Watercolor Illustrations of CAD Data

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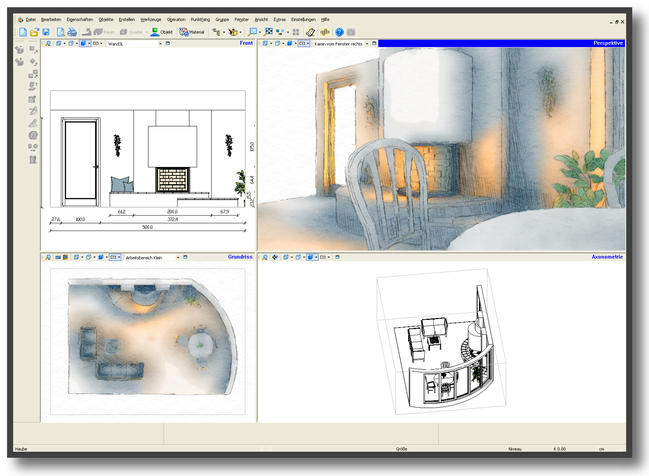
Introduction



An important step for non-photorealistic rendering is the application and integration into modeling and rendering systems to provide styles beyond traditional photorealistic rendering. A co-operation between the University of Konstanz and paletteCAD GmbH aims at this goal [Luft2008].

The basis is a CAD system that is specialized for designing furniture and infrastructure for private houses such as ovens and fireplaces. The target market for these individually designed products is a high-quality segment. In this market the product visualization is traditionally done by printing out CAD models and manually redrawing, coloring and beautifying them, a process that is quite expensive and depending on the artistic skills of the people in these companies.

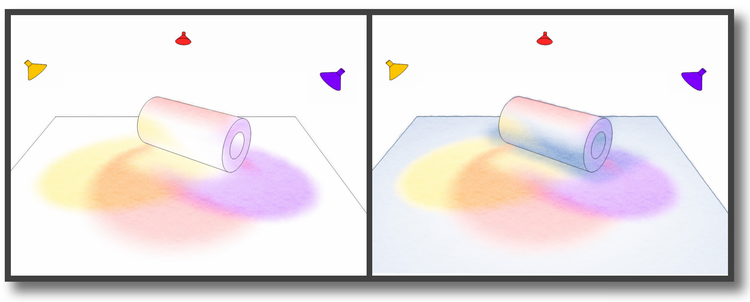
Our project integrates a non-photorealistic rendering pipeline into an existing CAD system in order to assist users by rendering aesthetically pleasing drawings directly from the CAD data. We reproduce a traditional watercolor style, whereby a sketchy line drawing is colorized with more or less abstract watercolor washes.

Tonal Shading

Artwork usually shows contrasts beyond a simple bright-to-dark shading: Harmonic or complementary color palettes are especially appealing to the human visual perception and thus, are often recognizable in paintings. Especially in watercolor paintings illumination effects are achieved by variations of tone and saturation. To provide such a methodology, our approach defines a tonal shading.

Hereby, the lighting is divided into tone and intensity. This separation allows us to obtain a shading, which solely collects the tone contribution of each light source without any darkening due to the lighting intensity. As an example, scene objects lit by a red light obtain a reddish tone, while a white light does not influence the scene objects' color at all.

The result of the tone-based lighting can be applied in many ways. For watercolor layers, it can be directly used as color input. To obtain more traditional color schemes such as a warm-to-cold shading, tone variations can be introduced by adding a secondary color, for example a dark blue weighted by the lighting intensity.



Tone-based lighting collects the tone of the light sources separately from the lighting intensity. It can serve as direct input for a color layer (left), or in combination with tone or saturation variations resembling traditional color contrast schemes (right).

Stylistic Means

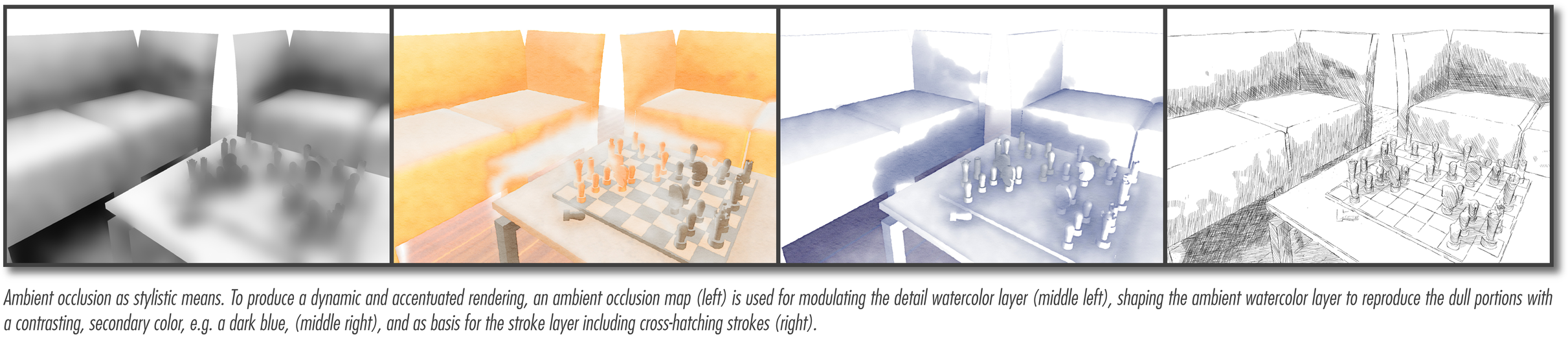
Artists achieve dynamic results through the application of stylistic means. Stylistic means appear very differently: They exist in form of abstractions of shape and shading, as a level-of-detail mechanism over different parts of the painting, or as indication of contours, shapes, and details.

To implement one form of stylistic means, we found ambient occlusion [Zhukov1998] as a suitable tool. Ambient occlusion is a simple technique to approximate global illumination in photorealistic rendering. By integrating the distances from a surface point to nearby occluders within that point's hemisphere, an approximation of the spatial density in world space is determined. This characteristic thus represents regions of particular spatial interest. We utilize this information to achieve an accentuated rendering. Hereby, ambient occlusion provides us a kind of visual level-of-detail to place local accents: Within our pipeline an ambient occlusion map is applied as a modulator and mask for the watercolor layers and as the basis for the cross hatching strokes.

Rendering

For the rendering of a watercolor wash, we combine existing techniques that already create a convincing reproduction of the visual elements of watercolor, such as pigment granulation, edge darkening, or the shape simplification due to a paint brush [Luft2006].

Our approach is mainly implemented using GPU shaders, which provide interactive rendering of the tonal lighting and the NPR style. Because of greater flexibility and simplicity, we simultaneously implemented a ray tracer for shadows and ambient occlusion. Hence, a complete rendering of a scene takes typically 20 to 40 seconds for 800 × 600 pixels, while style and color settings can be altered interactively at about 5 frames per second.



Ambient occlusion as stylistic means. To produce a dynamic and accentuated rendering, an ambient occlusion map (left) is used for modulating the detail watercolor layer (middle left), shaping the ambient watercolor layer to reproduce the dull portions with a contrasting, secondary color, e.g. a dark blue, (middle right), and as basis for the stroke layer including cross-hatching strokes (right).

[Luft2008]: LUFT, T., KOBS, F., ZINSER, W., AND DEUSSEN, O. 2008. Watercolor illustrations of cad data. In Proceedings of International Symposium on Computational Aesthetics in Graphics, Visualization, and Imaging. to appear.

[Luft2006]: LUFT, T., AND DEUSSEN, O. 2006. Real-time watercolor for animation. Journal of Computer Science and Technology 21, 2(mar), 159-165.

[Zhukov1998]: ZHUKOV S., INOES A., AND KRONIN G. 1998. An ambient light illumination model. In Eurographics workshop Rendering Techniques '98, 45–56.