Surveying illumination in public spaces: a prototype

SPIN Unit 2014

Goal of the project

This paper represents the first step of a pilot study initiated in Tallinn by MTÜ Spatial Intelligence Unit (SPIN Unit) in collaboration with the Politsei- ja Piirivalveamet (Police and Border Guard Board). Our study aims at deploying into the city of Tallinn the latest academic and practical knowledge about the spatial context of urban crime, by creating fresh links between advanced spatial analysis, geo-statistical monitoring of offences and the development of a technique to survey and map illumination in public spaces as a prime example of our methodological approach.

The project is expected to bring upon at least two tangible benefits: (i) A more complete description of existing crime-patterns, risk areas, times, and vulnerable environment types as opposed to relatively safe or 'defensible' areas and types, to help the planning and coordination of police work. (ii) Better understanding of the likely effects and performance of newly planned urban areas, both locally and city-wide, to facilitate evaluation of plans and professional communication for their improvement.

Work on both present and future urban landscapes acknowledges the complexity of crime and disorder as a research subject and the important societal, as opposed to situational, origins of crime. Our project is based on the belief that the spatial or urban context of crime deserves a more detailed study, as it may likely lead to improvements both in police practice and its citizen approval.

In the following sections, we present a short review of the starting points for this research. We also introduce the very first prototype of a device realised by SPIN Unit to conduct a quantitative survey of the illumination of public space.

Crime and space

Following the publication of C. Ray Jeffery's book "Crime prevention through environmental design" in 1971, a new, vast and multidisciplinary field of research started to develop innovative theories, methods and models to study how environmental design plays an important role in the reduction of opportunities for criminal behaviour in public space. Although this very first publication highlighted the relevance of biological and environmental determinants of crime events, the reference point in the fields of architecture and planning is the defensible space theory developed by Oscar Newman (1972). Newman develops his theory by noting the high crime rates observed in modern social housing projects, claiming

that architectural and urban design to be one of the factors that could foster or prevent the occurrence of crime (Ronald, 2009). The theory of defensible space states that it should be possible to design or transform the built environment in ways that help residents establish activity patterns in public space. Once the space is recognised by the local community as their own territory, crime is prevented by the new awareness of the residents. This practice also returns control of events that occur in public space, as well as general community policing duties, to the residents themselves (Stanley, 1977). Activist and journalist Jane Jacobs presented how architectural features, such as the location of windows on a building's facade, and the scale of urban development can also improve the naturally occurring surveillance of public space as deterrent against crime. Jacobs's argument does not look for a direct relation between spatial design and activity patterns, but it rather describes environmental design and social behaviours as variables of an organised complexity that can promote or discourage certain social behaviours (Jacobs, 1961).

Most of the studies that predate those based on urban configuration were rooted in social disorganisation and routine activity theories. In social disorganisation theories, the main factors for the occurrence of crime are found in the heterogeneity of poverty, racial and ethnic, and residential mobility patterns (Sampson & Groves, 1989). On the other hand, routine activity theories are based on the relation between the availability of attractive targets, the motivation of the offenders and the absence of capable guardianship (Cohen & Felson, 1979).

The approach and the sets of guidelines that go under the name of crime prevention through environmental design (later CPTED) has developed from Newman's bases, with a foray into the controversial broken window theory, in which localised acts of vandalism and decay of the built environment were theorized to cause antisocial practices to spread over the surrounding area (Wilson & Kelling, 1982). In contemporary practice, the first CPTED design principles have first been refined (Crowe, 1991) and applied to training programs, leading to a standardised set of recommendations for architects and planners involved in urban design (UNI EN 14383-1:2006) which may however not allow to take full advantage of a specialized social disorganisation analysis tailored to the space examined.

Crime and space syntax

With the similar goal of understanding how modern architecture was reshaping activity patterns, Hillier and Hanson initiated the development of the configurational approach now known as space syntax theory. Space syntax provides a technique to model urban morphology, and a quantitative method to study the relations between the perceived spatial configuration of a city and social behaviours (Hillier & Hanson, 1989). The spaces between buildings are modelled as axial lines, which can be defined as a linear representation of space, graphically represented by the longest lines of sight that it is possible to draw in space. The resulting network of lines is used to measure the topological distances between axial lines. This method was mostly used to study the distribution of pedestrian movement and socio-

economic activities in urban centres, reaching the conclusion that different spatial configurations are able to foster or stifle social interactions (Hillier, 1996; Hillier et al., 1993). Space syntax has also provided new tools for scientists to study accessibility of urban layouts in order to learn more about mobility and uses (Nes at al., 2012; Pereira & Holanda, 2011). As more qualitative studies were presented every year, a new branch of space syntax theory had to be developed to find evidence of the correlation between crime patterns and urban layouts (Hillier & Shu, 2000). First findings highlighted the importance of co-presence of several factors (e.g. different social groups in public space, the number of housing units having access on one street) as deterrents against crime, rather than finding a direct relation between urban topology and crime. It was clear that highly integrated urban spaces are capable of fostering movement and provide potential space for socio-economic activities. If on the one hand more people and activities that share the same space bring upon an increase in natural surveillance and crime deterrents, at the same time the high density of people and activities provides more opportunities for certain types of crimes, such as street robberies and burglaries. Eventually, with the refinements of theories and methods, it became clear that it is not possible to draw a direct causal correlation between urban layouts and crime patterns. On the contrary, the emergence of crime in urban areas appears to be a more complex phenomenon that can be studied from the point of view of urban layouts, which led to assessments of human co-presence in space (Baran et al., 2007, Hillier & Sahbaz, 2005, Friedrich et al., 2009).

Fear of crime and street lighting

Even though space syntax was a relevant contribution to the development of CPTED-based theories, the psychological factor of the fear of crime may still push people to avoid certain spaces and streets regardless of their configurational properties (Roman & Chalfin, 2008). Fear of crime is indeed subjective and related to the experience, perception and gender of each individual. Such perceptions may not match with actual crime hotspots (Chainey & Ratcliffe, 2005) and should therefore be studied in connection with the geographical location of crime events, as the physical configuration of the urban environment may induce high level of fear or safety regardless of crime rates (Foster & Giles-Corti, 2008). Carrying out extensive interviews is a valuable method to study the geographic distribution of the fear of crime, even though the space itself may not be the cause of this psychological discomfort but rather the social-extraction and gender of people who occupy the space (Pain et al., 2000, Koskela & Pain, 2000, Gray et al., 2006), particularly at night time (Ohno & Matsuda, 2013). During the day it is possible to experience a wider and more varied use of public space. During night time, however, the reduced opportunities to carry out socio-economic activities and the reduced visibility, together with the reduced presence of individuals who may contribute to the natural surveillance of the space, increase the incentives for anti-social behaviours to occur surreptitiously (Atkins et al, 1991). Yet, since the 1970's empirical studies have connected the fear of crime and crime rates themselves to the efficacy of street lighting

(Wright et al., 1974; Tien et al., 1979). These studies were based on statistical analysis of the occurrence of some categories of crime, such as robbery, assaults, larceny and auto theft, which were believed to be related to the intensity the illumination of public space. Improvements of the street lighting infrastructure have shown a drastic reduction of crime rates, making the efficacy of street lighting network a central planning issue.

Illumination in public space

The studies mentioned above have used qualitative and statistical methods to assess the relation between street lighting and crime. With the rise of geographic information systems (GIS), Rachal Pain and colleagues (Pain et al., 2006) demonstrated the effectiveness of these systems in the investigation of the relationship between crime rates and the location of street lights. It should be noted, however, that this methodology does not take into account any of the intrinsic properties of the street lights other than their position. After a formal discussion regarding this project with the authority for the coordination of security policies of the city of Rome, it was possible to learn that their SIRS (Integrated System for a Safer Rome) also included a map of luminosity in public space that consisted of heat maps based on the location of lamp posts and their nominal emission power. However, not all street lights emit the same amount of light and there are other factors that emit the effective brightness, such as the elevation from the ground or the shape of the three-dimensional emission pattern. It is for these reasons that just the locations of lamp posts is not enough to produce maps of luminosity in public space that accurately represent the actual situation on the ground, and it is therefore impossible to learn about the quality and quantity of public illumination available. To produce a cartography of luminosity of public space it is necessary to measure the amount of light from the ground level, where people walk, drive and ride, rather than using statistical models to predict how the public space is illuminated.

Measuring the illumination of public space at night it is a complex task. The amount of light that can be perceived by the naked eye in open spaces is the sum of the light emitted by any light source – like lamp posts, street lights, neon lights, signs and more – and the light reflected from different surfaces – such as building facades, street floor, street signs and more. These two components can be studied separately by measuring the light intensity of each given street light (called luminance) and the amount of light scattered by any other visible surface (called radiance). In an urban context, this very complex system of direct and reflected light may produce glare. This is a phenomenon that can reduce the ability to see in presence of a bright spot-light, depending on the amount of light emitted by a source and the angle between the viewer and the location of the source itself. Since the presence of glare or other similar conditions may cause temporary blindness or a reduction of the visual field, it is relevant to measure the occurrence of these phenomena along with luminance and radiance to acquire a deeper understanding of selected areas (Boyce et al., 2000). Highlighting the relevance of perception, it was found found that also the color temperature of light bulbs may change the atmosphere of place, which indirectly may prevent antisocial behaviours and road

accidents from occurring (Willis et al., 2005). Fear of crime may thus be perceived beyond actual risks, with tangible effects on mobility patterns, socio-economic activities. As such, it may have repercussions on the night-time economy of urban centres (Brands et al., 2013). A widespread and efficient lighting system for public space was found to be a good deterrent to the occurrence of crime, with positive effects not only during the night time but in daytime as well (Farrington et al., 2002; Painter & Farrington, 1997; Pease, 1999).

As our main research aims to learn how environmental design contributes to the fear and occurrence of crime, we have worked in three main areas: the perceived accessibility measured according to space syntax theory, the illumination of public space and the statistical data of crime patterns. The first step of measuring space syntax in Tallinn has been already carried out (Cerrone, 2012). In this paper, we introduce to the second part, which involved the measurement of the illumination in public space.

Methodology

Light intensity was measured using three digital luminosity sensors mounted on a box positioned on the car roof, or carried around in a backpack to reach less accessible or restricted areas by bike. Light was collected from the top, left and right sides of the box – defined in relation to the surveyor's motion. A GPS logged the location. Temperature and humidity were also recorded and used to calibrate all the other components. Temperature, humidity, position and luminosity from three directions were collected every two seconds on a micro-SD card by an Arduino-MEGA. A Python script was used to process the 33,581 points collected in a total of 400 km path surveyed in spring 2013, with the goal to remove invalid data, filtering adjacent points closer than 3 m to ease geoprocessing, and computing the direction of the surveyor's motion for each point. Using this data we were able to produce a geographic representation of the illumination of public space in central Tallinn, representing the mean values detected by the top and side sensors. Street light intensity and accessibility values were normalised to allow a comparison. As the topological features of the illumination were defined point-by-point, while for accessibility they were defined along a line, kernel density analysis was used to estimate their density on a grid surface of 10×10 metre cells. Once these values were placed on the grid, the absolute distance between the corresponding normalised light intensity and accessibility was computed.

Brief conclusions

We conducted a pilot project in which we surveyed public illumination in a sizeable area within the city of Tallinn. Based on the preliminary data, it was not possible to reach any conclusive results, as a wider area of Tallinn needs to be surveyed in order to acquire more statistically and geographically significant data. Yet we observed a strong correlation between illumination and integration - a normalised measure of the topological distance from a given axial line to all the others of the system. As highly integrated lines are the ones which can be

reached by the least complex path, empirically they are said to be representative for the spaces which are most capable of attracting pedestrian movement and foster social interactions. Both the measures of integration with respect to the Tallinn metropolitan region or to the local scale show a degree of correlation with the intensity of public illumination, highlighting how the most integrated areas are more illuminated than the ones at the edges, while the most integrated spaces of an urban locality are more illuminated with respect to the district. Acknowledging problems with the representational model of space syntax (Ratti, 2004) and the difficulties to find empirical validation that topological distances can influence pedestrians' path choice even more than metric distances (Sevtsuk, 2010), the linear correlation observed may suggest that integrated spaces are either perceivably easy to reach and perceivably safe to reach.

Bibliography

Atkins, Stephen, Sohail Husain, Angele Storey, G Britain, and CP Unit. 1991. The Influence of Street Lighting on Crime and Fear of Crime.

Baran, PK, W Smith, and U Toker. 2007. The Space Syntax and Crime: Evidence from a Suburban Community. 6th International Space Syntax Symposium.

Boyce, P.R., N.H. Eklund, B.J. Hamilton, and L.D. Bruno. 2000. Perceptions of Safety at Night in Different Lighting Conditions. Lighting Research and Technology 32 (2 79-91).

Brands, J., T. Schwanen, and I. V. Aalst. 2013. Fear of Crime and Affective Ambiguities in the Night-Time Economy. Urban Studies (October 1).

Cerrone, Damiano. 2012. Tallinn, Opening to the Seaside. Analytic and Planning Tools. Estonian Academy of Arts.

Chainey, Spencer, and Jerry Ratcliffe. 2005. GIS and Crime Mapping.

Cohen, LE, and M Felson. 1979. Social Change and Crime Rate Trends: A Routine Activity Approach. American Sociological Review.

Crowe, Tim. 1991. Crime Prevention Through Environmental Design: Applications of Architectural Design and Space Management Concepts, Boston: Butterworth- Heinemann.

Farrington, DP, BC Welsh, and G Britain. 2002. Effects of Improved Street Lighting on Crime: A Systematic Review (August).

Foster, Sarah, and Billie Giles-Corti. 2008. The Built Environment, Neighborhood Crime and Constrained Physical Activity: An Exploration of Inconsistent Findings. Preventive Medicine 47 (3) (September): 241–51.

Friedrich, Eva, Bill Hillier, and Alain Chiaradia. 2009. Anti-Social Behaviour and Urban Configuration Using Space Syntax to Understand Spatial Patterns of Socio-Environmental Disorder. In 7th International Space Syntax Symposium, 1–16.

Gray, Emily, Jonathan Jackson, and Stephen Farrall. 2006. Reassessing the Fear of Crime : Frequencies and Correlates of Old and New Measures. Social Science Research Network.

Hillier, B, A Penn, J Hanson, T Grajewski, and J Xu. 1993. Natural Movement Or, Configuration and Attraction in Urban Pedestrian Movement. Environ Plann B.

Hillier, Bill. 1996. Space Is the Machine. 2007th ed. London: Space Syntax.

Hillier, Bill, and Julienne Hanson. 1989. The Social Logic of Space. In .

Hillier, Bill, and Ozlem Sahbaz. 2005. High Resolution Analysis of Crime Patterns in Urban Street Networks: An Initial Statistical Sketch from an Ongoing Study of a London Borough. Proceedings of the Fifth International Space Syntax Symposium.

Hillier, Bill, and S Shu. 2000. Crime and Urban Layout: The Need for Evidence. In Key Issues in Crime Prevention and Community Safety IPPR, edited by MacLaren V, Ballantyne S, and Pease K.

Jacobs, Jane. 1961 The Death and Life of Great American Cities.

Jeffery, C. Ray. 1971. Crime Prevention through Environmental Design.

Kelling, George L., and James Q. Wilson. 1982. Broken Windows: The Police and Neighborhood Safety. Atlantic Monthly.

Koskela, Hille, and Rachel Pain. 2000. Revisiting Fear and Place: Women's Fear of Attack and the Built Environment. Geoforum 31 (2) (May): 269–280.

Nes, Akkelies Van, Meta Berghauser Pont, and Bardia Mashhoodi. 2012. Combination of space syntax with spacematrix and the mixed use index. The Rotterdam South Test Case.

Newman, Oscar. 1972. Defensible Space; Crime Prevention through Urban Design.

Ohno, Ryuzo, and Tokuko Matsuda. The Effects of Acoustic Environment on Pedestrians' Anxiety on a Night Street. In EAEA 11 2013 | Envisioning Architecture: Design, Evaluation, Communication.

Pain, Rachel, Robert MacFarlane, Keith Turner, and Sally Gill. 2006. 'When, Where, If, and But': Qualifying GIS and the Effect of Streetlighting on Crime and Fear. Environment and Planning A 38 (11): 2055–2074.

Pain, Rachel, Sarah Williams, and Barbara Hudson. 2000. Auditing Fear of Crime on North Tyneside: A Qualitative Approach. British Criminology Conference: … 3 (July 1999).

Painter, Kate, and DP Farrington. 1997. The Crime Reducing Effect of Improved Street Lighting : The Dudley Project. Situational Crime Prevention: Successful Case ….

Pease, Ken. 1999. A Review of Street Lighting Evaluations: Crime Reduction Effects 10: 47–76.

Pereira, RHM, and FRB Holanda. 2011. The Use of Space Syntax in Urban Transport Analysis: Limits and Potentials: 1–25.

Ratti, Carlo. 2004. Space Syntax: Some Inconsistencies. Environment and Planning B: Planning and Design 31 (4): 487–499.

Roman, Caterina G, and Aaron Chalfin. 2008. Fear of Walking Outdoors. A Multilevel Ecologic Analysis of Crime and Disorder. American Journal of Preventive Medicine 34 (4) (April): 306–12.

Ronald, V Clarke. 2009. The Theory of Crime Prevention through Environmental Design. Police management studies quarterly 1-20.

Sampson, Robert J., and W. Byron Groves. 1989. Community Structure and Crime: Testing Social-Disorganization Theory. American Journal of Sociology 94 (4) (January): 774.

Sevtsuk, A. 2010. Path and Place: A Study of Urban Geometry and Retail Activity in Cambridge and Somerville, MA.

Stanley, Paul R.A. 1977. Crime Prevention through Environmental Design.

Tien, James M, Vincent F O Donnell, Arnold I Barnett, and Pitu B Mirchandani. 1979. Street Lighting Projects.

UNI EN 14383-1:2006. Prevention of crime - Urban planning and building design.

Willis, K., N. Powe, and G. Garrod. 2005. Estimating the Value of Improved Street Lighting: A Factor Analytical Discrete Choice Approach. Urban Studies 42 (12) (November 1): 2289–2304.

Wright, Roger, M Heilweil, P Pelletier, and K Dickinson. 1974. The Impact of Street Lighting on Street Crime.