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## Applications of monocular depth cues

### Abstract

10 We focus our discussion on the application of monocular depth cues in movies, computer graphics and drawings in instruction manuals.

### Example 1: Depth cues in motion pictures

15 Traditional film is a two dimensional medium, yet we are able to perceive depth in movies. This can be explained by monocular depth cues. Ware groups these cues into static and dynamic monocular depth cues. Static cues can be extracted from a still image; dynamic cues require motion [R1].

20 In a previous essay we discussed some of these cues in a modern movie [R3]. In this section we want to examine depth cues used in one of the first motion pictures: the Lumière brother's "L'Arrivée d'un train à La Ciotat" from 1896. For the 50 seconds long clip Auguste and Louis Lumière used a static motion picture camera. It filmed a train appearing at the horizon and arriving at a railway station in the foreground. As one of the first public movies it was seen by excited thousands [R2]. It has been reported that  
25 the audience screamed and moved to the back of the theater due to the realistic appearance of the train on the screen, however this has been doubted by some experts [R4].

30 For the shot, the camera was placed closely to the railway tracks. The platform and tracks form strong diagonals reaching into the distance. Ware refers to this as 'linear perspective' [R1]; the motion picture community uses the term 'depth of field' [R2].

35 Mountains in the background appear hazy and un-sharp and are therefore interpreted as further away from the viewer. Ware refers to this as 'depth of focus' [R1], Cutting talks about 'aerial perspective' [R2].

Rather than a moving camera on a dolly [R2], the object (train) moves towards the viewer increasing in relative size (Ware: 'size gradient' [R1]).

40 One particularly interesting use of a depth cue is the reflection of the surrounding buildings off the polished, metallic surface on the train. 'Motion parallax' [R1] or motion perspective [R2] describes the velocity gradient of distant objects moving slower than close objects. In this example the reflection moves slower and inverse in direction depicting buildings further away and behind the viewer.  
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**Figure 1: Linear perspective, depth of focus and motion parallax depth cues in an early motion picture (1986)**

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**Example 2: Depth cues in three-dimensional renderings for two dimensional display**

Modern computer graphics enable real-time rendering of three dimensional structures for two dimensional displays. Common applications include video games, visual effects for movies and navigation. In addition to the depth cues discussed in the previous example the use of lighting and shadows [R5] and occlusion [R1] provide orientation in space. In the example of Google Earth, objects are rendered dynamically using a global illumination scheme depending on the ‘camera position’ which can be adjusted by the user.

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**Figure 2: Shadows and lighting and occlusion as depth cues in a rendering of San Francisco using Google Earth**

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**Example 3: Limited used of depth cues: Lego assembly instructions**

Lastly, an example to demonstrate that objects in space can be effectively displayed using very limited depth cues. I recently re-visited Lego block assembly instructions [R6] in light of perception, only to find that the designers make use of only two monocular depth cues: ‘linear perspective’ and ‘occlusion’ [R1] discussed in the literature. This seems in line with Cutting’s emphasis of occlusion as a depth cue in movies: “Occlusion is unavoidable [...] so we take it for granted. We should not.” [R2].

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75 **Conclusion**

Monocular depth cues are a powerful tool in many applications. We demonstrated their use in movies, computer graphics and instruction manuals. Some of the most obvious depth cues, such as occlusion and linear perspective, appear to be some of the most powerful ones.

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## References

- 85 [R1] Ware. "Information Visualization." Chapter 8.
- [R2] Cutting. "Perceiving Scenes in Film and in the World."
- [R3] Edmonton. "Perceptual mechanisms in movies." Psych 579, 9.2
- 90 [R4] Loiperdinger. "Lumiere's Arrival of the Train: Cinema's Founding Myth."
- [R5] Debevic. "Image-based lighting"
- [R6] Lego assembly instructions. <http://www.lego.com>