DATA BASE CONVERSION/CORRELATION ISSUES

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ABSTRACT

A full mission simulator, just as the device it simulates, consists of many different subsystems, each of which requires a uniquely formatted data base. Creating each of these data bases individually can be expensive and time consuming. Another problem to be solved is the correlation or interoperability of data bases. Although the formats for each subsystem (e.g. visual, sensor, moving map, etc.) are different, the data in each must correlate to some degree with all other simulation subsystems. Just as each simulator must correlate the various subsystems, a simulation facility must provide the capability to correlate each subsystem of one simulator with the comparable ones on other simulators. This paper will discuss the methodology used at McDonnell Douglas Helicopter Company to handle data base conversion between our many simulation systems. We will also examine many questions and issues that need to be discussed prior to developing correlatable (interoperable) data bases.

INTRODUCTION

The generation and correlation of data bases is rapidly becoming one of the critical components needed to accurately simulate mission related tasks. The increasing use of sensor systems is pushing simulator requirements toward multiple environments for each crewmember. These subsystems must support not only out-the-window (OTW) displays, but also the wide range of sensor systems, operator displays, and real-time software which also require data bases. Any simulation facility supporting many different subsystems needs to develop software and procedures to permit both the generation and correlation of data bases. Since data base development is expensive, building the same data base multiple times (once for each IG or other subsystem) is obviously not a cost-effective approach. The problem is compounded if the data bases for the different subsystems are also required to be correlated. A better solution than developing a data base multiple times would be to develop the data base once and use it on all subsystems. Because the formats of the data bases are not compatible between different subsystems, this is not possible. However, we feel it is possible to develop a data base once, reformat it, and with 'minimal' work by data base engineers, have it working on different subsystems in a relatively short period of time.

This paper will discuss many questions and issues that are raised when attempting to convert data bases from one system to another. Data base correlation will also be discussed, as it is a major factor in the conversion process. We will also discuss our approach for converting data bases between image generation systems.

BACKGROUND

The McDonnell Douglas Helicopter Company Simulation Systems Group (SSG) currently has two full mission simulators with three additional full mission simulators in development. These simulators consist of many different subsystems, each of which requires a data base in a unique format. Although the formats are different, the data in each subsystem must correlate (to some degree) with all other subsystems for that simulator. These subsystems support OTW displays, IR displays, night vision goggle (NVG) displays, moving map displays, operator displays, and real-time mission related software (e.g., line of sight, moving model control, and scoring).

We are currently using two six-channel GE CompuScene IV (C-IV) IGs which can generate OTW, NVG, and IR imagery. The arrival of two single channel Sogitec GI 10,000's (GI-10K) systems and a six channel E&S ESIG-1000 system signal the start of a new period for our data base engineers. It is conceivable that many or all of the data bases currently used on the C-IV may at some time need to be used on both the GI-10K and ESIG-1000. There will also be times when multiple IGs will be required to support a single simulation. If this occurs, all displays generated from the IGs must correlate with each other.

In addition to the IGs, our simulators are currently using different types of moving map generators - a Harris Digital Map Generator, a Chromatics-based graphics system and an IRIS-based graphics system. The procurement of different IGs and graphic systems magnifies the data base generation and correlation problem since these devices must be interoperable with each other as well as with all other subsystems currently supporting the simulation facility. Lastly, our systems must support the simulation operator displays and real-time software.

In addition to multiple environments for each crewmember, the ability to perform a full mission simulation and evaluation is becoming increasingly important in the training of pilots. This not only includes multiple cockpits, but also instructor/operator consoles, tactical situation displays, mission planning and the ability to review and critique each training exercise upon its completion. This full mission simulation demands much more correlation than simply matching the geometry of models seen on visual and IR displays.

DATA BASE CONVERSION

The conversion problem may not seem particularly difficult at first glance. Most image generators have the same data base components - terrain, culture, models, and texture. What could be so difficult about converting the data base to a different format? Unfortunately, the data base conversion problem is not so easily handled. It involves more than a simple rearranging of the data in files. IG systems store different types of data to represent the various data base components. Optimizing the data base for the target IG also needs to be considered. Prior to converting a data base, one has to determine the level at which the conversion will take place. For example, in some instances you may wish to convert a data base at the source level while others at the IG level. The availability of formats and the ability to make any required modifications to the data base once converted should be a consideration when determining the level of conversion.

DATA BASE CORRELATION

The generation and correlation of data bases has become a critical component in full mission simulation. Unfortunately, the term "correlated data base" does not have a clear, easily understood definition. To avoid confusion, misunderstandings, and lost effort, the questions and issues raised in the next section of the paper need to be discussed to ensure that everyone means the same thing when speaking of correlated data bases.

The data base engineer will usually be the person responsible for solving the bulk of the data base correlation problems for any simulation task. However, before this can be accomplished, details such as the purpose of the mission to be performed, any important task parameters, and the specific hardware supporting the simulation subsystems must be defined. It falls upon the shoulders of the data base engineer to explain the trade-offs involved to all users. Ideally, before any data base design has begun, all parties involved with the simulation will sit down, examine the various trade-offs, and reach an agreement in terms of an acceptable degree of correlation for each of the subsystems involved. Failing to discuss these correlation issues will only result in disappointments or even an unacceptable simulation.

DATA BASE CONVERSION AND CORRELATION FACTORS

It must be understood that the data base conversion software may never be totally automated. Data base engineers will be required to perform the fine tuning and optimization for the target IG. After conversion, the data bases on each system should correlate and function as a single data base, without any visual anomalies in any display due to exceeding system constraints. In the following sections we will try to discuss in more detail specific system, task, and data base issues and how they relate to the correlation of data bases.

Task Dependent Factors:

The first area to examine is what simulation tasks will be using the data bases. A data base will be designed differently depending upon whether the simulator using it is functioning as a fixed wing aircraft, ground vehicle, rotorcraft, or ship. The following paragraph lists some questions which must be answered about each task being simulated.

What is the type of mission to be simulated? A few of the mission types requiring different cues are scout, attack, supply, search and rescue, and covert operations. What are the speed and altitude ranges for this simulation? A data base should be designed to support flight at a specified range of speed and altitudes. In addition, each gaming area within the data base should also be designed to support the speed and altitude range for that area. What sensors will be required? Will the pilot need to perform any detection, recognition, and/or identification tasks? What are the possible targets? The pilot must look for specific visual cues during these discrimination tasks. It is the job of the data base engineer to provide sufficient cues to allow the task to be successfully completed.

System Dependent Factors

The second major area to consider is the impact made by the simulation hardware. If the same imagery must be displayed using two different IGs, the IGs involved must not be too divergent in their capabilities.

The data base engineers must be aware of the system capabilities and limitations when correlating data bases or converting data bases between systems. Are the polygon capacities the same? Does the system support special effects?

The use of different IGs always complicates the correlation problem. Should the correlation be designed to create data bases which will work on the system with the least capability? Different system architectures can dramatically increase the difficulty of the task. Defining separation planes and dealing with the on-line storage space they consume are two problems a data base engineer might deal with on a priority based IG. A data base engineer designing a data base for a Z-buffer system, on the other hand, tries to minimize the overwrite ratio. Therefore, it may be extremely difficult to develop a single data base to be used on both a Z-buffer IG and a priority based system.

Data Base Components

Each data base component must be examined carefully for a successful correlation to occur. These data base components include terrain, culture, fixed models, moving models, special effects, environmental effects, color, and texture. This section will briefly discuss each of the components and raise questions that should be answered prior to beginning the correlation process.

Terrain/Culture - How closely must the terrain correlate between the different displays? Do polygons need to be the identical size and shape? If this is not necessary, is it important for peaks to correlate, or only certain mission critical peaks. Is it important for valleys to correlate? The answers to these questions will greatly depend on the nature of the simulation tasks (e.g., high or low altitude, air-to-ground or air-to-air, etc.). Are identical cultural features necessary? Do trees need to be identical? For a helicopter simulation, the size and shape of trees may be important. To what degree do cultural features need to correlate? Can we substitute one large cultural feature for many smaller ones?

Models (Fixed and Moving) - How closely do the models in the data base need to match? It may be extremely difficult to convert a model initially designed for a Z-buffer system to one usable on a priority based system. The degree of difficulty will depend on whether the Z-buffer model was built with priority in mind. The allowable size of polygons may be a limitation as well. Also, levels of detail may be handled differently on different IGs. These issues may require a data base engineer to perform additional modifications to a converted model so it may be displayed more efficiently on the target IG.

Although instances exist when model geometry has to be modified by hand, converting model data by software is one of the more time saving elements of the data base conversion process. What may have taken months to create initially can be converted in a matter of minutes. By converting models automatically one can achieve a higher overall degree of correlation than if the model was rebuilt by hand. When converting a fixed or moving model through software, the goal is to convert it to a format or stage in processing that will allow it to be easily modified if necessary.

Special Effects - What do we do if one system supports dynamic special effects (explosions, fires, etc.) and another doesn't? What do we do if one system requires the use of a special effect to simulate a feature such as flowing water?

Environmental Effects - Environmental effects pose the same type of problem as special effects. On some systems environmental effects are modeled into the data base. Other systems can handle the same effect as a real-time feature of the IG.

Texture - The increasing use of texture by IGs generates another set of problems which need to be resolved. Texture can range from a checkerboard pattern on the ground to a bitmapped pattern generated from photographs. How and where is the texture information defined for the terrain or models? It may be extremely difficult to identically map texture patterns between different IGs due to the wide variation of texture mapping options. How do you convert monochrome patterns to color patterns? Is it really important that the texture look the same or just provide the same types of cues?

SENSOR CONVERSION/CORRELATION

The conversion of a data base developed for one sensor type to a data base supporting a different sensor type (even on the same IG) can result in a unique set of problems. For example, it would be extremely difficult to write a program to automatically convert an OTW data base to a high fidelity infrared (IR) data base. This is especially true for moving 3D features.

There may be little resemblance (in terms of both geometry and color) between a tank as seen OTW and that seen through an IR device. A tank stationary in the data base could be there for several different reasons. A tank which has just stopped to fire would look substantially different in IR than one which was damaged several days earlier. To properly convert an OTW version of the tank to an IR version would require the software to know the history of the tank. There are a great many modifications which will need to be made to convert an OTW tank to an IR version. The tank could require hot spots for the engine and the gun barrel. The treads of the tank may require modifications if they have been recently moving. An exhaust plume may also be visible with an IR sensor.

MCDONNELL DOUGLAS DATA BASE CONVERSION APPROACH

The Simulation Systems Group is developing software and procedures to permit conversion (and a varying degree of correlation) between the data bases supporting its simulation subsystems. The primary method we are using to correlate data bases is to convert the data bases by way of a common data base. This common data base is called the MDHCDB. All data base conversion software (both IG and non-IG) makes use of the MDHCDB. The MDHCDB will be used as the intermediate data file from which all other IG or subsystem specific data bases are generated.

As an example, if an existing C-IV data base needs to be used on the ESIG-1000, we will use a three step process to convert that data base. The first step is to use our C-IV to MDHCDB software to convert the C-IV data base to the MDHCDB format. The second step is to use our MDHCDB to ESIG-1000 program to generate a data base in the correct format for the ESIG-1000.

The first two steps result in correlated data bases. However, there is no guarantee that the second data base will work on the target IG. While correlating the data bases, engineers will manually try to optimize the data base and/or models for each IG to the maximum degree possible. This manual optimization effort is the third step in the conversion process. At times, very little can be done. However, other times it is possible to rework part of the data base and obtain a significantly better and more useful product. Figure 1 illustrates the conversion process.

MDHCDB

The common data base approach makes use of a generically formatted data file called the MDHCDB. The purpose of this generic format is to provide a common source data base from which all IG (or other subsystem) specific data bases can be generated. We expect that the MDHCDB data will typically be derived from an IG-specific data base. All data base conversion software (both IG and non-IG) will make use of the generic format.

The original design of the MDHCDB was based on the Standard Simulator Data Base (SSDB) format described in the RFP for Project 2851. While the final design fulfills some of the same goals as Project 2851, the actual data files are somewhat different. For example, the MDHCDB data is stored on a data base basis (i.e., there is one set of files for each data base), whereas the P2851 data is stored on a geographic basis with multiple levels of detail.

Because the generation methods for each of the four classes of data (terrain, culture, models, and texture) are distinct and separate processes, the MDHCDB logical design keeps these classes of data separate.

The terrain and culture components will be available for access on a data base basis. This approach is used because the same terrain and culture polygons are not generally used in different data bases. However, models and texture patterns are often used in multiple data bases. Therefore, the MDHCDB data structure must support the concept of a model library and a texture library.

After evaluation, we have determined that it is not practical to keep master model libraries or texture libraries in the MDHCDB format. Instead, we retain the concept of an IG specific master library

MDHC Data Base Conversion Process

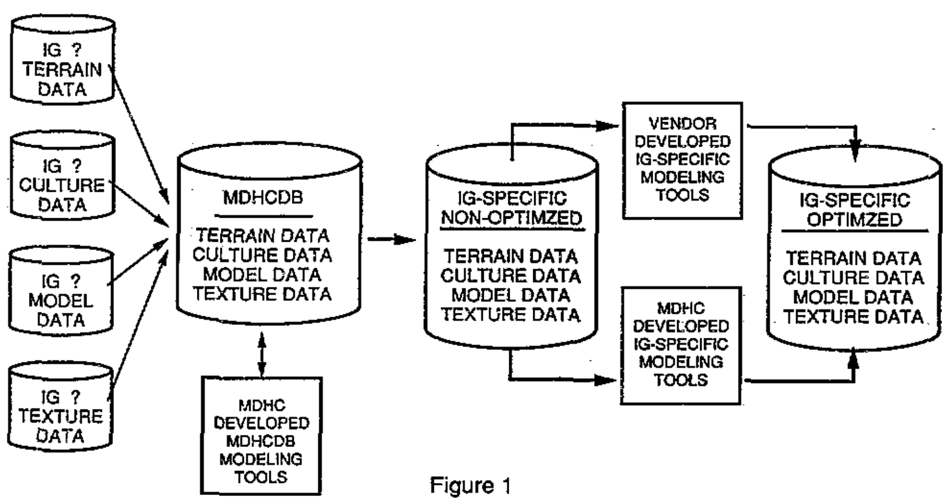

Figure 1

stored on the target IG's modeling system. A directory will be maintained in the MDHCDB indicating all versions of specific models which are on each of the targets and whether or not the model has been fully optimized for that IG. This will permit specific versions of models which have been built or optimized for an IG to be used in other data bases on the IG for which they are needed.

POTENTIAL PROBLEM AREAS

Before a data base conversion system is designed, many potential problem areas need to be addressed. Some of these areas are priority determination, texture, which files to convert, proprietary data, and the experience level of those involved in the project. The more differences, the more difficult the conversion process. This section will provide some discussion on these areas that must be examined before designing software to convert from one IG to another.

Priority Determination:

The method used by the IG for priority determination should be one of the first issues that must be considered when converting data bases among different systems. This is especially true when converting between Z-buffer and priority list systems. A conventional, priority based IG and a Z-buffer IG is the manner in which the priority between the polygons is computed.

Priority systems require separation planes, which divide the true and false sides of a priority scheme. Z-Buffer systems, on the other hand, do not require separation plane definitions at all. Z-Buffer systems also allow for intersecting polygons and objects in a model, a basic no-no on priority systems.

In most cases, models converted from a Z-Buffer system to a priority system will have to be modified if they weren't originally built with separation planes in mind. When converting from a priority system to a Z-buffer system, the polygons defining separation planes can be deleted.

Texture Issues:

A photographic type of texture (photo-texture) is one of the newer features supported by many IGs. In addition, each IG manufacturer implements texture differently. Thus, there are a number of issues and questions concerning texture which need to be answered during the data base conversion process. These issues can be divided into two categories: texture placement and the texture pattern.

Texture placement is concerned with the parameters used to locate the texture patterns correctly both on the ground and on 3D features. The texture pattern defines the appearance of the pattern. As is the case with most features, there is a broad range of techniques used to define these patterns. Different IGs can have texture patterns of different size and resolution. Texture patterns can be color or monochrome. Some IGs support multiple patterns on a polygon, others are limited to one. Translucency and transparency are also defined and used differently on the various IGs.

Data Base Files:

Each IG system has numerous files it uses at different stages in data base development. The vast majority of the files are used by the modeling system. In addition, there are some files used by the IG. One needs to be careful when choosing the files used by the conversion software. Since our software does not generate a data base optimized for the IG, we have found it convenient to choose a target file that can be edited. This allows us to make changes to the data base if any are required or desired.

Proprietary Data:

Before beginning the data base conversion effort, it is necessary to have the file formats for all the files used by the various systems involved in the conversion process. However, some of the file formats may be proprietary to the IG manufacturer. Before committing to any data base conversion, discussions need to be held with the IG manufacturer to determine whether the needed file format information will be available. It can be important to have the support of the IG vendor.

Experience:

The experience level of the people designing the conversion software will have a great impact on the quality and usefulness of the conversion package. We have found it helpful to have some experience at both modeling and using an IG before beginning the design process. Much time can be wasted if there is not a broad understanding of the IG systems to be used. The conversion software development will proceed much more smoothly if there is an understanding of the IG, the data base design philosophy, and all the files used during the modeling process.

CONCLUSION

The McDonnell Douglas approach to solving the data base generation and correlation problem has been, and will continue to be, a variety of programs which are used at different times to meet the specific requirements of the simulation task to be performed with that data base.

The conversion of data bases from one IG system to another will probably never be

100 percent automatic. Rather, our goal is to make generation and correlation of data bases as efficient as possible, thus reducing development costs.

We cannot stress enough the need for the designers and creators of the data bases to communicate in the early stages in order to ensure there are no misunderstandings involving the final product. The designers must be aware of the many trade-offs involved in the conversion and correlation processes.

ABOUT THE AUTHORS

Maureen Hrabar is a Member of Technical Staff in the Simulation Systems Group. Since joining McDonnell Douglas she has implemented data base generation tools as well as software systems to convert data bases between different types of IGs and graphics systems. Prior to joining the company, Ms. Hrabar worked for Singer/Link Flight Simulation and the University of Dayton Research Institute on contracts for the Air Force Human Resources Laboratory at Williams Air Force Base. With the University of Dayton she was involved in developing programs to convert data bases from one IG to another. While working with Singer/Link Ms. Hrabar's responsibilities included development and installation of software to support research studies using two Singer/Link DIG visual systems.

John Joosten is a Member of Technical Staff in the Simulation Systems Group. Since joining the company he has been involved in the design and development of data bases used on the C-IV and Sogitec GI-10K. He is *currently involved in developing software* for converting data bases between different IGs and graphics systems. Mr. Joosten has also been involved in data base software administration. Prior to joining McDonnell Douglas, Mr. Joosten worked as a data base modeler for General Electric in Daytona Beach.

Patricia A. Widder is a Member of Technical Staff in Simulation Systems. She joined McDonnell Douglas in 1984 and was responsible for organizing and managing the Data Base Engineering technical unit. She has been involved with the design and development of C-IV data bases, the conversion of data bases between different types of IGs and graphics systems, and the development of a wide variety of data base development tools. Prior to joining McDonnell Douglas, she worked for the Operations Training Division of the Air Force Human Resources Laboratory as a Computer Programmer Analyst working in the areas of project management, design, implementation, documentation, and maintenance of CIG systems for real-time flight simulators, including data base, real-time, and systems software.