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# SCIENCE NEWS

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**Crystal Tiling**

# The Reflective Vision

*A highly advanced design tool developed at the General Motors Research Laboratories uses computers to generate visual images from mathematical data with such accuracy that, soon, in-depth aesthetic evaluations of new concepts may be made prior to creating a costly physical model.*

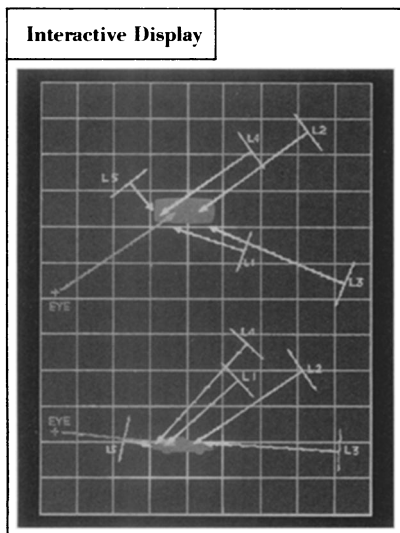
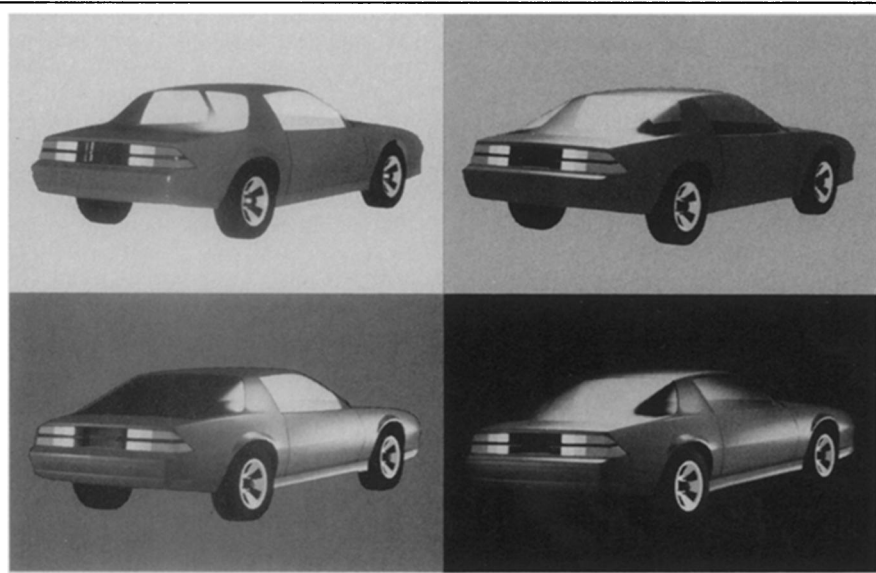


Figure 1: Computer display of plan view (upper) and side elevation (lower), indicating automobile location, lighting selections (L1-L5), and viewing position (EYE).

Figure 2: Four Autocolor images, showing the same view of an automobile as background and lighting change.



WITH AUTOCOLOR, users can synthesize three-dimensional, shaded images of design concepts on a color display and then quickly explore how major or minor changes affect the overall aesthetic impression. The system is completely interactive. By choosing from a menu on the screen, the designer can redefine display parameters, select a viewing orientation, or mix a color. Each part of an object can be assigned a surface type with associated color and reflectance properties. Built-in lighting controls generate realistic "highlights" on simulated surfaces composed of differing materials.

Before developing the system, David Warn, a computer scientist at the General Motors Research Laboratories, observed the complex lighting effects achieved in the studio of a professional photographer.

By simulating these effects, Autocolor can produce results unattainable by conventional synthetic image display systems. Previous systems used a point source model of light, which allows adjustments only in position and brightness.

The versatility of the lighting controls constitutes a major advance in Autocolor. An unlimited number of light sources can be independently aimed at an object and the light concentration adjusted to simulate spotlight and floodlight effects. The lighting model even includes the large flaps or "barndoors" found on studio lights. These comprehensive controls permit the user to view the simulation in studio lighting conditions, as well as to make revisions in color, paint type, and materials.

With real lights, direction and concentration are produced by reflectors, lenses, and housings. It would be possible to model these components directly, but that would introduce considerable overhead to the lighting computation. Instead of modeling individual causes, Autocolor models the overall effect, reducing complexity by simulating those aspects needed to produce realistic results.

Autocolor approximates the geometric shape of an object with a mesh of three or four-sided polygons. These polygons are grouped to form parts. For a car body, there might be separate parts for the door, hood, roof, fender, and so on. Each part is assigned a surface type, such as painted metal or glass, and each type of surface has associated color and reflectance properties. The

entire data structure is stored in tables using an interactive relational data base developed at the GM Research Laboratories.

**T**HE LIGHTING model determines the intensity of the reflected light that reaches the eye from a given point on the object. It takes into account the reflectance properties of the surface as well as the physics of light reflection. A hidden surface algorithm determines which point on the object is visible at each point on the display. For each of these visible points, the intensity is computed for each light source. The displayed intensity is the sum of the contributions from all the lights plus an ambient term which indicates the general level of illumination.

Using the point source lights of conventional image generation systems, highlighting a particular area of an object can be a difficult task and can result in unwanted highlights in other areas. By contrast, the light direction and concentration controls found in Autocolor make it possible to isolate the effect of a light to a particular area, and achieve a desired highlight easily and quickly (see Figure 2). This is not because Autocolor's lighting model computations are faster, but because its controlled "lights" behave in a more natural way.

Another unique feature of Autocolor is the ability to portray realistically a variety of different materials and lighting conditions.

The color seen from a surface is really a combination of two colors: the color of the surface or material itself (diffuse reflection) and the color of the reflected highlights (specular reflection). The highlight color may be the color of the material, the color of the light, or a color derived from the material and the light.

A different highlight color can be used for each different surface type that is defined. This makes it possible to simulate materials such as plastic, painted metal, and chrome—each of which has different reflectance properties and requires a different highlight color.

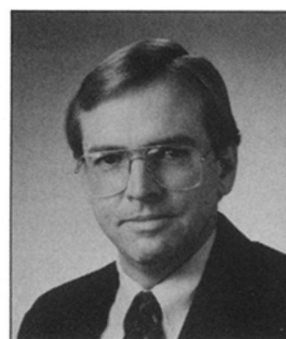
The user can interactively adjust the blending of the surface and highlight colors, watching the image change dynamically on the screen until a desired effect is achieved.

"Autocolor will free designers to be more creative," says researcher Warn. "Our goal is to move from controls that show changes in lighting, color, and materials, to software that will let the user change the actual shape, manipulating the image on the screen like a flexible clay model!"

**General Motors**



## THE MAN BEHIND THE WORK



David Warn is a Senior Staff Research Scientist in the Computer Science Department at the General Motors Research Laboratories.

He received his undergraduate degree in mathematics from Carnegie-Mellon University, and his M.S. in computer science from Purdue.

He has done extensive research in relational data management systems with special emphasis on user interfaces and human factors. He also designed the prototype for the network data manager used in the GM Corporate Graphic System. His previous work on other aspects of computer-aided design include system design, file management, and simulation models.

His foremost research interests are in color synthetic image generation and interactive surface design. He joined General Motors in 1968.