Open Source Technologies for Dyslexic Pupils

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Abstract. We describe how Open Source applications can be used to achieve aids for the integration at school of pupils suffering from dyslexia. The experience is based on speech synthesis tools, Festival and MBROLA, and requires a trilingual installation, supporting speech synthesis for Italian, German and English. Work is at present on going within some pilot schools of the Autonomous Province of Bolzano/Bozen, Italy.

Keywords. computer-aided learning, dyslexia, speech synthesis, open source

1. Introduction

The increasing number of early diagnoses of dyslexia has caused a corresponding growth in promotion of education for dyslexic pupils, especially in compulsory education after the age of 9–10. By means of teaching aids, these pupils can achieve a full education, despite the slower pace of their reading, with respect to normally able students. Social legislation is also enforcing the adoption of accessible technologies to help disabled pupils in their studies.

In many EU countries there have been also many actions in support of Open Source technology adoption within public administrations. To this respect, in 2006 the Italian schools in the Autonomous Province of Bolzano/Bozen have successfully moved nearly all personal computers to be used at school (more than 2.450 PCs) to a Linux-based distribution, called FUSS. This represents a pioneering effort in educational use of Open Source software in the classroom (described in [1]).

Yet today even in the Autonomous Province, most software to be used as computer-based aid for disabled citizens is proprietary and runs under Windows. Such software is often acquired with public funds, by schools and by National Health Services, thus representing a significant cost. Since the dyslexic student is the only one using Windows, while all others are using Linux, he-she is perceived by schoolmates as even "more different", being also isolated for some.

The possibility to use Open Source aids for disabled people has been investigated in the past ([2], and with the SoDiLinux distribution [2]). Desktop GNU/Linux distributions, which integrate speech synthesis tools, were installed in student labs at University level [3], and were employed by blind students. In the experience reported

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[2] http://sodilinux.itd.cnr.it/.

by this paper, a lab workstation was configured, running Open Source software or software available for free to non-profit organizations, in order to provide speech synthesis in Italian, German and in English, with easy keyboard commands to switch between the languages. No special device needed to be installed, only earphones.

We conclude with some comments on this experience, and on its relevance for the local school system.

2. The Current Use of Proprietary Tools for Dyslexic Pupils

Scientific research on computer aids for dyslexic students, for instance in the work of Oloffson [4], shows that primary school pupils generally improve their understanding of text when helped by a text reader. This effect is increased considering older students. In the work by Wise and Olson [5], the role of speech tools that can read a word in segments, and then pronounce the segments in order, is examined. Results showed that decoding, word recognition, and comprehension were improved. The experience of Magnan [6] described how students, trained with a software that identifies and reads syllables, improved their abilities in word-reading tasks. More recent studies of Ecalle [7] showed again the importance of the role of Computer-Assisted Learning tools in training low-progress readers, analyzing the results of tests held with two software packages, one able to highlight syllabic units, the other working with complete words.

The school system takes care of a dyslexic pupil at the age of 6–7: while other classmates start reading, the dyslexic pupil shows clear difficulties. Once the diagnosis is achieved, schools in the Autonomous Province of Bolzano-Bozen are supporting the learning processes of dyslexic pupils purchasing a specific computer program, and using a supplementary teacher for part of the schedule. The role of such teacher is to help pupils to become autonomous in their learning activities, using computer aids for a part of this task. The local healthcare service funds the purchase of two software packages, created for the Italian market, Carlo II and Superquaderno [3]. As a consequence, schools adopt these packages, not only for their effectiveness, but also because they do not represent an additional cost, neither to schools nor to families (but of course, the license is a real cost for the taxpayers). The packages propose a set of useful services, among them speech synthesis, using commercial text-to-speech voices of very good quality. Teachers use the packages, for instance, to let a student read a text, obtain help in reading the more difficult words and sentences, and then to record in an audio file the text on which they worked, so that the pupil shall be able to study that text at home, in full autonomy.

The need for dyslexic pupils to read or write a text in digital format can in principles be fulfilled also by use of Open Source software. Digital text can in fact be produced by any word processor, perhaps the most famous being now OpenOffice.Org [4]. What seems to be missing from OOo is the possibility for the pupil to have audio feedback for the text while he-she is writing, or a fast text-to-speech conversion when he-she is reading. This is precisely our first requirement: to integrate Open Source text-to-speech and Open Source word processing.

A second requirement, typical of schools in the Autonomous Province, deals with languages. In fact, the Province is bilingual, and approximately two thirds of its

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[3] http://www.anastasis.it.
[4] http://www.openoffice.org.

population are native German speakers, the rest being native Italian speakers. Students from Italian speaking families attend Italian schools, and they are offered every week German classes. At the age of eleven, pupils also start learning English as third language. This complicates the installation of text-to-speech aids, since for each language a specific proprietary software should be purchased. As we shall see in the following, integration of the support for the three languages has been achieved in the Open Source world.

3. Speech Synthesis

Let us briefly revise what can be achieved by today's text-to-speech technologies. Speech synthesis is the process of generating a human voice by means of electronic devices connected to a computer. It consists of two main steps. The first step is text analysis, where the input text is transcribed in a phonetic representation. The second step is the generation of sounds (waves), where audible output is made with a combination of phonetic and prosody information. The process is sketched in Figure 1. The software module implementing the first phase is often called NLP (Natural Language Processor), while the second is called DSP (Digital Signal Processor).
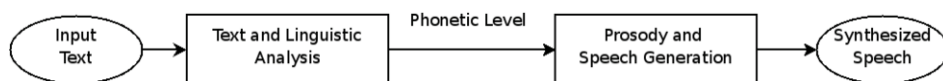

Figure 1. Organization of a speech synthesis suite

NLP contains translations from letters to sound and prosody generation, based on a morphological and syntax analysis. Extraction of a syntax tree from the sentence is extremely useful to achieve good phonetic and prosody translations.

Most DSPs use a voice database that is a collection of registered speech fragments. Elementary components in such database are sounds (a vowel, a consonant) or better, diphones, containing the ending of a sound and the beginning of the next sound (for example the transition between a vowel and a consonant). Starting from phonemes and prosody, the DSP outputs a sequence of segments, which are then adapted to the required prosody, eliminating discontinuities. Finally, the resulting flow is synthesized, and the voice is output [8].

Several text-to-speech tools are available under Linux (see for example those hosted in the BLINUX[5] website, dedicated to resources useful to blind people), but most of them support only one language, typically English, or provide just a minimal support to additional languages. The main reasons for this limitation lie in the length and cost of creating a database of sounds, containing all the relevant diphones for each language, and in the difficulty of expressing and tuning the rules for transforming texts into phonemes.

One of the most promising speech synthesis systems is MBROLA [9], which has a database of phonemes for about thirty languages, including English[6], German[7] and Italian[8] [10]. Unfortunately, the licensing policy of such project is quite restrictive:

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[5] http://leb.net/blinux/.
[6] http://www.speech.cs.cmu.edu/festival/.
[7] http://www.ims.uni-stuttgart.de/phonetik/synthesis/synthesis_demo.html.
[8] http://www2.pd.istc.cnr.it/TTS/It-FESTIVAL.htm.

MBROLA can be distributed only as a pre-compiled binary, and only non-military and non-commercial applications may use its databases of phonemes. In other words, it is not an Open Source product, even if it can be available for free.

Perhaps the most widely known Open Source text-to-speech tool is Festival [8]. It has been developed at Edinburgh University, as a research tool in speech synthesis. It includes a complete text-to-speech conversion module, which can be invoked by other applications, to "say aloud" their output text. The system can be used standalone, or as development environment for further speech synthesis tools. Festival is distributed without licensing restrictions, for both commercial and non commercial use, and can be combined with MBROLA, inheriting its licensing restrictions in combined use. Support for additional languages inside Festival requires installing additional files.

4. Integration of Three Languages in a Text-to-Speech Package

The package we assembled combines the mentioned projects (Festival, MBROLA, and their voices in English, German and Italian), and provides text-to-speech synthesis capabilities on top of Ubuntu GNU/Linux system. The reason for choosing Ubuntu is compatibility with the FUSS GNU/Linux distribution, which too is based on Ubuntu, and relies on the same software packaging format. The software license of our package is not 100% Open Source, as it is not a combination of Open Source software only. This means that the package, in its current form, is not freely redistributable. However, every school can use it free of charge, as the package is distributed internally to the organization that developed it.

FUSS, being based on Ubuntu, already provides a set of accessibility features, that leverage on Festival services. Our package does not modify the way in which Festival is used by other software (it simply extends its default language support, and simplifies the installation process of all languages). For this reason it can be used in place of the original one, without requiring any further customization. The user simply chooses the preferred language, and for example, this choice is sufficient to turn the PDF viewer into a PDF reader.

In the first experiences foreseen, we shall use a set of basic services included into Ubuntu: in this way, trilingual speech synthesis will represent an added value, not only for dyslexic pupils, but also for all pupils that are studying a foreign language, that is, German or English. The screen reader will actively support autonomous learning of all students. In the long term, we are investigating how to integrate our efforts with OpenOffice. This will extend one of the most widely available multi-purpose software by trilingual text-to-speech technology, so that it can be used in many more educational activities and contexts.

5. Future Experiences and Conclusions

The application domain, represented by aids for disabled people, seems to be especially suited for the Open Source paradigm, since the need for application adaptation to actual degree of disability is best satisfied by Open Source software. In practice, this has seldom occurred till now, probably for lack of awareness about the existence of valuable Open Source disability aids.

Our experience has shown that existing text-to-speech Open Source tools may represent good disability aids. Of course, proprietary software aids exist as well, with comparable or higher quality in the synthesized voices. However, the quality of an Open Source solution is already sufficient for many users.

The existence of speech synthesis Open Source software does not mean that it is trivial to run it, and that our installation shall represent a solution for all problems of dyslexic pupils. For Linux installations, care must be taken to configure the system in the appropriate way, and to choose carefully a distribution. To assist in this process, we experienced the interaction with developers and users communities, who gave useful feedbacks on how to solve configuration and interoperability problems, and how to modify or extend the available code.

The contribution of teachers shall be crucial for a successful integration of the disabled student in the classroom. For this reason, teachers have been involved from the beginning of the project, to derive our requirements. They are now going to apply the educational approaches, making use of our package, and will evaluate the contribution of the produced software package in their classrooms.

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