

Drawing Method and Device of Three-dimensional (3D) Earth

Field of the Invention

The invention relates to the field of computer science, in particular to a drawing method and device for 3D earth.

Background of the Invention

Imitated WorldWind, GoogleEarth, OSCEarth, etc., former domestic mainstream products were in the first stage of drawing a 3D earth with foreign engines or open source community engines adopted, which were pure 3D content products. However, such products have poor expressiveness and carrying capacity in 3D digital earth, which can not meet the growing demand.

Description of the Invention

This embodiment in application provides a drawing method and device for 3D earth, so that, at the minimum level, the problem of poor expressiveness and bearing capacity in 3D digital earth due to the only pure 3D content products obtained in 3D earth drawing by related technology can be solved.

In one embodiment of this invention, a drawing method for 3D earth is provided, which includes: dividing the 3D earth into a plurality of layered grids based on longitude and latitude of the earth; obtaining the first 3D rendering picture by rendering objects within the shooting range of the target camera device; wherein the shooting range overlaps one or more target grids; obtaining the second 3D rendering picture by rendering the first 3D rendering picture again with the resolution corresponding to the target distance between the target camera device and the target grid; wherein the target grid is any of the plurality of layered grids; finally drawing the 3D earth based on the second 3D rendering picture.

In another embodiment of the invention, a drawing device of 3D earth is provided, which includes: the dividing module which divides the 3D earth into a plurality of layered grids based on the longitude and latitude of the earth; the first rendering module, which obtains the first 3D rendering picture by rendering the object within the shooting range of the target camera device; wherein the shooting range overlaps one or more target grids; the second rendering module, which obtains the second 3D rendering picture by rendering the first 3D rendering picture again with the resolution corresponding to the target distance between the target camera device and the target grid; wherein the target grid is any of the plurality of layered grids; and the drawing module, which finally draws the 3D earth based on the second 3D rendering picture.

In another embodiment of the invention, a computer-readable storage medium is provided, in which the computer program is stored, wherein the computer program is set to execute the drawing method for 3D earth at runtime.

In another embodiment of the invention, an electronic device with a memory and a processor included is provided, in which the computer program is stored, and the processor is set to execute the drawing method for 3D earth by running the computer program.

With the present application, the problems of poor expressiveness and bearing capacity in the 3D digital earth caused by pure 3D content products obtained by drawing 3D earth in the related technology can be solved by means of taking the rendering picture as a basis for drawing a 3D earth. Such rendering picture is obtained by re-rendering the first 3D rendering picture obtained by rendering objects within the shooting range of the target camera device after dividing the 3D earth into a plurality of layered grids based on the longitude and latitude of the earth, providing high accurate 3D earth with better expressiveness and bearing capacity.

In addition to the objectives, features and advantages described above, the present invention also has other objectives, features and advantages. Hereinafter, a further explanation for the invention will be made with reference to the figures.

Brief Introduction to the Drawings

Drawings attached to the Specifications for further understanding the invention are parts of the invention. The illustrative embodiments together with the description explaining the invention do not constitute an improper limitation of the invention. As for the drawings:

Figure 1 is a block diagram of terminal hardware structure for the 3D earth drawing method used in the embodiments of the present application;

Figure 2 is a flow chart for the 3D earth drawing method used in the embodiments of the present application;

Figure 3 is a schematic diagram of layered grids of the 3D earth in the embodiments;

Figure 4 is a schematic diagram of tiles after dividing the 3D earth into layers in the embodiments;

Figure 5 is the schematic diagram I for determining the normal used in the embodiments;

Figure 6 is the schematic diagram II for determining the normal used in the embodiments;

Figure 7 is the schematic diagram of skirt in the embodiments;

Figure 8 is the schematic diagram of the distance between the camera device and tiles in the embodiments;

Figure 9 is the structural diagram of a 3D earth drawing device used in the embodiments of the present application.

Specific Mode of Execution

It should be noted that the embodiments of the present invention and the features in the embodiments can be combined with each other without conflict. The present invention will be further explained with reference to the figures and embodiments.

In order to let those skilled in the art have a better understanding of this invention, we will explain the technical solution in the embodiments clearly and completely in combination with the figures attached. Obviously, only part, instead of all, of the embodiments of the invention is presented. Based on the embodiments of the invention, all other embodiments obtained by those of ordinary skill in the art with no creative work shall be in the protection scope of the invention.

It should be noted that the terms “first”, “second” and the like in the Specifications, Patent Claims and the attached figures are used to distinguish similar objects rather than describe a specific order or sequence. Therefore, it shall be understood that such terms are interchangeable as appropriate for the embodiments of the invention described herein. Besides, the terms “include” and “have” and their variations are intended to provide non-exclusive inclusion. For example, not only those steps or units clearly listed are intended to be covered by saying “including the process, method, system, product or equipment of a series of steps or units”, but also the steps and units not listed or inherent in the process, method, system, product or equipment would be included.

It should be noted that the terms used herein are only for describing specific mode of execution instead of restricting the exemplary mode of execution based on the present application. Unless expressly stated in the text, words importing the singular only also include the plural. And it shall be understood that the features, steps, operations, components, elements and/or combinations thereof are presented when the terms “cover” and/or “include” are used in the Specifications.

Embodiment 1

The embodiment of this method provided in Embodiment I of this application can be executed in a terminal, a computer terminal or a similar computing device. Taking running on a terminal as an example, Figure 1 is a block diagram of terminal hardware structure for the 3D earth drawing method used in the embodiments of the present application; As shown in Figure 1, Terminal 10 may include one or more (only one is shown in the figure) Processor 102 (Processor 102 may include, but is not limited to, processing devices such as microprocessor MCU or programmable logic device FPGA), Memory 104 for storing data, and Transmission Device 106 for communicating. It can be understood by those of ordinary skill in the art that the structure shown in Figure 1 will not restrict the structure of the electronic device, it is only an indication. For example, Terminal 10 may have more or fewer components than those shown in Figure 1, or have a configuration that is different from that shown in Figure 1.

Memory 104 can store the software programs and modules of the application software, such as the program instructions/modules of the 3D data drawing method in the embodiment of the present application. Processor 102 executes various function applications and data processing by running the software programs and modules stored in Memory 104. Memory 104 may have a high-speed random access memory, as well as a nonvolatile memory, such as one or more magnetic storage devices, flash memory, or other nonvolatile solid-state memory. In some examples, Memory 104 may also have a memory set remotely relative to Processor 102, which may be connected to Terminal 10 via a network.

The network mentioned in the examples includes but is not limited to the Internet, Intranet, local area network, mobile communication network and combinations thereof.

Transmission Device 106 is used to receive or transmit data via a network. The above specific examples about the network may include the wireless network provided by a communication provider of Terminal 10. In an example, Transmission Device 106 includes a Network Interface Controller (NIC) that can communicate with the Internet by connecting to other network devices through a base station. In an example, Transmission Device 106 is a radio frequency (RF) module for communicating with the internet in a wireless manner.

In this embodiment, a 3D earth drawing method running on the terminal is provided. Figure 2 is a flow chart for the 3D earth drawing method used in the embodiments of the present application, and the following steps are included:

Step S202, dividing the 3D earth into a plurality of layered grids based on the longitude and latitude of the earth;

Step S204, obtaining the first 3D rendering picture by rendering the object within the shooting range of the target camera device; wherein the shooting range overlaps one or more target grids;

Step S206, obtaining the second 3D rendering picture by rendering the first 3D rendering picture again with the resolution corresponding to the target distance between the target camera device and the target grid; wherein the target grid is any of the plurality of layered grids;

Step S208, drawing the 3D earth based on the second 3D rendering picture.

Through step S202 to step S208, the problems of poor expressiveness and bearing capacity in the 3D digital earth caused by pure 3D content products obtained by drawing 3D earth in the related technology can be solved by means of taking the rendering picture as a basis for drawing a 3D earth. Such rendering picture is obtained by re-rendering the first 3D rendering picture obtained by rendering objects within the shooting range of the target camera device after dividing the 3D earth into a plurality of layered grids based on the longitude and latitude of the earth, providing high accurate 3D earth with better expressiveness and bearing capacity.

As for obtaining the first 3D rendering picture by rendering the object within the shooting range of the target camera device involved in step S204, the camera frustum of the camera device can be selected as the shooting range, which can be built on the basis of the position, field of view and far and near clip planes of the camera. Then test whether the object is within the scope of the camera frustum. If it is, it will be rendered; otherwise, it will not be rendered; clipping of the camera frustum can directly reduce the number of polygon to be rendered.

Optionally, further steps for dividing the 3D earth into a plurality of layered grids based on the longitude and latitude of the earth involved in step S202 in the embodiment of the present application can be:

Step S202-11, determining the first layer of grid based on the global topographic data indicated by the longitude and latitude of the 3D earth; wherein the first layer of grid shows the global terrain of the 3D earth;

Step S202-12, obtaining the second layer of grid by dividing the first layer of grid on the basis of the longitude of destination showed in the longitude and latitude;

Step S202-13, obtaining the third layer of grid by dividing the second layer of grid evenly with the provided longitude and latitude; wherein the third layer of grid consists of a plurality of tiles, the interval distances of longitude and latitude of which are equal.

For the steps S202-11 to S202-13, it can be found in a specific application scenario that the resolution of the first layer is the lowest while the layered strategy is adopted to the 3D earth grids which are divided into several layers representing different resolutions. As shown in Figure 3, 1) in the first layer is a sphere grid showing the global terrain; 2) the second layer is comprised of two hemispherical grids representing the eastern and western hemispheres and obtained by bisecting the earth grid from the primary meridian; 3) in the third layer, each grid in the second layer is divided into four equal parts (with a total of eight parts) in line with the longitude and latitude; 4) afterwards, all grids are divided into 4 parts on the basis of the previous layer as per the longitude and latitude.

Furthermore, it should be noted that the 3D earth grids are divided into several parts after being divided into a plurality of layered grids based on the longitude and latitude. Each part is a tile, for which only the minimum and maximum longitude and latitude are required in building in this embodiment. The tile grid in our sample is built by uniform grid based on the longitude and latitude, as shown in Figure 4, each uniform small grid is a tile. In the specific application scenario of the present application, start from the upper left corner of a tile to build a grid, and divide the tile into 32 rows and 32 columns equally based on the longitude and latitude so that each row and column will have 33 vertices.

Optionally, in the embodiment of the present application, the following steps in this application also are included after obtaining the third layer of grid by dividing the second layer of grid evenly with the longitude and latitude involved in step S202-13:

Step S302, determining the normals of vertices of adjacent tiles in the third layer of grid;

Step S304, establishing texture coordinates correspondence with the tiles;

Step S306, setting out the tile skirt with its vertex pointing opposite to the center of the 3D earth after obtaining the coordinates of vertices on adjacent edges of adjacent tiles in the texture coordinates;

It should be noted that there are two ways to determine the normal involved in step S302:

1) As shown in Figure 5, let the normals of all vertices point to the opposite direction of the center of the sphere. Connecting the vertex with the center of the circle, the vector pointing from the center of the circle to the vertex is the normal of the vertex. It is an easy and practical way to determine the normal while providing high performance.

2) As shown in Figure 6, calculate the normal on account of the points around the vertex. It is a better way to show light and shadow changes with the topographic relief

Optionally, for the tile-based texture coordinate setting method involved in step S304, the texture coordinate is the uv coordinate. As shown in Figure 7, the uv coordinates of each tile are set uniformly

corresponding to the relative position in the tile taking the upper left corner of the tile as the origin and the lower right corner as the (1, 1) point.

Optionally, for setting out the tile skirt with its vertex pointing opposite to the center of the 3D earth after obtaining the coordinates of vertices on adjacent edges of adjacent tiles in the texture coordinates involved in step S306, as shown in Figure 7, the uv of points on adjacent edges can be taken as that of the skirt with all normals pointing opposite to the center of the sphere. Possible inaccurate height alignment between tiles may lead to cracks between tiles affecting the visual effects. Therefore, a layer of grid is built around the tiles towards the center of the earth, which forms the skirts, thus solving the problem of cracks.

Optionally, further steps for obtaining the target distance between the target camera device and the target grid involved in step S206 in the embodiment of this application can be:

Step S206-11, building a quad-tree data structure on account of the first, second and third layers of grids; wherein the first layer of grid is taken as the root node of the quad-tree, the second layer of grid as the node under the root node, and the third layer of grid as the node under the second layer of grid;

Step S206-12, obtaining and determining the distances between the camera device and each node of the quad-tree as the target distance.

For the steps S206-11 and S206-12 taken in a specific application scenario, build a root node of the quad-tree, based on which a complete first layer of grid of the earth is showed. Owing to the second layer of grids of the 3D earth divided into eastern and western hemispheres, the second layer of nodes shall have two underlying nodes corresponding to the two hemispheres respectively, which is special. Based on the previous layer, each node on the third layer includes four child nodes, and so on. Each node is provided with a level, as well as x and y coordinates. On account of the given information, the minimum and maximum longitude and latitude of the node can be worked out, and then the longitude and latitude, as well as the coordinates, of the center point can be worked out.

Furthermore, as shown in Figure 8, whether it is required to split the node into child nodes with higher resolution can be determined by the distance between the camera and the node. Comparing the distance between the camera and the node center with the node level, split the node if it is smaller than the threshold and stop the split if it is greater than the threshold. For example, if the height and width are $400 * 400$ in the 10th level, the center of the four blocks split is 200,200, based on which, split the node into four blocks recursively until the bottom layer. The earth's circumference is about 40,076 km. Split by quad-tree method about 2 to the 21st power, the earth would be represented by blocks of $128 * 128$ pixels, each of which can represent about 19.109 m in real size. The accuracy is generally enough with each pixel represented in cm-level which is obtained by dividing 19.109 m by 128 pixels. Please be noted the split can be kept on if necessary.

Optionally, further steps for obtaining the second rendering picture by rendering the first 3D rendering picture again with the resolution corresponding to the target distance involved in step S206 in the embodiment of the application can be:

Step S206-11, obtaining the second 3D rendering picture by rendering the first 3D rendering picture again with the first resolution while the target distance is no greater than the preset distance;

Step S208-12, obtaining the second 3D rendering picture by rendering the first 3D rendering picture again with the second resolution while the target distance is greater than the preset distance; wherein, the first resolution is greater than the second one.

It should be noted that the preset distance, the first and second resolution can be set according to the actual situation, which is not restricted in this application.

Optionally, further steps for drawing the 3D earth based on the second rendering pictures involved in step S208 in the embodiment of the present application can be:

Step S208-11, obtaining the second 3D rendering picture from the memory;

Step S208-12, drawing the 3D earth on the basis of the second 3D rendering picture, if there is such picture in the memory;

Step S208-13, obtaining the second 3D rendering picture from the local disk if there is no such picture in the memory;

Step S208-14, drawing the 3D earth on the basis of the second 3D rendering picture, if there is such picture in the local disk;

Step S208-15, obtaining the second 3D rendering picture from the remote server, if there is no such picture in the local disk;

Step S208-16, drawing the 3D earth based on the second 3D rendering picture obtained.

And in the embodiment of this application, we use remote service plus local disk cache and memory cache to accelerate the access speed of resources. Deploy massive resources on remote servers. When client-side requires access to a resource, the memory is searched first, and the resource would be used immediately once found; if there is no such resource in the memory, the cache directory of the local disk would be searched, and the resource would be loaded into the memory once found; if there is no such resource in the local disk, the client-side would send a resource request instruction to the server, which would send the resource to the requester once the request is received.

It should be noted that in order to prevent the main thread and picture from getting stuck due to resource loading thus affecting the user experience, all resources required in the embodiment of this application are loaded in an asynchronous way. With an asynchronous queue, all resource loading tasks will be put into the task queue first, and the asynchronous processor will take out the loading tasks from the asynchronous queue in the sub-threads. After the tasks are completed, the callback of the main thread would be called for subsequent processing.

With the above description for the mode of execution, those skilled in the art clearly understand that the method used in the above embodiment can be realized by means of software and required general hardware platform, or by hardware. However, the former one is the preferred mode of execution in most cases. Based on this, essentially, the technical solution of the present invention, as well as its contribution to the skill in the art, can be embodied in the form of software products, which

are stored in a storage medium (such as ROM/RAM, magnetic disk, optical disk) and include several instructions making the terminal equipment (such as a mobile phone, a computer, a server, or a network device) execute the methods described in various embodiments of the present invention.

Embodiment 2

In this embodiment, a 3D earth drawing device is provided, which is used to realize the above embodiments as a preferred mode of execution. What has already been explained will not be repeated here. The term “module”, as used below, may be a combination of software and/or hardware carrying out the predetermined function. Although the device described in the following embodiments is preferably implemented in software, hardware or a combination of software and hardware are also possible for implementation.

Figure 9 is a structural block diagram for the 3D earth drawing device in the embodiment of the present application. As shown in Figure 9, the device includes:

Dividing Module 92, which divides the 3D earth into a plurality of layered grids based on the longitude and latitude of the earth;

First Rendering Module 94, which obtains the first 3D rendering picture by rendering the object within the shooting range of the target camera device; wherein the shooting range overlaps one or more target grids;

Second Rendering Module 96, which obtains the second 3D picture by rendering the first 3D rendering picture again with the resolution corresponding to the target distance between the target camera device and the target grid; wherein the target grid is any of the plurality of layered grids;

Drawing module 98, which finally draws the 3D earth based on the second 3D rendering picture.

Optionally, the Dividing Module 92 of this application may further include: the first dividing unit, which determines the first layer of grid based on the global topographic data indicated by the longitude and latitude of the 3D earth; wherein the first layer of grid shows the global terrain of the 3D earth; the second dividing unit, which divides the first layer of grid into the second layer of grid on the basis of the target longitude in the longitude and latitude; and the third dividing module, which divides the second layer of grid evenly into the third layer of grid on the basis of the longitude and latitude, wherein the third layer of grid consists of a plurality of tiles; the interval distances of longitude and latitude indicated by the tiles are equal.

Optionally, the device of this application may further include: a determining module, which determines the normals of vertices of adjacent tiles in the third layer of grid after obtaining the third layer of grid by dividing the second layer of grid evenly with the provided longitude and latitude; a building module, which establishes texture coordinates correspondence with the tiles; and the first processing module, which sets out the tile skirt with its vertex pointing opposite to the center of the 3D earth after obtaining the coordinates of vertices on adjacent edges of adjacent tiles in the texture coordinates.

Optionally, the Second Rendering Module 96 in the embodiment of this application may further include: a building unit, which builds a quad-tree data structure on account of the first, second and

third layers of grids; wherein the first layer of grid is taken as the root node of the quad-tree, the second layer of grid as the node under the root node, and the third layer of grid as the node under the second layer of grid; and the second processing unit, which obtains and determines the distances between the camera device and each node of the quad-tree as the target distance.

Optionally, the Second Rendering Module 96 in the embodiment of this application may further include: the first rendering unit, which obtains the second 3D rendering picture by rendering the first 3D rendering picture again with the first resolution while the target distance is no greater than the preset distance; and the second rendering unit, which obtains the second 3D rendering picture by rendering the first 3D rendering picture again with the second resolution while the target distance is greater than the preset distance; wherein, the first resolution is greater than the second one.

Optionally, the Drawing Module 98 in this embodiment of this application may further include: the first obtaining unit, which obtains the second 3D rendering picture from the memory; the first drawing unit, which draws the 3D earth on the basis of the second 3D rendering picture, if there is such picture in the memory; the second obtaining unit, which obtains the second 3D rendering picture from the local disk if there is no such picture in the memory; the second drawing unit, which draws the 3D earth on the basis of the second 3D rendering picture, if there is such picture in the local disk; the third obtaining unit, which obtains the second 3D rendering picture from the remote server, if there is no such picture in the local disk; and the third drawing unit, which draws the 3D earth on the basis of the second 3D rendering picture obtained.

It should be noted that the above modules can be realized by software or hardware, the latter of which can be realized by, but not limited to, including the above modules in the same processor; or including the combinations of any above modules in different processors.

Embodiment 3

The embodiment of the invention also provides a computer-readable storage medium. Optionally, the above storage medium may be set to store program codes for executing the following steps:

S1, dividing the 3D earth into a plurality of layered grids based on the longitude and latitude of the earth;

S2, obtaining the first 3D rendering picture by rendering the object within the shooting range of the target camera device; wherein the shooting range overlaps one or more target grids;

S3, obtaining the second 3D rendering picture by rendering the first 3D rendering picture again with the resolution corresponding to the target distance between the target camera device and the target grid; wherein the target grid is any of the plurality of layered grids;

S4, drawing the 3D earth based on the second 3D rendering picture.

Optionally, in the embodiment, the above storage medium may include, but is not limited to, USB flash drive, Read-Only Memory (ROM), Random Access Memory (RAM), mobile hard disk, magnetic disk, optical disk or various media storing program codes.

Optionally, the specific examples in the embodiment can refer to the examples described in the above embodiments and optional mode of execution, and will not be repeated here.

Obviously, it should be understood by those skilled in the art that the above modules or steps of the present invention can be realized by a general computing device, they can be concentrated on a single computing device or distributed on a network composed of a plurality of computing devices, alternatively, they can be realized by program codes executable by computing devices. Therefore, the modules or steps can be stored in a storage device and executed by computing devices. In some cases, the steps shown or described can be performed in an order different from herein. All or part of the modules or steps can be made into individual integrated circuit modules for realization. Thus, the present invention is not limited to any particular combination of hardware and software.

Unless otherwise specified, the arrangement of components and steps, numerical expressions and values set forth in the embodiments will not restrict the scope of the present invention. Meanwhile, it should be understood that the dimensions of various parts shown in the drawings are not drawn as per the actual scale for easy description. The technologies, methods and equipment known to those of ordinary skill in the art may not be discussed in detail, however, such technologies, methods and equipment shall be taken as part of the Patent Grant. In all the examples shown and discussed herein, all specific values should be interpreted as an example instead of a restriction. Therefore, additional examples of exemplary embodiments may have different values. It should be noted that similar codes and letters indicate similar items in the following drawings, so no further discussion on any item defined in one drawing is required subsequently.

For easy description, terms such as “on”, “above”, “on the upper surface”, “upper” and others, can be used to describe the spatial position of one component or feather against other components or feathers. It should be understood that terms describing spatial positions are intended to indicate the orientations of the components in use or operation other than the orientation described in the drawings. For example, the components will be positioned “below other components or structures” while described as “above other components or structures” if the components in the drawings are inverted. Therefore, the exemplary term “above” can include two orientations, namely “above” and “below”. The component can also be positioned in other ways (rotated 90 degrees or in other orientations), and the words describing spatial positions here will be explained accordingly.

In the description of the present invention, it should be understood that the orientations or positions indicated by “front, back, above, below, left, right”, “horizontal, vertical, perpendicular, level”, “top, bottom” and other noun localities are relative to the orientations or positions shown in the attached drawings. For easy and simplified description of the present invention, such noun localities do not indicate or imply the specific orientation, azimuthal structure and operation of the device or element. As a result, they do not constitute to restrictions on the protection scope of the invention. The words “inside and outside” indicate the positions inside and outside the outline of each part.

The above is only preferred embodiments of the present invention, and shall not restrict the invention. For those skilled in the art, the present invention can be modified and varied. Any modifications, equivalent replacements or improvements made within the spirit and principle of the present invention shall be included in the protection scope of the present invention.

Claims

1. It is a three-dimensional (3D) earth drawing method, which is characterized by:

dividing the 3D earth into a plurality of layered grids based on the longitude and latitude of the earth;

obtaining the first 3D rendering picture by rendering objects within the shooting range of the target camera device; wherein the shooting range overlaps one or more target grids;

obtaining the second 3D rendering picture by rendering the first 3D rendering picture again with the resolution corresponding to the target distance between the target camera device and the target grid; wherein the target grid is any of the plurality of layered grids;

finally drawing the 3D earth based on the second 3D rendering picture.

2. As for the method stated in Claim 1, it is characterized by dividing the 3D earth into a plurality of layered grids based on the longitude and latitude of the earth, in which,

the first layer of grid is determined based on the global topographic data indicated by the longitude and latitude of the 3D earth; wherein the said first layer of grid shows the global terrain of the said 3D earth;

the second layer of grid is obtained by dividing the first layer of grid on the basis of the longitude of destination showed in the longitude and latitude;

the third layer of grid is obtained by dividing the second layer of grid evenly with the provided longitude and latitude; wherein the third layer of grid consists of a plurality of tiles, the interval distances of longitude and latitude of which are equal.

3. As for the method stated in Claim 2, after obtaining the third layer of grid by dividing the second layer of grid evenly with the provided longitude and latitude, it is characterized in:

determining the normals of vertices of adjacent tiles in the third layer of grid;

establishing texture coordinates correspondence with the tiles;

setting out the tile skirt with its vertex pointing opposite to the center of the 3D earth after obtaining the coordinates of vertices on adjacent edges of adjacent tiles in the texture coordinates;

4. As for the method stated in Claim 2, it is characterized by obtaining the target distance between the target camera device and the target grid, in which,

a quad-tree data structure is built by the second and third layers of grids on account of the first layer of grid; wherein the quad-tree takes the first layer of grid as the root node, the second layer of grid as the node under the root node, and the third layer of grid as the node under the second layer of grid;

the distances between the camera device and each node of the quad-tree are obtained and determined as the target distance.

5. As for the method stated in Claim 1, it is characterized by obtaining the second 3D rendering picture by rendering the first 3D rendering picture again with the resolution corresponding to the target distance, in which,

the second 3D rendering picture is obtained by rendering the first 3D rendering picture again with the first resolution while the target distance is no greater than the preset distance;

the second 3D rendering picture is obtained by rendering the first 3D rendering picture again with the second resolution while the target distance is greater than the preset distance;

wherein, the first resolution is greater than the second one.

6. As for the method stated in Claim 1, it is characterized by drawing the 3D earth on the basis of the second 3D rendering picture, in which,

the second 3D rendering picture is gained from the memory;

the 3D earth is drawn on the basis of the second 3D rendering picture, if there is such picture in the memory;

the second 3D rendering picture is gained from the local disk if there is no such picture in the memory;

the 3D earth is drawn on the basis of the second 3D rendering picture, if there is such picture in the local disk;

the second 3D rendering picture is gained from the remote server, if there is no such picture in the local disk;

and the 3D earth is finally drawn on the basis of the second 3D rendering picture obtained.

7. It is a 3D earth drawing device, which is characterized by:

the dividing module, which divides the 3D earth into a plurality of layered grids based on the longitude and latitude of the earth;

the first rendering module, which obtains the first 3D rendering picture by rendering the object within the shooting range of the target camera device; wherein the shooting range overlaps one or more target grids;

the second rendering module, which obtains the second 3D rendering picture by rendering the first 3D rendering picture again with the resolution corresponding to the target distance between the target camera device and the target grid; wherein the target grid is any of the plurality of layered grids;

the drawing module, which finally draws the 3D earth based on the second 3D rendering picture.

8. As for the device stated in Claim 7, it is characterized by the dividing modules, which

include:

the first dividing unit determining the first layer of grid on the basis of global topographic data indicated by the longitude and latitude of the 3D earth; wherein the first layer of grid shows the global terrain of the 3D earth;

the second dividing unit dividing the first layer of grid into the second layer of grid on the basis of the target longitude in the longitude and latitude;

the third dividing unit dividing the second layer of grid evenly into the third layer of grid on the basis of the longitude and latitude, wherein the third layer of grid consists of a plurality of tiles; the interval distances of longitude and latitude indicated by the tiles are equal.

9. As a computer-readable storage medium, it is characterized by the computer program stored in the storage medium, wherein the computer program is set to execute any one of the methods stated in Claims 1 - 6 at runtime.

10. As an electronic device with a memory and a processor, it is characterized by the computer program stored in the memory, wherein the processor is set to execute any one of the methods stated in Claims 1 - 6 by running the computer program.