LEVERAGING WORD PREDICTION TO IMPROVE CHARACTER PREDICTION IN A SCANNING CONFIGURATION

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ABSTRACT

A considerable switch savings can be realized by adding a linearly scanned character prediction list to a static matrix scanned in row-column fashion. Past studies of such systems have utilized simple ngram and kgram character prediction methods that utilize only the current word context to generate the character list. Advanced word prediction algorithms can take advantage of several words of past context to predict likely words. This technology can be leveraged to improve the accuracy of character prediction, and thereby provide greater switch savings to a scanning system. Averaging switch savings during the production of seven representative texts, we found that adding word-based character prediction to a conventional character prediction approach can improve performance from 22.6% to 30.4%.

BACKGROUND

Although a substantial body of research has been devoted to improving word prediction methods in AAC, there have been few investigations into more effective character prediction techniques, despite the important role that accurate estimation of letter probabilities can play in augmenting communication. Our research has indicated that character prediction can provide better switch savings than can word prediction in certain scanning paradigms – over 30% in some cases (Lesher, Moulton, & Higginbotham, 1998). Other areas critically-dependent upon accurate character prediction include disambiguation for ambiguous keypads, spelling correction, and automatic abbreviation expansion.

Two common types of character prediction are generally utilized in AAC (Baletsa, Foulds, & Crochetiere, 1976). Both types rely upon a database of inter-character statistics, generated by analyzing a large corpus of representative text. In *ngram* prediction, the past *n*-1 character are used to predict the current (n^{th}) character. In *kgram* prediction, the first *k*-1 characters of the current word are used to predict the current (k^{th}) character. In general, kgram character prediction is more accurate. However, because kgram prediction breaks down when the user is typing words that didn't occur in the source corpus, ngram predictions are often used as a safety fall-back.

Character prediction generally relies only upon characters in the current word – although it's possible to use ngram techniques across word boundaries, they are generally not very effective. Word prediction, on the other hand, can be designed to take advantage of several words of past context. Our research team has performed extensive research into advanced ngram word prediction techniques, discovering prediction models that can provide keystroke savings of nearly 60% in a direct selection paradigm with a six word prediction list (Lesher, 1998).

Any word prediction method can be leveraged to generate character distributions by tabulating the probabilities of each character across each predicted word. For example, if after typing "th" the predicted words and associated probabilities were (the:0.5, there:0.2, this:0.2, though:0.1), the predicted characters would be (e:0.7=0.5+0.2, i:0.2, o:0.1). Provided that the word prediction technique is more accurate than kgram word completion, this approach will provide more accurate probability estimates than can kgram or ngram character prediction. A preliminary study using an ad hoc trigram (*n*=3) word prediction model to produce the character prediction list in a scanning system yielded an average switch savings of 2.4 percentage points (Lesher et al., 1998). Our research team felt that greater savings could be realized in a more thorough investigation of word-based character prediction.

RESEARCH QUESTION

The objective of this investigation was to establish how effectively advanced ngram word prediction algorithms could be utilized to increase the performance of a scanning array supplemented by a character prediction list. More specifically, we were interested in defining a method for combining word predictions with character predictions such that the resulting character list would minimize the switches necessary to generate a given message.

METHOD

Given a list of predicted words with associated probabilities, generating a character prediction list is straight-forward – one simply sums up the probabilities of each character for the current character position, then ranks the characters by summed probabilities. Of course, the length of the word prediction list will determine the accuracy of the character predictions. If the list only contains a few words, the resulting character probabilities will be skewed by the insufficiently large sample set. It is therefore important to use a longer prediction list than would typically be used with a word prediction interface. We found that a 50 word list was usually sufficient to ensure the accuracy of word-based character prediction. It is also possible within our evaluation software to set up a "virtual" word list that has no length limit. The computational requirements of this method are very substantial, and the accuracy gains minimal, so our studies utilized finite-length lists.

Our studies used a scanning model with supplemental character list, as described in Lesher et al. (1998). In this paradigm, a prediction list of 5 characters was scanned in a linear fashion before a static character matrix was scanned in a row-column fashion. The matrix was optimized for character prediction, such that characters that are not generally predicted well appeared in the upper left corner of the matrix (where they were easier to select). Our IMPACT evaluation platform was used to autonomously reproduce seven representative testing texts with lengths between 5 and 10 thousand words, keeping track of the required number of switch activations for each. Baseline switch counts were generated using a static matrix optimized for row-column scanning (the "Time logical" arrangement from Lesher et al., 1998). Switch savings were then calculated and averaged over the seven texts.

RESULTS

Word-based character prediction provided much more substantial performance improvement than we had anticipated, increasing switch savings by nearly 8 percentage points, from a baseline of 22.6% to 30.4%. This gain was consistent across each of the 7 testing texts. In our past studies of character and word prediction techniques (Lesher, 1998; Lesher et al., 1998), we have never witnessed a larger jump in performance that could be attributed to the addition of a single new algorithm.

While our pilot studies produced results that provided less than 3 percentage points, we found that increasing the relative weight of the word-based character prediction engine (with respect to the traditional kgram and ngram prediction components) provided substantial gains. Performance plateaued when the weight of the word-based component reached approximately 50%, and started to fall off again once the weight exceeded 90%.

DISCUSSION

The impressive gains realized by supplementing traditional character prediction techniques with context-sensitive word prediction methods have the potential to substantially increase the communication rate of persons forced to use scanning selection. Assuming constant switch selection times, an 8 percentage point switch savings theoretically translates to a rate gain of slightly over 11% (given by: (30.4-22.6)/(100-30.4)). By reducing the number of switch activations necessary to generate a given message, these prediction methods also help to minimize fatigue.

Despite the significant savings in switch activations offered by conventional ngram/kgram character prediction methods, there have been no comprehensive studies of these methods on communication rate. Indeed, only one commercial system (Enkidu Research's Portable IMPACT) even offers character prediction as a scanning option. The attentional requirements of monitoring a constantly changing character list will likely necessitate a decrease in scanning rates, which may offset some or all of the switch savings. The additional effects of the word-based prediction techniques described in this paper on the cognitive and attentional loads of character prediction are unknown. However, given the large savings in switch activations, it seems likely that these techniques will yield net improvements in communication rate when compared to conventional character prediction methods.

A number of supplemental techniques for improving character prediction performance were investigated by Lesher et al. (1998). These include delaying character prediction until after the first letter in each word is entered and additional optimization of the static character matrix. In the future, we will investigate how word-based character prediction methods can be integrated with these methods to further improve system performance. In addition, we hope to apply these techniques to the disambiguation of ambiguous keypads such as those found on telephones.

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