# Applications of Optical Illusions in Computer Graphics

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***Abstract***

*Pursuant to the purpose of developing the use of optical illusion in interactive graphical presentations, herein lies a brief summary of the current state of creation, manipulation, and use of optical illusions. Much is written on the cognitive basis of illusion, as understanding errors in perception can aid us in the understanding of the human brain itself. However, the purpose of this paper is not to explain how or why the brain misinterprets sensory input, but rather to describe methods for capitalizing on these errors in perception.*

## 1 Background:

At the most fundamental level, all computer graphics (CG) are an illusion. From the underlying motivation of the CG field, to the computational techniques used to present images to viewers, subtle use of illusion and trickery are the primary tools of a graphicist. I hope to show that less subtle use of optical illusion, specifically static illusions that result from errors in perception, can result in complex graphical effects at very cheap cost, in terms of overall processing power, minimum rendering hardware requirements, and in the context of handheld and embedded devices, power consumption.

The underlying motivation of computer generated imagery is to fool the viewer into believing they are seeing a scene that does not exist in reality. Point-like units of color comprise the component elements of a greater picture. These picture elements (pixels) converge to give the impression of an image that does not truly exist in the physical world. Because of this disconnect between reality and imagery, the CG developer has little motivation to use strictly accurate modeling. This becomes apparent when evaluating the various algorithms used for lighting and shading.

Through the application of lighting and shading algorithms, rendered geometry will appear much more detailed than its modeled representation. With the use of Gouraud Shading [Gouraud 1971], cubes may be rendered to appear round. With the use of Phong Lighting and Shading [Phong 1975], a two dimensional disk can be mistaken for a perfectly round sphere. Bump Mapping [Blinn 1978] (and the more detailed Normal Mapping), define complex surface geometry that is never rendered, only being used to calculate shadows for painting on relatively simple structures.

With an appropriate application of optical illusions, it may be possible to create effects that are either impossible given the medium or where the price of accurate modeling is not justifiable. For example, the current convention for displaying motion in a static image is the use of arrow icons pointing in the direction of motion. This does not actually give a sense of motion and also creates clutter. Conceivably, an illusion could be used to give the actually perception of motion [Freeman, Adelson, Heeger 1991].

## 1.1 Types of illusions:

There are many different types of illusions, some more subtle than others.

### 1.1.1 Illusions in Perceived Geometry:

Through the use of lighting and shading algorithms [Gouraud 1971][Phong 1975][Blinn 1978], objects may appear to have a different shape than what is actually rendered.

### 1.1.2 Illusions in Perceived Motion:

Certain types of illusions will create the perception of motion [Freeman, Adelson, Heeger 1991][Kitaoka, Ashida 2003][Fermeuller, Pless, Aloimonos 1996]. My subsequent research will focus mainly on this area of illusion. With derivations of such illusions like the Primrose Field [Kitaoka 2002], it may be possible to give the illusion of waving water where no motion actually exists.

### 1.1.3 Illusions in Perceived Orientation:

Certain types of illusions will fool the viewer into misinterpreting the true location of objects [Yu, Choe 2004].

### 1.1.4 Illusions in Perceived Size:

Certain types of illusions will fool the view into misinterpreting the true size of an object[Christie 1975]. This has been used to great effect in film with movies such as "Attack of the 50 Foot Woman" and "Honey I Shrunk the Kids". More recently, it has been used in video games like "Thief: the Dark Project" [Eidos 1995], in which the player is given a choice of halls to traverse. One hall is real and ends in a door of normal height, while the other uses forced perspective to trick the player into seeing a hall that ends in a 1 foot tall door as a normal hall, reminiscent of "Alice in Wonderland".

### 1.1.5 Illusions in Perceived Color

The computer display itself is representative of an illusion in color perception. Each pixel is a combination of three phosphorescent elements that, when struck by electrons, individually emit light of red, green, or blue wavelengths. When the viewer maintains adequate distance from the display, the colors converge and create a continuous spectrum of color.

### 1.1.6 Illusions in Perceived Passage of Time

Animation is also a fundamental illusion. Each frame of a computer generated animation represents a discrete, point-like moment in time. This is impossible to achieve using physical medium, such a moment in time is infinitesimally small and therefore impossible to capture. By displaying images at a rapid rate, these discrete moments in time converge and are perceived as a continuous flow of time.

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