BRAILLE-LAB,

A FULL HUNGARIAN TEXT-TO-SPEECH MICROCOMPUTER FOR THE BLIND

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ABSTRACT

The authors introduce Braille-Lab, a Hungarian-speaking microcomputer developed for the blind. This Z80 microprocessor-based personal computer is fitted with a Philips MEA 8000 formant synthesizer, providing for Hungarian text-to-speech conversion. The original version of the machine contains a speaking BASIC interpreter. The new version, Braille-Lab+, is also furnished with a speaking word processor and a speaking database management system running under a speaking CP/M compatible operating system. Braille-Lab has been approved and adopted by the Hungarian National Federation of the Blind, 95 sets have been installed so far.

INTRODUCTION

In the past few decades, intensive research into speech synthesis has been going on in a number of countries including Hungary. This research work has three main types of motivation.

1. Fifth-generation computers are to create a new, humanized type of man-machine-man relationship. Hence one of the main objectives of research is viva voce 'conversation' between man and machine. The various links of the man-machine-man communication chain (each constituting a research area in its own right) and the way artificial speech production fits into that chain are represented in Fig. 1.

2. Another impulse for attempts at speech synthesis was the desire to achieve a better understanding of the acoustics of speech. Indeed the principle of analysis by synthesis is more effective than any measuring apparatus, however sophisticated the latter may be: it shows what the essential components of speech really are [7]. That principle can be best implemented by formant synthesis. These considerations led to the establishment, under Kálmán Bolla's leadership, of a complex acoustic speech synthesizing system in the Linguistics Institute of the Hungarian Academy of Sciences, in the late 1970s. The hardware configuration includes an OVE III (Swedish-made) formant synthesizer [1] and a PDP11/34 computer. The effective operation of the system is guaranteed by a specially designed interactive program called FOPRO [11].

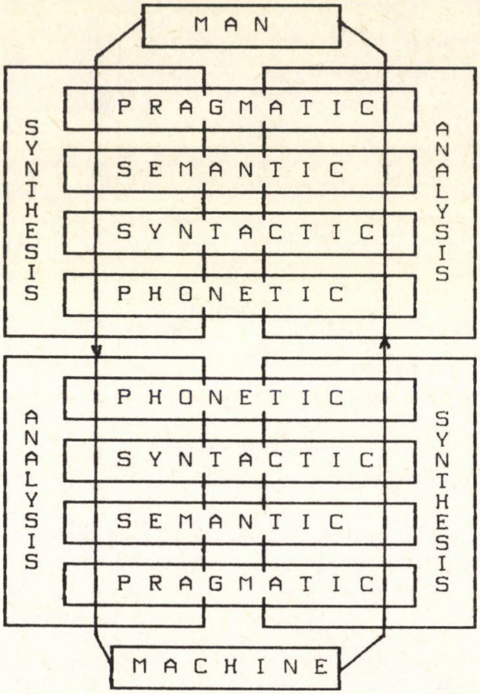


Fig. 1. The Man-Machine-Man communication chain

The utility of the system for phonetic research is demonstrated by a number of scholarly papers [5, 10]. The program was also used for designing an inventory of speech frames for a Hungarian text-to-speech (TTS) system based on the principle of formant synthesis in the early 1980s [13]. The inventory, in turn, was used in HUNGAROVOX, a Hungarian real-time TTS system for speech synthesis [9, 12]. Later, a developing system was also made for a Philips MEA8000 formant synthesizer [3].

3. The third type of motivation for research on speech synthesis is a desire to develop various appliances to help handicapped people (afflicted with speech disorders, blindness, etc.). The area was given a vast impetus by the appearance, in the early 1980s, of speech synthesizers contained in a single IC, e.g. UAA1003, TMS5200, SC-01, SP0256, MEA8000 [2, 4, 6, 8], since these could be built into various appliances. These considerations led to the development of Braille-Lab, a speaking computer to be used by blind people, introduced in the present paper. This Hungarian-speaking microcomputer fitted with a text-to-speech conversion system effectively helps the education of blind people in computational technology (thus creating high-qualification employment possibilities for them). Also, it accelerates their full integration into society.

THE HARDWARE OF BRAILLE-LAB

Braille-Lab is a Hungarian-made, Z80 microprocessor-based personal computer. Its memory is organized on a page basis, and consists of 64 kbyte RAM and 20 kbyte ROM. The card containing the speaking module has been built into the computer with MEA8000. The TTS software is located on page 2 of ROM. The keyboard of Braille-Lab contains every letter of the Hungarian alphabet, arranged in a way almost identical with the keyboard of standard Hungarian typewriters. The built-in small loudspeaker makes it possible for the speech produced by the system to be heard without an external loudspeaker. The built-in BASIC interpreter leaves 48 kbyte free memory capacity available for the user.

The basic version of Braille-Lab has been further developed. Braille-Lab+, the new version, runs under a CP/M compatible operating sysem. Along with a 64 kbyte operative memory, it is also furnished with a 192 kbyte RAM disk and a 1 Mbyte floppy disk drive. The new version further contains a speaking word processor and a speaking database management system. With these two programs, its possibilities of application by the blind have been multiplied.

THE TEXT-TO-SPEECH SOFTWARE SYSTEM OF BRAILLE-LAB

The basis for Hungarian TTS conversion by Braille-Lab is a text in Hungarian orthography, with no special symbols added. The program translates that text into a series of frame code numbers for the MEA8000 synthesizer. The frame code numbers designate the elements of a 218-member frame inventory, devised earlier. The TTS conversion is implemented in the following four steps:

1. First of all, the text to be converted to speech is transformed by the program into a series of (code numbers of) speech sounds. Hungarian orthography is a fairly accurate indicator of the series of sounds to be uttered. However, not only single letters but also combinations of two, and even three, letters may stand for single sounds. In the letter-to-sound transformation, the program basically relies on Fig. 2.:

Hungarian orthography has a unique letter or letter

1	2	3	4	5
1.	a	1	ɔ	-
2.	á	2	a:	-
3.	b	10	b	-
4.	bb	10	b:	+
5.	c	11	t͜s	-
6.	cc	11	t͜s:	+
7.	cs	12	t͡ʃ	-
8.	ccs	12	t͡ʃ:	+
9.	d	13	d	-
10.	dd	13	d:	+
11.	e	3	e	-
12.	é	4	ẹ:	-
13.	f	14	f	-
14.	ff	14	f:	+
15.	g	15	g	-
16.	gg	15	g	+
17.	gy	16	ɟ	-
18.	ggy	16	ɟ:	+
19.	h	17	h	-
20.	hh	17	h:	+
21.	i	5	i	-
22.	í	5	i:	+
23.	j	18	j	-
24.	jj	18	j:	+
25.	k	19	k	-
26.	kk	19	k:	+
27.	l	20	l	-
28.	ll	20	l:	+
29.	ly	18	j	-
30.	lly	18	j:	+
31.	m	21	m	-
32.	mm	21	m:	+
33.	n	22	n	-
34.	nn	22	n:	+
35.	ny	23	ɲ	-
36.	nny	23	ɲ	+
37.	o	6	o	-
38.	ó	6	o:	+
39.	ö	7	ø	-
40.	ő	7	ø:	+
41.	p	24	p	-
42.	pp	24	p:	+
43.	r	25	r	-
44.	rr	25	r:	+
45.	s	26	ʃ	-
46.	ss	26	ʃ:	+
47.	sz	27	s	-
48.	ssz	27	s:	+
49.	t	28	t	-
50.	tt	28	tt:	+
51.	ty	29	c	-
52.	tty	29	c:	+
53.	u	8	u	-
54.	ú	8	u:	+
55.	ü	9	y	-
56.	ű	9	y:	+
57.	v	30	v	-
58.	vv	30	v:	+
59.	z	31	z	-
60.	zz	31	z:	+
61.	zs	32	ʒ	-
62.	zzs	32	ʒ:	+
63.	sp	33		-

1= number, 2= letter (s), 3= code number
4= IPA symbols, 5= length of sound

Fig. 2. Table of letter-to-sound correspondences

combination for each speech sound (with the exception of j vs. ly). This statement is also true the other way round: any letter or letter combination always stands for the same speech sound. However, there is some problem at the internal boundary of compounds spelt as one word: the correct speech sound assignment is sometimes difficult in consonant clusters across such boundaries. For instance, in a word like <víz> +

⟨szegény⟩ = ⟨vízszegény⟩ (arid, lit. water + poor), our program wrongly interprets zsz as zs + z , instead of the correct z + sz . To contravene that source of error, we have introduced the notion of 'bachelor' letters. A bachelor letter does not form part of a letter combination but corresponds to a speech sound on its own, irrespective of what the following consonant letter is. To produce a bachelor letter, we have to keep the F2 key pressed while pressing the appropriate key on the computer keyboard. The letter appearing on the screen will not be affected but the otherwise empty seventh bit of its ASCII code will take up the value 1. Thus, in the above example, we get the correct sound assigment if the first z of ⟨vízszegény⟩ is pressed with a simoultaneous pressing of the F2 key. As a result of the letter-to-sound transformation, we get a series of code numbers, each code number being an integer between 1 and 33, corresponding to the thirty-two speech sounds plus pause.

2. The second step of TTS conversion is the designation of the series of frames that will realize the speech sounds of the text to be uttered. This designation is basically of a diadic naure. The 218 frames utilized are arranged in the inventory in a very special order. Each combination of sounds is realized by adjacent frames. Thus we can dispense with storing what is called a combination matrix and consequently save a significant amount of memory capacity. However, this simplified procedure results in a poorer speech quality. (For somebody whose ear is not accustomed to mechanic speech, the speech produced by Braille-Lab is seldom intelligible at

first hearing. This, however, does not represent a difficulty for regular users: experience shows that the blind users soon get accustomed to the way Braille-Lab speaks and they have no problem understanding it during regular use.) In order to further optimize the utilization of the frame inventory, various sound sequences can be realized by overlapping series of frames,as illustrated in Fig. 3.

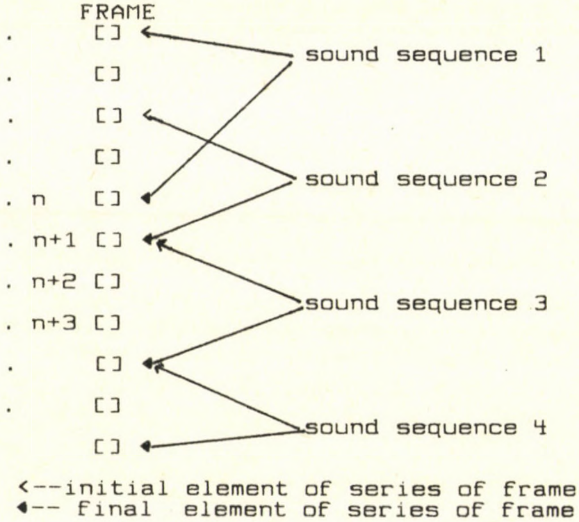


Fig. 3. The structure of the frame inventory and the way frames realizing sound sequences are specified

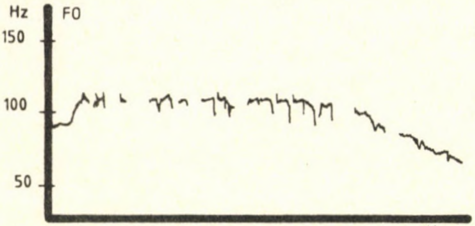
Long sounds are also produced at this stage by multiplying some component of the frame of the corresponding short sound (2 to 5 times, as the case may be) in the series of frame code numbers. Each element of the series of frame code numbers will be an integer between 1 and 218. That series then serves as input to the melody generating part of the program.

3. The melody is generated by the program by selecting the appropriate value of the PI parameter of the MEA8000 synthesizer frame-by-frame. The first step in producing the melody is the segmentation of the text into intonation units. The intonation units are marked off by .(full stop) ,(comma) ?(question mark) !(exclamation mark) or RETURN. Triggered by those punctuation marks, the program will supply the segmental structure produced so far with one of the melody patterns exemplifield in Fig. 4.
The break-points of intonation curves are assigned to vowel positions. Note that the melody triggered by an exclamation mark is identical with that of a question-word question. This way of producing the relevant Hungarian melody patterns has an additional advantage, particaularly for blind people, that the melody patterns unambiguously refer back to sentence-final puntuation marks. (If the intonation unit is concluded by RETURN without any punctuation mark, the melody produced is a level tone at 100 Hz.)

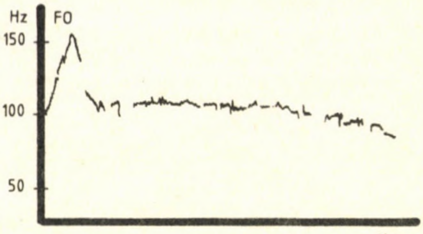
4.When the coding of segmental and suprasegmental structure is completed, Braille-Lab forwards the resulting series of code numbers to the MEA8000 speech synthesizer and the speech is simultaneously heard.

THE USE OF BRAILLE-LAB

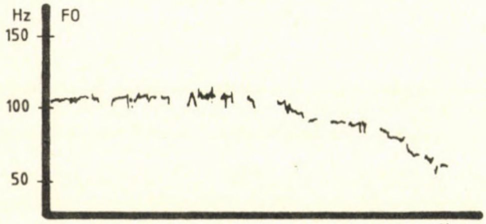
The computer is able to speak as soon as it is switched on. The following introductory words appear on the screen and are simultaneously heard [in Hungarian]: "Braille-Lab computer, version 3.1. 48843 bytes of free memory capacity."



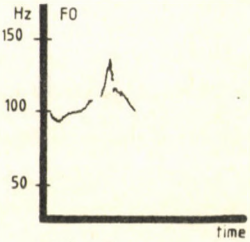
A feleségemet Budapesten ismertem meg.
'I first met my wife in Budapest'
Declarative sentence starting with a definite article



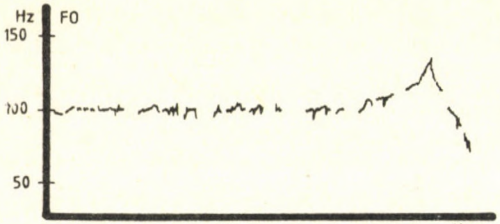
Mikor ismerted meg a feleségedet?
'When did you first meet your wife?'
Interrogative sentence starting with a question word



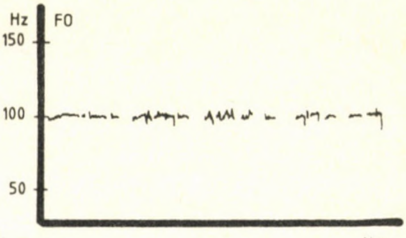
Budapesten ismertem meg a feleségemet.
'It was in Budapest that I first met my wife'
Declarative sentence not starting with a definite article



Nyáron?
'In the summer?'
Disyllabic question



Budapesten ismerted meg a feleségedet?
'Did you first meet your wife in Budapest?'
Interrogative sentence with no question word



Budapesten ismertem meg.
'I first met her in Budapest'
Sentence without end punctuation

Fig 4. The intonation system of the Braille-lab

After that, each time a key is pressed, the system utters the corresponding speech sound, in order to make it easier for a blind person to avoid typing errors. Names of non-letter keys, including numerals, are uttered as words. E.g. on pressing % the machine says "százalék" (percent), etc. Using the cursor keys, the user can aurally check the contents of any character position of the screen.

Basically there are two situations in which Braille-Lab actually speaks: 1. during entering and editing BASIC programs; 2. at run-time when any information appearing on the srceen is simultaneously said aloud.

1. During program editing, the echoing function mentioned above is in operation; in addition, at the end of each line when RETURN is pressed the computer reads out the whole line as a connected text. Numerals at this point are not read character-by-character but as wholes (e.g. twenty-five rather than two, five). The English terms of BASIC are read out according to the Hungarian value of letters, rather than in proper English pronunciation. At program listing, the list can be heard as it appears on the screen. In short, any information appearing on the srceen, including e.g. error messages, is also uttered without any special command.

2. The information appearing on the screen during the running of a BASIC program will also be heard automatically. For instance, as a result of the running of the following short program, all Hungarian numerals between 1110 and 1125

will be heard first with a question intonation and then with a statement intonation (i.e. "Is the next number 1110? Yes, 1110." etc):

```
10 FOR I=1110 TO 1125
20 PRINT "A következő szám" I "?"
30 PRINT "Igen" I "."
40 NEXT
```

BRAILLE-LAB AS THE SPEAKING PERIPHERY OF A READING MACHINE

At an exhibition called "Hungarians in the World" held in Budapest in August 1986, the authors, assisted by researchers of SZKI (Institute for Computer Research) connected Braille-Lab whith an IBM compatible PROPER-16 computer. On the other side, an MS300A Image Scanner was also connected with PROPER-16. The image recognition program developed by the SZKI people recognized printed Hungarian text. PROPER-16 forwarded the resulting ASCII code, via a standard RS232 interface, to Braille-Lab which uttered the text real time, with a proper Hungarian intonation, in an intelligibly pronunciation. To our best knowledge, this was the first time a Hungarian-speaking reading machine was presented in operation in Hungary. This presentation has proved that Braille-Lab is able to operate as the speaking terminal of a reading machine.

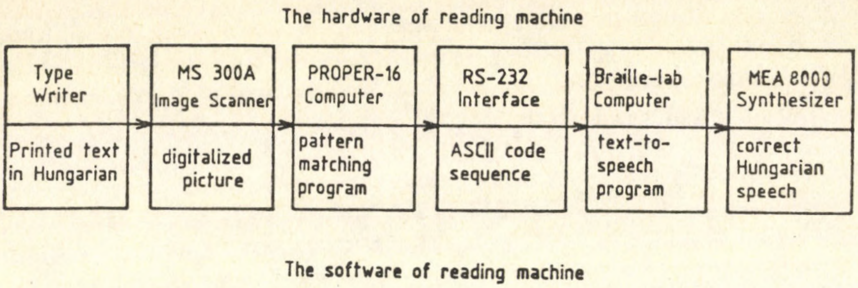


Fig. 5. The system of the reading machine when the Braille-Lab is speeking terminal

HOW TO MAKE BRAILLE-LAB SING

One of the special features of Braille-Lab is that it can also sing. To make the computer sing, the user has to specify the correct rhythm and the correct sequence of pitches. Rhythm can be represented by lengthening the vowels appearing in the words of the song, by entering vowel letters more than once. The length of the syllable containing the vowel will increase in proportion with the number of identical vowel letters entered. The melody has to be given in relative sol-fa letters, according to Zoltán Kodály's method. The pitch defined by a sol-fa letter assigned to a syllable will be superimposed by the program on the appropriate syllable which has been rhythmically defined as above. By that procedure, any Hungarian-text song can be produced. This special feature of the system opens up a novel area of application in the on-line representation and correction of Braille music notation [15]. Our experience shows that the fact that Braille-Lab is able to sing is a great help for blind (or any) users in overcoming their prejudice, if any, against computers. The opening line of the Hungarian folk song ”Érik a szőlő, hajlik a vessző” has to be entered in the following way:

re = ”ééérik” : la = ”a”

re = ”szőőőő” : mi = ”lőő”

BRAILLE-LAB AS AN AUTHORIZED APPLIANCE

Braille-Lab is an appliance authorized for use by the Hungarian National Federation of the Blind. By March 1987, a total of 95 sets have been installed in the schools of the Federation and by individual users. Based on the speaking BASIC of Braille-Lab, the Federation organized two beginners' courses on computation in spring 1986 and 1987. The speaking computer effectively helped the blind participants to acquire knowledge and skill in computation and to put them to creative use. The Users' Manual for Braille-Lab has been published on cassette tape and in Braille print as well.

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