# An Overview of Existing Writing Assistance Systems

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**ABSTRACT**
In this article, we want to make an overview of writing assistance systems since the beginning. As an introduction, we will define the part of writing assistance systems in Augmentative and Alternative Communication, and we will make a brief history of writing assistant systems. In the first part of the talk, a taxonomy of existing systems will be described according to user and designer point of view. In the second part, we will expose how systems efficiency could be increased, by firstly indicating numerous heuristic methodologies, secondly showing various specialised interfaces dedicated for disabled and/or new coming media. One can conclude that writing assistance systems have probably reached a rate temporary bounds. Nevertheless, thanks to new coming media interests, new methodologies should be found to go over the temporary bounds.

**KEY WORDS :**
Writing Assistance Systems, Augmentative and Alternative Communication (AAC)

## INTRODUCTION

Communication is very important in everyday life for everyone. They are various ways to perform it : speaking, writing, moving (harms, hands, face), … Unfortunately, some handicapped people such as motor disabled, cerebral plasy, vocal chord injured, are hampered to do it. They could be considered as "*communicating disabled people*". Moreover, disabled people need to be assisted for ordinary life acts. If communication is altered, troubled or impossible, assistance can not be done. Thus, it is important to have an Augmentative and Alternative Communication (AAC).

### The part of writing assistant systems in AAC

Depending on the time and where the communication takes places, according to the disable remaining abilities (physical, mental powers, …), several ways of communication could be selected. For example, in a hurry time, a very specialized and adapted pictograms system could be used for a quicker and unambiguous communication [Pino 00]. As we will demonstrate, the choice of the communication way could change and progress depending on handicap development [Abraham 03]. At the first stage, if the child (from 2 to 5 years) has no vocal expression, he can use a communication pictures notebook [Bourgeois 02 a, b]. Pictures of his relations (family, friends, nurses,…, pets, …), and his main life objects (house, school, wheelchair, …) are pasted in the book so that disable could designate pictures in order to express his message. When his mental power grows, pictures notebook is quite inadequate. Child has just past a major turning point in abstraction, using communication systems made with symbolic pictures and abstract symbols. There are a lot of pictures communication systems [Guenthner 92] that output (via a speech synthesizer) well formed sentences depending on the pictures selected by the user. AXELIA[1] is a new one created by [Abraham 00, 02], it deals with symbolic pictures and produces vocal output. It introduces grammatical attributes (masculine-feminine, singular-plural, past-present-future, …) so that a child can acquire linguistic notions and selects symbols in the grammatical order. Switching from pictures to abstract symbols, BLISS is also a communication system dealing with abstract symbols [Guillo 94], but it is sometimes difficult to interpret for people who have not a long experience of those symbols. In every communication systems (with pictures or symbols) the number of items are limited. When child mental power grows again, communication systems are once again inadequate. Phonetic representation has to be chosen, increasing both abstraction level and vocabulary expressions. In systems such as SYNTHE 4[2], CLAPOTI [Vella 03], disabled use phonetic symbols to compose messages that are automatically output by the system via a speech synthesizer. Finally, the last step of abstraction could be reached using writing which is the most powerful and the most common way of communication. Unfortunately, it takes a long time for some disabled people to write, so writing assistance systems had been developed.

The main part of this talk will focus on writing assistance systems, it is very useful for people who are able to use it.

### A brief history of writing assistant systems

Looking 20 years back, writing assistance systems were not very popular. As far as we know, the first one that appeared in French literature was found in 1983 [Derouault 83]. This system was built to translate a text from a stenography form to a readable text. But it was not very convenient for a disabled to write in a stenography form. One of the first international

[1] http://www.axelia.com/
[2] http://www.handica.com/produits_services/produit_rw_428.html

publication system specialized for disabled was made by S. Hunnicutt in 1985 [Hunnicutt 85]. Since this date, various systems and numerous publications were made taking into account the main evolutions in computer science using Natural Language Processing (NLP) and Speech Recognition frameworks. Those major changes will be fully explained forward. Currently, writing assistance systems are very popular because they are not only useful for disabled people, but they are also helpful in new coming media such as mobile phones (T9 system[3]) or PDAs [Ward 01]. Some workshops such as [EACL 03] are devoted to text entry methods for both "disabled" and "ordinary" people.

## TAXONOMIES OF WRITING ASSISTANT SYSTEMS

We are now going to describe the main writing assistance systems. In the first part of the talk, focus will be made on user's point of view. On the first hand, we will explain that writing assistance systems can be sorted according to user's interactions. Three interactions ways will be explored. In the other one, we will list main features that will help people to select a writing assistant system. In the second part, the state of the art of text entry will be drawn according to designer's point of view. Systems can be sorted according to language models criteria. Three approaches will be explored : the syntactical, the statistical and the mixed ones.

### User's point of view

The goal of all writing assistance systems is to reduce number of letters the user should type. In other words, the amount of text to be typed needs to be as short as possible. That is the coding principle [Cantegrit 01]. Two kinds of coding can be distinguished : *static* and *interactive* coding.

When a system deals with abbreviations [Ricco 01], the user knows a list of abbreviated words and rewriting rules. They are defined from the beginning and never change. Abbreviation coding method has been updated and popularized with mobile phones and SMS [Willis 02], [Shieber 03]. This is the *static* and *explicit* coding method. Inversely, when a user doesn't know the coding rules, he could use *interactive* and *implicit* coding. When a keystroke is typed, the system provides an output and user reacts with another input. There is an interaction between the user and the system. Two kinds of *interactive* coding can be distinguished. In the first one, the most common way is to display a list of words [Maurel 01], [Menier 01], [Matiasek 03]. Whatever the word mode selection (pointing devices, typing a commands list or the number of the word), coding has been done depending on the word list displayed. In the second one, not any list of words is displayed. When the user types a letter, the system displays either the ending of the word, or a part of it. As soon as the word remains incomplete, user provides letters to the system depending on system output. This is VITIPI [Boissière 96, 01] methodology. Those are an interactive, dynamic and implicit coding methods.

Coding principle is not the only feature of writing assistance systems. At the very beginning, systems dealt with *isolated words*. Previous words were not taken into account [Bertenstam 95] and syntactic or semantic rules were not integrated to the system. Over the years, syntax and semantic were progressively incorporated into systems ([Carlberger 97] [Pasero 98]), thanks to various methodologies that will be widely explained in next section. Nevertheless, most of the commercial systems are still running with isolated words. In opposition to isolated words, we talk about part of sentences, which means a succession or sequence of previous words.

Another feature of writing assistance systems is the ability to deal with new entities that have never been encountered by the system. What we mean by new entities is new words (words that don't belong to system database, misspelled words with orthographic and/or typing errors), or sequences of words that have never been encountered by the system. At the very beginning, when systems were faced with new entities, they stopped (WriteNow[4] in 1986). Nowadays, new entities are handled by systems, but for most of them predictions cannot be done for these new entities. New entities integration into database can be done on-line or off-line. If the integration is on-line the database is automatically updated and new entities are immediately usable, whereas with an off-line integration, the database needs user's intervention to be updated in order to add syntactical attributes new entities, which is not very convenient for the user.

Some systems have standard vocabulary automatically integrated in its database. It could be very convenient but can decrease in efficiency with a such standard vocabulary [Boissière 02]. So, it is very useful if user can set or unset the standard vocabulary and automatically generate its own vocabulary.

Another feature of a such system is the ability to generate a database regardless of the original language. For isolated words systems, language could be changed by swapping vocabulary. For systems that run with part of sentences, it is almost impossible except when grammatical rules and syntactical attributes are not explicitly coded into the system.

[3] http://www.t9.com/

[4] AIRUS Inc, 10 200 S.W. Nimbus Ave, SUITE G - 5 Portland, OR 97 223

Finally, the last useful feature is the aptitude for working into a separated window. Some systems, especially those built for disabled people, have their own editor and can not be used with a general commercial editor or other common software (spreadsheet, databases, e-mails,…).

**Designer's point of view: language modeling**
Moving from designer's point of view, discussion will be centered on systems implementation with a focus on language modeling (the heart of the system). Three main language approaches can be distinguished. Firstly, the *syntactical approach*, will be explained dealing with syntactical rules and grammatical attributes. We secondly discuss the *statistical approach* taking into account stochastic methodologies such as n-grams or Makov models. Finally, *mixed approach* will be exposed as a merging of the two previous approaches. Language modeling also deals with lexical materials. It probably was one of the first NLP problematics, but we will discuss it at the end of this section because all approaches need it and it depends of linguistic methods.

*Syntactical approach*
From this point of view, every syntactical and grammatical rule has to be clearly explained thanks to A.I. representations or programmed instructions. The main feature for such approach is a *lemmatizer*. Thanks to this device, system is able to determine the grammatical attributes of each words. According to syntactical rules and syntactical previous words attributes, system is able to predict syntactical features of actual word. This strategy has been elected by various projects such as KOMBE [Guenthner 93], ILLICO [Pasero 98 a, b], HandiAS [Maurel 00, 01]. We have to notice that all those projects (or team researches) are running with French or German languages, which are very inflected languages [Zagler 00]. They need a great amount of syntactical attributes and a very accurate language description to predict the ending of the word according to previous words.

*Statistical approach*
This approach is used in a great amount of systems because it is very relevant for uninflected languages such as English. Furthermore, they are well known methodologies already used in speech recognition such as Markov modeling [Levinson 85] and sometimes easy to implement such as n-grams modeling [Jelineck 89]. Markov modeling has been used on text entry system such as [Menier 01]. It is often used to model the transition between grammatical classes (or word classes). The n-grams modeling aim is to compute the frequency of words (uni-gram), word pairs (bi-gram) and tri-gram in order to propose the most likelihood word knowing the previous one. A lot of systems use Markov modeling or n-gram modeling [Lesher 99], [Shieber 03] like the EMBASSI project [Clemens 02]. Varying the size of *n*, several n-grams models can be used in the same system creating a multi-gram model that are commonly used in speech recognition as for example in language identification.

*Mixed method approach*
Halfway between this two approaches, the mixed ones tries to merge syntactic and stochastic point of view. The main syntactical attribute of each words is captured via a *lemmatizer*. Thus, sentences could be translated into a syntactical attribute string. Depending on the main attributes of previous words, system computes the most likelihood of the syntactical attribute actual word. Syntactical rules are not listed and implemented by designer (as syntactical approach are), but are automatically extracted from corpus learning. This mixed approach has been elected by various systems such as [Le Pevedic 97], [Carlberger 97], [Palazuelo 01], [Fazly 03].

Nevertheless, all those approaches cannot be run without a powerful lexical materials.

*Lexical materials*
Lexical materials are very important for language modeling and are used both with syntactical, statistical and mixed approaches. Ordinary lexicon were first used with few words, then word frequency were added to lexicon [Hunnicutt 85]. With the apparition of more sophisticated lexical database with syntactical attributes like BDLEX [de Calmès 98], automatic tagging could be done allowing Markov models learning. Nowadays, lexicons are still important, and thanks to electronic documents, corpora could be easy to collect. Both are essential for writing assistance systems.

We are now trying to expose advantages and disadvantages of those approaches .

*Syntactical approach* is well adapted for structured languages. Once grammatical rules are fixed (like programming languages), it is very easy to list and implement the set of rules. This approach seems to be advised for very inflected languages (cf. next section), Unfortunately, only very used languages (English, Spanish, French, German) have linguistic tools such as lexicons, lemmatizer and a suitable list of grammatical rules. On the other hand, linguistic rules are changing and have to be adapted according to various criteria such as age, linguistic levels (slang, popular or elaborated languages, friend letters, professional documents), linguistic topics (medical, legislation, botanic, …), and so on. Thus, it may be very difficult to update and customize such systems.

By the opposite, *statistical approaches* are well adapted for natural language which are not very inflected, with undefined and inaccurate rules (like English language). Unfortunately, it takes a very great amount of learning corpus to compute Markov and multi-grams models. Speaking about n-grams size, Lesher said : "*Predictive performances can be improved by using high order n-gram prediction techniques and larger training texts*" [Lesher 99]. He suggests training texts of more than 3 millions of words for bi-gram and tri-gram.

Between the *syntactical* and the *statistical* approaches, *mixed method approach* seemed to be very convenient because grammatical rules seemed to be automatically learnt via a bottom up methodology. However, like for *statistical* approach, it needs a great amount of corpora (81 millions of words for [Fazly 03]).

Regardless of designer's approaches, the aim is to increase systems efficiency.

## INCREASING SYSTEMS EFFICIENCY

There are two ways to increase systems efficiency. The first one is to improve systems results providing larger output strings. This goal can be achieved by heuristic methods regardless of the designer's approaches. The second one is to adapt systems interfaces to user's abilities and motor impairments. Specialized devices and interfaces have been created for disabled unable to use standard keyboards.

### Heuristic methods

Hunnicutt had already listed those various heuristic methods [Hunnicutt 01]. She estimated that depending on the number of words in the displayed list (5 words or 1 single word), heuristics could increase from 2.8 to 4.2 % the keystroke saving rate. Let us expound the main heuristic methods.

*New words learning*. At the very beginning, new words were added in a additional separated file. When the additional file was full, older words were deleted [Gibler 83}. An inference methodology was found allowing new words to be predicted by analogy with existing similar words [Boissière 92].

*Recency Promotion*. It is based on the fact that when a word appears in a text, it is likely that this word will reappear. Statistical approach increase the weight of this word so that it will be proposed in a few time with a higher probability. It could be almost similar to the Last Recently Use (LRU) methodology used in computer to register allocation.

*Trigger and target*. It could be considered as an alternative of the previous heuristic. It is based on the fact that sometimes two words are highly correlated. When a word appears (the "*trigger*") it could be followed with the same word (the "*target*"). The number of words between "*trigger*" and '*target*" could be variable. Matiasek [Matiasek 03] had provided mathematical indicators to compute word pairs correlation.

*Automatic capitalization*. First sentence name, propre names must begin with a capitalized letter. Automatic capitalization allows keystroke saving incrementation for each well capitalized letter. First letter of the first words sentences are automatically capitalized in some words processing (like *Word*). Palazuelo do it [Palazuelo 01], but first letter of proper names are not automatically capitalized. It will be a challenge for NLP to detect proper names. German language have special capitalization rules, it will be very useful to take it into account.

*Providing inflected forms of words*. Some languages like German, Dutch, Swedish, French, Spanish, … are very inflected. Unfortunately, Zagler noticed that most of writing assistant systems are English language devoted [Zagler 00], so they are not very efficient to deal with inflected forms. Thus, linguistic process are very sophisticated in order to have an efficient keystroke saving.

*Compounds*. Compounds are very numerous in German, Dutch and Swedish language. They are written in a single word in contrast to English or French compounds which are composed with two words separated by a space or a hyphen. A very sophisticated system was made in FASTY project [Matiasek 02] allowing user to write compounds.

Once systems are fully optimized, attention must be focused on user's interface adaptation. Owing to motor impairments, some disabled people are unable to use standard keyboards. Various alternative keyboards have been developed, some of them are very interesting for new coming media (mobile phones, PDAs, …).

### Specialized devices and interfaces

The main principle of such interfaces is to display keyboard on screen. Keypads are selected by the user either with a pointer devices (eye tracking, head moving, …), either by selecting the good one after scanning. Selection is made via a switch fully adapted to user's disability. Depending on the scanning way, various interfaces can be found.

*On screen keyboard optimization* AZERTY or QWERTY keypads organization is not the best one for an on screen keyboard. A more compact and square keyboard with an others letters organization should be found. Thanks to Fitt's law, OPTI system has been created by [Mackenzie 99] for PDAs. Other on screen keyboards can be found [Smith 01].

*Ambiguous keyboards*. Each virtual keyboard keypad has multi symbols affectation. User has just to press one time the keypad, then, thanks to a lexicon and probabilistic weights, system is able to disambiguate the input message (like T9 mobile phone). With the UKO specialized system [Kühn 01] the set of all alphabet letters is divided into four keypads. The keypads are scanned cyclically. When the keypad of the desired letter lights up, user has just to press on the switch. A list of selected words is displayed, user can select the desired one with an other switch.

*Dynamic keyboards*. On a virtual on screen keyboard, letters organization can be changed at any time. One can imagine that the most likelihood letters being placed at the first place of the scanning cycle so that user selects its desired letter more quickly. That is SibyLettre principle [Schadle 01]. Ward's system [Ward 01] is also a dynamic keyboard which has been developed both for disabled (using eye tracking) and PDAs systems.

To our opinion, those devices are on the roll since new coming media are very popular for teenagers and young people. A lot of systems, studies, publications can be found on this field. Will their results and systems easy to use and/or to adapt for disabled ? That is an open question.

## CONCLUSION

We have attempt to demonstrate that writing assistance systems have move from the very small "disabled" population to the large and wide "ordinary" people.

Progress have been done for users' interfaces which are more convenient and attractive for new coming media. But what about the core of writing assistant systems ? Does it goes up ? Actually, systems efficiency are sometimes gauged using keystroke saving rate (KSR), running around 35 to 45 %. Last papers [Matiasek 03], [Fazly 03] increase the KSR from 0.5 to 2.5 % using sophisticated algorithms. One can though that writing assistance systems have probably reached a KSR temporary bounds. Nevertheless, it could be observed that human anticipations is greater and quicker than writing assistance systems. New methodologies should be found to go over the temporary bounds.

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