Enhancing Image-Based Aging Approaches

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Abstract

Modern video games and computer-animated movies exhibit extremely realistic synthetic images. To achieve such a level of realism, artists have to consider several characteristics including material appearance changes from object aging such as rust, bumps, dents, or simply dust. Since adding these details is time-consuming, several approaches have been proposed to ease the aging process and reduce related costs. In this paper, we address some problems and limitations from image based aging techniques by proposing extensions intended to widen their range of application. First, we present a new automatic positioning system that handles special orientation cases, thus increasing the overall controllability on the aging framework. Also, we propose an innovative process to better handle multiple texture colorations during the synthesis phase of image-based aging techniques.

Categories and Subject Descriptors (according to ACM CCS): I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Color, shading, shadowing, and texture

1. Introduction

Over the years, progress in the realism of synthetic images used in modern video games and computer-animated movies is obvious. Yet, the demands associated with realistic computer-generated images are constantly increasing. To address this, artists have to consider several characteristics including material appearance changes from object aging such as rust, bumps, dents, or simply dust. Indeed, when considering real-life objects and environments, deteriorations are undeniable. One recurrent criticism about computer-generated images is that objects within a given environment often look too perfect. Manually adding aging effects is time-consuming and tedious when considering the large number of objects in today's virtual environments.

Several approaches have been developed to ease the aging process and reduce related costs. Physically based methods [DPH96, CS00, ADKK04] propose simulation models to replicate aging phenomena. Even if these approaches tend to produce high quality results, they are not commonly used. They often require the user, typically an artist, to manipulate complex physical parameters to control the aging process. Also, they are designed to address a single specific phenomenon. Empirical methods [WNH97, PPD01, CXW*05] can simplify simulation models and their corresponding parameters, resulting in a more intuitive control over the generated aging. However, they suffer from the same limitation regarding the specificity to a single type of aging effect. More recently, a few researchers have proposed image-based aging approaches [GTR*06, WTL*06, LGG*07, CP10] able to handle multiple types of effects using a visual example as input. The quality of their results combined with their intuitive controllability and interactivity make them ideal for artists. On the other hand, several image-based approaches require manual adjustments to control the positioning of the effects. This can get irritating, especially when considering multiple objects that require different yet similar aging patterns. Also, they have problems handling different colorations since their synthesis process is highly dependent on the color of the provided example.

This paper addresses some problems and limitations of image-based techniques by proposing extensions intended to widen their range of application. The key contributions can be summarized as follows: (1) An automatic positioning system that handles special orientation cases, increasing the overall controllability of image-based techniques; (2) A process to better handle multiple texture colorations during the synthesis phase of image-based techniques.

2. Image-based aging overview

Prior to explaining the details of our proposed extensions, it is important to explain the key features of typical image-based aging approaches. To establish the foundations of our work, this section gives a quick overview of such approaches. As shown in Figure 1, apart from a 3D mesh of the

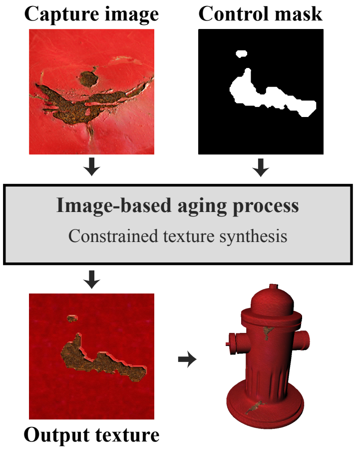

Figure 1: *Overview of a typical image-based aging process.*

synthetic object, a typical image-based method needs two important inputs: the capture image and the control mask. The capture image is a photograph containing an example of an effect an artist wants to add on a synthetic object. The control mask is a binary image indicating the aging pattern to be synthesized on the 2D texture of the object. A control mask is used to generate a specific instance of a given objet. Therefore, to produce multiple different instances, several control masks must be provided to the aging process.

Depending on the studied image-based aging technique, the control mask can be either produced manually [GTR*06, WTL*06], specified implicitly through an analysis of the local geometrical properties of the 3D object [LGG*07], or generated automatically from the local properties [CP10]. Even if the approach of Lu et al. [LGG*07] is highly versatile, it is not appropriate to generate multiple instances of a given object. Consequently, our approach is an extension of the image-based aging method of Clément and Paquette [CP10] which introduced the use of an aging recipe to define a general aging pattern. This approach allows an artist to easily apply a specific aging recipe to a single synthetic object to generate multiple different instances, or to multiple synthetic objects to produce similar deterioration.

3. Automatic positioning system

As stated in the previous section, effect positioning over the synthetic object is achieved via the control mask, which is automatically generated by the framework using an aging pattern defined in an aging recipe. The aging recipe contains several parameters controlling where and how the new effects will be distributed on the synthetic object. For the most part, the aging recipe contains acceptable ranges for different local properties, such as accessibility and curvature of the 3D object, identifying candidate texels where new effects should be positioned. During the aging process, when the algorithm selects a specific texel from the candidates, the new effect is positioned at this location without any considerations to its orientation. In many cases, this behaviour is acceptable and even advantageous, since it provides an adequate level of randomness used to generate multiple different instances. However, as shown in Figure 2, in some cases, the new aging effect should be oriented in a specific manner to be aligned with respect to a local property (i.e. abrasion along an edge with high curvature).

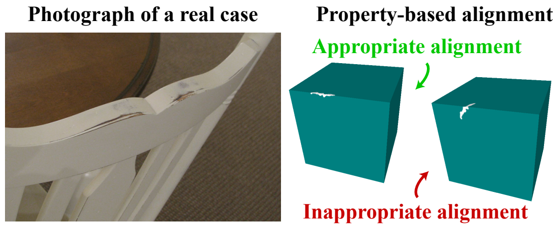

Figure 2: *Property-based alignment examples.*

To address this, we propose an algorithm to maximize a metric measuring the quality of the alignment through an iterative search technique. When positioning each instance of an effect, the proposed technique aligns the principal axis of the effect with four primary orientations (0°, 45°, 90° and 135°) and measures the quality of these four alignments. As shown in Figure 3, the hotelling transform is used to find the principal axis of the effect. From these four initial measurements, the technique selects the two orientations with the highest value. If they are next to each other, like 45° and 90°, the corresponding range is split in three sub regions. For each sub region, one additional measurement is computed at a random angle within. Finally, the algorithm selects the best possible orientation from these five candidate angles. If the selected basic orientations are not consecutive, like 45° and 135°, similar searches are done in both plausible ranges.

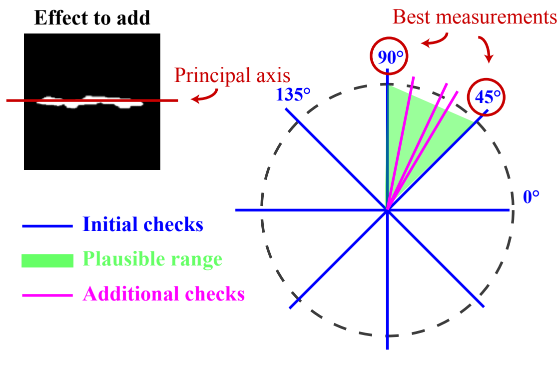

Figure 3: *The iterative search algorithm used for alignment.*

From experimentations, we determined that more than three additional checks within the plausible range only provide a negligible change in the appearance of the results. A mismatch by a few degrees is barely noticeable when the resulting texture is applied to the 3D object. Even though this approach may seem overly random, it provides the appropriate randomness needed for aging effects. Should a better alignment be needed, an hotelling transform could be computed locally with the properties of the object and the aging effect could be aligned very precisely.

To measure the quality of the alignment, a metric is computed for each texel (see Figure 4). Given the positioning ranges from the aging recipe, its value is maximal at the center of the range and it decays following a gaussian function. This computation is summed up for every texel inside the effect, and it can consider a single local property or multiple properties simultaneously.

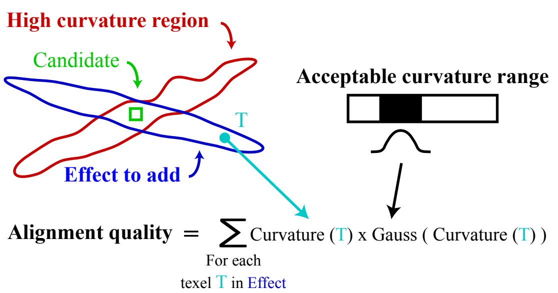

Figure 4: *The metric used to measure the alignment quality.*

Related alignment within a group of effects is another frequent case not handled properly by typical image-based aging techniques. Often, new effects develop in a particular manner related to how a given object is frequently used and because of repeated contacts. To handle this, we propose to add such an option in the aging recipe, so that the positioning algorithm can use the same rotation angle, with a slight random variation, for every effect of a group. Results for the automatic positioning system are presented in Figure 5.

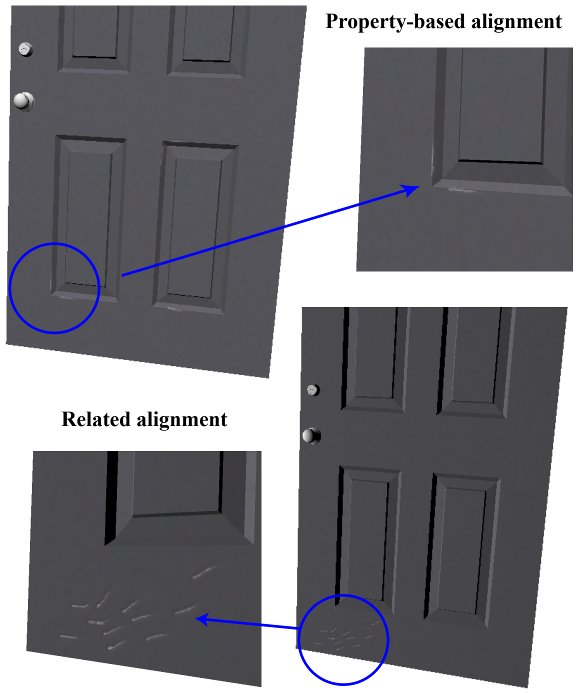

Figure 5: *Results from the automatic positioning system.*

4. Improved color-independent synthesis process

As explained in Figure 1, typical image-based aging methods synthesize the new effects in an RGB texture from the RGB example. Although this behavior is usually the main advantage of image-based approaches (in terms of controllability, usability, and intuitiveness), it can become problematic. The main difficulty is that output color is closely tied to the input color. To generate the desired result, the capture image provided to the system must have the correct shape, the correct aged color, and the correct intact color. It is impossible to produce a red scratch from a blue scratch example. Producing a scratch on a black door from a scratch on a white door is also impossible, since the resulting transitions between the aged and non-aged regions might contain the wrong color. If considering a single object on which few effects are to be added, the example could be altered to the required color. Nevertheless, when considering several objects in several colorations, manually altering the example quickly becomes time-consuming.

In their work, Clément and Paquette [CP10] proposed a color-independent synthesis process. It used grayscale height maps as input and output of the process instead of RGB images. Then, instead of synthesizing the texture of the aging effect, it interpolated between colors provided by the artist. Each of the provided colors is associated with a depth value from the height map. When the aged regions exhibit gradual changes in color, the results are adequate. For most of the other cases where the aged region contains a stochastic or structured texture, this approach fails. RGB generation allows the system to reproduce complex texture internal patterns from the provided RGB example. However, as stated earlier, the result is highly linked to the coloration of the source image.

As detailed in Figure 6, to overcome these limitations, we propose to let the artist specify *color transformations* instead of *fixed colors*. The system then synthesizes an RGB texture as in the typical image-based aging, and then modifies the color according to the transformations provided by the artist. This allows the method to synthesize an appropriate texture pattern as well as the appropriate coloration. The color adjustment is done in the HSV color space since it is often convenient to modify hue, saturation, and value components separately. Specifying the color transformation in the RGB color space would be much more difficult in most cases. For artists who are used to adjust colors in visual effects studios, it is relatively easy to specify the color transformations.

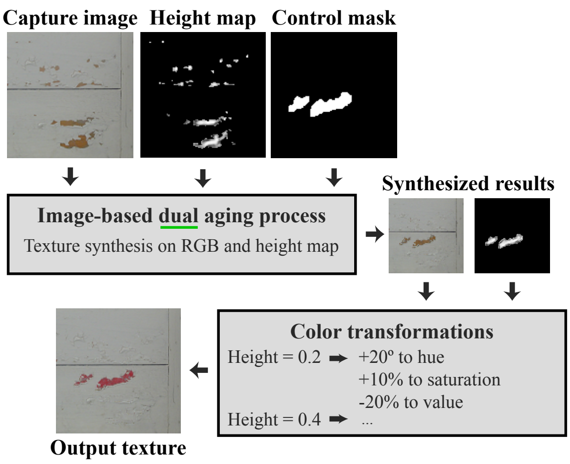

Figure 6: *Overview of the proposed dual synthesis process.*

The color transformation could be applied to different aging approaches, such as using the offset and rate of Gu et al. [GTR*06] instead of the height of Figure 6. When using the height map of Clément and Paquette [CP10], the synthesis process allows the system to also benefit from normal mapping (easily derived from the height map) to adjust the lighting calculations applied to the aging effects, and consequently to increase the realism from the RGB-only synthesis. Results for the process are presented in Figure 7.

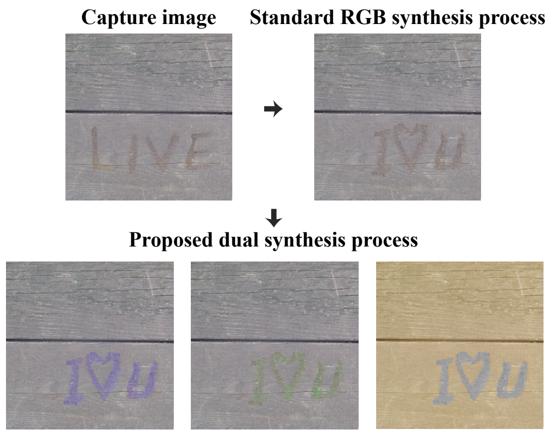

Figure 7: *Results from the proposed dual synthesis process.*

5. Conclusion

In conclusion, this paper presents two key extensions to image-based aging methods designed to increase their controllability and their applicability. First, an enhanced automatic positioning system was proposed to handle special orientation cases such as property-aligned effects. Also, we introduced an improved color-independent process combining RGB texture and height map synthesis to achieve notable flexibility regarding the coloration of the provided example. In both cases, even if calibration time is needed, our extensions considerably reduce the amount of manual work needed, especially when producing multiple instances. Finally, interesting future work could include an approach to reduce the extensive texture memory consumption required by image-based aging techniques.

6. Acknowledgements

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