



# Towards Cross Assessment of Physical and Digital Accessibility

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**Abstract.** Our digital and physical worlds are becoming increasingly interconnected. Digital services reduce the need to physically move hence to have to face physical accessibility barriers, but it becomes then more critical to make sure they are not replaced by digital accessibility barriers. In order to assess the interplay of both worlds from the accessibility perspective, we collected available data and used automated tools from three different perspectives: one starting from physically accessible places and looking at the digital accessibility of their online services, the second going the other way and finally a representative sample of services inside a smart city. Globally, we found a good combined level of accessibility in about one third of the places. Mutual strengthening could also be observed, usually greater on the digital accessibility side and revealing that awareness actions in one field also contribute to improve the other.

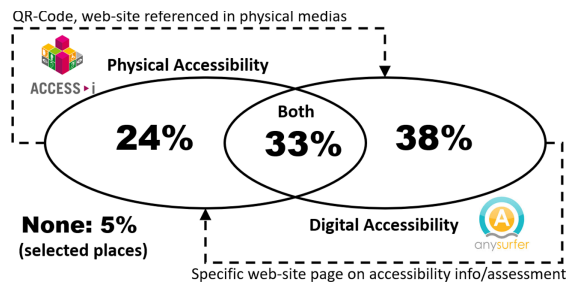
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## 1 Introduction

Physical world accessibility is about ensuring that the capabilities of physical places (e.g. administrations, shops, cultural places) matches the (dis)ability of people visiting them in order to ensure optimal access for all, including for the estimated 15% of the population living with some kind of impairment [21]. Currently our world is undergoing a strong digitalisation process: online maps are becoming precise to the point they capture the inner structure of buildings, the accessibility of several places is being ranked using crowdsourcing, Artificial Intelligence can provide help to guess the content of images, etc. This results in a wide range of new opportunities to break accessibility barriers and also better combine physical and digital aspects of accessibility, from removing the need to move using fully digital services to the in-depth preparation of a visit to a specific place and the constant guidance during the travel to cope with the unforeseen.

Physical Accessibility (PA) requirements are now well defined and documented, such as in the ISO21542 standard [8]. However, assessing physical accessibility is not straightforward because it requires identifying physical obstacles depending on the impairments, e.g. a doorstep for a wheelchair, no braille on lift buttons for blind people, audio only announcements for deaf people. Experts can reliably evaluate this accessibility by applying a well-defined measurement procedure and Web-oriented reporting [13]. However, the limited number of trained experts strongly restricts the ability to assess at large scale and keep the information up to date. On the other hand, dedicated social media apps like jaccede.com [9] or wheelmap.org [20] enable a crowdsourcing approach through the consolidation of partial information reported by different users, each with her own point of view, which may lead to inconsistency. Both approaches are naturally complementary and can efficiently be combined together, through the use of open linked data techniques [14].

Although information and communication technologies are a clear enabler for physical accessibility, it is also raising new obstacles as the end-users need to use a computer or mobile interface to make sure some place is physically accessible. Hence Digital Accessibility (DA) needs to be considered. The Web Accessibility Initiative (WAI) [18] provides specific guidelines like Web Content Accessibility Guidelines (WCAG) to help Web developers making Web sites accessible [19] while dynamic content is addressed through (Accessible Rich Internet Applications (ARIA)). Many useful evaluation and repair tools are also proposed, including for tailored and optimised usability and accessibility evaluation [17].



**Fig. 1.** The interplay between physical and digital accessibilities

Looking at both physical and digital accessibility together raises interesting questions about the current level of maturity and awareness about each kind of accessibility, the possible correlation between them, and what kind of synergies can further enhance the user experience. Through a preliminary unpublished study, we manually gathered and processed a first limited data set in Belgium from Access-I (for physical accessibility) [4] and AnySurfer (for digital accessibility) [2]. Both kinds of accessibility are summarised in Fig. 1 which already shows a satisfactory level of physical accessibility in 60% of cases, of digital accessibility in 70% of cases and both in 33% of cases.

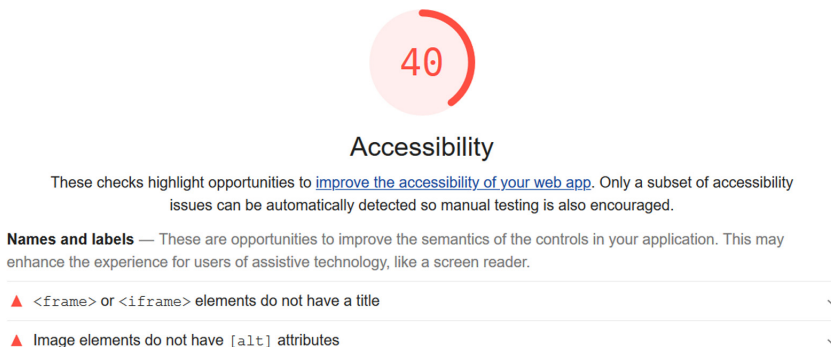
In order to push our investigation further, we decided to set up a wider and more automated assessment. This required a better methodology relying on the available data sources but also avoiding some related bias, e.g. organisations specifically reviewed or labelled for accessibility are more mature than those randomly evaluated by occasional visitors through crowdsourcing. Our priority is to ensure a data collection methodology that supports automation and yield comparable data even if some identified aspects of accessibility (requiring manual work) are not completely evaluated. In addition, we also decided to collect specific indicators reporting about accessibility scenarios ranging across both worlds, the simplest one being the presence of “how to get there” information in a website, or conversely, reporting about the website of a place (maybe using a QR code).

This paper is structured as follows. First, Sect. 2 presents our methodology as well as the data and tools used to carry out our assessments. Section 3 presents the results collected so far. Section 4 performs some analysis and discussion on them. Finally, Sect. 5 draws some conclusions and presents our future work.

## 2 Methodology and Tools

To answer the question “How does PA and DA relate?”, we used a triple approach:

- starting from an available PA data set (from access-i) and assessing the related DA through dedicated automated web assessment tool.
- starting from an available DA data set (from anysurfer) and assessing its PA (when relevant) using all available data (from expert or crowdsourced) data.
- using a control sample selected inside a specific geographic location which good coverage for both DA and PA: we selected the city of Namur (Belgium) which is strongly engaged in a smart city process.



**Fig. 2.** Example of typical physical assessment summary [7]

About the DA assessment, several tools are available to assess the WCAG at a specified level. Some can be directly run online. However, considering the additional requirements to be Open Source or freely usable with export capabilities reduces the number to a handful, usually based on the same underlying libraries like a11y project or pally [11]. After considering platforms able to scan a whole website such as BOSA accessibility check server [12] and Tanguro [10], we decided to use a separated crawler (crawl4j) to better control the visit (e.g. search depth, ignore irrelevant pages). As DA checker, we selected Google Lighthouse [7] which is a more general tool also assessing performance and search engine optimisation. It is mature and has an easy to use and well specified scoring mechanism (see Fig. 2). It relies on 35 key accessibility criteria, mainly for visually and auditory impaired, covering much of what WCAG tools automatically check for level AA. Of course, a whole set of manual checks are discarded making the assessment inaccurate. **Our DA score index is computed on the average Lighthouse score of the website, on a scale from 0 (worse) to 10 (best).**



**Fig. 3.** Example of typical physical assessment summary [4]

About PA accessibility, we relied on available local expert databases coming from access-i (collective of experts) and sometimes from access-city (focused on wheelchairs and providing more open data) [1, 4]. The crowdsourced information was extracted from jaccede [9] and wheelmap [20] through available APIs. **Our PA score is computed as the average of the scores on 4 main categories related to physical (wheelchair), visual, auditory and cognitive impairments. Like for DA, the scores are ranked on a scale from 0 (worse) to 10 (best).** For example, the simplified red-orange-green codes are respectively translated to 0, 5 and 10, resulting in a score of 7.5 for the case depicted on Fig. 3. When available more detailed scores can also be used using different mappings. A cross validation/alignment of those mappings is performed when different sources are available.

In order to assess more specific **awareness indicators linking both DA and PA**, we used a qualitative approach by looking for the following elements inside the website, from the most basic to the most advanced:

- presence of basic information about address, maps, opening hours
- mention of PA in “contact/how to get/access” page(s)
- mention of e-services or special on-site service (e.g. sign language tour)
- mention of an accessibility policy

- mention of specific DA or PA labels
- specialised controls (e.g. font size, contrast, video remote interpretation).

**Table 1.** Characteristics and scores of our data sets

| #    | Name             | Type            | Website URL                   | DA score | PA score | Mixed indicator                 |
|------|------------------|-----------------|-------------------------------|----------|----------|---------------------------------|
| DA1  | Kust Pass        | Multiple        | kustpas.be                    | 9.7      | –        | none                            |
| DA2  | Piet Devos       | Home            | pietdevos.be                  | 9.7      | –        | none                            |
| DA3  | Pink House       | Meeting rooms   | hetrozehuis.be                | 8.4      | 7        | map, label                      |
| DA4  | CPAS Charleroi   | Administr       | cpascharleroi.be              | 9.3      | 8        | map, charter                    |
| DA5  | Stavelot Abbey   | Religious       | abbayedestavelot.be           | 9.3      | 5        | map, label, virtual visit       |
| PA1  | Media cité       | Shopping mall   | mediacite.be                  | 7.7      | 6.8      | map, hours, label               |
| PA2  | Loncin Fortress  | Fortress        | fortdeloncin.be               | 8.1      | 6.8      | audio, map, hours               |
| PA3  | Gileppe Lake     | Touristic dam   | gileppe.com                   | 9.8      | 7        | raw address                     |
| PA4  | Jalhay Tourism   | Tourist office  | tourismejalhaysart.be         | 8.8      | 3        | broken map                      |
| PA5  | Mariemont Museum | Museum          | musee-mariemont.be            | 7        | 8.5      | address, label, info            |
| SC1  | Decathlon        | Sport shop      | decathlon.be                  | 5.5      | 9        | map, hours                      |
| SC2  | Citizen house    | Administr       | namur.be/                     | 8.4      | 8.3      | map, hours, e-services, charter |
| SC3  | CGT              | Tourist office  | tourismewallonie.be           | 8.4      | 6        | raw address                     |
| SC4  | Namur Expo       | Meeting hall    | namurexpo.be                  | 8.8      | 8.5      | map, (faq)                      |
| SC5  | Rops Museum      | Museum          | museerops.be                  | 3.0      | 7.5      | address, dog                    |
| SC6  | County Palace    | Administr       | gouverneurnamur.be            | 8.7      | 3.0      | nothing                         |
| SC7  | NAM-IP           | Museum          | nam-ip.be                     | 5.5      | 4.0      | map, hours, info                |
| SC8  | Terra Nova       | Fortress        | citadelle.namur.be            | 6.6      | 6.5      | map, page, special visits       |
| SC9  | IBIS             | Hotel           | all.accor.com/hotel/3151/     | 8.9      | 6        | map, hours                      |
| SC10 | Namur Cathedral  | Religious       | cana.be                       | 6.8      | 6        | address, hours                  |
| SC11 | St Loup Church   | Religious       | eglise-saint-loup.be          | 8.3      | 6.5      | map, label                      |
| SC12 | INNO Galleria    | General store   | inno.be/fr/stores/store_namur | 8.4      | 8        | map (inc. internal), hours      |
| SC13 | 1PasseTemps      | Restaurant      | 1pasetemps.be                 | 7.7      | 6.8      | hours, info                     |
| SC14 | Royal Snail      | Hotel           | theroyalsnail.com             | 7.1      | 3.0      | address                         |
| SC15 | Namur Station    | Railway station | belgianrail.be/.../namur.aspx | 7.3      | 8        | info                            |

### 3 Assessment Results

Table 1 reports about 25 representative samples coming from our three different sources: DAx initiated from the DA side, PAx from the PA side and SCx located in the smart city of Namur. The first columns characterise each place by their name, type, URL. The next columns give the assessment from the DA, PA and mixed perspectives. Note that the first two places could not be fully assessed because one had multiple locations and the second was private.

### 4 Analysis and Discussion

**DA Analysis.** The DA score are quite high across all categories (mean: 7.7, std dev: 1.5). This is likely related to be our tool not capturing the whole set of accessibility requirements, but this means most websites achieve good compliance with essential requirements. About the tooling itself, it proved quite reliable although some adaptation were sometimes required depending on the specific configuration, e.g. to correctly isolate specific pages part of a bigger website. More flexible tools are also emerging to cope with the fact that different viewpoints and different requirements need to be considered when checking a website [3]. On the long run they also shape how the accessibility standards evolve.

**PA Analysis.** The PA score is a bit lower with a wider spread (mean: 6, 5, std: 1.8). Although lower, those numbers may appear quite good as physical accessibility is more difficult to achieve in terms of adaptation cost, especially to very old infrastructures. This bias may be related to the fact the selection of places was done on important places for which accessibility was already pointed out. However, it means for such places the actions lead to measurable results.

**Mixed Indicators.** Most places stick to a minimal link using address and opening hours (many closed in the present version due to COVID19 lockdown). The map is present in about 60% of the websites. An interesting interrelation is the announcement of remote service in administrations, again here the COVID19 crisis may have encourage such updates but some were present before this event. Conversely, for very inaccessible places like fortress or underground, special adapted services may be proposed upon request. From this point of view, the digital can compensate the lack of accessibility (or the interdiction of accessibility in the case of the COVID19 crisis). E.g. a mobile phone application (hopefully accessible) maybe available as museum guide but also to give a remote experience. Virtual tours are also quite easy to create nowadays. A more complex immersive scenarios may be envisioned such as the used of virtual reality but is more complex and costly to implement and also needs to be accessible [16]. However they pave the way to new kinds of experience across both worlds. Going beyond the PA or DA, another important dimension is the social goal, e.g. to have a common experience which can also be achieved through digital means. Gamification is another area worth investigating from that point of view [15].

**No Strong Direct Link Between DA and PA.** Looking at relationship between DA and PA does not reveal any direct correlation between them. Considering a threshold score of 7.0 between less satisfactory and more satisfactory level, we can compute that about 74% of places have good DA, 34% have good PA and 22% have both which is lower as in our initial survey. Digital accessibility is quite better. The explanation can lie in the increased importance of digital presence and the lower effort required to achieve it compared to PA. Indeed, a Web site is easier and less expensive to repurpose than a building. However, the fraction of the considered places currently achieving both dimensions is still small which means that those issues are still largely being considered separately. A good point is that 60% of the places with good PA accessibility have also good digital accessibility which can indicate that awareness leads to change in that way. The other way, the ratio is much lower (only 30%). Again, the cost of change is probably a barrier to go beyond the awareness level.

**About the Intertwining of PA and DA.** PA and DA should also not be considered in isolation but in a mixed global scenario where each play its role on a part of the experience. Considering the whole experience from the preparation to the travel, arrival to finally reach the purpose of a visit may require a variable mixture of digital and physical activities. A typical scenario can include using a computer in preparation phase, a smartphone on the move and a specific device at the destination (e.g. lift). End-to-end scenarios are commonly used, e.g. for sports events [6] or tourism [5,14] but do not focus explicitly on each kind of experience and possible alternatives.

**The Use of Labels is not Very Convincing Both for PA and DA:** currently many labelled sites do not advertise about it or report a broken link. Finding the accessibility information is globally difficult and is comparable to locating the contact page with the additional uncertainty that the information might simply not be reported. Considering accessibility portal as a potential answer leads to other issues such as finding them and being sure of their quality. Probably an interesting move is that accessibility information should be gathered by search engines like what is done for location and opening hours.

**Threat to Validity:** our current dataset is still quite small which threatens the statistical validity of our analysis. We carefully selected the places for diversity and selected different strategies: from PA to DA, from DA to PA and in a smart city. However, our conclusions would benefit from a bigger dataset. At this stage our approach is quite well automated for DA but has a bigger bottleneck on the PA side because we are dependent on data sources that are partial, of different quality and not easy to aggregate. Starting from existing mature assessments, a total data set of 200 fully automated evaluations is beyond our reach. Another threat is to check the accessibility scores. DA scores are more homogeneous in nature but their automation only covers a restricted subset of web accessibility standards. The scores also needs to be evaluated from the complementary point of view of various kind of impairments. Actually both kind of scores can be

broken down in different subscores with sometimes overlapping checks but which allows us to carry out validation sessions with the concerned people.

## 5 Conclusion and Future Work

In this paper, we have proposed a method for the joint assessment of digital and physical accessibility and proposed supporting tools, essentially for the digital side while the physical side relies more on a diversity of data source mixing expert and crowdsourcing. We thoroughly analysed a subset of 25 locations, with a stronger focus on a nearby smart city.

We are currently busy extending our validation by considering an enlarged data set and by involving impaired people to check our PA and DA scores from their point of view. We also plan to release our tooling in Open Source and to publish the resulting data using available open data platforms. Our further research steps will be to refine our global indicators at impairment level, to quantify our mixed indicators and to develop a specific crawling agent that can help detecting such highly valuable information inside websites.

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