BRL MR 2690

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MEMORANDUM REPORT NO. 2690

GEOMETRIC PROCESSING AND ITS RELATIONAL GRAPHICS

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October 1976

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USA BALLISTIC RESEARCH LABORATORIES
ABERDEEN PROVING GROUND, MARYLAND

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER	MEMORANDUM REPORT NO. 2690
2. GOVT ACCESSION NO.	
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle)	GEOMETRIC PROCESSING AND ITS RELATIONAL GRAPHICS
5. TYPE OF REPORT & PERIOD COVERED	Final
6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s)	Morton A. Hirschberg
8. CONTRACT OR GRANT NUMBER(s)	ILIR Task #33
9. PERFORMING ORGANIZATION NAME AND ADDRESS	US Army Ballistic Research Laboratory Aberdeen Proving Ground, Maryland 21005
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	Project #1T161101A91A
11. CONTROLLING OFFICE NAME AND ADDRESS	US Army Materiel Development & Readiness Command 5001 Eisenhower Avenue Alexandria, Virginia 22333
12. REPORT DATE	OCTOBER 1976
13. NUMBER OF PAGES	14
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	
15. SECURITY CLASS. (of this report)	Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Graphics
Combinatorial Geometry
PATCH Code
Vulnerability Analysis
GIFT code
Manifold Theory
Digitization
Lethality Analysis

20. ABSTRACT (Continue on reverse side if necessary and identify by block number) (ams)

The results of a study using graphics for aiding vulnerability/lethality assessment are presented. Methods of target description and picture processing are also discussed. The need for a modern graphics system is shown and several graphics systems are briefly described.

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I. INTRODUCTION

The vulnerability and lethality analyses of weapons systems (tanks, helicopters, etc.) are heavily dependent upon a geometrical definition of the objects undergoing the analyses. Intimately associated with a geometric definition is the production of a picture from that geometric definition or vice-versa, the production of the geometric definition from a picture. In either event the process of producing a geometric definition, picturing an object, and performing the vulnerability and lethality calculations has been a costly, time-consuming effort.

In looking for ways to reduce the cost of the total analyses, the method of target description was chosen as the fundamental parameter of interest. There were several avenues to follow, these being:

1. given a particular method of target description, are there ways to reduce description cost?

2. among the methods of target description, is one method clearly superior to all the other methods?

3. assuming a target description, could the cost of producing pictures be reduced? and,

4. given a method of target description,could rudimentary vulnerability/lethality analyses be performed during the description/picturing phase?

While the above items seem loosely stated, operational definitions make more precise the meaning of each question. For instance, when one asks about the superiority of one method of target description over all the others, we must readily answer the question "Is the method cost effective?" That is, for the money invested does the method produce

1. timely results?

2. accurate results?

Speed and accuracy can be objectively determined and, therefore, one can take an object, define it using several methods, and make a comparative study of the methods employed.

It seemed reasonable, then, to assume that all aspects of the study would be neatly disposed of in short order. Oh were it only so!

Using the evidence at hand, the four questions posed earlier are simplistically answered as follows:

1. yes,

2. quite possibly,

3. slight in the context under which present analysis is performed, and

4. yes.

This paper will concern itself with the four questions asked and present supporting evidence to substantiate the rather tersely given answers.

II. METHODS OF TARGET DESCRIPTIONS

There were two major methods of target descriptions examined during this study. The first, the GIFT[1] code is a combinatorial geometric method using a catalog of 12 solid figures and the concept of intersection, union, and subtraction to combine solid into an object. The second, collectively refered to as "PATCH codes",[2] are typified by defining an object as a series of adjacent triangular or rectangular patches or surfaces (ruled surfaces may also be used).

The GIFT code embodies the Patch code concept in one of its solids, the ARS; however, processing of a many-faceted GIFT solid takes longer to process than its counterpart run in the PATCH code systems.

Both methods require some way of defining the basic building blocks of the system (e.g. GIFT uses a vertex and a radius to define a sphere; PATCH codes use three points to define a triangle. In addition, one needs a surface normal routine for each type of solid and a straight line-solid intersection routine for each type of solid in the catalog. Note, the PATCH codes need only a line normal to a plane routine and a line-plane intersection routine.

A more complete discussion of the two methods, their historical development, and some models which have been built using both methods may be found in reference 3.

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1 L.W. Bain, Jr. & M.J. Reisinger, "The GIFT Code USER Manual; Vol. I. Introduction and Input Requirements." BRL Report No. 1802, USA Ballistic Research Laboratories, Aberdeen Proving Ground, Maryland, July 1975. (AD #B006037L)

2 P. Bézier, <u>Numerical Control: Mathematics and Applications</u>, Wiley, NY, 1972.

3 G.B. Bennett, Jr. (ed.), "An Updated Summary of Aeronautical Systems Target Models for Vulnerability Analysis." Report No. ASD/XR-TR-75-9, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio, May 1975.

The Vulnerability/Lethality Division of the Ballistic Research Laboratory has adopted the GIFT code as its standard target description procedure. More will be said about this later.

III. REDUCING TARGET DESCRIPTION COST

The simplest way of reducing target description cost for vulnerability/lethality analyses would be to use the manufacturer's description of the vehicle. There are several problems with this approach. First, complete mathematical descriptions might not exist, so there would still be the need to define some subset of the object. Second, one would need to develop a vulnerability/lethality analysis interface for every vendor's target description. While many vendors use similar methods, they are not identical. Closely related to this is having the vendor provide the vulnerability/lethality analysis. This too has its problems, not the least of which is the validity of such analysis, let alone the veracity of the vendors. Finally, one can ask for a standardized description language; however, this again raises problems. Standards are not easily arrived at. In addition, the proprietary nature each vendor has which gives him a competitive edge, and hopefully reduces costs for the government, may be lost.

In lieu of the above, the next best solution for reducing cost is mechanization through the use of digitizing data.[4]

Reference 4 gives a method for digitizing GIFT code descriptions using the Bendix Datazied Digitizer. In addition, equipments built by several graphics manufacturers were evaluated solely on the basis of digitizing aids. Support for digitizing can be found in reference 5.

Although both of the above mentioned references concern themselves with GIFT code digitizations, similar digitizing methods can be employed for patch codes.

In essence we would prefer to describe a target once, striving for a suitable standard, and having a validated vulnerability/lethality analysis capability. The latter is a subject too large to be discussed here.

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4 M.A. Hirschberg & D.T. Jones, "Digitization of Data for Target Descriptions," BRL Report No. 1873, USA Ballistic Research Laboratories, Aberdeen Proving Ground, MD, April 1976. (AD #B011459L)

5 A. Morgan, "On the Preparation of Combinatorial Geometry Target Descriptions with Reference to Vulnerability and Lethality Analysis," BRL Interim Memorandum Report No. 511, USA Ballistic Research Laboratories, Aberdeen Proving Ground, MD, July 1976.

IV. MODEL SUPERIORITY

The author's personal preference is for the Patch codes as opposed to the GIFT code; however, the following will be as free from prejudice as possible.

The strongest feature of the GIFT code is that it is extremely accurate. By defining more and more solids and combining them into objects, one can be as precise as one cares to be. In addition, the catalog of solids can easily be increased with very little effort. There are some nice checking features in GIFT and it can produce pictures with hidden lines removed.

The weakest features of GIFT are that it takes a highly trained person to produce a target description in a reasonable length of time, the code is long running and costly, and it is very expensive to produce pictures.

In contrast, the Patch codes are less accurate unless one inputs myriads of points which becomes a tedious chore. In addition, debugging errors with thousands of points is very time consuming.

The strongest feature of the Patch codes is that they run extremely fast and pictures are cheap to produce.

In assessing the relative merits of the codes, one must realize that patch codes are excellent for surface definition; however, when one needs to consider interior spaces (such as shells), a great deal of definition is required.

As a last piece of information let us consider who uses which codes.

Reference 3 lists 33 models. Of these, 26 used Patch Codes, 6 used the GIFT code, and one used both Patch and GIFT. Therefore, the predominent codes used by the Air Force and Navy are Patch codes. In addition, NASA uses Patch codes[6] as well as those aircraft companies,[7,8,9] shipbuilding companies,[7] and automobile companies[2] who mathematically describe their products.

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6 C.R. Glatt & D.S. Hague, "ODIN: Optimal Design Integration System," NASA CR-2492, National Aeronautics and Space Administration, Washington, DC, February 1975.

7 R. Maier, Rockwell International, Personal Communication.

8 S.A. LaFavor & A.E. Doelling, "Some Implications of Interactive Computer Application to Aircraft Development," McDonnell Aircraft Co., St. Louis, Missouri.

9 R.E. Miller, Jr., "Structures Technology and the Impact of Computers," Boeing Commercial Airplane Co., Seattle, Washington.

The MAGI corporation (who originally developed a GIFT-like code for the BRL), the BRL, and those who interact with BRL use the GIFT codes. That is, most of the world does not use the GIFT code, but use Patch codes or other suitable surface definitions, such as Coon's surfaces.[10]

V. PICTURE PROCESSING

In the current context, the cost of processing pictures with GIFT cannot be significantly reduced (See Reference 5).

With new graphic devices[11,12,13] it would be possible to design and record for future use a part, an assembly, or even an entire object, depending on the level of complexity desired.

The Evans and Sutherland, and Vector General systems are refresh buffer systems and very sophisticated. The Computervision system is a storage tube system. Much of what Computervision does through software is done in firmware by Evans and Sutherland and Vector General. All are good systems and have their own special advantages. The Evans and Sutherland and Vector General systems are oriented toward dynamic displays suitable for scientists and engineers. Motion pictures can easily be made with such devices. The Computervision system seems more production oriented, especially in the area of wiring diagrams and systems.

The author would recommend having one of each; the refresh buffer system and storage tube system. The BRL is sadly lacking in its graphics capabilities and needs at least one good graphics system immediately. The applications for graphics abound. There is a group of people awaiting a graphics system, not only to work on vulnerability/lethality applications but other applications as well (e.g. fuel fires, breech failures, hydrocodes, etc.).

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[10] W.M. Newman & R.F. Sproull, Principles of Interactive Computer Graphics, McGraw-Hill, New York, 1973.

[11] "The Picture System," Evans and Sutherland, Form ES-PS-M-001-002, Salt Lake City, Utah, 1974.

[12] "Vector General 3400: Interactive Graphics Display," Vector General, Woodland Hills, California, 1976.

[13] "The Designer System," Computervision, 11-74-10M, Bedford, Massachusetts, 1974.

VI. VULNERABILITY/LETHALITY ANALYSIS

Graphic devices can play a major role in the calculation of vulnerability and lethality parameters. Once an object has been defined, its mass properties,[14,15] can easily be calculated. In fact, it is possible to develop a system for vulnerability/lethality analysis similar to design systems for reusable launch vehicles.[6] Such a system could calculate presented areas, volumes, moments of inertia, etc., for use in penetration and blast damage assessment models (e.g., the THOR[16] penetration equations.)

Mass properties such as presented area, center of gravity, moments of inertia, etc., form the basis for subsequent vulnerability/lethality analysis. In the PIPS system, for instance, after an object has been drawn, its mass properties are calculated and displayed. If one were designing, this interesting interactive computer-graphics mode of operation is highly desirable. One gets instant feedback. Once an object has all the attributes the designer likes, it is stored for future reference. In addition, PIPS provides a catalog of objects which may be dimensioned by the designer/user to suit his particular needs. Simple objects can be assembled from the catalog rapidly, displayed, and its mass properties calculated and displayed.

VII. DISCUSSION

The need for a first-class graphics system has been amply shown. In addition, some uses of graphics for vulnerability/lethality assessment have been detailed.

A test of the superiority of the PATCH codes versus the GIFT code is in progress. One vehicle is being described in both systems, so a comparative examination of the times to prepare the description and run the vulnerability analysis can be made. The results of this work will be reported shortly.

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[14] R.I. Isakower & F.R. Pepper, "PIPS - An Interactive Graphic Program for Determination of Mass Properties of Irregularly Shaped Planar Solids." Paper delivered at the 1976 Army Numerical Analysis and Computers Conference, Research Triangle Park, NC, February 1976.

[15] P.J. Norton & C.R. Glatt, "VAMP: A Computer Program for Calculating Volume, Area, and Mass Properties of Aerospace Vehicles," NASA, CR-2419, National Aeronautics and Space Administration, Wash., DC, September 1974.

[16] BRL Technical Report No. 47, "The Resistance of Various Non-Metallic Materials to Perforation by Steel Fragments; Empirical Relationships for Fragment Residual Velocity and Residual Weight," April 1961.

Left unresolved, however, even after the above test is made is how much detail one needs in a target description. Hopefully such work will also be accomplished in the near future.

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