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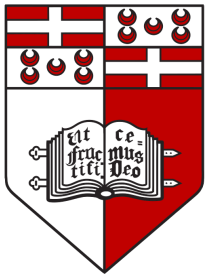
Kenny W. Lino

Msc. Dissertation



Department of Intelligent Computer Systems
Faculty of Information and Communication Technology
University of Malta
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Supervisors:
Claudia Borg, Department of Artificial Intelligence, University of Malta
Andrea De Marco, Institute of Space Sciences and Astronomy, University of Malta
Eva Navas, Department of Communications Engineering, University of the Basque Country

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Executive Summary

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CP Critical Period

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Chapter 1

Introduction

1.1 Voice Conversion

Voice conversion is the

1.2 Research Questions

In this thesis, I focus on investigating the following questions:

- How can we leverage deep neural network technology and voice conversion to convert language learner's speech into sounding more native-like?
- Should we be able to create a sound voice conversion system, would it be possible to convert the language learner's speech with minimal (non-parallel) audio?

1.3 Thesis Overview

The overview of the thesis is as follows: The main research question of this thesis is the following:

1.4 Background and related work

1.4.1 Theoretical and educational motivations

Linguists have long debated over the possibility of whether second language (L2) learners (e.g. adult learners) could ever acquire a language to the extent of a native speaker. Some still cite ideas like the Critical Period (CP) Hypothesis and neuroplasticity which claims that learners cannot acquire language (at least as well as a native speaker) after a certain point in time due to the loss of plasticity in the brain (Lenneberg 1967; Scovel 1988). This theory has been particularly cited in reference to pronunciation, perhaps due to the obvious difficultly in overcoming the L1 negative transfer that many, if not all, language learners experience in speaking a new language.

Since the emergence of the CP hypothesis, many researchers have come to find evidence that suggest the contrary. In Lengeris (2012), we are presented an overview of the interactions between factors that affect second language acquisition such as age, linguistic experience, and learning setting. Here, we find evidence of studies such as Bongaerts et al. (1995), which present a counterargument against the CP hypothesis. In this study, they discovered through a foreign accent rating study with Dutch learners of English that learners could be perceived as *indistinguishable* from native speakers. Other researchers such as Flege have also found that there is no distinct 'cut-off' point like the CP suggests. Thus, while age may have some effect on a speaker's pronunciation, there is no conclusive evidence to say that the loss of plasticity in the brain leads to an inability to acquire language. As Lengeris (2012) states, evidence for the CP hypothesis would require 'a sharp drop-off in a learner's abilities', and 'all early L2 learners should achieve native-like performance' (and vice versa). This is not to say that learners are not still deterred by other aspects like their own L1, but this does highlight the potential that learners could be taught pronunciation, given the right settings.

Aside from the issue of whether or not language learners could ever achieve native-like performance, another question that arises is whether or not there is even a *need* for learners to aim so high. In Munro and Derwing (1999), they discuss the interaction between foreign accent, comprehensibility and intelligibility and point out that the goal for many L2 learners is to communicate and not necessarily sound like a native speaker. They also conduct a study to prove that despite the fact that some speakers may have what some consider a 'heavy accent', that this does not automatically mean that they are unintelligible. They found in their study that errors in prosody tended to affect the speakers' intelligibility the most, which underscores the role of prosody in organizing our utterances.

While linguists make these discoveries and observations of L2 learning, it seems that it takes a lot of effort for them to trickle down to the foreign language classroom. In Darcy et al. (2012), they find through a small survey of 14 teachers that although teachers tend to find pronunciation to be 'very important', the majority do not teach it at all. When asked why they do not teach it, they cited reasons such as 'time, a lack of training and the need for more guidance and institutional support'. Even though the number of teachers surveyed may be significantly small, this gives us a glimpse through the lens of what language teachers themselves experience in relation to pronunciation. We see that even though teachers would like to address it, this would require a restructuring in their curriculum and training– something that would undoubtedly take even more time before students get more pronunciation attention. Compounded with the issue of time and the fact that not all learners need or want equal amount of pronunciation training, it may be unlikely to see such change in second language curriculum so soon.

This points to the potential solution of employing a technology-based system to improve pronunciation as learners could individually address their needs *outside* of the classroom.

1.4.2 Computer-assisted pronunciation training systems

With the improvements of technology and speech processing, researchers have attempted to make a number of computer-assisted pronunciation training (CAPT) systems. In general, CAPT systems utilize some form of automatic speech recognition (ASR) to record a speaker and compares their recordings (usually) with a native speaker gold standard. They also usually include a feedback mechanism with a combination of pitch contours, spectrograms or audio recordings to help the user adjust their pronunciation.

In Neri et al. (2002), we are presented with an overview of the interaction between language pedagogy and CAPT systems. Here, we see that aside from the classroom, there seems to be an issue in relating the findings of linguistics/language pedagogy with technology. Part of the reason, they suggest, stems from the fact that there are not 'clear guidelines' on how to adapt second language acquisition research and thus many CAPT systems 'fail to meet sound pedagogical requirements'. They emphasize the need for the learners to have appropriate input, output, and feedback and exhibit how the systems available at the time were lacking. For example, they criticize some CAPT systems that were prevalent at the time including systems like *Pro-nunciation* and the *Tell Me More* series for utilizing feedback systems that give the users feedback in waveforms and spectrograms, which cannot be easily interpreted without training. Further, they argue that although visual feedback has its merits, this kind of feedback suggests to

the user that their utterance must look close to what is shown on the screen, which is not the case. An utterance can be pronounced perfectly fine, but look completely different from a spectrogram, and *especially* a waveform due to the number of features represented in each visualization, such as the intensity, which will indefinitely vary from user to user and the given examplar. They conclude their article by making it a point to discuss recommendations for CAPT systems, by stating that they should integrate what has been found in research from second language acquisition, and to train pronunciation in a communicative manner to give context to the learners. They also point to the problematic area of feedback and advise that systems provide more easily interpretable feedback with both audio and visual information, and propose that systems give exercises that are 'realistic, varied, and engaging'. Despite the fact that this article was published in 2002, this article provides a sound basis in addressing the proper makings of a successful CAPT system.

In another article by Eskenazi (2009), we are given a brief review of technologies in CAPT systems, this time more focused from a technical perspective. In particular, she gives attention to the different CAPT system types and provides information on prosody detection and complete tutoring systems.

She first explains that CAPT systems can be generally split into two main types: individual error detection and pronunciation assessment. As indicated, individual error detection systems are more focused on one particular aspect of the user's speech, such as the phones or pitch, while pronunciation assessment systems are more designed to represent how a human would judge a non-native utterance.

Early individual error detection systems, including one of her very own Eskenazi and Hansma (1998), started by using a variety of speech recognition techniques such as forced alignment or unconstrained speech recognition. They also worked with a variety of measures to detect the differences between the individual errors and gold standard. Some of these measures include hidden Markov model (HMM) based recognition scoring, a confidence score based system known as Goodness of Pronunciation (GOP), and Linear Discriminant Analysis (LDA). Each of these measures were found to somehow detect the users' errors; however they suffer from issues like low precision or the need for a very homogeneous sample (e.g. Japanese speakers).

Here, Eskenazi (2009) makes a point that working to improve non-native pronunciation is not simply a binary question of native vs. non-native; instead the L1 of the system's users must be considered, as this can greatly affect the evaluation. She also points out that the level of language learning of the speakers can also impact the metrics and success of the system as well, and thus an appropriate population must be selected carefully when building a CAPT system, especially when considering individual errors.

In her discussion of prosody correction, she points to pivotal works that have used a variety of manners to address the issue. Some works include systems that use Pitch Synchronous Overlap and Add (PSOLA) to resynthesize the prosody of users to help them hear what an appropriate utterance would sound like. This in particular could be a potentially effective feedback mechanism to employ in future systems, as it has been said that imitating one's own voice is the most effective. Other systems she mentions include systems that use appropriate L2 phonological models and break prosody down into two levels— syllable-word and utterance-phrase, and systems that detect the 'liveliness' of a speaker. However, she does not discuss prosody correction systems in much detail, which may suggest that there is not as much research in this particular area as compared to the individual error systems. Regardless, these works all provide interesting paths to consider in developing a prosody correction system.

Similar to Eskenazi (2009), Chun et al. (2008), presents a review of various technologies, this time related directly to prosody. They discuss four main tools in teaching prosody: 'visualization of pitch contours', 'multimodal tools', 'spectrographic displays' and 'vowel analysis programs'. Citing previous work, it appears that they suggest that the visualization of pitch contours is the most robust method of feedback for learners as it is the most intuitive and non-language specific. Aside from this however, they also discuss the potential of a multimedia approach used by Hardison (2005) that integrate both audio and video in a system called *Anvil*. Following this research, users of this system were able to generalize their training beyond a sentence level and were able to perform better at a discourse-level. This again emphasizes the point that prosody training should put the language in context, which is an important aspect to consider prosody training, as we know how prosody works in relation to communication.

They also discuss the two main methods of such prosody systems: one which utilizes isolated scripted sentences and the other utilizing imitation. They conclude that neither method is useful for generalizing to novel methods and suggest that the training should relate to the ultimate goal. Other information they provide in this article are prosody models used in previous studies. We see that some previous studies have focused on utilizing a variety of sentence types to teach prosody, contrasting *wh*-questions, echo questions, either-or questions and statements. Like the other articles, the works examined in Chun et al. (2008) gives us insight on potential ways to improve future CAPT systems, as we are shown exemplars of potential input and positive reinforcements in successful types of feedback for the user. They conclude that in order to create better pronunciation training systems, we should take advantage of recent technology.

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