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(74) Agent: **AXIS INTELLECTUAL CAPITAL PTE LTD**;
21A Duxton Road, Singapore 089487 (SG).

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(71) Applicant (for all designated States except US): **SINGAPORE INSTITUTE OF MANUFACTURING TECHNOLOGY** [SG/SG]; 71 Nanyang Drive, Singapore 638075 (SG).

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(72) Inventors; and

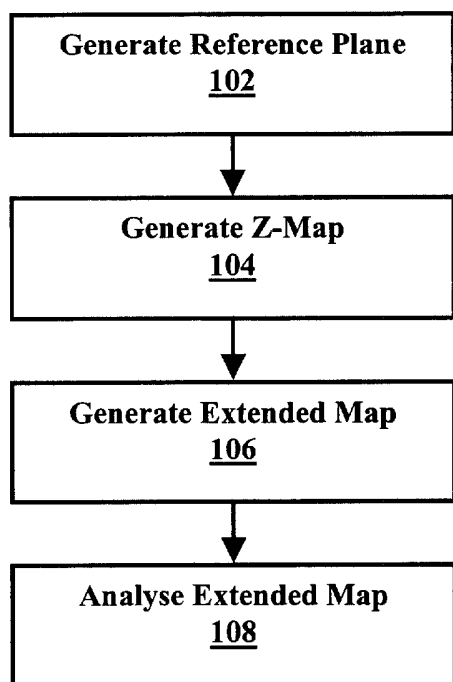
(75) Inventors/Applicants (for US only): **LIU, PeiLing** [SG/SG]; Block 826, Jurong West Street 81, #09-430, Singapore 640826 (SG). **LU, YiQiang** [CN/SG]; Block 923, Jurong West Street 92, #06-29, Singapore 640923 (SG). **AO, Yin Tai** [SG/SG]; Block 640, Choa Chu Kang Street 64, #05-09, Singapore 680640 (SG).

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(54) Title: AN OBJECT REPRESENTATION METHOD



(57) Abstract: Z-maps are conventionally employed as a format for representing objects. Data from the z-maps are readily extracted for use as coordinates in numerical control (NC) machines. A z-map uses a standard grid format with a plurality of grid points equally spaced apart to form a matrix. However, a presence of intricate features on a portion of a surface of the object results in a substantial increase in the number of grid points required by the z-map. The standard grid format of conventional z-maps requires the surface of the object to be segregated into at least two portions, for example a top face and a bottom face, and represented separately by multiple z-maps resulting in high object management complexity. An embodiment of the invention uses a combination of multiple z-maps and sub grid points for addressing the foregoing deficiencies of conventional z-maps.

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AN OBJECT REPRESENTATION METHOD

Field Of Invention

The present invention relates generally to an object representation method and
5 specifically to an object representation method implemented by an object
representation system for use in constructing a computer model of an object.

Background

Z-maps are conventionally employed as a format for representing objects. Data from
10 the z-maps are readily extracted for use as coordinates in numerical control (NC)
machines. A z-map uses a standard grid format with a plurality of grid points equally
spaced apart to form a matrix. General discussion of conventional z-maps can be
found in the following reference: B. K. Choi, *Surface Modeling for CAD/CAM*,
Elsevier, 1991, pp. 360-361.

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When using the z-maps, an increase in grid resolution for defining finer details
translates into an increase in the quantity of grid points required. Therefore, the
presence of intricate features on a portion of a surface of the object, which requires a
high grid resolution, results in a substantial increase in the number of grid points
20 required by the z-map.

United States Patent No. 6,363,298 by Shin describes a z-map construction process
for use in an apparatus for generating tool paths. In Shin, z-maps of both a surface
model and a solid model of an object are initially constructed. Subsequently, the z-
25 map construction process is used to integrate the z-maps to obtain a final z-map of the
object. Shin further describes a process for identifying features on the object. A
plurality of planes is used for partitioning the final z-map in order to identify different
features on the object. However, the conventional z-maps used in Shin does not
adequately represent the features of the object without increasing the grid resolution
30 for the entire z-map.

Furthermore, the standard grid format of conventional z-maps requires the surface of
the object to be segregated into at least two portions, for example a top face and a

bottom face, and represented separately by multiple z-maps resulting in high object management complexity.

5 A computer model generated from the conventional z-maps further requires a high level of processing power for rendering the computer model when the computer model is displaced virtually in a computing environment. Also, the high level of processing power results in a long processing time when a user changes the orientation of the computer model for viewing by the user via a graphical user interface. United States Patent No. 6,307,567 by Cohen describes a system for
10 extrapolating the virtual displacement of the model. However, the use of conventional rendering techniques, for example ray-tracing, still results in substantial time lag when the computer model is displayed to a user.

Hence, this clearly affirms a need for an object representation method for addressing
15 the foregoing disadvantages of conventional z-maps used for object representation.

Summary

An embodiment of the invention segregates at least one grid on a z-map grid into sub-grids. Only grids corresponding to intricate features on the surface of an object are
5 assigned sub-grids to improve representation of object features. A colour index is assigned to each grid point on the z-map grid and stored in a reference list containing cells corresponding to each grid point on the z-map. A computer model of the object is pre-rendered using the reference list onto a plurality of display lists corresponding to different portions of the computer model of the object. By recalling the required
10 display list for display when the computer model is virtually displaced, the time lag for displaying the computer model to a user is substantially reduced.

Therefore in accordance with a first aspect of the invention, there is disclosed an object representation method for use in constructing a computer model of an object,
15 the object representation method comprising the steps of:

providing geometric data of an object having a surface, the object constituting one of a physical object and a virtual object, and the geometric data being indicative of the surface of the object;

generating a reference plane having a z-axis being substantially perpendicular
20 to the reference plane;

constructing a z-map grid, the z-map grid being planar and substantially parallel to the reference plane;

constructing a first z-map of a first portion of the surface of the object, the first z-map being generated with reference to the z-map grid; and

25 constructing a second z-map of a second portion of the surface of the object, the second z-map being generated with reference to the z-map grid.

In accordance with a second aspect of the invention, there is disclosed an object representation system for use in constructing a computer model of an object, the
30 object representation system comprising:

means for providing geometric data of an object having a surface, the object constituting one of a physical object and a virtual object, and the geometric data being indicative of the surface of the object;

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means for generating a reference plane having a z-axis being substantially perpendicular to the reference plane;

means for constructing a z-map grid, the z-map grid being planar and substantially parallel to the reference plane;

5 means for constructing a first z-map of a first portion of the surface of the object, the first z-map being generated with reference to the z-map grid; and

means for constructing a second z-map of a second portion of the surface of the object, the second z-map being generated with reference to the z-map grid.

10 In accordance with a third aspect of the invention, there is disclosed an object representation model for use in constructing a computer model of an object, the object representation method comprising:

geometric data of an object having a surface, the object constituting one of a physical object and a virtual object, and the geometric data being indicative of the surface of the object;

15 a reference plane being constructed from a three-dimensional coordinate system having x, y and z axes;

a z-map grid, the z-map grid being planar and substantially parallel to the reference plane, the z-map grid comprising:

20 an array of first ruled and second ruled lines, the first ruled lines being parallel to the x-axis and being spaced apart along the y-axis of the coordinate system, the second ruled lines being parallel to the y-axis and being spaced apart along the x-axis of the coordinate system and the second ruled lines intersecting the first ruled lines at a plurality of junctions, and

25 an extended z-map comprising first and second z-maps respectively corresponding to first and second portions of the surface of the object, the first and second z-maps being generated with reference to the z-map grid and each of the first and second z-maps comprising:

30 a primary grid point at each of the plurality of junctions, each primary grid point having a z-value, the z-value being a distance between the primary grid point and the corresponding portion of the surface of the object;

at least one secondary grid point between each adjacent pair of primary grid points, the at least one secondary grid point being equally spaced apart

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along a planed formed by the array of first ruled lines and each of the at least one secondary grid point having an e-value, the e-value being a distance between the secondary grid point and the corresponding portion of the surface of the object; and

5 an array of at least one intermediate grid point on the z-map grid, each of the at least one intermediate grid point being disposed between each adjacent pair of secondary grid points and having an i-value, the i-value being a distance between each intermediate grid point and the corresponding portion of the surface of the object.

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Brief Description Of The Drawings

Embodiments of the invention are described hereinafter with reference to the following drawings, in which:

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FIG. 1 shows a process flow diagram of an object representation method according to an embodiment of the invention;

FIG. 2 shows a front sectional view of an object represented by an object representation system using the object representation method of FIG. 1;

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FIG. 3a shows a plan view of a z-map grid generated for the object of FIG. 2 using the object representation method;

25 FIG. 3b shows an exploded plan view of a portion of the z-map grid of FIG. 3a;

FIG. 4 shows a process flow diagram of generating a z-map in a step of the object representation method of FIG. 1;

30 FIG. 5 shows a process flow diagram of generating an extended map in a step of the object representation method of FIG. 1;

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FIG. 6 shows a process flow diagram of analysing an extended z-map in a step of the object representation method of FIG. 1;

FIG. 7 shows a process flow diagram of generating an image on a display list in a step
5 of analysing the extended z-map of FIG. 6; and

FIG. 8 shows a reference colour list generated for the object of FIG. 2 using the object representation method of FIG. 1.

10 Detailed Description

An object representation method for addressing the foregoing problems is described hereinafter.

15 An embodiment of the invention, an object representation method 100 is described with reference to FIG. 1, which shows a process flow diagram of an object representation method, FIG. 2, which shows a front sectional view of an object 22 in accordance with the object representation method 100 and FIG. 3a. The object representation method 100 of FIG. 1, is implemented using an object representation
20 system (not shown). The object representation system is computer-based and for maintaining a virtual representation of the object 22 as shown in FIG. 2.

An object 22 constitutes a physical object. Geometric data of the object 22, for example a plurality of 3-D coordinates, is obtained by digitising the existing object or
25 by modelling a projected object within a virtual environment. The geometric data is indicative of a surface 26 of the object 22 and typically being used for tessellating the surface 26 of the object 22 in a virtual environment. The geometric data of the object 22 is preferably stored in an XGL format on the object representation system for facilitating extraction and data exchange of the geometric data.

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The object representation system constructs a three-dimensional coordinate system having x, y and z-axes (all not shown). Using the x and y-axes in a step 102 of FIG. 1, the object representation system defines a reference plane (not shown) being

parallel to both the x and y-axes. The z-axis 33 is generally perpendicular to the reference plane. The object 22 has a first portion 34 and a second portion 36.

5 In a step 104 of FIG. 1, both a first z-map 38 and a second z-map 40 are generated for the first portion 34 and the second portion 36 respectively of the surface 26 for the reference plane. The first z-map 38 is spatially coincident with the second z-map 40. Each of the first z-map 38 and the second z-map 40 has a corresponding z-map grid 42 as shown in FIG. 3a. The z-map grids 42 of both the first and second z-maps 38/40 are planar and generally parallel to the reference plane.

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To obtain the z-map grid 42, the object representation system generates an array of first ruled and second ruled lines, the first ruled lines being parallel to the x-axis and being spaced apart along the y-axis of the coordinate system, the second ruled lines being parallel to the y-axis and being spaced apart along the x-axis of the coordinate system. The second ruled lines intersect the first ruled lines at a plurality of junctions as shown in FIG. 3a.

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Each of the first and second z-maps 38/40 is constructed by firstly generating a plurality of primary grid points 44 at each of the plurality of junctions on the corresponding z-map grid 42 in a step 120 of FIG. 4, which shows a process flow diagram relating to the step 104 for generating each of the first and second z-maps 38/40. With reference to FIG. 3a, the primary grid points 44 are arranged in rows and columns on the corresponding z-map grid 42 with the rows and columns being equally spaced and having a primary grid resolution 48. The primary grid resolution 48 is the distance between each adjacent pair of rows and columns formed by the primary grid points 44. In a step 122 of FIG. 4, a z-value is generated for each of the plurality of primary grid points 44. The z-value is a distance between each of the primary grid points 44 and the corresponding portion 34/36 of the surface 26 of the object 22.

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The surface 26 of the object 22 usually possess an appreciable level of surface features, for example protrusions, patterns, curvatures and the like surface features having a certain size. Usually, the primary grid resolution 48 is determined by the

size of these surface features. However, where only certain regions of the surface 26 of the object 22 possesses such surface features, the use of a small primary grid resolution 48 results in an increase in the quantity of primary grid points 44 required to generate the first and second z-maps 38/40 for the object 22.

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The object representation method 100 uses extended maps 50 to reduce primary grid point 44 redundancies. The z-map grids 42 are dimensioned to accommodate the object 22 of FIG. 2. The primary grid resolution 48 is pre-determined by the object representation system based upon dimension of the z-map grids 42. An extended map 50 is then generated for each of the first and second z-maps 38/40 in a step 106 of FIG. 1. The extended map 50 is used for regions of the surface 26 of the object where intricate features exist and where the intricate features require a higher resolution than that provided by the primary grid resolution 48.

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15 The extended map 50 comprises a plurality of secondary grid points 52 for defining and being representative of regions of the surface 26 having the intricate features. When intricate features are identified by the object representation system, the plurality of secondary grid points 52 are generated, in a step 124 of FIG. 5, and disposed spaced apart between each adjacent pair of the array of first ruled lines. FIG. 5 shows
20 a process flow diagram relating to the step 106 for generating the extended map 50. The plurality of secondary grid points 52 and primary grid points 44 are grouped into a plurality of clusters (not shown) with each of the plurality of clusters containing at least one of the plurality of secondary grid points 52 and at least one of the plurality of primary grid points 44. The at least one of the plurality of secondary grid points 52
25 in each cluster being representative of a particular region on the surface 26 of the object 22 having the intricate features.

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The model representation system contains a history database having a plurality of cluster records (all not shown). Each cluster record corresponds to one of the plurality of clusters. Preferably, each cluster record comprises of information indicating how the primary grid points 44 were created, for example, computer numerical code (CNC) data, geometrical data imported from a data file or amendments made to the object 22 and thereby to the primary grid points 44 and

secondary grid points 52 contained in the corresponding clusters. Preferably, each cluster record is updated with any changes made to the first z-map 38, second z-map 40 and the corresponding extended maps 50.

- 5 An e-value is generated for each secondary grid points 52 in a step 126 of FIG. 5. The e-value is a distance between each of the plurality of secondary grid points 52 and the corresponding portion 34/36 of the surface 26 of the object 22.

The extended map 50 further comprises of an array of intermediate grid points 54 on
10 each of the z-map grids 42 as shown in FIG. 3b. The intermediate grid points 54 are generated by the object representation system in a step 127a of FIG. 5 and are disposed between each adjacent pair of secondary grid points 52. An i-value is generated for each of the intermediate grid points 54 in a step 127b of FIG. 5, with the i-value being a distance between each of the intermediate grid points 54 and the
15 corresponding portion 34/36 of the surface 26 of the object 22.

Data generated from the generation of the first and second z-maps 38/40 and the corresponding extended maps 50 is extracted by the object representation system for generating an extended z-map (not shown) in a step 108 of FIG. 1.

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The object representation method 100 is applicable to, for example, the production of a mold for molding a plastic part. A representation of the object 22, the plastic part, is first generated using a three-dimensional (3-D) modelling software, the representation being the aforementioned geometric data. Alternatively, a digitising tool can be used
25 to generate the representation of the object 22. The plastic part is segregated into two portions for each portion to be individually molded by defining a parting line on the object 22. The parting line defines the periphery of a parting surface for segregating the object 22 into two portions with the parting surface forming an interface between the two portions of the object 22. A wire-frame model is preferably used for
30 indicating the parting surface. The object representation method 100 is applied to the object 22 to obtain the extended z-map as aforementioned in the steps 124 to 128 of FIG. 5. The extended z-map can then be readily used by a numerical control (NC) system for manufacturing the mold.

The extended z-map enables a user to visually inspect a computer model (not shown) constructed from the extended z-map. Besides being readily usable by an NC system, the extended z-map enables a computer model (not shown) of the object 22, the object 5 22 being for example the mold, to be graphically constructed from the extended z-map for visual inspection by the user.

A workstation (not shown), which is a computer-based system, is used for analysing the extended z-map generated by the object representation system in a step 108 of 10 FIG. 1. The workstation constructs the computer model of the object 22 from the extended z-map for analysis by a user.

The workstation constructs the computer model from the extended z-map. The workstation further generates a view-point for viewing an image of the object 22 in a 15 step 130 of FIG. 6, the view-point being a virtual representation of a point from which a user views the image of the computer model. FIG. 6 shows a process flow diagram of analysing the extended z-map according to the step 106. The workstation receives a plurality of inputs from the user in a step 132 of FIG. 6. The plurality of inputs received by the workstation comprises a display scaling factor and a computer model 20 orientation. The display scaling factor determines the distance between the view-point and the object 22 and thereby determining the size of the computer model as it appears to the user. The computer model orientation determines the orientation of the computer model as viewed by the user.

25 The workstation positions the view-point at an orientation and a distance from the computer model in a step 134 of FIG. 6, with the orientation and the distance being a function of the plurality of inputs. The workstation captures the image of the computer model on a plurality of display lists by generating a portion of the image of the computer model on each of the plurality of display lists in a step 136 of FIG. 6, 30 wherein the image of the computer model is generated with reference to the view-point.

In the step 136, the image of the computer model is generated by first determining a portion of the object 22 to be displayed with reference to the view-point in a step 150 of FIG. 7. FIG. 7 shows a process flow diagram of generating an image on the plurality display lists according to the step 136. In a step 152, the display scaling factor and the portion of the object 22 determines a combination of any of the primary grid points 44, secondary grid points 52 and intermediate grid points 54 for use in generating the image of the computer model. Using the combination of any of the primary grid points 44, secondary grid points 52 and intermediate grid points 54, a reference colour list 70 having a plurality of cells 72, as shown in FIG. 8, is generated in a step 154 of FIG. 7. FIG. 8 shows the reference colour list 70 generated for the object 22. Each of the plurality of cells 72 corresponds to each of the combination of the primary, secondary and intermediate grid points 44/52/54, as shown in FIG. 3a, of the extended z-map with reference to the plurality of inputs received from the user. Next, a colour index is assigned to each of the plurality of cells 72, the colour index 74 being indicative of the colour of a point on the surface 26 of the computer model corresponding to one of the primary grid points 44 and the secondary grid points 52 in a step 156. The colour of each corresponding point on the surface of the computer model is pre-calculated by the workstation based on a surface normal and a light angle of a corresponding point on the surface 26 of the computer model.

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In a step 158 of FIG. 7, each of the at least one display list is associated with at least one of the plurality of cells 72 of the reference colour index 70. The plurality of cells 72 associated with the at least one display list corresponds to the portion of the image generated by the at least one display list.

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Depending on the plurality of inputs received from the user, for example the zoom factor, a corresponding one of the at least one display list containing a corresponding portion of the image of the object 22 is selected for display to the user. The portion of the image on the selected display list is rendered, in a step 138 of FIG. 6, based on the colour index 74 of the corresponding at least one of the plurality of cells 72. The rendered portion of the image is displayed to the user via a display device (not shown), for example, a computer monitor, in a step 139 of FIG. 6.

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By rendering one portion of the image based on the plurality of input received from the user, the time required for rendering the portion of the image for display to the user is substantially reduced when compared to conventional processes that renders an entire image of an computer model.

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As aforementioned, the object representation method 100 utilises the extended maps 50 for representing intricate features on the surface of the object 22. The selective use of the extended map for representing the intricate features moves away from conventional practices of using z-maps with a high grid resolution. These high grid resolution z-maps are highly computation parasitic. Furthermore, the extended maps 50 enables selective use of grid points for generating an image of the object 22, thereby leading to substantial improvements in image rendering performance.

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In the foregoing manner, an object representation method implemented by an object representation system is described according to an embodiment of the invention for addressing the foregoing disadvantages of conventional object representation methods. Although only one embodiment of the invention is disclosed, it will be apparent to one skilled in the art in view of this disclosure that numerous changes and/or modification can be made without departing from the scope and spirit of the invention.

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Claims

1. An object representation method for use in constructing a computer model of an object, the object representation method comprising the steps of:
 - 5 providing geometric data of an object having a surface, the object constituting one of a physical object and a virtual object, and the geometric data being indicative of the surface of the object;
 - generating a reference plane having a z-axis being substantially perpendicular to the reference plane;
 - 10 constructing a z-map grid, the z-map grid being planar and substantially parallel to the reference plane;
 - constructing a first z-map of a first portion of the surface of the object, the first z-map being generated with reference to the z-map grid; and
 - constructing a second z-map of a second portion of the surface of the object, the second z-map being generated with reference to the z-map grid.
2. The object representation method as in claim 1, the step of generating a reference plane comprising the steps of:
 - 20 constructing a coordinate system being three-dimensional and having x, y and z axes; and
 - defining the reference plane, the x and y axes of the coordinate system being parallel to the reference plane.
3. The object representation method as in claim 2, the step of constructing a z-map grid comprising the steps of:
 - 25 generating an array of first ruled and second ruled lines, the first ruled lines being parallel to the x-axis and being spaced apart along the y-axis of the coordinate system, the second ruled lines being parallel to the y-axis and being spaced apart along the x-axis of the coordinate system and the second ruled
 - 30 lines intersecting the first ruled lines at a plurality of junctions; and
 - defining a primary grid point at each of the plurality of junctions.

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4. The object representation method as in claim 3, wherein each of the step of constructing a first z-map and the step of constructing a second z-map comprises a step of:
- 5 generating a z-value for each primary grid-point from the geometric data, the z-value being a distance between the primary grid point and the corresponding portion of the surface of the object.
5. The object representation method as in claim 4, further comprising a step of:
- 10 constructing an extended map for each of the first z-map and the second z-map of the corresponding one of the at least one reference plane.
6. The object representation method as in claim 5, further comprising a step of:
- 15 extracting data from the first z-map, second z-map and the corresponding extended maps; and
- generating an extended z-map from the extracted data.
7. The object representation method as in claim 6, the step of constructing an extended map comprising the steps of:
- 20 generating at least one secondary grid point between each adjacent pair of the array of first ruled lines, the at least one secondary grid point being equally spaced apart along a plane formed by the array of first ruled lines; and
- generating an e-value for each of the at least one secondary grid point, the e-value being a distance between the secondary grid point and the
- 25 corresponding portion of the surface of the object.
8. The object representation method as in claim 7, wherein the step of constructing an extended map further comprising the steps of:
- 30 generating at least one intermediate grid point on the z-map grid, each of the at least one intermediate grid point being disposed between each adjacent pair of secondary grid points; and

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generating an i-value for each of the at least one intermediate grid point, the i-value being a distance between each intermediate grid point and the corresponding portion of the surface of the object.

- 5 9. The object representation method as in claim 8, further comprising a step of analysing the computer model of the object by a user.
- 10 10. The object representation method as in claim 9, wherein the step of analysing the computer model of the object by a user comprising the steps of:
- 10 constructing the computer model from the extended z-map;
 providing a view-point for viewing an image of the computer model, the view-point being a virtual representation of a point from which a user views the image of the computer model;
 capturing the image of the computer model on at least one display list, the image of the object being captured from the view-point, and the display list being representative of the captured image of the computer model; and
15 displaying the image of the computer on a display device.
- 20 11. The object representation method as in claim 10, the step of capturing an image of the computer model on at least one display list comprising the steps of:
- receiving at least one input, the at least one input being one of pre-defined and received from the user;
 positioning the view-point at an orientation and a distance from the computer model, the orientation and the distance being a function of the input; and
25 generating the image of the computer model on the at least one display list, the image of the computer model being generated with reference to the view-point.
- 30 12. The object representation method as in claim 11, wherein the at least one input comprising a display scaling factor and a computer model orientation.

13. The object representation method as in claim 11, the step of generating the image of the computer model on the at least one display list comprising the steps of:
- 5 generating a reference colour list having a plurality of cells, each of the plurality of cells corresponding to each of the primary, secondary and intermediate grid points of the extended z-map;
- associating each of the at least one display list with at least one of the plurality of cells;
- 10 assigning a colour index based on the at least one input to each of the plurality of cells, the colour index being indicative of the colour of a point on the surface of the object corresponding to one of the primary grid point and the secondary grid point; and
- rendering the image of the computer model on the at least one display based on the colour index of at least one of the plurality of cells.
- 15
14. An object representation system for use in constructing a computer model of an object, the object representation system comprising:
- means for providing geometric data of an object having a surface, the object constituting one of a physical object and a virtual object, and the geometric data being indicative of the surface of the object;
- 20 means for generating a reference plane having a z-axis being substantially perpendicular to the reference plane;
- means for constructing a z-map grid, the z-map grid being planar and substantially parallel to the reference plane;
- 25 means for constructing a first z-map of a first portion of the surface of the object, the first z-map being generated with reference to the z-map grid; and
- means for constructing a second z-map of a second portion of the surface of the object, the second z-map being generated with reference to the z-map grid.
- 30
15. The object representation system as in claim 14, the means for generating a reference plane comprising:

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means for constructing a coordinate system having x, y and z axes; and

means for defining the reference plane, the x and y axes of the coordinate system being parallel to the reference plane.

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16. The object representation system as in claim 15, the means for constructing a z-map grid comprising:

means for generating an array of first ruled and second ruled lines, the first ruled lines being parallel to the x-axis and being spaced apart along the y-axis of the coordinate system, the second ruled lines being parallel to the y-axis and being spaced apart along the x-axis of the coordinate system and the second ruled lines intersecting the first ruled lines at a plurality of junctions; and

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means for defining a primary grid point at each of the plurality of junctions.

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17. The object representation system as in claim 16, wherein each of the means for constructing a first z-map and the means for constructing a second z-map comprising:

means for generating a z-value for each primary grid-point from the geometric data, the z-value being a distance between the primary grid point and the corresponding portion of the surface of the object.

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18. The object representation system as in claim 17, further comprising:
- means for constructing an extended map for each of the first z-map and the second z-map of the corresponding one of the at least one reference plane.

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19. The object representation system as in claim 18, further comprising:
- means for extracting data from the first z-map, second z-map and the corresponding extended maps; and
- means for generating an extended z-map from the extracted data.

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20. The object representation system as in claim 19, the means for constructing an extended map comprising:
- 5 means for generating at least one secondary grid point between each adjacent pair of the array of first ruled lines, the at least one secondary grid point being equally spaced apart along a plane formed by the array of first ruled lines; and
- means for generating an e-value for each of the at least one secondary grid point, the e-value being a distance between the secondary grid point and the corresponding portion of the surface of the object.
- 10 21. The object representation system as in claim 20, wherein the means for constructing an extended map further comprising:
- means for generating at least one intermediate grid point on the z-map grid, each of the at least one intermediate grid point being disposed between
- 15 each adjacent pair of secondary grid points; and
- means for generating an i-value for each of the at least one intermediate grid point, the i-value being a distance between each intermediate grid point and the corresponding portion of the surface of the object.
- 20 22. The object representation system as in claim 21, further comprising means for analysing the computer model of the object by a user.
23. The object representation system as in claim 22, wherein the means for analysing the computer model of the object by a user comprising:
- 25 means for constructing the computer model from the extended z-map;
- means for providing a view-point for viewing an image of the computer model, the view-point being a virtual representation of a point from which a user views the image of the computer model;
- means for capturing the image of the computer model on at least one
- 30 display list, the image of the object being captured from the view-point, and the display list being representative of the captured image of the computer model; and
- means for displaying the image of the computer on a display device.

24. The object representation system as in claim 23, the means for capturing an image of the computer model on at least one display list comprising:
- 5 means for receiving at least one input, the at least one input being one of pre-defined and received from the user;
- means for positioning the view-point at an orientation and a distance from the computer model, the orientation and the distance being a function of the input; and
- 10 means for generating the image of the computer model on the at least one display list, the image of the computer model being generated with reference to the view-point.
25. The object representation system as in claim 24, wherein the at least one input comprising a display scaling factor and a computer model orientation.
- 15 26. The object representation system as in claim 24, the mean for generating the image of the computer model on the at least one display list:
- means for generating a reference colour list having a plurality of cells, each of the plurality of cells corresponding to each of the primary, secondary and intermediate grid points of the extended z-map;
- 20 means for associating each of the at least one display list with at least one of the plurality of cells;
- means for assigning a colour index based on the at least one input to each of the plurality of cells, the colour index being indicative of the colour of
- 25 a point on the surface of the object corresponding to one of the primary grid point and the secondary grid point; and
- means for rendering the image of the computer model on the at least one display based on the colour index of at least one of the plurality of cells.
- 30 27. An object representation model for use in constructing a computer model of an object, the object representation method comprising:

geometric data of an object having a surface, the object constituting one of a physical object and a virtual object, and the geometric data being indicative of the surface of the object;

5 a reference plane being constructed from a three-dimensional coordinate system having x, y and z axes;

a z-map grid, the z-map grid being planar and substantially parallel to the reference plane, the z-map grid comprising:

10 an array of first ruled and second ruled lines, the first ruled lines being parallel to the x-axis and being spaced apart along the y-axis of the coordinate system, the second ruled lines being parallel to the y-axis and being spaced apart along the x-axis of the coordinate system and the second ruled lines intersecting the first ruled lines at a plurality of junctions, and

15 an extended z-map comprising first and second z-maps respectively corresponding to first and second portions of the surface of the object, the first and second z-maps being generated with reference to the z-map grid and each of the first and second z-maps comprising:

20 a primary grid point at each of the plurality of junctions, each primary grid point having a z-value, the z-value being a distance between the primary grid point and the corresponding portion of the surface of the object;

25 at least one secondary grid point between each adjacent pair of primary grid points, the at least one secondary grid point being equally spaced apart along a planed formed by the array of first ruled lines and each of the at least one secondary grid point having an e-value, the e-value being a distance between the secondary grid point and the corresponding portion of the surface of the object; and

30 an array of at least one intermediate grid point on the z-map grid, each of the at least one intermediate grid point being disposed between each adjacent pair of secondary grid points and having an i-value, the i-value being a distance between each intermediate grid point and the corresponding portion of the surface of the object.

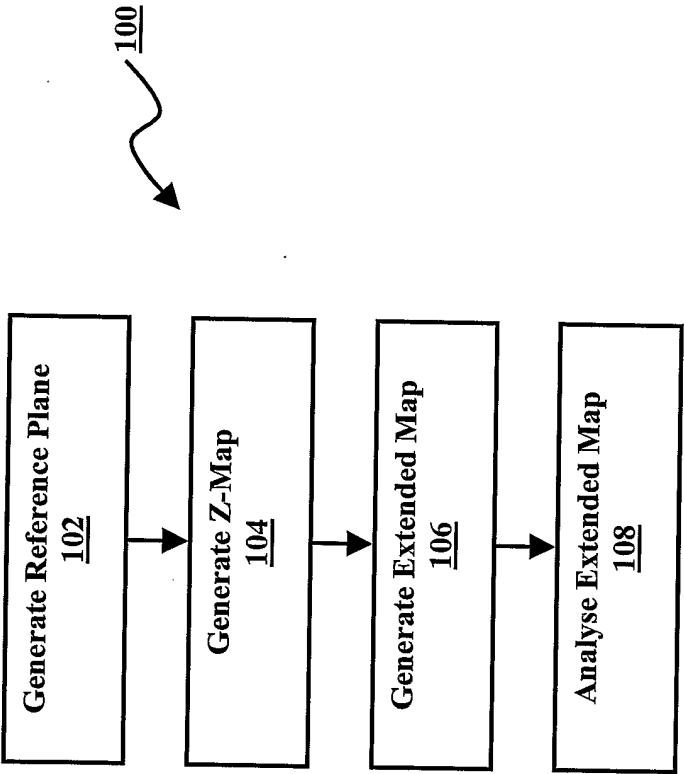


FIG. 1

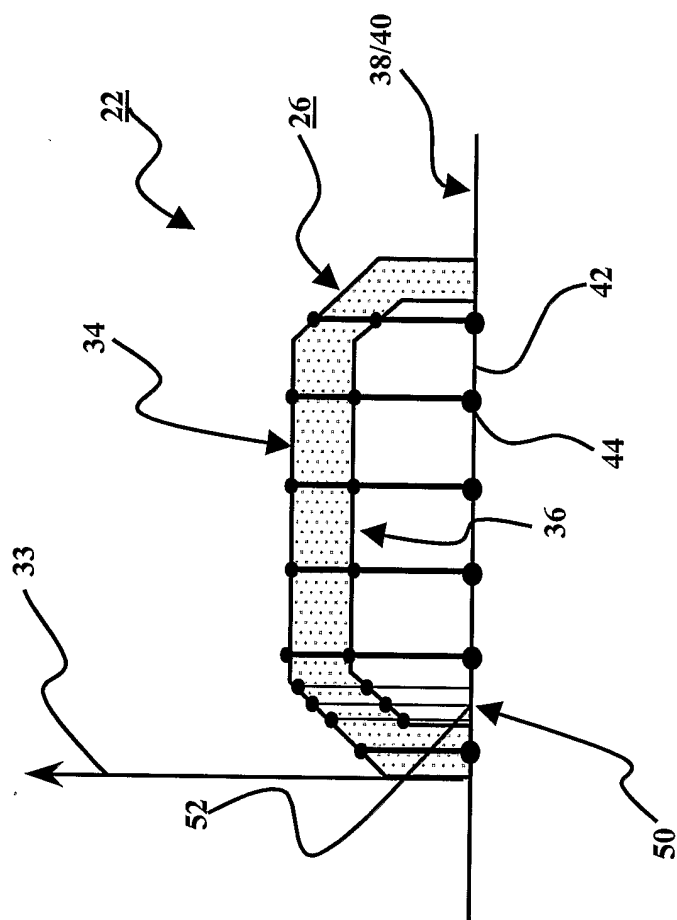
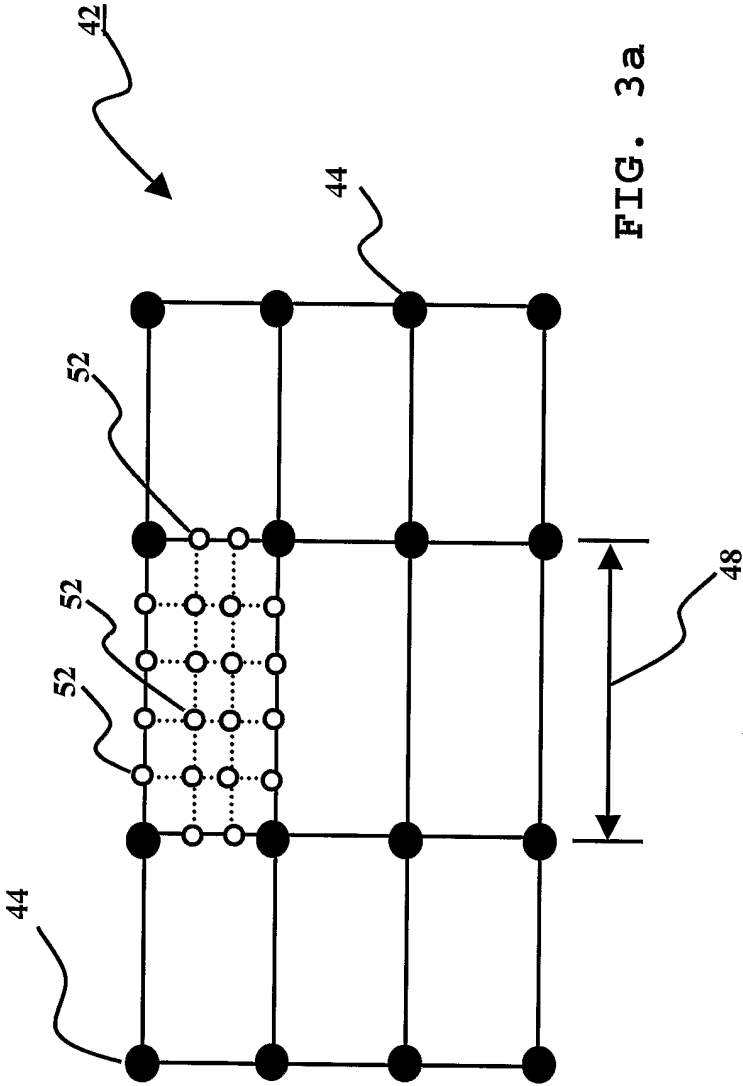


FIG. 2



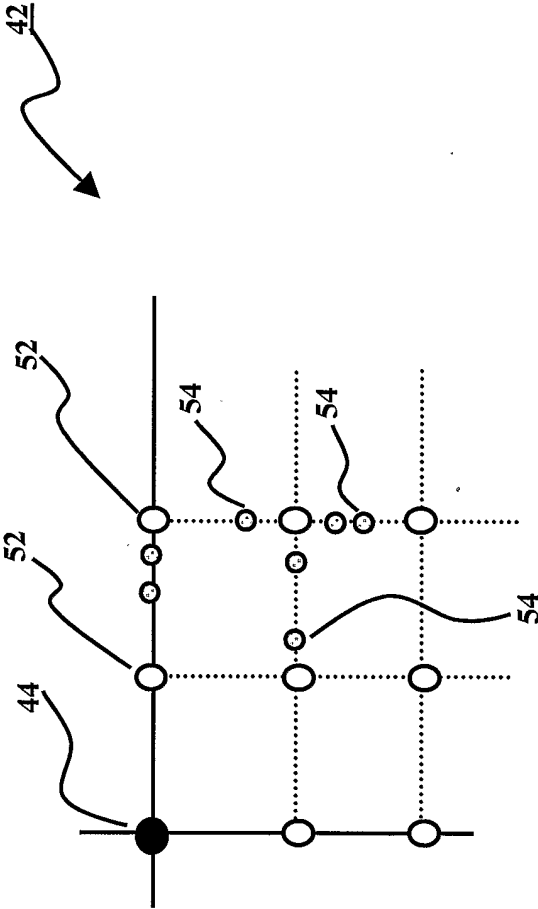


FIG. 3b

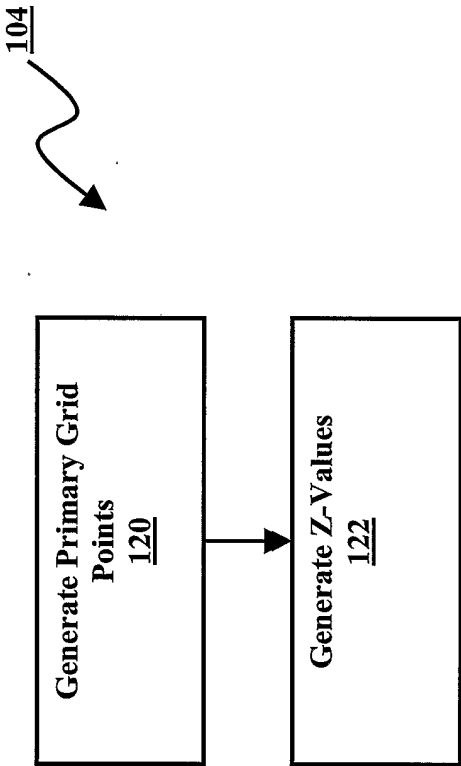
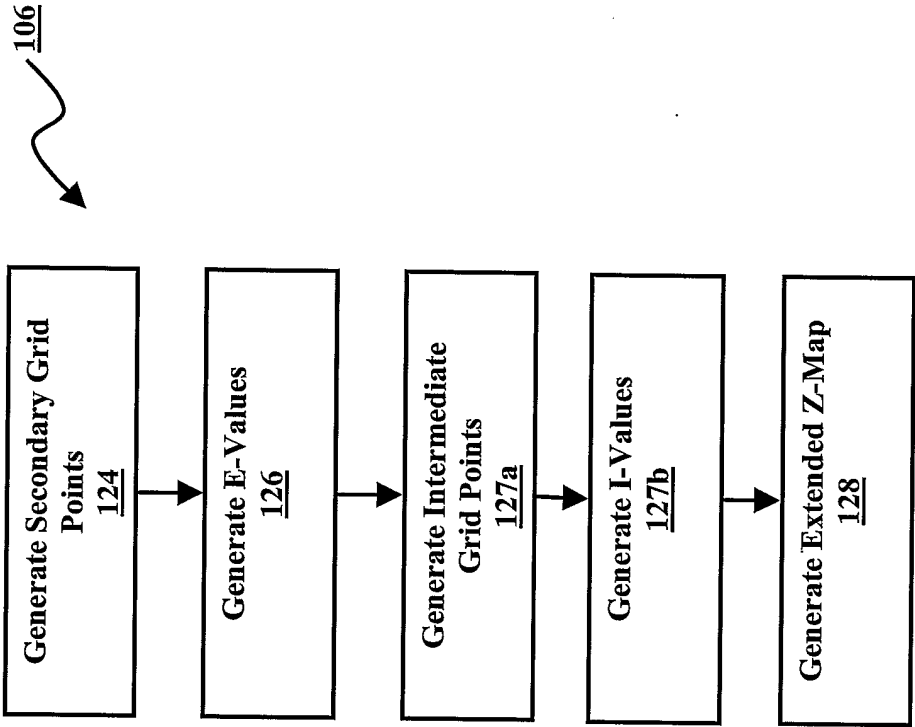


FIG. 4

FIG. 5



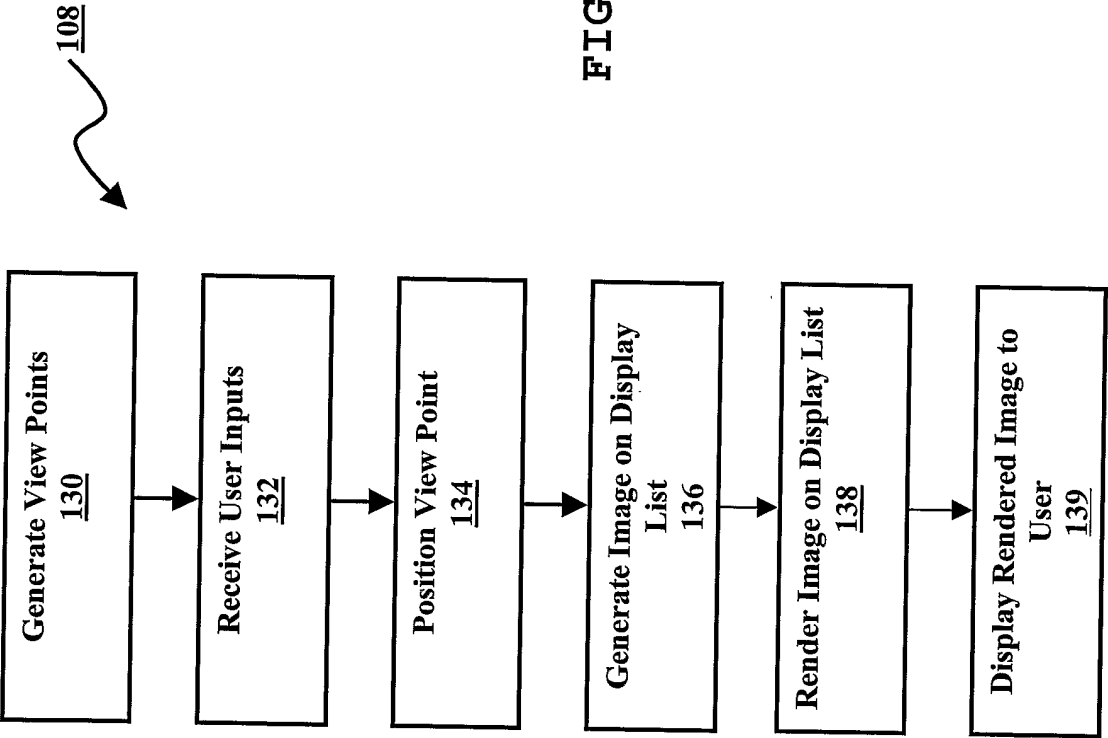


FIG. 6

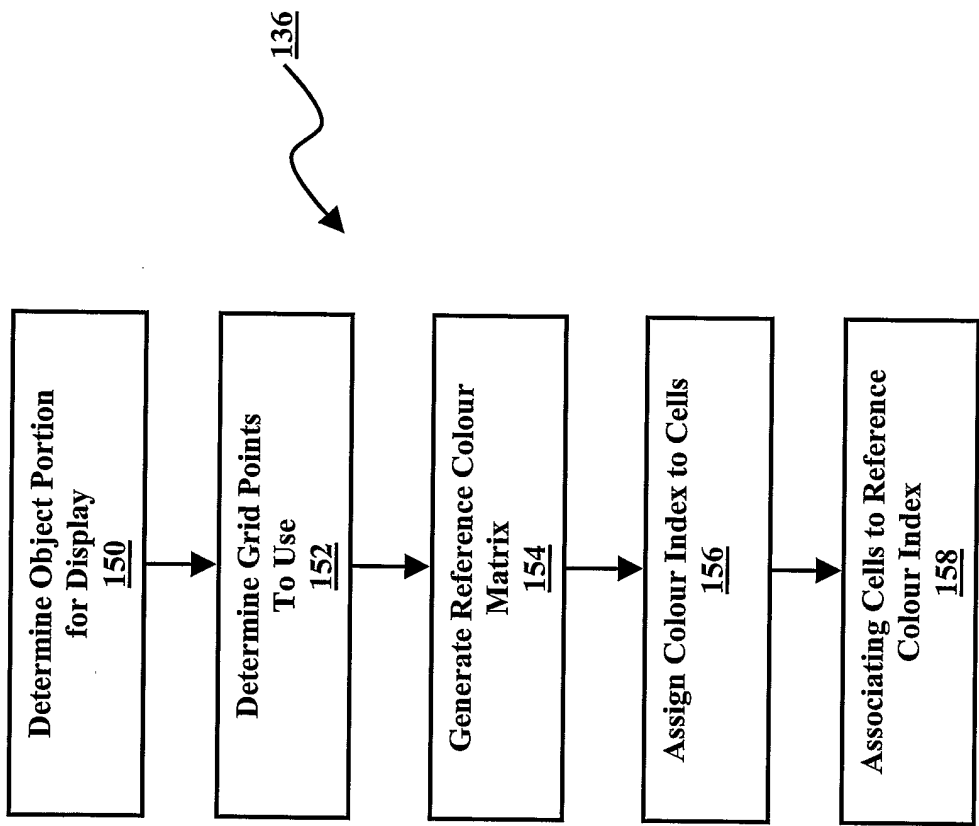


FIG. 7

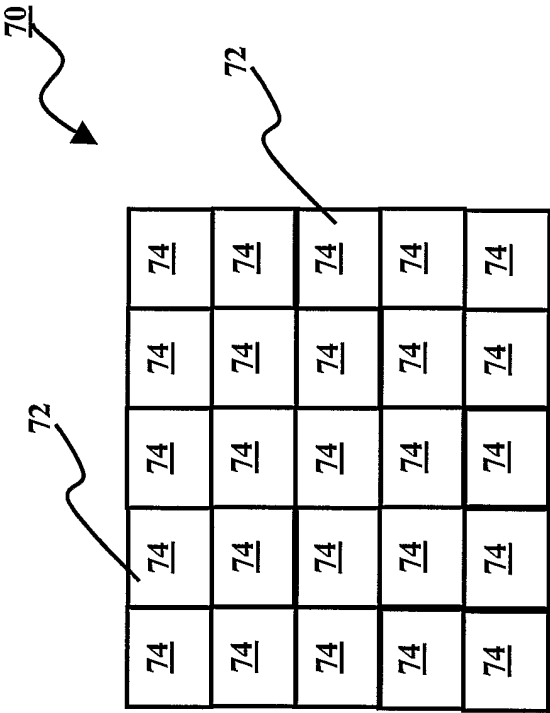


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG 02/00225

CLASSIFICATION OF SUBJECT MATTER

IPC⁷: G06F 17/50, 19/00; G06T 17/00; G05B 19/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC⁷: G06F 17/50, 19/00; G06T 17/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, WPI, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5257203 A (RILEY ET AL.) 26 October 1993 (26.10.93) <i>abstract; figures; column 1, lines 16-26.</i>	1
A	US 6389375 B1 (THOMSEN ET AL.) 14 May 2002 (14.05.02) <i>abstract; claim 1; figures; column 3, line 12 - column 4, line 18.</i>	1,2
A	WO 95/21417 A1 (RADICAL ADVANCED TECHNOLOGIES CORPORATION) 10 August 1995 (10.08.95) <i>abstract; claims 1,3-5,12; figures.</i>	1,2,14,15
A	US 5880961 A (CRUMP) 9 March 1999 (09.03.99) <i>abstract; claims 1,6 ; figures; column 3, line 11 - column 4, line 37.</i>	1,14
A	US 2002 59042 A1 (KACYRA ET AL.) 16 May 2002 (16.05.02) <i>abstract.</i>	1

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

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„&“ document member of the same patent family

Date of the actual completion of the international search

24 June 2003 (24.06.2003)

Date of mailing of the international search report

12 August 2003 (12.08.2003)

Name and mailing address of the ISA/AT

Austrian Patent Office

Dresdner Straße 87, A-1200 Vienna

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/SG 02/00225

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				US A 6091999	18-07-2000
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				WO A1 9521410	10-08-1995
				AU A1 61701/94	21-08-1995