To appear in: Biomedizinische Technik 49 Suppl. 1:53-54, 2004.

THINK AND SPELL: CONTEXT-SENSITIVE PREDICTIVE TEXT FOR AN AMBIGUOUS KEYBOARD BRAIN-COMPUTER INTERFACE SPELLER

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SUMMARY: A T9 ambiguous keyboard algorithm combined with context-sensitive word selection can reduce the decisions required to 'type' a word. This approach can benefit spelling brain-computer interfaces which typically have less than 100% accuracy and slow information transfer rates. We report on initial research in applying a modified context aware T9 predictive text algorithm to BCI spelling. To support our approach, we present results from a prototype context-sensitive predictive text system.

INTRODUCTION

Electroencephalogram (EEG) based brain-computer interface (BCI) spellers have achieved bandwidths from 1 to 4 letters/min and error rates from 10 to 30% [1,4], which is slow compared to a mediocre typist's 30 words/min.

Recently, Pfurtscheller [4,5] reported on an improved "virtual keyboard" called the VK-T8 which is based on the T9 cell phone ambiguous keyboard. In the virtual keyboard (VK) subjects use motor imagery, i.e. right versus left hand and left hand versus foot, to successively isolate letters [3]. The VK-T8 represents the alphabet plus a period on eight buttons grouped as follows, "ABCD",…,"UVWX", "YZ", ".". In a simulation with 100% selection accuracy and a 7.5 s trial length, a theoretical spelling rate of 2.73 (SD=0.94) letters/min was shown. In a study with three subjects writing five predefined words the spelling rate varied from 1.05 to 4.24 letters/min, an increase compared to the original VK with rates from 0.67 to 1.02 letters/min.

The ambiguous keyboard's advantage is its reduced number of decisions required to select a letter. Using the VK as an example, in the normal VK six decisions are required to select a letter in the English language, and in the VK-T8 four decisions are required to select a letter.

A problem with ambiguous keyboards, such as T9 and VK-T8, occurs when the algorithm guesses the incorrect word intended forcing the user to iterate through a frequency ordered sequence set of words to find the correct one.

Iterating through the sequence set can quickly reduce the benefit of an ambiguous keyboard. For example, the key-sequence 228 produces the sequence set of "act", "bat", "cat". If the user had previously entered the text "Yesterday a stray dog chased my " followed by the key-sequence 228, the system would first suggest "act." If the user intended "bat" one extra decision would be required and "cat" would require two extra decisions making the ambiguous keyboard system equivalent to the normal letter entry system.

T9 is a clever algorithm which takes advantage of the regularity of language, but it completely ignores the context and content of the message and knows nothing about what the words being entered mean.

Our approach to ambiguous keyboards uses common sense knowledge to make better guesses based on the context and content of the text message being composed. It uses two different background knowledge bases and the words of a message (context) to better guess which word is meant by a particular series of button selections. And when it is wrong, it orders the alternative meanings based on the same context and knowledge.

METHODS

To support the idea certain words are related to a particular context, the standard T9 algorithm must be altered to support *word excitation*. When a word is related to the current context the database must disregard the word frequency data and push the word to the start of its sequence set. The word will then be returned first if its associated key-sequence is entered. Because the context will change over time, the database must gradually return the word to its original position in its sequence set after excitation has occurred.

ConceptNet [2] was used to determine which words are related to an input word. ConceptNet is a semantic network containing over 250,000 entries covering everyday and commonsense knowledge. Entries in ConceptNet are concepts (e.g. "bottle", "plastic", and "opening a door") and are connected by a variety of relationships (e.g. "involves part" and "is a").

An issue with this approach is which words to extract from ConceptNet. In the standard approach words that commonly occur in text are always suggested before words that occur less commonly. If the context-sensitive approach suggests a related word for a sequence set that also contains one of the most common words in English ("tie" and "the" or "war" and "was", for example), then it is quite probable that the excited word may actually hinder text input. It is possible to derive a list of the most commonly occurring words and prevent any words being excited beyond them in their sequence sets. The trade-off is determining the appropriate number of commonly used words which should have their sequence sets excluded from excitation. For this reason, different prototype versions which exclude different numbers of common words from excitation were tested.

The ideal text entry system test corpus is a collection of texts similar to what users will enter into the system. There is no widely available corpus of typical BCI text messages, so we developed a set of corpora with similar features. The first corpus we used contained the most recent entries from the first twenty weblogs reporting the top story on BlogDex.net. The second corpus contained the most recent twenty posts from the message boards on Boards.ie. While these corpora may not accurately reflect the style of communication used in many text messages, they are the kinds of messages that will be entered with increasingly regularity as such systems evolve. Following [2], we use two corpora containing articles from cooking and wedding websites (www.cooking.com and www.weddingchannel.com). These topics were chosen because ConceptNet contains a great deal of knowledge about them.

RESULTS

In terms of average number of words suggested first across the entire data set, our context-sensitive approach to predictive text prototype generally offers a small improvement over the standard approach (1.42% improvement in the Cooking data set, 0.63% Wedding, -0.03% Weblog, and 0.46% MessageBoard).

Overall the prototype system performed better in the domains ConceptNet has more knowledge. The writings in the weblog and message-board datasets are on various topics and are typically less consistent about a particular domain; this made it difficult for the system to find strongly related words using ConceptNet. This is reflected in the case of the weblog dataset, where the context-sensitive approach actually decreases the performance of the standard approach. In the domains in which ConceptNet has less knowledge, it is seen that the results improve as more related words are excluded from excitation, causing the algorithm to rely more on frequency data.

Although the average improvements over the entire corpora were not particularly impressive, specific cases demonstrate a significant improvement over the standard approach. For example, the best results in Message Boards and Cooking data sets reduce the decisions required by 2.67 and 3.5 respectively.

When neither the standard or context-sensitive approaches place the desired word in the first position, the context-sensitive approach places it closer to the start of the list in the domains where ConceptNet is more knowledgeable. In the other domains the words are generally a little further down the list.

DISCUSSION

The results highlight two issues in the approach. First, the system lacks knowledge in particular areas. While it has a lot of information about cooking and weddings, there are many subjects that it knows nothing about. This leads to suggesting only weakly related words that end up degrading the performance of the system (by overriding the successful word frequency data). The second problem is that even when the system is knowledgeable about the domain, it runs the risk of hampering performance by exciting weakly related words along with the strongly related words. In short, the knowledge it has is not applied specifically enough. We feel that the problem of ensuring the system applies the available knowledge in a focused and specific way is related to our choice of contextual cues and the types of words we extract from ConceptNet.

CONCLUSION

We have developed an approach to apply commonsense knowledge to the problem of selecting a word from a sequence set for a text entry. The approach extends the standard predictive text approach to make it context-sensitive. It works by overriding the context-free frequency-based sequence set orderings to raise the prominence of words that are related to the current context. We presented some results from a prototype of this system. The results showed mixed success for the system dependent on the amount of knowledge it had for the tested context domain.

The preliminary results support that context-sensitive addition to ambiguous keyboards can reduce the number of next word selections when provided with enough knowledge about the domain. In continuing this research, we are in the process of creating an online P300 speller BCI to utilize this system. In addition, we intend to explore a short-cut mechanism to select the predicted word before all buttons corresponding to letters in the word have been selected to further reduce the number of decisions required.

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