Machine Vision: the Answer to the Optical Debate?

Antonio Criminisi

Microsoft Research Ltd., 7 J J Thomson Ave, Cambridge, CB3 0FB, United Kingdom

Abstract: Machine vision is a branch of artificial intelligence aimed at extracting useful information from images. Vision techniques have typically been applied to images acquired by cameras, but recent research efforts have seen novel algorithms work with paintings. Promising results have been obtained which cast a new light on the debate regarding the way traditional paintings were created. The author believes that only a careful scientific analysis of each painting can provide meaningful answers to the debate.
©2004 Optical Society of America

OCIS codes: (000.5920) Science and society; (000.2850) History and philosophy; (110.2960) Image Analysis

Answering questions like "Did the artist use optical tools while painting?" cannot be based on personal intuitions and/or superficial analyses such as quick line drawings and "eye-balling". Given the lack of corroboratory textual documentation, the only hope to give reasonably safe answers to the optical debate is by analyzing each painting in a rigorous and scientific manner. Recent research across computer vision and history of art [1,2,3] has paved the way to powerful new software tools for the digital analysis of paintings. Nevertheless, often not even the most powerful scientific investigation may yield conclusive results (*i.e.* the information is just not there). Thus, in order to obtain meaningful answers extreme care must be taken in interpreting the results of such investigation.

One widely used (and sometimes misused) geometrical technique checks the consistency of a picture's vanishing point(s). For instance, the fact that Jan van Eyck's "Arnolfini portrait" and "Madonna in Church" show inconsistent vanishing points for the direction orthogonal to the image plane was often thought to be sufficient proof that no optical tools were used. This is not necessarily true. In fact, the Hockney-Falco optical theory maintains that a painting might have been constructed by mirror-projecting a large scene on a support, patch by patch. The necessary movement of the mirror between patch-tracing episodes would have introduced imperceptible rotations in the mirror position thus causing large shifts in the location of the painting's vanishing points. In fact, vision literature teaches that vanishing points are extremely sensitive to the rotation of the projection device (*e.g.* camera or mirror). This example shows how an incomplete analysis may lead to weak or incorrect conclusions.

Similarly, interactive data manipulation such as manual image processing may yield misleading results if a rigorous approach is not applied. For example, in [4] the authors claim to have constructed a plan view of the Arnolfini chandelier and perspectively corrected its arms, but they fail to explain how exactly this 3D reconstruction was achieved (*e.g.* what assumptions were made? What geometric transformations were employed?). A photoshop-like image manipulation session would not leave much room for scientific rigor. In contrast, in [3] we registered pairs of chandelier's arms *to each other*, thus performing all computations *directly* on the picture plane. Rigorous and accurate estimation of rectifying geometric transformations (*planar homographies*) was employed and explained [1,3]. Measuring the incongruence in the different arms shapes and comparing the level of mis-registration with that found in photographs of similar existing chandeliers proved that the source of the geometric inaccuracy of the Arnolfini chandelier lies in the image formation process, rather than in the shape of the actual object. To set up an amazing optical device and then voluntarily settle for an imperfect painted geometry does not make much sense; thus, it is reasonable to conclude that optical devices were not used in painting the Arnolfini chandelier.

Nevertheless, there are cases of geometric imperfections which can be explained by a voluntary act of the artist. In [2], the analysis of the reflections of the mirror depicted in the "Arnolfini portrait" has highlighted some unexpected distortions in the shape of the portrayed windows. In this case, though, the geometric inaccuracies can only suggest that optical projections were not used, but provide no definite answer. In fact, it is entirely plausible that the artist wished to convey an enhanced perception of the bulge of the mirror, and achieved this by exaggerating the curvature of the reflected edges. In contrast, the geometry of the convex mirror in Robert Campin's "von Werl Triptych" was found to be extremely accurate; but is this information sufficient to conclude that the artist traced his painting? After all, talented artists can effectively render complex three-dimensional structures by eye [3].

In summary, while seeking answers to the question of how paintings were generated one must resist the temptation of jumping to sudden (though often exciting) conclusions. In many cases, only a careful scientific analysis supported by the guidance of expert art historians may lead to safe, conclusive answers. Computer vision and projective geometry may provide some of the basic tools to effectively tackle the problem at a scientific level.

References:
1. A. Criminisi, M. Kemp, A. Zisserman, "Bringing Pictorial Space to Life", CHArt yearbook 2003.
2. A. Criminisi, M. Kemp, S.B. Kang, "Reflections of Realities in Jan van Eyck and Robert Campin", Historical Methods 2004.
3. A. Criminisi, D.G. Stork, "Did the Great Masters use Optical Projections while Painting?", Proc. IEEE ICPR, Cambridge, 2004.
4. D. Hockney, C. Falco, "Optics at the Dawn of the Renaissance", Proc. Annual Meeting Optical Society of America, Tucson AZ 2003.