The following is the first part of a two part article (the second to appear next month), on the past, present and possible future of 3-D in the movies by freelancer John Bertram.

This month Bertram examines perception of real third dimensionality, the three-dimensional illusion of 'flat' cinema, and the history of attempts to provide real 3-D images. Included are an examination of the psychology of dimensional perception, and a regard for the artistic merits of attempting serious production in this medium.

film and the third dimension (part 1)

by John Bertram

Every so often, it seems, 3-D movies are rediscovered, reborn, and revitalized. They make a comeback. And then, once again, they fade away. It now appears that another re-emergence of 3-D is in the wind. (And holographic movies are "Just Around The Corner!" – Oh that proverbial corner.)

Why is it that 3-D motion pictures have gone through this cycle of disappearance and reappearance?

Proponents of 3-D cinema believe this to be an indicator of the importance and validity of depth in film – the fact that it has lasted in the face of so many technical difficulties. Its detractors argue that this merely reveals the shallow nature of 3-D cinema – that it has little more to offer than novelty value for a new generation.

This article attempts to bring together the many aspects of film's strained relationship with depth, its past and possible future, both from historical and aesthetic viewpoints.

But first, some background information on the third dimension itself will be helpful:

The Perception of Visual Depth

How we perceive our three dimensional world as such has long been an area of inquiry. Over the years researchers into this field have drawn up a list of "cues" – information from our environment of which we make use in our perception of space. These include:

1) **Familiar Size:** A person's prior knowledge or experience, sometimes tactile, of the objects being viewed weighed against the size of the image they are producing on the retina.

2) **Discontinuity of Texture:** The progressive loss of detail as the viewer-to-object distance increases.

3) **Linear Perspective:** The "convergence" of parallel lines.

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4) **Motion Parallax:** The fact that as the viewer changes his position, objects between him and his point of fixation appear to move in the opposite direction. The rate at which this motion takes place is determined by the ratio of the background-to-object distance to the object-to-viewer distance: the closer the object is to the viewer and the further it is away from the background, the greater will be its motion parallax. This is why from a moving train the horizon appears to be moving slower than the nearby trees.

5) **Good Gestalt:** The overlap of far objects by nearer ones, and our desire for continuous edges and simple closed figures.

6) **Accomodation:** The change in the shape of the eyes' lenses in order to bring an object into sharp focus. A weak cue, particularly in bright light situations where the smaller pupils give increased depth of field.

7) **Binocular Disparity:** The seemingly obvious fact that the horizontal displacement of our eyes causes us to see everything in the world from two different angles.

8) **Convergence:** The coming together of the eyes at the proper angle in order that the two images may be fused more easily. Not a very strong cue on its own, like accomodation its purpose is basically to facilitate the production of stereopsis through binocular disparity.

9) **Doubling:** The inevitable result of binocular disparity: everything except for our point of fixation is seen double. We are not usually aware of this fact however, as our mind tends to suppress one of the images. The doubling naturally increases the further away an object is from the point of fixation.

10) **Peripheral Vision:** The rather large fringe areas that we never see clearly but which give us the sense of wrap around vision and really being *in* the space. As a depth cue it often works in conjunction with linear perspective and motion parallax, an example of this being walking down a long hall where the exit sign is not growing appreciably larger but where the almost subconscious sensation of the walls moving by on either side gives a strong feeling of depth.

Psychologists studying perception often disagreed on the relative importance of these depth cues. For many years a widely held belief was that it was largely through monocular cues, such as the first five on the above list, that visual space was perceived. Thus the perception of depth was considered a learned process. Some went so far as to say that space was a non-visual idea, that we see a constantly changing two dimensional world into which we infer depth.

Recent experiments have tended to disprove this. They have shown 1) that stereopsis is innate, 2) that it can be produced through binocular disparity alone, and 3) that it takes place in our minds even prior to form recognition.

(These experiments were conducted in the 1960's largely by Bela Julesz, using a technique of computer-generated random-dot stereograms. When normally viewed these appear to be meaningless aggregates of randomly arranged dots. When fused stereoscopically however, forms such as circles and triangles appear in vivid depth against the background. These forms are quite unrecognizable until the pictures are viewed stereoscopically. Even six-day-old babies fixed their attention on a bar presented in depth through a random-dot stereogram, when otherwise their eye movements occurred at random.)

In discussing the evolutionary significance of stereoscopic vision, Mr. Julesz writes in his book **Foundations of Cyclopean Perception:** "Originally binocular vision served to provide panoramic vision by evaluating the two separate views that were cast on the retinae, which point sideways. ... For animals that capture food with their heads monocular parallax led to satisfactory depth evaluation.

"The recession of a protruding snout or beak in some animals who capture food by paws, hands, or pouncing, with the accompanying complex vergence movements of the eyes permitted a course registration between the two monocular fields. A finer registration between overlapping areas of correspondence was achieved by a neural mechanism that evolved and yielded a new sensation of stereoscopic depth. The advantages of stereoscopic depth perception probably outweighed the loss of panoramic vision for most animals. Indeed, with stereopsis, spatial localization of objects is perceived vividly as an independent sensation (similar to the sensation of color and brightness), and as such, helps to form an internal model of the outside world."

Depth in Two Dimensions

Conventional 2-D films, as do all pictorial representations, use monocular depth cues such as familiar size, discontinuity of texture, linear perspective, motion parallax, and "good gestalt", to suggest the spatial relationships between the objects being depicted. If the filmmaker wishes to emphasize these relationships he may, for example, use an oblique camera angle to intensify linear perspective. Orson Welles' **Citizen Kane** (1940) has many scenes in which deep focus and marked contrasts between background and foreground give a strong sense of depth to a two dimensional image. Perhaps the more recent vogue for shallow focus and rack shots is an attempt to simulate the depth cue of accomodation.

The furthest that 2-D cinema went in attempting to appear three dimensional was with the wide screen, and variations thereof.

The human visual field is roughly 3:1 horizontal to vertical. As screens approached these dimensions and became curved the depth cue of peripheral vision became paramount. The first "Cinerama" films in the early fifties used a three-camera synchronized set up. This system was soon replaced by one using special anamorphic lenses, one on the camera to "squeeze" the image into normal frame dimensions and one on the projector to "stretch" the picture back out to its proper wide screen width.

The ultimate extension of the synchronized camera system came in special films produced for world's fairs, such as Expo '67, in which some nine cameras would photograph 360 degrees of action. The pictures were then shown, by synchronized projectors, on curved screens which completely encircled the viewer. The wrap-around peripheral vision thus produced imparted a powerful feeling of depth, particularly in moving sequences (which inevitably resulted in the exclamation "Ooooooooo!").

The ultimate extension of the special lens system was one in which all the pictures were taken through a "fish eye" lens, and subsequently projected up onto a dome-shaped screen, much the same as those found in planetarium theaters. The result was not only to give peripheral vision horizontally, but omnidirectionally. (I viewed such a film at the Canadian National Exhibition in 1972, and it too produced its share of "Oooooo!"s.)

It is known that people with only one eye are able to develop a very good sense of depth perception by learning to rely entirely on monocular cues. With this in mind I have viewed portions of conventional films while covering one eye, and was intrigued to get a strange sense of depth, especially from those shots which made the greatest use of monocular cues such as linear perspective and motion parallax. (Upon uncovering the other eye, after watching the film monocularly for several minutes, the picture seemed disconcertingly flat. In reality, of course, the audience and the viewing room had taken on an extra dimension while the picture had remained unchanged.) This sort of false depth would probably be much greater with the addition of peripheral vision from a large, curved screen. With this in mind, perhaps the attendants at Ontario Place should hand out eye patches to patrons entering the "Cinesphere"!

No matter how hard 2-D cinema attempts to suggest depth, however, it is always using basically monocular cues. The fact that each image is seen from only one angle by definition negates the possibility of stereopsis, which appears to be the single most important depth indicator.

Stereo Images

In the sense that we see everything in the world from two different points of view, the single lens of a camera is giving us only "half the picture". This idea is not new, in fact stereo cameras have existed almost as long as photography itself.

The first double lensed stereo cameras appeared in the 1840's. They had a single shutter and produced a pair of images on one photographic plate. Each image roughly corresponded to what each eye of an observer might see. Thus the crucial element in viewing these photographs was to have the left eye see only the left image and the right eye see only the right image.

This was accomplished by means of an ingenious little device called the stereoscope. It was basically a hand held wooden frame with a bar at one end onto which the stereo view card was placed. A person would then look at the images through a pair of lenses mounted on the other end of the viewer. These lenses redirected the line of sight for each eye allowing it to see only one image. Proper binocular disparity thus assured, stereopsis was easily obtainable. Stereoscopes and stereo view cards achieved tremendous popularity; in the latter 19th century "no parlour was without them". So mass produced were the view cards that today only the rarest are of any significant value.

The production of moving stereo images posed new problems. Firstly, either special double lensed cameras had to be devised to produce a pair of images on each frame of film or two cameras had to be precisely synchronized. Similar projection systems were also necessary. But beyond keeping the two pictures synchronized the big problem was, and still is, how to have each eye see only one image – moving pictures after all had to be projected on a screen and viewed by many people simultaneously.

Not surprisingly the first suggestion was simply an extension of the well-established stereoscope: project the two images side by side and give each member of the audience a hand held viewer through which the pictures could be fused stereoscopically. This idea proved too impractical to ever get past the experimental stage.

In the 1920's an elaborate system called "Teleview" was introduced. It involved projecting the left and right images alternately on the same screen. This "blurred" double image was then viewed through a special mechanical device with a rotating shutter precisely synchronized to the projector. It alternately allowed the left and right eyes to see their designated left – and right – view frames. The obvious practical limitations of this system resulted in its quick demise.

In the forties and fifties Russian filmmakers experimented with a lenticular 3-D system. It was based on the same theory as were those 3-D post cards which enjoyed a vogue in the late sixties. The two images were projected at precise angles from two separate, synchronized projectors onto a screen composed of thousands of vertical "ridges". The reflected picture was thus composed of the left and right images slit into tiny lines and interwoven to form one composite picture. But owing to the ridged nature of the screen the left eye saw more of the left image and the right eye more of the right image. Although it did not require any viewers or glasses, the lenticular system had several limitations: the screens were costly and difficult to produce, projection was awkward and demanded great precision, and the 3-D effect could be appreciated only in limited "viewing zones" within the theater, and even then only with the head held vertically. After producing several films with this process, it appears that the Russians have abandoned lenticular 3-D.

The two stereoscopic film systems to survive are: 1) Anaglyphic, and 2) Polarized.

The first method used red and green coloured filters. Either the left-view image was projected through a red filter and the right-view image through a green filter, or both filtered images could be printed onto one film and projected normally. Each member of the audience was then given an inexpensive pair of cardboard viewing glasses, with red plastic for the left eye and green plastic for the right eye. If the film was viewed looking through these glasses, the red plastic would permit the left eye to see the red-filtered left image, but would absorb the green-filtered right image. Likewise, the green plastic would permit the right eye to see the green-filtered right image, but would absorb the red-filtered left image. Thus we have each eye seeing each shot from a different angle, binocular disparity producing stereopsis, and voilà: 3-D movies. A significant drawback to this system is the fact that these movies are necessarily limited to a washed-out, black and white image, as the filters would drain away virtually any colour that was present.

The anaglyph 3-D method existed even prior to the 1920's. In 1925 the great French filmmaker Abel Gance produced an anaglyphic 3-D sequence for his classic **Napoleon.** Unfortunately it was never included in the finished film.

In the 1940's a new system was developed using polarized materials. In this case the left and right images were projected through polarizing filters oriented at right angles to each other. The audience wore special glasses in which the alignment of the polarized lenses corresponded to the filters on the projectors. Once again stereopsis could be obtained by virtue of the fact that each eye was permitted to see only its designated image, the other image being blocked out by the axis of the polarized lens. Though this method produced full colour 3-D movies, it required more elaborate projection facilities plus special metallic screens that would not disrupt the axis of polarization.

In 1953 and early '54, 3-D movies achieved a sudden but short-lived popularity. (Alfred Hitchcock's **Dial M for Murder** was originally shot in 3-D. Walt Disney produced animated 3-D cartoons. Almost every major studio produced a few 3-D features.) Even today the odd 3-D movie will make a fleeting appearance in one of the less prestigious film houses. But why they failed to really last is hard to say. Added production costs? Probably not – the wide screen format was introduced at roughly the same time, and surely it was as costly. Perhaps the technology involved proved too cumbersome for most theatres. Some would speculate that for the audience the wearing of special glasses was psychologically somehow too great a hindrance in the viewing of a film. Others counter that people readily adjusted to wearing glasses but that improper projection and misalignment of early 3-D films resulted in eye strain.

For whatever reason, the first 3-D movies never really got beyond the fad stage; consequently few serious filmmakers attempted to explore their possibilities. It appears then that while 3-D movies exist, 3-D cinema is yet to be invented.

(to be continued next month)

Next month, Bertram investigates the basics of the next generation of 3-D cinema, the laser-generated hologram. He explains how it works, and compares it to the earlier methods of 3-D production before going into its limitations and discussing some of the concepts involved in "movies without a screen". He will also discuss many of the pitfalls of thinking about the future possibilities of 3-D.