CONNECTING COMMUNITIES AND DATA: AN INTERACTIVE SPATIAL DECISION SUPPORT TOOL FOR SOCIAL HOUSING STAKEHOLDERS

E. PRITCHARD,
University of New South Wales, Sydney, Australia
ebony.prit@gmail.com

Abstract. Sydney is "one of the least affordable cities in the world" where the average home price exceeded $1 million in 2017, which was 12.2 times the median household income. (Committee for Sydney, 2017). The current 'Housing First' model that is a part of the NSW homeless strategy 2018-2023 requires available housing, which is severely lacking in the current Greater Sydney area. The lack of prioritisation for the needed 500,000 social and affordable homes by 2030, highlights the need for new tactics. (Toomey, 2019)
Through the use of action research, computational design tools can be developed to engage stakeholders in new ways and facilitate community consultation for the development of social housing. The Spatial Decision Support Tool (SDSS) that uses 3D and 2D data interactions, furthers the users understanding about the data by generating a scenario in the area of Parramatta City. Allowing non-experts and community members to spatially visualise and investigate options, generate feedback, and engage communities in new ways in the decision-making process. Data gathered from the Census and NSW Cadastral data from SixMaps and Open Street Maps, translated into Grasshopper, using the plugins Decoding Spaces and Urbano to translate the data into 3D geometry and 2D calculations based on the user interaction. Translation of this tool online to Mapbox makes the tool accessible for a larger range of users. 2D interactions would connect quantitative data to spatial outcomes and contexts. Using tools that integrate and communicate data to both decision-makers and community members will contribute to influencing the development of housing that is better aligned to community needs. As data about the cities we live in becomes more robust, real-time data could be a future opportunity to enhance the tool and outcomes. The gap between the decision makers and the people impacted by those decisions is reduced by generating a space that allows for collaboration, communication and education. Whilst simultaneously adding humanisation to the numeric values and understand the impacts to the communities we live in.

Keywords. Homelessness: Social Housing; Spatial Data; Interaction Design; Community Engagement.

1. Introduction

"Technology by itself will not solve homelessness. Getting people housing they can afford will solve homelessness. Technology can be used in service of that goal" (Froshman, 2020). Currently within the Sydney Greater area, there is not enough housing available for those in the lower quantiles of income. The provision of affordable and social housing within the Greater Sydney area is of significant issue for those experiencing or are on the brink of becoming homeless. Particularly as seen during the COVID-19 pandemic, a rise in "some regions [of] NSW will experience a 40.5 per cent increase in homelessness." (NCOSS, 2020)

Current systems of generating community response to projects such as the development of social housing tend to rely mainly on face to face forums and meetings, social media updates and surveys. The development of a tool that displays data visually and numerically, and creating connections spatially, will assist in the development of further new understandings for community about possible changes presented in a scenario generated by the tool. Integrating features similar to a Spatial Decision Support System (SDSS), analytical descriptions allow for complex data to be represented spatially.

There is a demand to generate "500,000 social and affordable homes … by 2030." (Toomey, 2019) More low-income housing is needed for the 'Housing First' model used internationally but also integrated into Australia, where housing is given to those experiencing or are in high risk of homelessness. It gives "safe and permanent housing" that is not conditional. (AHURI, 2018) The results found show that not only do people retain accommodation, such as seen in the USA, where 88% retained their housing after two years, but also reduce the cost in the health and justice system. (Wood, 2016)

"Australia has been constrained by the lack of appropriate affordable housing stock." (AHURI, 2018) There is a mismatch with the demand for social housing in Australia. With one in five social housing being over 50 years old, not only are the cost of maintaining the older buildings considerably more but are also too large for current needs. (Family & Community Services. 2019) Smaller single dwelling housing types are in demand.

Using computational design methods and generating a tool with grasshopper that aims to address the issue of generating more social housing, whilst allowing for community in an online environment gives understandings and incorporation for the users through interactions and investigation of the data. This system is important to Architecture, Engineering and Construction (AEC) industries as it translates spatial city data, for contextualisation understandings, but also provides hypothetical scenarios for early development options. Insurance to avoid any 'clusters' of lower-quartile income earners, the tool spreads out the options selected, whilst still allowing a walkable distance to public transportation, in the case study, being train stations.

The research aims to close the gap between the decision makers and the people impacted by those decisions. Adding value to data spatially, for both community and decision makers, and allowing feedback and communication.

2. Research Aims

The key aims of this project is to develop a new tool for assisting the early development of social housing within existing areas of Sydney. The case study of Parramatta City was chosen as it is an area that currently has available data both spatially and numerically available, whilst also being a valuable place to develop social housing due to the close access of public transport and other essential services.

Further, this research aims to emphasise spatial data interactions within a hypothetical scenario and the outcomes and understandings produced, considering both communities affected by the changes presented in scenarios, and the interaction, whilst also holding value to experts and decision makers for very early consideration and planning options for social housing

3. Research Questions

Based on the issues outlined in the introduction, the question the research investigates is:

How can spatial and numerical data be used in a computational tool to generate concept stage space-planning options for social housing?

Specifically, how can spatial representation and interactions offer new ways of communicating data?

4. Methodology

"Action Research (AR) intervenes through experimentation." (Baskerville, R. 1999). When conducting this research, the adoption of AR methodology, largely understood to be a repetitive, iteration process. Essentially learning by doing and then in turn, evaluating and specifying the value of the outcomes. "[AR] is actively addressing ... an immediate situation, while also trying to advance scholarly knowledge" (O'Brien 2001). This methodology allows for possible further research ideation and tactics to address the issue.

Developing a decision tool that harnesses spatial data to generate a hypothetical scenario, needs to be assessed for the value of the outcomes generated and investigate the intervention the outcomes generate. Reflecting upon the initial tool, in its first iteration, moving it into an online environment offers accessibility to a larger range of users being both community and experts. The effectiveness of the outcomes and comprehension needs to be assessed when considering user groups. Accessibility to the tool, that meets the requirements of a community, an online into mapbox environment offers many opportunities for people. Moving the tool from an offline, scripting grasshopper environment to online, needs to reflect upon the outcomes and assess if they are applicable but simultaneously useful for the early development of social housing.

Reflecting and specifying allows for the researcher to share specifics about how and why this process or outlook was important, even if the project potentially failed in some way, which is vital to incorporate into my own project, as the understandings produced despite potential failure is vital for the project. Also having a record of how new methods are used to produce research is important within furthering current or possible existing research. Through AR seeking discoveries that are "interpolations of the comparison, contrast, and constancies" of ongoing research is critical for reflecting and understanding the value of the research and project. (Hearn, G. and Foth, M 2005) How and if the tool intervenes with current issues, and why is that important in relation to the issues.

5. Background Research/Literature review

'It is widely agreed that homelessness will not end without a significant expansion in the stock of housing that is affordable to households.' (Evans, L. and Klodawsky, F 2020) Current systems of spatially descriptive tools that allow for community involvement in decision making surrounding social housing are seemingly limited. Mainly consisting of face-to-face forums and meetings, or over social media and engaging community in feedback through surveys. Most current systems fail to incorporate models that aim to solve the issue of homelessness. Emerging technologies are impacting traditional project delivery models, "moving towards an integrated inclusive … paradigm in architecture." (Barrow, Arayedh 2020) Working with a computational workflow, offers new processes and interaction with statistical and spatial data, in turn generates a change in how early decisions and planning is carried out by decision makers.

5.1 DATA COMPREHENSION AND DECISION TOOLS

5.1.1. Decision Support Systems

Decision Support Systems (DSS) are information systems that support decision-making activities. The paper by Troy, L., Ryan and Randolph, B. conveys the use a 2D costing tool, a decision support tool (DSS), within NSW to understand the geographical disparity with housing, highlighting a need to understand variation of 'fill the gap' in the cost of housing provisions and how current monetary aspects help with social and affordable housing in Australia. (Troy, Ryan, Randolph, 2019) Pointing out variation despite there being a flat rate to help support those who need it. The variation has yet to see action or impact by decision makers despite the data showing issues with the current system in place.

5.1.2 Spatial Decision Support Tools

SDSS can contribute to communicating complex problems and data understanding of complex data and problems.

This paper finds through comparisons of different modelling types, 3D digital representations give a freedom and an advantage in the representation of data. Interaction allows users to come to understandings on their own volition, a beneficial factor when the user audience includes the communities and non-experts, as the apparent 3D abstraction of space 'helps bring more ideas to the discussion process.' (Baltazar., Malard,, Kapp,. and Schultz, 2008) Another level of anonymity through the web could allow for differing communication results that was not presented in this research, but the 'alone time' with the 3D spatial modelling enhances the communication about the data presented.

Barton et al (2004) generated a tool in managing social housing using dummy data to connect users to information. The tool developed intended to be used to manage social housing. The first iteration used dummy data to generate a 3D environment and 2D environment. Users could view and create understandings extracted from the data despite complexities in the problems. Alternatives could be conveyed while showcasing any constraints to non-expert user groups in an interactive environment. (Barton, Parolin, Weiley, 2004) The paper was released in 2004, and significant advancements in spatial display and interactive design have developed since, particularly allowing real data, over dummy data, and incorporation of accessible versions of the tool.

A recent Spatial decision support tool focusing on implementation of social housing in the USA allows for "flexible strategies" where a locational model presents mathematical numerical representation and 2D geometry. (Zhong, 2017) The tool generated from this research is of high fidelity, and produces complex outcomes intended for expert user groups to gain understandings about the location opportunities for social housing.

5.2 COMPUTATIONAL METHODS AND HOMELESSNESS

Computational methods have been used to generate short-term solutions that tend to manage people experiencing homelessness yet fails to solve the issue. In research undertaken by Ghandi (2018), the USA's technological systems of managing homelessness are discussed. Through the use of emerging technologies and methods, and providing a temporary solution, a shelter. Part of the conclusion, it states that the shelters developed 'might be considered as a homeless shelter of the future' (Ghandi, M. 2018) reflects the lack of priority of trying to eradicate homelessness, rather generate an 'improved' homeless shelter, which are very lacking systems, that do not provide much benefits to the user groups, the people experiencing homelessness, in the long term. Improved systems and upheavals of current processes are needed, that incorporate successful models such as 'Housing First,' which has shown successes when eradicating homelessness.

Literature on affordable housing spatial decision models and using computational methods, reveals several opportunities. First, limited models have directly interacted with 3D projective data to generate outcomes or integrate community involvement when designing a tool. To address this gap, data interacts both on 2D and 3D, whilst intending the tool to be comprehensible for community and decision makers. Online accessibility would offer the tool to the majority of user groups.

6. Case Study

This research explores the development of a spatial decision tool through incorporating data, both 2D and 3D. In doing so, the system aims to portray a hypothetical scenario that showcases and generates understandings about changes within a community. The focus is the development of social housing within existing communities of Sydney that allows users to interact and gain alternatives through the statistical and spatial outputs.

6.1 AREA SELECTION

The area chosen had to be plausible, by being an area that currently:

1. requires social housing,
2. having points of accessibility for transportation; and
3. avoids any ‘clustering’ of people already experiencing homelessness within Sydney.

The source of the data was from the 2016 Census. Being the latest dataset available at the time of the development of the prototype, despite being slightly older, the data within Tableau, was able to present the SA2 areas with hotspots of those experiencing homelessness, hence the SA2 areas to avoid.

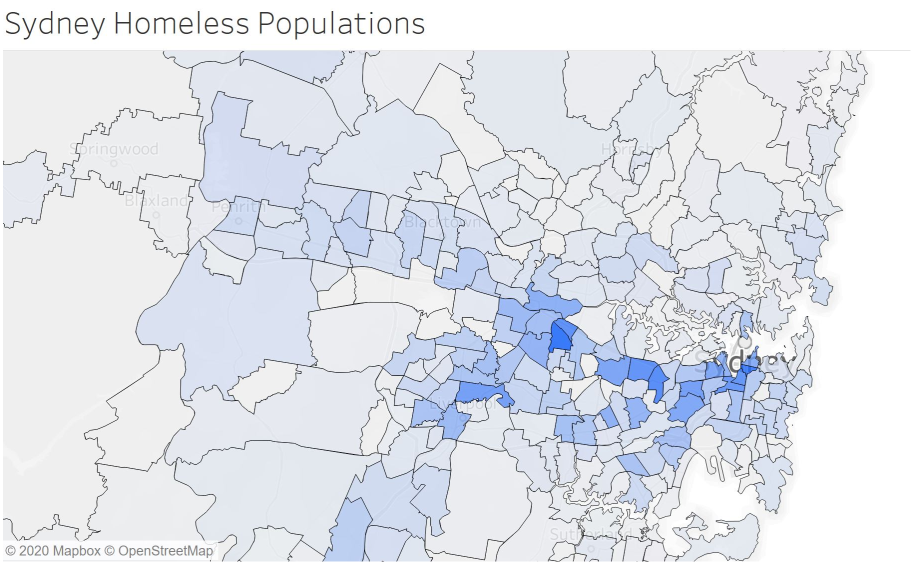

Figure 1. 2016 Census data SA2 areas to homelessness populations, presented in Tableau.

From the data, the area that best fit the criteria above was Parramatta, more specifically the area surrounding Parramatta Station and Harris Park station. The identified area contained appropriate spatial data needed from SixMaps and OpenStreetMap.

6.2 COLLATION AND REPRESENTATION OF SPATIAL DATA

To achieve an accurate model of the area, data was first collected in OpenStreetMap. Initially, the first attempt to translate the geometry into grasshopper was using Elk, which gave the OSM file as a flat mesh.

It was then changed to using Urbano, as it gave detailed metadata of the area, showcasing important amenities and features of the area, along with detailed roads, cadasters, building plots and 3D extrusions spatially describing the height of the buildings.

This data was then overlaid with SixMaps data, as a shapefile. The data within grasshopper contained the cadasters, roads, and train lines. That allows for user spatial understandings in detail.

Figure 2. OpenStreetMap data extracted and translated into Grasshopper with Urbano, specifically the area surrounding Parramatta and Harris Park train stations, NSW, Sydney

The data was overlaid again and collated to fit the OSM file as the features generated a new working origin point due to Urbano translation into grasshopper. The SixMaps data imported incorrectly, to ensure accuracy of the model. The roads, and train lines were moved to the correct positions. In turn, the SixMaps data was large and extremely detailed, the data was cropped to fit the OSM data.

The most vital aspects of the collated data incorporated for the tool were, train stations, roads, cadasters and buildings and heights.

Figure 3. SixMaps data extracted and translated into Grasshopper with Urbano. Extremely large shapefile of Parramatta City and surrounding areas.

Consideration into the bus network, and incorporating bus stops as an accessible transportation point, was an option, however decided against it, as bus stop spatial data incorporation was deemed, organised inefficiently and time consuming. The data gathered from the train stations offered enough data for the tool to work.

6.3 PROTOTYPE

The train stations identified were Parramatta and Harris Park. The missing building data from OSM provided an opportunity to showcase possible scenarios to develop social housing on cadasters from SixMaps. The generated projection is a hypothetical scenario for early planning, the empty cadasters offered suggestions for the placement of social housing.

Cadasters outside 800m radius distance removed from new dataset, as building outside this range would be further than a 10-minute walk from cadaster to train station. This decision was made to allow for accessibility to the stations, as it was found, walking further than this was not a feasible transportation option. Cadasters also at a minimum had to be 300 meters apart to avoid intense clustering of social housing, which would generate hotspot of low-quantile income earners, which can possibly generate undesirable impacts within communities. Outliers were removed from the dataset, such as extremely small or large cadaster areas, which were unusable for the projected buildings.

Single dwelling apartment type chosen for the floorplan estimation, as it is most in demand type of housing needed to be developed in Australia. Later, the option for double or a two people dwelling floorplan option was added into the interaction.

Dummy data had to be generated to create a city from OSM, where the heights found from the original data set were applied to the building curves found from the OSM data. This was added to allow for user contextualisation in the 3D space. The intention for this, is to be a placeholder, to help users understand and interact with the data in a 3D context.

The calculations were derived from "NSW LAND AND HOUSING CORPORATION – DESIGN STANDARDS 2014"

Estimation to find the number of floors from an extrusion building:

$$\frac{x}{3m} = y$$

x = building height
$3m$ = floor to floor height (large to give room for error)
y = amount of floors

Estimation to find the amount of new housing in a building:

$$\frac{a}{b} - 3m \ \times (1m \times c)$$

a = building floor area
b = dwelling type floor area (max floor area to allow for error)
 single dwelling = 55m2
 double dwelling = 85m2
$3m$ = floor to floor height (large to give room for error)
$1m$ = corridor width
c = longest length from building floor

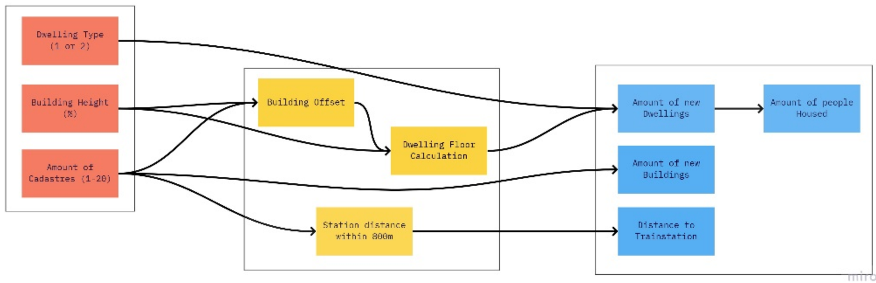

Figure 4. Simplified Diagram of the Grasshopper Script interaction inputs and outputs

The offline iteration of the tool allowed for user interactions on a 2D and 3D level. Valuable to understanding estimates through the hypothetical scenario presented. It showcases the changes to the community on a spatial level and is valuable to people in the early development of social housing. Community members gain an understanding how the building may be located in an area in relation to transportation and other possible social housing opportunities. Community members then can understand distances and provide feedback to decision makers.

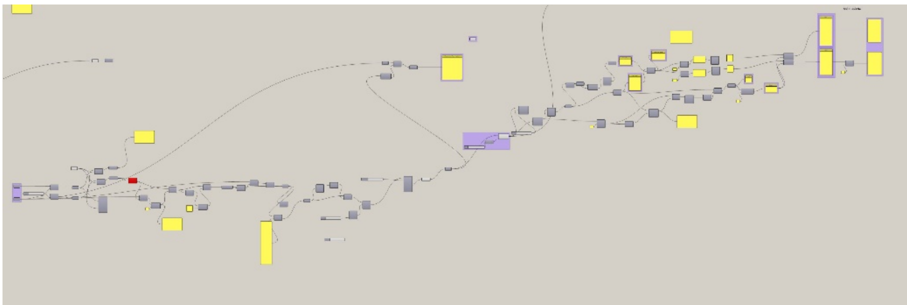

Figure 5. Grasshopper code overview

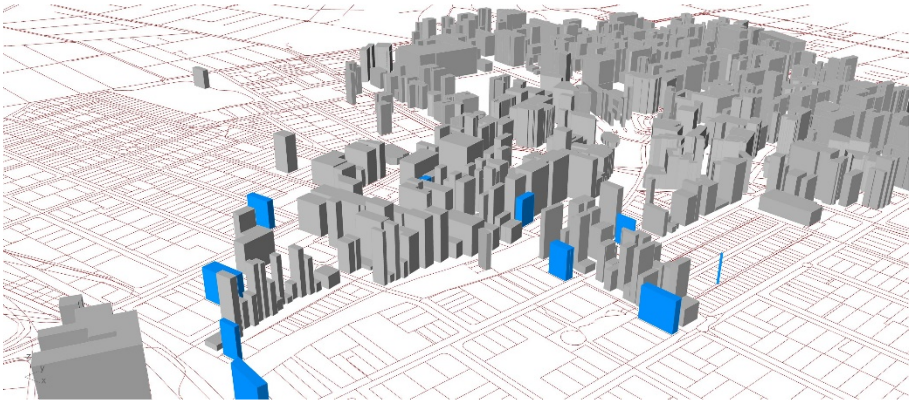

Figure 6. 3D spatial outcome from data interaction, Offline iteration in Grasshopper.

6.4 ONLINE TRANSLATION

The next stage was to allow accessibility and communication between decision makers and community via an interface for both user groups. Online space seemed plausible for accessibility for multiple user groups.

To get the 3D geometry into an online space, converting the buildings into a readable file for Mapbox. The Decoding Spaces plug-in allows for conversion from grasshopper geometry into a GeoJson file, a readable file type for the internet.

Decoding spaces transforms the geometry to represent accurately within a GeoJson file type, however, distorts the representation in Grasshopper. Urbano uses metadata that correlates with how the spatial data translates into Grasshopper. That is at first a system of points. Decoding Spaces cannot translate accurately the metadata, as the plug-in worked with point conversion preparation for the GeoJson yet fails with the metadata due to the distortion of the point placement. Also, any data that was in the z-axis, hence 3D, was flattened.

This issue was solved by converting the needed buildings at the end of the tool into the floor plate boundaries and using the vertices extracted. The heights were translated into the GeoJson as a numerical value.

Transforming the working origin point to the accurate origin point relied on the use of the original OpenStreetMap file coordinates and transforming it through Decoding Spaces and offsetting the geometry to the correct coordinates to display correctly on the map, in Parramatta, rather than in Russia as an example.

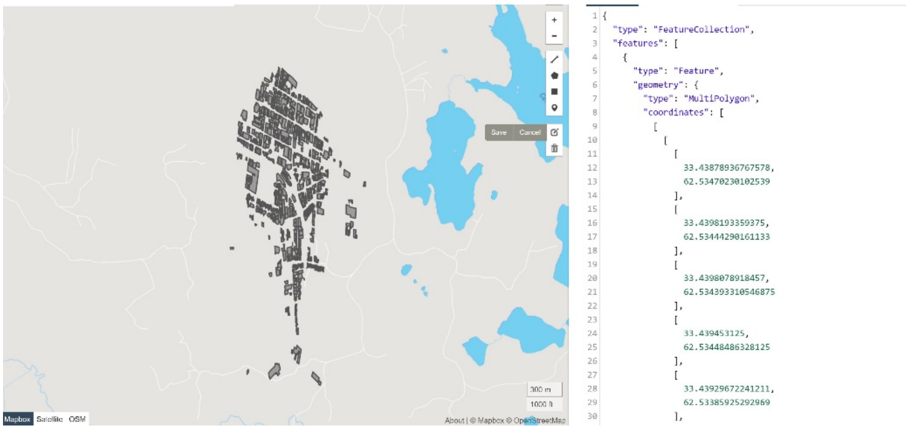

Figure 7. Distortion of GeoJson representation in the Longitude, in Russia, rather presented correctly in Parramatta, NSW, Australia

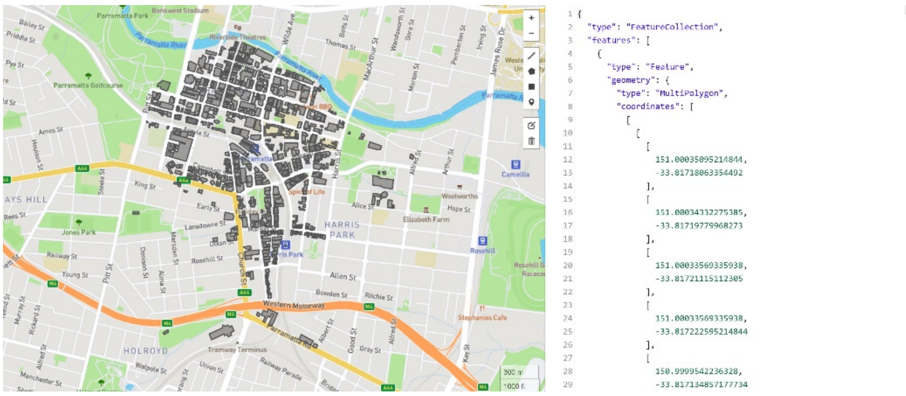

Figure 8. GeoJson representation accurate and positioned correctly in Parramatta, NSW, Australia

The coordinate system transformation, EPSG:32756 into the EPSG:4326, the used spatial reference system that is comprehensible and displays the data spatially accurate on the map within Mapbox

Once the GeoJson file was correct, it was uploaded to the tile sets of mapbox to be incorporated spatially in a 3D online context. A simple user interface that consisted of a comment box was added to the website application.

Figure 9. Online context data generated from grasshopper represented in mapbox, in an online environment.

The online components can be accessed on GitHub via this link:

https://ebonyy.github.io/tool_boi/

7. Discussion (evaluation and significance)

The goal of this research was to generate a tool that harnesses the use of multiple data sources both 2D and 3D and generate options for a hypothetical scenario spatially and numerically. The tool is not fully polished, however investigates the value of presenting data that is comprehensible through interactions with the data.

The project led to the realisation that generating a tool that represents spatially accurate data and in turn create outcomes that generate understanding is important for those living within the community but also those who control the decisions. Careful consideration and sensitivity are needed in order to generate portrayals that are empathic and considerate, yet simple enough for non-experts, yet feedback is essential for decision makers. The input interactions with the tool needed to allow for positive changes and educate people why the changes in a community are required. Simplicity was identified as a key element so community members could effectively understand changes and provide quality feedback. Balancing the needs of both user groups within a tool creates harsh dichotomies in what a user may want.

A limitation is the lack of user testing and user input for the tool. Having multiple user groups would definitely enhance the tool and the outcomes generated. A substantial constraint was the 10-week timeframe in which the research was conducted. Challenges such as getting the tool to have a comprehensive user interface working in an online environment, with correct input variables would have been overcome if more time was available.

The cleaning of the 3D data to ensure it was spatially accurate took extensive time. Messy data is confusing and highlights the need for better structured data, as it is extremely hard to pull anything of importance from data that is unstructured. Developing a system that could organise this data could be a future direction when working with multiple sources of 3D data.

Moving the tool into an online space gave arise to unseen issues, such as Urbano's transformation of the data, and how to bypass the restrictions, such as the losing the coordinate origin point, correcting the EPSG, and projection distortions and produce a GeoJson file that could work within Mapbox. The use of other plug-ins may be a better option for the incorporation of Shapefiles and GeoJson into Grasshopper.

Regardless of the constraints, the tool in an offline environment worked in an offline status. Simple numerical inputs generated both 2D and 3D outputs. An attempt to get the tool working in an online status, where the GeoJson 3D geometry was exhibited and users could spatially understand the hypothetical context and scenario presented online.

The significance of this project is the spatial attempt to generate understandings to multiple types of users. A future direction would be the incorporation of updated data, such as the 2021 Census or real-time data, where the generation accurate understandings of the current community surrounding a user through appropriate data comprehension and translation, a more detailed hypothetical scenario, that eradicates the need for the dummy data contextualization, particularly as we move into future cities. The exponential growth of data, particularly that impacts the communities we live in, can and should be incorporated into comprehensive tools, that reflect understandings in new ways about the communities we live in.

It builds on the incorporation of using data to help assist with decisions surrounding social housing whilst also contributes to remedy the ongoing challenges in participatory processes. The research attempts to use a workflow that gives access to a wide range of user groups on an online setting, and how the translation of data from online to offline, to an online space as an interactive tool.

8. Conclusion

This research study has developed a tool that generates social housing early planning options, spatially and numerically. The lack of spatial descriptive tools available to communities that contextualises understandings of the data. Directly interacting with data that represents and creates scenarios, such as presented by the tool generated in the case study, offers new ways of inspecting data.

Generating tools that give affected communities new understanding of possible changes, whilst also allowing a space for education and inquiry is vital. Temporary solutions for people affected by homelessness are failing, causing a need for long term solutions, like the Housing First model, which the tool generated supports. With the increase, particularly over the Covid-19 pandemic, decision makers will need to make fast, smart decisions in the near future. Data assistive tools that give community understandings and feedback opportunities, in turn delivers better communication to ultimately leads housing generation that matches the community's needs.

Whilst currently, the tool lacks some data representation, the complex data and problems are described visually in an attempt to allow the opportunity for both communities and decision makers to come together with discussion feedback. The tool also fails to be accessible for communities to interact with currently, however the attempt to move the tool online, allows for a future direction of the tool.

What was achieved, allows for user investigation into the data. Despite the use of dummy data, integration of accurate representation spatially in the 3D, is highly likely to become available and integrated into the tool.

The exponential growth of data, particularly the data that impacts and influences the communities we live in, can and should be incorporated into comprehensive tools that reflect understandings in new ways about the

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