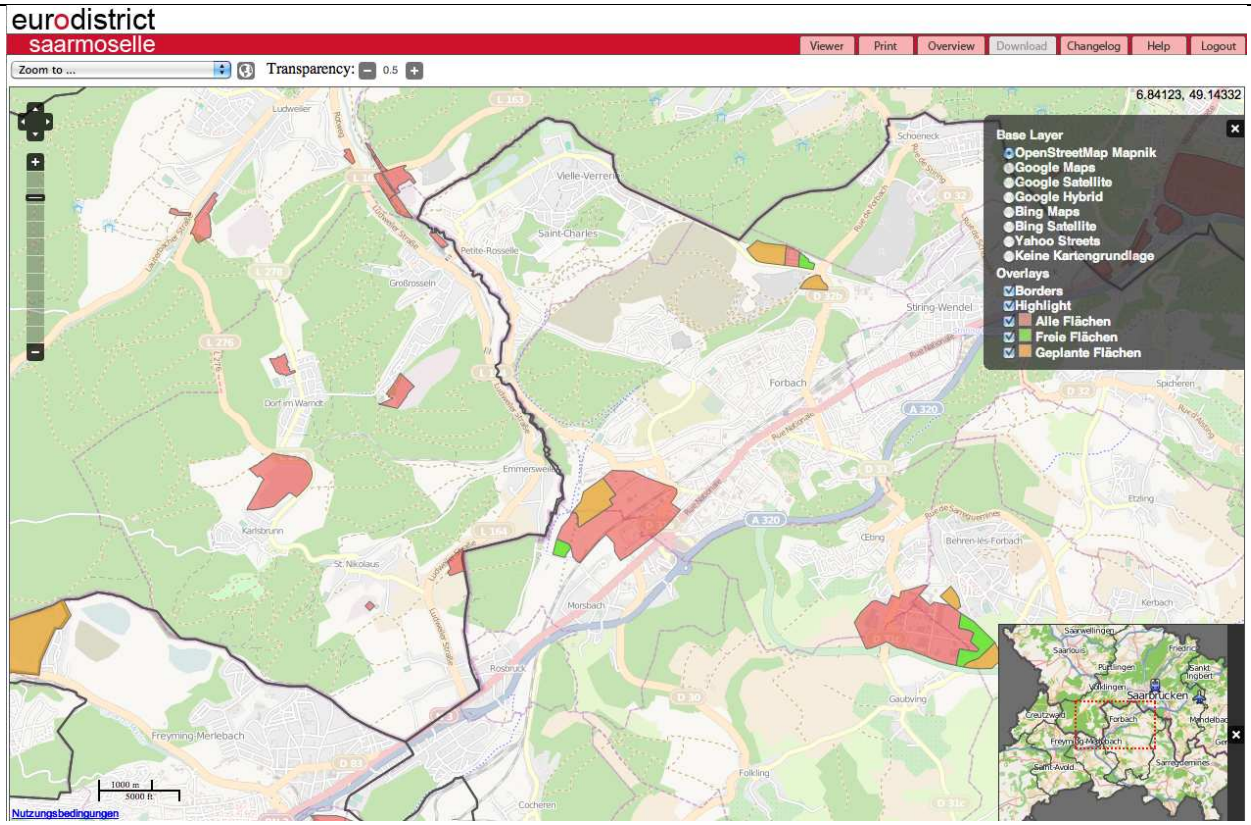

Figure 3: Web interface of eurodistrict saar-moselle (Own source)

4.2 Case study: Humans as sensors

Another project with a strong sensorial influence was “Human as sensors” whereas students tracked their ways and correspondingly purposes over a specific period of time so and to conclude the planning relevant data out of it. This could be the choice of their means of transportation as well as a shortage in the supply with public transport. The SENSEable City Lab by the MIT with the project “LIVE Singapore!” for example did research for this topic in this context (senseable.mit.edu/livesingapore). An observation was, that ”People moving within a city in most cases base their decisions on information that is static and that does not reflect the actual state of systems and dynamics in their city”. However, the focus of this project has a much stronger emphasis on information technologies than our research. Therefore, scientific aim of the study “Humans as sensors” was supplementary to excerpt planning relevant information out of less multidimensional data gained by students as test persons. Results were several planning relevant statements, as for example suggestions for improvement of the public transport. Another focus was besides this the analysis the visualization of this data. The result is often in homogeneity and manipulation at this step of the procedure simple – conscious or unconscious. For the same statement, the planner has the availability to prepare data visually in many different ways. Depending on the task, workflow and the addressee, a certain mood may be generated. So, it is essential that a certain “ethic of illustration” is included in the presentation of design results and will be understood by planners. The subsequent picture shows a visualization of all ways done by nine students – hence based on the same dataset – and their different arrangement by the purpose of the same task – to visualize all ways during their study time in the best expressive way with the visualization tools of ArcGIS. The different realizations show chance for manipulation, which can be made with visualizations and of which planners have to be aware of.

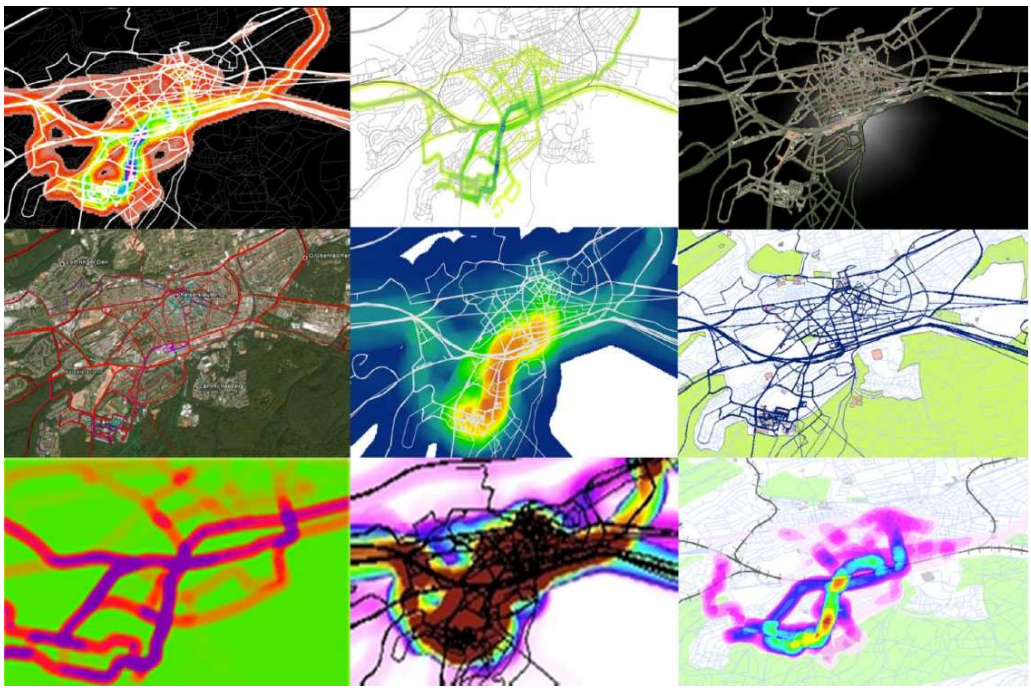

Figure 4: Results and Visualization variety from the study project “tracking people” (Zeile et al 2010)

4.3 Participation via augmented reality

Beside the possibilities of sensing and the representation of urban data on maps and in a 2D-presentation, mobile phones have the ability in combination with the GPS-sensor and the compass, to visualize urban data with the help of augmented reality services. Urban development processes and in some cases “hidden or invisible knowledge of a city” can be viewed by using applications like Layar, Wikitude or ALOQA. The problem with these applications is, that the generation processes of these data are not easy to handle and every service has its own complex workflow. All these parameters bar the way to distribute augmented reality information for a larger user community. With the help of the new developed, open-designed RADAR (Resource Annotation and Delivery for Mobile Augmented Reality Services) system (Memmel 2010), it is possible to “manage and aggregate arbitrary location-dependent multimedia from different sources like the Social and Semantic Web or digital repositories (Memmel and Groß 2011)“. The RADAR infrastructure allows planners to integrate in a very simple way the distribution of geocontents. “To create a geocontent in RADAR, only geocoordinates as well as a title have to be provided. Yet, arbitrary multimedia resources (e.g., text documents, videos, audio files, or even 3D models) can be associated with each geocontent” (Memmel and Groß 2011). Within the design of the Laboratory for Monitoring and Spatial Sensing, an informal cooperation between DFKI and CPE was arranged in the developing process with a circulating flow of knowledge creating this project. For the planning disciplines, especially for urban design, the easy integration of 3D-content is remarkable for further use.

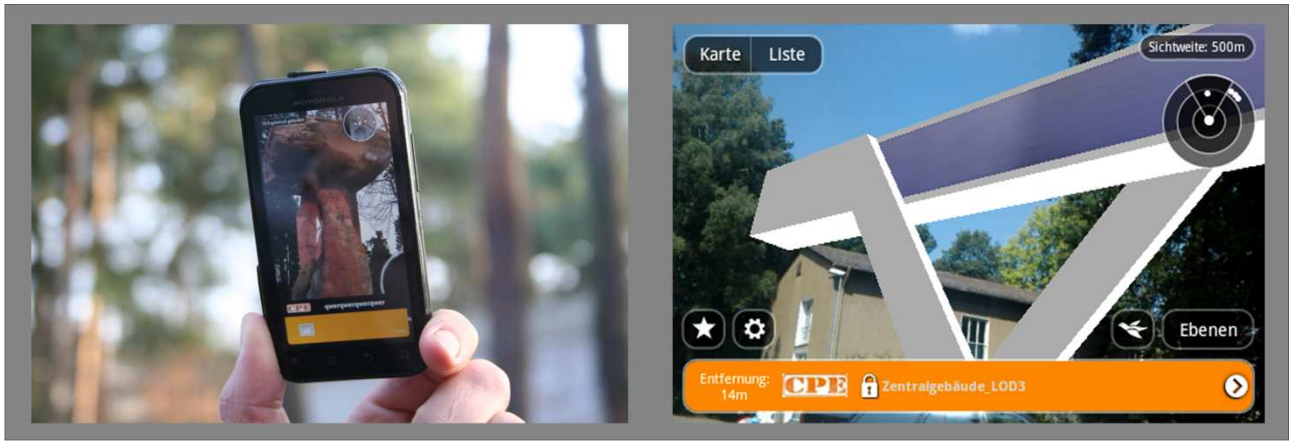

Figure 5: 3D-Models integrated in the LAYAR Augmented Reality Application: The devil’s stone in the palatinian forest is now located in the Neckar valley and a new building structure on the campus of TU Kaiserslautern (Own source)

5 FUTURE RESEARCH TOPICS

As mentioned before, plenty scientific questions are appearing or will appear in the future. How to define a central hub for this purpose for many more or less independent cooperation projects could be one of them. Furthermore, it is questionable how to gain awareness for monitoring and sensing in a technical perspective in relation with social, and planning relevant issues. An interesting approach how such a portal could for geospatial information might be configured is GEMMA – A geospatial engine for mass mapping application (gemmaproject.blogspot.com), developed by Centre for Advanced Spatial Analysis from the University College of London, which has the aim, to bring "geo to the masses" (Resch 2011). It would be necessary to observe, how such a portal could be accepted and especially adopted and how I could be integrated in planning processes. Comparing to the „traditional web 2.0" phenomena, where the possibilities of full publication of personal opinions, photos, videos or any other content are the essential part of the social web strategy, the user generated content will be individual, but vulnerable with reference to privacy. Therefore, a new media competence is essential: People need to learn that messages and content in the Internet have to be selected and considered carefully (Ruffing 2009:137). Maybe relevance analysis via social media could be a solution to solve this task, but their deployment has to be deliberated wisely. Figuratively speaking, this must be done as well with the acquired sensor data, to prevent unnecessary and sometimes exaggerated debate about the use of (personal) data. Hence, data privacy is a very important issue to be explored because on one hand, research approaches will indentify individual profile by the analysis of datasets but this rightly attracted criticism by data protectionists. In addition to this topic, the social perspective and potential value of communities should be deliberated. Some preliminary considerations with the German Research Center for Artificial Intelligence (DFKI) (dfki.de/web) in order to establish a hub for the social community data were taken and are aiming to analyze and visualize the planning social (community) data. However, the important point to focus will be the awareness of especially the greater urban perspective to be aware and as well the target-oriented smaller scale solutions for the citizens.

6 CONCLUSION

"In the next century, planet earth will don an electronic skin. It will use the Internet as a scaffold to support and transmit its sensations. This skin is already being stitched together. It consists of millions of embedded electronic measuring devices: thermostats, pressure gauges, pollution detectors, cameras, microphones" was foreseen by Gross (1999) more than 10 years ago. This development will be part of the future, especially in the urban planning issues. Thus, this information would make it possible, to understand the city in its complex matter better and "urban planners would be able to promptly detect (…) the livability and sustainability of a city and (...) to switch to a more reactive real-time management of a city. Aim is to build more efficient, intelligent and sustainable cities" (Martino et al. 2010). The emerge of pervasive sensoring and monitoring of this data is inevitable. Hence, it will be important on one hand how to handle import and harmonization of data and information, however on the other hand to be aware of the obstacle, that there is still a gap between sensor network research and mostly very heterogeneous end user requirements as Resch stated in 2011.

Ongoing research is needed to understand implicit and explicit values in human behavior and participation via sensing and in this context and to elict risks and potentials for the monitoring approach. There will be no blueprint with dealing with monitoring and sensing, field experience in this growing field is needed. The "Laboratory for Monitoring and Spatial Sensing" at the University of Kaiserslautern will be an appropriate test area for this and aims for integration in research and education and for the participating departments. Hence, it will be anchored an early stage in a planners professional life and emphasize the importance in the future. Furthermore, data privacy and data protection will gain more importance as well and new questions will arise, like for example: Who knows and who decides how and what data to display? Questions like for example "Could Crime Mapping for example as it is provided by the Police of the United Kingdom (police.uk) may lead to a vicious circle and falling real estate prices in the according quarters?" have to be answered. The development of the relation between the profit-oriented business companies and their influence on the city management has to be observed, too. As stated by Jang and Suh, "it is the informatization city and intelligent city, which is the congregation of concentrated technological growth engine" and hence, how will planers deal with this fact. How could rising commercial field of "Smart Cities" for example in this context by considered? Are large corporations like IBM or Siemens for example aiming

to make business or do they draw enough attention on planning issues? Does the technologist know that is data is relevant and does the city planner in the council know if is data could be maybe erroneous or manipulated? Hence, extreme challenges on social-political domains will emerge, not just on technological levels (Resch et al. 2011). Ethic questions will emerge about how to handle sensitive data and who should decide about them. This points and the ones made previously paraphrases a the complex reciprocal system in the context due to Monitoring of sensing data in times of the Geoweb. This fields of work on technological, social and political levels will evolve an important field of research and work for planners planers at the in the future.

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