# De-noising of Nuclear spectra by Employing Spencer and Savitzky-Golay FIR Filters

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**Abstract**

In this paper the authors have employed FIR Spencer filter developed for actuarial data processing for the purpose of de-noising observed nuclear spectrum, and compared its performance with that of widely used Savitzky-Golay (S-G) filters. The frequency response of the filters was also compared. It was concluded that the performance of Spencer filter compared favorably with that of an optimal S-G filter. Spencer filter holds a good potential for its maximal application to nuclear spectral processing and other fields.

**Introduction**

From an electrical engineering perspective to nuclear spectrum it is concluded that over 90% of the information is lost [1-3]. Nuclear spectra are Type II signals by a new classification of signals proposed by Madan et al. [2]. Savitzky-Golay (S-G) filters are widely used for de-noising nuclear spectra but are not well known in the field of the DSP community [4, 5]. In this paper the authors have employed rather unknown Spencer filter [6,7] developed for actuarial data processing for de-noising observed nuclear spectrum, and compared its performance with that of an optimal S-G filter. It was observed that the performance of the spencer filter and that of S-G filter compared favorably with each other.

**Type I and Type II signals**

To widen the scope of DSP to nuclear spectral processing, a new classification of digital signals was proposed by Madan et al. [4] as Type I and Type II signals. It is based on the fundamental problems of aliasing and quantization noise.

**S-G and Spencer FIR filters**

The S-G FIR filters are also known as polynomial smoothing, or least-squares smoothing filters. Spencer filter was based on superposition of two applied filters simultaneously to a linear operation.

**Frequency Response**

Fig. 1 depicts frequency response of Spencer's 15 point, S-G 15 point and S-G 13 point filters. The stop-band ripple is pronounced in S-G filters while for Spencer filter it is comparatively negligible. The transition band of S-G filters is narrower (desirable) as compared to that of Spencer filter.

**Experimental Results**

Spencer 15 point, S-G 15 point and S-G 13 point filters were employed for de-noising an observed nuclear spectrum. Fig. 2 depicts the raw and filtered spectra using Spencer's 15 point, S-G 15 point and S-G 13 point filters. The visual inspection of the filtered spectra depicts that the method of filtering by Spencer Filter were effective. The quantitative parameters of comparison between the raw and each of the S-G filters includes error squared values and percentage change in peak area.

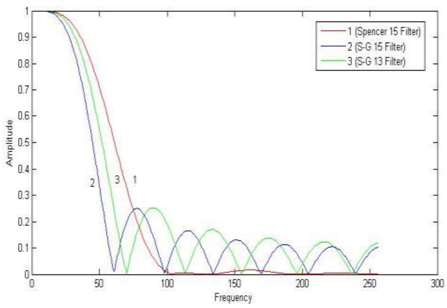


**Fig.1**: Frequency Response of Spencer 15 point, S-G 15 point and S-G 13 point filters

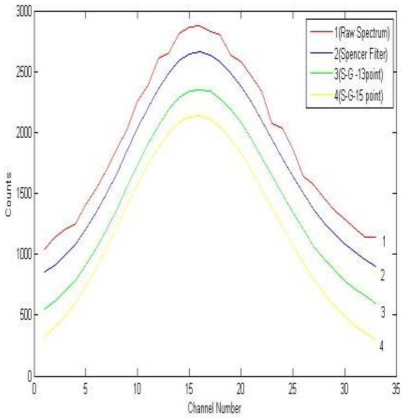


**Fig.2:** Raw and De-noised Spectra, shifted arbitrarily, using Spencer Filter and S-G Filters, 13 Point and 15 Point.

Table 1 and Table 2 depict the computed values for error squared values and percentage change in peak area. From the Tables, it is concluded that the performance of the Spencer filter for filtering nuclear spectrum was favorable with that of S-G 13 point filter while for S-G 15 point filter, the performance of Spencer filter was better.

**Table 1:** Sum of error squared values

| Filter Type | Error squared |
|---|---|
| Spencer (15 Point) | 28070 |
| S-G (13 Point) | 31105 |
| S-G (15 Point) | 298650 |

**Table 2:** Percentage change in peak areas

| Filter Type | %change in area |
|---|---|
| Spencer (15 Point) | 0.0286 |
| S-G (13 Point) | -0.0118 |
| S-G (15 Point) | -6.7459 |

Hence it is concluded that Spencer filter, though not used for nuclear application, holds a good potential.

**Conclusion**

For de-noising a nuclear spectrum, the authors have employed FIR Spencer filter developed for actuarial data processing for de-noising observed nuclear spectrum, and compared its performance with that of widely used optimal Savitzky-Golay (S-G) filter. The Spencer filter holds a good potential and its more applications should be developed.

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