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**Lin et al.**

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(54) **METHOD AND ELECTRONIC DEVICE FOR ENHANCING EFFICIENCY OF SEARCHING FOR REGIONS OF INTEREST IN A VIRTUAL ENVIRONMENT**


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(51) **Int. Cl.**

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| ***G06T 7/50*** | (2017.01) |
| ***G06T 7/70*** | (2017.01) |
| ***G06T 3/60*** | (2006.01) |
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| ***G06T 19/00*** | (2011.01) |
| ***G06F 3/048*** | (2013.01) |

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CPC .......... ***G06K 9/3233*** (2013.01); ***G06F 3/048*** (2013.01); ***G06T 3/60*** (2013.01); ***G06T 7/13*** (2017.01); ***G06T 7/50*** (2017.01); ***G06T 7/70*** (2017.01); ***G06T 19/00*** (2013.01); ***H04N 5/45*** (2013.01)

(58) **Field of Classification Search**

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USPC .......................................................... 382/173

See application file for complete search history.


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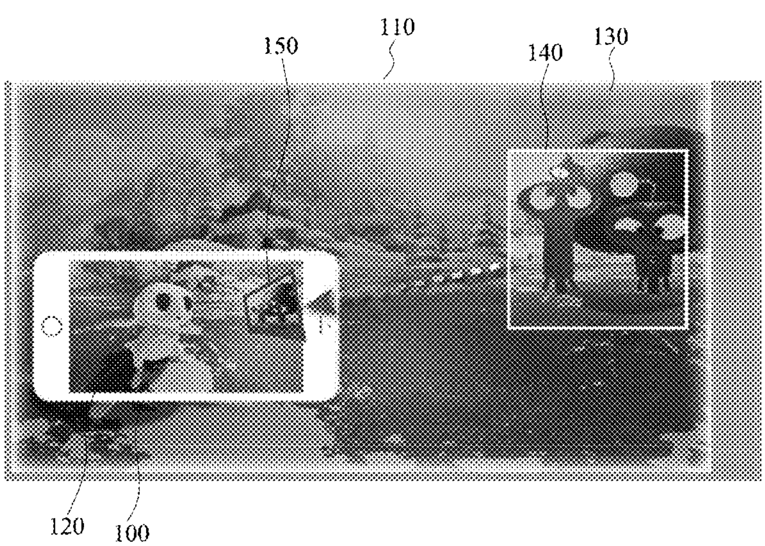
(57) **ABSTRACT**


A method and an electronic device for enhancing efficiency of searching for a region of interest in a virtual environment are provided. The virtual environment includes a visible scene and an invisible scene. A picture-in-picture (PIP) is displayed in the visible scene as a directional guidance or distance hint related to the region of interest in the invisible scene, thereby saving time and enhancing efficiency of searching for the region of interest.


**8 Claims, 6 Drawing Sheets**



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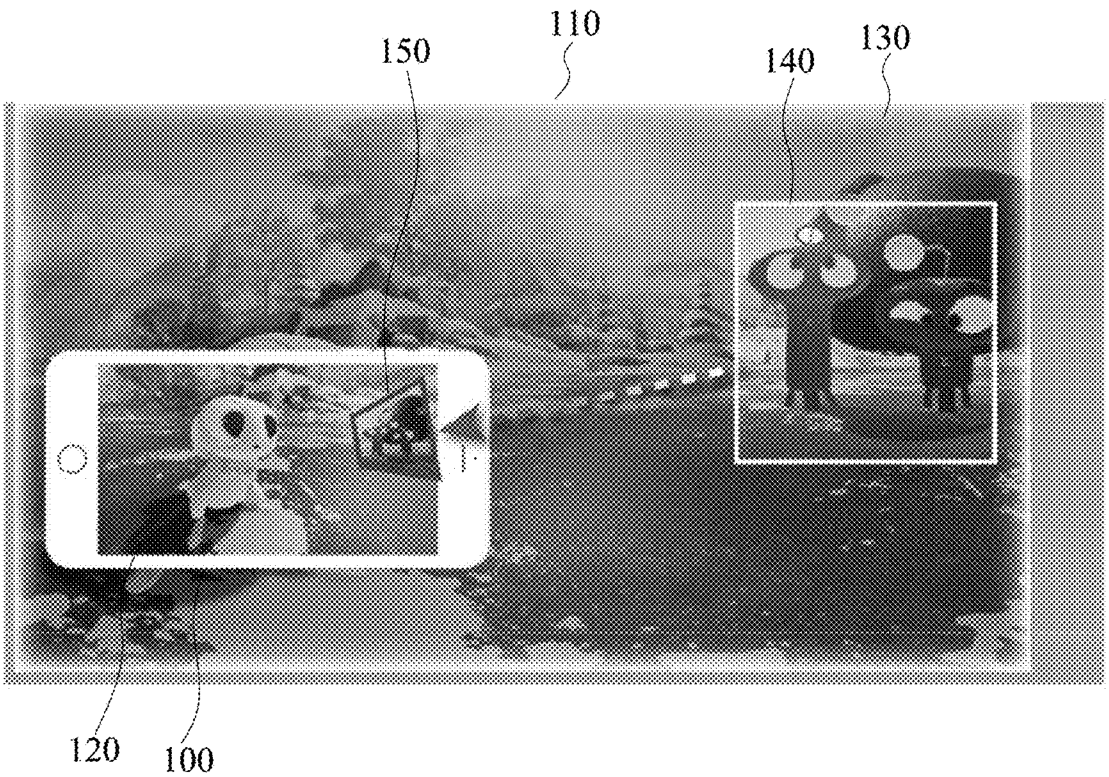


FIG. 1

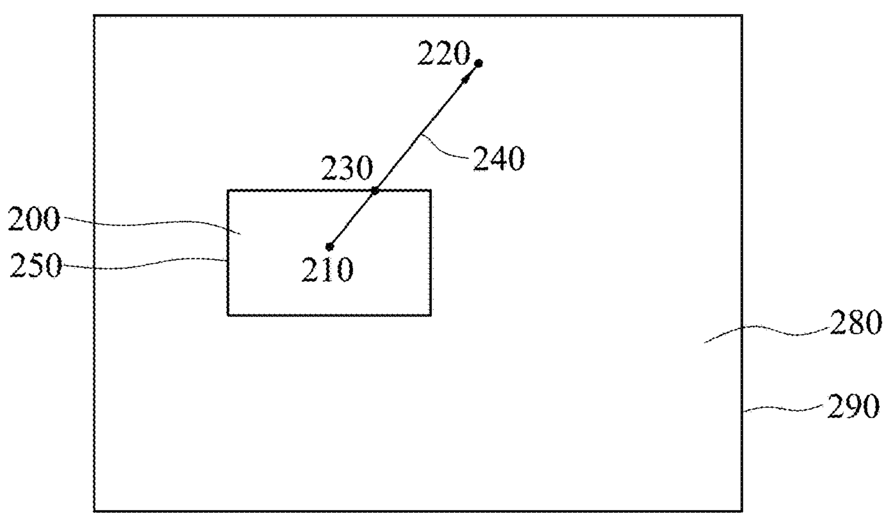


FIG. 2

locating a position of a region of interest in an invisible scene — S310

↓

locating a position of a center of the visible scene — S320

↓

displaying the region of interest as a PIP of the visible scene at an intersection of a line connecting the position of the region of interest and the position of the center of the visible scene and an boundary of the visible scene — S330

FIG. 3

rotating the PIP around its center to generate a rotated picture such that the rotated picture has an outer edge facing the region of interest and an inner edge facing the center of the visible scene — S410

↓

fixing the outer edge of the rotated picture and tilting the rotated picture along a Z-axis to generate a simulation picture — S420

FIG. 4

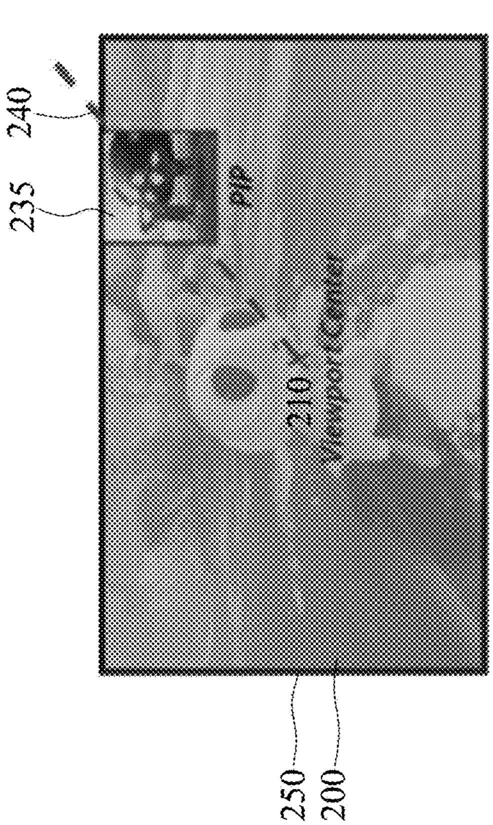

FIG. 5a

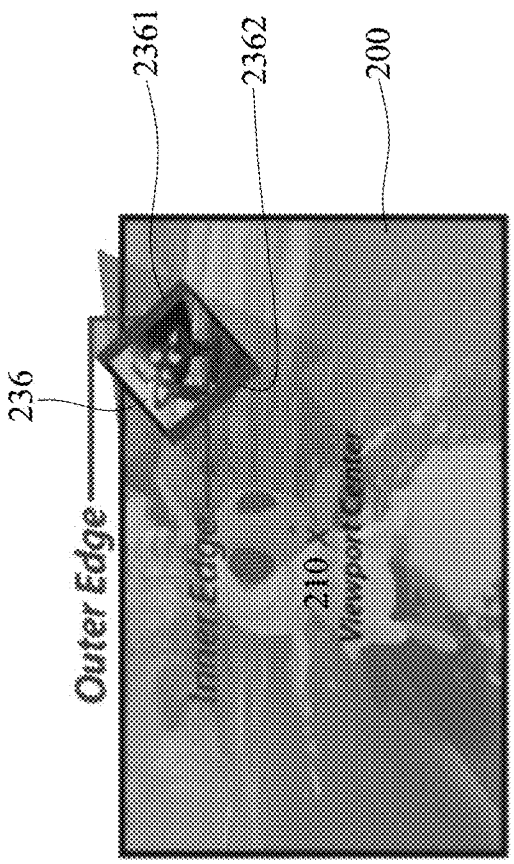

FIG. 5b

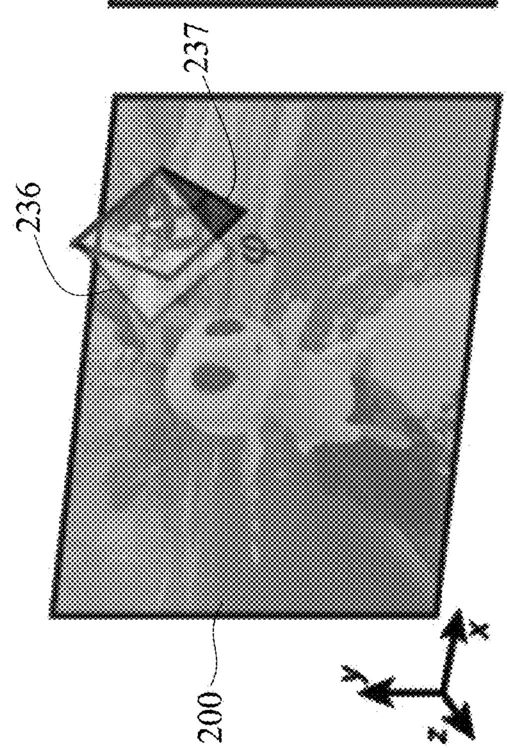

FIG. 5c

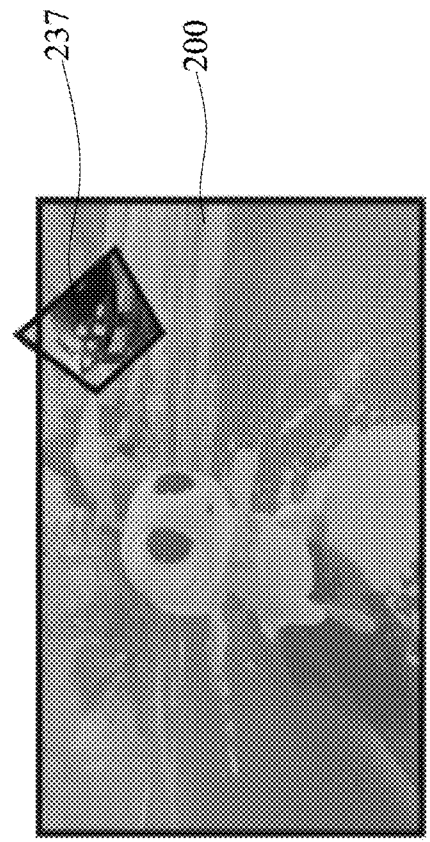

FIG. 5d

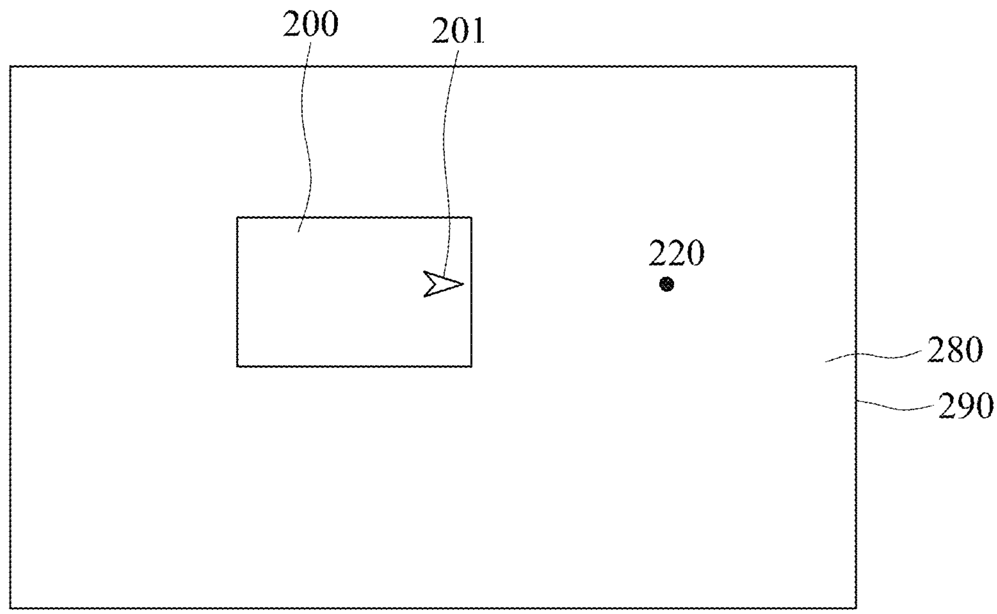
200
201
220
280
290

FIG. 6

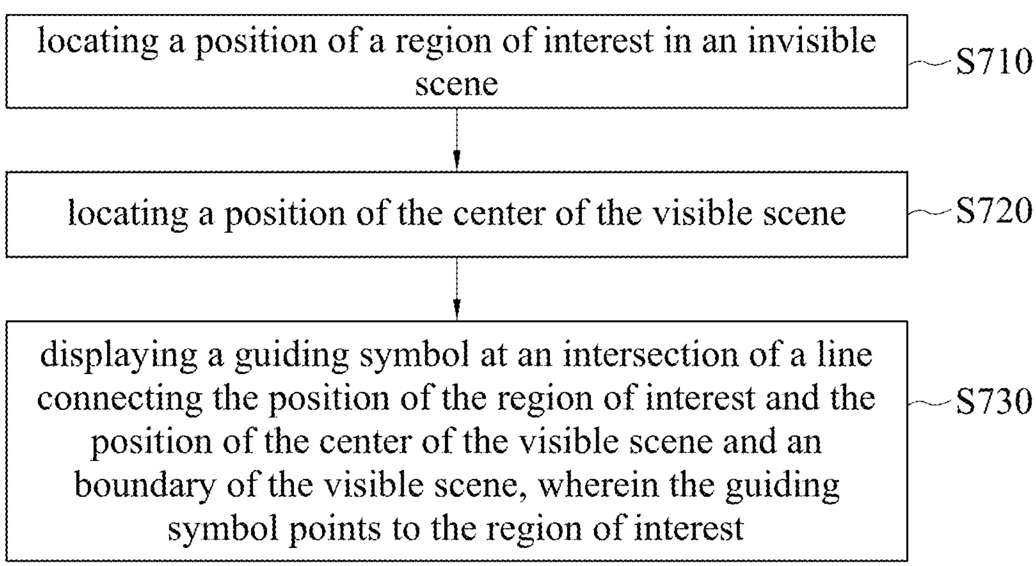
locating a position of a region of interest in an invisible scene
S710
locating a position of the center of the visible scene
S720
displaying a guiding symbol at an intersection of a line connecting the position of the region of interest and the position of the center of the visible scene and an boundary of the visible scene, wherein the guiding symbol points to the region of interest
S730

FIG. 7

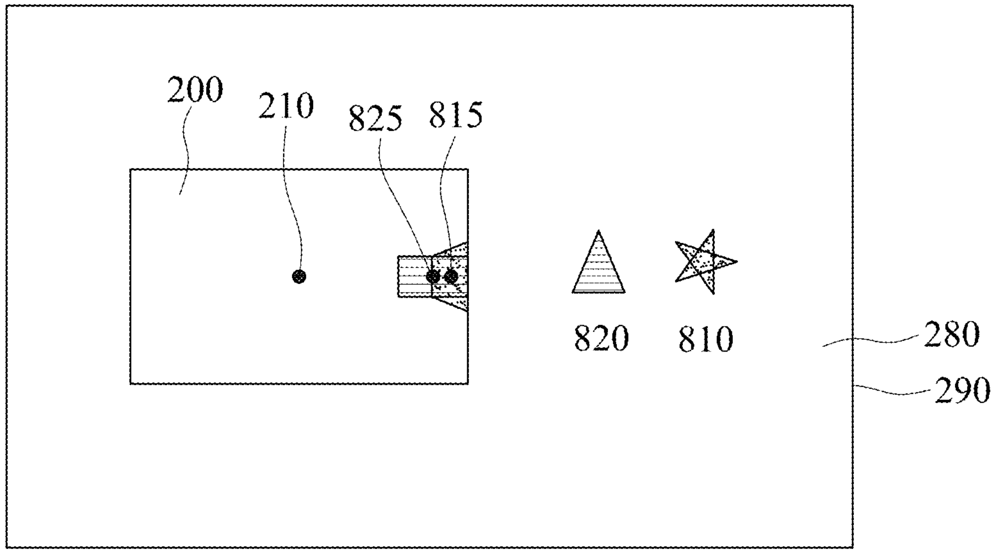


FIG. 8a

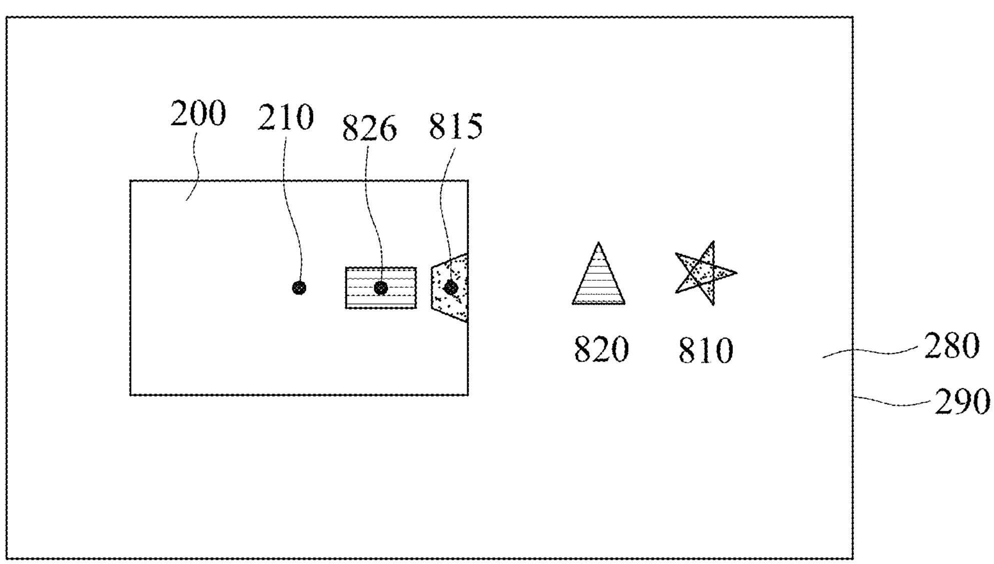


FIG. 8b

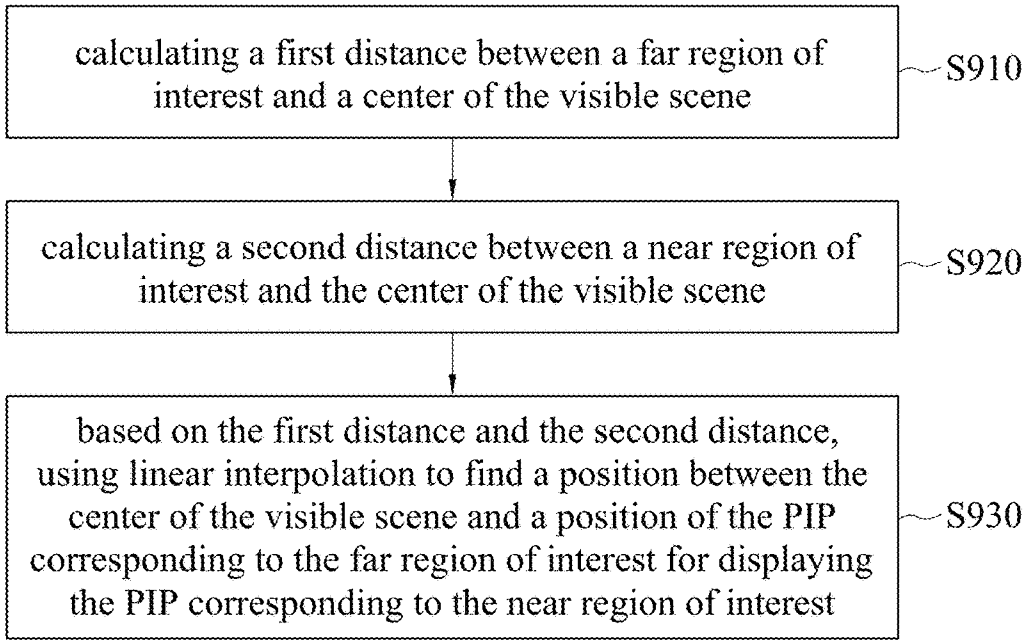
calculating a first distance between a far region of interest and a center of the visible scene
S910
calculating a second distance between a near region of interest and the center of the visible scene
S920
based on the first distance and the second distance, using linear interpolation to find a position between the center of the visible scene and a position of the PIP corresponding to the far region of interest for displaying the PIP corresponding to the near region of interest
S930

FIG. 9

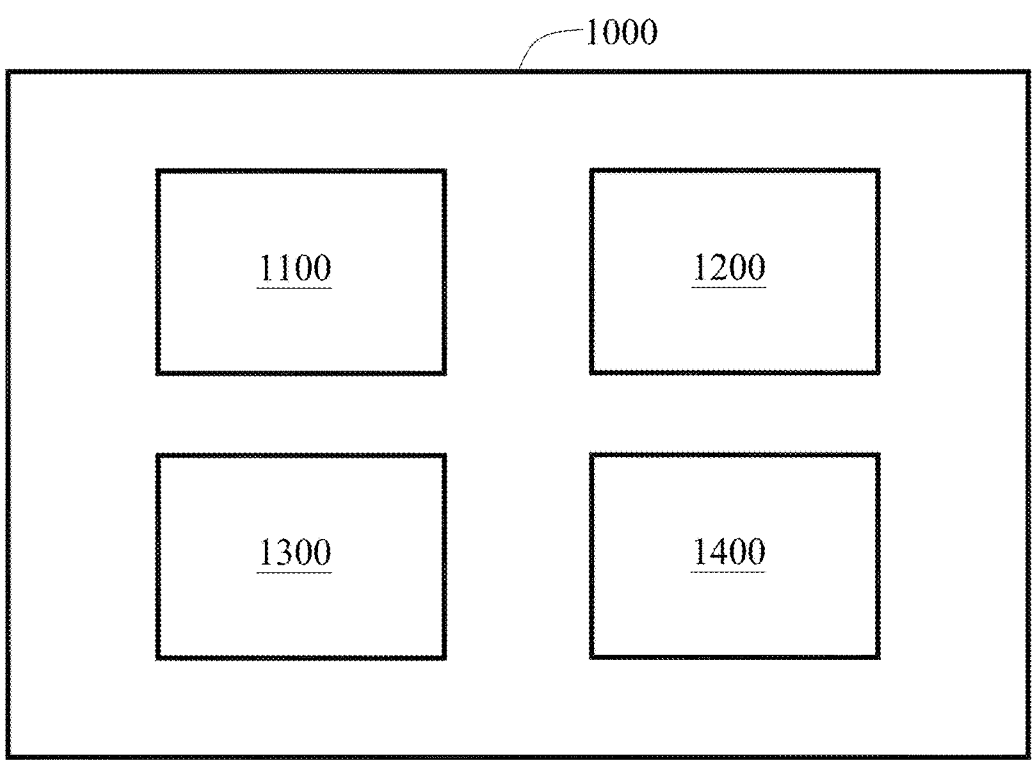
1000
1100
1200
1300
1400

FIG. 10

# METHOD AND ELECTRONIC DEVICE FOR ENHANCING EFFICIENCY OF SEARCHING FOR REGIONS OF INTEREST IN A VIRTUAL ENVIRONMENT

## BACKGROUND

### 1. Technical Field

The present disclosure relates to technologies for enhancing efficiency of searching for regions of interest in a virtual environment, and, more particularly, to a method and an electronic device that present a region of interest of an invisible scene as a picture-in-picture (PIP) in a visible scene so as to enhance efficiency of searching for the region of interest in a virtual environment.

### 2. Description of Related Art

In recent years, 360-degree panoramic videos are becoming increasingly popular. Particularly, they can provide a user with immersive visual experiences when being applied in the fields of mobile and virtual reality.

Further, 360-degree panoramic videos can present full scene content of virtual reality. However, limited by the user' visual field and the size of a display of an electronic device such as an electronic device with a touch screen or a head-mounted display device, the user can only see portions of the contents of virtual reality.

Although such a viewing mode brings relatively natural visual experiences to general users who browse without any subject limitation, it is not convenient for users who want to search for objects of interest such as extraterrestrials, balloons, cats, dogs, airplanes and idol singers, or regions of interest in virtual reality.

Conventionally, a user can operate an electronic device to search for objects of interest or regions of interest in virtual reality. For example, the user can make a gesture on a touch screen to operate an electronic device, or move his head to make a tilting or turning operation when he wears a head-mounted display device.

Such a method is convenient for the user if regions of interest are in the visual field of the user. But if the regions of interest are not in the visual field of the user, the user cannot know in advance how much time he will spend searching for them. The reason is that the user does not know in which direction or how far away the regions of interest are.

As such, in a 360-degree panoramic video, to search for regions of interest that are not in the visual field of the user will adversely affect visual experiences of the user in virtual reality and even cause the user to miss some important events such as appearance of other more interesting virtual objects in the virtual reality.

Therefore, how to overcome the above-described drawbacks has become critical.

## SUMMARY

In view of the above-described drawbacks, the present disclosure provides a method and an electronic device for enhancing efficiency of searching for a region of interest in virtual reality (a virtual environment). In an embodiment, the region of interest is presented as a picture-in-picture (PIP) in a visible scene so as to save time for the user to search for the region of interest.

The present disclosure also provides a method for enhancing efficiency of searching for a region of interest in a virtual environment, wherein the virtual environment is comprised of a visible scene and an invisible scene. The method comprises the steps of: (1) locating a position of the region of interest in the invisible scene and a position of a center of the visible scene; and (2) displaying the region of interest as a PIP of the visible scene at an intersection of a line connecting the position of the region of interest and the position of the center of the visible scene and a boundary of the visible scene.

In an embodiment, the position of the region of interest is a center-of-mass coordinate of the region of interest.

In an embodiment, the method further comprises projecting the visible scene and the PIP on a display device through a projecting means.

In an embodiment, the projecting means is selected from the group consisting of equirectangular projection, cube mapping and equi-angular cubemapping.

In an embodiment, the method further comprises rotating the PIP around a center thereof to generate a rotated picture such that the rotated picture has an outer edge facing the region of interest and an inner edge facing the center of the visible scene.

In an embodiment, the method further comprises fixing the outer edge of the rotated picture and tilting the rotated picture by a tilting angle $\Phi$ along a Z-axis in a three-dimensional space to generate a simulation picture.

In an embodiment, the tilting angle is varied based on the distance between the region of interest and the center of the visible scene.

In an embodiment, a maximum angle of the tilting angle is 105 degrees and a minimum angle of the tilting angle is 0 degree.

The present disclosure provides another method for enhancing efficiency of searching for a region of interest in a virtual environment, wherein the virtual environment is comprised of a visible scene and an invisible scene. The method comprises: (1) locating a position of the region of interest in the invisible scene and a position of a center of the visible scene; and (2) displaying a guiding symbol at an intersection of a line connecting the position of the region of interest and the position of the center of the visible scene and a boundary of the visible scene, wherein the guiding symbol points to the region of interest.

In an embodiment, the guiding symbol is an arrow.

In an embodiment, the distance of the region of interest from the center of the visible scene is indicated by a length, a width, an area or a shape of the arrow.

In an embodiment, the longer the arrow is, the greater the distance between the region of interest and the center of the visible scene is, and the shorter the arrow is, the less the distance between the region of interest and the center of the visible scene is.

The present disclosure provides a further method for enhancing efficiency of searching for regions of interest in a virtual environment, wherein the virtual environment is comprised of a visible scene and an invisible scene. The method comprises the steps of: (1) calculating a first distance between a first region of interest in the invisible scene and a center of the visible scene and calculating a second distance between a second region of interest in the invisible scene and the center of the visible scene, wherein the first region of interest and the second region of interest correspond to a first PIP and a second PIP in the visible scene, respectively, and the second PIP partially overlaps with the first PIP, and wherein the first distance is greater than the second distance; and (2) based on the first distance and the second distance, using linear interpolation to find a position between the center of the visible scene and the first PIP for displaying the second PIP.

In an embodiment, the linear interpolation of step (2) is based on an equation pip_near=pos_center+(pip_far−pos_center)×dist_near/dist_far, wherein pip_near represents a position for displaying the second PIP, pip_far represents a position of the first PIP, pos_center represents the center of the visible scene, dist_near represents the second distance, and dist_far represents the first distance.

The present disclosure further provides an electronic device for enhancing efficiency of searching for a region of interest in a virtual environment, which comprises: a storage unit for storing computer readable program codes; and a processor executing the computer readable program codes to implement a method for enhancing efficiency of searching for a region of interest in a virtual environment.

It should be noted that the subject matter described above can be implemented as a computer-controlled device, a computer program, a computer system, or an artifact such as a computer readable storage medium.

The above and other features and advantages of the present disclosure will become apparent from the following detailed description taken in conjunction with the accompanying drawings. The description is illustrative and not intended to limit the present disclosure.

## BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a schematic diagram showing presentation of a region of interest as a picture-in-picture (PIP) in a visible scene on a mobile device for enhancing efficiency of searching for the region of interest according to the present disclosure;

FIG. **2** is a schematic diagram showing presentation of a region of interest of an invisible scene as a PIP in a visible scene according to the present disclosure;

FIG. **3** is a schematic flow diagram showing a method for presenting a region of interest as a PIP in a visible scene according to an embodiment of the present disclosure;

FIG. **4** is a schematic flow diagram showing a method for simulation processing of a PIP in a visible scene according to an embodiment of the present disclosure;

FIGS. **5***a* to **5***d* are schematic diagrams showing variation of a visible scene and a PIP when the PIP is simulation processed according to an embodiment of the present disclosure;

FIG. **6** is a schematic diagram showing application of a guiding symbol in a visible scene for enhancing efficiency of searching for a region of interest according to an embodiment of the present disclosure;

FIG. **7** is a schematic flow diagram showing a method for applying a guiding symbol in a visible scene according to an embodiment of the present disclosure;

FIGS. **8***a* and **8***b* are schematic diagrams showing separation of partially overlapped PIPs in a visible scene for enhancing efficiency of searching for regions of interest according to an embodiment of the present disclosure;

FIG. **9** is a schematic flow diagram showing a method for separating partially overlapped PIPs according to an embodiment of the present disclosure; and

FIG. **10** is a schematic diagram of an electronic device according to an embodiment of the present disclosure.

## DETAILED DESCRIPTION OF EMBODIMENTS

The following illustrative embodiments are provided to illustrate the disclosure of the present disclosure, these and other advantages and effects can be apparent to those in the art after reading this specification.

It should be noted that all the drawings are not intended to limit the present disclosure. Various modifications and variations can be made without departing from the spirit of the present disclosure.

Further, some or all operations and/or equivalent operations of the disclosed methods or processes can be performed by executing computer readable instructions on a computer storage medium. Computer readable instructions refer to routines, application programs, application modules, programs modules, programs, components, data structures, algorithms and so on. Computer readable instructions can be implemented on various system configurations, including a single-processor or multiprocessor system, a minicomputer, a mainframe computer, a personal computer, a palmtop computing device, a programmable consumer electronic device based on a microprocessor, or a combination thereof.

Therefore, it should be understood that the logical operations described herein are implemented as a sequence of acts implemented by a computer or program modules running on a computing system and/or as interconnected machine logic circuits or circuit modules within the computing system. The implementation is a matter of choice dependent on the performance and other requirements of the computing system. Therefore, the logical operations described herein are referred to variously as states, operations, structural devices, acts or modules. Such operations, structural devices, acts and modules can be implemented in software, firmware, special purpose digital logic or any combination thereof.

The present disclosure provides a method for enhancing efficiency of searching for regions of interest in a virtual environment. FIG. **1** is a schematic diagram showing presentation of a region of interest as a picture-in-picture (PIP) in a visible scene on a mobile device for enhancing efficiency of searching for the region of interest according to the present disclosure.

As shown in FIG. **1**, when the user uses a mobile device **100** to experience a virtual environment **110** consisting of a visible scene **120** and an invisible scene **130** and a region **140** of interest such as an extraterrestrial, a balloon, a cat, a dog, an airplane or an idol singer is in the invisible scene **130** of the virtual environment **110**, the present disclosure can present the region **140** of interest of the invisible scene **130** as a picture-in-picture (PIP) **150** in the visible scene **120**.

The user can view the PIP **150** in the visible scene **120** to know what region **140** of interest exists in the invisible scene **130** and in which direction the region **140** of interest is located relative to the visible scene **120**, thereby saving time for the user to search for the region **140** of interest in the invisible scene **130**.

FIG. **2** is a schematic diagram showing presentation of a region of interest of an invisible scene as a PIP in a visible scene according to the present disclosure.

As shown in FIG. **2**, in a virtual environment **290** consisting of a visible scene **200** and an invisible scene **280**, the visible range of the visible scene **200** is a region from a center **210** to an edge **250** of the visible scene **200**, and a region **220** of interest is located in the invisible scene **280**.

In an embodiment, when introduced into the visible scene **200** and displayed as a PIP, the region **220** of interest of the invisible scene **280** is displayed at a position along a line **240** connecting the position of the region **220** of the interest and the position of the center **210**.

As such, when seeing the PIP at a position **230**, the user will know that the region **220** of interest is located along the line **240** and hence can search for the region **220** of interest along the line **240**.

In an embodiment, when introduced into the visible scene **200** and displayed as a PIP, the region **220** of interest of the invisible scene **280** is displayed on the edge **250** of the visible scene **200**.

As such, when the user wants to search the invisible scene **280** for a plurality of regions of interest, the regions of interest are displayed as corresponding PIPs on the edge **250** of the visible scene **200**. Since these PIPs are not presented in the main view region of the visible scene **200** (for example, the region near the center **210**), the visual experiences of the user will not be adversely affected.

It should be understood that the presentation of a PIP on the edge **250** of the visible scene **200** includes, but not limited to, the presentation of the entire PIP inside the visible scene **200** (that is, the entire PIP is presented inside the edge **250**) or the presentation of a portion of the PIP inside the visible scene **200** (that is, a portion of the PIP falls outside the edge **250** and is not presented inside the visible scene **200**).

FIG. **3** is a schematic flow diagram showing a method for presenting a region of interest as a PIP in a visible scene according to an embodiment of the present disclosure.

First, at step S**310**, the region **220** of interest in the invisible scene **280** is located to determine its position in the virtual environment **290**. In an embodiment, a center-of-mass coordinate of the region **220** of interest (for example, its longitude and latitude in the virtual environment **290**) is used to represent the position of the region **220** of interest in the virtual environment **290**.

In an embodiment, the region **220** of interest may be manually chosen and marked and its position in the virtual environment **290** is manually marked and recorded so as to locate the position of the region **220** of interest.

Alternatively, recognition techniques using feature engineering or artificial intelligence such as deep learning may be used to find what regions **220** of interest exist in the invisible scene **280** and locate their positions.

Thereafter, at step S**320**, the position of the center **210** of the visible scene **200** in the virtual environment **290** is located.

Then, at step S**330**, the region **220** of interest is displayed as a PIP of the visible scene **200** at an intersection (i.e., position **230**) of the line connecting the position of the region **220** of interest and the position of the center **210** of the visible scene **200** and the edge **250** of the visible scene **200**.

In an embodiment, the visible scene **200** and the PIP may be projected on a display of an electronic device through a projecting means. The electronic device may be, but not limited to, a desktop computer, a notebook computer, a smart phone and a wearable device.

Further, the visible scene **200** and the PIP may be projected on the display through equirectangular projection, cube mapping, equi-angular cubemapping and so on.

FIG. **4** is a schematic flow diagram showing a method for simulation processing of a PIP in a visible scene according to an embodiment of the present disclosure.

First, at step S**410**, the PIP at the display position **230** is rotated around its center to generate a rotated picture. In an embodiment, an outer edge of the rotated picture faces the region **220** of interest in the invisible scene **280** and an inner edge of the rotated picture faces the center **210** of the visible scene **200**.

In an embodiment, the direction and angle of the rotation may be changed according to the orientation of the region **220** of interest relative to the center **210** of the visible scene **200**.

For example, if the region **220** of interest is located to the east, southeast or northeast of the center **210** of the visible scene **200**, the PIP may be rotated clockwise (or counterclockwise) around its center to generate the rotated picture. Otherwise, if the region **220** of interest is located to the west, southwest or northwest of the center **210** of the visible scene **200**, the PIP may be rotated counterclockwise (or clockwise) around its center to generate the rotated picture.

Thereafter, at step S**420**, the outer edge of the rotated picture is fixed and then the rotated picture is tilted by a tilting angle Φ along a Z-axis in the three-dimensional space to generate a simulation picture.

Compared with a PIP that is not processed, the simulation picture presents more 3D spatial information. As such, when experiencing virtual reality, the user has a more realistic spatial experience and captures visual information of the region of interest more easily.

In an embodiment, the tilting angle is varied based on the distance between the region **220** of interest and the center **210** of the visible scene **200**.

For example, the longer the distance between the region **220** of interest and the center **210** of the visible scene **200** is, the greater (or the less) the tilting angle becomes.

As such, when viewing a plurality of simulation pictures corresponding to different regions **220** of interest, the user can determine the distances between the regions **220** of the interest and the center **210** of the visible scene **200** according to the tilting angles.

In an embodiment, a maximum angle of the tilting angle may be 105 degrees (maxTilt) and a minimum angle of the tilting angle may be 0 degree (minTilt). Since the titling angle is limited to the range of minTilt to maxTilt, the present disclosure avoids too large a tilting angle that could adversely affect the user's visual experience.

In an embodiment, the tilting angle Φ can be calculated according to the following equation:

$$\Phi=\text{maxTilt}+(0-\text{maxTilt})\times(\text{dist\_max}-\text{dist})/\text{dist\_max},$$

wherein dist_max represents the distance between the farthest region of interest of the invisible scene **280** and the center **210** of the visible scene **200**, and dist represents the distance between the current region of interest and the center **210** of the visible scene **200**.

FIGS. **5***a* to **5***d* are schematic diagrams showing variation of a visible scene and a PIP when the PIP is simulation processed according to an embodiment of the present disclosure.

Referring to FIG. **5***a*, the PIP **235** in the visible scene **200** is located at the intersection of the edge **250** of the visible scene **200** and the line **240** and corresponds to a region of interest (not shown) that is located at a position in the outwardly extending direction of the line **240**.

Referring to FIG. **5***b*, the PIP **235** in the visible scene **200** is processed at step S**410** to generate a rotated picture **236**. The outer edge **2361** of the rotated picture **236** faces the region of interest outside the visible scene **200** while the inner edge **2362** of the rotated picture **236** faces the center **210** of the visible scene **200**.

Referring to FIG. **5***c*, the rotated picture **236** is processed at step S**420** to generate a simulation picture **237**. Φ represents the tilting angle along a Z-axis in the three-dimensional space. To facilitate viewing of the spatial effect of the simulation picture **237** generated by tilting the rotated picture **236** along a Z-axis in the three-dimensional space, the viewing angle of the visible scene **200** and the simulation picture **237** are changed by Φ degrees, as shown in FIG. **5***c*.

Referring to FIG. **5***d*, the visible scene **200** and the simulation picture **237** of FIG. **5***c* are viewed in the original viewing angle.

FIG. **6** is a schematic diagram showing application of a guiding symbol in a visible scene for enhancing efficiency of searching for a region of interest according to an embodiment of the present disclosure.

Referring to FIG. **6**, if the region **220** of interest is located outside the visible scene **200** (i.e., in the invisible scene **280**), a guiding symbol **201** is applied to guide the user toward the region **220** of interest so as to save time.

The number of the guiding symbol **201** may be varied according to the number of the region **220** of interest. For example, if three regions **220** of interest exist in the invisible scene **280**, three guiding symbols **201** are displayed in the visible scene **200**. If one region **220** of interest is added to (or deleted from) the invisible scene **280**, the number of the guiding symbols **201** becomes 4 (or 2).

FIG. **7** is a schematic flow diagram showing a method for applying a guiding symbol in a visible scene according to an embodiment of the present disclosure. Referring to FIG. **7**, steps S**710** and S**720** are substantially the same as steps S**310** and S**320** of FIG. **3**, respectively, but step S**730** is different from S**330**.

At step S**730**, a guiding symbol **201** is displayed at an intersection (i.e., position **230**) of the line connecting the position of the region **220** of interest and the position of the center **210** of the visible scene **200** and the edge **250** of the visible scene **200**. The guiding symbol points to the region **220** of interest.

In an embodiment, an arrow is used as the guiding symbol **201** pointing to the region **220** of interest. Further, the length, width, area and/or shape of the arrow may be used to indicate the distance of the region **220** of interest from the center **210** of the visible scene **200**.

For example, a long arrow indicates a long distance between the region **220** of interest and the center **210** of the visible scene **200** and a short arrow indicates a short distance between the region of interest **220** and the center **210** of the visible scene **200**. In another embodiment, a wide arrow indicates a long distance between the region **220** of interest and the center **210** of the visible scene **200** and a narrow arrow indicates a short distance between the region of interest **220** and the center **210** of the visible scene **200**. In a further embodiment, an arrow with a large area indicates a long distance between the region **220** of interest and the center **210** of the visible scene **200** and an arrow with a small area indicates a short distance between the region of interest **220** and the center **210** of the visible scene **200**.

It should be noted that the guiding symbol is not limited to the arrow. In an embodiment, a graphic symbol or a character symbol may be used.

FIGS. **8***a* and **8***b* are schematic diagrams showing separation of partially overlapped PIPs in a visible scene for enhancing efficiency of searching for regions of interest according to an embodiment of the present disclosure.

As shown in FIG. **8***a*, if the regions of interest are a star **810** and a triangle **820**, a star PIP corresponding to the star **810** and presented at a location **815** and a triangle PIP corresponding to the triangle **820** and presented at a location **825** are partially overlapped.

As the number of the regions of interest increases, the number of the PIPs in the visible scene increases accordingly and the PIPs may be overlapped. As such, it becomes difficult for the user to capture visual information of the regions of interest such as the orientations of the regions of interests from the overlapped PIPs.

According to the present disclosure, linear interpolation is used to find a position **826** (as shown FIG. **8***b*) for presenting the triangular PIP, thereby overcoming the overlapping problem and enhancing the efficiency of searching for the regions of interest.

FIG. **9** is a schematic flow diagram showing a method for separating partially overlapped PIPs according to an embodiment of the present disclosure.

At step S**910**, a first distance between a far region of interest such as the star **810** in the invisible scene **280** and the center **210** of the visible scene **200** is calculated.

At step S**920**, a second distance between a near region of interest such as the triangle **820** in the invisible scene **280** and the center **210** of the visible scene **200** is calculated.

It should be noted that although the first distance is greater than the second distance, the star PIP presented at the position **815** partially overlaps with the triangle PIP presented at the position **825**.

At step S**930**, based on the first distance and the second distance, linear interpolation is used to find a position **826** between the center **210** of the visible scene **200** and the position **815** for displaying the triangle PIP corresponding to the triangle **820** of the invisible scene **280**.

For example, the linear interpolation is based on the following equation:

$$pip\_near=pos\_center+(pip\_far-pos\_center)\times dist\_near/dist\_far,$$

wherein pip_near represents the position for presenting the PIP corresponding to the region of interest near the center **210**, pip_far represents the position for presenting the PIP corresponding to the region of interest far from the center **210**, pos_center represents the center **210** of the visible scene **200**, dist_near represents the distance of the near region of interest from the center **210**, and dist_far represents the distance of the far region of interest from the center **210**.

It should be noted that the above equation is used only when the far region of interest and the near region of interest are located in the same direction.

In an embodiment, an area for presenting PIPs may be defined in the visible scene **200** so as to prevent the PIPs from occupying the main view region and adversely affecting the visual experience of the user.

Also, it is ensured that the PIPs are completely presented inside the edge **250** and hence the user captures complete visual information of the regions of interest.

In an embodiment, a maximum distance between a display position and the center **210** is set to be MaxShowDist (for example, 35%, 40%, 45% of the length (width) of the visible scene **200**) and a minimum distance between a display position and the center **210** is set to be MinShowDist (for example, 5%, 10%, 15% of the length (width) of the visible scene **200**).

In an embodiment, the distance of a region of interest A (not shown) of the invisible scene **280** from the center **210** is dist_max and the distance of the display position pip_max of the corresponding PIP from the center **210** is MaxShowDist. Further, the distance of a region of interest B (not shown) of the invisible scene **280** from the center **210** is dist_min and the distance of the display position pip_min of the corresponding PIP from the center **210** is MinShowDist.

For a region of interest C (not shown) in the same direction as the region A of interest and the region B of interest, the display position of the corresponding PIP thereof can be calculated through the following equation:

$$pip\_candidate=pip\_min+(MaxShowDist-MinShowDist)\times dist\_max/dist\_candidate$$

FIG. **10** is a schematic diagram of an electronic device according to an embodiment of the present disclosure.

As shown in FIG. **10**, the electronic device **1000** includes a storage unit **1100**, a sensing unit **1200**, a computing unit **1300** and a display unit **1400**. The electronic device **1000** includes, but not limited to, a desktop computer, a notebook computer, a smart phone or a wearable electronic device.

The storage unit **1100** may be a computer readable memory device. The computer readable storage medium can be implemented via one or more of a volatile computer memory, a non-volatile memory, a hard drive a flash drive, a floppy disk or a compact disk, and a comparable medium. The storage unit **1100** may store computer executable instructions for performing the above-described methods, and data related to the virtual environment **290** such as picture information and position information of the visible scene **200**, the invisible scene **280** and the regions **220** of interest.

The sensing unit **1200** detects physical information of the electronic device, including but not limited to the orientation of the electronic device (for example, the electronic device facing east, west, south or north) and the state of the electronic device relative to the horizontal plane (for example, the electronic device having an angle of elevation or depression relative to the horizontal plane). In some embodiments, the sensing unit **1200** can be implemented as an accelerator, a gyroscope and other devices capable of detecting the physical information of the electronic device.

The computing unit **1300** may be implemented in the form of a computer processor, including but not limited to a single core processor, a dual microprocessor, a multi-core processor, AMD's Athlon, Duron and Opeteron processors, and Intel Celeron, Core 2 Duo, Core2 Quad, core i3, core i5 and core i7 processors. The computing unit **1300** controls operation of related hardware and software and executes the computer executable instructions of the storage unit **110** to implement the above-described methods.

The display unit **1400** may be implemented as various physical and/or virtual display devices, including but not limited to a computer screen, a laptop computer screen, a mobile device screen, a PDA screen, a tablet screen, and a display screen of a wearable electronic device. The display unit **1400** may display data related to searching for regions of interest in a virtual environment. For example, the display unit **1400** may display a visible scene and PIPs.

The above-described descriptions of the detailed embodiments are only to illustrate the preferred implementation according to the present disclosure, and it is not to limit the scope of the present disclosure. Accordingly, all modifications and variations completed by those with ordinary skill in the art should fall within the scope of present disclosure defined by the appended claims.

What is claimed is:

**1**. A method for enhancing efficiency of searching for a region of interest in a virtual environment, wherein the virtual environment is comprised of a visible scene and an invisible scene, the method comprising:

(1) locating a position of the region of interest in the invisible scene and a position of a center of the visible scene;

(2) displaying the region of interest as a picture-in-picture (PIP) of the visible scene at an intersection of a line connecting the position of the region of interest and the position of the center of the visible scene and a boundary of the visible scene; and

(3) projecting the visible scene and the PIP on a display device through a projecting means.

**2**. The method of claim **1**, wherein the position of the region of interest is a center-of-mass coordinate of the region of interest.

**3**. The method of claim **1** wherein the projecting means is selected from the group consisting of equirectangular projection, cube mapping and equi-angular cubemapping.

**4**. The method of claim **1**, further comprising rotating the PIP around a center thereof to generate a rotated picture such that the rotated picture has an outer edge facing the region of interest and an inner edge facing the center of the visible scene.

**5**. The method of claim **4**, further comprising fixing the outer edge of the rotated picture and tilting the rotated picture by a tilting angle θ along a Z-axis in a three-dimensional space to generate a simulation picture.

**6**. The method of claim **5**, wherein the tilting angle is varied based on a distance between the region of interest and the center of the visible scene.

**7**. The method of claim **5**, wherein a maximum angle of the tilting angle is 105 degrees and a minimum angle of the tilting angle is 0 degree.

**8**. An electronic device for enhancing efficiency of searching for a region of interest in a virtual environment, comprising:

a storage unit configured for storing computer readable program codes; and

a processor configured for executing the computer readable program codes for implementing the method of claim **1**.

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