Using Multi-touch Tabletops to Create and Compare Neighbourhood Designs that Satisfy Constraints

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1 Introduction

We have designed and implemented a multi-touch tabletop application to support a collaborative constraint-based neighbourhood design task. The interactive system helps Landscape Architects easily create and compare neighbourhood patterns that must meet predetermined constraints, including objective and subjective targets as well as sustainability and livability goals. We began by gathering requirements while observing the group collaboratively develop patterns using paper maps and buildings–their currently established technique. We then actualized these requirements, creating a pattern design system for a SMART Table that offers users familiar interactions while providing new functionality to help them easily produce, evaluate and compare several neighbourhood layouts. The effectiveness of this tabletop interface will be evaluated in an upcoming user study. We hope that these findings will provide insight into the usefulness of tabletops for solving constraint-based collaborative tasks over traditional methods.

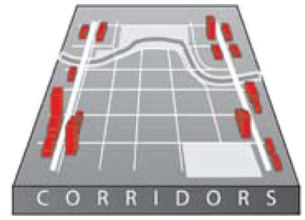
2 Problem Description

We are working with a group in the School of Architecture and Landscape Architecture at the University of British Columbia who specialize in designing sustainable neighbourhood patterns [3]. They collaboratively configure groups of buildings together to create a portion of a neighbourhood, called a 'pattern'. The buildings are of various land use types such as residential, commercial, or mixed use, each with one of three densities (low, medium, high) and dwelling types (detached, attached, stacked). Buildings also have numerical attributes (population, jobs).

Once a pattern is created, they are evaluated based on several objective and subjective criteria and an optimal pattern will satisfy as many criteria as possible. Objective criteria include totals of the numerical attributes, percentages of land use types, and percentages of dwelling types. Subjective considerations may include the overall pattern layout as well as an adherence to six key sustainability principles derived from a book by the Design Centre for Sustainability [1] as shown in Figure 1.

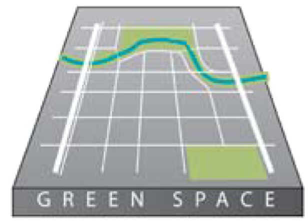
1. **Jobs:** job sites located within communities reduce time spent travelling to work.

2. **Corridors:** high density commercial and residential corridors focus growth along transit routes.

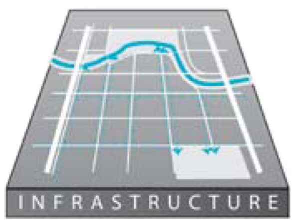


3. **Walkability:** interconnected street systems link residents with the services they need.

4. **Green space:** green spaces provide recreation opportunities and connect people with natural systems.



5. **Infrastructure:** integrating natural systems reduces infrastructure costs and environmental impact.



6. **Housing:** a range of housing types allows residents of differeing economic situations to live in the same neighbourhood and have access to the same services.

Figure 1. Six key sustainability principles.

The combination of all of these criteria results in a complex optimization problem that is currently too difficult to formulate using a purely computational approach. The group's current paper-based method of designing patterns to meet these goals also suffers from several limitations, suggesting a need for a hybrid approach where computational intelligence augments and complements human expertise. Numerical outputs are calculated manually, which is both tedious and prone to human error. In addition, paper designs cannot easily be saved, recreated, compared to other patterns, or shared with distributed collaborators. We aimed to address these limitations as well as offer additional functionality with our multi-touch tabletop system. Our goal was not to automatically solve the constraint problem for the group, but rather provide them with additional functionality, visualizations and affordances so they can design an optimal pattern layout using our system as a support tool.

3 System Solution

We conducted an observation session with all design group members to oversee their current paper-based pattern creation approach and obtain design insights. The session consisted of a mock neighbourhood design task utilizing real buildings and their data, represented by small pieces of paper, along with a large paper map that was used in a real previous session.

With our list of requirements and design insights, we built a pattern design system for a multi-touch tabletop. Unlike Urp [4] or the workbench created by Ishii et al. [2], our system is entirely electronic. It consists of three main components: a menu for scrolling through the buildings list; a pan- and zoom-enabled map to place buildings onto; and a series of bar charts that display target and output values for the current pattern and any saved patterns, as illustrated in Figure 2.

The scrollable menu allows users to select buildings to place in the map. Users are given affordances with the buildings to indicate their candidacy for selection; they are displayed with their input parameters as well as additional data to indicate, for instance, how many more instances of the building could be placed in the map before a specific target value is reached. The buildings can be dragged with a finger from the menu onto the map, much like their paper counterparts, and their parameters are automatically added to the chart values. The map can be zoomed out to analyse the overall pattern layout subjectively.

The charts display the current totals and target values for jobs and population as well as ratios for land use and dwelling types. They indicate how close users are to satisfying the objective constraints as buildings are added to the map. Users can save patterns, in which case a small iconic representation of it is created and its output values are saved in the chart area. The icon can be dragged to the map area to restore the pattern. Multiple saved patterns can easily be compared both in terms of layout, by comparing the icons, or resulting output values, by comparing the saved chart data. Pattern data can be saved to a file and restored on a different machine, a tabletop or a PC, that is running the application.

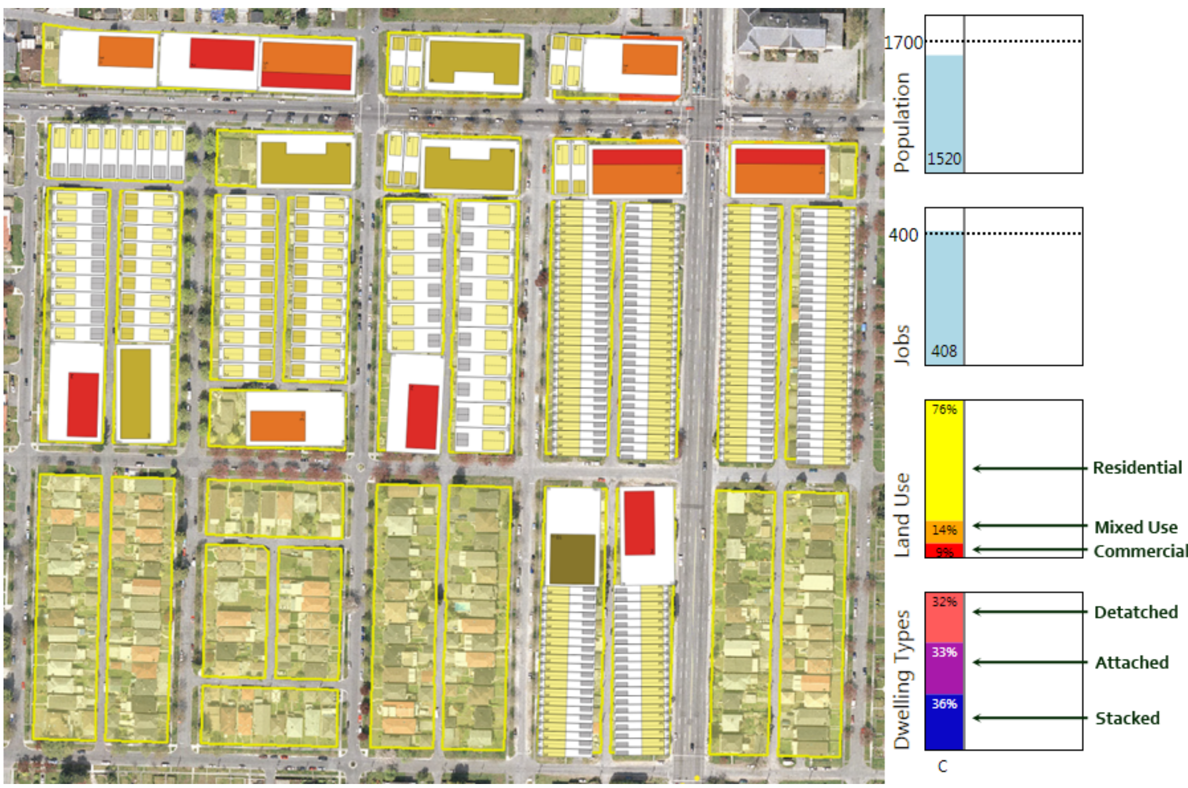


Figure 2. **Left:** An example pattern created with our system for the Sunset neighbourhood in Vancouver, Canada. A variety of building types have been used, including single-family dwellings, medium and high density residential towers, along with mixed use and commercial buildings. **Right:** the charts displaying the output values for this pattern. The values for the current pattern in the map area are displayed on the far left side of the charts under column C and saved pattern data is stored in the remainder of the chart to easily compare output values.

4 Future Work

The system described above can be considered to be a first step in a long partnership towards an ultimate goal of automatically computing an optimal neighbourhood layout given inputs and objective and subjective constraints. Our next step will be to complete our evaluation of the current system and implement improvements the evaluation suggests. Further work may include modularizing the system so that individual components may be fully formulated. We may also include a recommender system that would offer intelligent suggestions for particular buildings or elements to place or locations for elements given current contextual information.

References

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