

Web Augmentation for Open Data Accessibility based on Voice Interaction

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Abstract. Nowadays, Web accessibility of open data is far from being guaranteed, specially for those data enthusiasts with visual disabilities because they experience barriers while accessing open data portals. In this article, we propose a Web Augmentation Framework for Accessibility for Open Data (WAFRA4OD) in order to facilitate visually-impaired users to navigate through open data portals and get the desired data easily. The main focus of this approach is the improvement of Web accessibility in open data portals using Web augmentation techniques and voice commands. Therefore, WAFRA4OD allows users to access open data through a voice interface including a set of operations: guide users to find relevant open datasets within a portal, read aloud datasets' metadata and read aloud datasets' details and contents. Therefore, by using WAFRA4OD the accessibility of open data portals is improved: data enthusiasts with visual disabilities are now able to interact with open data using voice commands. Also a case study is introduced in this article, in order to show the suitability of the WAFRA4OD proposal for data enthusiasts with visual problems such as blindness and low vision to easily access open data.

Keywords: Web accessibility · Web augmentation · voice interaction · open data.

1 Introduction

Nowadays, the publication of data on the Web by governments and institutions all over the world is becoming a trend [12,22]. This open data growth is due to the importance of transparency and participation of the citizenship to gain confidence and responsibility in our current society [12,22]. This transparent resulting from opening data reduces the information gaps between government/institutions and the citizens, but providing information does not necessarily translate into transparency if the available information is not comprehensible

and easy accessible by users [12]. Therefore, the importance of transparency relies also in the accessibility to relevant data for the citizenship [14].

In this sense, governments have set up open data portals, such as the European Data Portal⁴ shown in Figure 1, for publishing datasets equipped with metadata and organised as searchable catalogues [14]. They help users to obtain relevant datasets by browsing the catalogue using different categories, tags, organisations and formats [14]. Generally, government and institutions that create open data portals adopt guidelines for publishing open data aligned to the rest of portals [14], such as the Comprehensive Knowledge Archive Network (CKAN) for the storage and distribution of data, and DCAT, a vocabulary designed to facilitate interoperability between data catalogues published on the Web.

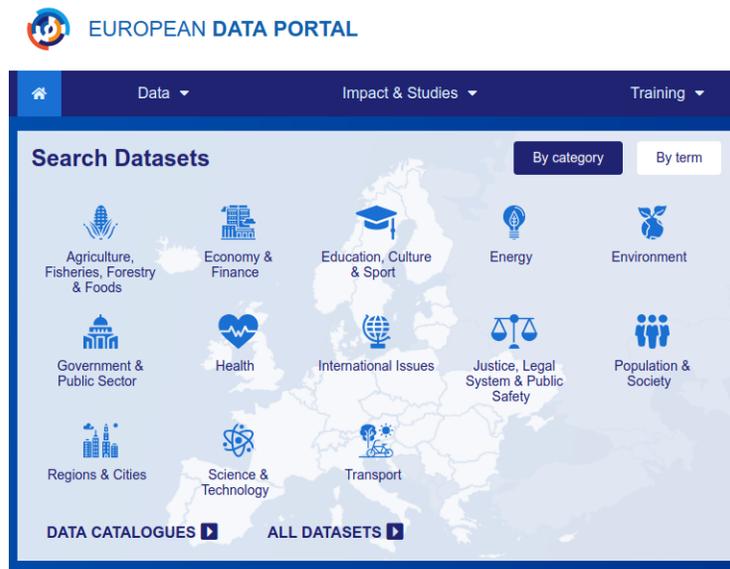


Fig. 1. Extract from the European Data Web Portal main page.

A must for open data portals is to provide reusable data that is universally available and consumable by the society [14]. However, the accessibility of these portals remains an issue [14], even more when it comes to visually-impaired users because of their special needs, which are not widely considered in current open data Web portals. For example, in the European Data Portal, users must select one of the available categories or they can also search by term selecting the appropriate option. Then, a large list of datasets is shown so that users choose according to their needs. Finally, in the dataset's webpage, a great deal of information and metadata is available, including the distributions which are

⁴ <https://www.europeandataportal.eu/en>

links to specific dataset's contents. It is also important to consider that the access to dataset's distribution is relying in third parties websites or programs (such as Excel) to access the data itself. Therefore, in order to find relevant data, users should be able to easily navigate within the portal and be able to obtain datasets' information and contents. The importance of highlighting important parts of the portal such as categories, filters, information, metadata and content is the key to all users being able to take full advantage of open data.

Therefore, there is a data gap for visually impaired users that are not able to properly access open data from portals. This audience out there really interested in data are called Data Enthusiasts [?] (i.e. data consumers and knowledge-seekers), who are non-technical users and they do not know about programming either [?]. Data enthusiasts look for data in order to answer domain specific questions [?].

In order to allow visually impaired data enthusiasts to access generic websites there are several approaches such as screen readers, which have been proposed many years ago, improved recently with annotation and/or transcoding of Web contents processes [1,18] to facilitate Web browsing. However, even with these modifications, website interaction is still complex for users with disabilities because their needs are not (sufficiently) taken into account. For example, users cannot use their voice to ask for specific information. Moreover, for visually-impaired users who have recently acquired this condition or who have not yet acquired effective browsing strategies, it can be difficult to learn how to access Web contents using screen readers [4]. On the other hand, there are approaches that suggest voice interfaces [2,21] to improve Web accessibility, but these are not easily applicable in open data portals because the requirement to access data from external files (distributions) is not currently considered.

In summary, so far, existing approaches that deal with Web accessibility problems provide solutions for generic websites, but there is still a gap between the open data Web portals and users with disabilities, especially visually-impaired users. This is due to the fact that open data portals have a special structure that can be discoverable using DCAT and CKAN, and also they include datasets distributions as external files that must be downloaded by users. Therefore, with our approach we aim to help to bridge this gap between open data and data enthusiasts users with visual disabilities.

The proposed Web Augmentation Framework for Accessibility for Open Data (WAFRA4OD) offers a voice interface that allows visually-impaired users to navigate within an open data portal and access relevant data through voice commands. The novelty of our approach relies first in the application of voice interactive assistance in open data portals, then in the speech synthesis of texts and speech recognition, and finally, in the way in which external datasets' resources can be read aloud through a process which is transparent for users, so that they do not need to make an extra effort.

This article is structured as follows: Section 2 describes in detail the related work, Section 3 presents the proposal to improve Web accessibility in open data

portals, then Section 4 introduces a case study that exemplifies the approach, and finally, conclusions are drawn in Section 5.

2 Related Work

In the literature we can find different approaches to improve Web accessibility. At first, screen readers such as JAWS⁵, BrowseAloud⁶ and WebAnywhere [3] can be used to facilitate the interaction with computer systems for users with disabilities, including the Web browser. However, they read websites in a straightforward way, reading even metadata; therefore it is usually slow and difficult for users to find what they are looking for [19,4,13]. In order to tackle screen readers problems, SuggestOmatic [1] predicts the most likely next browsing action of the user, improving the interaction with the screen reader. Also, a framework [24] is proposed to allow speech-based web access. However, they do not provide access to open data through voice interaction. Another approach, Dante [25], aims to improve websites so they can be easily accessed by screen readers. This tool annotates Web objects by applying semantic annotations using the Web Authoring for Accessibility (WAfA) ontology [11], and then it transcodes the contents of a website to improve its accessibility. The main transcoding operation they propose is to restructure the Web so that the navigation process is improved. A conversational Web interaction system [2] has been proposed in order to change the way users interact with the Web. With this system, users are able to ask a chatbot to obtain specific contents in natural language, but the main focus is usability. The accessibility of existing websites in the client is not really addressed, so the original website must be adapted by their authors to be compliant with the proposed specification. The HearSay system [5] proposes an improvement for voice browsing, a similar approach to screen readers which do not provide filtering of Web content to eliminate “noise”. This proposal presents a dialog interface, a voice interactive way of obtaining the information from websites. This approach is specifically committed to help only blind people navigate to contents. In another work [21], the authors presented an approach to specifically allow end users to extract Web contents using voice assistants. However, the access to datasets is not possible because these approaches cannot access external resources such as the tabular data from open data portals.

Moreover, there are other related works which augment the Web in order to improve its accessibility [15,20,17,8]. Most of the approaches deal with removing barriers that prevent access to websites by people with disabilities through a set of predefined operations through manual interaction [7]. One of these approaches that offers Web Augmentation for accessibility is Farfalla [15], which proposes a set of transformation options for content presentation such as changing the font size. Additionally, other solutions propose adaptation [23], personalisation [16] or refactoring [9] to improve the accessibility of websites, but voice interaction

⁵ <https://www.freedomscientific.com/products/software/jaws/>

⁶ <https://www.texthelp.com/en-gb/products/browsealoud/>

to provide full Web accessibility is not proposed, so blind and visually-impaired users may still have problems to access open data portals and their data.

In conclusion, so far some approaches have dealt with Web accessibility problems by offering predefined voice or manual solutions, but a comprehensive solution that offers the benefits of both approaches focused on open data, which helps users with visual disabilities obtain specific data from different existing open data portals is still missing. Consequently, there is still a gap between users with disabilities and open data, and we believe that WAFRA4OD may reduce this gap.

3 Web Augmentation Framework for Open Data Accessibility

In this section we present a Web Augmentation Framework for Accessibility for Open Data (WAFRA4OD) which aims to enhance accessibility. It is specifically designed for visually-impaired users interested in open data coming from portals such as the European Data Portal⁷. This project is the next step of our starting point project WAFRA, created previously by the authors [10]. The research started with WAFRA that improves the accessibility of websites with large amount of information on the screen, such as Wikipedia. In this paper, we focus on augmenting open data portals with voice-based interaction at the client side, with the main novelty of allowing users to interact not only with the portal but also with file contents from open data distributions.

As shown in Figure 2, the main beneficiaries of this approach will be users interested in open data, specially those with visual disabilities including blindness and other visual problems. These data enthusiasts are now impeded to access these data because they need help to browse the open data catalogue to find relevant data and also help to read it aloud. Therefore, we aim to help these users to easily access relevant open data.

In order to use our approach and improve the accessibility of open data portal, the user needs to install WAFRA4OD. First, the browser extension Tampermonkey⁸ is required in order to add our WAFRA4OD script, which can be easily installed through Greasy Fork⁹. Once installed, the framework is ready to be used by visual-impaired data enthusiasts. The accessibility of open data portals, such as the European data portal, is then improved automatically with voice interaction, so that users are able to use these available operations through voice commands which facilitate the access to the open data.

Our framework (see Figure 3), is based on a main class called “WAFRA4OD”, which provides with default functionality to manage the speech recognition and synthesis. The framework allows to add new operations. Developers who want to extend WAFRA4OD need to construct a JavaScript class inheriting from

⁷ <https://www.europeandataportal.eu/en>

⁸ <https://www.tampermonkey.net/>

⁹ <https://greasyfork.org/es/scripts/395494-wafra>

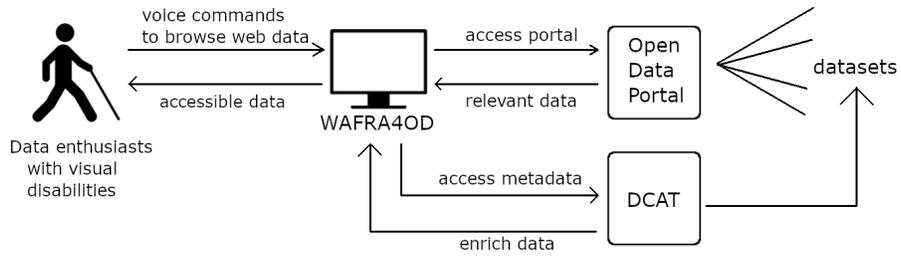


Fig. 2. Overview of WAFRA4OD that helps data enthusiasts with visual disabilities to access open data from Web portals.

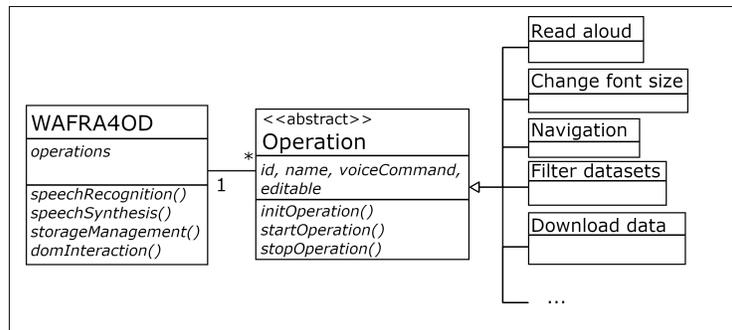


Fig. 3. Framework structure overview of WAFRA4OD.

the “Operation” abstract class, filling its properties and implementing at least the initialise, start and stop operation methods. A default implementation of all these methods from the operations abstract class is provided, facilitating the task of creating new operations. Moreover, the set of predefined operations already follow this class inheritance structure, which serves as examples for the implementation of new WAFRA operations.

The operations available in WAFRA4OD are specified in the following subsection 3.1.

3.1 Accessibility operations

WAFRA4OD proposes a predefined set of accessibility operations, which have been defined by the authors considering the Web Content Accessibility Guidelines¹⁰ from the World Wide Web Consortium accessibility initiative. As the accessibility operations will be applied to an open data portal such as the European, we aligned the suggested operations to the DCAT Application Profile for data portals in Europe (DCAT-AP¹¹), which is a specification based on the Data Catalogue Vocabulary (DCAT) developed by W3C. We will use a CKAN API¹² provided by the open data portals which is aligned with DCAT in order to offer the suitable accessibility operations for open data access and search. Moreover, for speech operations regarding tabular data, we have considered specific guidelines pointed out in related works [6]. The consideration of guidelines for creating our own list of accessibility operations help us to really improve the accessibility based on reliable sources but also well aligned to open data portals because DCAT offers us the actual structure of the portal and helps in the search of relevant data and the access to its contents.

Among the most important objectives of the operations offered by WAFRA4OD are: guide users to browse the data catalogue and find relevant data, read aloud datasets’ metadata such as title and description, and read aloud specific open data contents. These available operations can be classified (Figure 4) as accessibility operations related to the portal’s information and operations that interact with open data contents. On the one hand, the operations that deal with information about the open data portal can be similar to the functioning of a screen reader, but with the benefit of taking into consideration the structure of the open data portal through DCAT standard. Moreover, this information about the portal comes from the CKAN API that offers relevant information which can be difficult to find in the screen. The operations about portal information include operations to guide users to datasets (“welcome”, “search”, “filters”, “categories”, “results”, “order”, “choose”, etc.) and operations to present information about specific datasets (“read title”, “read description”, “read distributions”, “read details”, etc.). On the other hand, the operations related to

¹⁰ <https://www.w3.org/WAI/WCAG21/quickref/>

¹¹ <https://joinup.ec.europa.eu/collection/semantic-interoperability-community-semic/solution/dcat-application-profile-data-portals-europe/about>

¹² <https://docs.ckan.org/en/2.9/api/>

access open data contents from external resources are the main novelty of our approach. These kind of operations (“read columns”, “read all”, “read rows”, “read row n”, “read rows from n to m”, etc.) are able to read aloud the contents of specific tabular data even though they come from third party websites. Therefore, visually-impaired users can directly access open data by themselves in different ways (by voice commands and keyboard shortcuts).

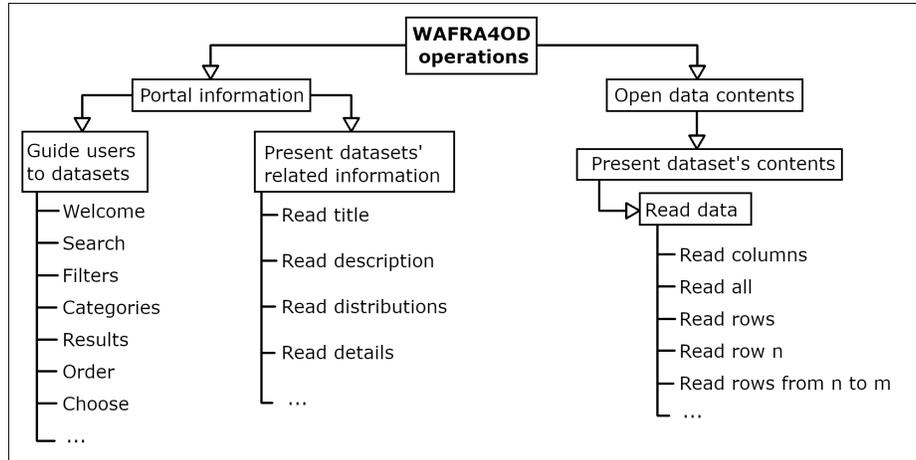


Fig. 4. Classification of operations offered by WAFRA4OD.

Other operations included for low-vision users are related to the presentation of contents with increase and decrease the font size options, but also to facilitate the navigation through the open data portal through voice. All the offered operations can be performed using voice commands but also manually with keyboard or mouse. The voice commands, which are available in both English and Spanish languages, can be personalised according to users’ needs. Furthermore, as WAFRA4OD is a framework, volunteers or other users with programming skills are able to extend the approach with new accessibility operations. Therefore, with these accessibility operations, which are explained in detail in the following subsections, users are able to improve open data portals’ accessibility by using voice commands. Implementation wise, the necessary speech synthesis and recognition is performed using the Web Speech API¹³ of JavaScript.

The complete list of default operations offered by WAFRA4OD are:

“Welcome” operation. When you first access an open data portal, the available accessibility operations are read aloud by WAFRA4OD. This operation is launched automatically when a webpage of the open data portal is loaded. However, because Web browsers usually prevent websites to activate sounds without

¹³ <https://wicg.github.io/speech-api/>

user activation as described here¹⁴, we also provide the option to ask for the list of operations using the voice command “welcome”, “hello” or “list operations”. The “welcome” operation is available in any webpage of the open data portal, but depending on the page the available operations will be different in order to adapt the accessibility to user needs. Within an open data portal we are going to differentiate 3 levels: open data portal main page, list of datasets filtered by different parameters and the dataset’s details page.

“Category” operation. In an open data portal, a set of categories is defined to classify the datasets and users can filter them. Therefore, WAFRA4OD offers the possibility to filter by any of the available categories. In order to know which categories are available in the open data portal, WAFRA4OD uses DCAT through a CKAN API. Users can ask for these categories just with the voice command “categories”, and they can easily apply a category as a filter for the datasets using the voice command “category” followed by the category name. This operation can be applied in the open data portal’s main page, redirecting you to the list of datasets within the selected category, but it also can be used in the results page to add the category as new filter (many filters can be applied to search for datasets).

“Search” operation. In addition to the categories, other filters can be applied in an open data portal. One of the most important filters is the “text” search. Users can search by specific words using the voice command “search” followed by the term to use for the search of datasets. In case no term is used, the system will read aloud the instructions to apply a correct search for data. When a correct search is performed, the user is redirected to the list of datasets that include the term indicated. Therefore, the search operation can be used in the main page of the open data portal but also in the results page in order to add new terms to filter the information.

“Add filter” operation. Many filters can be applied to search for datasets in an open data portal. All these available filters are obtained by WAFRA4OD using the corresponding CKAN API. Among the filters which are available in open data portals are the type of dataset, the publisher and the date. In order to know the complete list of filters, the voice command “add filter” operation is offered to users. Once the users knows all the filters to apply, the voice command “add filter” followed by the specific filter can be used. For example, in order to filter by datasets of type “CSV”, the voice command would be “add filter type csv”. This operation can be used in the the results page in order to add filters to the existing ones (categories, search terms or other filters).

“Remove category”, “remove filter” and “remove search” operations. After including different filters to search for datasets in an open data portal,

¹⁴ <https://www.chromestatus.com/feature/5687444770914304>

we also offer the possibility to remove filters previously applied to the search. Therefore, the voice command “remove category”, “remove filter” and “remove search” operations are offered to users, depending on what users want to remove and followed by the concrete category, filter and search to remove. For example, in case of removing a category called “education”, the voice command to use is “remove category education”; when removing a filter for datasets of type “CSV”, the voice command is “remove filter type CSV”; and finally, when removing the term to search for “education in spain”, the voice command to use is “remove search education in spain”. All these operations can be used in the the results page in order to remove those unwanted filters (categories, search terms or other filters).

“Results” operation. When a search or category operation is performed, the user is redirected to the results page. In order to read aloud the results obtained for the applied search terms and filters, the voice command “results” may be used. In case there are plenty of results, a short list of them are read aloud (at least one page of the results), but only the title and its position is read aloud. In order to stop the reading of all the list of results, the keyboard shortcut *control* + *space* is available. The position of the dataset corresponds to its the order in the results list, which will be used next to get more details and access a concrete dataset. This operation is available only in the results page within the open data portal.

“Order” operation. The list of datasets when a search is performed can be ordered by different criteria. This sorting methods, which are obtained from the DCAT using the CKAN API, can be selected by users with the “order” voice command followed by the sorting method choosen. If no method to sort is choosen, WAFRA4OD can read aloud the available methods for sorting the list of datasets. This operation is only available for the list of datasets in the results page.

“Details” operation. When a search or category operation is performed, the user is redirected to the results page where there is a list of datasets with its name, description and other properties. The “results” operation presented before can be used to read aloud only the title of a set of results, but in order to get more information of a specific dataset, the “details” voice command can be used, followed by the position of the dataset. If the position is missing in the voice command, the instructions to perform a correct “details” operation are read aloud. With this operation, which is only available in the results page, users can get more information to decide wether the dataset is relevant for them or not.

“Choose” operation. Once a user wants to access a specific dataset (after applying operations such as “results” and “details”), they can use the “chosed” voice command followed by the position of the dataset. When users miss the

position in the voice command, suitable instructions to perform the “choose” operation correctly are read aloud to users. This operation is available only in the results page, redirecting users to the dataset’s webpage within the open data portal.

“Read aloud” operation. The most important accessibility operation offered by WAFRA4OD consist of reading aloud, as there are many people who find it difficult to read the text of a website because of vision problems. Therefore, our approach offers a set of voice commands that allow users to listen to the text instead of having to read it. This set of operations consists of the voice command “read” followed by the name of a section to read out loud by WAFRA4OD. In order to facilitate users to know which parts of the open data portal can be read aloud, there is also the possibility to use the “read aloud” voice command to read aloud all the possible sections by their names. After that, users are able to use the “read aloud” operation followed by the section name. The following sections can be read aloud:

- **Read title.** The voice command “read title” can be used to read aloud the dataset’s title when the user is at the dataset’s webpage. The title of the dataset is obtained from the CKAN API, which includes all the metadata related with the dataset itself.
- **Read description.** The voice command “read description” can be used to read aloud the dataset’s description when the user is at the dataset’s webpage. The description of the dataset is also obtained from the CKAN API.
- **Read details.** The voice command “read details” can be used to read aloud the rest of the dataset metadata when the user is at the dataset’s webpage. These metadata of the dataset is also obtained from the CKAN API. Among the available metadata of a dataset can be the publisher, the data of publication, the format and more related details.
- **Read distributions.** The voice command “read distributions” can be used to read aloud the available distributions of the dataset when the user is at the dataset’s webpage. These distributions of the dataset are also obtained from the CKAN API, and the speech synthesis includes the title and format of each distribution.
- **Read data.** This is one of the most important operations offered by WAFRA4OD as it allows users to interact directly with data contents obtained from third parties. Therefore, the voice command “read data” can be used to read aloud the actual contents of the dataset when the user is at the dataset’s webpage. The contents of the dataset can be read aloud by WAFRA4OD using the URL of the data obtained using the CKAN API. In case the dataset includes a set of distributions, WAFRA4OD considers the latest tabular data (“CSV” format) added because it is one of the most important data types in open data portals. However, the distribution to read can be changed using the “choose distribution” command explained in next operation. In order to

correctly read aloud the contents of the dataset, WAFRA4OD offers different ways: “read columns” can be used to read aloud only the name of all the columns in the dataset; “read all” allows users to navigate by themselves through keyboard shortcuts (*control + arrow keys*) allowing them to read one cell after the other; “read rows” is the voice command to start reading out loud all the rows contained in the dataset; “read row” followed by the number reads only the specified row; “read rows from n to m” reads aloud the rows from the position “n” to the position “m”. In case the user wants WAFRA4OD to stop reading the contents, the shortcut *control + space* is also available. The technique to read tabular data is based on the principles found out in previous research [6], which recommends to allow users to easily navigate through the data (i.e. using keyboard shortcuts), and indicating row and column numbers everytime. An example of reading aloud a cell from a tabular dataset is: *column 1 row 2, the value of “City” is “Alicante”*.

“Choose distribution” operation. At a dataset’s webpage, there is a list of available distributions which can be read aloud to users. The default distribution chosen to read aloud and download the open data can be changed by using the corresponding “choose distribution” followed by the position of the distribution (which can be known with the “read distributions” command. The “choose distribution” operation can only be used at the dataset’s webpage.

“Download” operation. Users are also able to download specific datasets by using the “download” voice command. This operation automatically starts the download of the dataset in the Web browser. This operation can only be used at the dataset’s webpage.

“Main page” and “go back” operations. In order to improve navigation within an open data portal, WAFRA4OD offers the following voice commands: “main page” to redirect users to the open data portal’s main page; and “go back” to navigate back to the previous webpage visited in the open data portal. These operations can be used in both the results and the dataset’s page in order to return back. Moreover, a breadcrumb menu with the last visited pages is offered at the top of the webpage in order to facilitate users’ navigation.

“Stop reading aloud” operation. While WAFRA4OD is reading aloud any instructions, text or data, users are able to stop the reading aloud by using the keyboard shortcut *control + space*. There is no voice command for the stop reading aloud because WAFRA4OD is not listening for commands while reading aloud because it will listen to itself in case the user is not using earphones.

“Stop/start listening” operation. Our approach is always ready to process the voice commands by listening all the time to users speech (except while it is

reading something aloud). In case the users wants WAFRA4OD to stop listening for voice commands, the voice command “stop listening” can be used. Moreover, the keyboard shortcut *control + space* is also valid for this operation (if the system is reading aloud, it stops the speech, but when it is not reading, it stops the listening and voice commands are no longer available). In order to reactivate the listening and voice commands, the same keyboard shortcut may be used (*control + space*).

“Change” operation. All available commands can be personalised by users. WAFRA4OD offers the voice command “change”, asking then the name of the voice command to change. If the command to change exists, WAFRA4OD asks about the new voice command to assign to the operation.

“Increase font size” and “decrease font size” operations. For people with vision problems but not blindness, the default font size is generally problematic to read. By default, browsers have an option to increase the font size by a zoom option, but this enlarges everything, making the website disproportionate and also yielding readability problems. Therefore, WAFRA4OD offers the voice command “Increase/decrease font size” in order to adapt the size of the text in the screen to the user’s needs.

“Faster” and “slower” operations. In order to change speech velocity, WAFRA4OD offers the voice commands “faster” and “slower”, thus better adapting to all kinds of user needs regarding the velocity in which our approach reads aloud and speaks.

4 WAFRA4OD case study

A case study is now introduced in order to illustrate how the Web augmentation process is performed and to show the feasibility and usefulness of our proposal for users with visual disabilities. This case study consists of using WAFRA4OD in an open data portal to access relevant data. With this example we attempt to demonstrate that visually-impaired users are helped in the process of accessing open data while using our proposed approach.

In this scenario WAFRA4OD is used in the European Data Portal to access tabular open data because it is one of the most important portals with plenty of tabular datasets. In this case, a user with blindness will search for open data about “Candem council” within the European Data Portal. Then, the user will access a relevant dataset and try to obtain information from its tabular distribution.

Therefore, the first step starts installing WAFRA4OD, which also requires to install the browser extension Tampermonkey¹⁵ and then our script from Greasy Fork¹⁶. After that, in the European Data Portal main webpage (Figure 1) visually-impaired users can start using the accessibility operations of our approach to access open data.

When accessing a portal such as the European data portal with WAFRA4OD activated, it automatically reads aloud the available operations. At any moment, the overview of available operations can be re-heard using the voice commands “welcome”, “hello” and “list operations”. Then, the user is able to use voice commands to filter the available datasets. In this case, the user filters by the term “Candem council” using the voice command “search Candem council”. After that, WAFRA4OD redirects to the results’ list of datasets that fulfill that search criteria (Figure 5). Then, the user wants to add filters about the format and about the country in order to better find the dataset of interest. By using the voice commands “add filter”, the user is able to know which filters are available and which ones adapt best to their needs. In this case, the user is going to filter the “type” by the voice command “add filter type csv”, and then, filter the country with the command “add filter country United Kingdom”.

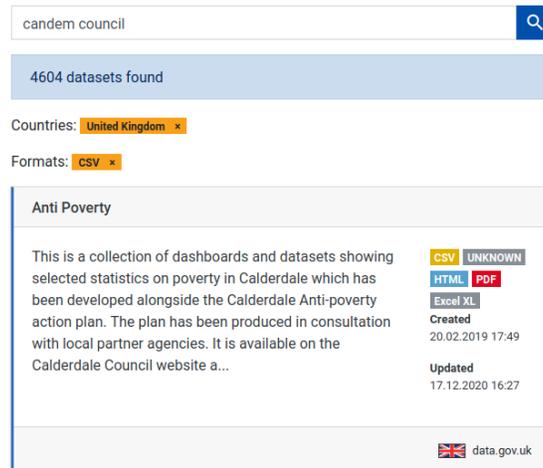


Fig. 5. Extract from the European Data Web Portal results page.

Once the user has filtered the results, the “results” voice command is used in order to know which datasets are available. This operation reads aloud a list of datasets identified by their position in the list and their names. When an interesting dataset is read aloud, the user stops the reading by using the *control + space* shortcut and then uses the “details” voice command to make

¹⁵ <https://www.tampermonkey.net/>

¹⁶ <https://greasyfork.org/es/scripts/395494-wafra>

sure the dataset is relevant. Now, the user selects the dataset to access its specific webpage by using the command “choose 4” due to its fourth position in the list of results.



Fig. 6. Extract from the European Data Web Portal dataset’s page.

The user is now redirected to the datasets webpage shown in Figure 6. In order to know which parts of this webpage and the dataset can be read aloud by WAFRA4OD, the user takes advantage of the “read aloud” voice command that reads all the instructions and sections available. As the user already knows the metadata related to the dataset, which has been read aloud previously with the “detail” operation, the user starts directly by reading the data contents. In order to get specific content from tabular data, there are different available options. In this case, the user wants first to read the available columns with “read columns” command, and then, to read all the dataset by navigating using the keyboard. Therefore, once the user knows the columns, the voice command “read all” allows the user to freely navigate through the data by using the shortcuts *control + arrow keys*. After reading some cell values from different rows and columns, the user stops the navigation by using *control + arrow keys*. An extract of the dataset is presented in Figure ???. As can be seen, ...

This case study in the European data portal is shown also in a demo video¹⁷ in order to better see how the user interacts through voice with WAFRA4OD.

4.1 Discussion

Once presented WAFRA4OD and a case study of using the approach to facilitate the access to data from an open data portal by visually-impaired people, we can conclude that our system achieves the objective of providing users with a voice-interactive system that allows them to navigate within an open data portal and access relevant data. We have already tested the approach in the European Data Portal by accessing tabular datasets provided by different publishers and with data related to different categories. However, our approach grants generality as it can be easily included in any open data portal which contains tabular data and uses the DCAT standard (through CKAN API) for accessing portals’ metadata. Therefore, using WAFRA4OD allows users with visual disabilities to be able to find and access relevant open data by interacting through voice.

¹⁷ <https://youtu.be/LWXYeAG0lig>

5 Conclusions

In this paper we have presented an approach that aims to help data enthusiasts with visual disabilities in accessing open data. Using WAFRA4OD, users are able to interact through voice with available accessibility operations, such as navigating within the open data portal and reading aloud datasets information, metadata and contents.

First of all, users with our approach installed access the data portal such as the European data portal, and then WAFRA4OD offers the available operations. For example, users can search for relevant data by interacting by voice, and then, they are redirected to the results searched. After looking for data within the portal, users are now able to access a specific dataset and interact with its contents also by using voice commands. Therefore, with our approach visually-impaired users are now able to fully interact by voice with open data portals and navigate between their catalogues and datasets.

As future work, our main objective is to create new operations regarding data processing. Additionally, we plan to perform an experiment with real users in near future in order to evaluate the actual impact of our approach within data enthusiasts and visually-impaired users.

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