Disambiguation (predictive texting) for AAC

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Abstract

Disambiguation is an input technique commonly known as 'predictive text', although now very much in mainstream use on mobile phones, it can be used for AAC and originated in the Assistive Technology field. This review paper presents disambiguation and suggests its use for AAC.

This paper discusses the basic theory of disambiguation as a text entry method and provides a review of relevant research and development, including the technique's roots in Assistive Technology and more recent developments. Finally, the use of disambiguation as an AAC and recording method is investigated and the set of currently available systems is reviewed.

For practitioners, this paper may be best read backwards – looking first at the case study examples and available systems and then the theory and literature review.

Theory of Disambiguation

An ambiguous keyboard is one where the number of possible selections is less than the number of possible characters – i.e. the number of keys on a keyboard is less than the number of letters in the alphabet. Ambiguous keyboards have recently come into the popular domain through the popularisation of mobile phones for SMS messages. In AAC we are very familiar with ambiguous keyboards – many AAC systems allow a user to say more things than there are keys.

If you type with an ambiguous keyboard, you will most likely end up with gibberish on your screen, you need a disambiguation process for it to make sense. Disambiguation looks at what key presses you have made (for example, using the above keyboard: '3def', '6mno', '4ghi') and works out what you wanted to say ('dog') – it does this by having some knowledge about the language and using this to guess the most likely thing you could have said. The ambiguity is completely removed when you look at the word and confirm it is correct (or select an alternative word).

This is the disambiguation process commonly used on mobile phones, the most common method of which is called T9 and patented by Tegic [1985]. There are other ways of disambiguating and it is also possible to have any number of keys – down to 3 – rather than the 12 you normally use on a mobile. These topics are discussed later on in this paper.

Disambiguation relies on the fact that language has a certain amount of redundancy – about 50% in English. This is because the way we use letters is not random, it is partially defined by the structure of the language, for example in English, no words contain the string 'pq', not

many contain ‘dr’ and lots contain ‘er’. These features of language were first identified by Shannon and Weaver [1963] who described the ‘Information Entropy’ of language.

Within the context of this paper, we are discussing disambiguation for character entry, in other words – typing. We should not ignore, however, that although this paper will mostly discuss letters and keyboards, the process is applicable to any alphabet and language – including those represented by symbols.

Review of the Literature

Early Disambiguation Papers

Initial work on ambiguous keyboards was carried out in the early 80s and driven by the desire to allow deaf people to communicate over the telephone network. The telephone keyboard (or dial) presented a challenge to researchers wanting to use the system to transmit text. Glaser [1981] looked at encoding methods for the telephone keypad for deaf people – encoding required the user to dial two numbers for each letter – the user having looked up on a chart which numbers to dial for a certain letter. Encoding is an Assistive Technology access method and has also featured in recent work in text entry for handset computers for example Perlin [1998] proposes a type of encoding for stylus entry. Johnson and Hagstad [1981] also looked at similar encoding methods, and are the first to consider the application for people with speech impairments.

Some of these authors discuss language based disambiguation systems, however the methods they propose for removing ambiguity in the keypad use key encoding, not a language model. This work, however, formed the basis for the next developments in ambiguous keyboards – the use of a language models in the disambiguation process.

Witten [1983] discusses the possibility of a word-level disambiguation system, though the system is not detailed, he also introduces ambiguous keyboard entry combined with speech synthesis as an output (over the telephone network). In his book, Witten also discusses the ‘disambiguation accuracy’ for keystrokes on a telephone keypad. Disambiguation accuracy is a measure of how many times the disambiguation system will correctly predict the desired word. Witten reported that only 8% of words in a 24,500 word dictionary would be ambiguous if using 9 keys for entry. Witten also proposed a feedback mechanism to allow the user to discriminate between possible duplicate words as well as describing other entry methods for an ambiguous telephone keypad – including the method known today as ‘Multitap’. It can thus be seen that this book described many of the techniques now employed and used everyday by people using mobile phones to send text messages.

Although Witten describes a language based disambiguation method, he does not propose a particular system to achieve this. Minneman [1985] is the first to document a system for disambiguation of an ambiguous keyboard. Minneman describes a system developed called the ‘T decoder’ and reports a disambiguation accuracy of 95%. Minneman’s system uses both word and character level disambiguation and also allows for the adding of novel words into the dictionary. Minneman does not present a method for distinguishing between ambiguous words but does refer to AAC applications, suggesting the use of the DECTALK speech synthesiser in the context of speech problems associated with hearing impairment. Minneman also describes a small study (n=12) comparing the disambiguation system to coded entry and ‘Multitap’. The results of the study report a preference for the disambiguation entry method and a novice typing rate of 11 words per minute.

Minneman’s work was quickly built upon, with Kondraske and Shennib [1986], Levine, et al. [1987], Foulds [1987], Kreifeldt et al [1989], Levine and Goodenough-Trepagnier [1990] and Arnott [1992] investigating the topic. Areas investigated by these authors include using syllable level disambiguation (i.e. looking up pairs of syllables instead of waiting until the end of the word); the use of a ‘Retry’ button; optimising the layout of the letters on the keys;

modelling input rates for different methods and varying the number of keys. Throughout this period there is a recognition in the literature that this work is orientated towards text-input or communication for people with disabilities.

The first patent related to disambiguation was registered by Tegic in 1995, the company that license the T9 disambiguation technique (Reduced keyboard disambiguating system, Patent - US6307549, 1995). Kushler [1998] and James and Long [2000] describe the T9 system, explicitly mentioning AAC as an original motivation for its development.

More recently the rising importance of mobile communications especially for short text messages has made such systems familiar to many more people – reviews of mobile text input methods are available in: Starner [2004], Johansen and Hansen [2006], Mackenzie and Soukoreff [2002]. Research into the area has mostly moved into the field of Human Computer Interaction and the interest in language based disambiguation for AAC/AT has reduced.

Recent Research Topics

Word and character level disambiguation: mobile phone systems are mainly based on word-level disambiguation, i.e. the probability of words, not characters, are stored. Although the very first systems (Minneman [1985]) suggested word-level systems, further early work tended to be on character level systems since these used less memory. Recent work, following the explosion of such systems on mobile phones, has mostly further examined word-level systems, looking at improving disambiguation accuracy (the percentage of times the right word is predicted) and dictionary size.

Use for AAC/AT: The main work in this area recently has been by Harbusch K, Kuhn M [2003] who developed a disambiguation system that can be used with switches and scanning. With this system they investigated its use with different layouts and variations on disambiguation methods. Their system, UK0-II is available and detailed in the 'Current Systems' section below.

Letter distribution: Conventionally, letters are arranged alphabetically on a telephone keypad, this arrangement is purely conventional and is not optimal for using a disambiguation process. Foulds [1987] showed some small changes in typing rate using alternative layouts on a standard phone keypad. There are, however, significant changes between layouts as the number of keys is reduced and scanning is considered (Venkatagiri [1999]). In addition, optimising layouts on reduced key sets can allow ambiguous text entry to approach 1 keystroke per character as investigated by (Arnott [1992]).

Corpus: The generation of word frequency tables – on which disambiguation relies - requires a corpus (examples of written text) to be examined, and the choice of corpus can greatly alter input efficiency (Tanaka-Ishii et al. [2002]). Ideally a large representative volume of texts should be considered, but in some cases it is better to examine fewer documents more directly related to the domain in which the user will be writing – be it conversation or a scientific article.

Man-Machine Interface: Finally overall good design and HCI must not be forgotten, as Johansen and Hansen [2006] point out, though theoretically efficient key sets and selection techniques can be used often more humble factors of interface design can be more important in determining input efficiency.

The use of Disambiguation Techniques for AAC

One of the interesting things about disambiguation is that it originated in Assistive Technology (AT) and AAC and made its way most thoroughly into the mainstream – 41.8 billion SMS messages were sent in 2006, 5.3 billion in October 2007 alone (Text.IT [2007]). This upward technology transfer is not a common occurrence in Assistive Technology and so it is

paradoxical that disambiguation does not now appear to be a widely used as a technique for AAC/AT.

It can be said that some of the 'principles' of disambiguation, or at least of the theory of entropy of language on which it is founded, can be found in some modern AAC techniques, however it does not appear to be accepted as a popular and widespread technique in it's own right. In addition, 'traditional' word prediction and more modern methods of word prediction such as Dasher (Ward et al. [2000]) also rely on the entropy of language in their method of operation.

The hypothesis of this paper is that disambiguation offers an appropriate method for AAC entry in some cases. The case studies below provide practical examples of where disambiguation may be an appropriate method. These case studies illustrate the following characteristics, which it is suggested make the use of disambiguation appropriate as an AAC method:

- Reduced keyboard size – disambiguation has been popularised through use on mobile phones which have 9 keys. Reducing the physical size of the keyboard and the number of keys required to be accessed be advantageous for many AAC users with motor difficulties.
- Minimising keystrokes – disambiguation strives to maximise the number of key presses per letter – this should minimise the effort required by a user.
- Familiarity of 'texting' – mainstream adoption of texting means that many people are familiar with the concept of disambiguation. Increasingly, AAC users and their carers will have been exposed to and be familiar with the method.

Ultimately, these characteristics of disambiguation may mean that it may present the most efficient, quickest or most acceptable method for a particular client.

Example Case Studies

In order to give examples of disambiguation's possible application within AAC, some hypothetical case scenarios are presented. The objective of these scenarios is to provide stimulus for practitioners to consider their practice and where disambiguation might be an appropriate solution.

Case 1 – Ataxic movements

Case History: Betty had a stroke in 2006 resulting in hemiplegia and severe ataxia. Betty struggles to use a standard keyboard because of incidental key presses and needs a keyguard and 'filter keys' to be able to type, with these modifications Betty is able to type at approximately 4 words per minute.

Use of disambiguation: Betty is able to use a numberpad keyboard with keyguard combined with disambiguation software. Using this system Betty is able to:

- reduce the range of movement required to type - only having to move over the numberpad rather than the whole keyboard and being better able to stabilise her hand and isolate her fingers for typing.
- reduce the number of keystrokes required for text entry, reducing the required effort and potentially increasing her input rate.

Case 2 – Two switch scanning

Case history: Bob is 13 and attends a mainstream school, her has Cerebral Palsy and uses a communication aid with two switch user-scan to communicate. Bob's two switch access method was developed over time and found to be his best method since it allows for his athetoid movements. Bob has recently been struggling to keep up with the recording requirements of his school work. Bob uses a symbol based communication aid, however he has roughly age appropriate literacy. Bob's friends have mobile phones and

he understands the way that they use them and sends text messages to people through his communication aid.

Use of disambiguation: Bob is able to use his two switch scanning method to scan a disambiguation keyboard, the disambiguation dictionary is custom built to incorporate words relevant to the curriculum. Bob uses a 9 key disambiguation keyboard which he scans as 3 rows of 3 – this is significantly less keys than his 256 key based communication aid. This method means that Bob's scanning requirements are significantly reduced. Bob is currently investigating using 'halving' as an access method – meaning that each key would have a 'code' that Bob would be able to learn as a motor pattern.

Case 3 – Limited range of movement

Case History: Ian is 32 and has spinal muscular atrophy, he is an avid computer user and is able to use an upside-down mouse with this thumb to access the computer. To type Ian currently uses an on-screen keyboard with word prediction, however Ian finds it difficult to move the mouse cursor over a wide area, required by the on-screen keyboard – it is easier for him to role his thumb on the ball rather than having to lift his thumb and replace it to enable him to get the mouse to go further.

Use of disambiguation: Ian uses on-screen disambiguation software to type, with practice he is able to make the keypad and prediction screen very small and is able to access it with only small mouse movements.

Case 4 – Familiarity with texting

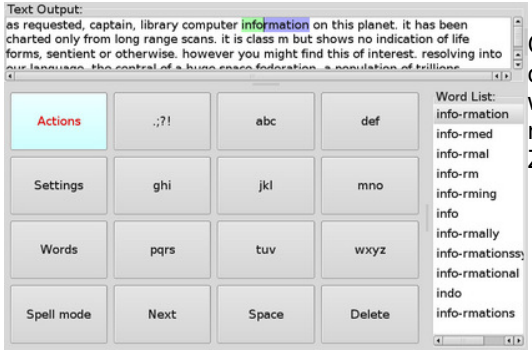
Case History: Tom has cerebral palsy and is 16, he has age appropriate literacy and intelligence and is able to use a mobile phone to text, with some difficulty. Tom communicates using a portable VOCA with touch-screen and keyguard and he records his school work using a keyboard and keyguard and a joystick-mouse. Tom is reluctant to accept use of the VOCA since he feels it is slow and often uses non-verbal forms of communication to compensate.

Use of disambiguation: In order to allow Tom to use verbal communication more effectively, some alternative communication options were investigated. Disambiguation software was put onto Tom's portable VOCA and a custom keyguard made for the screen. In addition, Tom's mobile was equipped with text to speech software and an amplifier to allow him to use it as a VOCA. Tom is able to use the same method of access on both devices, the portable VOCA providing him with more powerful communicative strategies (i.e. phrase storage and retrieval), however his mobile phone allow spontaneous and less stigmatising communication.

Currently Available Systems

It may be a surprise to some that a few 'predictive text' AAC systems exist and can be used for communication or text input. These systems and their different features are summarised below. It should be noted that a number of hardware solutions exist – either to provide access to a mobile phone with predictive texting, or using disambiguation – only software solutions known of by the authors are covered below.

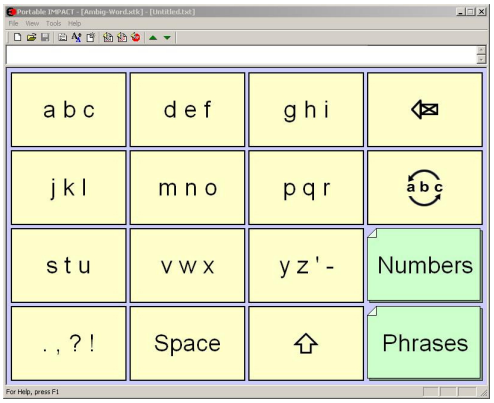
Tapir (www.inference.phy.cam.ac.uk/tapir/):



Developed by Piotir Zielinski of the Cambridge Inference Group, this system was optimised for use with eye-gaze, however it will work with any mouse input. It uses a novel form of disambiguation documented in Zielinski P [2006], however it behaves as you

would expect it to if you are used to the T9 method on a mobile phone. The main noticeable difference is the word list - making it seem more like 'standard' word prediction. This software is free and open source and will run on any operating system, however the down side of this is that it does not currently send text to other applications (you can, however, copy and paste the text). The window size can be dragged to any size/shape and font altered, however the keyboard layout and dictionary are not configurable. It is possible to switch to 'spell mode' for Multitap entry.

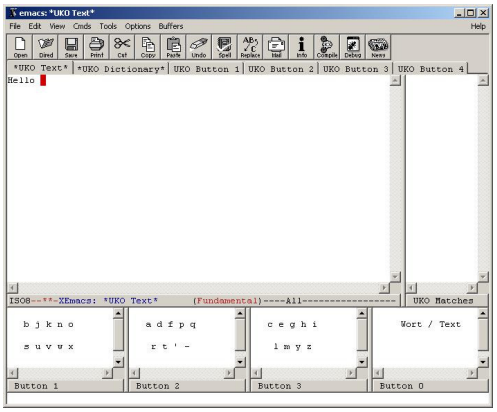
Enkidu Impact XL (www.dynavoxtech.com/products/impact_pcdemo.aspx):



The only current commercially supported software system known to the authors. The software is also in the work by Lesher et al [1998] to investigate keyboard layouts.

The Impact XL package is an AAC package with a number of different layouts and the ability to edit layouts and pages. Impact XL comes with two disambiguation layouts – 'Ambig-word' and 'Ambig-char' (word and character level disambiguation respectively). The software can be used with a mouse, or switch input. The layout and operation is similar to the T9 method familiar on mobile phones, with no word list and a 'retry' button for other words. Text can be output as a synthesised voice, but can not be output to other programs (other than by copying and pasting it). It is possible to edit pages and layouts (for example to add phrases or link to another communication package) however it is not possible to edit the disambiguation keyboard setup or layout. This software is free to download as a demo, the demo restricts the use of symbols and the synthesised voice (for 60 days) – other than that, the software works fully – the full version can be purchased from Dynavox Systems.

UKO-II (www.cogain.org/results/applications/uko-ii):



This software was written by Harbusch and Kuhn [2003] for their research. The software is predominately designed with switch input and a small number of keys (e.g. 4) in mind, however it can be used with mouse input too.
The free and open source software runs through xEmacs – an open source text editor, normally used in the Linux operating system. This makes it quite difficult and to configure without technical support. Instructions have been written on setup by the first author, available at

www.assistech.org.uk/doku.php/research:setting_up_uko-ii. Once setup, the character and key layout can be configured as can the input method and the dictionary. Like Tapir, UKO also features a word list on the right hand side, text is sent to the text area of the screen and can be copied and pasted into other programs.

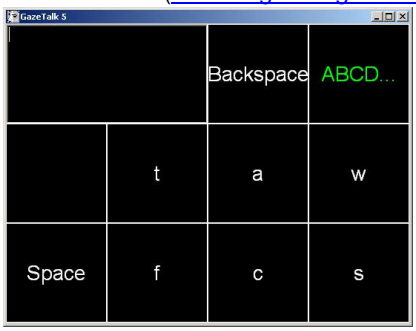
DKey

This program was written by the second author to allow people using a computer keyboard to use disambiguation. This software allows someone to use the number pad keyboard as an ambiguous keyboard. This could be useful for people who are able to use a keyboard (maybe with a keyguard) but would rather not move across the full keyboard – e.g. people with tremor, ataxia, mouth stick users or people with weak movements such as spinal muscular atrophy. The keyboard layout and dictionary are configurable as are the keys used to access it. The window size, font size and colour can all be adjusted. The software is only accessed using a keyboard, and not using a mouse or scanning. Currently this can be obtained on a restricted license from the author, although the plan is to release it as free and open source software.

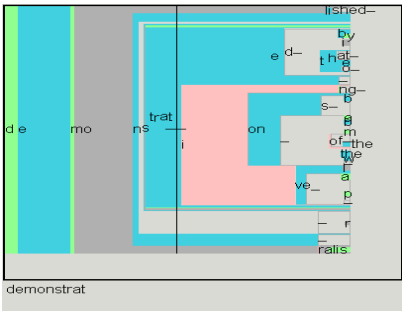
GazeTalk and Dasher:

Although not strictly disambiguation, these are both based on the same work on Information Theory by Shannon and Weaver [1963] that disambiguation relies on.

GazeTalk (www.cogain.org/results/applications/gazetalk) presents a keyboard of the 6 most probable letters and the option to find the letter with A-Z. This generally allows typing without frequent page changes and minimal movement. The software integrates access to speaking, typing, internet and email. This free and open source software was developed by ITU, Hansen et al. [2004], originally for use with eye-gaze interaction although it works with any mouse input and now integrates switch access.



Dasher (www.inference.phy.cam.ac.uk/dasher/) , developed by the Inference Group at Cambridge University also uses language information to present the next most likely characters. To select letters in Dasher you 'drive' through them with the cursor. The most likely letters are displayed larger and so the system often looks as if it is predicting whole words. Dasher allows relatively high typing rate (Ward et al. [2000]) with minimal movement of the cursor. A switch access variant has also been developed as well as a variant that is used in conjunction with voice access.



Summary

Predictive texting, known as disambiguation, originated in the AAC and AT field a long time before mobile phones even existed. It allows efficient and quick entry of text for recording or speaking since it uses information about language to reduce the number of keys required for input.

Research and development on disambiguation methods has been carried out since the early 80s and continues today, although now it is mainly in the Human Computer Interaction field with relation to text entry to handheld computers.

A number of software systems exist that can be used today to allow someone to use disambiguation for text input or communication and this paper has presented these systems and example case studies highlighting the potential areas of use as AAC applications. It is hoped that as awareness of this method increases, in parallel with the increasing pervasiveness of text entry on mobile phones, more people using AAC will find disambiguation to be an efficient and effective method for communication.

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