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Introductory Chapter: The Role of Assistive Technologies in Smart Cities

Marion Hersh, Marcelo Gitirana Gomes Ferreira and
Alejandro Rafael Garcia Ramirez

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1. Introduction

1.1. What is a smart city?

There is not (yet) a generally accepted definition of the term 'smart city'. However, 'smart' systems are often considered to have the following three characteristics [1]: (i) the provision of technological assistance, including through the use of a combination of a physical infrastructure and information and communication technologies (ICT); for carrying out activities; (ii) information sharing and networking between different applications, systems, services and/or appliances and (iii) the application of the combination of ICT and other technologies, information sharing and networking with the aim of improving the quantity or quality of systems, services or applications provided.

These three characteristics can also be used to define smart cities. Smart cities have the potential to provide higher quality, more accessible services at a lower cost [2]. In addition, they have the potential to improve the city environment, the quantity and diversity of services and quality of life. They may have particular benefits for disabled and older people and may reduce or eliminate some of the barriers they might otherwise experience to participating in all aspects of life and enjoying the same opportunities and quality of life as non-disabled and younger people.

As will be discussed further below, smart cities have considerable potential to improve quality of life for both disabled and older people and the population as a whole. Technological and other systems also have disadvantages, but the focus has been on positive applications, with minimal attention to any potential disadvantages or problems. One potential problem is

avoiding unauthorised access to personal and confidential organisational data and ensuring that citizens are able to manage their privacy in a way that enables them to make the maximum use of applications. This is important because privacy is valuable both in itself and to avoid risks to disabled and older people and other groups who may be seen as soft targets by unscrupulous people. Attention to privacy management could improve the design of smart cities. In addition, though beyond the scope of this chapter, the very aspects of smart cities that give them their positive potential also give rise to the potential for abuse, whether by totalitarian regimes to remove civil liberties or by more ordinarily corrupt city administrations to hide their excessive expenses. Awareness of such possibilities could be used to design in safeguards to reduce the likelihood of abuse.

1.2. Smart homes

Interest in smart cities is relatively recent, though a body of literature has developed. Smart home technologies date back to the 1970s home automation technologies. A smart home involves the use of sensors, actuators and computational units to interconnect appliances and other features and anticipating and responding to the occupant's needs by means of ICT [3, 4]. Alternatively, a smart home involves systems equipped with sensors and actuators to enable them to communicate with each other, monitor the occupants and support them in their daily activities [5]. This integration of home systems, including with the assistance of multi-agent systems, allows communication between them through the home computer and the simultaneous control of different systems in operating or pre-programmed modes using speech and single buttons [6]. Data mining and machine learning techniques can be applied to this data to discover frequent activity patterns and predict events to support automation of interactions with the environment and enable context-aware responses. Adaptation to changing requirements can also be facilitated by context awareness [7].

Active or passive radio frequency identification device (RFID) tags which are able to identify people, animals and objects and which are now inexpensive can be used to support the smart and context-aware functions [7]. Mobile robots with RFID readers can be used to navigate tagged environments and locate and move objects. Technological advances have enabled sensors to be located in the environment rather than on the robot, reducing its size and weight [7]. However, despite various proposed solutions, RFID tags are an insecure technology and could be used to track people and their activities [8, 9].

Initially, smart home design was based on a centralised architecture with all appliances connected to the home network and controlled by the home gateway. However, the availability of ubiquitous computing devices has enabled the use of distributed architectures with incompatibility between different products avoided by the use of open standards. Options include the Open Services Gateway Initiative (OSGi); a peer-to-peer architecture with multiple platforms [10]; and a generic five-layer context stack with each layer having a different function [11]. The OSGi is generally based on the client-server model, and is unfortunately at risk of single point of failure in the home gateway [10]. The use of multiple platforms can avoid this by distributing the working load over the system with service-oriented components augmented by mobile agent technology for system interaction [10].

There has been some involvement of disabled people in smart home design. Consultations with them have obtained the following preferences [12]: (i) lights turning on automatically when they return home, go into a room and at night; (ii) access to a garden and items of equipment; (iii) security, including an option for viewing visitors at the front door before opening it; (iv) automatically closing curtains and insulating shutters at night; (v) an 'ordinary' external appearance; (vi) a non-open-plan layout, with sufficient space for manoeuvring and activities and (vii) a self-contained home in a central, secure, quiet, private location on the ground floor and on level ground. An investigation of different projects has found a greater focus on physical and functional health rather than social interaction, possibly because it is more difficult to integrate social interaction technologies [13, 14]. Examples include the Portsmouth Smart Home [12] and The Intelligent Sweet Home [15, 16] developed at KAIST, Korea and aimed specifically at wheelchair users. There are also home healthcare (telemedicine) applications, for example, [17].

1.3. Smart city technologies and applications

While an initial smart cities approach could draw on smart home technologies and link some or all buildings in the city, smart cities have considerably greater potential. They may involve various stakeholders, including citizens, city administrations, local projects (non-governmental organisations), private firms, researchers and educational institutions. They can support city administrations in providing services of different kinds and promoting culture and education [18]. Citizen-centred approaches to smart cities with a focus on people rather than technology, administration or business are likely to be particularly valuable. One model involves an ecosystem of participative innovation [19] leading to innovative user-centred services and needs to be supported by new models of city government [17].

Smart city applications generally rely on perceivable or ubiquitous sensing, and anytime/anywhere access and control [19]. The available infrastructure (including sensors, personal technologies, smartphones and use of the Internet) allows the exploration of different options for development, quality of life, welfare and the economy [20]. However, they are not some sort of universal panacea. As well as opportunities, bringing a large number of people together in a relatively compact geographic area can also lead to problems which smart city approaches are not able to resolve.

There has been particular interest in the use of the Internet of things (IoT) as an enabling technology for smart cities [21]. The IoT involves a proliferation of different types of devices which are wirelessly interconnected and interacting [22]. Sensors and actuators are integrated into the environment and information sharing takes place across various platforms. In principle, the IoT can be used to measure, analyse and understand environmental indicators of different types and of different sizes and complexities [21]. Smart city services are generally based on a centralised architecture with a dense and diverse set of peripheral devices [22]. In addition to the IoT supporting smart cities, the very dense techno-social city ecosystems can serve as a useful test bed for IoT research [21]. A number of very different approaches have been used to the design of smart city architectures, but there are some common features. In particular, smart cities are generally data-centric and multidisciplinary [20].

Examples of smart cities include the Barcelona smart city initiative [23], the Padova smart city [22] and SmartSantander [18]. The main aim of the Padova smart city is encouraging early adoption of open data and ICT solutions by the city administration. It is being used to collect environmental data and monitor street lighting via different types of sensors mounted on the lamp poles and connected to the Internet [22]. The Barcelona smart city initiative is part of its strategy for transformation from deep economic crisis and infrastructure deficit to becoming a leading metropolis [23]. Its main components are smart districts, living labs, initiatives, e-services, infrastructures and open data. In particular, smart services have been used to encourage cooperation, innovation and development.

Smart cities have a wide range of different (potential) applications. A hierarchical classification includes the domains of transport, mobility and logistics, education and culture and public administration and (e-)government [24]. At least some and frequently many or most disabled and older people experience barriers to participation in all these areas. Smart cities offer potential solutions, as long as they are appropriately designed to take account of the accessibility and other requirements of older and disabled people. In some cases, it may be necessary to target solutions at particular groups of disabled or older people.

However, there are advantages in design for all/universal design to make all (smart) facilities and features accessible and usable by as wide a range of the population as possible, regardless of factors such as age, gender, disability, size, culture and class [25]. Design for all should be considered part of standard good design practice [26]. A set of seven design for all principles have been drawn up [27, 28] including the following: the same or equivalent means of use for all users; accommodating a wide range of user preferences and characteristics; minimising negative consequences of user errors or unintended action; and efficient and comfortable use with a minimum of fatigue. Smart Cities for All [29] is an important initiative for the dissemination of universal design in the ICT business environment. It aims to close the digital divide between disabled and older people and the rest of the population. It is trying to develop the strategies necessary to build more inclusive smart cities in partnership with ICT companies.

Smart city approaches to overcoming the barriers experienced by disabled and older people will only have their full potential if restrictive assumptions about what facilities are appropriate or of interest to them are avoided. For instance, it has been suggested that smart cities should address the needs of older people across the areas of housing, transport, social participation, social inclusion, health care, communication, community support services, leisure and culture [30]. Unfortunately, employment and learning (education, training and informal learning) are not mentioned, though they are equally important for many disabled and older people. The authors also provide a very brief overview of various systems for older people developed and, in some cases, implemented in the Finnish city of Oulu. They include basic IT skills training at home, online grocery order and home delivery and a pilot for nurses to open locks with mobile handsets. However, considering some of the other applications mentioned smart city applications is probably stretching the concept.

This chapter is part of a small body of work on the applications of smart cities to disabled and older people. The focus seems to be health-related applications, rather than using smart approaches to overcome the barriers to full participation, including in employment, education, travel, leisure and other activities. However, other potentially interesting applications

include connecting public buildings and public transport. This could be used, for instance, to determine when a disabled person needs to leave their house to reach a public building in time for an appointment [25]. This type of connection could be extended to, for instance, enable autistic people to choose times when buildings and public transport are relatively quiet. A networked system could be used to provide tactile and audio information and alerts to support unaccompanied travel by visually impaired people [31].

2. Conclusions

Research on smart homes dates back to the 1970s, whereas that on smart cities is considerably more recent. They have the potential to overcome many of the barriers to full participation experienced by disabled and older people. However, this requires consideration of their accessibility and usability requirements, preferably as part of design for all approaches and recognition of the wide range of applications that they might be interested in. To date, there has been very little work on smart cities for disabled and older people or design for all approaches to smart cities.

This book aims to start filling this gap. The five chapters present a number of different approaches to smart city design for older and disabled people. They consider interfaces, design approaches, specific technologies and applications. Haptic interfaces are proposed as a means of overcoming information overload and improved city design based on communication and local clusters is discussed. IoT is presented as the basis of smart city architectures. The applications presented are accessible tourism and health care.

Author details

Marion Hersh¹, Marcelo Gitirana Gomes Ferreira²
and Alejandro Rafael Garcia Ramirez^{3*}

*Address all correspondence to: ramirez@univali.br

1 University of Glasgow, Glasgow, Scotland

2 Universidade do Estado de Santa Catarina, Florianópolis, Brazil

3 Universidade do Vale de Itajaí, Itajaí, Brazil

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