Mobile Crowdsourcing Older People's Opinions to Enhance Liveability in Regional City Centres

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***Abstract*—With larger numbers of older people living longer, an increasing proportion of the population will require a more supportive and responsive regional city environment. However, regional local governments have neither the resources nor the appropriate tools needed to understand and respond to the infrastructure needs of older persons. As mobile devices such as tablets and phones proliferate, there is an opportunity to use mobile apps to engage older people more effectively with their local government associations in planning the future of their regional city centres. In this paper we discuss the potential of this application for crowdsourcing older people's opinions as a form of community engagement. The application was developed in partnership with the Local Government Association and the partnership of the two regional local governments who participated in our pilot. We begin by describing the architecture of our platform, addressing choices regarding user interface design, modes and models for data capture, and standards guidelines. We then discuss methods we use for analyzing and visualizing the collected data to facilitate better decision making by governments. Lastly, we discuss the results of the field trials of our platform with mobile focus groups comprising senior citizens in two coastal regional cities in New South Wales, and interpret how our findings relate with the planning and development of these towns. Our work is the first step towards the use of mobile technologies to enable large scale data collection that can lead to smarter and more liveable cities for senior citizens.**

I. Introduction

The world population is ageing at an unprecedented rate, largely due to falling fertility and mortality rates – whereas only 10% of the population was 60 or older in 2000, this number will rise to 21% by 2050 [10]. For the first time in history, by 2050 the number of older persons will exceed the number of young. In western countries, the problem is more acute – for example, Australia's proportion of people over 65 years of age increased from 12.8% in 1998 to 14.5% in 2011, and is predicted to grow to 25% by 2051 [5], [11]. Given these growing numbers, it is in the interest of society to have older people live in the community rather than enter aged care, and it is recognized that an enabling and supportive environment increases the chances of continued community living, as well as longer and higher quality life outcomes [9].

The World Health Organisation (WHO) has prioritized the identification of environmental and social factors that contribute to active ageing in urban settings. The immediate built environment conditions, such as the design of pedestrian paths, transport infrastructure, availability of open space, provision of street furniture, and safety and security in public spaces, have been identified as critical factors in increasing the mobility of older people, that reduce isolation and depression [5], aiding in positive and active ageing [8]. Addressing these problems is particularly urgent in regional cities, which are ageing faster as people retire and move away from urban areas. Further, regional cities are more disadvantaged than their urban counterparts, due to lower budgets and lack of resources to address these concerns.

Over the past several decades most developed nations, including Australia, have enacted a number of pieces of legislation to control and direct planning and infrastructure outcomes, with a view to reduce discrimination against groups such as the disabled. However, insufficient attention has been paid to the needs of the "older user", and as a consequence in many instances the wider built environment outcomes have been reduced to compliance with a set of minimum standards. Unfortunately, such guidelines often group older people with the disabled, and view them as a homogenous group of wheelchair users, thereby disenfranchising the functionally impaired with hidden disabilities like emphysema and arthritis. Moreover, human functional and size variability is generally poorly understood, and the use of a narrower range of variation than is in fact present in our older population has led to the failure of our current physical infrastructure to accommodate older people appropriately.

Overcoming the above challenges requires a better understanding of older peoples responses to city structure and environment, taking into account their number, location, disabilities (physical, sensory, cognitive), and age skew. The smart city of tomorrow cannot rely on legislation and minimum standards to create age-friendly town centres, parks and facilities. It should instead engage actively with the community to develop everything from seating design and the width of footpaths, to the planning of transport, roads, amenities, public spaces and housing. It is also critical to understand not just what fails but also what enables, such as additional services, landmark buildings, etc., as our cities are in a constant state of flux, and therefore monitoring, maintaining and enhancing built environment enablers is also important. This requires governments to have tools using which they can actively engage with residents to develop an empirical base of what works and does not work in their local community, and to act upon such accumulated information to make optimum decisions. The development of such a tool that empowers citizens and governments is the subject of this paper.

We describe an innovative iPad application we developed to allow active older people to voice their perspectives, both positive and negative, about aspects of the built environment as and when they are encountered. Our app is designed to be easy-to-use, has an underlying model for the data capture and standards guidelines, and provides a rich interface that geocodes user annotations and includes pictures and voice recordings. The app provides a vehicle by which a local council can crowdsource over time much more information about the suitability of the built environment than was previously possible using phone calls and spot surveys. We trialled our app, in conjunction with local government, in two coastal regional cities in New South Wales, using mobile focus groups comprising volunteers over the age of 60 from the community. The data that we collected is aggregated, analyzed and mapped by our back-end system, and reveals several aspects that can be used by local councils in addressing these issues. We relate our findings to the history, development, and planning of these regional cities, and discuss the potential for such technology to transform the way governments engage with citizens to enhance liveability for older people in the community.

The rest of this paper is organized as follows: in §II we survey prior work that has been done in this area, including current methods used by governments for data collection, and emerging apps that address specific aspects of the built environment. In §III we describe our overall system architecture and iPad app , and in §IV the back-end database and visualization of results. §V describes our field trials in two coastal regional cities in New South Wales, and the paper concludes in §VI.

II. Background and Prior Work

The WHO, using a participatory action-based form of research, has developed a comprehensive guide as to what constitutes an aged-friendly city [12]. Our work in this paper addresses the three WHO topic areas most relevant to the built environment, namely social participation, outdoor spaces and buildings, and community support and health services. Further, the age-friendly built environments report [5] uses six fact sheets to determine relevant strategies, including: (a) Promote age-friendly built environments, (b) Create safe and secure pedestrian environments, (c) Foster age-friendly community planning and design, (d) Improve mobility options for seniors, (e) Support recreational facilities, parks and trails, and (f) Encourage housing choices. Each fact sheet includes a list of initiatives local councils could use to support age-friendly built environments. However, the methods used to source the the data needed to customize, prioritize and implement these strategies in a local area are largely based on surveys and town-hall meetings. It is unclear if the data obtained from such methods is representative of segments of the population that are most affected by these decisions, since the less mobile and less vocal citizens are at risk of being excluded.

The growth of mobile technologies presents an opportunity to engage citizens in community issues at their leisure and in a comfortable setting without inherent time and social pressures, and can augment existing methods at very low cost. Several mobile apps relevant to local government have been launched in the past few years, see the recent survey [3]. One example is FixVegas [4], a free mobile iPhone application that allows users to submit photos and reports to their local council regarding things that need to be fixed, such as blocked drains, potholes, cracks in footpaths, etc. Another example is the myDistrictD app for Apple and Android platforms that allows users to report graffiti to their local council. Yet other apps, such as WalkScore [6], crowdsource data to find neighborhoods where people can walk more and drive less. Several councils in New South Wales have begun to offer personalised services for residents via apps, such as for waste collection bookings, shuttle bus tracking, parking availability, local events, and problem reporting. While all these apps are indeed useful, they are special-purpose in tackling only specific aspects of the built environment. Moreover, they seem more appropriate for tackling immediate problems, and the collected data does not seem to be used by local governments for strategic planning purposes, especially for older groups in the community.

Our work takes a more holistic view of strategic planning for age-friendly cities, and we aim to work closely with local and state governments to develop a system that can be used for long-term understanding of the impact of the built environment on the independence and well-being of older residents. There is evidence that seniors are increasingly taking up smart tablets, such as the iPad, as a way to read books, exchange emails, view photos, engage in social networking, and chat with their grandchildren. By empowering them with an easy-to-use app that lets them voice their opinions on any good or bad aspect of the built environment, and by integrating such collected information into government databases, we can help citizens be heard better, and help governments better align their planning with community needs. The architecture of our system that aims to meet these needs is described next.

III. System Architecture and Mobile App

The system we set out to build requires us to develop an easy-to-use app that allows general users (including senior citizens) and council workers to enter information about (aka "audit") objects in their built environment. The information should be as rich as possible, including photos and audio commentary, and aggregatable over a population, such as by including numeric scores. The audits are uploaded and stored centrally at a database server, which is designed with an underlying data model that enables easier aggregation, analysis, and comparison with standards. The processed data can then be mapped and visualized to provide feedback to councils so they can easily identify issues and trends that

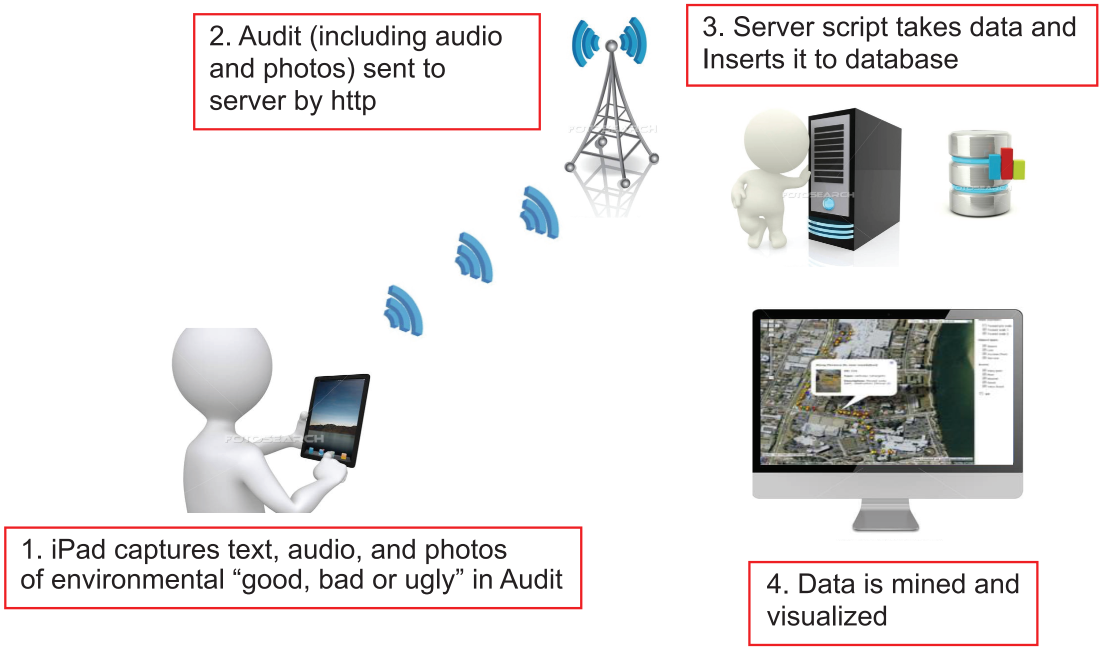

Fig. 1. Overall system architecture

require remedial or preemptive action. The architecture of the system that we developed to meet these objectives is shown in Fig. 1. In the rest of this section we briefly describe the iPad application design, while the server database, analysis, and visualization will be described in the next section.

Our app for the Apple iPad and iPhone is written in Objective-C for iOS v5.1 or later, and is available from the app store under the name "Liveability" (we expect to release an Android version within a few months). Support in the form of a training video is available via the project web-page [13]. The app communicates with our server to retrieve data (such as objects in the user's vicinity) to display to the user, as well as to upload data from the user (such as audit ratings and photos). Our app uses the HTTP protocol for all interactions with the server, and is stateless to simplify design and prevent data loss in the event of crashes. The text data is wrapped in JSON format, while for media we reduced communication overhead by employed compression: audio files of original size 1-3 MB in caf format are compressed using IMA4 down to 270-860 KB, while photo image resolution was modified to reduce file size from 1-1.5 MB to 200-500 KB.

The overall layout of the application screens is shown in Fig. 2. It consists broadly of four sections: the login/registration screens on the left, the objects themselves viewed in a map or as a list in the top-middle, object details in the bottom-middle, and the object audits on the right.

Login and Registration: The application can be run in "individual mode" whereby a user registers, logs in by entering their email address, and enters their perceptions on the built environment around them. Alternatively, the application can be run in "group mode", typically by a local council worker who organises a session with some volunteers, and in this case the app lets the group record its composition and weather conditions.

Objects in Map and List View: After login, the screen transitions to a map view, centred on the user's current location. The best possible accuracy for location determination provided by the software was used, and though this was found to consume significant battery power (reducing battery life from the typical 7.5 hours to approximately 4.7 hours), it was deemed essential for correct identification of objects based on location during our field trials. On the map, icons are shown corresponding to the objects in the user's vicinity, as shown on the screen marked "objects on map" in Fig. 2. Alternatively, the user can see the objects as a list, as shown by the next screen titled "objects as list" in Fig. 2. The objects are retrieved by the app from our server, which contains a database repository of known objects, obtained from a combination of white pages, council database of assets, and previous entries by users. The underlying information model used for storing and accessing the objects and their audits will be described in more detail in the next section.

Object Details and New Objects: Detailed information can be obtained on an object by tapping on it (in the map or list views). These include the object type (a pre-defined set from our data model described below), a name (common name such as "library lawn clock"), a comment (describing the object, such as "this clock is to the west side of the library building"), and a photograph. The user can also create a new object at their present location by clicking the "+" button. Objects can now be "audited" as described next.

Audits and Comments: Our app allows an object to be audited by a specialist, such as a council engineer who is checking for conformity of the object with standards guidelines (e.g. whether the ramp gradient is within prescribed limits), as well as by a lay user who wants to enter some general comments on the amenity (e.g. regarding how slippery the ramp gets for them in wet weather). To accommodate

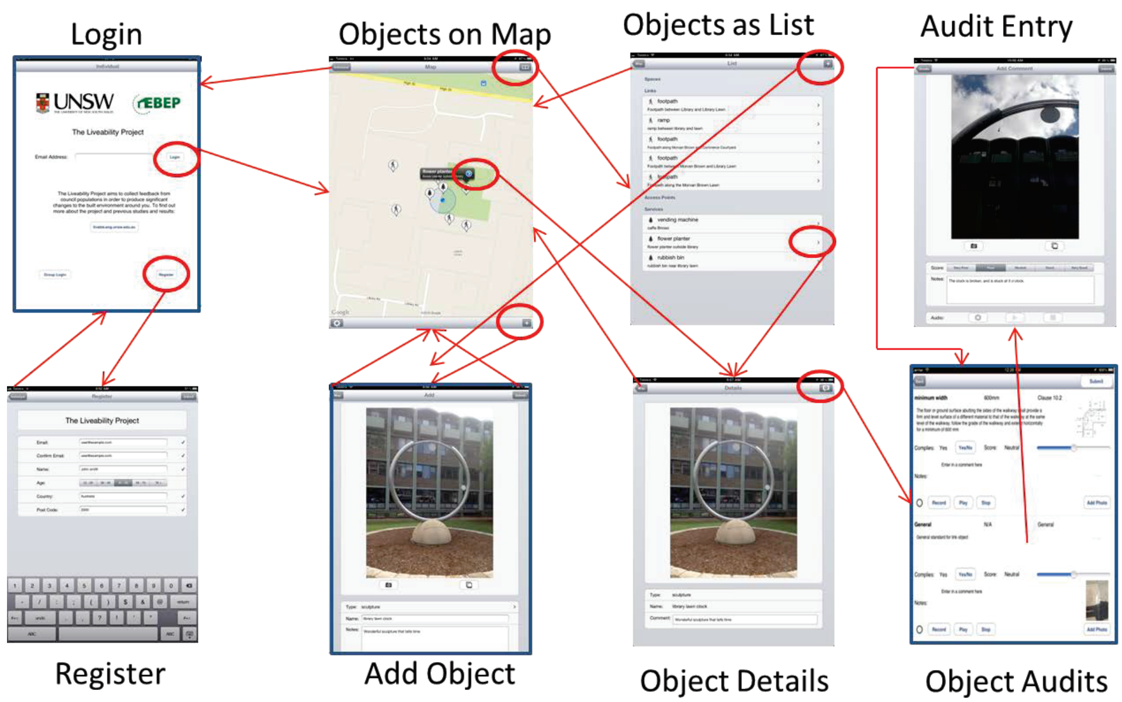

Fig. 2. Layout of application screens

these differing requirements, our back-end database associates one or more standards guidelines with each object type, and the corresponding audits are automatically downloaded by the app when the user selects an object. For example, the bottom right screen in Fig. 2 shows two audit entries – the first is based on Australian Standards (AS1428 series) clause 10.2 that stipulates a minimum width for the walkway object (and additionally includes a description and image clarifying the standard), whereas the second audit entry is general, allowing any user to enter general comments on the walkway. The audit includes a score for the object on a 5-point Likert scale (very poor, poor, neutral, good, very good), text-based notes, a photo to highlight the particular aspect of the object that is good or bad, and a voice memo (so these can be relayed to decision-makers in the citizen's own words).

IV. Data Storage, Analysis and Visualisation

Our server hosting the data is located at the University data-center, and uses the LAMP configuration (Linux operating system, Apache web-server, MySQL database, and Python application software). The data is managed on the server in a MySQL database. The Django framework provides interface between the MySQL database and the iPad application via the well established HTTP get protocol (served by Apache) and the JSON strings passed to the server are converted into the data structures they represent by the python back end. A user interface to the uploaded data is provided for the administrator by Django in the form of an authenticated web interface.

The data model we use in this project is derived from the one co-developed in an earlier work by one of the authors for computer assisted accessibility auditing [2]. There are four categories of physical objects, namely; spaces (buildings

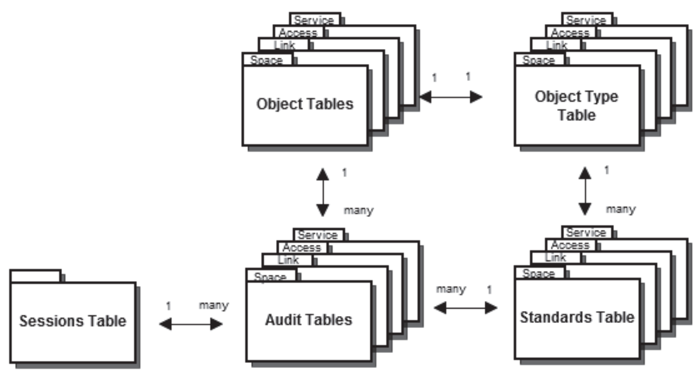

Fig. 3. Database Schema

and parks), links (walkways and ramps), access points (doors and gates) and services (park benches, telephone booths, and toilets). There are specific types associated with each object, allowing it to be assessed against the specific standards guidelines. The database structure is shown in Fig. 3. Objects are stored in tables, one corresponding to each of the four categories described above. Each object has a many-to-one relationship to the type, which is also stored in tables, one per category. Each type is associated with one or more standard stored in the standards table (recall that every type has a "general" standard that allows the lay user to enter free-form information about the object). Lastly, the audit table stores the actual entries from users, where each entry associates one object with one standard for one session (user). This scheme is simple yet powerful, allowing arbitrary expansion to accommodate new standards, object types, and users.

The audit/comment data entered by users can be viewed (in real-time or later) on a dynamically generated map at the project web page (examples will be shown when we describe

Fig. 4. Route of Tweed Heads Walk and Talk along with Results Visualisation

our filed trials next). These maps are generated using location data from the MySQL database and javascript functions obtained from GPSVisulasation.com. Audit data points on the map are shown by coloured markers (very poor is red, poor is orange, neutral is yellow, good is green and very good is dark blue), giving a quick visual indication of the audit scores, and can be used to identify regions that need more attention. Clicking on any data point will bring up a speech bubble that shows data for the audit, including image, name, IDs, session from which the data was collected, and a link to the audio. In addition to maps, we also generate bar graphs and plots in various dimensions, and perform keyword searches and analytics on the user notes/comments to identify specific patterns and trends. For example, one can ask what type of object is most useful or problematic in the community, and whether road crossings or trip hazards are bigger obstacles to mobility for older people. Specific analysis of the data collected during our field trials is presented next.

V. Field Trials

We built a fully functional system, including our iPad app, back-end database and server web-interface, and did pilot runs (called "walk-and-talks") with local council support in two coastal regional cities in New South Wales. We obtained appropriate ethics approvals to conduct such trials, and recruited volunteer older people from local walking groups. The walk and talks are similar to mobile focus groups and involved walking along a 400m pre-defined walking route in the town centre, auditing the built environment from the older peoples perspective and identifying possible hazards or problems as well as features of the town centre that were pleasant or supportive. This allowed the older people who participated to have a structured conversation about what they see as the positive and negative aspects of the town centre in relation to active ageing and what they view as possible solutions.

Before each walk and talk, members of the research team met the groups of older people at the pre-arranged start point of the walk route. The aims and purposes of the project were explained further, and consent forms and the quality of life survey were administered to participants. The group then followed the nominated walking route, pausing often to audit the built environment, take photos and discuss positive and negative aspects of the town centre as the group walked towards the end of the route. In the walk and talks the older people themselves did not use the iPad application and instead members of the project team entered data as the volunteers commented on objects along the route.

A. Tweed Heads

Tweed Heads was chosen as one of the regional town centres in which to hold a field trial due to the fact that one in four of the total population is already over the age of sixty and it is the fastest growing area for older people in New South Wales outside of Sydney [1]. Two sessions were conducted in Tweed Heads North, occurring at different times of the day and different groups comprising of five and three older people respectively. The average age of the volunteers was about 68 years, and they were all physically fit as they were all part of the local walk group.

In all, around 100 audits were performed with the volunteers in Tweed Heads on the walk and talks. The overall results can be seen visually on the map in Fig. 4. As can be seen, there were relatively few positive comments (15%), and 85% of all comments were neutral or negative. The majority of comments (53%) were made about objects classed as a link (linking aspects of the built environment such as roads, footpaths and other walkways). This was followed by objects classed as "services" (publicly provided infrastructure for use by individuals, such as public toilets and park seating or benches), which received 37% of comments.

Most comments about links were negative (given a score of 3 or less). Comments relating to links were primarily concerned with various trip, slip or fall risks (54%), ramp slopes (18%) and the need for indicated pedestrian crossings (20%). Trip hazards, which concerned 28% of the comments, were attributed to: 1) uneven surfaces, caused by changes in material types or poor maintenance; and 2) temporary obstructions, such as fallen palm branches, trolleys and construction fences. There were a large number of comments on the vegetation, including trees and shrubs. Negative comments centred on the need for maintenance of fallen branches etc. along the walk route. However, some of these trip hazards had been flagged by the council as present and in need of attention at the time.

Positive comments centred on the wide walkways provided by pedestrian paths, as well as colour indication for slopes.

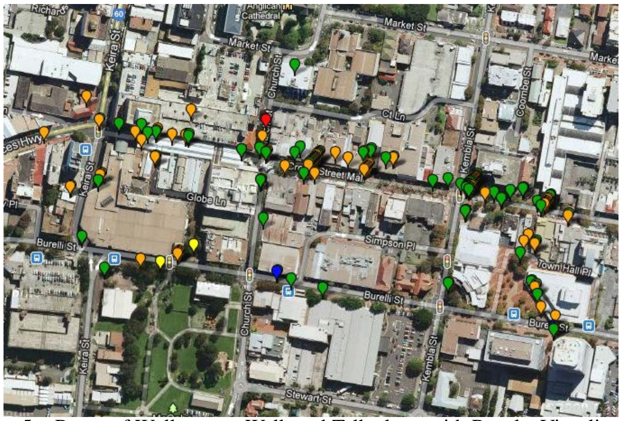

Fig. 5. Route of Wollongong Walk and Talk along with Results Visualisation

The participants were very positive in their comments about the businesses and services along the walk route in the town centre, and their close proximity to each other, allowing for ease of access. The groups particularly noted the "After Hours Surgery" on Wharf St as very valuable. However, in terms of public services, a number of comments made by the walking groups as they progressed along the route were concerned with the lack of benches and rubbish bins or the insufficient amount of street lighting provided.

B. Wollongong

Wollongong was chosen as one of the regional town centre due to its involvement in the Better Cities Illawarra program [7] and costal location. The Wollongong trials involved two groups, one in the morning and another in the afternoon, taken on the route shown in Fig. 5. The volunteer groups consisted of eight people in all, with an average age that was higher than Tweed Heads, but the volunteers were also fit and part of a community group for older people.

As shown in the map of Fig. 5, the predominance of green colored markers indicates that people in Wollongong had a fairly positive perception of their built environment, with an overall rating of 51% positive comments and 49% being neutral or negative. The majority of comments were about spaces (39%), followed by services (33%) and links (28%). In terms of links (footpaths and other walkways), as in Tweed Heads, the vast majority of comments were negative. Of these negative comments, many (57%) negative comments were about trip hazards, with causes mainly associated with brick being used as a primary footpath/walkway building material and not being properly maintained for loose segments. However, other Wollongong participants noted that the brick material used was locally sourced, potentially explaining its usage over other materials.

Positive comments about links focused on the wide walkways provided that allow prams, shopping trolleys and mobility aids easy access to footpaths, and on to scramble intersections. Participants commented positively on public signage indicating security, such as the presence of the police station and 24hr security of the street mall. Audits were negative on the reputation of some parts of Crown St. There was an indication that the signage acted as a deterrent to this perceived threat. The Wollongong groups also commented that the disappearance of public drinking houses in the area reduced public access to toilets in the evenings.

There were also a large number of comments concerning the historical importance of the Wollongong town centre, and the benefit of preserving historical sites and buildings. The participants of the walk and talk groups were generally positive about preservation of building facades, and negative about businesses such as pubs and bookstores disappearing. Participants were divided on the "bird cage" structure in the town centre: some felt that the structure was out dated, provided no cover, made the area cluttered and was "depressing" in winter; while a few others disagreed. This seemed to indicate that participants prioritised practicality over historic gestures. A possible reason for this might be that many of the volunteers had lived in the area for a very long time.

C. A Comparison

Tweed Heads North and Wollongong are two different costal town centres – the first has a fast growing older population, while the second has an older population that is growing with the city. By contrasting the two we hope to identify positive

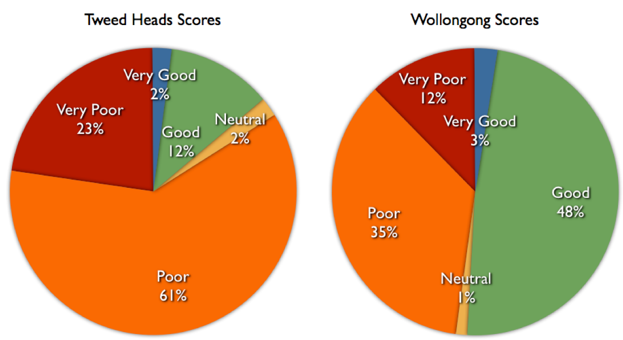

Fig. 6. Comparison of Score distribution

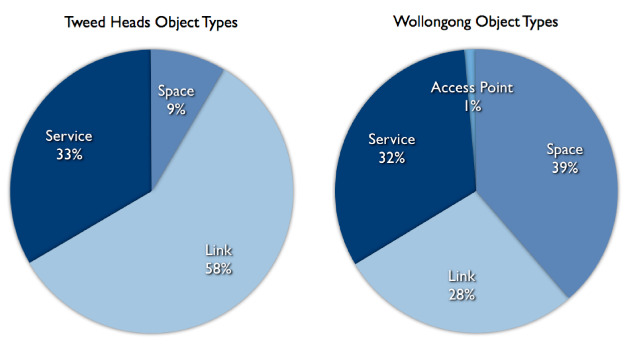

Fig. 7. Comparison of Object Type distribution

Overall, we can see from Fig. 6 that the groups in Wollongong have a much more positive perception of their city centre than those in Tweed Heads. We believe the most important reason for this is that Wollongong has for many years been part of the Better Cities Illawarra program [7] and has hence seen more planning effort to accommodate older people. A secondary reason could be that the residents in Wollongong have in general been living there much of their lives and have developed a strong emotional attachment to it, unlike Tweed Heads where many residents moved in post-retirement.

In terms of **object categories** that received most comments, Fig. 7 shows that Tweed Heads had a majority of comments about links (53%) followed by services (37%), whereas Wollongong residents commented mostly on spaces (39%) followed by services (33%). Regarding **trip and slip hazards**, both Tweed Heads (25%) and Wollongong (11%) had several comments, all of them being negative for the injuries they could potentially cause. Service covers in both town centres were always pointed out as trip hazards. Additionally a number of slip hazards were noted in Wollongong pertaining to the leaves from trees in autumn. Nevertheless, participants from both areas commented positively on the large width of walkway areas.

Both Tweed Heads and Wollongong residents commented positively on the availability of **services** in the town centre. This demonstrates why centralising the services needed by older people can improve older people's experience in the town centre. Both locations commented on the availability of **benches**. Tweed heads residents were generally more negative, noting there were no benches along most of the walk, and that the benches outside the shopping centre were inappropriately located. Wollongong residents were more positive in noting the greater availability of benches along the walk route; however they did note the protruding bolts on the benches as a problem and the presence of smokers in the area as decreasing the availability of viable benches.

Several other issues were noted to different extent by residents of the two towns. **Signage** was a problem in both. Shared walkways (bike and pedestrian in Tweed Heads; bike, pedestrian and car in Wollongong) did not have very visible signage, however Wollongong did have line markings. Signs to indicate road names and directions were mainly for road traffic and not pedestrians (e.g. street sign in the middle of the roundabout in Tweed Heads). The species of **trees** along walkways on the route were also noted. Tweed Heads responded positively to native species and negatively towards poorly maintained vegetation. Wollongong were very positive about the deciduous species of tree, however noted that the wet leaves were dangerous and were a slip hazard. Both towns noted the availability of public **phone booths** as positive, as participants pointed out that mobile phones are not ubiquitous or infallible. Both locations commented on cleanliness and the availability of **bins**. A distinct lack of bins was noted in Tweed Heads and while there were positive comments about the number of bins in Wollongong, there were still not enough. Several of the (seemingly minor) issues noted above can have a large impact on quality of life for seniors, but are difficult to ascertain without engaging with residents. Using our mobile crowdsourcing system can facilitate this at low cost, unlike today's methods that rely on paper surveys or town hall meetings.

VI. Conclusions and Future Work

As the population ages, improved neighbourhood design that better satisfies the needs of older people will not only increase their active participation and the capacity of older people to age in place, but will also enhance the accessibility, safety, and hence the social sustainability and cohesion of the wider community including those with disabilities. To this end in this project we have developed a system comprising an iPad app, back-end database, and server for analysis and visualization, that together enable local governments to engage with older residents to collect large-scale data on the adequacy and quality aspects of their built environment. Our field trials with local residents in two regional cities have shown promising results, and helped local governments to see residents' perspectives on the relative importance of issues. As budgets tighten, we believe a system like ours can greatly outperform traditional paper-based surveys and town-hall meetings as way for local governments to prioritize their expenses and plan towards a better environment for their ageing residents. Our future work includes releasing an Android tablet version, improving the app for greater user engagement, and making it more usable for the mildly impaired and disabled.

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