Intelligent Environments 2016
P. Novais and S. Konomi (Eds.)

doi:10.3233/978-1-61499-690-3-348

Towards Integrating People with Intellectual Disabilities in the Digital World

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Abstract. Information and Communication Technologies have radically changed the way in which we access and share information. However, accessibility for all is still far from being a reality. People with Intellectual or Developmental Disabilities (IDD) currently have very limited access to the information society and, in particular, to social media websites. Even though the recent technological advances have provided valuable support for people with disabilities, the focus has in most cases been placed on sensory and physical impairments, while IDD is normally not on the agenda of technology developers. In this paper, we will describe how the *Able to Include* project is changing this situation, using various Natural Language Processing (NLP) techniques. We will also describe how the pilot studies guide us in improving our tools.

Keywords. IDD, social inclusion, social media, full access, safe access, pilots

1. Introduction

Able to Include will improve the Quality of Life of people with Intellectual or Developmental Disabilities (IDD)[1] and similar conditions, such as dementia. To achieve this, the project will integrate and further develop a set of previously developed technologies to create a context-aware Accessibility Layer that, when integrated with these technologies, can improve the day-to-day life of people with IDD. By understanding the users' surroundings, the Accessibility Layer helps them to interact with the information society. The project focuses on some of the most important areas that a person needs to live independently and find fulfillment as an individual: to socialize in the context of the web 2.0, to travel

[1] Also called Intellectual Disability (ID), Intellectual Disorder (ID), etc.

without the need of assistance, and to be able to work independently.

Just like their family and friends, people with an intellectual disability want to make use of social media websites such as Twitter, Facebook, and WhatsApp. These are inherent parts of life in the 21st century and should be accessible to anyone. However, the issue arises that people with IDD are often to some extent functionally illiterate.
In the current project, we want to offer them a way to overcome these problems. We are working on a personalized, context-aware Accessibility Layer (cf. Sec. 2), offering them the possibility to make use of one or more of the following three Natural Language Processing (NLP) technologies:

- Text and content simplification for English and Spanish (Sec. 3.1)
- Pictograph translation for English, Spanish, and Dutch (Sec. 3.2)
- Read out messages for English, Spanish, and Dutch (Sec. 3.3)

Able offers several solutions, as the needs may differ per user and/or circumstance. For example, in a noisy environment, a read aloud message may not be clearly audible. In such a case, it may be better to make use of one of the other available options. And more complex messages may first need to be simplified, even when the user just wants to listen to them or wants to have them translated into pictographs

Able to Include is a 3-year project that started March 2014. The first year was mainly devoted to adaption of existing NLP tools and resources to this specific set of intended users, while the second year focused on the pilot studies (Belgium, Spain, UK) in collaboration with these users and their coaches. Their feedback was used to improve the NLP tools. This work will be continued in the last year.

In the following, we first address the Accessibility Layer (Sec. 2), thereafter the three key NLP techniques (Sec. 3). In Sec. 4 one of the pilots is discussed, whereupon in Sec. 5 some new additions will be described.

2. A personalized, context-aware Accessibility Layer

The Accessibility Layer is the core development of *Able to Include*, whose main objective is, cf. above, to improve the quality of life of people with IDD and similar conditions. To achieve this, the project integrated a set of NLP technologies to create a context-aware Accessibility Layer that can improve the day-to-day life of people with IDD. In Fig. 1, we present an overall structure of the Accessibility Layer.

The layer is context-aware, the formats offered depend on the language and social media settings of the user. For example, by accessing the Text2Picto or Picto2Text technologies, the user gets the possibility to translate natural language text into pictographs and vice versa. Three natural languages and two pictograph languages are provided. In the near future, we will enable users to upload their own photographs as well, such as images that depict their family, pets, or local football team. These photographs are not part of the fixed pictograph sets that are offered by the pictograph translation systems and give the user the possibility

to personalize their sets. They will also be able to choose between a full set of pictographs or a more reduced set, if the full set is deemed too complex for them. Examples like this make the Accessibility Layer a personalized, context-aware layer, adaptable to the needs and preferences of the individual user.

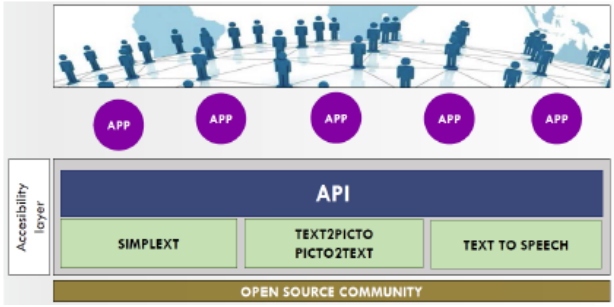

Figure 1. The overall structure of the Accessibility Layer.

The various NLP techniques used (simplification, translation into and from pictographs, and text-to-speech) are described in the following section.

3. NLP to the rescue

More and more NLP tools and resources are made available as open source products. For *Able to Include*, this was a prerequisite. The *Able* tools and resources all meet this requirement.

3.1. Automatic text simplification

Automatic text simplification is a research field in Computational Linguistics which studies methods and techniques to simplify textual content. Text simplification methods should facilitate or at least speed up the adaptation of available and future textual material, making accessible information *for all* a reality. Although research in text simplification has intensified in recent years, many text simplification solutions are yet to be incorporated in information access systems.

Text simplification systems usually address two different tasks:

1. *Lexical simplification*, which is concerned with the substitution of difficult or uncommon words or expressions by their simpler synonyms; and
2. *Syntactic simplification*, which is concerned with the simplification of long and complicated sentences into equivalent simpler ones.

The following example shows a complex sentence (O) containing complex syntax (e.g., a relative clause) and complex vocabulary (e.g., words such as *automobile* or *marvelous*) simplified into two shorter and simpler sentences (S).

(O) The president, who is visiting London, owns a marvelous automobile.
(S) The president owns a great car. The president is visiting London.

Our technology is able to address different types of syntactic phenomena. We have developed a state-of-the-art text simplification system able to simplify both Spanish and English content. Here, we will explain the methods used to simplify English. For the Spanish system, the reader is referred to [1]. The English simplifier YATS [2] has been built aiming to improve text readability and understandability in order to help people with IDD. It is highly adaptable and the resources used can easily be changed to meet the needs of people with special demands.

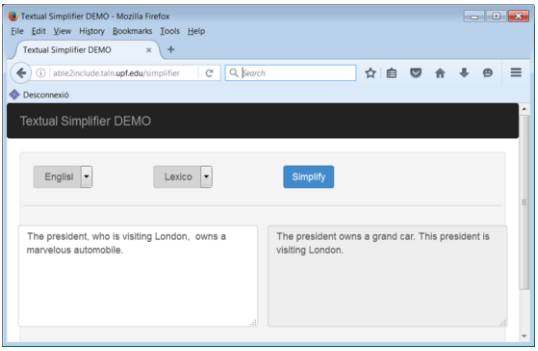

Figure 2. Online demonstration of the English simplification system.

The system comprises two different parts: (i) a lexical simplifier, which identifies complex words in text and finds simpler synonyms to substitute them, and (ii) a syntactic simplifier, which, given a sentence, checks for complex syntactic constructions transforming them into simpler ones.

The lexical simplifier is a pipeline of NLP components which carries out the following tasks:

- Document analysis using available algorithms from the GATE system [3];
- Complex word identification using word frequency thresholding based on several word frequency lists;
- Word sense disambiguation and synonym selection using a word vector space model to represent word meaning following the method in [4];
- Synonym ranking using frequency information; and
- Language realization using an available library (i.e., SimpleNLG[2]).

In addition to the basic natural language processing modules from the GATE system, we rely on WordNet-3.1[3], a large database of words, as our source for target words and synonyms and a dump from Simple English Wikipedia[4] which we use to compute term vectors for each word in WordNet-3.1.

The syntactic simplification system comprises three main steps:

- Dependency parsing of the sentences so as to produce a word-dependency graph as the one shown in Fig. 3;

[2] `https://github.com/simplenlg/simplenlg`
[3] http://wordnet.princeton.edu/
[4] `https://simple.wikipedia.org/wiki/Simple_English_Wikipedia`

- Syntactic analysis of the parsed sentences to match in the dependency graph a set of syntactic simplification patterns implemented in JAPE [5], and to identify components which will be used to re-write the sentence in a simpler way. For example, for the sentence in Fig. 3, a JAPE rule would identify a relative clause (i.e., "whose real name is Evangeline St. Claire"), which will be removed from the sentence and used to create an independent new sentence (i.e., "Eva's real name is Evangeline St. Claire.");
- Finally, the sentence realization module uses the identified syntactic elements and produces grammatically correct sentences, adding/removing punctuation, implementing proper upper-casing for words, etc.

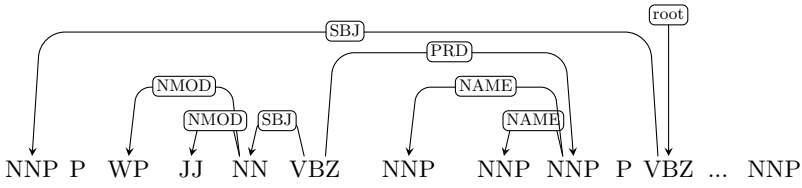

Figure 3. Sentence (partial) representation as syntactic dependencies.

Our simplifier tackles sentences of different complexities, namely: appositions, relative clauses, coordination of sentences and verb phrases, passive constructions, adverbial clauses, and several cases of subordination. Due to space constraints we can not provide here a description of the evaluation carried out of the system output. However, for details on the state-of-the-art capabilities of the system, the reader is referred to [2].

3.2. Picto: machine translation from and into pictographs

The Picto translation system offers both Sclera and Beta[5] pictographs. The first set consists of black and white pictographs, while the latter one consists of colored ones. A noteworthy difference between both sets is the fact that, in Beta, one pictograph usually represents one concept, whereas in Sclera, it is quite common for a pictograph to represent several concepts. The Picto translation system was developed to deal with both types of pictographs. The sets were already widely used in schools and daycare centers in Belgium, whereas in Spain, and the UK, no alternative set was prominently used. It is important to note that users who did not receive prior training or instruction need to familiarize themselves with the pictographs first, for example, by playing games like the ones developed in the Pictogram project (www.pictogram.se).

For our Text2Picto and Picto2Text translation systems, we had to link all Beta and Sclera pictographs to WordNets. Using WordNets ensures a relatively easy extension to new languages, but it also allows us to handle synonymy, antonymy, and hyponymy relations between words, among other things [6],[7]. Our

[5]http://www.sclera.be; https://www.betasymbols.com

approach is as language-independent as possible, i.e., other sets of pictographs[6] can be added, as well as other natural languages.[7]

Currently, we offer translations from natural languages (English, Dutch or Spanish) into Sclera or Beta pictographs, or the other way around.

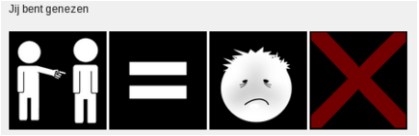

Figure 4. Text2Picto translation for *you have recovered*.

Fig. 4 shows the sequence of pictographs automatically generated when entering the sentence *jij bent genezen* (*you have recovered*) in the Text2Picto system. Note that *recovered*, for which no pictograph is available, is depicted as *not ill*.

Figure 5. Possible Picto2Text translations for a Beta and Sclera sequence. Pictographs can correspond to different words and word forms. Note that the Sclera sequence contains a complex pictograph, namely the jumping dog.

At the bottom of Fig. 5, some of the sentences are shown that could be generated by the Picto2Text system when pictographs are selected for *my*, *dog-jump*,[8] *in*, and *river*. The winning translation depends on frequencies of such constructions in a large corpus.

When composing a message in pictographs, the pictograph selection tool can be used. This tool offers both a static pictograph hierarchy and two dynamic modules that suggest new pictographs to the user, based on previous input [8].

3.3. Text2Speech

After an investigation of open source engines for speech synthesis that are widely used for desktop, server, mobile, and internet applications, the original *Able to Include* Text2Speech service was developed using the eSpeak speech synthesizer (http://espeak.sourceforge.net) as it is compact, fast and addresses many lan-

[6] Like Arasaac (arasaac.org) or Pictogram (www.pictogram.se)
[7] As long as a Wordnet is available for that language, preferably linked to Princeton WordNet.
[8] In Beta, the user needs to select the separate pictographs for *dog* and *jump*

guages. However, in the pilots, many users did not like its speech quality and found it difficult to understand. So, a setup option was added to enable the *Able* Social app to instead use the local Text2Speech synthesizer available on the user's device.[9] This is immediately available in the user's own language and also allows various speech settings, such as speed and voice, to be set to meet the needs and wishes of each user. The slow speed option is proving to be particularly useful for our users with IDD. The speech quality is excellent and proving to be very popular with users.

4. The moment of truth: the pilots

Within the *Able to Include* project, three types of pilot studies are carried out. One concerns 'Leisure within the Information Society', another one 'Mobility', and the third one 'Labor Integration'. These pilots are a very important part of the *Able* project, as they allow, through the interaction with real users, for a permanent adjustment of the project, especially of the tools and resources involved. Of course, not all desiderata can be met. This can be due to technical reasons, legal reasons, or simply because they go against the principles of the project.

At the start of the project, the idea was to create a safe internet environment, with an application somewhat resembling Facebook. But it turned out that the users wanted the real thing. So, the plans were adjusted. The Accessibility Layer now contains videos showing the users how to use Facebook safely.

Below, we will discuss the Belgian 'Leisure within the Information Society' pilot which aims to familiarize people with IDD with Social Media.

4.1. The Leisure pilot study (Belgium)

The work with the users in the second year of the project was based on the results of the work with the users from the first project year [9] and literature research. It became clear that all of the users and their coaches needed training on Facebook use [9] and media literacy [10] to ensure a safe online environment while testing the *Able* Social app.

In Belgium, 52 users and their coaches from five different care centers for People with Intellectual Disabilities were involved. Sessions were organized approximately once a month in every center during six consecutive months. In total, five training sessions with the researchers were set up at all different centers.

Tablets were handed out for all the participating people with IDD who did not have a device. We set up a private Facebook group for the coaches, together with a Symbaloo (www.symbaloo.com) platform, where helpful documents were uploaded. Feedback was communicated to the technical partners repeatedly during the pilot.

The first three training sessions, which were addressed solely at the coaches, mainly focused on how to effectively train users on Facebook and tablet use. In the first phase, the expectations for the coaches and users were explained and the informed consent forms were handed out to the users, coaches, and guardians.

[9] See for instance https://developer.android.com/reference/android/speech/tts/TextToSpeech.html

Specific training was given about creating a safe environment for people with IDD on Facebook. The coaches were also trained in the basic usage of the tablet. They were stimulated to familiarize themselves with the device and use Facebook at home. Finally, a nine-step Train-the-Trainer model [11] for teaching ICT skills to people with IDD was printed out on a poster as an encouragement for the coaches to aim for well-planned training sessions with their users. The coaches were then told to hand over the tablet to the users and to use the device as much as possible in everyday life. Some users could only use them under supervision, others were allowed to use them more independently.

The fourth training session also involved the users themselves. A classic memory game was developed on the topics of media literacy and Facebook. When playing the game, the goal was also to familiarize the users with the symbols and vocabulary used on Facebook and to encourage discussion about media literacy and Facebook use between users and coaches. Whenever a user would find a pair of cards, a statement, such as *my coaches are allowed to see everything I do on Facebook* or *I have met all my Facebook friends in real life*, was read out loud. These topics were then discussed with the group.

The fifth and last session brought together the coaches and users and was organized to receive feedback about the pictograph translation system. The users were asked to translate a number of Facebook sentences into pictographs. Permission was asked to get access their personal news feed, profile, and messenger app and translate real conversations between users and their environment.

Coaches highlight all the possibilities Facebook holds, especially concerning the expansion of their clients' social network. Both coaches and users provided positive feedback on the updated Text2Speech translation and believed it will be of great help to better understand written text on social media platforms. Feedback about the pictograph translation was more specific and forwarded to the technical partners. For example, we received a proposal for more simplified pictograph translations. The users are interested in learning new things and report that they feel less excluded. None of our users have dropped out of the pilot project.

4.2. Additional assessment

Parallel with the training sessions and the testing of the app, 30 people with IDD were assessed with help of applied psychology students with respect to:

- Facebook use
- Self-esteem
- Size and type of social network[10]

Separate interviews with users and coaches were organized to gather data on Facebook use and on the content of the individual training sessions organized by the coaches. The MSNA-VB revealed that the 30 users have an average of 9 people in their social network (range 2-18). They have significantly more family members in their network than friends or caregivers. People with IDD are very

[10]Using the Facebook intensity (FBI)-scale [12], the Rosenberg Self Esteem scale (RSES) [13] and MSNA-VB [14], respectively.

satisfied about their social network. There is no significant difference between the satisfaction scores on their network of family members, caregivers, or friends.

People with IDD have significantly more face-to-face contact, compared to contact by phone, or contact through computer, tablet, or smartphone. The difference between contact by phone, or by contact through computer, smartphone, or tablet is negligible.

Before carrying out the analysis of the RSES, calculation of Cronbach's alpha showed that the reliability score was highly insufficient after the pre-measurement. After excluding two items that were written in a negative form, reliability grew to a sufficient level (alpha .76). Participants scored an average of 16.43 on the positive self-worth-scale (a sum of four remaining items) at the pre-measurement moment. The reliability score was insufficient at the post-measurement, even after excluding the negatively formed items. Thus, this scale could not be used in this analysis.

Before carrying out the analysis of the FBI, Cronbach's alpha was calculated: the reliability score was sufficient (alpha .89 at pre-measurement and .83 at post-measurement). Participants attributed more importance to Facebook during the post-measurement than during the first measurement. This significance disappeared when only people with IDD who already used Facebook at the time of the first measurement were included in the analysis.

The results of the additional interviews will be analyzed and reported on in the second half of 2016.

5. Conclusions and further work

The results thus far are very promising. Our users are all very enthusiastic about being part of the project and being able to contribute to scientific research. They are eager to learn more about the technologies and positive about using Facebook. We still receive lots of feedback from them. In this last year of our project, we will try to meet their wishes. A new tool to be added, for the time being just for Dutch, is a spelling corrector geared to people with IDD [15]. Near the end of the project, a Quality of Life measurement will be performed. Did *Able to Include* achieve what it wanted to: a better Quality of Life for people with IDD?

Acknowledgments

The work represented in this paper is partially funded by the *Able to Include* project through the European Commission's ICT Policy Support Programme as part of the Competitiveness & Innovation Programme (Grant no.: 621055).
We want to thank the *Able to Include* colleagues, and, last but certainly not least, our users.

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