Sibyl: AAC System Using NLP Techniques

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Abstract. This paper presents Sibyl, a new AAC (Augmentative and Alternative Communication) computer system, that aims at improving text typing for persons with sever speech and motor impairments. Typical AAC systems display virtual keyboard on screen which enables key selection via a few switches device. However, text typing is cumbersome. Sibyl aims at allowing faster typing by means of two predictive modules SibyLetter and SibyWord. SibyLetter facilitates key selection through a dynamic keyboard by predicting next letter. It takes advantage of a n-gram statistical model applied on letters. SibyWord allows keystroke saving by word completion. It predicts next word using natural language processing techniques. A robust chunk parsing (non-recursive constituent) is achieved and prediction is based on the last chunk heads occurrences. Best predictions are displayed in a word list. This paper presents the two predictive modules and the Sibyl software used in the Kerpape French rehabilitation center.

1 Introduction

This paper presents Sibyl, a new French AAC (Augmentative and Alternative Communication) computer system for persons with speech and motion impairments. When disabilities aim with sever impairments, most of common interaction modalities are unavailable and the communication capabilities are limited. AAC is the field of research concerned with providing techniques to (partially) restore the communicative abilities of handicapped people. A typical computer based AAC system consists of four components (Fig. 1).

The first one is the physical input interface (command by breath, command by eye-tracking, joystick, pushbutton …) that replaces the real keyboard, unsuited device for much of disabled people. An important point is the degree of freedom for interacting with the computer. The choice of the input depends on the user's abilities. The second part is the virtual keyboard displayed on screen and driven by the input device. It allows the user to select items of vocabulary (letters and words in Sibyl, but icons or a phonetic alphabet in other systems) to compose sentences. In the case of single switch device, the key selection is achieved by scanning. In linear scanning, a cursor highlights successively each key. The user hits when reaching the desired key. In the faster row-column scanning, the selection takes two steps, first the row and then the key in the row; however, it takes two hits, source of errors. The last two components are a text editor, which shows the message and a speech synthesis to pronounce the final text.

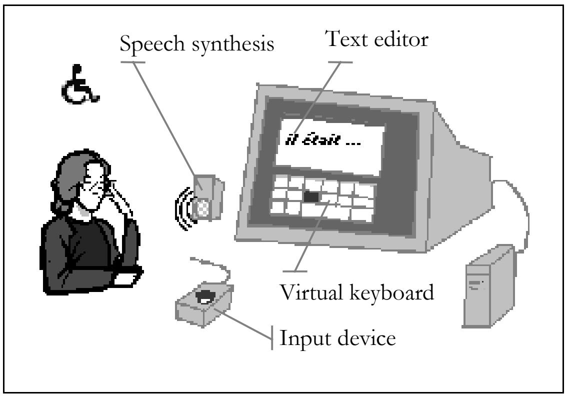

Fig. 1. Computer based AAC system

The main problem in such AAC system is the speed of text input because typing is very slow and time consuming. To allow faster typing, two additional approaches are available: fast key selection and keystroke saving. The aim of the first approach is to reduce the number of steps to reach the correct key, when scanning. Faster key selection can be achieved with appropriate scanning (e.g. row-column scanning vs. linear scanning), by arranging keys in an efficient order to facilitate access to the most used keys [3], or with letter prediction like SibyLetter of our Sibyl system [8]. Nowadays, research for communication aids focuses on methods for keystroke saving. The recall of pre-stored phrases is useful for common phrases or urgency communication. Some systems make use of abbreviations [7]. Finally, a growing number of systems, including Sibyl with SibyWord, allow automatic word completion by displaying a list of predicted words: Profet [4], HandiAS [6]. The use of Natural Language Processing (NLP) techniques increases the accuracy of the predictions.

In spite of significant advances, communication aids can be still improved. The research in assistive communication technologies is especially dynamic and tends towards a pluridisciplinary approach with psychologists, linguists, ergonomists, computer scientists, like, for example, the universities of Dundee (Scotland), Stanford and Delaware (USA), the Royal Institute KTH (Sweden) and the LIM, IRIT French laboratories.

In this paper we present the Sibyl project. Part 2 describes the interface of the Sibyl software, its main characteristics and the principle of our *dynamic keyboard*. The next two sections are dedicated to the predictive modules, part 3 for SibyLetter and SibyWord in part 4. In both cases, we present model, results and the evaluation in the French rehabilitation center of Kerpape with children with cerebral palsy.

1 Interface of Sibyl

Presentation

The Interface of Sibyl (Fig. 2) is especially designed for single switch input device. It consists of a text editor, a virtual keyboard and used linear or row-column scanning. The inputs with word prediction are in light gray.

Fig. 2. Display of Sibyl

The keyboard is a set of keypads (called keyboards), this split reducing the number of steps to reach key in scan mode. *Jump keys* provide moves between keyboards; these are usually in the first keys of keyboard. The picture of the key specifies the target keyboard. On same principle, a shortcut key (at the end of the first row of the keyboard of letters) facilitates, in linear scanning, access to punctuation marks (on the last row).

Text Input

Let us now give a sample of text input on the sentence “comme chaque…” (like every…). When starting, there’s no context, the word list displays the most common words at a beginning of a sentence (determiners, conjunctions, prepositions) and the letters keyboard the most common letters starting a word (“d, l, p…” in French). The word “comme” doesn’t appear in the word list, letter “c” must be typed. The cursor moves from the first key of the letters keyboard (initial position) to key “c” (Fig. 3).

Fig. 3. Input of word *comme* (*like*)

After hit, display is refreshed: cursor goes back to the initial position, the ordering of the letters and the words in the list take new context into account. A short time is let to read the words, word *comme* appears. For word input, two steps are required: access to word list and then word selection. The “jump key” to words is the second of letters keyboard. After typing *comme*, an additional blank char is written at the end of the word.

Fig. 4 shows the input of the next word *chaque*. Note that the ordering of the letters is the same as previous (the context of letters prediction is the beginning of the word) but words are different.

Fig. 4. Input of word *chaque* (*every*)

Dynamic Keyboard

As we’ve just seen, the ordering of letters is changing while typing, giving the letters keyboard its name of dynamic keyboard. Basic idea is to arrange letters so that most frequently letters are positioned on first keys and hence, facilitating their access in scan mode. For example, in *qwerty* keyboard, the most frequently hit key, the *space bar,* is improperly located because in last row. Some new virtual keyboards have taken this problem into account and sort letters by frequency. But the probability of letters differ with the context and the aim of the dynamic keyboard is to reflect this changing order.

After each input, the current context (the first letters of the current word) are given to the letters prediction module, SibyLetter (see Part 3). This one returns the letters sorted by an estimation of their probability to appear. An *end of word* letter (the blank char) is added to prediction. The keyboard is refreshed, the next input can start. The dynamic keyboard uses linear scanning, because as the keys are moving, the row-column scanning became unsuitable (during searching the desiderate letter, row scanning can pass above the row of the letter).

Table 1 and Fig. 5 present the input of each letter of word "comme". Table 1 gives the context sent to SibyLetter, the first propositions returned and the letter to type.

Table 1. Context and first propositions when typing word *comme*

Context	Propositions	Letter
∅	D L P A E C …	C
C	O E H …	O
CO	N M U …	M
COM	M P B …	M
COMM	E…	E
COMME	_…	_

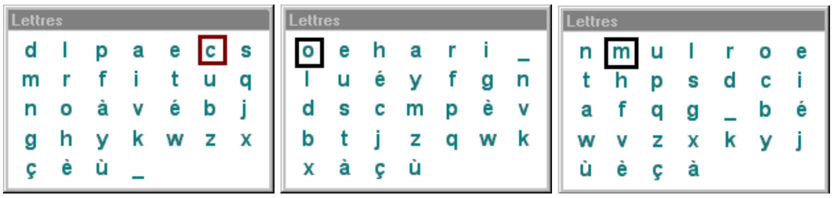

Fig. 5. Dynamic keyboard when typing COM …

The efficiency of letters prediction and dynamic keyboard will be discussed in the next part on SibyLetter.

3 SibyLetter

In Sibyl, the prediction of letters is based on the statistical model N-gram [5]. This one makes it possible to estimate the probability of an event (here of the letters) according to the n-1 last events (according to the 4 last letters of the word in Sibyl). The estimate of the parameters of the model was carried out on the "Le Monde" newspaper (more than one hundred million words).

The theoretical evaluation shows, that on average, the desired letter appears at row 2,9. On the same corpora of training and test, we also calculated the performances of three other modes of selection:

1. row-column scanning on a AZERTY keyboard organized in 3 x 10 ("traditional" keyboards),
2. linear scanning on a keyboard whose keys are classified according to their frequency of use without context ("frequential" keyboard),
3. row-column scanning on the same keyboard as previously.

Table 3 gives the performances obtained in number of steps to reach the desired letter (by taking account only letters).

Table 2. Performances of various modes of selection

Keyboard	Scanning	Steps (average)
AZERTY	row-column	7,3
frequential	linear	7,1
frequential	row-column	4,3
Sibyl	linear	2,9

The results show a significant saving of access time with Sibyl compared to the other modes of selection. This gain is all the more appreciable as the selection of a letter is done into 1 click contrary to the modes of selection using the row-column scanning which require two validations.

The improvement of the effectiveness given by the prediction of letters was confirmed during the evaluation by ten children with cerebral palsy (CP) in the French rehabilitation center of Kerpape [8]. Moreover, this evaluation (without the prediction of words) shows a fall of the typing errors (thanks to the linear scanning) and a fall of the spelling mistakes (necessary in the school context in Kerpape). However, the dynamic aspect can be awkward and we note the failure of the use of Sibyl with one person.

4 SibyWord

For the prediction of words, Sibyl uses an advanced language model [9] with a robust *chunk* parsing (non-recursive constituent [1]. The prediction is carried out in two stages: a preliminary stage of analysis of the sentence then a stage of prediction. The stage of analysis determines for each word their grammatical category (noun, adjective, verb, …), their inflection (gender, number, person, tense). The sentence is then parsed in *chunks* :

l'année du dragon

↓

[l' (article, singular) année (noun, feminine singular)] Nominal Group
[du (preposition, masculine singular) dragon (noun, masculine singular)] Prepositional Group

Fig. 6. Example of sentence analysis on « l'année du dragon » (the year of the dragon)

In the second stage, the system delivers the estimate of the probability of each word of its lexicon (50 000 entries). The predictions are based on the last words and the last heads of the chunks (the main words of the chunks). The model allows a partial management of the grammatical agreements and also a presentation of words in relation to the context. On the previous example, the verbs suggested are "to start, finish", (in relation with "year"), at the third person of the singular and firstly in the present indicative.

The model was evaluated on a test corpus of 50 000 words (from the "Le Monde" newspaper) after a training on two million words. The results of the experimentation show, for a list of 5 words, a rate of keystroke saving of 57 %.

Some commercial systems propose already a list of words. However, the proposals are established without context. The interest to adopt a language model is thus double:

1. It makes it possible to increase the performance of the system in keystroke saving. For example, during the evaluation, we measured a rate of only 43 % with a prediction without context,
2. As mentions [2], the presentation of incoherent words with the sentence disturbs the user.

The integration of the words prediction in the Sibyl application is relatively recent and the evaluation by the users of Kerpape is in hand.

At the present time, the predictions of Sibyl do not adapt to the vocabulary of the user, the proposals are based only on the training of the newspaper "Le Monde". Thus, the rate of keystroke saving expected is lower than that estimated in a theoretical way. The adaptation to the user is one of the prospects for Sibyl.

5 Conclusion

In this article we presented the Sibyl AAC system. The aim of this system is to restore partially the communication function for people with severe motor impairments. We propose to integrate linguistic knowledge to increase the input speed. One of the originality of Sibyl is the dynamic keyboard, tested successfully at Kerpape. Now the evaluation continues for the prediction of words and by the addition of a black box to collect quantitative information.

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