Do New Urban Densities Provide Urban Landscape Identity? A Concept for Operationalizing Qualitative Factors Combining Sophisticated Visualization Workflows

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1 ABSTRACT

Continuing pressure on urban areas due to growing population and further urbanization affects urban quality. Many cities and agglomerations try to cope with negative effects of urban sprawl by further densification of existing built-up areas. As a consequence green and open spaces are disappearing. Among other ecological and socio-economic urban qualities, this is affecting the sense of a place and place attachment of the local inhabitants. However, there are no indicators available, which allow in planning processes for an effective assessment of the impact of further densification on the urban landscape's identity. One challenge is that assessing the impact on the landscape's identity requires both objective and subjective approaches. Objective approaches are well established, for example, in environmental impact assessments untypical elements of a landscape contributing to a loss in landscape aesthetics and character are evaluated. However, these approaches are rather applicable on the rural than on the urban landscape. Furthermore, subjective approaches still lack of suitable tools for integrating individual perceptions of stakeholders into the evaluation process.

In this paper we present an approach based on GIS- and rule-based interactive modeling and visualization tools, which allows for objective and subjective assessment of the urban landscape's identity in participatory planning processes. For the case study of Schlieren, an agglomeration of the city of Zurich (CH), we show exemplarily the implementation of this approach. Combined assessment of hard and soft factors of urban green and open spaces contributing to the urban landscape's identity provides a powerful tool to identify local thresholds of urban densification, and thus proactive planning of sustainable urban development taking into account the residents' requirements directly.

2 INTRODUCTION

In Switzerland, official settlement development concepts focus on a higher utilization of built-up areas (Bundesamt für Raumentwicklung ARE 2009). The main goal of this strategy is to contain urban sprawl (Gennaio et al. 2009) by increasing densities in existing built-up areas of cities and agglomerations. There are evident benefits of planned densification, e.g. support of regional thinking and controlling, setup of priorities, development of economy, sustainable and optimized transportation connections (Bundesamt für Raumentwicklung ARE 2009). However, urban densification may also entail threats to urban quality.

An important factor of urban quality is the sense of place and the people's place attachment, defined as "the positive emotional bonds that develop between individuals and their environment" (Brown & Raymond 2007: 89). Changing urban environment – e.g. due to increasing floor area ratios in land use plans - can have an impact on the people's place attachment. Thresholds with regard to this aspect are not yet known. Existing planning instruments for securing spatial identity are predominantly based on objective indicators. These comprise, for example, the amount of recreation offers or the connectivity of foot and bike paths in or next to the settlement areas (Bundesamt für Raumentwicklung ARE 2003). More recent approaches stress the relationship between social aspects of urban densification and the people's identity with their area (Bundesamt für Raumentwicklung 2011). The significance of relationships between soft and hard factors are too important to be disregarded (Soini et al. 2012).

For solving most of the challenges in future urbanization, spatial knowledge of both urban and spatial planning and stakeholders are required (Taubenböck & Esch 2011). The emphases of individual and emotional (soft factors) compared to physical (hard factors) indicators are still unknown so that they are not yet taken into account in urban planning processes comprehensively. Moreover, subjective perception contributes to individual place identity (Soini et al. 2012). In order to achieve an urban densification, which is accepted by the people and is identity generating, the subjective perception has to be integrated into the assessment of urban densification proposals.

We present the framework for preparing 3D visualizations linked to objective indicators that offers suitable means for assessing both the soft and hard indicators for the quality of urban densification. First, a literature review is given on the theory of landscape perception and indicators to measure a landscape's potential to generate identity. Then, a case study area in a suburban region in Switzerland, the community of Schlieren, is presented. In the methods section, the framework is described and results of preliminary 3D visualizations linked with objective indicators are given. These are discussed with regard to their suitability and further development possibilities for future application as assessment instruments.

3 THEORETICAL FRAME

3.1 Landscape perception

As Rodewald (2011) describes, there is a three-component view of a place (Figure 1). The first component is evolution based and allows for »reading« the landscape. This view supports orientating oneself and gathering information on a situation in a landscape. The second view component is for receiving colors and aesthetical stimuli. Through this a place gets its characteristic appearance. The third component of our viewing is linked with individual cognitions. A symbolization and identification gives any place a special importance, which depends on preferences, values, preconceived imaginations and individual signs. This third component converts a place to an emotional place, which gets a personal recognition value. Such a sensual, informative and associative view generates the sense of a place.

Girot and Wolf (2010) describe the three components as analytical, physical and poetical view. The analytical view measures the spatial composition and builds relationships between objects. The physical one is described as a corporal experience of cognition. The individual touch is here given by the poetical component, which combines the viewing results to something new and gives them a distinctive attribute for dealing with compositions in landscape.

Figure 1: Illustration of the three component view of landscape perception.

Such subjective parameters should be considered to guarantee comprehensive planning for sustainable urban developments. This requires making aesthetical effects of future developments measurable and visible (Meijer et al. 2011).

3.2 Indicators for a landscape's potential to establish identity

In practice and research, visual impacts are indicated by observers' expressions of preference or judgments/ratings of visual aesthetic quality, which include scenic quality, visual quality and scenic beauty as well (Daniel & Meitner 2001). These preferences are not yet linked with more comprehensive tools, which allow for analyzing both the sense of a place and other factors of urban quality, e.g. urban density, costs for green space infrastructure, energy efficiency and others. Providing tools for subjective and objective assessment, which allow a weighting of different indicators, could support trade-off decision making and the identification of thresholds for aesthetical aspects.

The concept of ecosystem services (ESS) offers a vast systematic framework for goods and services to humanity. The ESS can be categorized into provisioning services (e.g. wild foods, crops, fresh water and plant-derived medicines), regulating services (e.g. filtration of pollutants by wetlands, climate regulation through carbon storage and water cycling, pollination and protection from disasters), supporting services (e.g. soil formation, photosynthesis and nutrient cycling) and cultural services (TEEB 2010). The latter comprise landscape and place identity as well as spiritual and aesthetical services (de Groot et al. 2010). The principal of valuing ecological landscape components by ESS allows a new approach to quantify and bring landscape in comprehensible indicators for enabling a trade-off of several socio-economic values (Grêt-Regamey et al. 2008, 2012).

In urban areas, the ecosystems services depend on the quality of the following major ecosystems: street trees, lawns/parks, urban forests, cultivated land, wetlands, lakes/sea, and streams. Services provided by these ecosystems are, for example: air filtration, micro climate regulation, noise reduction, rainwater drainage, sewage treatment, and recreational and cultural values (Bolund & Hunhammar 1999). In fact, ecosystem services provided by urban green space patterns can provide healthy environments and physical as well as psychological health benefits to the people residing within them. A healthy environment can also contribute an improvement of socio-economic benefits (Tzoulas et al. 2007). The number or area of culturally important landscape features or species support the service of providing signs of cultural heritage and identity (de Groot et al. 2010). Since land use management affects the provision of mainly regulating and cultural ecosystem services (van Oudenhoven et al. 2012), it is very important to develop suitable approaches for integrating the assessment of the impact of landscape changes on the identity into urban planning.

4 CASE STUDY AREA

The 3D urban model is developed for the case study area Limmattal (valley of the river Limmat), an agglomeration in the northwest of Zurich (Figure 2). Special focus will be laid on a dwelling zone in the community of Schlieren. It comprises an area of about 6,38 km² and a population of 16'100 (about 2'462 inhabitants/km²) (Statistisches Amt des Kantons Zürich, 2010).

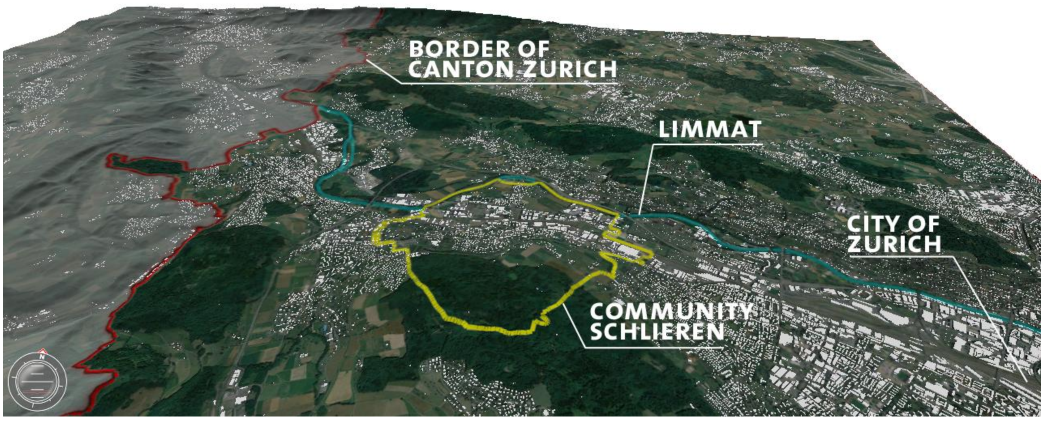

Figure 2: Overview of the community of Schlieren (yellow line) situated in the valley of the river Limmat. Red line marks the border of Canton Zurich with the city of Zurich in the lower right corner of the figure.

Schlieren is a Swiss city in the agglomeration of Zurich. It combines residential areas, industry and, at the river Limmat, important recreational area for the core center of Zurich city in tight space. Since the 1960s the population increased rapidly up to 10.000 inhabitants (Statistisches Amt des Kantons Zürich, 2010) due to relocation of industry to the agglomerations and good traffic connections to Zurich. Today, it has an important role as transit area and as arising living space for a heterogeneous population. Currently, Schlieren has an annual growth of 800 people and an increase of 4'000 inhabitants was registered for the last seven years. The problem of such a moving in is that living space for only 2'500 people is in planning (Vögli 2012). Thus, this focus area is ideal for analyzing different possible future situations and development strategies in order to cope with the development pressure.

5 METHODS

A participatory approach is necessary for detecting accepted thresholds of densification in dwelling zones taking into account place attachment (de Groot et al. 2010). 3D visualizations of the urban landscape offer high potentials to effectively support such participatory processes (Xu & Coors 2012). New and innovative steps in data acquisition and mapping offer a flexible back-end for land use modeling and 3D visualization (Grêt-Regamey & Wissen Hayek 2010). An interactive approach might be important for a high rate of return and variety of indicator information from the participants (Belton & Elder 1994; Bruigat & Chittaro 2008; van Schaik 2010).

Taking into account these requirements, we set up an interactive collaborative modeling and visualization platform linked with objective indicators of identity and urban density. The preliminary platform was tested with stakeholders with regard to its suitability for participative assessment. The final platform shall be suitable for identifying trade-offs and thresholds associated to urban densification scenarios and place identity. In the following, the major components of this platform (Data acquisition and mapping, Procedural 3D visualization, Participative assessment) are described (Figure 3).

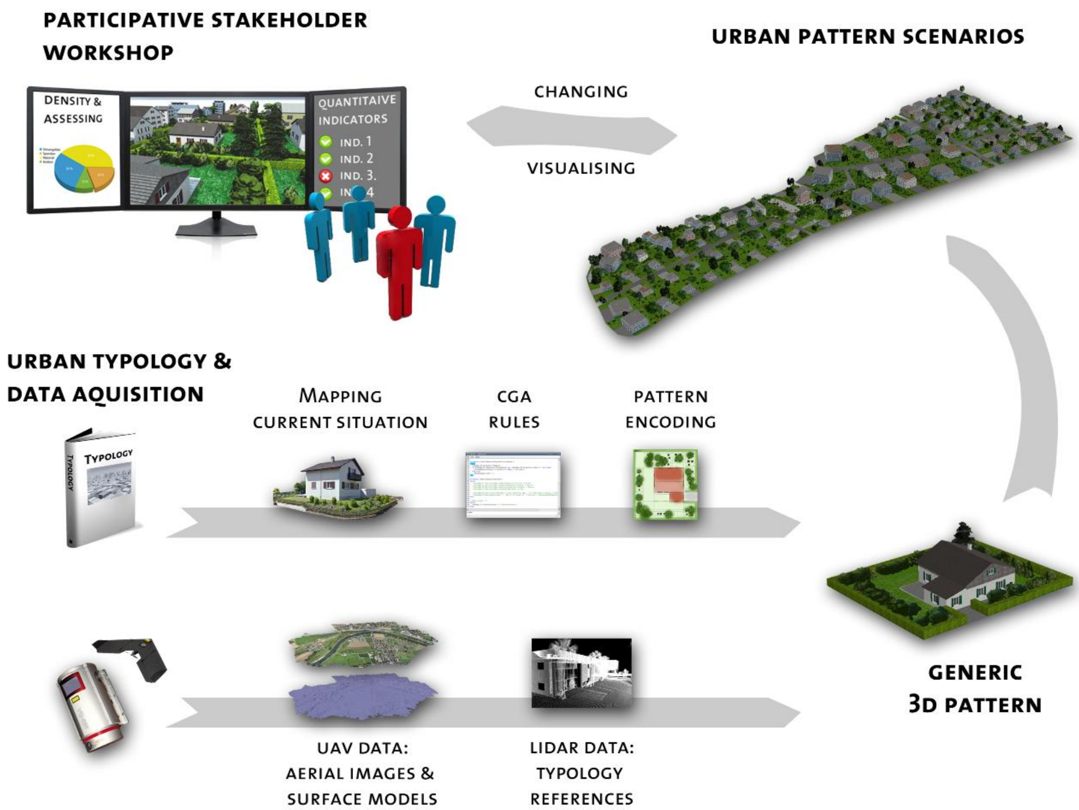

Figure 3: Framework demonstrating the strings of data acquisition and 3D pattern generation suitable for interactive scenario visualization in participative stakeholder workshops or interactive choice experiments.

5.1 Data Acquisition & Mapping

On the one hand, modeling approaches are necessary in order to assess and communicate consequences of complex urban system scenarios and calculate meaningful indicators. On the other hand, realistic 3D visualization with a high level of detail is necessary to assess effects of landscape change scenarios on the landscape view and the people's landscape perception (cf. Wergles & Muhar 2009).

For these reasons, we focused on highly accurate data acquisition methods for accurate modeling and realistic 3D visualizations. To this end, modeling and 3D visualization is based on two methods of data acquisition. We generate high accurate and up to date elevation models and aerial images by implementing (1) a terrestrial laser scanner (TLS) (Riegl VZ-1000) and (2) an unmanned aerial vehicle (UAV).

(1) A terrestrial laser scanner scans with a horizontal and vertical moving laser beam over the landscape. Through detection of the back-reflected laser beam from objects, the distance to these target points can be calculated by time-distance method. The device registers in this way point clouds of landscape objects, which are hit by laser. Depending on the defined scan resolution (moving speed of laser beam on horizontal and vertical axes) a dense point cloud is created, in which each single point has its own geo-referenced xyz-coordinate through GPS localisation of the scanner position itself. With a mounted camera on top the point cloud can be colorized by the RGB values of the photos (Lemmens 2011).

(2) The unmanned aerial vehicle consists of a modified camera, GPS autopilot and radio module. Linked with a ground-based notebook, the fly path for the airframe is defined. The UAV flies autonomously by defined waypoints and heights over the terrain and takes images. Through exact trigger-coordinates and attitude of the images by GPS-autopilot and inclination sensors, a afterwards auto-processing of control points is possible to generate geo referenced surface models and orthophotos (Figure 4), (Manyoky et al. 2011).

Figure 4: Processed high resolution digital surface model (DSM) with orthophoto texture of an Unmanned Aerial Vehicle (UAV). The data shows a part of the case study area of Schlieren (Canton Zurich, Switzerland) and has an accuracy of 8 centimeters (DSM and orthophoto).

Both data pools are complementary, which simplifies the acquisition and modeling parts. Aerial images are used for GIS data processing (orthophotos, digital surface/elevation model) as well as for typology mapping next to field work. Point cloud data gathered from terrestrial laser scanning is used for generating elevation models and for generating 3D building objects (direct implementation of architecture details by manual and automatic modeling tools). Particular strength of these acquisition methods is that they offer a new level of detail and spatial coverage in up-to-date basic data.

5.2 Procedural 3D visualization

3D visualizations have been proved to be supportive tools for participatory landscape planning workshops (Pettit et al. 2011; Wissen Hayek 2011). For 3D visualization of urban densification scenarios, we implement a procedural urban modeling approach using CGA shape grammar implemented in ESRI's CityEngine system (www.esri.com/cityengine). The software can quickly visualize urban environments including green spaces in interactive three-dimensional views with a high level of detail (Neuenschwander et al. 2011; Wissen Hayek et al. 2010) enabling for evaluation of alternatives and iterative design workflows (Halatsch et al. 2008; Ulmer et al. 2007).

In field mapped building types (e.g. single-family houses, multi-family houses) are encoded as CGA rules. Combining rules for building types leads to rule sets for urban patterns, in our case a dwelling zone. The density aspects are integrated in those rule sets. Executing these rules, 3D urban patterns are generated. Rule parameters can be changed interactively, which allows for iteratively assessing alternatives in real-time to detect the trade-offs between urban densification and place identity. These quantitative parameters offer stakeholders the possibility to check the basic assumptions of the scenarios and thus can contribute to the transparency of the visualization model. Through a live reporting option of quantitative indicators in ESRI's CityEngine system, iterative analyses based on objective indicators are possible. In our preliminary model, we calculated floor area ratios, population densities, population of dwelling zone, green space, green space maintenance costs, potential habitat population, infrastructure costs, for an indicator-based comparison of scenarios.

Newer features in ESRI's CityEngine support import of geo-located Google Warehouse buildings (http://sketchup.google.com/3dwarehouse). However, 3D object models can also be generated from the TLS and UAV data. The data can be easily prepared and processed to get high detailed 3D objects and ground data. This workflow is useful for modeling static non-CGA based buildings, which won't be influenced in scenarios and support the stakeholders' in orienting themselves and thus contribute to the suitability of the model for assessing place identity (Figure 5).

Figure 5: Colorized point cloud from terrestrial laser scanning (left), static 3D building object model based on point clouds (mid), example of a building type generated in the CityEngine system implementing CGA shape grammar rules (right).

Furthermore, there is high potential to automate CGA rule processing and reconstruct buildings by detection tools (Mathias et al. 2011, Becker 2011). This automatic detection methods offer new flexibility in generating a larger set of CGA building rules for more detailed scenarios with realistic appearance. In this way, rules can be automatically detected out of real architectonic patterns. With an integration of such detection technologies in the data acquisition workflow, the creation of present conditions in CGA would highly reduce manual visualization work. The scenario setups would base on detected CGA grammar out of real field data by modifying rule parameters.

5.3 Design of a participative assessment of place identity implementing the tools

Expectations with regard to the landscape scenery differ between heterogeneous population groups (Soini et al. 2012). To this end, participation of a broad population should be aimed at, to collect these various individual opinions and conceptions about threshold values of landscape components concerning place identity. In combination with the interactive modeling approach, online surveys can facilitate an extensive participation. Van Schaik (2010) has shown that interactive 3D visualization for public consultation has a broad acceptance – also of older people – and that it can be offered also in a "survey mode" with back-channel for user comments, questions, preferences and critics for a qualitative data collection.

Technical options increase the quality of feedback (quantitative and qualitative data) on thresholds and trade-offs. The possibilities of NVidia's RealityServer (www.mentalimages.com) supports CityEngine models in interactive and photorealistic web-application and low system resources (e.g. mobile devices) through cloud computing. This setup can bring the CityEngine models as interactive experiments online. Thus, all interviewees can define their own thresholds and supply a high return-rate and extensive data of individual trade-off decisions.

5.4 Pre-Test Design

We conducted a pre-test for assessing preliminary results of implementing the presented framework focusing on the interactive procedural 3D visualization with linked objective indicators. The pre-test was set as interview with the goal to identify the critical steps and technical issues in participative application of the tool and get also first comments and critics of potential users. It was not set up as representative study. Five experts were interviewed to get information on their impressions of the model. The interview was divided in three stages: introduction, presentation and interview.

In the introduction part, the interviewee was introduced to the topic, the visualization method and goals of the interview. The second part comprised a presentation of the case study area, scenarios, thematic integration, theoretical impacts of indicators and technical background. In the actual interview we asked first for the interviewee's ambitions of interacting with the model (indicator setting and navigation). After demonstration of indicator influences by interactive modeling, we asked for stating preferences for a scenario referring to the indicators. Finally, the provided level of detail was assessed by the interviewees.

6 PRELIMINARY 3D URBAN VISUALIZATION MODEL AND PRE-TEST RESULTS

First visualizations and pre-test results show a quite good acceptance of interactive modeling with ESRI's CityEngine system. In a first interview series with stakeholders and experts it was said that interactive modeling helps to understand the presented scenarios (see example in Figure 6).

In these interviews, the participative part was applied as a semi-interactive survey. This means, the model parameters were directly shown in CityEngine. Positive feedback from stakeholders supports that this helps to understand the scenarios and their coherence with the indicators. The option to change camera positions within the visualization to get a close distance view to dwelling zones of special interest or positions with special view axes (Figure 7) was rated as a positive feature.

Figure 6: Example of a densification scenario generated in ESRI's CityEngine of the case study area in Schlieren.

However, the interviewees did not want to navigate themselves through the model and change between the scenarios. Because of the interview structure and option for model interaction after only a short theoretical introduction, the participants asked rather for being navigated through the model.

The most adverse point identified in this pre-test was the complexity of the CityEngine's user interface. Because of this and the big variety of indicators, the stakeholders were deterred to modify them and set up their own scenarios. It was not directly clear for them, where they have to set the parameters, because there are no options for designing any custom bars or buttons for indicator setting. For presentation mode a full-screen option with custom possibility for rule and indicator setting is still missing in CityEngine.

Although the CityEngine system generally supports interactive change of scenes, for real interactivity in participatory situations the need of system recourses is a hindrance. For generating the scene, a 24GB Ram Workstation with high-performance GPU and CPU was used. For large-scale visualization with included vegetation such a configuration is necessary to handle the changed model parameters re-rendering rapidly. In interview situation we had to use a mobile device, which has a comparatively bad system performance. Therefore, a preparation of the scene was inalienable – the renderings for all scenarios were done before the interviews and interactively modifying and re-renderings were only done for selected lots.

Figure 7: Example of different close up camera positions of two scenarios generated in ESRI's CityEngine.

7 DISCUSSION AND CONLUSION

Our goal was to set up a framework suitable to integrate objective and subjective indicators for assessing urban landscape identity in participatory settings. To this end, we elaborated a workflow combining sophisticated data acquisition and 3D modeling and visualization approaches.

Implementing the framework resulted in 3D visualizations with a rather high level of detail, which were linked to a set of indicators. The used techniques allowed visualizing large landscapes as static high realistic visualizations, which can display relevant aspects for assessing landscape identity. With regard to the visualization workflow, (semi-)automatic generation processes for CGA rules should be implemented in order to generate even more realistic landscapes with reduced effort.

In the pre-test, the interactive modeling supported the interest of interviewees and helped them to understand scenario parameters. However, they did not try to interact with the setting of indicators or change the parameters themselves, which considerably can be ascribed to the complexity of the interface (van Schaik 2010). Further software options of the CityEngine are desirable, such as e.g. hiding complex parameter windows that are confusing for the interviewees. Next to already known benefits of visualizations as communication tool for common strategy development in stakeholder workshops (Figure 8, left), the software design allows new approaches for stakeholder involvement (Figure 8, right), which might be suitable for citizen-sourcing (Nam 2012; Fritz et al. 2012).

Figure 8: Future application of interactive modeling in stakeholder workshop (left) and in future online applications (right).

Already existing solutions (e.g. RealityServer) can handle the high system requirements of interactive realistic real-time modeling. These techniques could be used for interactive online experiments to get general threshold values of indicators and use these for setting trade-offs in stakeholder workshops with experts. The variety of web application is high, so the integration of the models in game engines is also conceivable (Bishop 2011), which run on nearly all mobile devices and operation systems. This flexibility offers also a high rate of return and the interviewees get an interactive user interface with navigation and indicator setting possibilities online.

Current technical possibilities offer multiple options for an operationalization of qualitative factors like landscape aesthetics and identity. Although concepts of how to develop the supporting tools already exist, the lack of operable interfaces makes their implementation difficult. All methods of the modules in the presented workflow are rather sophisticated. The challenge is to design the interfaces between the modules in order to let the workflow run smoothly. Then, the resulting tool can really improve participative planning processes and potentially provide suitable means to also taken into account urban identity.

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