Errors in automatic speech recognition versus difficulties in second language listening

Maryam Sadat Mirzaei[1], Kourosh Meshgi[2], Yuya Akita[2], and Tatsuya Kawahara[2]

Abstract. Automatic Speech Recognition (ASR) technology has become a part of contemporary Computer-Assisted Language Learning (CALL) systems. ASR systems however are being criticized for their erroneous performance especially when utilized as a mean to develop skills in a Second Language (L2) where errors are not tolerated. Nevertheless, these errors can provide useful information and propose further implications. In this study we investigate the relationships between the underlying features causing ASR errors and those that make L2 listening difficult. This research is inspired by the comparable nature of the difficulties both ASR and L2 listeners encounter in recognizing speech. The aim of this study is to enhance Partial and Synchronized Caption (PSC) systems, which we previously developed for fostering L2 listening skill. PSC presents only a selective set of words (those leading to listening difficulties) in order to encourage listening to the audio and read for problematic words only. To enhance PSC's word selection, we strive to detect individual difficult sentences/words in terms of recognition by referring to ASR errors. Our system compares these errors with PSC choices to find the overlaps and seek further enhancement. The results revealed a close relationship between ASR errors and factors leading to L2 listening difficulties. The findings indicated that ASR errors can contribute to word selection in PSC.

Keywords: automatic speech recognition, L2 speech recognition, listening, partial and synchronized caption.

[1] Kyoto University, Japan; Maryam@ar.media.kyoto-u.ac.jp

[2] Kyoto University, Japan; Meshgi-k@sys.i.kyoto-u.ac.jp; Akita@ar.media.kyoto-u.ac.jp; Kawahara@i.kyoto-u.ac.jp

How to cite this article: Mirzaei. M. S., Meshgi, K., Akita, Y., & Kawahara, T. (2015). Errors in automatic speech recognition versus difficulties in second language listening. In F. Helm, L. Bradley, M. Guarda, & S. Thouësny (Eds), *Critical CALL – Proceedings of the 2015 EUROCALL Conference, Padova, Italy* (pp. 410-415). Dublin: Research-publishing.net. http://dx.doi.org/10.14705/rpnet.2015.000367

1. Introduction

There has been increasing interest in the use of ASR technology in the field of second language acquisition. Some possible applications include the pronunciation evaluation in order to improve oral skills and caption generation in order to facilitate listening comprehension (Shimogori, Ikeda, & Tsuboi, 2010; Thomson, 2013).

In spite of their significant advancement, ASR systems are still endeavoring to achieve better accuracy. The limitations of these systems have raised a number of criticisms when they are utilized as a means for L2 development. This is partly because of the particular challenges involved. For instance, the difference between L2 learner's speech (non-native speech) and standard speech used to train ASR systems makes recognition cumbersome and leads to poor ASR performance especially for spontaneous speech (Thomson, 2013). In addition, as regards the ASR-generated caption, the recognition errors in the output often make the captions undesirable for the end-users. In such cases, even captions including less than 5% Word Error Rate (WER) – a significant performance for ASR systems – can cause distraction (Vasilescu, Adda-Decker, & Lamel, 2012).

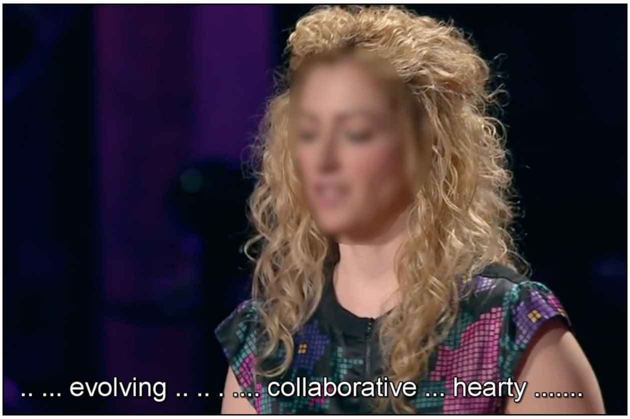
On the other hand, instead of being constantly seen as the major drawback of ASR systems, some research implications could be considered for ASR errors. This exploratory study conducts a root-cause analysis to investigate the potential of using these errors as an inspiring source to determine difficult speech segment.

The goal of this research is to enhance the PSC[3] system, which we previously developed (Mirzaei, Akita, & Kawahara, 2014). In PSC, with the aim of improving L2 learners' listening skill, we created a smart caption that presents a principled selection of words instead of all words in order to encourage listening to the audio by restricting learners to read only for the selected words (Figure 1).

Word selection in PSC is done by referring to factors that lead to comprehension impairs i.e. by focusing on the words, which are difficult to recognize. In this view, we considered several factors such as the speech rate of the speaker, the difficulty level of the words based on their frequency of occurrence in well-known corpora and also the presence of specific words (e.g. academic terms) in speech.

[3] Watch videos on http://www.ar.media.kyoto-u.ac.jp/psc/

Figure 1. Screenshot of PSC on a TED talk made from the original transcript "We are evolving to be a more collaborative and hearty species"


.. ... evolving .. .. collaborative ... hearty ....

In order to enhance word selection in PSC, we need to incorporate more features to enrich the selection criteria. However, the correlation of these features is complicated. As an alternative, in this study we investigate the ASR errors to detect difficult words.

ASR-related studies often compare such systems with native speakers of the target language or with those having no knowledge of that language – Human Speech Recognition (Vasilescu et al., 2012). However, comparative analysis of ASR errors and L2 learner speech recognition would be a more prudent choice, as both parties deal with almost similar difficulties, using available resources and background knowledge. As listed in Table 1, for example, literature emphasizes the important role of high speech rate in deteriorating the performance of ASR systems (Goldwater, Jurafsky, & Manning, 2010) and impairing L2 comprehension (Rost, 2013).

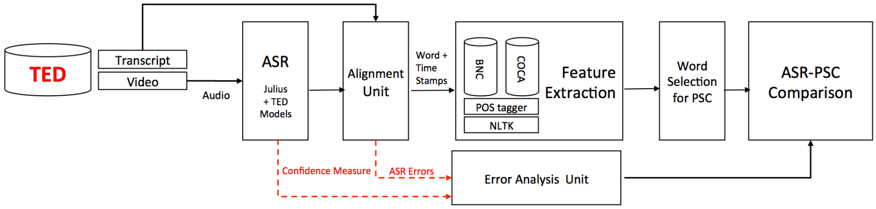
Table 1. ASR errors and L2 listening difficulties

ASR Errors	L2 Listening Difficulties
Pronunciation, co-articulation, speaking style, accent, age, physiology and emotions lead to ASR difficulties (Vasilescu et al., 2012).	Pronunciation, stress, intonation patterns and accent affect L2 listening comprehension (Rost, 2013).
Infrequent words are more likely to be misrecognized (Shinozaki & Furui, 2001).	Infrequent words in speech correlates to complexity (Webb, 2010).
Fast speech / very slow speech increases error rates (Goldwater et al., 2010).	Whether too fast or too slow, speech rate can impair listening (Rost, 2013).
Word length is considered as a useful predictor of high WER (Shinozaki & Furui, 2001).	The length of a word can affect its recognition (Field, 2008).
Open class words have lower error rate compared to closed class (Goldwater et al. 2010).	Learners transcribe the content words significantly better than the function words (Field, 2008).

2. Method

In order to conduct our analysis, we used 64 videos from the TED website (https://www.ted.com/talks). TED provides videos together with human-annotated transcript. This transcript is utilized as a reference to detect ASR errors. Next, the ASR transcripts for these talks are generated by our ASR system based on Julius 4.3.and TED models. The output is then compared with the human-annotated transcript, and the ASR errors together with their confidence measures are stored for the next step. Figure 2 depicts the schematic of this framework.

Figure 2. System schematic



Next, we classify the errors into insertion, deletion or substitution categories and perform a root cause analysis in order to extract profound features such as “speech rate”, “word frequency”, “word length”, etc. As Figure 2 presents, this framework is built on PSC system so that eventually the results can be easily compared with PSC’s output.

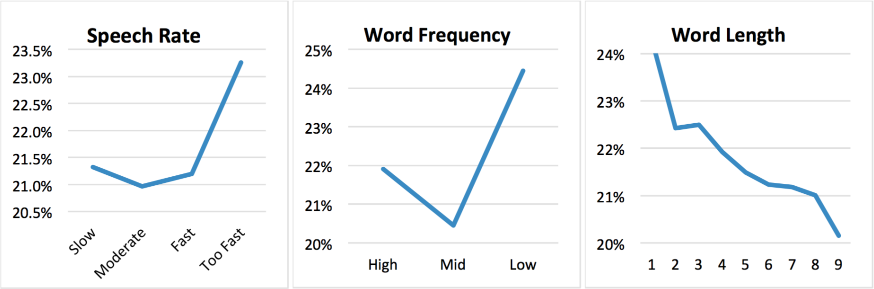
3. Results and discussion

In total there were 169,402 word tokens, of which 13,755 words were erroneously recognized. WER averaged 8%. These errors are categorized into:

- Substitution errors: ASR output is different from human-annotated transcript (7.0%).
- Deletion errors: ASR omits a word that exists in human-annotated transcript (0.4%).
- Insertion errors: ASR outputs a word that does not exist in human-annotated transcript (0.7%).

We then further analysed these errors to identify the features that led to their occurrences. Findings suggest that for both ASR and L2 learners, the most contributing features to difficulties are following similar trends. Figure 3 illustrates how each feature affects ASR WER. As the figure presents WER increases for too fast/slow speech rates, infrequent words and also words with shorter length.

Figure 3. ASR error trends for different features; vertical axis depicts WER (%)



This finding suggests that the errors of the ASR system can be used to predict L2 learners' difficulties in listening. Therefore, in the next phase, we compared these errors with the selected words in the generated PSCs. As Table 2 suggests, around 60% of ASR errors were included in PSC word selection, which indicates that both PSC and ASR found these words difficult to recognize. However, approximately 20% of PSC's selected words were recognized correctly by the ASR system. A part of this mismatch can be explained by the inclusion of proper names and academic words in PSC. However, this finding calls for further investigation to explain the features that induced these errors. Our preliminary analysis indicates that most of these errors are the product of multiple factors such as general ASR processing. Yet, some of them contain useful information such as those related to minimal pairs or proper names. Finally, to verify the difficulty of those ASR errors, which are hidden in PSC, an experiment with L2 listeners is recommended.

Table 2. ASR errors and L2 listening difficulties

	ASR Correct (92%)	**ASR Errors (8%)**
PSC Shown Words (25%)	20%	5%
PSC Hidden Words (75%)	72%	3%

4. Conclusions

This study made a comparison between ASR errors, L2 listening difficulties and PSC word selection to diagnose the words/phrases, which are hard to recognize. ASR can serve as a simplified model of a language learner. In this view ASR errors can provide useful information and introduce pedagogical implications. The findings of this research suggest that ASR errors can indicate difficult/problematic speech segments and hence can be incorporated into PSC system to better meet L2 listeners' requirements.

References

Field, J. (2008). Bricks or mortar: which parts of the input does a second language listener rely on? *Tesol Quarterly*, *42*(3), 411-432.

Goldwater, S., Jurafsky, D., & Manning, C. D. (2010). Which words are hard to recognize? Prosodic, lexical, and disfluency factors that increase speech recognition error rates. *Speech Communication, 52*(3), 181-200. doi:10.1016/j.specom.2009.10.001

Mirzaei, M. S., Akita, Y., & Kawahara, T. (2014). Partial and synchronized captioning: a new tool for second language listening development. In S. Jager, L. Bradley, E. J. Meima, & S. Thouësny (Eds), *CALL Design: Principles and Practice - Proceedings of the 2014 EUROCALL Conference, Groningen, The Netherlands* (pp. 230-236). Dublin Ireland: Research-publishing.net. doi:10.14705/rpnet.2014.000223

Rost, M. (2013). *Teaching and researching: listening*. New York: Routledge.

Shimogori, N., Ikeda, T., & Tsuboi, S. (2010). Automatically generated captions: will they help non-native speakers communicate in English? In *ICIC '10 Proceedings of the 3rd international conference on Intercultural collaboration* (pp. 79-86). New York: ACM. doi:10.1145/1841853.1841865

Shinozaki, T., & Furui, S. (2001). Error analysis using decision trees in spontaneous presentation speech recognition. In *ASRU'01*,198-201. doi:10.1109/asru.2001.1034621

Thomson, R. I. (2013). Computer assisted pronunciation training: targeting second language vowel perception improves pronunciation. *Calico Journal*, *28*(3), 744-765. doi:10.11139/cj.28.3.744-765

Vasilescu, I., Adda-Decker, M., & Lamel, L. (2012). Cross-lingual studies of ASR errors: paradigms for perceptual evaluations. In *LREC* (pp. 3511-3518).

Webb, S. (2010). Using glossaries to increase the lexical coverage of television programs. *Reading in a Foreign Language*, *22*(1), 201-221.

Research-publishing.net

Published by Research-publishing.net, not-for-profit association
Dublin, Ireland; info@research-publishing.net

Critical CALL – Proceedings of the 2015 EUROCALL Conference, Padova, Italy
Edited by Francesca Helm, Linda Bradley, Marta Guarda, and Sylvie Thouësny

Disclaimer: Research-publishing.net does not take any responsibility for the content of the pages written by the authors of this book. The authors have recognised that the work described was not published before, or that it is not under consideration for publication elsewhere. While the information in this book are believed to be true and accurate on the date of its going to press, neither the editorial team, nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, expressed or implied, with respect to the material contained herein. While Research-publishing.net is committed to publishing works of integrity, the words are the authors' alone.

Trademark notice: product or corporate names may be trademarks or registered trademarks, and are used only for identification and explanation without intent to infringe.

Copyrighted material: every effort has been made by the editorial team to trace copyright holders and to obtain their permission for the use of copyrighted material in this book. In the event of errors or omissions, please notify the publisher of any corrections that will need to be incorporated in future editions of this book.

Typeset by Research-publishing.net
Fonts used are licensed under a SIL Open Font License

ISBN13: 978-1-908416-28-5 (Paperback - Print on demand, black and white)
Print on demand technology is a high-quality, innovative and ecological printing method; with which the book is never 'out of stock' or 'out of print'.

ISBN13: 978-1-908416-29-2 (Ebook, PDF, colour)
ISBN13: 978-1-908416-30-8 (Ebook, EPUB, colour)

Legal deposit, Ireland: The National Library of Ireland, The Library of Trinity College, The Library of the University of Limerick, The Library of Dublin City University, The Library of NUI Cork, The Library of NUI Maynooth, The Library of University College Dublin, The Library of NUI Galway.

Legal deposit, United Kingdom: The British Library.
British Library Cataloguing-in-Publication Data.
A cataloguing record for this book is available from the British Library.

Legal deposit, France: Bibliothèque Nationale de France - Dépôt légal: décembre 2015.