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Modelling housing typologies for urban redevelopment scenario planning

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ABSTRACT

Increasing levels of urbanization, combined with growing populations and a need to manage urban redevelopment more sustainably has prompted the need for new tools for urban regeneration in established urban areas. While significant activity is occurring in the areas of volumetric analysis and 3D visualization, utilising these technologies in the development of urban planning tools requires a data schema for defining precinct objects for performance assessment while simultaneously addressing the complexity and interconnected nature of issues relevant to the urban built environment. This paper presents the outcomes of the research and development of a web-based 3D precinct visualization and assessment system, Envision Scenario Planner (ESP), which uses a library of housing typologies to generate easy-to-use, bottom-up, precinct-scale reports on residential infill. The paper illustrates how, through the specification of a residential precinct object data schema and the provision of a set of housing typologies, end users can quickly, and without domain knowledge, generate visualizations and assessments for a variety of housing scenarios, which allows them to determine fit-for-purpose solutions that address a range of issues relevant to contemporary planners and policy makers.

1. Introduction

A global trend towards increased urbanization (OECD, 2012) combined with responses to resource depletion and sustainability more broadly (Newman, Beatley, & Boyer, 2009, OECD, 2011) has led to significant attention being directed towards maximising the potential of existing urban land. By focusing urban development policies on residential infill (Newton & Glackin, 2014), local, state and national governments are attempting to curb urban sprawl by housing growing populations in the already established but redeveloping suburbs (Giltz, 2007; Landis, Hood, Li, Rogers, & Warren, 2006; Phan, Peterson, & Chandra, 2008; SGS Economics and Planning, 2011). While the strategic involvement of governments in currently ad-hoc redevelopment presents significant opportunities, it also presents some incredibly complex planning challenges. Systems such as Envision (Glackin, 2013) and STEPP (Carsjens & Ligtenberg, 2007) attempt to identify areas of likely redevelopment; however, the challenges of strata title (Randolph & Easthorpe, 2007), existing planning and approval regimes (Newton et al., 2011), poor community engagement (Kelly, 2010) and a host of other issues relating to inertia in the existing development norms, make this a highly contentious and problematic planning space.

The sensitivities and challenges of redevelopment call for scenario planning tools, where the benefits and disbenefits of different redevelopment strategies can be explicitly illustrated, as without explicit and rigorous outputs to convince stakeholders there is no argument to move away from existing urban policies. While scenario planning tools have been around for several decades, their uptake has been limited due to a variety of reasons including high costs, system complexity, a lack of staff resources, difficulties accessing data and lack of interoperability with other tools, although the emergence of new visualization technologies and better data availability is increasing their use (Holway et al., 2012; Uran & Janssen, 2003; Vonk & Geertman, 2008). Envision Scenario Planner (ESP) is a web-based 3D precinct sketch planning and assessment system that was developed as part of a federally funded project in Australia titled 'Greening the Greyfields' (Newton et al., 2012). The system addresses many of the barriers to adoption by using the latest 3D web visualization technologies, providing a user-friendly interface, including a typology library for users to populate their scenarios with, having all required data and modelling logic built into the application and making the system open source and freely available.

ESP was specified for an end user group consisting of state and local government officers to use the tool to design and assess the performance of different precinct regeneration scenarios. An augmented reality (AR) extension is also being developed that will be able to visualize various scenarios as a tool for community consultation. Aside from the visualization and design aspects of ESP, due to the sustainability focus of the research the outputs of the system include reports on key sustainability metrics, such as embodied and operating carbon, operating energy demand (space heating and cooling, hot water heating, lighting, etc.), operating water demand (internal and external), stormwater runoff, capital and operating costs, parking, district energy generation, private vehicle travel and greenhouse gas emissions, and travel mode

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share. The broadness of the outputs required a considerable amount of technical input and careful design for making the system useful to users without necessitating them to specify and code their own formulas, algorithms and modelling parameters.

By way of example, commercial 3D urban scenario modelling systems, such as CommunityViz and CityEngine, enable users to tackle complexity, but they do so by providing an incredibly complex interface and without modelling logic or data content. Apart from containing some default options, settings and data models to get users started, the systems are virtually void of assessment logic and data, putting the onus on the user to have the relevant information and domain knowledge to populate them. UrbanCanvas is another commercial system for urban scenario modelling and although it can be more readily used "out of the box", it treats buildings fairly abstractly and doesn't inherently model detailed performance outputs relating to construction materials, appliance energy efficiency, use of sustainable technologies for energy generation and so on. In an environment where not everyone has access to a suite of domain experts or the time to become an expert, uptake of these systems for decision support can be merely for data visualization and communication (Ahmed & Sekar, 2014) and generally low with use being prone to error. There is also the issue of data accumulation. Very few users will be in a position to have available to them all of the datasets required to enter into a system. Then in instances where interdisciplinary complexity can be reported on, without power-users and domain experts or a significant consulting budget these systems are largely ineffective at a local government level and quite impractical for smaller (greyfield precinct) projects. More generalised systems, such as MUtopia (Ngo, Aye, Arora, Mendis, & Malano, 2014) are reasonably simple to use but overly generalised, with a high level of abstraction that is more useful in large brownfield sites or significant urban regeneration programmes. They do not have the granularity to explore the effect of variables at an individual precinct object level. In order to study precincts we need a way of assessing smaller units (Jing, Heppenstall, Harland, & Mitchel, 2014), in which case a bottom-up approach is needed. But how do we limit the complexity so that users do not need to have or understand all of the information required to develop a detailed modelling scenario?

Typologies, as covered by Young, Zanders, Lieberknecht, and Fassman-Beck (2014), provide a mechanism for encapsulating complexity through providing objects that are representative of real-world structures. Rather than attempting to absolutely model every attribute of every object, these typologies capture data that is relevant to the issues of planners and can be used as a proxy for reality; the only limitation being the number of variables, or the range of representative typologies that are generated. By using typologies of objects it is possible to abstract, instantiate and begin to replicate any planning issue. Examples include typologies of industrial districts (Markusen, 1996), typologies of river ecologies (Turak & Koop, 2008) and typologies of farmland (Lopez, Valino, & Perez, 2008), each of which contains fields of data relative to their use and output requirements.

Housing typologies have been used to a far lesser extent, and typically to address singular issues, such as risk mitigation (Santos, Ferreiira, Vicente, & da Silva, 2013) or energy use (Florio & Teissier, 2015). Typically these have had a small number of variables defining them (3 or 4) but can have significant numbers of typologies to reflect national differences in housing. To date, none have been found to operate within a decision or planning support system (DSS or PSS), and yet for urban planners and policymakers they are an essential way of communicating built form outcomes. The most successful attempt to generate typologies that are equivocal with housing typologies in a DSS is that of Neuenschwander, Hayek, and Gret-Regamey (2014). Although they represent green-space typologies, they are reasonably elaborate in their definition and can be manipulated and analysed within a 3D environment; providing users with a simple interface to produce technical feedback and visualization relevant for collaborative planning. As such, sets of typologies provide the methodology whereby complexity can be encapsulated within a discrete entity. They allow users to manipulate objects that are pre-loaded with information and to, without domain knowledge, assess the outcomes of different redevelopment scenarios. The concept of typologies is also important to urban planners who need to engage on the topic of good and bad housing design when establishing planning controls and design guidelines.

Given the significant number of typologies to be generated for ESP (numbering over 100 at the time of writing) and its urban redevelopment focus, the classes of typologies were categorised according to the land uses that would typically (and could potentially) be found in a greyfield precinct. These were:

- Residential (separate and attached houses, walk-ups and high rise apartments),
- Commercial (strip shops, shopping centres, office buildings),
- Mixed-use (buildings with commercial ground floors and residential above),
- Open space (parks, community gardens and playgrounds),
- Pathways (freeways, highways, local roads, bicycle paths and footpaths),
- Institutional (schools, medical centres and community centres), and
- Assets (trees, park benches, etc.).

Due to their varying uses and characteristics, a separate data schema was designed for each typology/land use class. As the residential schema is the most significant and detailed in the ESP system, in this paper we focus purely on that schema and then demonstrate the use of the system by presenting business-as-usual (BAU) and alternative redevelopment scenarios for a hypothetical redevelopment site. We begin by providing some background information on the ESP system by explaining some of its functionality and architecture in Section 2 and then describing aspects of its internal logic in Section 3. We discuss the residential typology schema in Sections 4 and 5 and describe the process of residential typology creation. Section 6 then provides an example use case demonstrating ESP's use of typologies and Section 7 concludes.

2. System functionality and architecture

ESP is a web-based application for designing, modelling and assessing urban precincts in a 3D environment. It is a precinct sketch planning and assessment tool providing users with a host of functions for creating and transforming an urban landscape. The system allows users to either import cadastral (lot boundary) data in ESRI Shapefile format or draw and subdivide lots directly on the 3D virtual globe. With cadastral data present, users are able to zone or rezone land, amalgamate and subdivide lots, apply height limits to lots and extrude them to visualize massing and scale and even import and extrude building footprint data for visualizing the existing built form for context. Lots can also be flagged for redevelopment, which hides any existing building footprints occupying them to allow users to place new precinct objects on lots in their place.

With cadastral data loaded into a project, the system can perform its primary function of allowing users to either drag-and-drop or auto-allocate precinct objects chosen from a typology library to land parcels. As a precinct is populated with objects, a series of reports in a panel on the right-hand side of the screen update to generate feedback on the user's design. As the system is object-based, subset reporting as well as reporting across typology classes is supported. If users hold down the "Shift" key while clicking on individual objects, reports will automatically refresh to report on only the selected objects and when objects from different land use classes are selected then a generic Precinct Report is presented. Everything happens asynchronously and appears seamless to the end user. The system also allows users to visualize objects in either 3D extruded footprint or 3D mesh formats, as the typology data schemas allow for both Shapefiles (for 2D data) and KMZ files (for 3D data) to be provided.