Blotch Detection for Digital Archives Restoration based on the Fusion of Spatial and Temporal Detectors

Sorin Tite (stilie@ina.fr), Louis Laborelli (llaborelli@ina.fr)
Institut National de l’Audiovisuel (France)

Isabelle Bloch (Isabelle.Bloch@enst.fr)
ENST (France)
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ABSTRACT: This paper proposes a method based on the Dempster-Shafer evidence theory for the detection of blotches in digitized archive film sequences. The detection scheme relies on the fusion of two uncorrelated fast but inaccurate, spatio-temporal blotch detectors. The imprecision and uncertainty of both detectors are modeled using Dempster-Shafer evidence theory, which improves the decision, by taking into account the ignorance and the conflict between detectors. We found that this combination scheme improves the performance of single blotch detectors, and compares favorably to more complex and time consuming blotch detection methods, for real archive film sequences.

In this paper we focus on the detection of the most frequent defects, which are dirt and sparkle. Dirt and sparkles are impulsive (single frame) defects. Dirt can be seen as opaque or semi-transparent clusters with random size, shape and position, caused by dust and dirt stuck on the film, while sparkle are white and sparkles are impulsive (single frame) defects. Dirt can be seen as opaque or semi-transparent clusters caused by the local abrasions of film gelatin.

Dirt occurs as clusters of different sizes, shapes, and positions, which can be opaque or semi-transparent. Sparkles are white and impulsive defects that occur as single frame defects.

In order to take advantage of the redundancy and complementarity of the detectors, we combine their outputs in the framework of the evidence theory, which easily handles the concepts of uncertainty, ignorance and imprecision of data. We assume that each pixel can be explained by two mutually exclusive and exhaustive hypothesis: “defect” and “no-defect”.

Disjunctions or compound hypotheses allow the representation of the ignorance of a source, i.e. if the source cannot distinguish between hypotheses A and B, the corresponding belief is assigned to the union of these hypotheses, beta. The DS evidence theory allows representing both imprecision and uncertainty through two functions: belief and plausibility, which are derived from a mass function, shown on graphs. The mass assigned to ignorance should be maximum near the boundary between defect and no defect. The combination of the two detectors has been done by applying Dempster’s combination rule on the previously estimated masses. This table shows the principle of the DS fusion: some of the mass is transferred from the combined hypotheses to simple hypotheses.

The decision rule we have chosen selects the singleton hypothesis (green is defect, red no defect) which corresponds to the maximum of belief, but only if its exceeds a given threshold otherwise, the decision is total ignorance, shown in blue here:

**Data fusion by Dempster-Shafer theory**

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**Experimental results**

The performance assessment was performed using sequences scanned from archive 16mm colour film, using a four channels scanner, with infrared detection of dirt. These sequences are challenging, because motions are large and complex, and because the areas of moving objects and of blotches are quite similar. There is a choice of a threshold for obtaining a binary ground truth from the infrared images. Various statistics are computed and compared to implementations of existing blotch detectors.

**Comparison of the results with ground truth**: correct in green, false alarms in red, missed in blue.

**CONCLUSIONS**: In this paper, we propose a fusion scheme for the detection of blotches in digitized archive film material.

Performances in terms of correct detections and false alarms were improved, as the decision has been performed after the combination step, taking the conflict between detectors into account.