CORRELATED DISPLAYS FOR TRAINING -- ONE STEP CLOSER TO THE REAL WORLD

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INTRODUCTION

Techniques for generation of images and displays by digital computation have advanced at a rapid pace over the past several years. Systems are currently in use in which visual scene simulation with computer generated images (CGI) is applied to pilot training and in which digital radar landmass simulation (DRLMS) is applied to navigator training. Developments in both these areas have been reported in previous years at the NTEC and INDUSTRY Conference.[1,2,3,4,5]

Effort is currently under way to apply similar technology to the simulation of displays from forward looking infrared (FLIR) sensor systems and from low light level television (LLLTV) systems.

The human information processing in operational situations may be described as follows. The observer obtains information from available displays, viewing of the scene, and any applicable instruments. By a mental correlation process using these inputs and a priori knowledge of his location and the world, he forms an image of the actual environment represented by these inputs. He then takes action based on this image.

Existing systems provide to the trainee only a portion of the inputs available to him on an actual mission and, to this extent, fail to provide a realistic training situation. Requirements for correlated simulation of displays from various sources must be determined and met.

REQUIREMENTS

When a pilot or observer looks out a window at displays from one or more sensor systems, he sees different representations of the same portion of the world. There are many differences. A distant round lake will appear as an ellipse visually, but as a circle on a radar display. On the radar display its size is independent of its distance from the observer, but a function of the radar range setting. Visually, of course, the size is an inverse function of distance. A corner reflector will be the brightest spot on a radar display but may be invisible to an observer. On an infrared sensor display, the spatial transformations correspond to those of the visual simulation, but the tonal characteristics will be quite different. This is illustrated by Figure 1, a photograph of a fuel storage area, and Figure 2, an infrared sensor display of the same area.* The photograph shows the visual characteristics—the color of the paint on the storage tanks. On the infrared display, the temperature difference clearly indicates the level of fuel in the tanks.

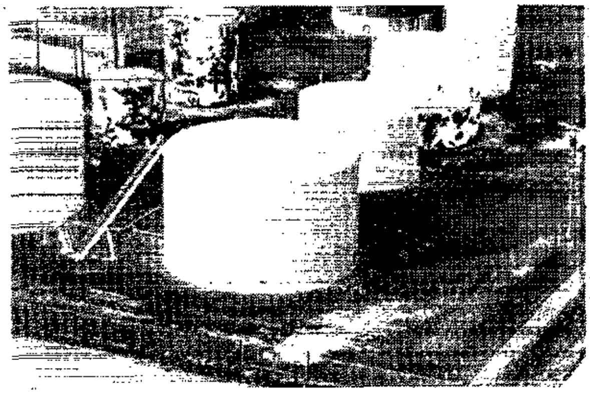

Figure 1. Fuel Storage Area, Photograph

Figure 2. Fuel Storage Area, Infrared Display

In training for navigation, reconnaissance, and target-recognition missions, the trainee must gain experience in correlating the various sources of information to the same real world. If a part of the training is to be accomplished in a simulator

*Figures 1 and 2 provided by Human Resources Laboratory, Wright-Patterson Air Force Base.

rather than in actual flight, then the displays produced by the various simulators must be correlated in the same sense as above—the displays must validly represent the same portion of the world. Only recently have the separate technologies matured to the point of making feasible this additional step toward simulation of the entire real-world environment.

In the simpler cases, the task is near trivial. Consider an IFR approach through fog to a carrier landing. A radar simulator, capable of representing a single target whose position on the display validly indicates the relation of the aircraft and the carrier, will provide guidance as the aircraft approaches visual contact with the carrier. In the more general case with mountains, hydrography, and cultural features as well as discrete targets, the task is far more difficult. It is this more general case which is currently under attack.

LABORATORY EXPERIMENT SETUP

Laboratory systems for simulation of both visual scenes and radar displays are available in the General Electric Advanced Technologies Laboratory at Daytona Beach, Florida. The two systems were developed independently. Each has data bases representing a number of different scenes and locations, which were prepared for experimentation, evaluation, or demonstration of features or capability associated with the specific system. Each has its own dynamics simulation. These two systems, each proven in its own area, were available for use when it was decided to investigate correlated display simulation.

Since the visual system had the most complete and valid dynamics simulation, the radar simulation was slaved to it, with provision for the roll and pitch stabilization of the radar antenna. A remote display driven by the DRLMS was located in the cockpit. Duplicate controls for some of the radar functions were provided in the cockpit.

It was desired to evaluate the subjective effect of flying the combined systems in a variety of situations involving hydrography, cultural features, and mountainous terrain. An extensive data base of the San Francisco region existed for the DRLMS. A CGI data base was prepared covering a portion of the same region. It was prepared, not from the radar data, but independently from source information.

A detailed CGI data base of Hancock Airport in Syracuse, New York, had been prepared previously. Hancock Airport was moved a couple of thousand miles, and placed on a flat region near San Francisco. This airport was also added to the radar data base. Since we have not yet undertaken the simulation of the air traffic control operator, a line of point targets, simulating a power line extending west from the runway, was added to the radar data base as an aid in finding the field in heavy fog flying. A SAM site northwest of Richmond, a tugboat in the bay, and bridges over the bay were included both in the CGI and the DRLMS data bases.

When such a system is first flown with data bases intended to be compatible, any discrepancies noted can provide corrective feedback for rapid data base modification. It is thought that this will be a valuable feature of operational systems in exacting requirements.

RESULTS AND SAMPLE SCENES

Figure 3 is a view of the cockpit with the radar display shown, and the screen with the simulated visual scene in front of the cockpit. Aircraft location is west of Stockton, looking toward San Francisco. Also, we are west of the runway mentioned above. Altitude is 7500 feet, and light haze is simulated. Radar is set on the 20-mile range. Two estuaries can be clearly noted on both displays. Mountains can be seen in the distance, and their radar shadows can be noted on the radar display.

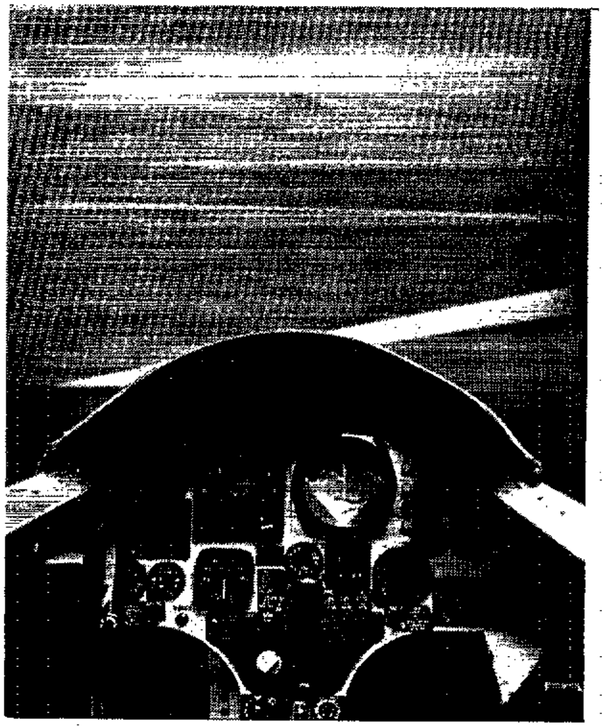

Figure 3. Combined Radar/Visual Simulation System

On Figure 4, the aircraft is 33 miles closer to San Francisco and at 10,000-foot altitude. We can see over the mountains, past the Golden Gate to the Pacific in the background. The radar display photographed from this location was set on a 20-mile range and did not show the bay and bridges. Figure 5 was taken from a 7,500-foot altitude and from a point 20,000 feet north of Figure 4, and it clearly shows these features. The actual simulated visual scenes were in color, and it is regretted that the printing process cannot accommodate color, as the hydrography in particular shows up far more clearly.

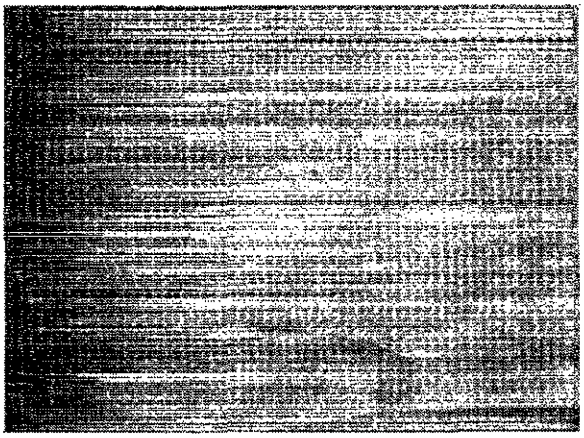

Figure 4. Visual Scene, Overlooking San Francisco Bay

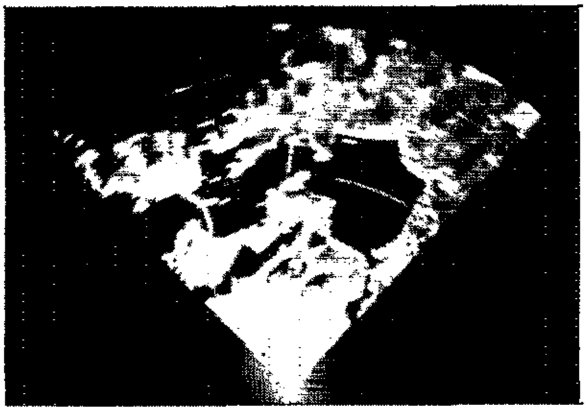

Figure 5. Radar Display, San Francisco Bay from the East

This system has been flown not only by General Electric personnel, but by a number of potential users of such equipment. Among the sequences they have found most convincing is flying an IFR approach to the airport guided by the radar and cockpit instruments. When they visually break out of the fog, the runway is seen precisely where it is expected. Figure 6 shows the runway from 75,000 feet to the east and at a 15,000-foot altitude. The fog has been turned off—otherwise nothing but fog is visible from this point. Figure 7 shows the radar display from the same location with a 20-mile range setting.

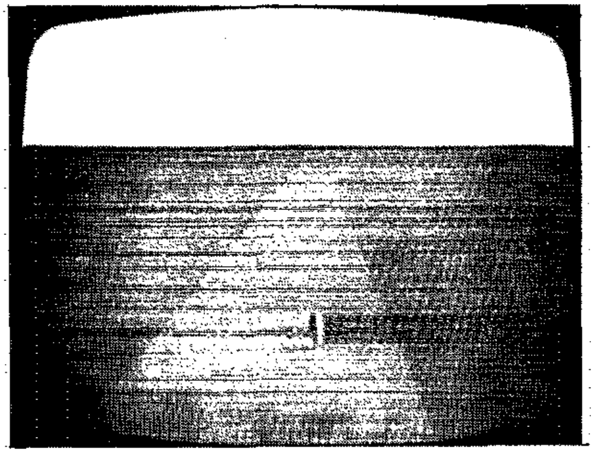

Figure 6. Runway from 75,000 Feet, 15,000-Foot Altitude. Visual Scene, Fog Turned Off

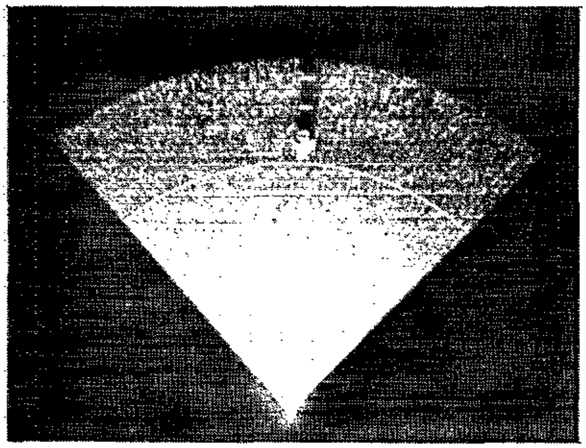

Figure 7. Runway from 75,000 Feet, 15,000-Foot Altitude. Radar Display, 20-Mile Range Setting

Figure 8, from 5000 feet and 600-foot altitude, is the runway just as we're breaking out of the fog. Figure 9 is the corresponding radar display with a 10-mile range setting.

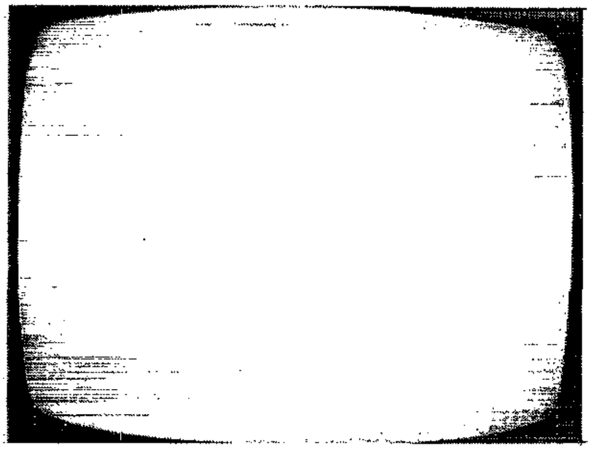

Figure 8. Runway from 5000 Feet and 600-Foot Altitude. Visual Scene—Breaking Out of Fog

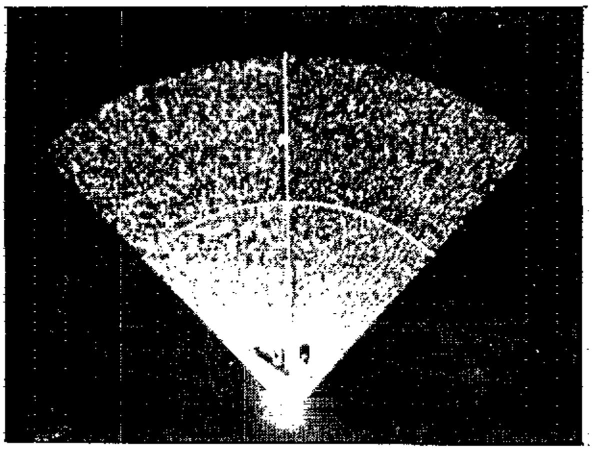

Figure 9. Runway from 5000 Feet and 600-Foot Altitude. Radar Display, 10-Mile Range Setting

FURTHER EXPERIMENTATION

The simulation specialist can provide the scene and display generation capability—the tools for training. He must work closely with the training personnel—the system users—to develop the most effective techniques for using the system. Any finite system has limits on the amount of scene detail that can be generated. This must be applied to the set of visual cues of greatest significance to training. This may involve continuous experimentation and modification as classes of trainees are processed and results evaluated, as has been the case with the use of visual scene simulation with the 2F90 trainer[4].

A fruitful approach might involve the use of the laboratory combined system by training specialists for preliminary evaluation to determine requirements for an operational field system. This could then be used in a manner similar to the 2F90 system for refining requirements and measuring effectiveness of such simulation in training. Equipment and techniques are now available for taking these steps.

FURTHER DEVELOPMENT

In considering the application of this technology to an operational training system, a question which naturally comes to mind is whether efficiencies could be realized by combining some of the computational functions, data bases, etc., rather than having completely separate but interconnected systems. There is indeed promise of such improved efficiency, and this area is currently under investigation.

Consider a region of rolling terrain. The past terminology in the radar simulation area speaks of it as being represented by a network of ridge and valley lines. Visual simulation terminology refers to faces and edges. In both cases we are speaking of a planar segment approximation to the terrain, and spatially identical representations may be used both for radar and visual simulation. Similarly, the boundaries of lakes may be defined by identical line-segment approximations for both systems.

The differences must also be considered. For the visual system, a dry plain may be defined as tan sand color, and a hillside as green pine-forest color. These same spatial features need radar reflectivity characteristics defined for the radar simulation. Many visual features, runway markings for example, have no radar significance. The difference in resolution of the two systems leads to other differences in data base requirements.

Some results of current development in this area are shown on Figures 10 and 11. These show a radar display and a perspective display of a region near Lock Haven, Pennsylvania. Both were produced from the same data base, originally developed for the radar display simulation. To orient the viewer, it might be noted that the island in the bend of the river is the most distinctive feature readily identifiable on both displays.

To take advantage of the common features and efficiently handle the differences, one might envision a composite data base containing sufficient information for both types of displays. If such a data base is used in real-time simulation, the hardware of one or both systems might have to be more complex and expensive than if it were presented with data in a form just matched to its requirements. A possible approach is to use such a composite data base with provision for update functions, which can be far less frequent than the display generation. These would extract and format data as required for each type of hardware, as the operating region changes during flight.

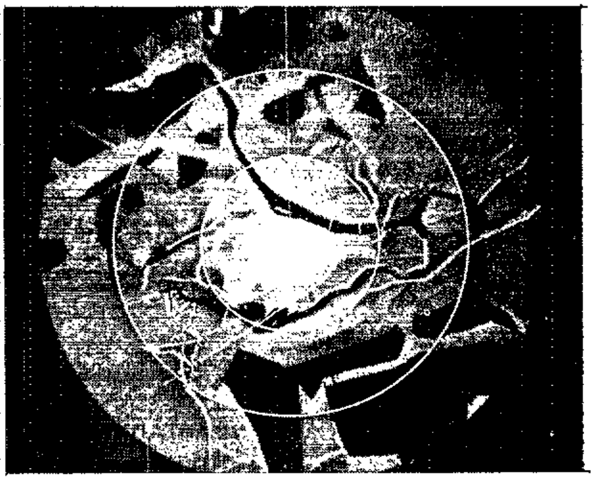

Figure 10. Simulated Radar Display of Lock Haven, Pennsylvania Region

Figure 11. Perspective Display from Radar Data

It is anticipated that as simulations of FLIR and LLLTV displays are developed, it will also prove desirable to use them in combination with visual and radar displays. The spatial characteristics required are those of visual scene simulation, but characteristics such as transfer function and display noise are best simulated by applying techniques that have been used in the DRLMS area. It is therefore anticipated that combined displays incorporating FLIR and LLLTV will follow directly from the current development effort on radar and visuals.

REFERENCES

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ABOUT THE AUTHOR

DR. W. MARVIN BUNKER is presently a Consulting Engineer in Advanced Technologies Engineering at General Electric in Daytona Beach, Florida. He received a B.S.E.E. from the University of Oklahoma, and an M.E. and Ph.D. in Electrical Engineering from the University of Florida. Dr. Bunker joined General Electric/Apollo and Ground Systems in early 1963. His current assignment includes research and consultation effort on training simulators. This includes conceptual and mathe-

matical areas, as well as hardware considerations. It involves computer generation of images, both visual scenes and simulated radar displays. His visual simulation developments include the basic organization of the vector calculator functions, the development of the hardware priority determination concepts and fading technique for fog and cloud simulation, as well as consultation on all system aspects. He developed an automated technique for converting elevation data defining three-dimensional terrain to a planar segment approximation. This is applicable to radar display data compression, and to automatic modeling of such features for CGI applications. Prior AGS experience included Advance Engineering responsibility in the areas of data collection, transmission, processing, and on-board checkout. This included reliability analysis to compare redundant and non-redundant systems performing the same function, with development of failure annunciation capability to assure retention of full redundancy. Dr. Bunker's prior GE experience, beginning in 1958, included Systems Engineering and Integration responsibilities on the Atlas Radio-Intertial Guidance System, and on the MISTRAM tracking system. Other experience includes design, test, and analysis effort on the Falcon and Polaris programs, and on Naval radar and Air Force fire control systems, including training programs on these systems. He has taught at Northeastern University, the University of Florida, and Florida Technological University. He has published papers in the areas of instrumentation, network theory, and simulation. Dr. Bunker is a member of IEEE, Society for Computer Simulation, Society for Information Display, and of a number of honorary societies, including Tau Beta Pi, Eta Kappa Nu, and Pi Mu Epsilon. He is a member of the Board of Visitors of Embry Riddle Aeronautical University.