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REVISITING THE EXPANSION OF THE DIPHONE DATABASE OF KAZAKH LANGUAGE, WHICH IS THE BASIS OF INTERACTIVE SPEECH SYNTHESIZER

Rakhmetov A.M.
mailto:almaz.rakhmetov@gmail.com
Postgraduate at Eurasian National University, Astana
Supervisor – G.Bekmanova

Speech synthesis for several centuries occupied the minds of many scientists around the world, their main purpose is to provide a speech synthesizer, that would be as close as possible to the human voice. More specifically, speech synthesis is a computerized simulation of human speech which translates written sentence to the sound. Nowadays, it is becoming essential part of the systems developed by commercial as well as non for profit organizations. For instance, mobile applications such as voice-mail support, translator with voice support, and applications aimed at visually impaired people.

At the moment, there are many speech synthesizers of most common languages such as English, Chinese, Russian, Japanese and other languages of developing countries. Today in the area of synthesis of Kazakh language there already exists already progresses such as[1]:

1) Developed algorithms of transcription of Kazakh words and sentences;
2) Developed methods and algorithms for the analysis and synthesis of words, wordforms, phrases and sentences of the Kazakh language;
3) Developed mathematical model of the phonetic system of the Kazakh language;
4) Developed an algorithm for training the model of Kazakh speech synthesis to a certain speaker.

Kazakh scientists are making great efforts to explore the possibilities, methods and techniques for the synthesis of the Kazakh language, but the results do not yet have reached to the complete stage. In recent years, various strategies and programs being introduced, in one of them, namely in the state program "Information Kazakhstan-2020" stands acute need to build information systems that support human-machine interface. In public policy one of the main priorities is the preservation and development of the state language. In this regard, it is necessary to form a real demand for the Kazakh language in various spheres of information life.

There exist three main techniques of text to speech synthesis.

The first one is the Articulatory Synthesis method, which is based on the simulation of the principles of speech production. It is accomplished by creating a synthetic model of a human physiology and making it speak [2]. The model contains speech articulators such as tonque, jaw, lips, nose etc . The human speech production organs and an idealized model is shown below in the figure 1.1 Despite the fact that there have been couple of promising articulatory synthesisers, it is very hard to build synthesisers using this method [3]. Therefore, this method is considered as least used synthesiser.

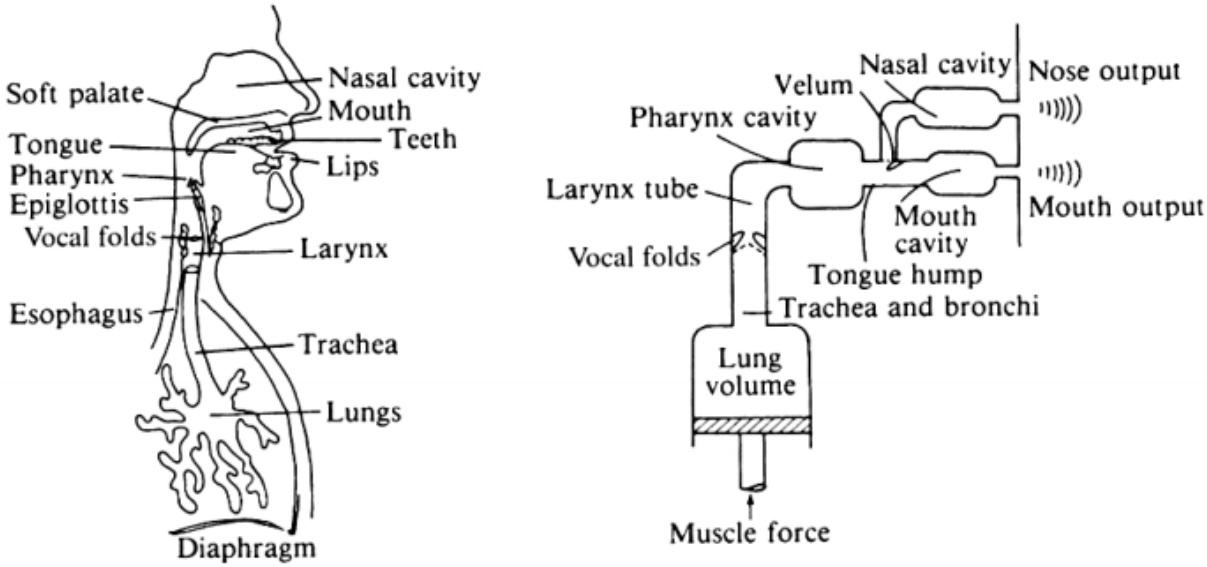

Figure 1.1: The human speech production organs and an idealized model [5]

Another method of speech synthesis is Formant Synthesis. Formant synthesisers specify directly the formant frequencies and bandwidths as well as the source parameters. At least three formants are generally required to produce intelligible speech and up to five formants to produce high quality speech. Each formant is usually modeled with a two-pole resonator which enables both the formant frequency and its bandwidth to be specified. There exists two methods for combining formants: parallel and cascade. In the parallel formant synthesiser the excitation is applied to all the formants in parallel and their outputs are summed up as a speech. In the cascade formant synthesiser the output of first formant is applied to the input of the second one, output of the second format is applied to the input of third one, and so on. The output of the last formants is considered as an overall output speech [4].

The third and the most used method is Concatenative Synthesis. This method to synthesis speech is based on producing sentence by simply concatenating word pronunciations which are stored in the memory of the device. The method's performance depends on the amount of the words saved in the database. This method is good for synthesising predefined messages. However, it might not be as efficient when it comes to the messages not predefined beforehand, because it is quite impossible to store all the pronunciations of the words and common names.

Thus to solve this problem the concatenation of phonemes can be used instead of concatenating words. This approach is better because it does not need huge memory to store the phonemes, as most of the languages does not contain more than 50 phonemes. For example, English language contains approximately 44 phonemes, German 46, Spanish 24, Portuguese 38 [5]. However, pronounciation of the phoneme in a phrase can be affected by neighbouring phonemes [6]. Hence concatenation of phonemes might produce bad quality sound. Therefore, in modern concatenative synthesis methods the syllables, diphones or triphones are used as the speech unit length.

Kazakhstani scientists developed diphone list of Kazakh language, which contains around 500 (incomplete database in which each sound combination has only one analog) and 1,000 diphones (complete database in which consonants sound combinations have 4 options). [7] To clarify the diphone database that will be used in the development of a speech synthesizer, we performed an analysis of the database of Kazakh words used in the free encyclopedia "Wikipedia.org". Performed the following activities:

1) Downloaded the database dump of Kazakh words used in the free encyclopedia " Wikipedia".
2) Written a script to remove unnecessary data such as tags, attributes, parameters of xml-file to get a clean list of Kazakh words.

3) Implemented a program to determine the list of diphones.

The analysis revealed additional 442 diphones, wherein each sound combination has only one analog (Table 1).

ав	аг	ае	аи	ак	ао	аф	ах	ац	ач	ащ	аэ	аю	ая	бв
би	бф	бх	бц	бч	бъ	бь	бэ	бю	ва	вб	вв	вг	вд	ве
вз	ви	вк	вл	вм	вн	во	вр	вс	вт	ву	вф	вш	вы	вь
вю	вя	га	гв	ги	го	гх	гц	дв	ди	дф	дх	дц	дъ	дь
дэ	дю	еа	ев	ее	ео	еф	ех	ец	еч	ещ	ею	ея	еі	еғ
еә	жи	жэ	зв	зи	зх	зъ	зь	зю	иа	иб	ив	иг	ид	ие
иж	из	ий	ик	ил	им	ин	ио	ип	ир	ис	ит	иу	иф	их
иц	ич	иш	ищ	иы	иэ	ию	ия	иі	иғ	иқ	иә	иө	йв	йо
йф	йх	йц	йэ	йю	йя	кс	ка	кв	ки	ко	кф	кх	кц	кч
кы	кэ	кю	кя	ле	лв	ли	ло	лф	лх	лц	лч	ль	лэ	лю
ля	ме	мв	ми	мф	мх	мь	мэ	мю	не	нв	ни	нф	нх	нц
нч	нъ	нь	нэ	ню	ня	оа	ов	ог	ое	ои	ок	оф	ох	оц
оч	оы	оэ	ою	оя	оі	пв	пи	по	пф	пх	пц	пч	пъ	пь
пэ	пю	ре	рв	ри	ро	рф	рх	рц	рч	рщ	ръ	рь	рэ	рю
ря	се	св	си	сф	сх	сц	сч	съ	сь	сэ	сю	ся	те	тв
ти	тф	тх	тц	тч	ть	тэ	тю	тя	ув	уе	уи	уф	ух	уц
уч	уы	уэ	уя	уі	фа	фв	фг	фе	фи	фк	фл	фм	фо	фп
фр	фс	фт	фу	фф	фш	фы	фь	ха	хб	хв	хг	хе	хи	хк
хл	хм	хн	хо	хр	хс	хт	ху	хх	хш	хы	хь	хэ	хұ	ца
цб	цг	цд	це	цз	ци	цк	цл	цм	цо	цп	цт	цу	цх	цц
цы	цэ	ча	че	чж	чи	чк	чм	чо	чр	чс	чт	чу	чч	шв
ши	шх	шь	шю	ща	ще	щи	щы	ъе	ъю	ыа	ыв	ыг	ые	ык
ыо	ыу	ых	ыц	ыч	ыы	ыю	ыя	ыұ	ыә	ыө	ьб	ьв	ьг	ьд
ье	ьж	ьз	ьк	ьл	ьм	ьн	ьо	ьп	ьр	ьс	ьт	ьф	ьх	ьц
ьч	ьш	ьэ	ью	ья	эб	эв	эг	эд	эж	эз	эй	эк	эл	эм
эн	эо	эп	эр	эс	эт	эу	эф	эх	эш	юб	юв	юг	юд	юж
юз	юи	юй	юк	юл	юм	юн	юп	юр	юс	ют	юф	юц	юч	юш
юы	юі	яб	яв	яг	яд	яж	яз	яй	як	ял	ям	ян	яп	яр
яс	ят	яу	ях	яц	яш	яғ	яқ	яң	ғи	ғі	қи	қф	қх	үс
үф	үх	үю	ұх	ұщ	ұю	ұя								

Table 1: additional 442 diphones

Part of those 442 additional diphones encountered in the words which are borrowed from different languages such as russian, arabic, french, etc. Others encountered in the proper nouns.

Based on the results of our analysis in order to develop the Kazakh speech synthesizer, we need to solve the following tasks:

1) Create diphone database of Kazakh language voiced by a specific speaker.
2) Analyze the existing diphone concatenation algorithms.
3) Investigation of possibilities of their application in realization to the diphone-based Kazakh language synthesizer.
4) Development of interactive speech synthesizer of Kazakh language.

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КОНЦЕПЦИЯ *SMART GRID*: УПРАВЛЕНИЕ ПРЕДЛОЖЕНИЕМ, ПРИ НАЛИЧИИ АЛЬТЕРНАТИВНЫХ ИСТОЧНИКОВ ЭЛЕКТРОЭНЕРГИИ И СПРОСОМ БЫТОВЫХ ПОТРЕБИТЕЛЕЙ, РЕАЛИЗОВАННОЕ НА БАЗЕ НЕЧЕТКОЙ ЛОГИКИ *(FUZZYLOGIC)* АЛГОРИТМА МАМДАНИ *(MAMDANI ALGORITHM)*

Седляр Константин Валентинович
sedlyar.konstantin@mail.ru
Студент 5 курса Белорусского Государственного Технологического университета,
Минск, Республика Беларусь
Научный руководитель – А.С. Дмитриченко

В большинстве индустриально развитых стран в качестве основополагающего решения энергетических проблем принят путь инновационного развития электроэнергетики, заключающийся в радикальном изменении системы взглядов на ее роль и место в современном обществе и в обществе будущего на базе концепции *Smart Grid*.

По различным прогнозам, мировое потребление электроэнергии в ближайшие 20 лет вырастет на 25-30%. Этот фактор формулирует проблему: как в условиях значительного износа энергетического оборудования, который наблюдается практически во всех странах мира, и ограниченного финансирования обеспечить все возрастающие потребности экономики и населения в электроэнергии? Концепция *Smart Grid* и призвана ответить на этот вопрос. Идея заключается в том, что, если нельзя кардинально реконструировать сеть, необходимо сделать ее более умной [1].

1. Сущность управление спросом и предложением

К настоящему времени, повышение эффективности использования энергоресурсов и поиск альтернативных источников энергии является приоритетной задачей общества, но решение ее предоставлено нам – ученым. Сегодня, в развитых странах, разработаны и активно внедряются различные технологии использования таких возобновляемых источников энергии (ВИЭ) как энергия солнца, энергия ветра, энергия приливов и отливов и др. Пока, стоимость энергии от возобновляемых источников энергии достаточно высока в сравнении с традиционными, но все же все чаще стоит вопрос выбора между различными источниками. Это связано с тем, что с вопросом стоимости дополнительно стоят вопросы энергетической и экологической безопасности, устойчивости поставок, политические вопросы и некоторые другие. Случаи, когда вопросы стоимости энергии, энергетической и экологической безопасности, устойчивости поставок сходятся, будут рассмотрены в данном докладе.