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MODELLING OF ACOUSTIC SIGNALS BASED ON OPTIMUM POLE STRUCTURE FOR MATERIAL BASED CLASSIFICATION

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In this paper, we utilize an autoregressive (AR) model for acoustic signal modelling and classification. It is shown in this work that through proper estimation of the pole structure classification, performance can be improved for material based classification.

Classification based on the acoustic properties of materials and systems, is used in many applications in various fields. For example, sports – Snickometer system in cricket, medical diagnosis - acoustic stethoscopes, automobile fault diagnosis - engine trouble, speech processing - automatic speech recognition.

The modelling and classification of these data is performed here using three types of signals generated by the impacts between glass–metal (GM), glass–plastic (GP) and metal–plastic (MP) with a database consisting of forty six signals from each class.

These three types of signals were modelled using an AR model structure given by:

$$R(z) = \frac{S(z)}{E(z)} = \frac{1}{1 - \sum_{k=1}^{p} a_k z^{-k}} \quad . \qquad (1)$$

Though the frequency spectrum can be obtained by directly substituting $z = e^{j\omega}$, inaccurate pole locations can result due to resolution limitation. In order to circumvent this resolution issue, we resort to "residue method" which can be described as,

$$R(z) - \sum_{i=1}^{N} \frac{A_i}{z - p_i}, \qquad (2)$$

where, A_i is the residue corresponding to each pole P_i. In particular, we may interpret that A_i represents the "strength" or the level of contribution of pole P_i.

The resultant spectrums were then utilized with the AR model for twenty five coefficients in order to extract parameters for classification. The optimum number of poles were obtained using pole-zero plots, hence two coefficients were selected for the classification. As another method of minimizing the error, the optimum number of poles was selected to be four, since it yielded the minimum squared error. According to this analysis, it was observed that there is a clear separation of the three signals into different cluster regions with a minimal number of false alarms.

In conclusion, we show that, signals can be classified according to their acoustic system using AR modelling with the optimum number of poles, as less number of poles will not model the signal accurately and large number of poles will model the noise components as well, which will lead to erroneous results.