Color for Black-and-White Cartoons

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In this paper we discuss a challenging problem of applying novel color information into the old black-and-white cartoons. Thanks to possibility, which allows us to convert the original analogue material to the sequence of digital images, we are able to solve this task using methods of digital image-processing.

Classical works from the history of cartoon making stay still in front of the recent worldwide cartoon production and become an invaluable source of inspiration for every new generation of children. Unfortunately aged cartoon animations were usually shot in black-and-white. However it has been proven that presence of color in cartoons stands for the most important influence on final artistic quality especially when it is intended for the adolescent audience. Novel color information usually emphasize original art style and increase overall visual impression.

Colorization of black-and-white movies has been extensively studied since 1970's. The general problem of adding color information to the grey-scale images introduces large ambiguity, which should not be resolved without additional knowledge about the scene structure. This crucial information is usually provided by human interaction and plays an important and time demanding role in the whole colorization process. To accomplish this difficult task an exhaustive brute force approach or various semi-automatic techniques have been used. While an amazing piece of work has been done on colorization of classical movies, a semi-automatic colorization of grey-scale images is not yet supported in recent cartoon authoring systems. Due to these circumstances artists endows on featureless and repetitive work, which disturbs them from real creative artwork.

For example well-known semi-automatic colorization technique luminance keying is able to apply selected hue, saturation and brightness on the each level of grey-scale intensity. However only additional tedious hand-driven image segmentation allows one to simultaneously use different luminance keys, which cover the same intensities on different locations in the original grey-scale image. Another problem is that usual cartoon world is not planar but in fact 2.5D. Occlusion and other topology variations imposed by virtual depth should destroy important local structure, which significantly decrease predictability. The intensity itself or shape-based features provide insufficient information to solve this topological problem. Additionally the movement in classical cartoon animations seems to be coarse in contrast to computer generated movies. The same motion phase is usually exposed twice using two consecutive movie frames. Accordingly the structural difference between current and novel animation phase becomes really noticeable. Moreover moving entities are not only characters that look like human but also some extraordinary creatures and other strange objects. Due to these circumstances we are not able to look to real world physical laws of motion because we have to track movements in fuzzy artificial world. Creating extra model for each novel entity is going to be inefficient.

We have introduced a novel semi-automatic colorization framework suitable for aged cartoon animations [1]. More specifically we focus especially on the foil or paper cartoon making technology. In this case the foreground layer usually consists of several homogeneous regions that are separated by force of boundary contours. Background layer is represented by a static image and only dynamic foreground has to be colorized frame-by-frame.

For this type of cartoon animations we show how to automate colorization pipeline, to reduce amount of hand-driven corrections, and to make the whole process cost effective and temporally feasible. Our framework consists of various image-processing techniques able to process animation sequences in television broadcasting quality on standard PC workstation preserving interactive performance.

More concretely we have developed a robust unsupervised contour-based image segmentation able to determine which part of the original image belongs to the foreground layer [2]. This technique allows us to divide foreground layer into the set of homogenous regions. Patch-based sampling [3] and probabilistic reasoning [4] are then used to predict which color will be used for particular region. Afterwards a user defined hue and saturation are applied to each pixel in the foreground layer while final color brightness is modulated using pixel intensity in the original grey-scale image. Moreover dust spots and band scratches are removed automatically exploiting region homogeneity. Limited manual interaction avoids propagation of prediction errors into the successive frames and consequently guarantees visual quality of the final colorized sequence. Foreground separation allows us to track camera movement over background layer and to reconstruct one big plane, which contains visible parts of the whole background. A skilled designer applies colors on this layer at once using standard image manipulation software. Finally background incremental movement vectors are used again to extract proper rectangle from already colorized background plane. Using such a color rectangle as background layer for current animation frame we make smooth composition with a yet colorized foreground to produce resulting color image.

Proposed framework has been used in practice to produce color version of Czech black-and-white cartoon "*O loupežníku Rumcajsovi*" which has been originally designed by Radek Pilař in 1967. In average two trained artists were able to colorize the whole episode (cca 10000 full PAL frames) during one week (40 working hours), in contrast to hand-driven luminance keying approach which takes in average one month to process the same amount of frames. Additionally our framework also increase the overall visual quality.

References:

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