IMAGE DISPLAY APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an image display apparatus, in particular, a head mounted display (HMD) worn by the user on his or her head to view images displayed before the eyes, and more specifically, to an HMD having a function to detect a movement of the head of the user wearing the HMD.

2. Description of the Prior Art

In a system to view images taken by a three-dimensional camera with a three-dimensional viewing apparatus, it has been proposed to vary the direction of the three-dimensional camera according to the viewing direction of the three-dimensional viewing apparatus to obtain more realistic images. For example, Japanese Laid-open Patent Application No. H3-56923 discloses to control the direction of the three-dimensional camera according to the direction of the HMD.

On the other hand, as an angular velocity sensor, a piezoelectric vibrating gyro has been proposed as shown, for example, in Japanese Laid-open Patent Application No. H2-80911. The piezoelectric vibrating gyro has been in the actual use in recent years for sensing camera shake of, for example, a video camera. The present applicant proposed a detector for detecting the direction of the HMD by use of the piezoelectric vibrating gyro in Japanese Patent Application No. H6-254910. This detector enables with a simple structure a detection of the direction of the user's head without the place of use being limited.

However, the above-mentioned direction detector detects the direction of the head by integrating an output of the angular velocity sensor and is defective in that a small error of the angular velocity sensor is integrated into a great angle error. It is difficult to completely reduce the output of the piezoelectric vibrating gyro of its stationary state to zero and a minute angular velocity is detected although the head is kept stationary. If the value is integrated for a long time, a great error is caused in the detected angle. Consequently, the direction of the viewing of the user and the image displayed in the HMD disaccord with each other, so that the realism is impaired.

It is desirable to widen the angle of view of the image displayed on the HMD in order to improve the realism. However, the widening of the angle of view has a limitation because of an optical constraint. If the angle of view of the displayed image is widened, the displayed image becomes coarse unless a high-density display device is used, and the realism is impaired. For this reason, the angle of view of the displayed image is generally set at approximately 40° and a small-size and light-weight HMD has been realized.

However, an angle of view of approximately 40° is very narrow compared to the angle of the human field of view. When the angle of view of the displayed image is narrow, the surroundings cannot be seen as if the user were walking in the dark only with the light from a flashlight, and the sense of direction is difficult to obtain. In particular, when the direction of the displayed image varies in accordance with the direction of viewing, the sense of direction tends to be lost unless some kind of reference direction is provided and the sense of direction is not easy to restore once it is lost.

The conventional display apparatus which varies the direction of the displayed image according to a rotation of the user's head can cause a physical pain to the user

depending on the direction of the image to be viewed, since the relation between the directions of the user's head and the image to be displayed is fixed and can not be changed. For example, when an upward object is viewed, since it is necessary to look upward, the user's neck becomes fatigued from a long-time viewing. That is, since it is necessary to look strictly in the direction of viewing, the user cannot view the image in a relaxed posture.

When it is impossible for the user to freely change his or her posture, another problem is caused that the image to be displayed is limited. For example, a bedridden user could view only the images corresponding to the condition of lying in bed, even if an HMD is used.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an HMD which correctly detects the direction of the user's head even after a long period of use for varying the displayed image according to the detected direction.

To achieve the above-mentioned object, according to the present invention, an HMD is provided with an angle sensor for detecting an angle of rotation of the user's head, an angular velocity sensor for detecting a velocity of rotation of the head, a calculator for calculating an angle of rotation of the head based on an output from the angle sensor or the angular velocity sensor, and a display controller for displaying an image of a direction in accordance with the angle calculated by the calculator.

The angular velocity sensor has an advantage that it can detect a rotation very quickly, while the angle sensor has an advantage that it can detect the amount of rotation very accurately in a stationary state. The direction of the head of the user wearing the HMD can be detected quickly and accurately by the calculation based on the outputs of these sensors.

Other objects of the present invention are to enable the user to view an image in a desired direction irrespective of the direction of his or her head, and to provide the user with a sense of correct direction in viewing an image, when an image display apparatus which varies the image in accordance with the direction of the head.

To achieve these objects, an image display apparatus is provided with a display device for displaying an image, a direction detector for detecting a direction of viewing by detecting an angle of rotation of the user's head, a direction input device for inputting a direction of viewing manually therefrom, a selector for selecting one direction out of the directions of viewing detected by the direction detector and inputted from the direction input device, and an image display controller for displaying on the display device an image in accordance with the direction selected by the selector.

An image display apparatus for displaying an image varying in accordance with the direction of the head of a user may be provided with a direction detector for detecting a direction of viewing by detecting an angle of rotation of the head, an image display controller for displaying an image in accordance with the direction detected by the direction detector, and an information display controller for displaying information on the direction of viewing.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and features of this invention will become clear from the following description, taken in conjunction with the preferred embodiments with reference to the accompanied drawings in which: