COLOURING AUSTRALIA: A PARTICIPATORY OPEN DATA PLATFORM

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ABSTRACT:

Colouring Australia is a digital platform for collecting and visualising building level information across several Australian cities. It provides a valuable resource for bringing together data on building age, material, sustainability ratings, walkability and other key metrics as we plan for net zero cities. Colouring Australia comprises part of the international Colouring Cities Research Programme, which supports the development of open-source platforms that provide open data on national building stocks. In this paper we outline the technical architecture of the platform, and the development and visualisation of a building level walkability metric based on pedestrian access to destinations. This platform provides a useful digital tool for planners to understand which parts of the city are walkable and in turn this can support future active transport programs and policies. Future research will be to validate this novel walkability index through a series of stakeholder and public workshops using the Colouring Australia platform in an interactive tabletop environment where usability testing can be undertaken.

1. INTRODUCTION

Data is widely recognised as an indispensable resource in the planning and development of the built environment. From the ongoing digitisation of the planning system (Dunleavy and Margetts, 2015; Pettit et al., 2022); new connections for city IoT networks (Chowdhery et al., 2018; Hudson-Smith et al., 2021); to upcoming smart developments that give promise to the ambitions of smart city policies (Batty et al., 2012; Al Nuaimi et al., 2015), the generation of urban "big" data today has been both transformative and contentious.

In this paper, we present the current challenges of using building stock and street context data as a resource in planning and development. We outline trends in urban big data and city analytics today, and discuss the need for structured and accurate open datasets as a catalyst for public participation and innovation; and ultimately inclusive urbanism.

We present Colouring Australia as an open data platform for building-level data, and a place for multidimensional integrated Australian datasets, with an outline of its technical architecture and background in the Colouring Cities Research Programme. We conclude with a use example based on walkability metrics, where the platform can be used both to disseminate data on dimensions of walkability, and to gather citizen insights, leading to a potential research-engagement cycle.

2. BACKGROUND

In an urban context, it is proposed that big data has the potential to remodel the way policy formulation is carried out in administration. It is theorised that the comprehensive data now available may percolate into more informed decision-making; and provide a means to substantiate and validate development policy and practice (Pettit et al., 2017; Hudson-Smith et al., 2021; Pettit et al., 2022). "Big data" and "city analytics" have become buzzwords buttressing so-called "data-driven" urban strategies (Gamage, 2016; Kashyap and Shinghal, 2019). However, as these approaches play a growing role in shaping our urban futures, the question arises as to the implications for citizens: as users of the built-environment, consumers of its services, and participants in the urban community.

Herein lies the crux of concerns regarding urban data administration. Barbosa et al. (2014) noted that, whilst policy-makers were in the past constrained in obtaining and processing the relevant data to evaluate policies, this challenge has been remedied with the surge of available data intermediaries and open data sources. Particular attention now is being cast on the potential for big data and city analytics to move away from its technocratic origins; so that data can be used to both substantiate policy-making and keep citizens informed and able to participate in future city design (Höchtl and Reichstädter, 2011; Dyson, 2013; Barbosa et al., 2014). In particular, the methods and principles by which urban big data is processed, managed, and, most importantly communicated to the general public have become central themes in the current discourse (Harford, 2014; Foth et al., 2015; Hardy and Maurushat, 2017; Arribas-Bel and Reades, 2018; Pettit et al., 2022) — in which issues of data transparency, usability, accessibility are central (Barbosa et al., 2014; Pettit et al., 2022).

Shaw and Graham (2017) argued that the rapid progression of technology and the ubiquity of the internet today has allowed citizens to play a much larger role in the urban decision-making process. It was argued that, as the ultimate users in the built-environment, the role of the urban resident needed to be reconceptualised to one of collaboration, rather than as the passive subject of survey collections and feedback consultations. Foth (2017) posits four stages in this movement towards participation and collaboration, with the idea of citizens moving from residents, to consumers, to participants, to co-creators. Dyer

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et al. (2017) also argues that increasing the consensus towards such citizen-centred engagement is essential, allowing participation in design and formulation of development objectives; ultimately, acknowledging citizens in the decision-making process and facilitating the progression towards more evidence-based urbanism.

The question thus turns to how inclusive urbanism, in the sense of participation and collaboration can be achieved. Whilst the many social, economic, and political dimensions must be acknowledged, this paper focuses on the technological facilitation of these broader objectives of collaboration. In particular, we consider how a more open approach to data and analytics may be foundational to this. It is an approach favoured by Moreau et al. (2011) and Barbosa et al. (2014), who consider creation of open repositories of urban data to be a starting point for engagement and innovation in the city. Similar approaches have also been adopted by Pettit et al. (2017) and Pettit et al. (2022) in Australia, who point to the value of urban data that can be obtained by the harmonising and integration of unconnected datasets that feature the multidimensional characteristics of the built-environment. Pettit et al. (2022) argue that tangible change can be effected through the consolidation of Australia's many urban datasets, via a coordinated system of data management and exchange to create more efficient and transparent systems. When the technological barriers to processing large volumes of urban data, and the expert knowledge required to manage, analyse, and objectively communicate, both visually and anecdotally, are reduced we ease the way in which data can be explored, evaluated, and modelled.

Building on these developments, this paper puts forth the Colouring Australia project as an exemplar of open data governance, and as a model for obtaining voluntary geographic information. First, we present the Colouring Australia platform, and discuss its scalability, reliability and suitability for citizen engagement. In particular, we discuss the platform as a means to address issues around multidimensional building-level data, its availability to the general public, and its potential use-cases in urban planning. The final section details a particular use case of disseminating data on one aspect of walkability, and the creation of a feedback loop with the use of citizen gathered data on perceived walkability.

3. COLOURING CITIES RESEARCH PROGRAMME

3.1 Building Data

Buildings comprise 80% of total capital in industrialised countries, representing "the largest physical, economical and cultural capital of a society" (Hassler, 2009; Schlosser et al., 2020; Bradley and Kohler, 2007, p. 530). Owing to the scale of social and financial capital held, these resources also function as essential physical, economic and socio-cultural reserves needing to be drawn from in future (Thomsen et al., 2011). Building stocks are also complex, dynamic systems, although hitherto now the notion of temporal dynamics in the scientific study of cities has been 'almost entirely absent' (Batty, 2007, p. 3).

However, current data surrounding buildings are not without their problems. Issues with incompleteness, fragmentation, aggregation, inconsistency, inaccuracy and inaccessibility of many types of building attribute data necessary to support sustainability research have been raised by many authors (Aksözen et al., 2017; Evans et al., 2017; Huuhka and Lahdensivu, 2016; Miatto et al., 2017; Tooke et al., 2014). Difficulties with access at international level were already being noted by Kohler and Hassler by 2002 (Kohler and Hassler, 2002). Scientific models on stock behaviour continue, in many countries to rely on assumed, rather than actual data, with information on form, age (and lifespan) 'very seldom available reliably' (Huuhka and Lahdensivu, 2016, p. 3).

Reasons for these problems include longstanding fragmentation of data owing to: individual sectors' interest focus on specific types of building; the prioritisation of new build and technological innovation by the construction industry, architectural profession, and planning, over adaptation and reuse supported by tax incentives. Lack of drivers to encourage governments to invest in public auditing and monitoring of stocks as a whole, and to publicly release spatial building attribute data collected for taxation purposes, have also been contributing factors.

3.2 Colouring Australia

In light of the above issues, we present Colouring Australia, as part of the Colouring Cities Research Programme (CCRP), as an example of a novel open source building data platform that aims to address these issues.

Colouring Australia (CA) is a partner in the Colouring Cities Research Programme set up at The Alan Turing Institute - the UK's National Institute of Data Science and Artificial Intelligence - to facilitate knowledge exchange and open data sharing about buildings, across and within countries. The CCRP brings together academic institutions across countries to test and cowork on open data platforms that address issues of fragmentation, completeness, quality, interoperability, range, geographic coverage, granularity, security and accessibility of building attribute data. It also tests a low cost academic governance model. The key challenge has been creating an efficient, effective, low maintenance model that advances research goals as well as maximising platform accessibility, reproducibility, usefulness and quality, allows for ongoing testing and improvement across countries, and that combines crowdsourcing techniques with automated approaches to create the highest quality, most comprehensive and granular databases possible.

CA is the first CCRP partner to begin to set up a country-wide network, linking higher education institutions across Australia based on their specific expertise relating to the composition, performance and/or dynamics of domestic or non-domestic building stock. Colouring Australia will be launched in the cities of Adelaide, Canberra, Brisbane, Melbourne, Perth, and Sydney. Its aims are to increase building stock quality, sustainability, efficiency and resilience, and to assist communities and other stakeholders in this process. CA will work to effect a step-change in the amount and type of building level attribute data available for use in scientific research, and in the application of AI and machine learning to advance understanding of the stock as a complex dynamic system.

CA platforms also function as free multiple purpose tools designed to advance the democratisation of data, support a whole-society-approach to urban sustainability and to maximise participation in planning and quality control. Whilst CCRP platforms rely on crowdsourced data, drawing from the highly successful methods advanced by Wikipedia and OpenStreetMap, they are more closely aligned to citizen science initiatives such as Zooniverse[1] where data collection is driven by specific research questions. In these citizen science initiatives, the use

[1] Link available: https://www.zooniverse.org/

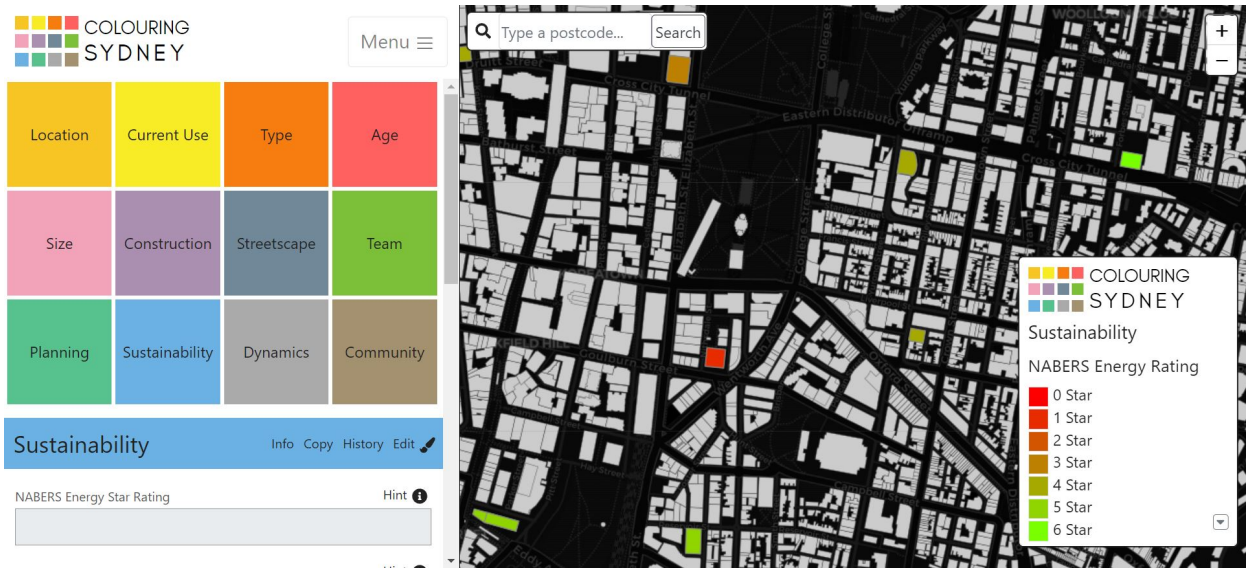

Figure 1. NABERS: building footprints in inner Sydney with Energy Rating data

of accessible, inclusive platforms able to encourage engagement by diverse audiences is key. Where the Colouring project differs is its specific use of colour to engage and thank audiences and to highlight patterns and gaps. Specific features currently being tested in the CCRP's prototype platform, Colouring London, to increase public engagement in the planning system include those permitting live streaming and colour coding the status of planning applications, allowing communities to input on whether buildings work well and contribute to the city (the more positive comments recorded about a building the deeper the colour), and enabling developer performance, and loss or gain of buildings that serve communities as a whole, to be tracked.

4. TECHNICAL ARCHITECTURE

The code for the Colouring Australia implementation was forked from the Colouring London repository on GitHub (Hudson et al., 2018). In line with the Colouring London project, the Colouring Australia project is published under a GPL-3.0 license, and the code is released through the CFRC github[2].

Colouring Cities is built with buildings as a fundamental unit of analysis. For Australian cities, it is not straightforward to determine from where building footprints for the platform should be sourced. Many datasets are either released under proprietary license (e.g. PSMA Geoscape), or are incomplete (e.g. OpenStreetMaps contains building footprints for many CBD areas, but is typically missing data for residential or rural locations). The most complete source of permissively licensed footprints available to date is the Microsoft (MS) building footprints data[3]; footprints generated via machine learning from Microsoft Bing aerial imagery and released under an ODbL license. Unfortunately when using the MS building footprints for Colouring Australia slight quality issues were noticed; for example building footprints for towers with setbacks in the Sydney CBD typically were often misaligned, or incorrectly identified building boundaries. To overcome this limitation we created footprints by performing a spatial merge of the MS and OSM footprints; all OSM footprints were included, as were any MS building footprints which did not intersect with an OSM footprint. Attribute data for buildings (e.g. NABERS ratings, Walkability score, or G-NAF records) are joined based on a spatial merge with these footprints. This is an example of the lack of complete, unfragmented, open data currently available in many countries, and how the Colouring platform can be used to disseminate an improved, integrated dataset.

The Colouring Sydney platform will be the first in a series of colouring projects to be released for Australia cities. These will be hosted by UNSW's City Futures Research Centre and made publicly available for anyone to use. Each Colouring Australia project will be customised to suit each individual region, and will provide scope for users to interact with and visualise building focused data (and in some cases non-building focused data, such as walkability data discussed in section 5, where a suitable mapping can be performed).

User input can be solicited in the form of data entry/correction for certain fields (the platform provides the option to restrict the fields which can be changed). This means the platform can be used not just as a means for data visualisation and analysis, but as a means for crowdsourcing new data.

Previous work with crowdsourced data (including with the Colouring London platform) has noted potential for noise (Hudson et al., 2018; Girres and Touya, 2010). Some form of data curation is essential; we expect to incorporate such functionality as a combination of manual inspection, automated filtering of input text, and frequent backups.

Finally, the Colouring Australia platform also serves as a means for dissemination of open data (curated, or user generated/refined); users can download dumps of data shown in the platform, with their use in diverse and innovative applications designed for the public good, also encouraged.

5. USE CASE: WALKABILITY

Walkability is an example of an urban attribute of such interest and curiosity that platforms already exist just to display walkability metrics, such as walkscore.com. However, commercial

[2] Link available: https://github.com/UNSW-CFRC
[3] Link available: https://github.com/microsoft/AustraliaBuildingFootprints

Figure 2. Building footprints in the CBD and inner suburbs of Melbourne with walkability data

metrics such as Walk Score are opaque in their construction, and thus do not function as repositories of open urban data. It is widely identified that cities where more people can and do walk for transport experience benefits such as improved public health (Talen and Koschinsky, 2013), robust property values (Roper et al., 2021) and decreased environmental cost of transport (Larouche, 2012). Less agreed upon, however, are exactly what physical features of the environment affect whether people can and do walk, with varying features used in published metrics (Maghelal and Capp, 2011).

5.1 Walkability Index Design

The walkability index currently presented is based on pedestrian multi-activity accessibility, ie. the travel time by foot to a "basket" of commonly visited destination types, such as employment, shopping, education, entertainment and public transport. The impetus for basing walkability on destination accessibility is found in reviews such as Saelens and Handy (2008), which found proximity to destinations had the strongest evidence of relationship to walking, compared to density and aesthetic qualities.

The index uses a standard gravity model formulation where the potential for walking between an origin and destination is proportional to the attractiveness of the destination, and reduced by the impedance between the points. In this case, the attractiveness is taken to be the same (1) for all destinations in each category, except employment where the number of jobs at a location is used. The impedance is a exponential of the network distance, using a pedestrian-accessible network, and a uniform distance decay constant of 0.001 for all destination types. This formulation does not change based on the different possible emissivities of buildings with different numbers of inhabitants (residents, workers etc), as it is not trying to model the absolute number of walking trips, but rather the potential of the environment around the building for each possible walker.

The inclusion of walkability is an extension of the original Colouring Cities concept as it is not a building attribute, but rather an attribute of the location around a building. However unlike previous methods of calculating walkability which were often at a neighbourhood level, our method produces a separate value for any particular origin point in a city. Choosing building footprints as origins is a useful way of disseminating and visualising this fine scale data, thus supporting the inclusion of the walkability index in Colouring Australia.

Data on destinations is from OpenStreetMap, the Australian Bureau of Statistics, and NSW Spatial Services. The pedestrian network used is from OpenStreetMap with some manual cleaning. The full code to produce the walkability index is available on Github (Roper, 2021).

5.2 Validation

The incorporation of the walkability index is partially motivated by the potential use of the platform to crowdsource insights on walkability. Two approaches are planned:

5.2.1 Data collection about specific locations on the public platform. This takes the form of questions below the walkability index, allowing users to input their own perceptions of walkability. Below the walkability index shown, the tab will show questions such as "Do you agree with the walkability score for this location?" . This will be accompanied with a slider allowing users to enter their own perception of walkability in this location, by dragging on a scale from 0 to 100, in line with the scale of the index. The dashboard will show other users' answers, and how many people have commented on each building, to build engagement by attracting attention to popular locations.

Further questions will ask about specific aspects of perceived walkability. There is relatively little research on perceived walkability, and what does exist is often trying to answer the question of how perceived vs 'objective' walkability is linked to walking behaviour (Arvidsson et al., 2012; McGinn et al., 2007). Our aim with data gathering via Colouring Australia is to collect opinions on separate facets of walkability: destination accessibility, walking experience, and walking behaviour.

Destination accessibility refers to the destinations available by walking, while 'walking experience' is here used as catch-all

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term for whether an area is pleasant to walk around. Walkability research focusing on walking behaviour has sought to measure both facets (Forsyth et al., 2008), yet pleasantness is harder to measure objectively, with a profusion of possible indicators (Day et al., 2006). The current walkability index on Colouring Australia is focused on answering the walking accessibility question: what percentage of their needs an average person in this location could satisfy by walking. But in future data gathering, we are interested in whether public perceptions of 'walkability' overall align more closely with destination accessibility or with walking pleasantness/enjoyment.

5.2.2 Workshops in conjunction with the Smart Data Smart Cities conference In addition to publicising the platform, workshops will be held, initially recruiting conference attendees and other stakeholders in the field. The decision-support theatre of the City Analytics Lab at UNSW will be used to display the Colouring Australia platform on multi-touch screen tables. Workshop attendees will be able to contribute in two ways: by entering data on the platform (as above) and by contributing to an instrument gathering opinions on the relative weighting of destination categories, other aspects of the index design, and potential use cases.

Both of these validation activities engage participants as active constructors of the information on the platform. The Colouring Australia interface shows users that their input is immediately reflected by the platform (unlike a survey with aggregated research results possibly available years later). The latter activity is an opportunity to leverage expert local knowledge from conference attendees in order to further develop the walkability metric, and the user interface of the interactive platform.

5.2.3 Data Interpretation As discussed in Technical Architecture, the granularity of data in the Colouring Cities platform is at building footprint level. Our walkability index can show fine gradations in pedestrian accessibility from one building to the next, but users are unlikely to input results for multiple nearby buildings, or be able to decide on small differences between them. Therefore, interpolation can be used to deduce perceived walkability results for buildings that are close to buildings with submitted data. Another difference from the original design of Colouring Cities is that Colouring assumes one correct value of data for any given attribute of a building (eg age, size, current use), and any user updating the building attributes overwrites what was there before. We are interested in collecting multiple values of perceived walkability for any given location, and therefore multiple values will be shown for perceived walkability, along with an aggregate value.

6. CONCLUSIONS

In summary, the CCRP is unique as a programme that works with diverse stakeholders, at national and international level, to identify over 50 types of spatial data required to improve building stock sustainability, efficiency, quality and resilience, to increase understanding of the stock as a complex dynamic system, and to ensure relevance to those designing, constructing, managing, monitoring, conserving, retrofitting, analysing, researching into, and using buildings.

A key aim of the platform is increasing public engagement and transparency. The Colouring programme uses colour to maximise accessibility and inclusivity, promote diversity, and bring together and celebrate the expert knowledge of citizens, and of building professionals working across science, the humanities and arts. The future of CA requires testing the efficiency of multifunctional open data/digital mapping platforms that double as performance tracking and public auditing tools, and free public education resources, and exploring the potential to support building attribute data capture in emergency situations.

CCRP and CA experiment with a number of data capture methods, including computational approaches and crowdsourcing, as well with feedback loops between these, to maximise data richness and quality. Walkability has been shown as an example of this approach. Potential benefits of sharing open walkability data include more informed housing choice, and impetus for walkability improvements from engaged, informed citizens. The example of walkability data also shows the potential of open data platforms for representing more abstract data on people's lived experience of their cities, as well as the concrete data of building attributes and street networks.

The walkability use case shows how as the Colouring Cities Research Programme grows and evolves, it can also become a powerful tool in a research pipeline: taking existing research outputs, visualising these, creating engagement, and gathering more data on stocks across the globe. By using the Colouring platform in this way, Australia will have the benefits of a data platform joined and aligned with data from many dimensions, a robust common infrastructure, and increased possibilities of comparing and sharing its data, and testing innovative features such as the walkability index, across the world.

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