A Measure of Psychological Realism on a Visual Simulator

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Theme

A FUNDAMENTAL question of simulation technology is how to determine if an aircraft simulation is creating the proper psychological space necessary to assess manned-system performance.[1] The standard approach to this problem for visual simulators is to measure how well pilots can make approaches and landings on the simulator. Experiments of this type[2,3] generally show that simulator performance is worse than actual landing performance and that there is an excessive amount of training required to reach acceptable performance. Unfortunately, in these experiments it is difficult to sort out the inadequacies of the visual subsystem from possible inadequacies in other simulator subsystems, such as the motion subsystem. This synoptic presents the results from one of a series of five experiments[4] which attempted to provide direct measures of the psychological realism on a computer graphics night visual flight attachment. These experiments used experimental procedures and methodologies that psychologists have developed in their attempts to determine how people perceived visual space in the real world.

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In a typical visual-space perception experiment involving size estimation, subjects adjust the height of a near object so that it appears to be the same physical height as a distant object. If the experiment is done with full visual cues available, subjects are able to make very accurate matches, even when the object is up to a mile away.[5,6] This is called size constancy. The apparent physical sizes of the near and far objects remain constant even though the angular or image size of the far object is halved whenever its distance is doubled. Further, as the visual cues to depth are reduced (monocular viewing or reduced background), subjects tend to adjust the near object so that the angular sizes rather than the physical sizes of near and far objects are equal.[7] Angular-size matches have been obtained by viewing with one eye through a reduction tube which eliminated all background texture. In fact, Gilinsky[6] showed that, if subjects were asked to compare the angular sizes of near and far objects in a naturalistic setting, they made large systematic errors. The angular size of the far object almost always was overestimated. The angular judgments were biased in the direction of size constancy. These large biases were present in spite of the fact that the subjects stated that the angular-size judgments were much easier to make than the physical-size judgments, and they were also more confident that they were correct when making the angular-size judgments.

In the present experiment, pilot subjects made angular-size judgments of triangular stimuli generated on a computer graphics night visual attachment. The computer graphics system was programmed to display a static monochrome perspective view of a runway and background city as seen from an eye height of 5 m and a distance of 300 m from the runway threshold (Fig. 1). The subjects were randomly assigned to one of three viewing conditions: 1) the runway seen directly on a CRT monitor with no collimating lens, 2) the runway seen through a collimating lens, and 3) the runway with 10-m vertical poles spaced 100 m apart along each side of the runway, seen through a collimating lens. The collimated and uncollimated conditions were chosen because, although pilot opinion strongly favors the collimated display as being more realistic, it is difficult to measure any difference between these displays by standard measures. The 10-m-pole condition was chosen to determine whether additional height information influenced visual space perception.

The pilots' task was to adjust a variable-size triangle by means of a joystick so that it appeared to equal a standard-size triangle in angular size. The subjects were instructed: "Imagine that the view you see is a scene in a picture or photograph. Every image in the picture is fixed in size. If you were to cut out the fixed image of the standard triangle and paste it on the image of the variable triangle, would the two images be the same? Set the variable triangle so that its cutout image would be exactly the same size as the image of the standard triangle." The variable triangle was always 50 m from the pilot on the left side of the runway. The standard triangle was presented twice at the following eight different distances from the pilot: 50 m, 75.0 m, 112.5 m, 168.8 m, 253.1 m, 379.7 m, 569.5 m, and 859.3 m. The order of presentation of the distances was chosen randomly. The distance from the center of the base of each triangle to the centerline was a uniform random variable between 2 and 6 m. The actual height of the standard triangle was a uniform random variable between 2 and 4 m. This task was designed to be as similar as possible to Gilinsky's angular-size match condition.

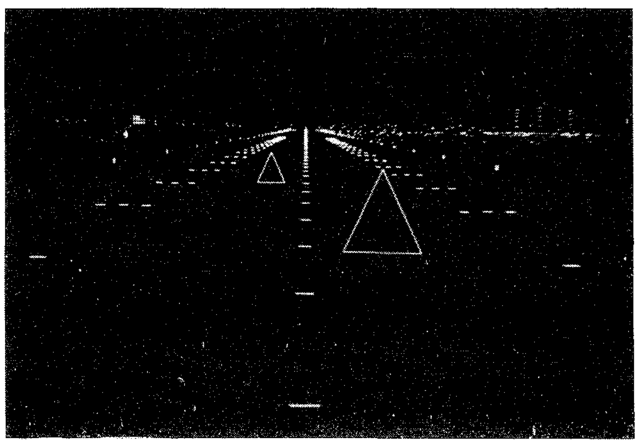

Fig. 1 Pilot's view of the computer graphics night visual attachment for the angular-size judgment task. (In the experiment, only one of the triangles could be seen at a time.)

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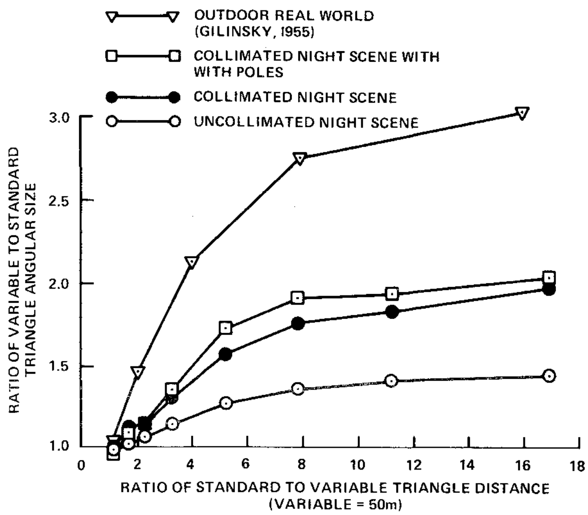

Fig. 2 Perceived angular size as a function of distance. ($N=5$ subjects per viewing condition.)

The subject indicated satisfaction with his judgments by pushing a red button on top of the joystick. The subject could view the standard and variable triangles as often or as long as he wished, and he could readjust the variable as many times as he wished before finalizing the judgments by pressing the red button. The standard could be seen only by pushing the joystick to the left. This caused the variable to disappear, and after a 0.5-sec delay, the standard appeared. Centering the joystick caused the standard to disappear, and after another 0.5-sec delay, the variable appeared.

The computer graphics display was drawn on a 53-cm (21-in.) cathode ray tube (CRT). When no collimating lens was made, the CRT was located 55 cm from the pilot's eye (1.8 diopters). The collimating lens increased the image distance of the entire scene to 10.0 m (0.1 diopter). For all conditions the horizontal and vertical field of view was 28°, and the magnification was unity. The experiment was a between-subjects design with five paid airline pilot subjects assigned to each of the three viewing conditions.

The angular-size judgment results from this and Gilinsky's experiments are plotted in Fig. 2. It can be seen from the graphs that the four curves for perceived angular size as a function of distance are similar. Gilinsky's outdoor data reveal the typical overestimation of angular size by a factor of 3 at long ranges. The "poles" condition shows a smaller overestimation factor, the "collimated" condition a slightly smaller one yet, and the "uncollimated" condition showing the smallest degree of overestimation. It can be seen from Fig. 2 that the perceived angular size of the standard triangle increased as a function of the distance of the standard triangle. When the standard triangle was more than 8 times farther away from the observer than the variable triangle, the standard triangle was perceived as being from 1.25 to 3 times its actual angular size. Outdoors, perceived angular size was about 3 times the actual angular size at these distances. With a collimating lens (whether or not there were runway poles) in the simulator, perceived angular size was about 2 times the actual angular size. With the plain, uncollimated simulator scene, the overestimation factor was about 1.25.

The overall means for each viewing condition were compared to one another and to the value of 1.00 which would indicate that perceived angular size would be exactly equal to true angular size. The differences between the uncollimated condition and each of the two other conditions were significant, whereas the difference between the collimated and poles conditions was not significant. These results suggest that the two collimated conditions were more realistic than the uncollimated condition because, somewhat ironically, the former induced more overestimation of the angular sizes of objects than the latter. The greater overestimation is said to be more realistic because it more closely resembles the relationship found by Gilinsky which describes perceptual reality for outdoor viewing. The uncollimated scene provided perceptions which were closer to objective reality and were therefore actually more distorted than the perceptions provided by the other scenes.

Gilinsky's results and those from the present study reveal that angular size overestimations increase with the logarithm of distance. The slope of the curves for perceived angular size as a function of log D can be used as a numerical measure of the realism of each viewing condition. On a 100-point linear scale with outdoor viewing equal to 100, these indices would be as follows: collimated simulator viewing with poles = 34, collimated simulator viewing without poles = 32, and uncollimated simulator viewing = 15. These figures indicate that the collimated scene, although more realistic than the uncollimated one, still differed by a wide margin from the real, outdoor world.

Two general conclusions can be drawn from these results. First, collimating lenses contribute to the realism of the simulator viscual scene when compared to direct viewing of a CRT display. Second, the discriminative power of this type of experiment is a useful measure for assessing the effects of hardware components and visual conditions on simulator realism.

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