A Multifragment Renderer for Material Aging Visualization

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Abstract

People involved in curatorial work and in preservation/conservation tasks need to understand exactly the nature of aging and to prevent it with minimal preservation work. In this scenario, it is of extreme importance to have tools to produce and visualize digital representations and models of visual surface appearance and material properties, to help the scientist understand how they evolve over time and under particular environmental conditions. We report on the development of a multifragment renderer for visualizing and combining the results of simulated aging of artwork objects. Several natural aging processes manifest themselves through change of color, fading, deformations or cracks. Furthermore, changes in the materials underneath the visible layers may be detected or simulated.

Related Work

Artificial Aging. The aging process depends on material composition, object usage, weathering conditions, and a large number of other physical, biological, and chemical parameters. Some aging phenomena often play a key role in realistic rendering (except when the desired result is specifically a brand-new virtual object). Their absence results to non-realistic surfaces, looking too clean and too smooth. To solve these problems, artists either compose complex textures manually or through other techniques [MG08]. Aging also can describe a number of methods used in computer graphics to simulate object morphology changes due natural influences, such as cracks, fractures, patina, corrosion, erosion, burning, melting, decay, rotting and withering. Those approaches consider effects which influence the geometry of an entire object, instead of the surface appearance alone [FVG15].

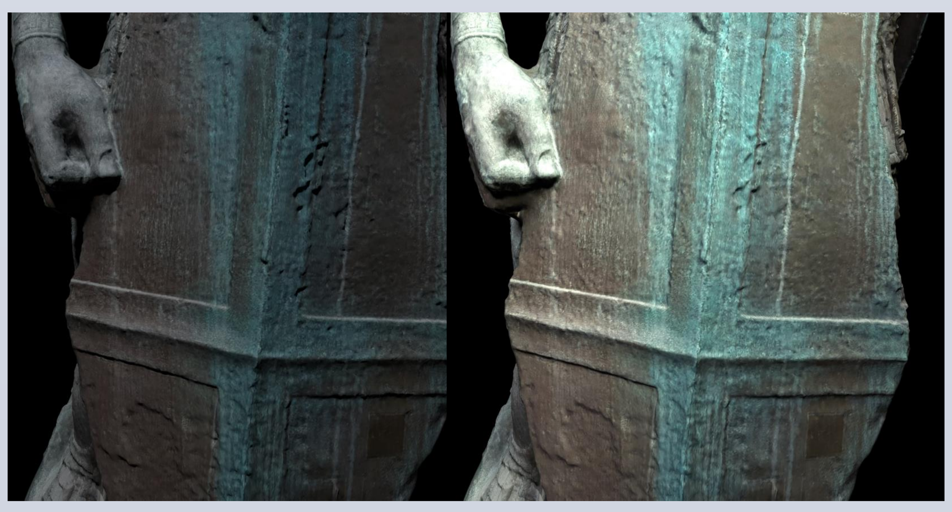
Simulation Techniques. Simulation is one of many techniques used for deriving sample results. Specifically photo-realistic rendering techniques are capable of rendering images that predict the appearance of yet to be manufactured objects [Rus09]. Physical, chemical, biological, environmental, and weathering effects produce a range of 3D model, shape, and appearance changes. To be able to visualize all these effects we need a novel simulation technique for geometrically and visually simulating these processes to create visually realistic scenes [Kid12].

Multifragment Rendering. Depth-ordered fragment determination is a standard stage in developing numerous appealing and plausible visual effects for interactive 3D games and graphics applications. A variety of algorithms ranging from photorealistic rendering, such as global illumination, order-independent transparency for forward, deferred, volumetric shading and shadowing to volume visualization and processing of flow, molecular, hair and solid geometry require accurate multifragment processing at interactive speeds. [VF13] presents a thorough survey and comparison of multifragment methods. In this work we have adapted S-buffer [VF12], a two-geometry-passes A-buffer implementation on the GPU, that overcomes the limitations of both linked-lists and fixed-array techniques by taking advantage of the fragment distribution and the sparsity of the pixel-space.

A Multifragment Visualization Tool

In our visualization tool we render and combine data from (i) microprofilometry using normal and displacement maps (ii) photos and photogrammetry using detailed meshes and texture maps, (iii) RTI using albedo, specular and roughness maps (iv) infrared, xrays, ultrasound and ultraviolet light using multiple layers. An example of gradually adding sensor data information is illustrated in Figure 1.

(a) (b)



(c) (d)

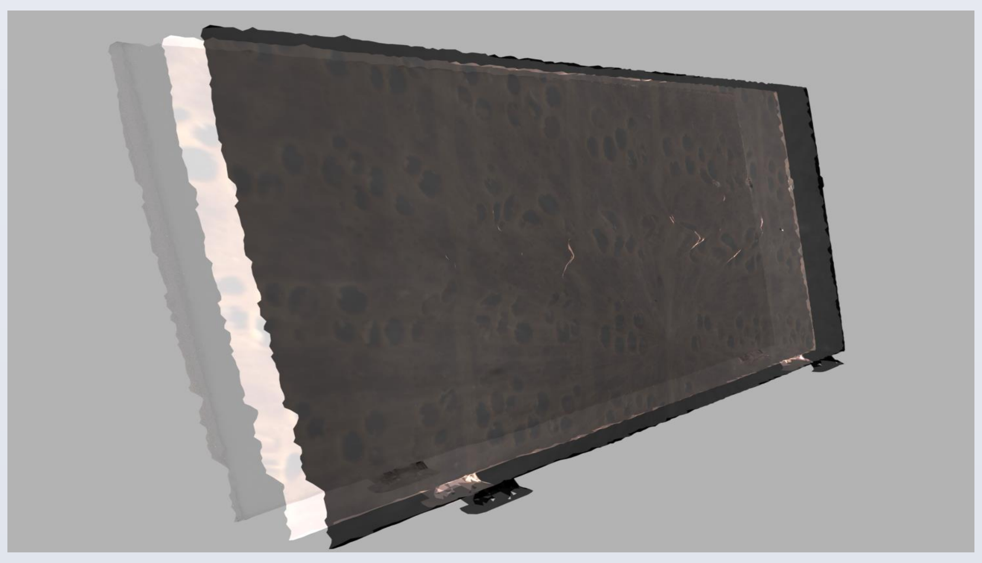
Figure 1: (a) low resolution, (b) low resolution with diffuse texture, (c) high res using normal maps an (d) incorporating RTI data.

We adapt S-buffer [VF12] to obtain a multifragment renderer for visualizing multiple layers of materials and of their properties and sensor data. Multiple layers are produced using either offsets of the original object or displacement maps. The layers are then rendered using a variation of the original alpha blending order independent transparency algorithm. For each pixel all fragments are stored and sorted by their depth. Then only the k nearest fragments that belong to alternating layers (from layer 1 through layer k) are rendered. The k nearest fragments correspond to the k material layers rendered by our visualization tool. The renderer works as follows. First, the user determines two parameters: the number of highlighted layers d,$d \le k$ and a parameter $0 \le v_\alpha \le 1$ that specifies how visible the non highlighted layers will be. When $v_\alpha = 1$ only the highlighted layers are visible, when $v_\alpha = 0$ only the non highlighted layers are visible. The rgb color *col.rgb* of each pixel is a weighted sum of the color of the fragments f_i of each layer as follows:

$$col.rgb = \sum_{i=1}^{k} col(f_i).\alpha * col(f_i).rgb$$

where $col(f_i).\alpha = \begin{cases} \frac{1}{d} v_\alpha, & if \quad f_i \text{ is highlighted} \\ \frac{1}{k-d}(1 - v_\alpha), & if \quad f_i \text{ is not highlighted} \end{cases}$

The result with 3 layers with the middle layer highlighted is illustrated below:



Conclusions

We have reported on the design and development of a multifragment rendering visualization tool for browsing, analyzing and combining several sets of sensor data for representing material aging.

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References

[FVG15] FRERICHS D., VIDLER A., GATZIDIS C.: A survey on object deformation and decomposition in computer graphics. Comput. Graph. 52, C (Nov. 2015), 18–32. URL: http://dx.doi. org/10.1016/j.cag.2015.06.004, doi:10.1016/j.cag. 2015.06.004. 1

[Kid12] KIDER JR. J. T.: Simulation of Three-dimensional Model, Shape, and Appearance Aging by Physical, Chemical, Biological, Environmental, and Weathering Effects. PhD thesis, Philadelphia, PA, USA, 2012. AAI3542821. 1

[MG08] MÉRILLOU S., GHAZANFARPOUR D.: Technical section: A survey of aging and weathering phenomena in computer graphics. Comput. Graph. 32, 2 (Apr. 2008), 159–174. URL: http://dx.doi. org/10.1016/j.cag.2008.01.003, doi:10.1016/j.cag. 2008.01.003. 1

[Rus09] RUSHMEIER H.: Computer graphics techniques for capturing and rendering the appearance of aging materials, 01 2009. 1

[VF12] VASILAKIS A., FUDOS I.: S-buffer: Sparsity-aware multifragment rendering. In Eurographics (Short Papers) (2012), pp. 101– 104. 2

[VF13] VASILAKIS A.-A., FUDOS I.: Depth-fighting aware methods for multifragment rendering. IEEE Trans. Vis. Comput. Graph. 19, 6 (2013), 967–977. 2