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PRESERVATION AND DIGITAL RESTORATION OF AUDIO ARCHIVES

We describe or experiences in Bulgaria regarding preservation and digital restoration of audio archives.

Key words: preservation, digital restoration, audio archives

Introduction

The dialectological archive of Bulgarian language consists of more than 250 audio tapes. All tapes were recorded between 1955 and 1965 in the course of regular dialectological expeditions. The records typically contain interviews with inhabitants of different small villages in Bulgaria, selected according to the research strategy of the scientists in order to locate and register all existing dialects in the country. The interviews typically include a general talk with aged people from both sexes, where such issues as birth, everyday life, marriage, family relationship, death, etc. are covered. A few tapes contain folk songs from different region of the country.

Degradation mechanisms of sound recording

Let’s have a brief look on the degradation mechanisms of sound recording and more specifically on these, concerning magnetic tapes. Typically the magnetic tape is made up of two layers: a "base" layer, and a thin "binder" layer which is bonded onto the base. The binder contains ferromagnetic particles whose permanent alignment within the binder produce the copy of sound waves.

The project for the preservation and restoration of the dialectological archive of Bulgarian language has started in 1997 with a thorough inspection of the tape status in order to define the seriousness of the situation and to single out corresponding measures. As a result of the inspection the observed degradation effects have been summarized as follows:

- binder shedding. This effect produced a gummy and tacky material which caused tape layers to stick together and inhibited the playback when deposited onto the tape recorder heads. The added friction increased tape stress and caused

even incidental stops of the tape player. Fortunately, this kind of degradation has been observed in very rare occasions (less than 1 percent);
- loss of signal (dropout) due to a weak bond that caused the binder to separate from the backing;
- fine oxide powders that shed from tapes and deposit onto heads, inhibiting playback.
- dimensional changes (tape curling, edge fluttering, tape stretch) that affect the tape-to-head contact, thus directly degrading audio quality;
- extremely low tensile strength causing tapes to be easily broken during playback;
- Vinegar Syndrome – an auto catalytic self destruction process by cellulose acetate – based tapes . Fortunately most of the tapes were from polyester– based type and among cellulose acetate – based tapes only a few were subject to a catastrophic failure (i.e., an irreversible loss of data). Almost 90 % of the magnetic tapes were from type ELA 10040/180 of Philips and CH (190 m) of Agfa, Bitterfeld (German Democratic Republic).

Till1997 when the project for the preservation of the dialectological archive of Bulgarian language started, the tapes have been stored in their own boxes without any special care. There are essentially only three concerns to consider when handling and storing sound recordings:

1. that they be kept free of any foreign matter deposits;
2. that they be kept free of any pressure that might cause deformations; and
3. that they be stored in a stable, controlled environment.

Till 1997 none of these requirements has been met.

The results of the inspection have forced us to take urgent measures in two different directions:

1. To ensure the further preservation of the audio tapes;
2. To start immediately the digitisation of the records and their storage on a digital recording media (CD).

Preservation of magnetic tapes

Here are some details about the measures that have been taken in order to ensure the further preservation of the audio tapes:

- We removed all paper labels inside the reel-to-reel tape boxes;
- We vacuumed all reel-to-reel tape packs in order to remove dust particles. We used a vacuum cleaner which has a hose, and kept the motor away from the tape in order to reduce the risk of magnetizing the tapes;
- We cleaned the tape surfaces using a special "Tape Cleaning Fabric". This soft fabric product picked-up all loose debris commonly found on tape surfaces after being dislodged by the fabric fibres;
- We stored tapes away from any sources of magnetic fields;
- We removed all plastic bags within the tape boxes. The plastic bag trap moisture;

- We rewinded (exercised) the reel-to-reel tapes to work out stresses which may have crept in through linear expansions and contractions;
- We winded back the tapes slowly to avoid air pockets between layers causing successive layers to be placed unevenly on top of each other. The unevenness can cause stress, can expose binder to air and edges to possible physical damage by the flanges;
- In order to wind and rewind tapes we used a reel-to-reel tape deck in the regular play mode with the heads removed. The tape tension have been readjusted in order to compensate for the removal of the heads.
- We stored recordings in a dark room with temperature 15-20°C;
- We maintained in this room a relative humidity of 25-45%;
- We maintained in this room a proper ventilation and air circulation to avoid any micro climates;
- We changed the light bulbs with fluorescent tubes with minimal ultraviolet radiation;
- We separated and isolated from tape vault acetate tapes exhibiting an acetic acid odour.

Digitisation of archive records

Our next goal was to start the transfer of archive records on a digital recording media. Since 1997 more than 30 % of the records were digitised and stored on CD's. This activity is going on further at accelerated pace due to the acquired experience of the staff and the increased speed of today's computers.
Basically, the process includes following steps:

1. Digitise the records and store them in a digital format (.wav) temporarily on the hard-disk drive;
2. Digital restoration;
3. Recording on a CD-R.

We will focus mainly on the digital restoration procedure. For completeness we will only mention that the records were digitised and further resampled with a sampling frequency of 44.1 KHz, 16 Bits, Stereo, using a professional sound card equipped with a high end analog to digital converter.

Digital Restoration

The Digital Restoration is a sophisticated software procedure for the restoration of archived audio recordings. Archive recordings are corrupted with many different kinds of disturbances. Among the most frequently encountered ones are:

1. impulsive disturbances (such as clicks, pops and record scratches);
2. wideband noise(such as a tape hiss or surface noise of vinyl records) ; and
3. harmonic disturbances (such as the power line hum).

According to these different types of disturbances we developed our restoration program, which includes following utilities and tools:

- Utility which eliminates impulsive disturbances and low intensity wideband noise;
- Utility which eliminates broadband noise of known characteristics;
- Utility for wideband noise reduction based on a standard noise model;
- Utility for elimination of harmonic disturbances;
- A set of software filters.

The process of eliminating impulsive disturbances and low intensity wideband noise is based on the indications of a software outlier detector – a device which searches for noise pulses – the program isolates and reconstructs the irrevocably distorted signal samples. Low intensity background noise can also be removed in the same pass of this renovation utility. Processing is done in two stages. First, impulsive disturbances are removed along with a portion of wide-band noise. Then a special postfiltering technique is used to further reduce the noise. The quality of this elimination procedure is strongly dependent on the adopted detection threshold. Increasing the detection threshold decreases at the same time the sensitivity of the detector, which means that the system is prone to overlook a larger number of outliers. If the threshold is too low, the detector starts to object to the slightest departures of signal from its regular pattern. A reasonable compromise between the two tendencies has to be found experimentally. Pitch excitation, typical of a voiced speech (which is exactly our case), is another source of potential problems. Since the pitch frequency can change dramatically (up to 40% over one period of variation), the system may occasionally confuse pitch impulses with outliers, causing local degradation of the restored signal.

Wideband noise reduction is performed using two techniques. Both operate in the frequency domain and are based on the same principles. They differ in the way noise characteristics are taken into account in the process of sound renovation. The first procedure incorporates in the process of disturbance elimination the specific noise characteristic, extracted from an archive recording. If no reference noise can be identified then the second procedure based on a standardized noise model is used. This procedure is more robust than the first one; it may yield better results if noise characteristics are time-varying. In cases like that the first procedure may fail to provide a uniform renovation quality along the entire soundfile. Even though both tools are not equipped with any explicit mechanism for click elimination, they are capable of removing also most of low-amplitude clicks and pops. However, to obtain the best results the procedure for impulsive disturbances should be used.

Harmonic disturbances consist of harmonically related sinusoidal signals - a number of tones with frequencies which are integer multiplies of the basic frequency, called fundamental. The AC power mains is the most common source of harmonic noise. In this particular case the fundamental frequency is equal to 50 Hz . Electric appliances working in the background, switched on accidentally or intentionally constitute another group of typical buzz sources.

The hum-like disturbances can be eliminated using a combined filter - a collection of notch filters designed so as to suppress the fundamental frequency along with the dominant harmonics. Since hum is a combination of harmonically related sinusoidal signals it introduces a number of sharp spectral peaks, which are clearly visible on

spectral plots. The By changing the fundamental frequency, the number of notches and their relative bandwidth the comb filter can be tuned so as to suppress all dominant harmonic noise components. Audition test can be performed to prove if restoration is satisfactory. Otherwise the procedure can be repeated as many times as to obtain the best results.

When tuning different renovation procedures, we relied on our own subjective evaluation of the results. One has to take into account that forcing noise attenuation that is too strong may result in a signal, which is noiseless, but sounds dead.

Software filters can be used to eliminate following disturbances:

- Crackles (series of small clicks), often resulting in buzz-like artifacts, can be eliminated by lowpass filtering;
- Low-frequency thumps, typical of large scratches, can be removed by highpass filtering with the cutoff frequency set in the range 50Hz -200Hz;
- Buzz and hum disturbances (such as the power supply hum) as already discussed can be in most cases eliminated using notch filters.

Recording on CD

The records that have been restored were written on recordable digital media in CD-DA format. Recently, in order to be able to store more records on a single disk we have started to compress the records and to store them in MP3 format.

Conclusions

We would like to emphasize that our project was not aimed at ”discovering the wheel”. There are a lot of methods and techniques to preserve and restore phonoarchives on magnetic tapes. We’ve tried to summarize the existing problems in order to formulate adequate actions to be performed in a prescribed sequence and to elaborate corresponding software tools as a simple and efficient way to overcome these problems. Our experience can be used in similar institutions like our institute: phonetic and dialectological archives, folklore archives, history related records etc.

Of course, there is a lot to be done in the future. First of all we have to continue our efforts in order to transfer all records on digital recording media. But what is not less important is to think about how this digital information will be better used. It is obvious that the audio format is not suited for automatic searches and comparative analysis. Voice recognition techniques (now in development for Bulgarian language) unfortunately will not be able to digitise such specific voice information. We consider the keyboard data input as the only possible way for this specific case of speech to text conversion. We are convinced that preserving this small part of the national cultural heritage and making it available for further processing is effort worthwhile.

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OČUVANJE I DIGITALNA RESTAURACIJA ZVUČNIH ARHIVA

Opisujemo naša bugarska iskustva u očuvanju i digitalnoj restauraciji zvučnih arhiva.

Ključne reči: očuvanje, digitalna restauracija, zvučne arhive