研 究 終 了 報 告 書

「対話型パーソナライゼーション AI によるコンテンツ制作の拡張」

研究期間： 2018 年 4 月～2021 年 3 月
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1. 研究のねらい

The objective of this research is to push the limits of artificial intelligence applied to content creation by developing advanced interaction and personalization techniques. In particular, the focus is on tackling individual and concrete problems of content creations, such as rough sketch inking or black and white image colorization, in order to propose and extend general approaches that will be applicable to large classes of problems. Besides the more academic objective of research, a focus will also be given to making the techniques and supporting source code publicly available such that content creators, artists, and other researchers can fully reproduce the results and apply the techniques to novel problems.

For the success and adoption of the proposed research we can identify the following five critical points:

Naturalness: mimic standard and well developed design processes.
Interpretability: results should be easy to understand and manipulate.
Interactivity: give the user full control to modify the results.
Personalization: automatically adapt to the user's specific needs.
High performance and Robustness: give convincing results for even tough inputs.

2. 研究成果

（1）概要

The main contributions of the research project have consisted of new interactive, personalization, and general application techniques with a particular focus on computer graphics problems. In particular, approaches for editable enhancement of photography, re-illumination of images, and remastering of videos have been proposed. All developed approaches have been designed to be compatible with common content creation workflows to maximize potential adoption and impact.

Full details of all the proposed approaches and source code for replication of results can be found at https://esslab.jp/~ess/publications/ .

（2）詳細

「Interactive Techniques」

Advancing interactive techniques has been one of the pillars of the research focus for this project. Two of the more important techniques developed have been optimization-based data generation technique for the enhancement of photographs and re-illumination approach based

on RGB-geometry.

One of the common issues of machine learning-based photo enhancement approaches is that they are fully automatic and hard to manipulate and control. Furthermore, given the subjectivity and difficulty of obtaining training photography data, we proposed a data synthesizing technique based on optimization. Using existing off-the-shelf photo editing software, we can sample the parameter space to generate low quality "de-enhanced" photographs from high quality professional quality photographs, allowing for fully supervised training data. However, instead of training in the traditional approach of directly enhancing the image, we opt to use a parametrization based on standard photo editing software. Thus, for each photograph to be enhanced, we predict a set of parameters that can enhance it and can be loaded directly in photo enhancement software. This not only makes the output of the machine learning algorithm easy to interpret, but it makes it easy to integrate into existing photo enhancement workflows.

Re-illumination of images plays an important role in content creation for augmented reality and illustration. One of the main limitations of existing approaches based on machine learning is that they have very little applicability to domains not related to the training data. To overcome this limitation, we have developed a RGB-geometry based technique that exploits the observation that areas with lots of color variety tend to be heavily affected by illumination. Although this approach was designed for illustrations in mind, results show that it generalizes very well to natural images and other image types.

「Personalization Techniques」
One of the common approaches for personalization is online learning, in which models are updated real-time as more training data is obtained. However, this general approach has several outstanding issues such as data drift, training instability, and high computation costs. As an alternative approach, we have developed a source-reference attention mechanism that is able to exploit additional data without having to perform additional training. The approach consists of compressing the additional data and performing a pixel-level comparison with the inputs to the model to identify similar regions in real-time. This approach is able to directly see what data is useful and exploit the commonalities when performing a diversity of tasks.

We evaluated the approach on the challenging task of video remastering, in which an old deteriorated grayscale video has to be restored, enhanced, and colorized. Results show that this approach is able to significantly outperform existing approaches and has a large applicability to different tasks.

3. 今後の展開

The techniques developed during this project still hold a lot of potential for improvement and application to other projects. Furthermore, although all the source code and details are made public, tighter integration with existing tools is necessary for more widespread usage. Despite there not being additional funding, it is expected that the servers and resources acquired through this project shall still bring future research results in the upcoming years.

4. 自己評価

I believe that, despite all the difficulties due to the Corona crisis and the difficulties associated with the creation of a new research laboratory that have occurred during this research project, most of the research goals have been successfully achieved. The provided resources have permitted tackling ambitious research problems that have resulted in high profile publications in the top computer graphics venues such as Transaction on Graphics. Not only has this created a reference in the research of interactive and personalization of content creation techniques, but through the release of the associated software, the research has had a direct impact on content creators both within Japan and abroad. Furthermore, this impact does not end with the project and is expected to endure during the following years.

5. 主な研究成果リスト

（１） 代表的な論文（原著論文）発表

研究期間累積件数：20 件

1. Lvmin Zhang, Edgar Simo-Serra, Yi Ji, Chunping Liu. Generating Digital Painting Lighting Effects via RGB-space Geometry. ACM Transactions on Graphics (Presented at SIGGRAPH) 39(2), 2020.

We present an algorithm to generate digital painting lighting effects from a single image. Our algorithm is based on a key observation: artists use many overlapping strokes to paint lighting effects, i.e., pixels with dense stroke history tend to gather more illumination strokes. Based on this observation, we design an algorithm to both estimate the density of strokes in a digital painting using color geometry, and then generate novel lighting effects by mimicking artists' coarse-to-fine workflow. Coarse lighting effects are first generated using a wave transform, and then retouched according to the stroke density of the original illustrations into usable lighting effects.

Our algorithm is content-aware, with generated lighting effects naturally adapting to image structures, and can be used as an interactive tool to simplify current labor-intensive workflows for generating lighting effects for digital and matte paintings. In addition, our algorithm can also produce usable lighting effects for photographs or 3D rendered images. We evaluate our approach with both an in-depth qualitative and a quantitative analysis which includes a perceptual user study. Results show that our proposed approach is not only able to produce favorable lighting effects with respect to existing approaches, but also that it is able

to significantly reduce the needed interaction time.
2. Satoshi Iizuka, Edgar Simo-Serra. DeepRemaster: Temporal Source-Reference Attention Networks for Comprehensive Video Enhancement. ACM Transactions on Graphics (SIGGRAPH Asia) 38(6), 2019.
The remastering of vintage film comprises of a diversity of sub-tasks including super-resolution, noise removal, and contrast enhancement which aim to restore the deteriorated film medium to its original state. Additionally, due to the technical limitations of the time, most vintage film is either recorded in black and white, or has low quality colors, for which colorization becomes necessary. In this work, we propose a single framework to tackle the entire remastering task semi-interactively. Our work is based on temporal convolutional neural networks with attention mechanisms trained on videos with data-driven deterioration simulation. Our proposed source-reference attention allows the model to handle an arbitrary number of reference color images to colorize long videos without the need for segmentation while maintaining temporal consistency. Quantitative analysis shows that our framework outperforms existing approaches, and that, in contrast to existing approaches, the performance of our framework increases with longer videos and more reference color images.
3. Mayu Omiya*, Yusuke Horiuchi*, Edgar Simo-Serra, Satoshi Iizuka, Hiroshi Ishikawa (*equal contribution). Optimization-Based Data Generation for Photo Enhancement. Conference in Computer Vision and Pattern Recognition Workshops (CVPRW), 2019.
The preparation of large amounts of high-quality training data has always been the bottleneck for the performance of supervised learning methods. It is especially time-consuming for complicated tasks such as photo enhancement. A recent approach to ease data annotation creates realistic training data automatically with optimization. In this paper, we improve upon this approach by learning image-similarity which, in combination with a Covariance Matrix Adaptation optimization method, allows us to create higher quality training data for enhancing photos. We evaluate our approach on challenging real world photo-enhancement images by conducting a perceptual user study, which shows that its performance compares favorably with existing approaches.

（２） 特許出願

該当なし

（3）その他の成果（主要な学会発表、受賞、著作物、プレスリリース等）

1. Visual Computing 2019 最優秀研究発表賞, 2019.
2. 科学技術への顕著な貢献 2018（ナイスステップな研究者）に選定, 2018.