AN IMAGE PROCESSING SYSTEM FOR SMOKE PLUME SOUNDING

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This paper presents results from experimental processing of plume video images. Applicability of TV systems to automatic identification of smoke emission is demonstrated.

Active lidar sensing methods appear to be most promising for rapid remote assessment of the state of the atmosphere in industrial zones. [1] Modern lidar systems are sometimes equipped with passive optical units – TV viewers, through the use of which the operator can search for an object and determine the sounding sector.

The present paper describes such a TV system, interfaced with an image processing system with the specific aim of assessing the possibilities of constructing am automatic device for identifying smoke emissions into the atmosphere. In our experiments video images of smoke plumes from industrial enterprises in the city of Barnaul were processed, using the CDP (color display processor) microprocessor system of color image processing. The system also included a video unit operating together with an HT68X computer. Its configuration is shown in Fig. 1. The system was connected to a black-and-white Minilux Super CCTV video camera. One frame is obtained in 40 μs. The running video signal amplitude from a given frame is compared to 64 contrast grades possible in the system, and each of them is assigned its own pseudo-color on the color display. The pseudo-color image is in no way related to the original target color. To process the images a KEPIR package of applied software was employed.[2]

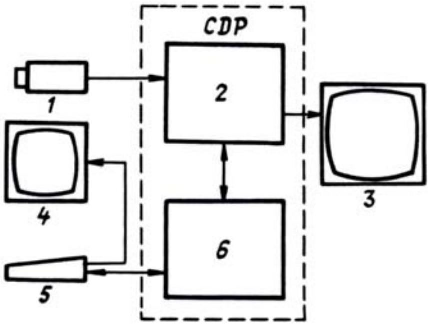

FIG. 1. Video imaging system configuration. (1) – video camera; (2) – video units; (3) – scanning color monitor; (4) – operator monitors; (5) – keyboard; (6) – 68HTX processor.

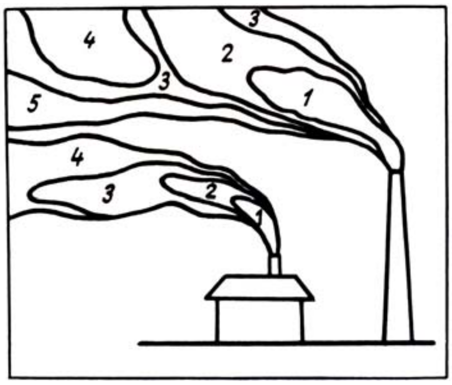

FIG. 2. Pseudo-color presentation of a smoke plume (July 25, 1989, 11:30 LT).

Experiments were staged from July 10 to 31, 1989 during daytime at visibility ranges of within 20–30 km for the most part. The instrumentation was mounted at the eighth story of a high-rise building providing a good view of the industrial part of the city. Before measurements, the system was adjusted to with respect to a homogeneously illuminated white screen. The data obtained demonstrated that such a system provided 4–5 typical contrast grades, described by their respective pseudo-colors, from observations of smoke plumes, 2–3 km from their sources. The contrast level of a plume is determined by its optical density and related to the concentration of particles in it. Thus, from the pseudo-color distribution on the screen one can evaluate indirectly the concentration of particles in the smoke plume. As an example, Fig. 2 presents a distribution of pseudo-colors along such a plume.

The studied sources of smoke were at distances from one to eight kilometers from the observation site.

Image processing could be done in two modes. In the first the signal was received directly from the video camera. In this mode one could follow the spatial-temporal variability of the plume on a real-time basis directly from the screen of the color monitor. In the second mode (the "static mode") separate still images were processed. In this mode pseudo-color distribution histograms across the whole frame or across a selected section were con-

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structed, boundaries were outlined, and their areas measured. Graphical data were output on a scanning monitor, and digital information - on an alphanumeric operator display.

It was possible to select and outline spatial areas of differing optical densities in all the observed smoke plumes. The presence of fog and haze in the atmosphere at visibility ranges up to 10–12 km shrank the contrast range to 3–4 pseudocolors per plume.

The conducted studies demonstrated the feasibility of a TV image processing system for smoke plumes detection. Lidar stations may be organized using such instrumentation for the automatic identification and assessment of smoke emissions. It is further possible to measure optical densities corresponding to each given pseudo-color in the TV images by a lidar, and thus monitor smoke emission by TV systems alone, employing lidar only in the capacity of a calibrating instrument.

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