Feature Extraction and Classification of Wide Angle Optical Scattering Patterns from Single Aerosol Particles

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Abstract— The aim of this investigation is to discriminate between elastic light scattering patterns produced by reference materials, namely clusters of polystyrene (*PSL*) spheres, and by spores of *Bacillus globigii* (*Bg*), a known simulant of anthrax. *TAOS* (two-angle optical scattering) is an experimental technique which records the intensity patterns of laser light scattered by single aerosol particles over an extended range of the scattering angles θ and ϕ [1]. Particles are produced at a controlled rate and illuminated by a Q-switched Nd:YAG laser at $\lambda = 532\,\mathrm{nm}$. The *TAOS* patterns are recorded by an intensified *CCD* camera and stored for off-line processing. Typical patterns from *PSL* aggregates and *BG* spores are shown in Figures 1 and 2, respectively. Since in this context deterministic obstacle inversion is impossible, pattern recognition is a must. The pattern classifier under development consists of four stages. *1)* Pre-processing. *2)* Feature extraction by spectrum-enhancement [2]. *3)* Training, in which principal component (*PC*) analysis is applied to features extracted from a training-set (T) of images and classification is rated

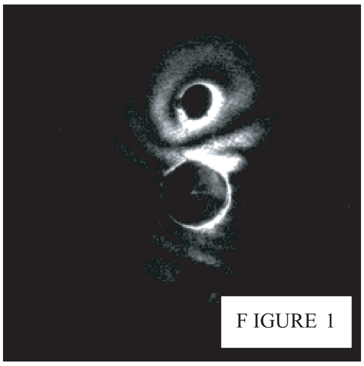

Figure 1: Scattering pattern of a polystyrene (*PS*) sphere aggregate.

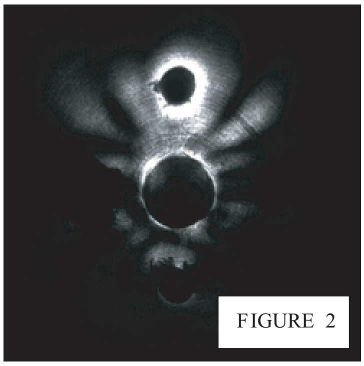

Figure 2: Scattering pattern of *Bacillus globigii* (*Bg*) spores.

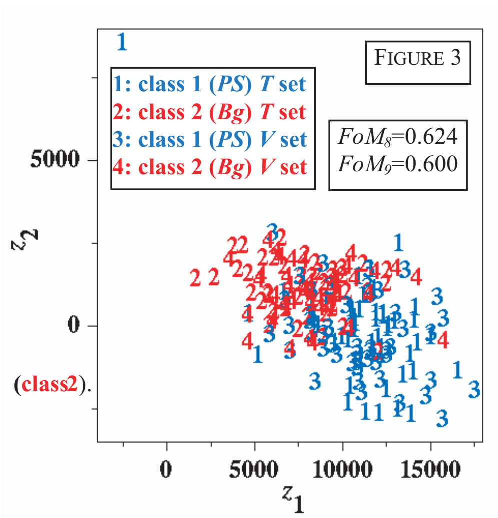

Figure 3: Classifier output: Representation of *TAOS* patterns on the plane of the first two *PCs*, z_1 and z_2.

by the following figure of merit (FoM):

$$FoM_8 = \frac{1}{2} + \frac{1}{2M_T} \sum_{m=1}^{M_T} \sum_{\substack{j=1 \\ j \neq i[m]}}^{2} \frac{d_{m,\,j} - d_{m,\,i}}{d_{j,\,i[m]}}. \tag{1}$$

Here M_T is the number of patterns in the T set, $i[m]$ is the class, 1 or 2, to which pattern m is known to belong and $d_{m,\,j}$ is the distance from pattern m to the class (i or j) centroid. *4)* Validation, rated by FoM_9, a figure of merit where M_V, the number of patterns in the validation (V) set, replaces M_T of FoM_8. A typical classification result, which corresponds to $FoM_8 = 0.624$ and $FoM_9 = 0.600$ is shown in Figure 3. Feature extraction depends on a few parameters. The latter are optimized via the $FoMs$. Sensitivity of results to T and V set composition is assessed by swapping patterns between T and V sets and then repeating classification. The above described classifier can be applied to $TAOS$ patterns in real-time.

REFERENCES

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