REVIEW OF TEXT-TO-SPEECH CONVERSION FOR ENGLISH

Presented by
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INTRODUCTION

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Trace the history of progress toward the development of systems for converting text to speech.

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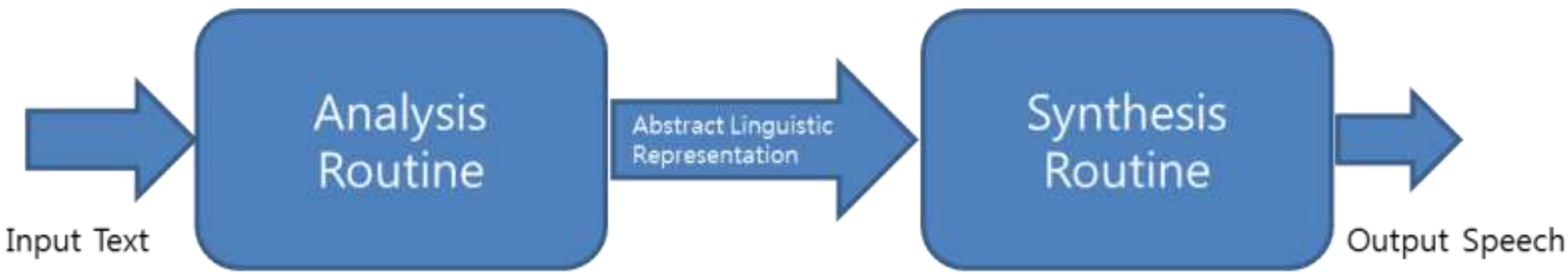

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  - Assign a stress pattern to each word

KLATTALK

INPUT TEXT:

The 23 protesters were arrested.

REFORMATTED INTO WORDS:

The twenty-three protesters were arrested.

(PARTIAL) SYNTACTIC ANALYSIS:

The twenty-three protesters) were arrested.

SEMANTIC ANALYSIS:

None.

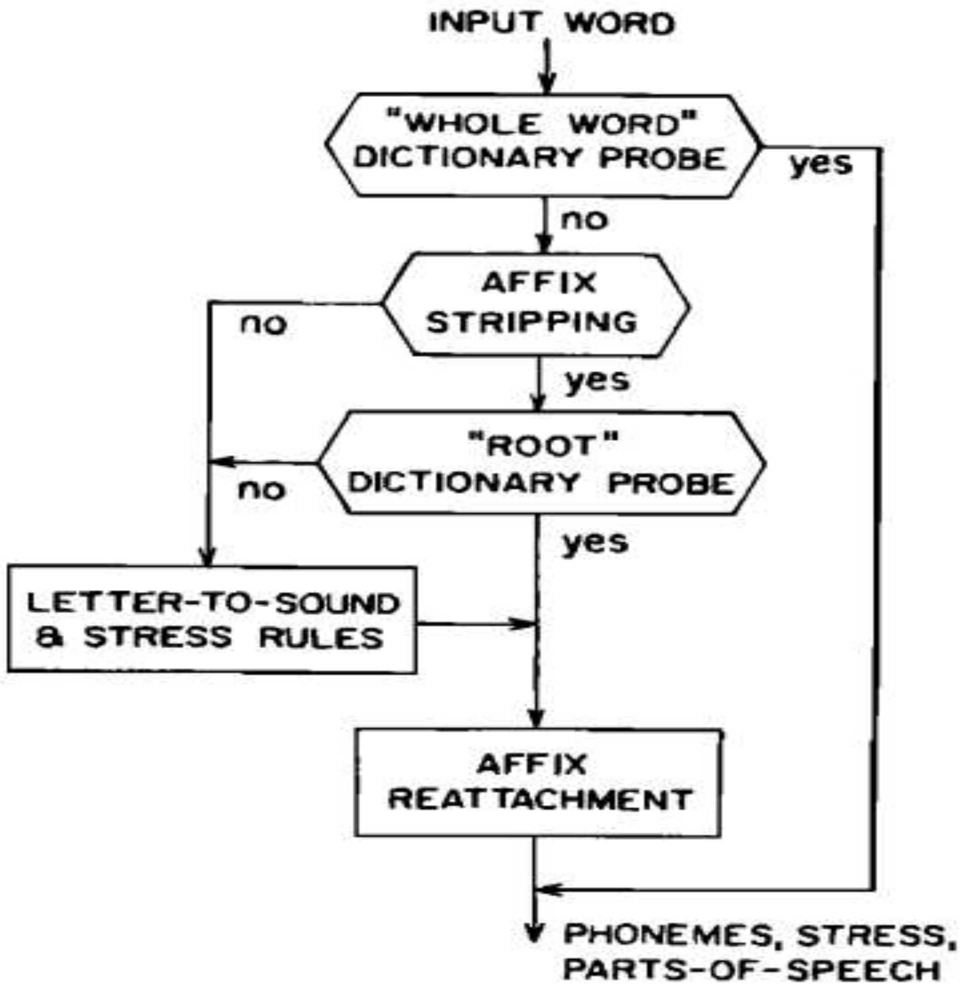
(PARTIAL) MORPHEMIC ANALYSIS:

The twenty-three protest-er-s) were arrest-ed.

PHONEMIC CONVERSION AND LEXICAL STRESS ASSIGNMENT:

/ðə tw´ɛnti θr´i pr´otɛstɝz) wɝ ər´ɛstɨd./

PHONEMIC REPRESENTATION



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- Infovox and Prose provide the user with a set of logical switches which determine what to do with certain types of nonalphabetic strings such as “-” is translated into dash or minus

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- O'Malley point out that many abbreviations are ambiguous but can be disambiguated in particular applications.
- For example "N" is spoken as a letter in a name as "North" in a street address and as "New" in a state abbreviation.

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- Phonemes Representation
  - Dictionaries generally do not agree on a standard representation
  - Computers require a representation that can be printed within the limitations of ASCII character set.
  - There is no agreement on either the set of phonetic symbols to be represented or the phonetic/alphabetic correspondence.

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  - Easy to type and learn
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- Single ASCII character per phonetic symbol
  - Efficient way to store dictionaries and compare strings.

TABLE IV. Two-character and one-character representations for phonemes in DECtalk.

Phoneme	Two characters	One character	Example
i	IY	i	beet
ɪ	IH	I	bit
e^y	EY	e	bait
ɛ	EH	E	bet
æ	AE	@	bat
ɑ	AA	a	pot
ɔ	AO	c	bought
ʌ	AH	^	but
o^w	OW	o	boat
ʊ	UH	U	book
u	UW	u	boot
ɝ	RR	R	Bert
$ɑ^y$	AY	A	bite
$ɔ^y$	OY	O	boy

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  - And so on…

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- Over time pronunciation habits changed, sometimes dramatically, so that the spelling reflects more nearly an underlying historical antecedent of current pronunciation instead of the synchronic phonemes.

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  - Remote silent “e”
  - Number of consonants following a vowel
  - Grouping together of special letter pairs such as ‘ch’, ‘gh’ which normally function like a single letter but not if in separate morphemes.

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- An alternative is to develop a large morpheme dictionary and try to decompose each input word into its constituent morphemes.

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  - A letter or letter pair could be converted to appropriate phoneme if just the right amount of adjacent letter context was examined.
- Based on this view, a set of conversion rules was devised to take care of letter pairs such as ‘ch’ and ‘ea’ and then single letters were converted to phonemic form.

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- Systems of this kind may have more than 500 such rules for the interpretation of letter strings.

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  - Correct analysis often required detection of morpheme boundaries
  - Letter contexts had structural properties such as VC vs VCC that one would refer to rather than enumerating all the possible letter sequences.

Pattern Matching Approach
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  - 29 input neurons for each of the seven letters
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- The weighting of input connections and output connections of hidden units was initially random but was adjusted through incremental training on a 20000 word phonetic dictionary.

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- However a typical knowledge based rule system is claimed to perform at about 85% correct at a word level in a random sampling of a very large dictionary, which implies a phoneme correct rate of better than 97%.

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- For example, a novel word might be compared with all words in the lexicon and the word sharing the largest number of letters with the unknown word would get to determine the pronunciation of that local substring.
- Accuracy of this strategy was 91%

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- Five vowels and the letter 'Y' accounted for four-fifths of the errors.
- But this is still not good enough to compete with conventional rule system.

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  - The considerable extent of letter context that can influence stress patterns in a long word (photograph/photography)
  - The confusion caused by some letter pairs like CH, which function as a single letter in a deep sense
  - The difficulty of dealing with compound words i.e. compound words act as if a space were hidden between the two letters inside the word (e.g. houseboat)

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- A good fraction of error of this letter to phoneme system was stress error.

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- Stress assignment is perhaps one of the weakest link in all systems.
- Newer systems not only base stress assignment on factors such as morphological structure and the distinction between strong and weak syllable but also on presumed part of speech and etymology.

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- Working backwards through word string and having stress prior to making vowel decisions has obvious advantages.

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- This exception list if added to the system, will make overall performance much better than for a system that only uses rules.
- Data indicate that a small number of words, around 200, are required to cover half the words occurring in a random text.

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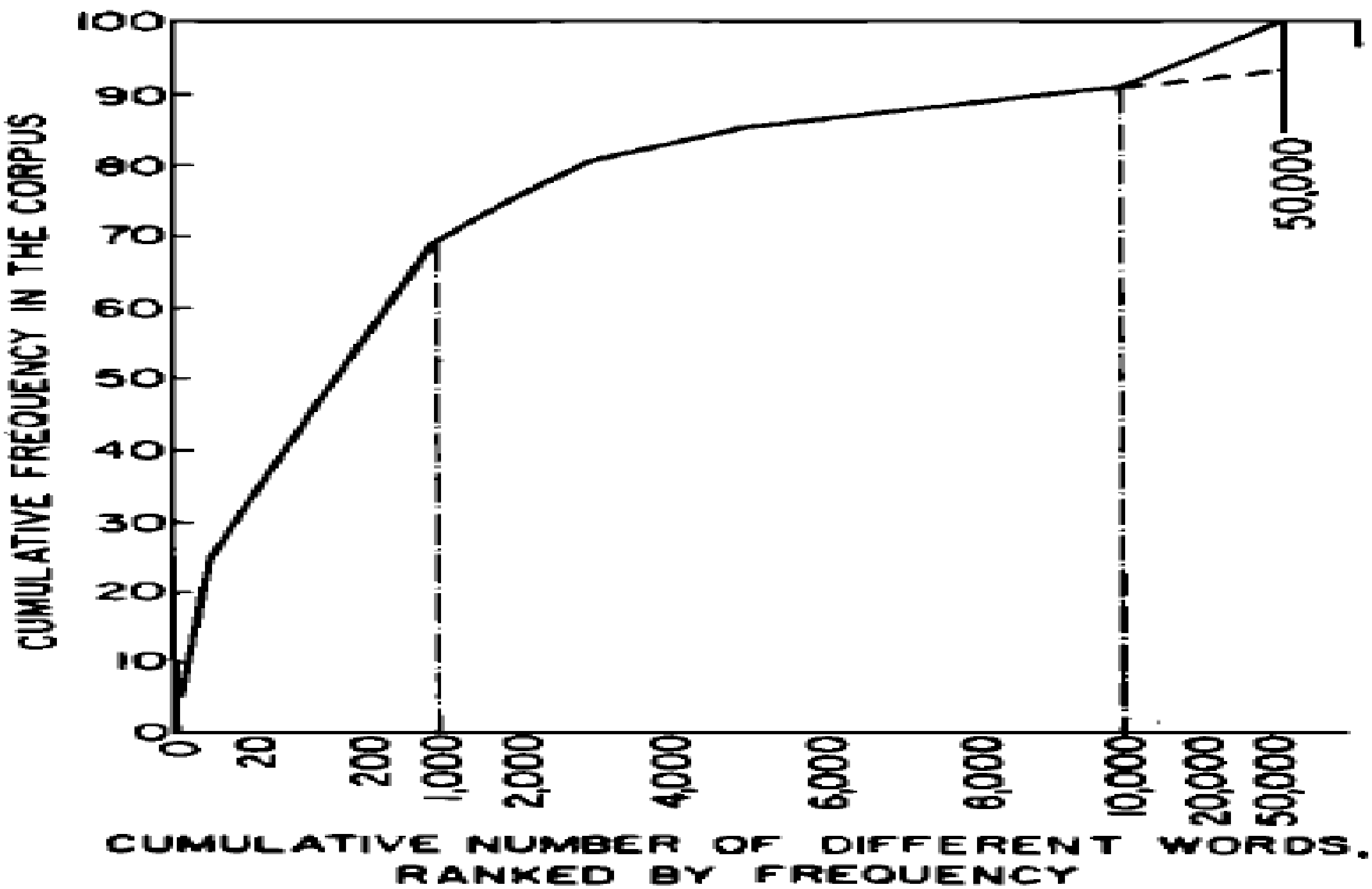

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- For example the 3000 word exceptions dictionary in SPProse coupled with rules that were 85% correct, results in an overall performance of better than 97%
- On the other hand a 6000 word dictionary coupled with 65% rule accuracy result in 95% of overall accuracy.

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- The above example illustrate that affixing is more likely than compounding.
- MITtalk morpheme decomposition is able to parse about 98% of the words in a typical text.

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  - Morpheme lexicon specify parts of speech information to a syntactic analyzer in order to improve prosody of a sentences.

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- An exception dictionary consisting 2000 proper names will cover about 60% of the names in a telephone directory.

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- For example the word "permit" can be pronounced with stress on first syllable if a noun and with stress on second syllable if a verb.
- Morphemic decomposition yields reasonably accurate syntactic information.

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- In a sentence such as "She hit the old man with the umbrella” there may be a pseudo-pause between the words "man" and "with if the woman held the umbrella, but not if the old man did.
- No text-to-speech system is capable of dealing automatically with any of these issue

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- Applications are possible where the computer simply not only attempt to speak ASCII text, but may know a great deal about the meaning of the message, perhaps having formulated the text from a deep-structure semantic representation.

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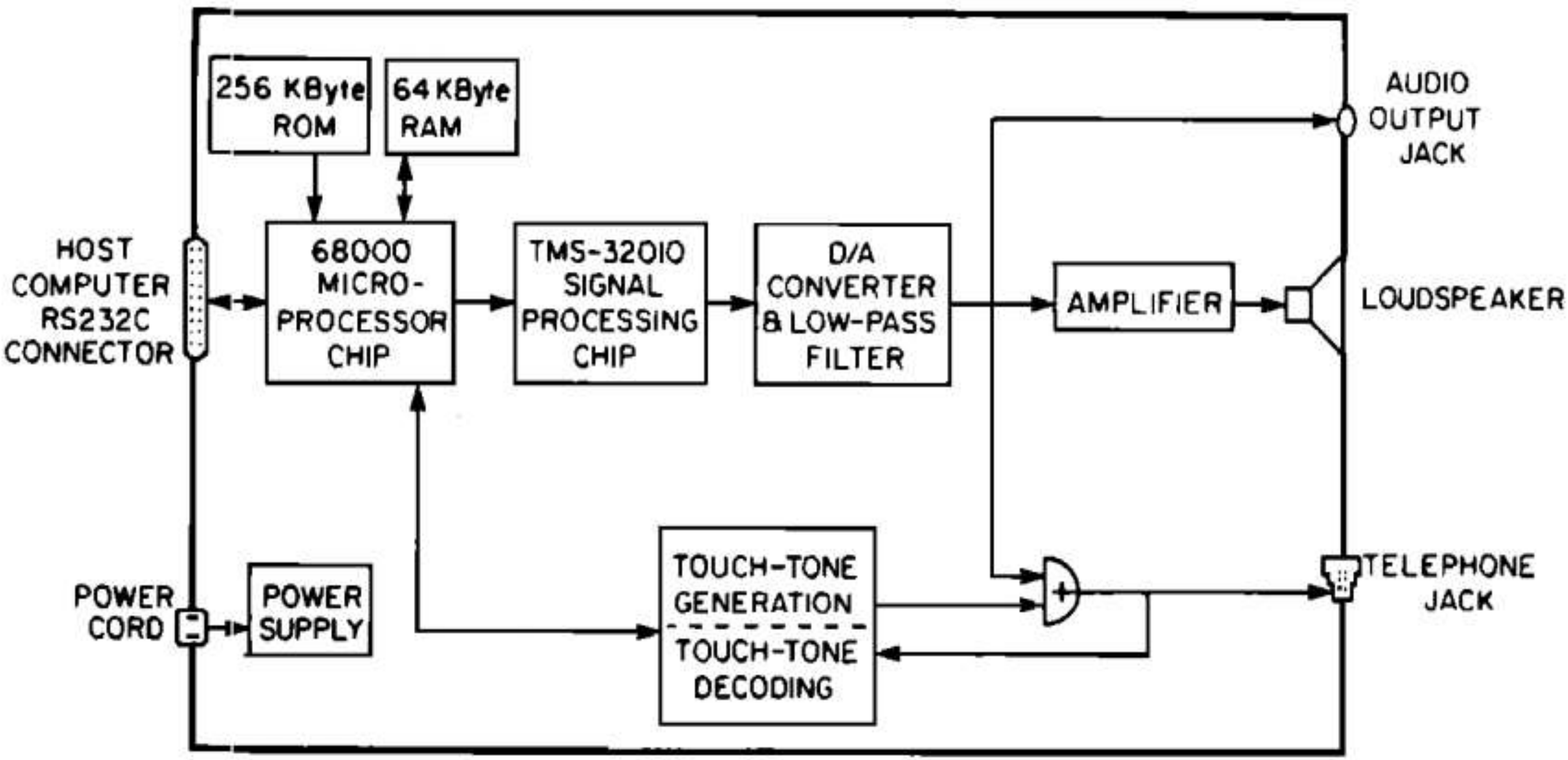
- One important design consideration is the sampling rate and resultant high-frequency cutoff of the output speech

HARDWARE IMPLEMENTATION



DECTALK 1.8 HARDWARE

CONTD…

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- “I am told, it would be possible to put the entire text-to-speech algorithm on a single wafer-sized integrated circuit chip”

Perceptual Evaluation of TTS

PERCEPTUAL EVALUATION OF TTS

- Intelligibility of isolated words

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PERCEPTUAL EVALUATION OF TTS

- Intelligibility of isolated words
  - Since consonants have been more difficult to synthesize than vowels, the modified rhyme test is often used, in which the listener selects among six familiar words that differ only by an initial consonant or a final consonant.
- The frequency of occurrence of perceptual errors in running text is approximated by the reciprocal of the percent error values given in the table for isolated words.

PERCEPTUAL EVALUATION OF TTS

TABLE VII. Performance of selected text-to-speech systems with respect to CVC intelligibility using the modified rhyme test, closed response, after Logan *et al.* (1986) and Cooper *et al.* (1984).

Device	% correct	% error
Type-n-Talk	73	27
Infovox	88	12
MITalk-79	93	7
Prose-2000 3.0	94	6
DECtalk 1.8	97	3
Natural speech	99	1
Haskins system	93	7
Natural speech	98	2

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- The test used is perhaps not ideal for detection of all likely consonantal confusions.

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  - Syllables synthesized using the Olive LP di-phone concatenation scheme.

CONTD…

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TABLE VIII. Consonant intelligibility in nonsense syllables encoded in various ways (Pols and Olive, 1979).

Condition	% correct	Typical errors
OLIVE (1977) DIPHONE SYNTHESIS	66	voicing, nasality
LPC-10, no quantization	86	b-v-ð,m-n-ŋ
DIGITIZED NATURAL, 5 kHz, 12 bit	93	f-θ,v-ð

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- Tests of word intelligibility in sentence frame include
  - Sentence list consisting of simple short predictable sentences known as the CID sentence
  - Harvard sentences for speech in noise
  - Haskins anomalous sentence test consisting of nonsensical word strings that were syntactically acceptable of the form "The (adjective) (noun) (verb) the (noun)," e.g. "The old farm cost the blood”

INTELLIGIBILITY OF WORDS IN SENTENCES

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TABLE IX. Performance of selected text-to-speech systems with respect to word intelligibility in Harvard test sentences and Haskins anomalous sentences, after Pisoni *et al.* (1985) and Cooper *et al.* (1984).

Device	Meaningful % correct	Anomalous % correct
Prose-2000	84	65
MITalk-79	93	79
DECtalk	95	87
Natural speech	99	98
Haskins system		78
Natural speech		95

Reading Comprehension

READING COMPREHENSION

- Since synthetic speech is less intelligible than natural speech, what happens when one tries to understand long paragraphs? Do listeners miss important information?

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- Since synthetic speech is less intelligible than natural speech, what happens when one tries to understand long paragraphs? Do listeners miss important information?
- To answer these questions a standard reading comprehension task is used. Half the subjects read the paragraphs by eye, while the other half listened to a text-to-speech system.

READING COMPREHENSION

- Since synthetic speech is less intelligible than natural speech, what happens when one tries to understand long paragraphs? Do listeners miss important information?

TABLE XI. Performance of several text-to-speech systems with respect to listening comprehension (percent of questions about paragraph contents that were answered correctly), compared with visual presentation, after Pisoni and Hunnicutt, 1980).

Device	% correct	
Natural speech	68	
MITalk-79	70	(75% on second half of test)
Prose-2000	65	
Visual presentation	77	

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- Naturalness is a multi-dimensional subjective attribute that is not easy to quantify. Any of a large number of possible deficiencies can cause synthetic speech to sound unnatural to varying degrees.
- A standard procedure is to play pairs of test sentences synthesized by each system to be compared, and obtain judgments of preference.
- As long as the sentences being compared are the same, and the sentences are played without a long wait in between, valid data can be obtained

SUITABILITY FOR A PARTICULAR APPLICATION

TEXT-TO-SPEECH BUSINESS APPLICATIONS
• Telephone information: e.g., 800 numbers for stock quotations, weather, ski conditions, sports scores, museum exhibits/schedules, talking Yellow Pages, ... (information that is changed frequently, and is available in computerized text form)
• Remote (on the road) access to computer mail
• Catalog ordering by phone, banking by phone (requires keypad or speech recognition for input)
• Data-base inquiry, especially for unsophisticated users: e.g., sales reps can determine status of purchase orders
• Generation of cassette recorded instructions for assembly plants, back-plane wiring, telephone circuits, etc. (Flanagan *et al.*, 1972)
• Telephone access to computerized repair "experts" on, e.g., computers, telephone circuits.
• Coordination of large numbers of people on the road through a central computer information bank
• Warning and alarm systems concerning malfunctioning equipment
• Talking terminals and training devices (speech is often better than reading)
• Proofreading (catches kinds of typing errors that are often hard to detect visually)

SPECIAL APPLICATIONS

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- Talking Aids for the vocally handicapped.

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- Talking Aids for the vocally handicapped.
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- Talking Aids for the vocally handicapped.
- Training Aids
  - Language learning
  - Spoken Tutorials
- Reading Aids for the Blind
  - Scan printed material and produce speech
- Medical Applications
  - **Centralized computer based records on patients to be accessed through phone.**