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24. A Proposal for Pre-Processing, Reduction, and Selection of Visual Information in Airborne Flight Simulation

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Every pilot who has flown on instruments knows the difficulty of learning to translate a number of indicators into a mental image to provide him with the feeling of the attitude, level, and orientation of his aircraft. Even the most intimate familiarity with the cockpit instruments does not lend to the pilot the flight sensation which he knows from the familiar references of the horizon, the earth surface, and the sky.

With the increasing level of aircraft complexity numerous technical sensors have been developed to assist human perception, e.g., radar altimeters, interial platforms, etc. The information picked up by these sensors is presently in most cases still displayed on single independent instruments. In critical situations, however, the pilot is overstrained by observing the wide variity of instruments. The time he has availableto read all instruments relevant to a specific flight situation, frequently is not sufficient for reactions adequate to critical phases of the flight. Furthermore the pilot is known to read preferably only those display parameters which he subjectively selects as important parameters. Thus he becomes a limiting factor for the efficiency and safety of modern man-machine systems.

Integrated displays comprise on a single screen information, which formerly has been obtained by checking a variety of different instruments. The introduction of flexible electronic displays made possible, on the one hand the technical verification of integrated flight displays, and on the other hand the presentation of complex image information.

This development resulted in the need for the selection of the most suitable data to be presented to the pilot in order to facilitate the interpretation of flight situations and to optimize the decision process with regard to the displayed information.

This paper will give a contribution to the solution of this fundamental problem.

For the purpose of onboard visual simulation the image contents of the out-of-the-window scene are to be simulated by technical means. The purpose is to produce artificially as a stimulus field on the eye retina a nearly true image of the heterogeneous textured outside world, in order to obtain a realistic impression of the simulated out-of-the-window scene.

The entire scope of practically relevant complex situations could be covered by the so called "textured" visual flight simulation. This assumes an image generator of very high optical fidelity which, till date is not to be realized technically.

In order to overcome this difficulty, the necessary information contents of the image can be reduced by means of a critical analysis of the information contents of the real world scene. This image analysis and the information reduction derived from this are essentially based on psychological rules and lead to flight scenes of characteristically modified, so-called "stylized" image contents: Coarse structures of the scene remain almost unchanged, while fine structures are simplified or modified. The described procedure, i.e., simulate an artificial out-of-the-window scene by considering the special image contents, is referred to as "stylized visual flight simulation." This method of visual simulation forms an alternative to the textured visual flight simulation mentioned earlier, which processes arbitrary empirical image contents without critical modification.

There are two tasks remaining in regard to application of stylized visual flight simulation:

(1) Clarification as to the image stylization method. In this respect, primarily psychological aspects must be considered.

(2) Examination of technical means for generation of abstracted visual flight scenes.

At first, images are examined as to their subjective information content. Objective and subjective image contents are visual image information carriers. Objective image contents appear as colorimetrically measurable local color valence distributions. The subjective image contents constitute the essential object of the psychological perceptual process. With the perception of the out-of-the-window scene, certain image content elements prove to be of predominant importance for three-dimensional perception, so that these elements have to be reproduced with ahigh degree of fidelity in the stylized visual flight simulation. Other elements are of minor importance and may, therefore, be resorted to for the technically necessary reduction in information capacity by abstraction, without making this process a disturbing factor noticed by the pilot in the aircraft. The image content elements thus compiled and determined to be important constitute the psychological main components for the construction of stylized synthetic visual flight images.

Figure **1** illustrates the difference between the textured and the stylized visual simulation. Both methods aim to create an artificial replica of the outside visual scene. The direct approach via a noncritical empirical detail-by-detail transformation of the environmental information into the simulated image by purely physical methods characterizes the textured visual simulation, whose result would, ideally, be indiscernibly identical with the real scene.

The generation of a stylized image starts from an analysis of the original image contents with

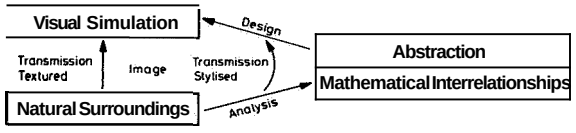

FIGURE 1.—Schematic illustration **of** the stylized visual flight simulation.

respect to mathematical, mainly statistical regularities and to possibilities of simplifying abstractions justified psychologically. The stylized image consequently is built up constructively from the analytical results.

The analysis is compiled by questioning and observation of reactions of test persons. Evaluation of respective statements would require a quantitative perceptual psychology. However, a quantitative psychology is nonexistent, neither is the mechanism of perception understood. However, a rough understanding of the perceptual process briefly described below is assumed to be achieved in perceptual psychology today.

The information acquired by man through his sensors is not processed as an entity by the brain; due to a preprocessing in the sensory areas only a very limited flow of information is fed to the brain. Although this model of the perceptual process is not quantitatively understood as yet, it may be used to justify the stylization of images.

With the knowledge of how preprocessing of visual information takes place such preprocessing, performed already during image generation, appears justified, which means that the eye receives already processed information and that the physiological preprocessing system becomes "unemployed."

Today, the central element of modern aircraft is the electronic computer, and it is the aim to accomplish also airborne visual simulation with computer systems. This requirement poses the question as to whether the information quantities provided by the flight scene can be processed by electronic means. This appears to be possible only with reduced image quality, i.e., image simplification or information quantity reduction, which provides for the desired technical feasibility since it seems quite possible to produce simplified visual flight images with electronic computers. In this case, however, the degree of realism must, at least, be so high that the objective information content is sufficient to supply the pilot with the subjective information required by him.

Therefore only those technical solutions appear usable, which start from a comprehensive description of the original image contents and comprise a subsequent abstraction. The best

applicational future aspects for generators of stylized images result from the selection of suitable flight missions. In these image generators the simplification still acceptable has to be balanced against the psychological and operational fidelity requirements for visual flight scenes.

Now the task remains to examine the technical possibilities for stylized visual simulation. The process of visual flight simulation consists of four subprocesses (ref. **1)** :

image storage→readout→image transformation -+display

The image storage contains the total information to be presented to the pilot during flight (fig. **2).** From this, however, only a small fraction is read out. In image transformation a true perspective of the scene is created.

The result of image transformation is a synthetic true-perspective and true-color visual flight image which is presented to the pilot on board the aircraft.

At present, and presumably for a long time to come, only the cathode ray tube, preferably in the proven form as used in TV, is available for image displays. It is envisaged to generate in a purely electronic manner stylized visual flight images to be displayed by standard TV techniques. After close examination the analog-hybrid computer technique appears to be a very suitable means for the solution of the new task.

As suggestions for solution of the simulation of landing approach, stylized flight images have been verified in a purely electronic manner, employing the analog-hybrid technique (ref. 2).

Figure **3** shows as an example the landing approach scene computed according to the raster method (ref. **3).** Storage of the image content "runway" is achieved through applicable dimensioning of electronic computers, e.g., resistors.

Such an airborne stylized visual simulation

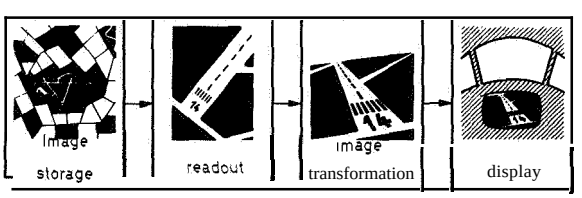

FIGURE 2.—The process of visual flight simulation.

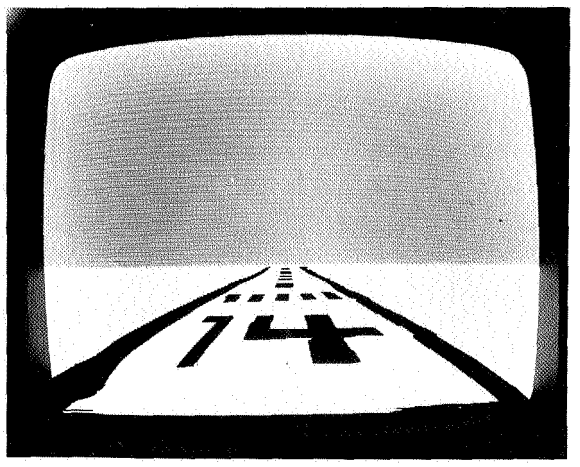

FIGURE 3.—TV screen photograph at a moment **of** a simulated landing approach.

may be used for visibility zero-landing in the future.

The novel methods described permit for the first time by means of an accessory system to the flight instruments of an aircraft the generation of extremely well focused, high-contrast, color-true stylized images on standard TV screens with a very high freedom of maneuver. Future tendencies will presumably aim to utilize the control board computer of the aircraft instead of an independent accessory system, so that the following conclusion should be permissible.

The visual flight simulation onboard an aircraft has up to now been a rather difficult and complex hardware problem. Through abstraction, approaches become evident which suggest that visual simulation of out-of-the-window scenes, e.g., runway will become a software detail in the future and will thus cease to constitute a technical bottleneck within the field of visual flight displays.

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