AUTOMATION OF DATA BASE DEVELOPMENT IN COMPUTER IMAGE GENERATORS

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ABSTRACT

Military requirements for large scale training missions on computer image generation (CIG) systems have placed increased emphasis on the CIG data base development process. General Electric produces large scale data bases in a semi-automatic process involving the transformation and enhancement of Defense Mapping Agency digital data bases into CIG scene descriptors. The enhancement process is the limiting factor in the evolution of a fully automated data base development system, and suggests a requirement for a single source data base. Future General Electric CIG systems will incorporate automation technology to allow for low cost generation of visual scenes meeting strategic applications of specific weapon systems trainers.

INTRODUCTION

The emergence of computer image generation (CIG) in aircrew training as a multimillion dollar industry is primarily attributable to advances in electronic technology. Recently, however, CIG manufacturers have diverted research and development activities from computer hardware improvements to an increasing emphasis on the development of sophisticated techniques used in the generation of mathematical descriptors supporting simulation displays. These CIG data bases supply the necessary scene content constituting such cockpit panoramas as radar, forward looking infrared radar (FLIR), low light television (LLTV), and "out the window" visuals.

While early simulators provided visual cues for aircrew training in various airport (and aircraft carrier) maneuvers, more recent simulator systems have undertaken the portrayal of large geographic areas containing sufficient scene detail to support low altitude visual navigation. The ultimate goal of this development trend appears to be the manufacture of aircraft simulators capable of global flight paths arbitrarily selected by the flight instructor.

The complexity arising from the real time retrieval and display of high detail scenes has placed an enormous burden on the design of CIG hardware, and has forced most manufacturers to combine large core memory storage with high speed parallel processing in order to generate adequate cockpit displays.(1) In most cases, however, the industry has overlooked problems associated with preparation of the CIG data base itself. While data bases in early CIG systems were prepared in the tedious fashion described by Sutherland,(2) experience has shown that the manual preparation of large scale data bases is both expensive and impractical. It seems evident that overall progress in the CIG technology now relies on the total automation of the data base development process.

HISTORICAL BACKGROUND

General Electric's Electronic Systems Laboratory developed the first computer image generator in 1958. This primitive device produced a regular line pattern over a ground plane to create the illusion of motion, but was clearly inadequate as a practical training tool. Subsequent CIG systems produced by General Electric and other manufacturers have shown significant progress in the enhancement of detail in the CIG displays.

Scene detail, in the language of the industry, is measurable by counting the number of visible edges displayed by the CIG at a given instant during real time operation. As is illustrated in figure 1, the growth in the number of displayed edges in various General Electric systems has been virtually exponential over the last 12 years. It is no coincidence that this growth curve parallels the exponential miniaturization of computer components arising from technological advances in medium and large scale electronic integration. The growth in complexity of CIG data bases, on the other hand, is small by comparison. In fact, figure 2 indicates the number of environment edges contained in General Electric CIG data bases actually declined after 1974.

The disparity apparent in the evolution of CIG hardware versus CIG data bases arises from the modest applications around which early CIG devices were designed. These products were intended primarily for use in landing/take-off maneuvers, and as such, required only a single airport complex in the data base environment. More recent projects have reflected a change in this application philosophy, and have encouraged expansion of flight scenarios to include air-to-air combat, in-flight refueling and low altitude navigation. One current aircraft simulation, for example, will require a supporting data base portraying a geographic area of 40,000 square miles. The generation of a data base of this

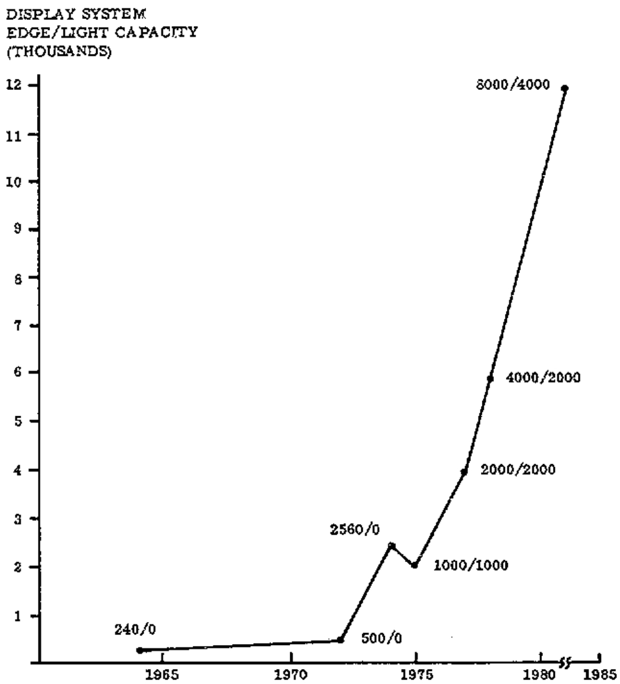

Figure 1. Growth in General Electric CIG System Display Capacities(1)(3)

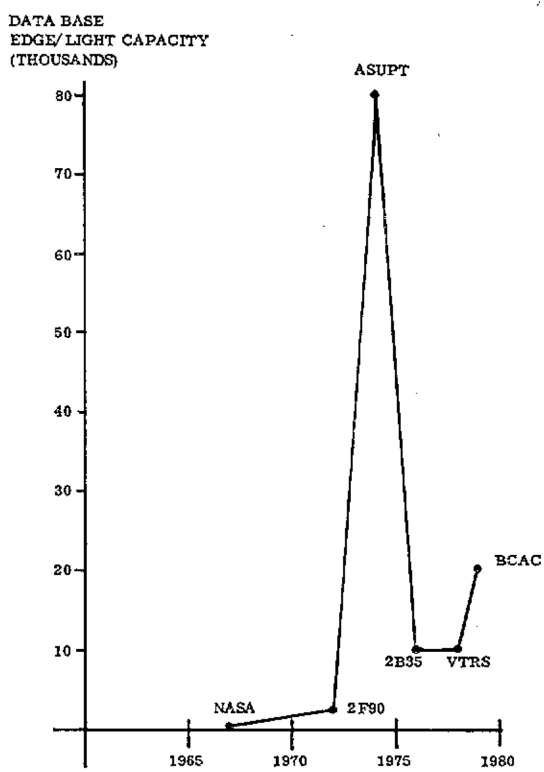

Figure 2. Growth in General Electric CIG Data Base Capacities(1)(3)

magnitude using traditional manual techniques would require thousands of man years to produce at a cost of hundreds of millions of dollars to the product consumer.

AUTOMATED DATA BASE GENERATION

In 1977 General Electric initiated the development of a computer program capable of generating CIG data bases with a minimum of human interaction. As shown in figure 3, inputs to this program are supplied by the Defense Mapping Agency Aerospace Center (DMAAC) in the form of digital terrain and culture data bases. DMAAC terrain files consist of elevation values sampled at regularly spaced intervals over the surface of the earth. The raw grid data is first blocked into geographic areas of manageable size, and a simplified subset is then obtained by detecting points of significance in the topological environment such as mountains, valleys, and ridge lines. Finally, a triangular faceted surface is fitted to the selected elevation values to force an approximation of rolling terrain.

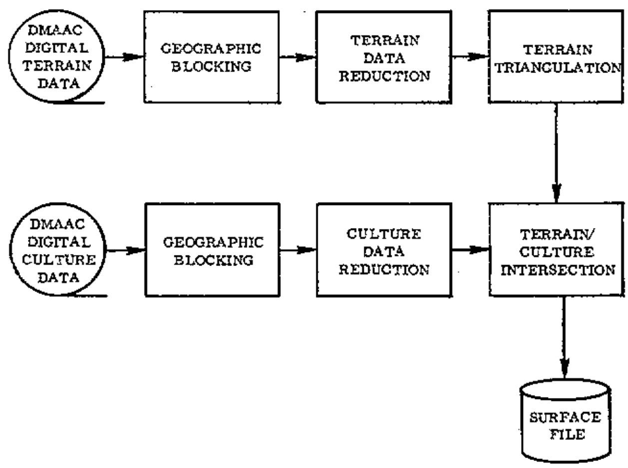

Figure 3. CIG Data Base Development Using DMAAC Digital Data

Planimetric features such as lakes, forests, and highways are also derived from DMAAC digital data bases. After blocking the raw input data in correspondence with the underlying terrain, DMAAC cultural features are processed to the degree of simplicity required by the CIG. The resulting culture data is then combined with the underlying triangulated terrain to form a single surface file.

Data Base Enhancement

Although DMAAC data bases contain more information than the CIG can process, nevertheless, certain cultural features used by aircrews as navigational cues are often absent from the DMAAC cultural data bases. Therefore, the enhancement of the original DMAAC data using supplemental inputs such as Joint Operations Graphic (JOG) and U.S. Geological Survey (USGS) Quandrangle charts is a necessity.

General Electric presently employs a turnkey interactive graphics system to digitize data from JOG and USGS inputs. The digitized data from this process must be formatted to match DMAAC culture

Figure 4. Sun Shaded DMAAC Terrain Elevation Data (Sun Angle = 45°)

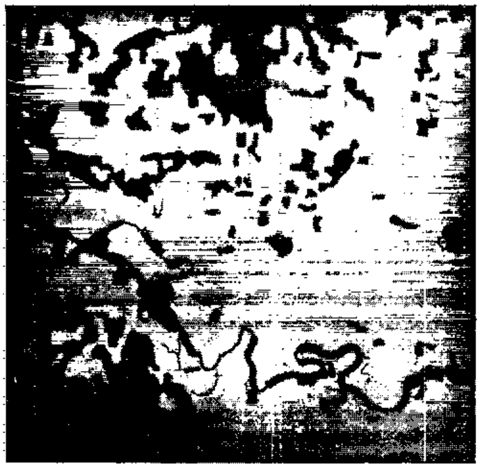

Figure 5. Unprocessed DMAAC Culture Data (Surface Material Categories are Color Encoded)

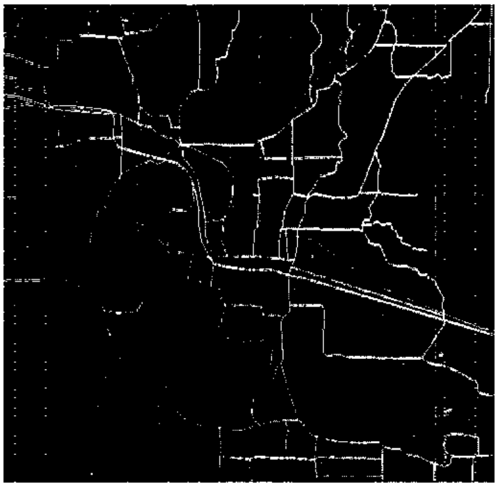

Figure 6. DMAAC - JOG Data from Manual Digitization (Roads, Railroads, and Waterways)

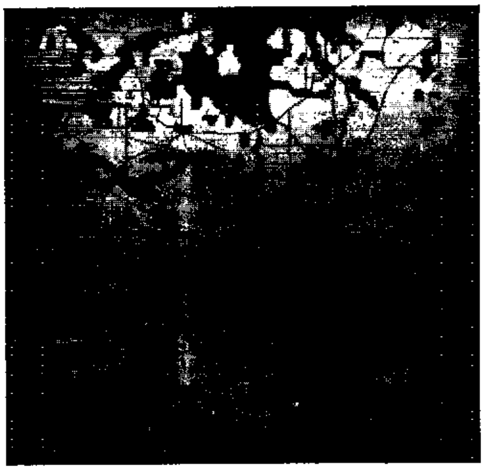

Figure 7. DMAAC Culture Data Enhanced with Manually Digitized JOG Data

Figure 8. Enhanced DMAAC Culture Data Merged with DMAAC Terrain Elevation Data

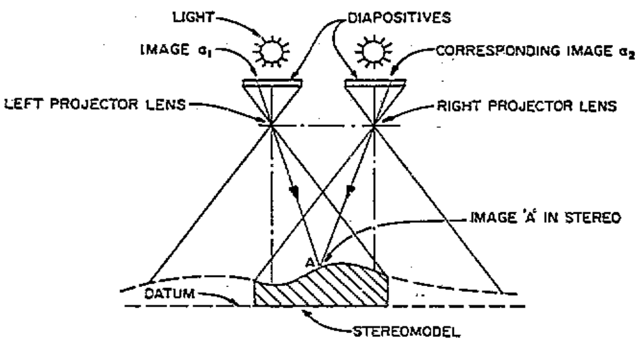

Figure 9. Generation of Three Dimensional Image from Stereopairs

file specifications, and the two files must be merged to form a single input to the automated data base generation program. Figures 4 through 8 illustrate the output of various steps of the culture enhancement process.

Traditional manual methods of data preparation are still required as a final step in the data base generation process. In addition to certain planimetric features not contained in DMAAC or supplemental data, models such as buildings, dams, bridges, and aircraft are painstakingly drafted and positioned in the final CIG data base. This final step is responsible for a large portion of data base development costs.

FUTURE DIRECTIONS IN AUTOMATION

Manual enhancement of CIG data bases necessitated by Defense Mapping Agency data deficiencies is the limiting factor in total automation of the CIG data base development process. A joint effort of commercial and government agencies might someday lead to the production of a single source data base containing sufficient detail for all CIG visual data bases. In the meantime, at least two possibilities exist for the improvement of CIG data base quality which may also lead to lower system costs.

Automatic Digitization

Cultural enhancement of CIG visual data bases involves the extraction of planimetric data from various maps, charts, and photographs using manual digitization methods, and the human operator must make decisions regarding the relative importance of features that are candidates for inclusion in the final data base. The lack of selection criteria, combined with errors arising from eye-hand coordination and operator fatigue, make manual digitization an inherently error prone and costly process.

Alternatives to manual digitization have been of interest to cartographers for many years, and devices such as facsimile and Brush recorders are routinely used in the preparation of maps and charts. Unfortunately, these products are usually designed to generate raster-formatted data which is incompatible with the vector-formatted data required by most CIG systems. Also, facsimile and Brush devices are extremely slow, and in general, the data output from these systems is too dense for use in flight simulation data bases. Recently, Boyle reported the development of an automatic digitization system using a flying spot scan of map separations.(4) This device is of potential value to CIG data base development systems by virtue of the vector-formatted output generated by the product, and the high speed with which data is captured. Furthermore, the use of map separations lends itself to the segregation of cultural data into logical groups such as water, forests, and highways for enhancement of DMA digital data bases.

Stereometric Photography

Photogrammetry is the science of detecting information about physical objects by recording, measuring, and interpreting photographic images. As with automatic digitization, photogrammetry has been used for some time by government and commercial cartographers for the preparation of maps and charts. Metric photogrammetry involves the processing of overlapped photographs known as stereopairs to extract accurate three dimensional information about real world objects. The use of translucent positives, or diapositives, to form a three dimensional image is illustrated in figure 9.

The potential application of stereometric photography to CIG data base development was demonstrated recently for the Naval Training Equipment Center in Orlando, Florida. In this experiment, a Russian ship was digitized from stereophotographs taken of a scale model using close range camera equipment. As shown in the calligraphic plot in figure 10, the 350 polygon feature contains more than sufficient detail to be very effective in a CIG visual simulation, and furthermore, the feature was prepared in just two days using photogrammetric methods. The preparation of a similar feature utilizing traditional CIG data base development techniques would consume several months of effort.

CONCLUSION

Visual scenarios now demanded of CIG flight simulators have forced the re-evaluation of traditional data base creation methods. General Electric has undertaken the automation of the data base generation process, and is committed to providing low cost simulators that will meet future consumer requirements. It is evident that government sponsored research should be aimed at the acquisition of high technology CIG data base generation techniques, such as metric photogrammetry and automatic scan digitization, which will lead to lower costs in future CIG systems.

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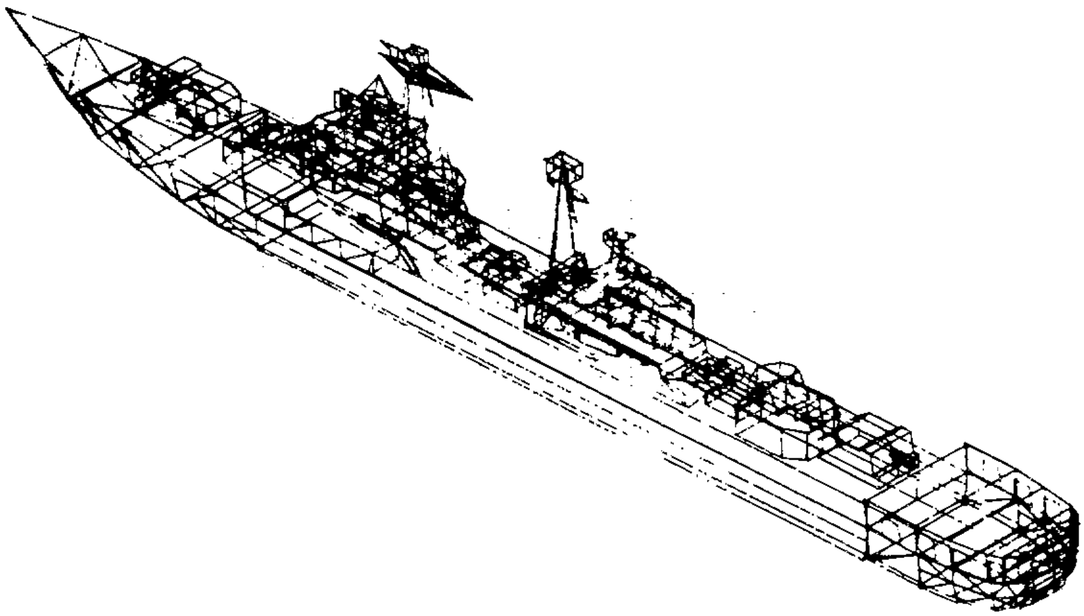

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EDIT LEVELS ALL REF LEVELS NONE
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Figure 10. Russian Ship Digitized from Stereometric Photographs
(Computer Systems Laboratory, NTEC, Orlando, Florida)