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Frame Border Detection for Digitized Historical Footage

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Abstract. *Automatic video analysis of digitized historical analog films is influenced by video quality, composition and scan artifacts called overscanning. This paper provides a first pipeline to crop the main frame window by detecting Sprocket-Holes and interpreting the geometric hole layout to distinguish between two different film reel types (16mm and 9.5mm). Therefore, an heuristic approach based on histogram features is explored. Finally, our results demonstrate a first baseline for future research.*

1. Introduction

In the age of digitization analog film collections are digitized by using modern technologies and processes[1]. During these processes the frame content as well as the area around the exposed frame is scanned. This area includes black borders of the film reel, *Sprocket-Holes (SH)* or parts of the next or previous frames. This effect is called *overscanning* and is needed to ensure preservation of significant information (see Fig.1-a). Furthermore, it is a fundamental procedure for sustainable film digitization and archival. However, for developing automatic video analysis tools of scanned historical analog films, this additional information is undesirable and can influence the performance of those systems [1, 3, 4]. The project *Visual History of the Holocaust (VHH)*[2] has been funded in order to digitize analog media collections related to the liberation phase of the Nazi concentration camps. These collections are used for further explorations on automatic video content analysis. However, they do not include annotated metadata such as the film reel type or masked overscan areas. Therefore, automatic mechanisms for detecting and removing overscans in film reels such as 16mm or 9.5mm (see Fig.1-b) can be used to provide more efficient ways for exploring analog films.

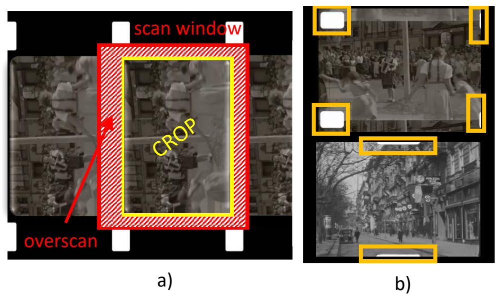

Figure 1. (a) Demonstration of *overscanning*, (b) real world examples of a 16mm (top) and 9.5mm (bottom) film reels.

Mühling et al. [2] and Zeppelzauer et al. [4] explore the challenges of cinematographic techniques in historical videos. However, to our best knowledge no comparable scientific investigation on automatically removing overscan information by detecting SH has been published in the last decade. This paper proposes a first Frame-Border-Detection (FBD) approach to remove overscan areas in scanned analog frames by detecting SHs as well as interpreting the hole geometry and layout. This information is used to classify two different film reel types (16mm and 9.5mm). Moreover, the hole positions are used to extract the final frame window using traditional computer vision techniques.

2. Methodology

We propose a multi-stage pipeline split into four main blocks: *Threshold-Filtering (THF)*, *Connected-Component-Labelling (CCL)*, *Calculating-Crop-Window (CCW)* and *Reel-Type-Classifier (RTC)*. The original input frame is first converted into a grayscale image. In the THF-stage, the input image is thresholded to get a binary mask. The threshold T_{h} is calculated for each input frame dynamically by analyzing the fields 1-6 visualized in Figure

[1] https://dft-film.com/products/archive-challenges-and-solutions.html - last visit: 2020/02/08
[2] https://www.vhh-project.eu/en/ - last visit: 2020/02/08

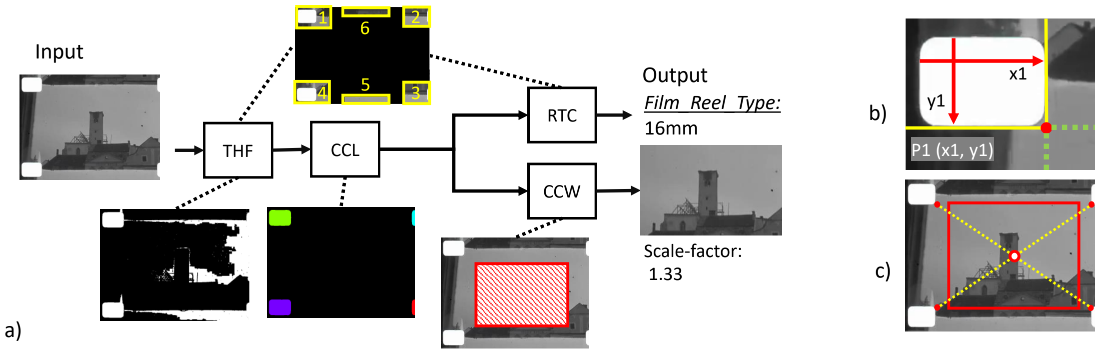

Figure 2. Illustration of (a) the pipeline, (b) the generation of the corner point and (c) calculation of the final crop window.

Exp.	P	R	Acc	mIoU@0.95	IoU@0.70
16mm-fixed	0.95	0.94	0.88	-	-
9.5mm-fixed	0.94	0.68	0.82	-	-
16mm-dyn.	0.96	0.84	0.90	-	-
9.5mm-dyn.	0.97	0.64	0.81	-	-
overall-fixed	0.948	0.812	0.85	0.747	0.867
overall-dyn.	**0.962**	**0.74**	**0.86**	**0.763**	**0.895**

Table 1. Precision (P), Recall (R) and Accuracy (Acc) on the test set - classification of the reel-types 16mm and 9.5mm. mean Intersection over Union scores at thresholds: 0.95 and 0.7.

2-a. After a filtering process, the mask is used in the CCL-stage for labeling all detected potential SH. This step includes a further filtering process to remove outliers. Finally, this step is the base for the CCW- and RTC-stage. In CCW the corner points are calculated as demonstrated in Figure 2-b. The center of the resulting square is used as reference point for the final crop window which is defined with a configurable scale factor (e.g 1.33) to get the correct scaled frame crop related to the original film reel such as 960x720 pixels (see Fig.2-c). In the RTC-stage, our pipeline is able to classify the input frame into the reel types: 16mm and 9.5mm. Therefore, the locations of the labeled holes are analyzed in the masked input image. SHs in the fields 5 and 6 (see Fig. 2-a) are related to the 9.5mm film reel whereas the other ones identify the 16mm reels.

3. Results & Conclusion

The evaluation of our pipeline is based on a self-generated dataset including 100 labeled frames randomly selected out of 10 videos related to the National-Socialism[3]. The dataset contains 50 annotated frames for each class: 16mm and 9.5mm reels. The metric mean Intersection over Union (mIoU) is used for evaluating the predicted locations. Precision and Recall are utilized to evaluate the classification of the two reel types. For the evaluation, two experiments have been conducted: a fixed and dynamic T_{h}. The results show that the mIoU scores significantly depending on the THF process. Historical film frames include damaged and under-/overexposed areas which make the selection of an optimal T_{h} challenging. Furthermore, SHs are not on the same positions in each frame due to the movements and the varying speed of the film reel during the scan process. The results are summarized in Table 1. We provide a first baseline for further research. However, optimizing our pipeline as well as using Deep Learning-based methods are planned to improve detection and classification results.

[3]http://efilms.ushmm.org/ - last visit: 2020/02/11

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