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ASSESSMENT OF SMOOTHED SPECTRA USING AUTOCORRELATION FUNCTION

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Recently, data and signal smoothing became almost standard procedures in the spectrometric and chromatographic methods. In radiometry, the main purpose to apply smoothing is minimisation of the statistical fluctuation and avoid distortion.

Every procedure of smoothing leads to some distortions of the smoothed spectra. However, it is difficult to find an objective measure of the degree to which the smoothed spectrum was distorted, because the shape of "ideal" spectrum is unknown. Most of the smoothing and denoising procedures are based on the assumption of the additive noise model:

$$\mathbf{w} = \mathbf{w}_p - \mathbf{v} \quad (1)$$

where: $\mathbf{w}$, $\mathbf{w}_p$ – vectors of the raw and "ideal" spectrum respectively; $\mathbf{v}$ – vector of noise.

In practice, if a smoothing procedure is applied to a spectrum, the experimentator knows, beside the raw spectrum, the smoothed spectrum only (vectors of $\mathbf{w}$ and $\mathbf{w}_s$), and can compute the vector of removed part assuming the linear model:

$$\mathbf{v}_s = \mathbf{w} - \mathbf{w}_s \quad (2)$$

The aim of this work was to find a qualitative parameter, which could be used, as a figure of merit for detecting distortion of the smoothed spectra, based on the above linear model.

It is assumed that as long as the part of the raw spectrum removed by the smoothing procedure ($\mathbf{v}_s$) will be of random nature, the smoothed spectrum can be considered as undistorted. To detect the random nature of the $\mathbf{v}_s$ one can use its autocorrelation function $\mathbf{r}_{vs}$ [1]:

$$\mathbf{r}_{vs} = \frac{\mathrm{cov}\left[\mathbf{v}_s(i),\ \mathbf{v}_s(i+p)\right]}{\sigma^2(\mathbf{v}_s)} \quad (3)$$

where: p – shift (lag), $\sigma^2(\mathbf{v}_s)$ – variance of removal noise, i – 1…k, k – number of channels.

If the vector $\mathbf{v}_s$ is of random nature (*e.g.* white noise) its autocorrelation function has a zero value at all lags except a value of unity at lag zero, to indicate that the removed noise is completely uncorrelated. A correlated noise on the other hand

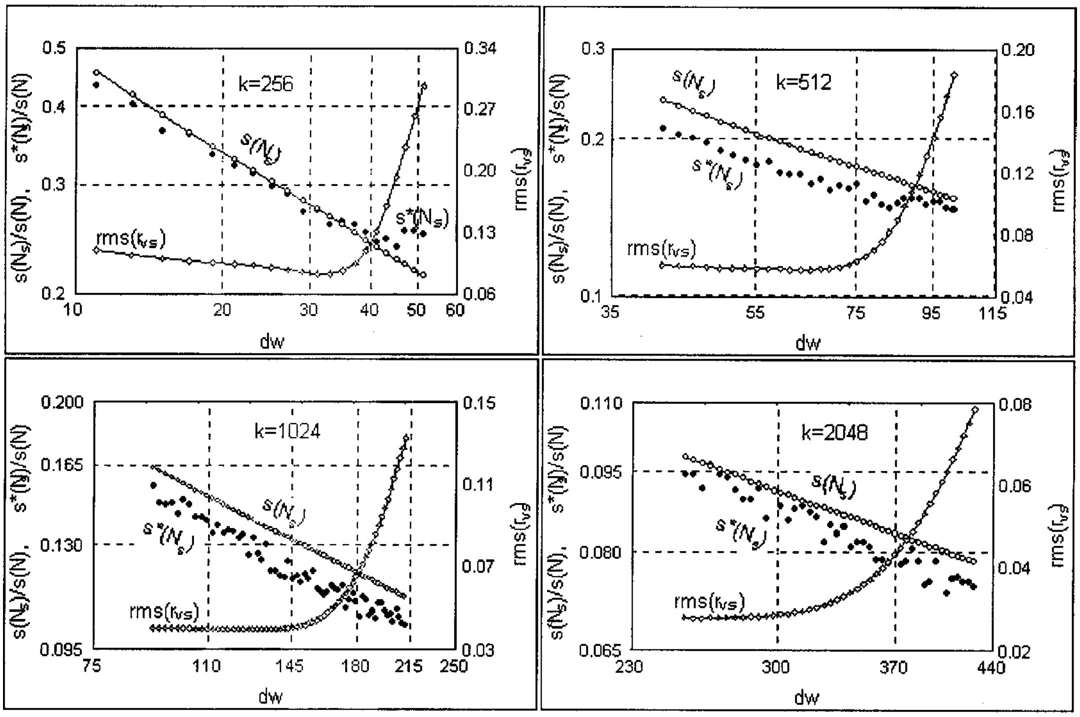

Fig. Root mean square error of total counts for the smoothed and raw spectra and *rms* of the autocorrelation function of the removed noise *vs*. filter width for simulated spectra smoothed with the Savitsky-Golay procedure.

will produce non-zero values at lags other than zero to indicate a correlation between different lagged observation. Thanks to this feature of the autocorrelation function, drifts of the mean value in the removed noise $\mathbf{v}_s$ as well as its periodicity can be more easily detected from the autocorrelogram than from the original data. As a measure of the random nature of the removed noise, the root mean square value of the correlation function $rms(\mathbf{r}_{vs})$ was used:

$$rms(\mathbf{r}_{vs}) = \sqrt{\frac{1}{p}\sum_{i=1}^{p}\left|\mathbf{r}_{vs}(i)\right|^2} \tag{4}$$

The above considerations were checked on simulated spectra consisting of k channels and corrupted with Poisson distributed noise and then smoothed with the Savitsky-Golay procedure using second order polynomial and variable filter width dw [2]. As a measure of the smoothing quality, the ratio of the root mean square error (RMSE) of the total counts for the smoothed and raw spectra $s(N_s)/s(N)$ was applied [3]. The $s^*(N_s)/s(N)$ ratio was computed using bootstrap method [4] for a single spectrum. The both ratios and $rms(\mathbf{r}_{vs})$ *vs.* filter width were plotted and are shown in Fig.1.

It is seen that with increasing filter width, the quality of the smoothing also increases (RMSE ratio is lower), however, beginning from a certain channel, the $rms(\mathbf{r}_{vs})$ also increases sharply indicating that in the removed noise some non-random component appear. If the goal of the optimization is to minimise distortion and maximise smoothing quality, the filter width should be chosen for the $rms(\mathbf{r}_{vs})$ lying on the flat part of the plot and in "safe" distance left from the observed knee of the plot.

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WIRELESS AIR MONITORING NETWORK WITH NEW AMIZ-2004G DUST MONITORS

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Since many years, MIZA and AMIZ dust monitors are used for the measurement of airborne dust concentration. The principle of operation of the monitor is based on determination of dust mass deposited on an air filter from a known volume of air sample. The dust mass is determined from radiation attenuation of a Pm-147 beta source. Additionally, relative humidity, atmospheric pressure and temperature of the air are measured [1].

Usually, the dust monitors are installed in places where wire communication not always is secured. In such a case, direct collection of measuring results is impossible and requires that personnel of the environment protection units has to go frequently to the monitors to collect the measured data. In case the measurements are made in a few different places, such situation restricts the measurements from economical reasons.

To solve the problem, a new version of dust monitor AMIZ-2004G was developed (Fig.1). The monitor, after a general reconstruction, is equipped with a GSM modem enabling communication with a central computer that is also equipped with such a modem. Thanks to the new construction not only a remote wireless communication with AMIZ is possible, but also a monitoring network containing a higher number of dust monitors can be made. The measuring data from all the monitors in the network can now be collected in one central computer equipped with the GSM modem and a proper acquisition program [2,3].

At the beginning of the year 2005, dust monitoring network was put into operation in the Kielce

Fig.1. Airborne dust concentration gauge AMIZ-2004G.