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FULL TEXT OF ARTICLE:

1. [Article by Dr. Jochen Winkler, VEB Robotron-Elektronik Dresden]

2. [Text] The K-1845 computer and its variety of peripheral equipment enables the user to format complicated and efficient CAD/CAM application solutions, the effective development of which can be achieved with the following basic graphic and geometric software:

3. --GKS1800 (2D) /1/ Implementation of the Graphic Core System (GKS) corresponding to ISO 7942 and TGL 44610;--GKS1800 (3D) Implementation of the Graphic Core System for Three Dimensions (GKS-3D) corresponding to ISO 8805 and TGL 44611 /2/;--GEKO1800 /2/ Geometric modeling software (border and CSG display) in polyhedron approximation;--GEMO1800 /3/ Geometric modeling system for linear and circular geometry; and--GBS1800 Complex CAD basic system for 3D mechanical construction.

4. The GKS1800 continues the trend in the GDR to provide the application programmer with a uniform, internationally standard graphic interface in all Robotron-produced computers. In addition, graphic data can be exchanged between various systems using the GKS1800 image data set. Various complex geometric modeling tools were

developed using GEKO, GEMO, and GBS1800 /4/. The most comprehensive system is GBS1800. It supports modeling, storage, processing, visualization, drawing preparation, and piece list generation of complicated 3D geometric objects in volume presentation. The following is an overview of the aforementioned software.

5. GKS1800 (2D)

6. The Graphic Core System (GKS) has been the international standard since 1985 for defining the graphic interface between an application program and a graphic system.

7. GKS1800 is a standardized implementation on the RVS K-1840/K-1845 computers with the SVP1800 or MUTOS1800 /5/ operating systems. FORTRAN-77 /6/ was selected as the language shell. The following devices are currently integrated into GKS1800:

8. --Intelligent Graphic Terminal IGT K-8918;-- Intelligent Graphic Terminal IGT K-8919;--A2 Plotter PLT K-6411;--A0 Digitizer DG K-6404/20/30;--Matrix Printer ND K-6313/14;--A0 Plotter DGF 1208 3.5G; and--selected imported devices.

9. Although the integration of additional devices is being planned, the user can also choose to add on devices himself.

10. GKS1800 achieves the maximum GKS performance level, level 2c. A variant at level 0a is also available for applications with few passive requirements.

11. In addition to the functions defined in the GKS-Standard, the GKS1800 contains numerous options for generating display elements. These include:

12. --22 type fonts (including Cyrillic);--128 seriph types;--circular arcs, sectors, or segments (filled in selectively);--elliptical arcs, sectors, or segments (filled in selectively);--disjoint polyline;--polygon (filled in selectively); and--rectangle (filled in selectively).

13. The GKS1800 image data set corresponds to the E add-on of the GKS-Standard /7/. Two codes (ASCII, RVS internal code) are possible. Data transfers, which were already produced with GKS1600 or DIG1600 /5,8/ are also possible for GKS image data sets.

14. GKS1800 is the result of close cooperation between **Wilhelm-Pieck University** Rostock and Robotron Dresden.

15. GKS1800 (3D)

16. Three-dimensional functionality is becoming increasingly necessary for many application solutions. Because GKS-2D has only limited applicability here, this task has been accomplished by the GKS-3D since 1988. Upward compatibility to the GKS-Standard is guaranteed by the fact that GKS-2D is a subset of GKS-3D. Every application program with a GKS-2D interface can immediately be run on GKS-3D implementations. Considerable expansions of the GKS-3D over the GKS-2D are:

17. --3D display elements;--fill field sequence (display element with border attributes);--3D system and transformation of coordinates including projection transformations; and--ability to connect with processes for removing hidden surfaces and edges (HLHSR).

18. GKS-3D is essentially a 3D system. Although it also contains 2D primitives for running application programs with a GKS connection, these are immediately converted into 3D display elements. In this way it is also possible to describe a planar object and subsequently manipulate it in a 3D space.

19. The following display elements are stipulated:

20. --continuous line (sequence of 3D points that are extended to interconnect;--polymarks (sequence of 3D points, each with an allocated centered symbol);-- text (character sequence at a defined position in a defined plane within the 3D space);--fill field (planar polygonal surface (hollow, colored, patterned, or hatched) on a defined plane within the 3D space);--fill field sequence (number of polygonal surfaces within a plane of the 3D space, which are processed together, with alternative display of the borders);--cell matrix (made from a parallelogram composed of single-sized and monochrome cells on a defined plane within the 3D space); and--generalized display element (VDEL) for using specific device intelligence for such things as circular or elliptical arcs.

21. The visibility of edges can be controlled using the fill field sequence display element. A fill field sequence can contain gaps; it also may not be continuous.

22. The number of attributes for the display elements was expanded compared with GKS-2D. GKS-3D contains, for example, not only border attributes, but also the new attributes HLHSR-flagging, HLSR-mode, and projection-index, which are allocated to every output primitive. HLHSR-flagging is used to create classes for HLHSR processing.

23. Depending on the work station, the HLHSR-mode attribute controls the selection of appropriate processes to solve the problem of hidden

edges and surfaces. Depending on the work area, the projection-index describes the standpoint and line of sight of the observer, as well as the type of projection (e.g. parallel, perspective), and the clip volume of the 3D scene.

24. GKS-3D contains five 3D coordinate systems:

25. --world coordinate system;--standardized coordinate system;--projection coordinate system;-- standardized projection coordinate system; and-- device coordinate system.

26. Transition between the coordinate systems is accomplished with the following transformations:

27. 1. The standardizing transformations are used in composing various partial images, which are described in their own (world) coordinate system in a common standardized coordinate system.

28. 2. The segment transformation is an image within the Standardized Coordinate System, whereby defined images (segments) can be inserted in accordance with the desired size and the arrangement of the partial images to one another.

29. 3. The standpoint and line of sight of the observer of the 3D scene is determined by the projection coordinate system. The projection orientation transformation is implemented with every point of the graphic display elements using matrix multiplication. GKS-3D contains help functions for producing the necessary 4 x 4 transformation matrix. The projection orientation transformation is followed by the projection image transformation, which supports the parallel or perspective projections. This transformation is also implemented using homogeneous coordinates by means of a 4 x 4 matrix and a 3D projection window.

30. 4. The device transformations are images of the 3D standardized projection coordinate system in the respective specific 3D device coordinate system. Because the graphic output devices allow only two-dimensional displays, the z-coordinate is disregarded after being used selectively in the HLHSR-processing.

31. GKS-3D supports the same input classes and modes as GKS-2D (locator, line giver, value giver, selector, picker, text giver). The difference lies in the 3D functionality. Analogous to the output pipeline, all inverse transformations are also images between 3D coordinate systems. The projection index and the standardizing transformation number characterize the inverse transformations. The results correspond to those of the GKS-2D, except for the input classes of locator and line giver. If there is no 3D input device

available (e.g. 3D digitizer), the z-coordinate can also be input via the keyboard or the value giver. GKS1800 (3D) is a standardized implementation /9/. It is completely upward compatible to the GKS1800 (2D). GKS1800 (3D) is available for the SVP1800 and in 1990 will be available for the MUTOS1800 as well. The GKS1800 (3D) was developed jointly by Robotron-Elektronik Dresden and **Wilhelm-Pieck University** Rostock.

32. GEKO1800

33. The modeling system GEKO1800 is a basic software for modeling 3D geometric objects in border and CSG displays. It has a special purpose language for defining, storing, modifying, and graphically displaying geometric objects /2,10/. GEKO1800 consists of three building blocks: the language portion, the geometry portion, and the output portion for passive graphic display. The GKS1800 is the graphic interface, and the operating system is SVP1800.

34. GEKO1800 is a 3D modeler for bodies with flat surfaces and borders. Set operations (union, average, difference) are defined on these objects.

35. The output portion contains sight and projection transformations, i.e. the standpoint and line of sight of the observer of the 3D scene can be selected as desired. Some views are already predefined (horizontal and vertical projection, side elevation, orthogonal projection, orthogonal axonometry (isometry, dimetry), cavalier projection). Hidden edges can be extracted.

36. In addition to the operations for defining and modifying geometric objects, rotation and translation operations are also possible.

37. One can work off GEKO1800 both in conversational and batch processing. It was developed by the Technical University Dresden.

38. GEMO1800

39. The GEMO1800 subprogram package is used to model, calculate, and construct geometric objects in a 3D space. It consists of three components:

40. --GEMO-G (modules for unit operations);--GEMO-P (modules for set-theoretical operations with polyhedrons); and-- GEMO-R (modules for rotation objects).

41. With the GEMO-G subprogram, calculations can be made between geometric objects (e.g. parallelism, section formation, distance

calculation) and constructions (e.g. of verticals and tangents).

42. With the GEMO-P subprograms one can model any kind of flat-surfaced, bordered geometric objects by means of modified set operations on elementary polyhedrons (e.g. parallelepipedons, prisms) and the bodies resulting from them. The description of the objects occurs in border representation.

43. With the GEMO-R subprograms one can model surfaces or bodies of rotation, which are composed of cone, cylinder, or torus portions. GEMO1800 includes the following geometric objects in the modeling:

44. --point;--curve (straight, segment, progression, circle, circular arc);--surface (polygonal surface, contoured surface, circular area, gliding plane, surface of rotation-- including cylinder, cone, and torus surface-- polyhedral surface); and--bodies (polyhedron, sphere, gliding planes, body of rotation--including cylinder, truncated cone, torus).

45. The available operations include:

46. --relationships test (incidence, parallelism, orthogonality);--metric unit operations (e.g. distance determination, angle calculation);-- geometric unit operations (connecting, cutting, constructing parallels, verticals, and tangents);--transformations (translation, rotation, scaling, reflection); and--modified set operations (union, average, difference).

47. GEMO1800 does not contain any display routines.

48. The user receives the GEMO subprograms in the form of an object module library. They are written in FORTRAN-77, and the operating system is SVP1800. Its geometry interface is the IGOO Interface /11/. As a basic software, the GEMO1800 can be used to rationally develop CAD user software. It was developed by the Technical University Dresden.

49. GBS1800

50. The geometric modular system GBS1800 is a CAD system, whose high efficiency makes it suitable for solving challenging tasks in the construction of spatial mechanical parts and componentry. It can be used in machine construction, automobile manufacture, equipment and plant engineering, in light industry and civil engineering. The GBS1800's integrated data bank system can store geometric, technical, and technological data. GBS1800 possesses numerous functions for modeling, visualization, dimensioning, drawing preparation, calculation, data management, piece list generation, provision of NC

data, and product data exchange (IGES Interface) of technical 3D objects.

51. GBS1800 can be used immediately as a turnkey interactive system. Dialog is supported by menu and window technology as well as by extensive information and help services.

52. GBS1800 can be connected directly to its own application solutions via its language interface. Because of the availability of all internal GBS routines, the language is highly functional, understands FORTRAN instructions, and runs via the internal data structure.

53. The functions of the GBS1800 are particularly numerous in its capacity as a volume-oriented CAD system for the modeling of geometric objects (CSG and border representations). In addition to the exact analytical description of the objects, there is a polyhedral convergence of the object surface in the data base, particularly for the support of graphic interaction.

54. The GBS1800 integrates the following object classes:

55. --points;--curves (progression, circular arcs, BEZIER curves, contours, bezels, roundings, construction subsidiary lines); --surfaces (closed curves, flat surfaces, polyhedral surfaces, BEZIER surfaces, rotation and translation surfaces);--bodies (prisms, cylinders, cones, bodies of rotation and translation, tubes, enveloping volumes with free-form surface bordering); and--drawings (combination of objects, e.g. componentry).

56. Creating parameters for geometric objects is also possible, such as performing set operations (union, average, difference).

57. The construction of mechanical piece parts is supported by many construction aids, whereby construction elements such as planes, vectors, axes, centers, lengths, factors, radii, and angles are used. Auxiliary constructions (e.g. medians, mean perpendiculars, verticals, normal lines, projections, and intersecting points) are also suited for this.

58. GBS1800 provides an efficient visualization of geometric objects, including:

59. --definition of up to 10 light sources and 16 projections simultaneously;--any standpoint and line of sight;-- parallel or perspective projections, including the use of predefined projections (e.g. horizontal, side, and vertical projection, axonometric projections, central projections; panoramic projections,

fisheyes);--selective extraction of hidden edges with lattice-sided display;--colored, tinted display of bodies using Gouraud tinging;--variable partitioning of the screen to display several projections simultaneously;-- interactive work in every projection through inverse visual transformation; and--zoom and pan functions.

60. A CAD-system for mechanical construction would be incomplete if it did not also contain user-friendly functions for dimensioning and drawing preparation. The following functions are available for dimensioning:

61. --semiautomatic dimensioning with direct transfer of the dimension drawings from the object data base;-- different measurement methods (circular, line, diameter, radius, and angle dimensioning);--text and symbol generators;--specification of tolerances and roughnesses;--ability to edit the dimensioning, including standard values and symbol tables;-- creation of one's own and modification of already existing character sets; and--large number of graphic attributes (e.g. line width, line type, seriph, text justification) for displaying dimensioned drawings.

62. The further usage of dimensioned objects to make complete construction drawings is also supported. In this way, drawing frames and title blocks can be defined and dimensioned objects can be positioned on the drawing as desired. Drawings can be stored separately, changed later, or transferred into a plot data set for output.

63. To support the design engineer, there are calculation functions to determine geometric (point coordinates, distances, angle, circumstance) and integral characteristics of objects (curve length, surface contents, volume, mass, center of gravity, moment of inertia). A collision test is also possible.

64. GBS1800 contains its own data management system for temporary and long-term storage of technical 3D objects and drawings. This includes depositing data in various hierarchically arranged data bases, which belong to a certain subproject or to an overriding project. Objects of general interest (e.g. standard tables, dimensioning tables, character sets, symbol tables) are stored in specific data bases. GBS1800 provides the definition of access rights for reading and writing on the specific data bases, so that a high degree of data security is achieved. The principle of referencing subobjects is applied in the data bases in order to avoid multiple storage.

65. The following modules are available for communicating with other systems:

66. --module for connecting with the VDA-FS surface interface;--module for connecting with the EGES 2.0 interface for product data exchange; and--module for transferring standard parts from a standard parts library.

67. A module for connection with the FEM is under development. Also planned are an expanded free-form surface module and modules for realizing NC-interfaces for boring, rotating, and 2.5-axis milling as well as 3- and 5-axis milling of free-form surfaces.

68. The technical device prerequisites are the RVS K-1840 or K-1845 computers (at least 8 MByte general memory and 70 MByte external memory) with the SVP1800 operating system. The graphic Display IGT K-8919 (19'' color monitor) and/or the EC-1834 and A-7150 personal computers with appropriate coupling software are used for graphic interaction. In addition, plotters produced by Robotron and suitable imported devices were integrated. The GBS1800 geometric modular system was a joint effort by Robotron-Elektronik Dresden, the Central Institute for Cybernetics and Information Processes, the GDR Academy of Sciences' Institute for Data Processing and Computer Technology, and **Wilhelm-Pieck University**. It is currently being upgraded with additional expansion levels.

69. All the aforementioned software packages can be obtained from Robotron Berlin/Magdeburg factory.

70. Footnotes

71. 1. Multiple authors: Graphic Core System (2D/3D), version 2.0 and 3.0 GKS1800--application description 6/88. Programming description:--information (version 1.0) 6/88--instructions for the systems analyst (version 1.0) 6/88--instructions for the programmer (version 1.0) 6/88--output advice

72. 2. Multiple authors: geometric construction (3D modeler, version 1.0 GEKO188--application description 11/ 87, programming description 11/87 .

73. 3. Multiple authors: GEMO1800 geometric modeling system--application description 9/88, programming description--instructions for the programmer 9/88

74. 4. Multiple authors: GBS1800 basic system, application description 9/89, system handbook 9/89, user handbook 5/89 (developmental version)

75. 5. Mikut, M.; Urban, B.: Graphic core system GKS1800 NTB 32

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76. 6. ISO 8651 Information Processing Systems-Computer Graphics, Graphical Kernel System (GKS), Language Bindings Part 1: FORTRAN Part 2: PASCAL Part 3: ADA Part 4: C

77. 7. ISO 7942 Information Processing Systems-Computer Graphics, Graphical Kernel System (GKS), Functional Description 1985

78. 8. Baier, W,; Mikut, M.: The image data set of the GKS1800 NTB 32 (1988) 4, pp. 103-107

79. 9. ISO 8805 Information Processing Systems-Computer Graphics, Graphical Kernel System for Three Dimensions (GKS-3D), International Standard Oct. 1988 10. Hartwig, A.; Mager, K.: 3D Modeling with GEKO, research texts, computer geometry (documentation), publication series WBZ/IV of the Technical University Dresden 86/86 11. Ludwig, Ml; Richter, Ch.; Klix, W.D.: Interface for geometric objects and operations (IGOO), Preprint Technical University Dresden, 1985, No. 07-05.85 12. ISO 8806 Information Processing Systems-Computer Graphics, Graphical Kernel System for Three Dimensions (GKS-3D), Language Bindings Part 1: FORTRAN Part 2: PASCAL Part 3: ADA Part 4: C 13. TGL 44510/01 Graphic Core System (GKS), 2D Graphics; Language Links, FORTRAN part 14. TGL 44530/13 Information Processing Terms and Definitions for Computer Graphics (ISO 2382) 15. TGL 44610 Graphic Core System (GKS), 2D Graphics 16. TGL 44611 Graphic Core System for Three Dimensions (GKS-3D)