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NASA TECH BRIEF

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Monte Carlo Direct View Factor and Generalized Radiative Heat Transfer Programs

The problem:

To develop a method to find the view factor from a surface segment to another surface segment and to find Radiative-Transfer Coefficients between the surface segments.

The solution:

A package of computer programs was written: (1) to find, using the Monte Carlo technique, the "black body" view factor from one surface segment to another surface segment defined on a primary surface; and (2) to define the primary surfaces (collection of simple geometric objects) in three-dimensional space, and find the radiative-transfer coefficients from a surface segment defined on a primary surface to all other surface segments defined in a real enclosure.

How it's done:

The Monte Carlo Direct View Factor Program uses the Monte Carlo technique to find the "black body" view factor from a surface segment defined on a primary surface to another surface segment defined on a primary surface. The collection of geometric objects (primary surfaces) includes a sphere, cylinder, cone, disc, and parallelogram.

The function of the program is numerical evaluation of the integral:

$$A_I F_{IJ} = A_J F_{JI} = \int_{\text{Surface I}} dA_I(\bar{x}_I) \int_{\text{Surface J}} dA_J(\bar{x}_J)\, B(\bar{x}_I, \bar{x}_J)\, H(\bar{x}_I, \bar{x}_J)$$

where $\bar{x}_I, \bar{x}_J$ are vectors representing points on surfaces I, J of area $A_{I, J}$. $B(\bar{x}_I, \bar{x}_J)$ is a blocking factor which is unity if $\bar{x}_I$ can "see" $\bar{x}_J$, and zero otherwise. $H(\bar{x}_I, \bar{x}_J) = \hat{n}_I \cdot (\bar{x}_J - \bar{x}_I)\, \hat{n}_J \cdot (\bar{x}_I - \bar{x}_J) / \pi|\bar{x}_I - \bar{x}_J|^4$, where $\hat{n}_I$ and $\hat{n}_J$ denote unit surface normal vectors.

The segment (or node) object numbers are obtained from the view factor command. The nodes are located in the definition table. From the nodes come the primary surface object numbers and K values. The primary surfaces are located in the definition table and copied into temporary storage. An error message is printed if nodes or primary surfaces are missing. The areas of the nodes are calculated and the canonical forms are generated for the subroutines:

1. Reset the interation sums and parameters
2. $N = N + 1$
3. Generate random points $\bar{x}_I$ and $\bar{x}_J$.

Two random numbers are obtained from a uniform distribution. These numbers are modified so that the points generated on the different surface window will cover the surfaces evenly. The surface points and normals are obtained using the subroutines.

The Generalized Radiative Heat Transfer Program finds radiative-transfer coefficients from a surface segment defined on a primary surface to all other surface segments defined in a real enclosure. The program permits radiation heat transfer analysis for enclosures containing surfaces which have, in general, both diffuse and specular reflectivities.

A geometric configuration is defined by the customer, consisting of a set of defining primary surfaces and their nodes. A primary surface may be a parallelogram, disc, cylinder, sphere, or cone. Nodes are defined as subsurfaces on the primary surfaces. One input data case consists of a geometric configuration together with commands for finding Script F's between objects within the configuration. Commands are executed as they are encountered; when a Script F command is encountered, the following operations are performed: The node summation areas are cleared

(continued overleaf)

to zero. These areas consist of "Script-F" sums for 1 and 2 wavelength nodes along with force and torque sums. The presence of these areas is entirely dependent upon the type of node being encountered. The counter for the total number of rays considered is set to zero. The counter is incremented by 1.

Notes:

1. The program is written in FORTRAN IV language for use on the IBM 360 computer.
2. At most, no more than 100 primary surface tests may be made per second. In addition, there is a relatively high machine-time cost for high-precision parametric results.
3. An advantage is the great generality of problems treatable and rapidity of solution from problem conception to receipt of results.
4. Inquiries concerning this program may be directed to:

   COSMIC
   Computer Center
   University of Georgia
   Athens, Georgia 30601
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Patent status:

No patent action is contemplated by NASA.

Source: James H. Scates and Jerry L. McWilliams
of The Boeing Company
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Marshall Space Flight Center
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