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Jun 25th, 9:00 AM

Identifying inclusive design goals for the blind and visually impaired in Venice

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Identifying inclusive design goals for the blind and visually impaired in Venice

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Abstract: The aim of this paper is to understand how the use of inclusive design methodologies can contribute to the creation of projects for mobility and access to cultural information. Specifically, the research focuses on visual disabilities in a unique context such as the city of Venice. Starting from ethnographic research and a comparison of different case studies, the purpose of this paper is to identify some Design Goals useful to visually impaired users in the Venetian context. The Design Goals definition allowed us to investigate how the use of inclusive design methodologies for visually impaired users can contribute to the creation of products and services for a larger audience in the Venetian context, according to the Design for All methodology.

Keywords: inclusive design, visually impaired, mobility and orientation, cultural heritage

1. Accessibility in Venice

Venice is a unique city in the world for its geographical context and for the great variety of its historical, cultural and museum heritage. In addition to its inhabitants there are millions of tourists who visit Venice every year, with consequent implications also on aspects related to inclusion and accessibility for experiencing the city.

From a morphological point of view, Venice is a particular city: it is composed of about 120 islands connected by more than 430 bridges and these features can be seen as a great "architectural barrier" for people with mobility disabilities. Actually, thanks to the numerous interventions initiated by the municipal administration in recent years (Tatano, Guidolin, & Peltrera, 2017) and to the public transport system, the level of accessibility for people in wheelchairs is much more satisfactory than one might think and almost 70% of the surface of the historic city is accessible (AA.VV., 2009, pp.144-145).

However, accessibility is not only for users with mobility impairments. Accessibility for tourists needs to be designed in its totality, and must include a system composed of urban mobility, transport, museums, cultural sites, hotels and restaurants. If only one of these parts is not accessible, it will constitute a barrier, a limitation of the tourist's holiday and enjoyment, creating a negative impact on the overall experience (AA.VV., 2010, p.15).

The methodologies of Inclusive Design (Coleman, 1994), Universal Design (Mace, 1985) and Design for All (EIDD, 2004) represent an ideal approach to support the plurality and diversity of users. Over the last 30 years, these methodologies have interested many researchers and designers, and issues of inclusion have become relevant in the contemporary landscape. On a national and international level, governments and institutions are incorporating the principles of inclusion into laws and new standards. For example, the 17 Sustainable Development Goals, defined by the United Nations as a strategy to achieve a better and more sustainable future (AA.VV., 2020), provide recommendations for inclusive design.

As expressed by the Design Council, in order to determine the involvement of multiple users and to develop design solutions that are coherent with needs, it is preferable to adopt: "a general approach to designing in which designers ensure that their products and services address the needs of the widest possible audience" (Design Council, 2008).

The intention of this methodology is to make products and services accessible and easy to use, but it also involves the active participation of users in the construction of new social interactions. Inclusive design involves a plurality of people, not only those with physical, sensory, cognitive or intellectual disabilities but also users of different ages, languages, genders, ethnicities and health (Preiser, 2008, p.78).

Furthermore, inclusive design suggests that designing for someone with a disability can also benefit someone with a temporary limitation: "The persona spectrum is an inclusive design method that solves for one person and then extends to many" (Holmes, 2018, p.203).

The aim of this paper is to understand how the use of inclusive design methodologies can contribute to the creation of projects for mobility and access to cultural information from a Design for All perspective. Specifically, the research focuses on visual disabilities in a specific and unique context such as the Venice lagoon, which could be considered a quite protected place and ideal for experimenting with new systems of orientation and access to cultural information. In relation to the analysed context and following the concepts of inclusive design, it may be possible to define and design solutions related to services that could then be useful to a wider public, such as residents or tourists moving around or visiting Venice.

2. Research and methodology

This contribution presents the first phases of the research project called AD4A (Artefact Design 4 All Lab), started in 2021 within the Università Iuav di Venezia for a total duration of 18 months.

The main objective of AD4A project is to improve the quality of life of people with visual disabilities, through the study, research and development of products and services based on digital technologies. The research activities are focused on the design of artifacts that have the potential to offer useful solutions to generate accessibility and social integration in the Venetian context.

The methodology adopted refers to the Double Diamond design process model of the British Design Council (AA.VV. 2005), which has been adapted for this specific research.

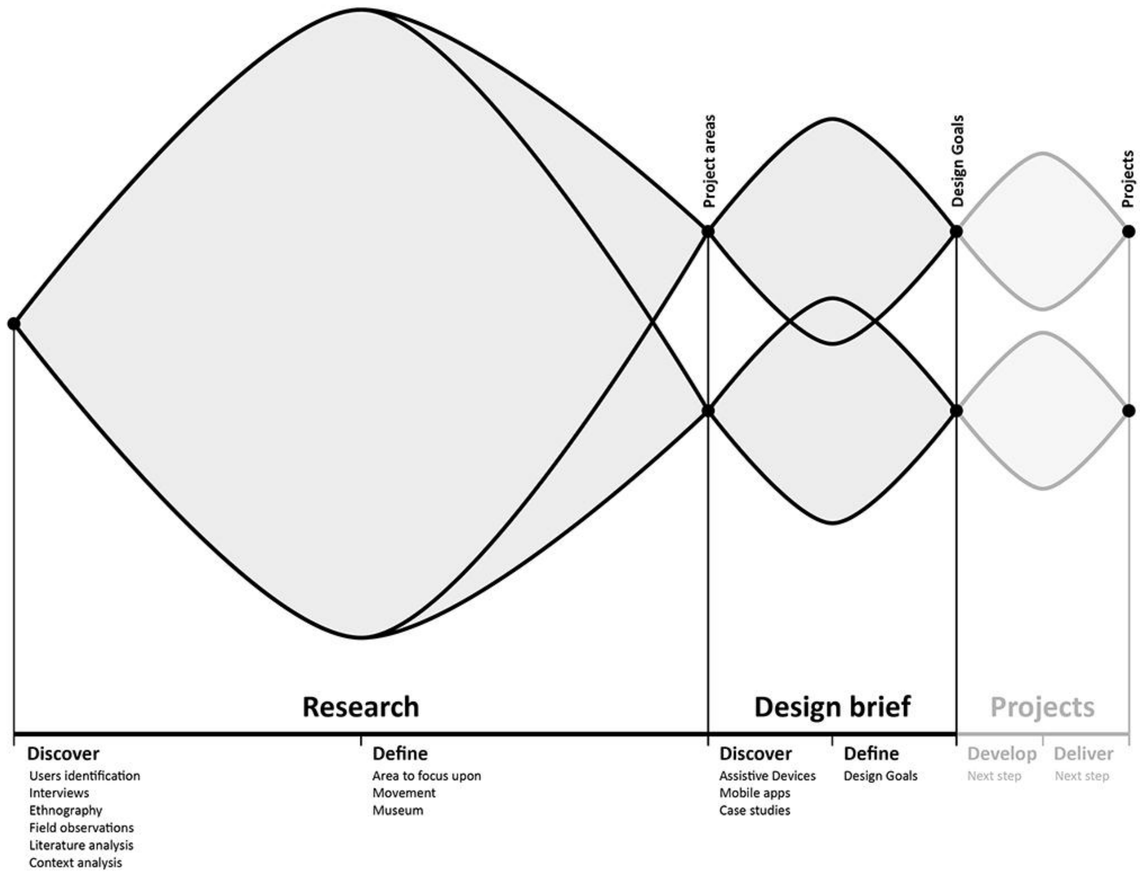

Figure 1. AD4A project (Artefact Design 4 All Lab) design process model.

The first phase of the research ("Research - Discover" phase) aimed to define the users and their needs, through interviews, field observations and literature analysis. Once this was defined, the research was oriented ("Research - Define" phase) towards two project areas focused on facilitating mobility and orientation in pedestrian routes in Venice and on the accessibility of Venice's cultural heritage.

Subsequently ("Design brief - Discover" phase) we analysed the existing technological systems and the assistive devices developed to support people with visual impairment. Through the analysis of case studies, we defined some Design Goals ("Design brief - Define" phase), useful features to support users in the Venetian context. The Design Goals will become the guidelines during the development of the projects ("Projects" phase) in the next months.

3. Research phase

3.1 User identification

Italian legislation (law 3th April 2001, n. 138) distinguishes five categories of visual disability, two for blindness and three for partially-sighted. However, this classification is not the same in all countries (table fig. 2): for example, less restrictive criteria are adopted in the USA. The criteria of the World Health Organization (WHO) are more similar to the Italian ones, but WHO also includes the category “near-normal vision”, i.e. users with any kind of visual problem, including people wearing glasses and the elderly.

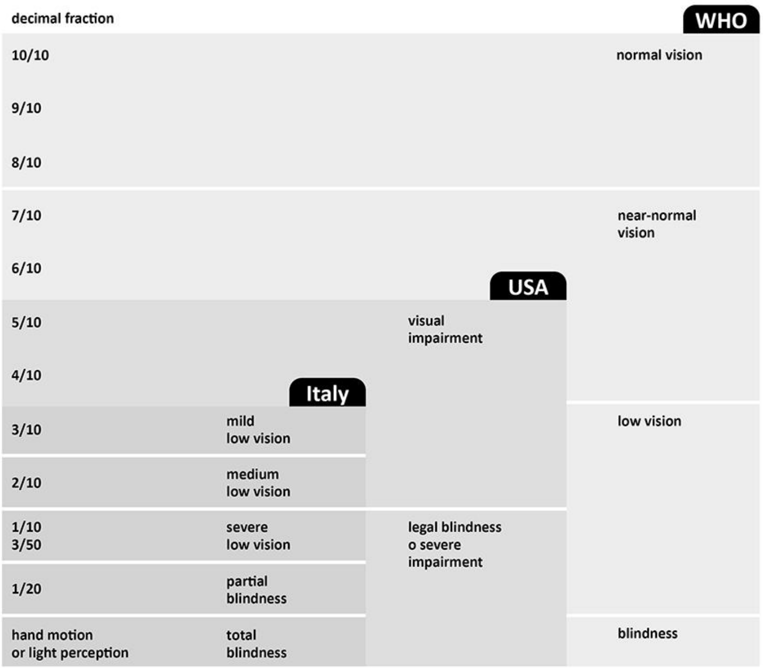

Figure 2. Classification of visual disabilities (depending on visual acuity) for the World Health Organization (WHO), for the USA and for Italy (Baracco, 2016).

In order to understand the different characteristics of people with visual impairments, a useful contribution for designers is suggested by Badalucco et al. (2010), in accordance with the recommendations of WHO:

> “when planning strategies to solve problems related to the accessibility of museums by visually impaired users, it is possible to divide the population we are referring to into three major categories with different needs: blind people, low vision people and people with near normal vision” (Badalucco et al., 2010, pp.54-65).

Due to the progressive ageing of the world's population, the number of people with visual impairments is estimated to increase, especially in the most developed countries. In 2019, more than one-fifth (20.3 %) of the EU-27 population was aged 65 or over (Eurostat, 2020). Italy is one of the leaders in this ranking, in 2020 it was the country with the highest average age in Europe. Within a few decades, the population pyramid has reversed and this transformation is forcing us to take on the responsibility of designing. In design projects, this change requires us to take into account the problems of the older population groups, in order to guarantee them a good quality of life.

In 2001, WHO redefined the concept of disability, which since then has also been closely linked to people's interactions with their environment:

> "Disability is characterised as the outcome or result of a complex relationship between an individual's health condition and personal factors, and of the external factors that represent the circumstances in which the individual lives.[...] Society may hinder an individual's performance because either it creates barriers (e.g. inaccessible buildings) or it does not provide facilitators (e.g. unavailability of assistive devices)". (AA.VV. 2001, p.17).

Social interactions and design choices can become key factors for inclusion or exclusion because "[...] disability arises from interactions with the surrounding environment" (Clarkson & Coleman, 2013, p.235), so it is essential that the design of environments, products and services has a positive and inclusive impact on people.

3.2 Insight from interviews and field observations

Understanding the users' needs is the basis of a good project, so in the first operational phase we used ethnographic research methodologies such as field observation and interviews. In particular, during this period of research there was a direct confrontation with blind people living in the historical centre of Venice (4 interviews), associations, professionals experienced in visual impairment (6 interviews) and museum managers (3 interviews), for a total of 13 interviews. The data obtained were fundamental to understand and analyse their real daily problems and to identify some project opportunities. For example, in the case of blind people it's evident the importance of interaction with other people to move and orient themselves in the urban context (interview 3 - "When I'm moving, I have difficulty to identify the presence of obstacles and landmarks along the way and I have to ask for assistance from people on the street"). In fact, they use primary aids such as the white cane to move around independently, but in case of difficulty, disorientation or confusion, they ask for help and information from the people they meet along the way. Generally they have all created a widespread network of contacts that supports them in situations of difficulty or emergency. In this sense the theories of Bigham, Brady, White are confirmed:

> "Despite advances, this technology remains both too prone to errors and too limited in the scope of problems it can reliably solve to address the problems faced by disabled people in their everyday lives [...] access technology tools (and intelligent user interfaces in general) would be more reliable and useful if human workers, volunteers, and friends could quickly back up fragile automatic techniques. [...] many disabled people already solve problems when their existing strategies fail: ask a friend for assistance". (Bigham, Brady & White, 2011).

Another interesting area of investigation emerged from the interviews: access to museums and cultural information. The opportunity to visit the museum exclusively with an operator is limiting. Some of the interviewees expressed the desire to visit a museum only with family or friends (interview 4 - "When I visit a museum with friends, I would like to be able to share the experience with them in complete autonomy"), so they suggested to design the exhibitions to facilitate autonomous visits also through the use of technological tools.

Other interviewees point out that in museums there is a lot of attention for blind people and not much for other types of visually impaired people (interview 9 - “Currently, many Venetian museums offer reservation-only visits, with tours available on set dates. There are not always audio or tactile aids available, which is a serious limitation”). Also in this case the most evident suggestions are related to the improvement of the exhibition design in order to improve the readability of information.

4. Project areas

4.1 Pedestrians in Venice

In the Venice province there are more than 300 blind and visually impaired people, but blind tourists are certainly far more numerous and in almost all cases they visit the city with family members or friends. Visually impaired people who visit the city on daily basis are more numerous and constantly growing.

Venice is one of Italy's historic centres completely free of car traffic. This makes the city very “friendly” for visually impaired people, because it allows them to move safely compared to other cities (Baracco, 2007).

In Venice there is no danger of being hit by a car or a bicycle and there are no obstacles on the pavements that force the pedestrian to move on the roadway. A visually impaired person can reach and visit most places in total autonomy. In addition, there is no noise pollution in Venice, as in other cities.

However, the context also presents problems, some of which can be found in all cities: uneven pavements, awnings, overhanging cornices and temporary construction sites are just a few examples. Some typically Venetian dangers are high-water walkways and bridges. The difficulties are different depending on the level of familiarity the user has with the place. For the visually impaired people there is a risk of falling into the water at the end of the “calli” (narrow streets, that could end in water) and in the unprotected sidewalks (short stretches used for loading and unloading goods).

For those who do not live in the city Venice can seem like a labyrinth, creating orientation difficulties for all types of tourists. To solve this problem there are tools usually used to orientate oneself, such as paper maps, or technological systems like GPS, which in Venice, due to the narrow “calli”, often commits location errors.

4.2 Monuments and museums in Venice

The city of Venice offers tourists the opportunity to visit many historical buildings, churches and museums. Between the historical centre and the islands there are more than 40 museums, including civic museums, state or private museums, foundations and other types of organisations or religious institutions. There are 148 churches and many other buildings of public interest and historical importance.

Access to cultural places, with the removal of architectural and perceptive barriers, are a fundamental right established by law, and Italian museums have begun to adapt their spaces and cultural offerings (Cetorelli & Guido, 2020).

In fact, the 2019 Istat Report on Italian museums (Istat, 2019) indicates that 53% (over 2,600 museums) have implemented strategies to overcome architectural barriers. Conversely, the report indicates that only 12% of museums have a strategy for sense-perceptual accessibility and this statement makes it important to develop projects in this context.

Today 12 Venetian museums offer guided tours to visitors with visual impairments. These activities are focused on tactile exploration of original works and in some cases of other tactile media (3d models, bas-reliefs and relief drawings etc...). In some cases, in order to make the experience more interactive, installations were created to use other senses such as smell.

In order for the blind and visually impaired people to understand what they have in front of them, tactile exploration is not enough, but it's also needed a description to make the experience complete. This is why there are often museum operators or external tour guides to guide the visits.

The methodological choice of having an accompanying person is considered by many experts and associations as the first step for a museum accessible to people with visual impairments and it is a method that is also highly appreciated by the users themselves (Handa et al., 2010). However, this opportunity is also a constraint. Guides usually ask for a reservation or there is a predefined schedule of sessions, with obvious limits for the autonomy of a user visiting Venice.

The Istat Report 2019 on Italian museums (Istat, 2019) also highlights the spread of digital technologies in museums. Generally they are used to enrich the experience and engage the public, but only 44% of institutions provide at least one device among smartphones, tablets or touch screens, video and/or multimedia rooms, QR Code technology and augmented reality tours.

Therefore, the development of technological tools is another aspect that can be further developed and used to offer new possibilities for inclusive projects in a Design for All perspective.

5. The assistive technologies role

The scientific literature reviewed shows that designing technological artifacts helps to generate accessibility.
In fact, all systems, services, and devices developed to aid and facilitate the daily activities of people with disabilities are identified as assistive technologies:

> "Assistive technology is a generic or umbrella term that covers technologies, equipment, devices, apparatus, services, systems, processes and environmental modifications used by disabled and/or elderly people to overcome the social, infrastructural

> and other barriers to independence, full participation in society and carrying out activities safely and easily". (Hersh, 2010)

In addition to the existing traditional primary aids used by people with visual impairments, which include white canes, guide dogs, screen readers, users may choose to use mobile assistive technologies because they are more unobtrusive (e.g. smartphones). They could also help mitigate the cultural stigma associated with more traditional assistive devices (Hakobyan et al., 2013, p.514).

Due to the rapid advances in technology and the increasing focus on people's inclusion issues, researchers and designers are researching and planning for new design opportunities related to the development of wearable technology. Wearable technology has the potential to provide people with visual impairments with better access to services and information:

> "The advantage of wearable technology is that they enable users to collect, process, and transfer data even without (strenuous)interactions with the device. [...] Output can be visual on a screen, but also through (a combination of) sound, spoken words, vibration, movement, temperature change, small shocks, etc". (Wentzel, Velleman & van der Geest, 2016)

In the last decade, different solutions related to wearable devices for people with visual impairments have been developed, which can be classified into three subcategories: Electronic Travel Aid (ETAs), Electronic Orientation Aid (EOAs), and Position Locator Devices (PLDs). (Elmannai & Elleithy, 2017; Tapu, Mocanu & Zaharia, 2020; Dakopoulos & Bourbakis, 2010).

Table 1. Visual assistive technologies.

Electronic travel aid (ETAs)
Devices that through sensors, cameras, sonar or laser scanners, transform the information collected about the environment into a sensory modality different from sight.
Electronic orientation ais (EOAs)
User transportable devices that provide orientation directions in unfamiliar locations.
Position locator devices (PLDs)
Devices that determine the precise location of the user, through GPS technology, EGNOS (European Geostationary Navigation Overlay Service), etc.

In addition to wearable devices, generally designed to improve movement and autonomy or support access to content and information, more and more people with visual impairments are using smartphones in their daily activities.

This is evidenced by the study conducted by Griffin-Shirley et al., which explores the use of mobile apps by people with visual impairments. The results show that "persons with visual impairments frequently use apps specifically designed for them to accomplish daily activities" (Griffin-Shirley et al., 2017, p.307).

6. Case studies

Starting from the interviews, it was possible to identify 5 key issues that subsequently oriented the case studies research: assisted mobility, obstacles identification, social interaction, autonomous visit and management of cultural content.

Within the scientific literature, some case studies were identified as representative of the key issues, as they are products and services already implemented or in an advanced state of prototyping. Through the comparison of different case studies, the purpose was to identify some Design Goals useful to visually impaired users in the Venetian context, in particular for orientation in pedestrian routes and for accessing information about cultural heritage.

Below is a selection of the case studies analysed that highlight some of the Design Goals found. Many of the case studies reviewed often solve a specific aspect of the problem and it is useful to analyse them in order to identify the goals that are useful for the two project areas in question.

6.1 Orientation and use of pedestrian routes in Venice

Key factors impacting on the mobility of people with visual impairments are numerous and complex.

One of the main problems that blind and visually impaired people have when walking is to detect the route:

> "The navigational components of orientation and mobility are sometimes ambiguously defined in the literature, but in general, orientation refers to the process of keeping track of position and heading in the environment when navigating from point A to point B, and mobility involves detecting and avoiding obstacles or drop-offs in the path of travel". (Giudice & Legge, 2008, p.482).

In this context, the design proposal by Bousbia-Salah & Fezari (2006) is interesting: they present a device for the creation of routes that uses an accelerometer to measure the distance travelled by the blind user between geo-localized points. The user, thanks to a switch, chooses one of the two operating modes of the system: recording, which stores a list of geo-localised waypoints; or playback, which guides the user to the destination through vocal instructions.

However this type of feedback could be problematic:

> "In the absence of visual feedback, spoken instructions are normally used. However, they have a high level of intrusion as the feedback delivery timing cannot be controlled. Furthermore, speech feedback is not an effective solution in noisy environments, such as public spaces or during a conversion. An alternative approach has been

> widely investigated in recent years based on the usage of tactile feedback" (Kammoun et al., 2012).

The study conducted on the potential of tactile feedback by Karuei et al. (2011) concludes that body points such as the wrists and the spine are the optimal ones.

In this sense, Kammoun et al. (2012) developed two wristbands, equipped with a vibration actuator, to send haptic feedback to the user concerning navigation directions.

In addition, the work of Pielot et al. (2011) demonstrated that pedestrians are able to distinguish between directions through different vibration patterns that are called 'tacton' (Brewster & Brown, 2004).

Design goals: Assisted mobility

- Track and define the best route (through waypoints geo-localization)
- Keep track of user location and direction
- Provide instructions and directional signals related to the route (through haptic feedback)
- Promote environmental perception

In general, people with visual impairments use tools to detect obstacles on their way:

> "The white cane is by far the most widely used assistive device for visually impaired orientation and mobility today. It is efficient in finding ground level obstacles close to the user (<1 m), but does not help in detecting obstacles that are not standing on the ground, or obstacles farther away"(Kiuru et al., 2018).

To ensure safe navigation, it is recommended to complement primary mobility aids with technological solutions that can implement obstacle detection capabilities.

A variety of solutions can be found among the case studies analysed (Jevoy, Nizamadeen & Richi, 2019; Hoyle, & Waters 2008; Akita et al., 2009; Mutiara, Hapsari & Rijalul, 2016; Dernayka et al., 2021).

The most common principle of operation is the detection of an obstacle in front of or around the user using sonar-based sensor technology (Lesecq, 2018) and the transmission of this information to the user through auditory or haptic feedback.

Among the case studies, Sunu Band and WeWalk are interesting as they have been implemented.

Sunu Band (Gupta et al., 2021) is a device with a sonar sensor that guides visually impaired people and helps them to avoid obstacles. When the sensor detects a nearby object or a person, it alerts the user of a possible collision through vibration. As the user gets closer and closer to the obstacle, the frequency and intensity of the vibration increases.

WeWALK (Kugler, 2020) is a smart cane for the visually impaired people, designed to implement the functions of the normal white cane. Compared to this, the handle has been modified and a touchpad has been added. WeWALK detects objects and alerts the user through vibration to the presence of obstacles both on the ground and above chest level, within a radius of 160 cm.

Design goals: Obstacles identification

- Detect obstacles (through sonar sensors)
- Convey information about obstacles (through haptic feedback)

Through direct confrontation with users and from the literature (Bigham, Brady & White, 2011) it has been noted that many disabled people solve their problems or needs by asking people for assistance. Therefore, recent theories focus on the need to generate participative and collaborative services. They are based on the interaction between individuals and on the creation of communities, which are able to generate empathy, trust, reciprocity, for the creation of new accessible communities:

> "We need to move from the service society we have known to a society in which services, instead of pushing people to feel and act as passive clients, support their ability to be active, to collaborate, to produce common goods and to care for each other." (Manzini, 2021, p.78)

Ezio Manzini reinforces this concept (Selloni, 2021), stating the need for "proximity services", capable of fostering the construction of sociality and extending the network of actors to include, diversify, connect and coordinate all services.

In this sense, among the case studies analysed, BlindWiki (Martin, 2017) is a network that collects geolocalized voice messages in which both visually impaired and people with normal vision share geolocalized audio recordings using their smartphones.

Users contribute to the creation of a collaborative cartography by sharing information on architectural barriers (e.g. steps, bridges, ramps, etc.) and points of interest in the city.

Moreover, Be My Eyes (Avila et al., 2016) is a service consisting of a global community of blind, visually impaired people and volunteers, who provide visual assistance for daily tasks and needs through video calls.

Design goals: Social interaction

- Co-creating value (through networks and collaborative activities)
- Generate relationships and community
- Sharing information

6.2 Access to information on Venice's cultural heritage

Concerning the access to museums and information, it emerged that the solutions adopted so far in Venice are tactile explorations of original works or relief models and drawings supported by the museum operators' narration. Interviews with users revealed that the possibility of visiting only with guided tours is useful but often limiting.

The analysis showed how the use of new technologies can provide new opportunities for museum accessibility. For example, several case studies use technologies that integrate different tactile media and enables blind people to explore tactile materials in a more autonomous way.

For instance, Tooteko (D'Agnano et. al, 2015) integrates NFC Tags in 3D models to transmit information to a special ring (NFC reader) that the user wears during tactile exploration. It is connected to a mobile app that plays the audio tracks associated to the different tags. Thus, the user touches the areas and listens to the description/audio track.

The research of Reichinger et al. (2016) explores two other solutions: a 3D model that integrates touch sensors and a Gesture-Based Interactive Audio-Guide that uses a depth camera to detect the user's movements while exploring a bas-relief, without embedded sensors.

Both examples are interesting because they create audio guides that allow interactive and hypertextual modes freely chosen by the user.

Other experiments, such as Tooteko's exhibition “VIBE, Voyage Inside a Blind Experience” (see https://bit.ly/3d3ZT2j), show how these accessible systems are also of interest to people with normal vision, opening up new scenarios for tactile and multimedia/multimodal visits for all.

Design goals: Autonomous visit

- Explore tactile materials
- Audio/Multisensory access to informations
- Autonomous access to content and informations

In our analysis, we also considered technologies for the augmentation of 2D graphics and tactile graphics, including the so-called Talking Pens.

Talking Pen Devices detect barely visible printed patterns and could be used to reproduce audio texts in combination with images (visual or tactile) or even just to read or translate texts. This technology is very flexible and it’s already being used in various fields: games, educational books, tourist maps, etc.

The experimentation of Engel, Konrad & Weber (2020) and projects such as Tttoool (Zinnatova, Wacker, & Bergmann, 2017) are interesting to report because they attempt to make this technology open source, replicable and user-programmable to create content.

Design goals: Management of cultural content

- Open source system
- Sharing information
- Content customization

6.3 Design goals scheme

Below we summarise the Design Goals identified in both project areas after ethnographic exploration and case study analysis:

Table 2. Venice design goals.

Orientation and use of pedestrian routes in Venice
Co-creating value
Convey information about obstacles (through haptic feedback)
Detect obstacles (through sonar sensors)
Generate relationships and community
Keep track of user location and direction
Provide instructions and directional signals related to the route
Promote environmental perception
Sharing information
Track and define the best route
Access to information on Venice's cultural heritage
Audio/Multisensory access to information
Autonomous access to content and information
Explore tactile materials
Open source system
Sharing information
Content customization

7. Conclusion

The Design Goals definition allowed us to complete the first part of the AD4A (Artefact Design 4 All Lab) research and to investigate how the use of inclusive design methodologies for visually impaired users can contribute to the creation of products and services for the mobility and accessibility of cultural heritage information in the Venetian context. The two operational areas of research are obviously closely related to each other and, for example, solutions for pedestrian mobility adopted for the first area can certainly be applied to facilitate the autonomous visit to museums. The projects will be developed in response to the needs of a specific target group, but will be useful and profitable for a larger number of people, according to the Design for All methodology.

In the field of mobility, research is focusing on the development of a co-creative service to enable the creation of pedestrian routes through the geo-localisation of waypoints and collaboration between users. The service could be based on a wearable device or mobile app complementary to primary navigation aids, allowing users to be actively involved in contributing to the generation of accessible and safe routes to help improve the experiences of people with special needs.

In the field of access to information on the cultural heritage of Venice, research is focusing on the development of technological tools to facilitate autonomous access to information and museum collections, providing an effective alternative to the cultural mediation offered by a museum operator. Complementary tools to the normal audio guide will be designed, e.g. interactive audio guides (IAG) or portable systems such as Talking Pens.

This type of product should have specific functionalities, such as supporting a blind person in reading a tactile support, but also reading a written text to a visually impaired person, or translating a text in different languages. In this way it will be possible to allow new ways of interacting with contents or to improve the possibility of moving in unknown environments for different types of users. It will also be possible to generate participative and collaborative services that will facilitate the construction of communities and the active participation of users.

Another aspect of the proposed solutions will be to allow easy replication and dissemination at low costs, by promoting open source software and developing applications that allow even people without particular technical skills (museum operators but also operators of other information and culture fields) to develop their own customisable contents and projects.

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