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(54) Title: APPARATUS AND METHOD FOR SINGLE CAMERA MIRRORED PANORAMIC IMAGING

(57) Abstract: The invention provides for an imaging apparatus that uses a single camera and a single lens to capture a wide-angle view of an area while the camera is positioned in a bottom up position.

Apparatus And Method For Single Camera Mirrored Panoramic Imaging

Field of Invention

This invention concerns an imaging system. More particularly, it concerns imaging system for capturing a 360-degree image of a space using a single, stationary camera.

Background of Invention

Improved wide-angle imaging is increasingly required for many applications including surveillance systems, video teleconference systems, and vehicle vision systems. Essential to such applications is the need to monitor a wide operating area and to form a composite image for easy comprehension in different user modes. To minimize the number of cameras and cost, cameras with panoramic lens enable a wide field of view.

In a surveillance application, multiple panoramic cameras may cover the entire exterior and interior area of a building, and the system can provide continuous view of the area and, manually or automatically, track objects through the area. In a video teleconferencing system, single camera may capture all the present audience, however it would be in a theater like scenario rather than the more preferred round table conference environment. In a vehicle vision system, multiple panoramic cameras can provide a full 360° view of the area and around obstructive objects. Such systems can adapt display views to specific operator modes such as turning, reversing, and lane changing to improve situational awareness. Additional advantages of a vehicle vision system are the capability to detect objects in motion, provide warning of close objects, and track such objects through multiple viewing regions. Vision systems could also greatly enhance night vision through various technologies such as infrared, radar, and light sensitive devices.

However, in all the systems above, either more than one camera is required, or where a single camera is applicable it would have to be mounted on high altitude such as a ceiling in order to capture the entire scene with a single camera.

It is therefore desirable to provide for an imaging apparatus and system, where the image capture device is mounted in a down-up looking manner on a horizontal surface as opposed to the conventional top-down looking mounting arrangement.

Summary of Invention

It is an objective of the present invention to provide for an imaging apparatus that uses a single camera and a single lens to capture a wide-angle view of an area while the camera is positioned in a bottom up position.

The imaging apparatus of the present invention further has the capability of sound detection and night vision.

Description of Drawings

Figure 1	Embodiment of the present invention
Figure 2	Arrangement of the apparatus and support means
Figure 3	IR LED ring arrangement
Figure 4	Illumination area by a IR LED ring
Figure 5	Microphone array according to the present invention
Figure 6	Graph for Detection of the highest amplitude
Figure 7	Method to vary field of view by means of distance
Figure 8	Method to vary field of view by means of rotation.

Detailed Description

The present invention will now be detailed with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. The invention may, however be embodied in other different forms and should not be construed as being limited to the embodiments discussed herein, rather these embodiments are provided so that this disclosure will convey the concept of the invention to those skilled in the art. In the following description of the present invention, known methods and functions will be omitted as it would be already known to those skilled in the art.

The present invention comprises of an image capturing device, a wide-angle lens, a detachable reflective means, a detachable illumination means, a detachable sound detection means, vertical adjustment means and support means.

Figure 1a illustrates one of the preferred embodiments of the present invention. As illustrated, the image-capturing device such as a panoramic video camera is coupled with a wide-angle lens, wherein the camera lens is enclosed by the wide-angle lens. The detachable reflective surface such as a mirror is placed above the apex of the wide-angle lens. The mirror is supported by moveable rods which are typically in the range of 10 to 15 cm, wherein one end of the rods are attached to the circumference of the mirror, so that the mirror is secured in the horizontal plane. The other ends of the rods are attached to stationary rods, which extends from the side surface of the lens. The mirror is rotatable around its horizontal axis.

A detachable sound detection means such as directional microphone array is mounted on top of the reflective means, such that the microphone rings are encircling the circumference of the mirror.

A detachable illumination means is mounted on top of the detachable sound detection means, such that the circumference of the illumination means is abutting the circumference of the sound detection means.

The camera is mounted detachably on a support means such as a tripod or a desktop stand.

In another preferred embodiment as illustrated in Figure 1(b), one end of a rotational control is attached to the vertical surface of the camera. The other end of the rotational control is attached to the vertical adjustment means, which is a moveable rod. The reflective surface is supported by the vertical adjustment means, wherein one end of the vertical adjustment means is attached to the circumference of the mirror. The other end of the vertical adjustment is detachably attached to the support means, which is a tripod or a desktop stand.

The entire imaging arrangement as can be seen in Figure 2 is mounted on a horizontal plane such as the floor, desktop or vehicle roof. Figure 2 also illustrates the arrangement of the apparatus and the support means.

In its most common usage, the panoramic camera and the wide angle lens would be mounted on a high surface such as a ceiling in a top down looking direction in order for the camera to capture the scene below, such as a corridor in a shopping complex, in order to capture a wide-angle view

of the scene with a single wide-angle lens. However this common method is not useful in places where a ceiling is not available to mount the camera in a top down position, such as open space parking.

Therefore, the camera is arranged in a bottom up arrangement such that the camera's lens are facing skyward. A reflective surface such as a mirror is placed above the apex of the wide-angle lens so that the camera captures the images that are being reflected by the mirror i.e. the top-down view of the area.

The functions of each component of the apparatus will be described in detail below:

Camera coupled with a wide angle lens

The image-capturing device used in this invention is a video camera that is able to capture real time video image of an area. The camera lens is coupled with a wide-angle lens. The wide-angle lens enables the camera to capture a wide-angle view of an area without the need for. The camera captures a real time video stream that will be fed into automated systems for various functions such as surveillance, video teleconferencing or vehicle audit trail.

Reflective surface

The reflective surface in this invention is a mirror. The mirror is placed directly above the apex of the lens such that the images reflected by the mirror is captured by the lens of the camera, which would appear as an image captured by a top-down looking camera.

Infra Red LED ring

The IR LED ring provides the needed illumination when there is insufficient light source for the camera to capture visible images. The IR LEDs are arranged in a circular i.e. ring shape as illustrated in Figure 3 to provide an even illumination across the panoramic image. The wide-angle lens captures an evenly illuminated circular view, which is converted to a rectangular representational panoramic view. An example of the illumination area provided by the LEDs is as illustrated in Figure 4.

The working range of the IR LEDs are dependent on the type(s) of LEDs used, which determines the range up to which the illumination of the LEDs can span. Few examples of the LEDs that are used are standard and high power LEDs.

Microphone Ring

The directional microphone array is used as the direction determining means to determine the source of noise. The microphones are arranged in a circular ring as illustrated in Figure 5 with an interval range from 5 to 20 degrees. The entire ring would consist of 18 to 72 microphones depending on the interval range selected.

The point of origin of the noise or the noise source is assumed to be the source from where the highest amplitude is detected by comparing the audio signals that are collected by the microphone array. The direction of the audio input can be detected using the amplitude of the signal as illustrated in Figure 6. The microphone capturing the highest amplitude will be selected as the active microphone. Further to this, the percentages of amplitude detected between two adjacent microphones are calculated to determine the exact angle of the sound source.

An example of calculating the exact sound angle of the sound source is as given below:

Let take the two highest amplitude, say between angle X and angle Y, amplitude for X is Ax and Amplitude of Y is Ay and the separation angle between X and Y is (Y-X), the angle calculation should be like this:

Detected angle: X + (Ax/(Ax+ Ay) * (Y-X))

The angle information obtained in further processed and plotted on the panoramic image.

Vertical Adjustment means

The vertical adjustment means is used to vary the height difference between the reflective surface and apex of the wide-angle lens. The heights are varied to give rise to the coverage of the field of view. The camera is attached to a vertical orifice on the vertical adjustment means by means of a screw. The position of the screw can be varied along the height of the vertical adjustment.

Therefore, the distance between the reflective surface and the camera is varied by varying the position of the screw.

In the first embodiment the vertical adjustable means are at least two moveable rods wherein one end of the rods are attached to the circumference of the mirror, so that the mirror is secured in the horizontal plane. The other ends of the rods are attached to stationary rods, which extends from the side surface of the lens.

In the second embodiment the height adjustable means is a single moveable rod, to which the vertical side of the camera is attached to by means of a rotatable means.

Support means.

The entire apparatus arrangement is supported by the support means, which is a tripod or a desktop stand. The support means is also used to improve the field of view of the apparatus as can been seen in figure 7. The increase in the height of the apparatus from the ground level increases the overall field of view.

In the first embodiment the base of the camera is attached to the support means, which is a tripod or a desktop stand.

In the second embodiment, the vertical adjustment means is attached to the support means, which is a tripod or a desktop stand.

In the following paragraphs the methods of adjusting the field of view and imaging method will be explained in detail.

The field of view that will be captured by the camera of the present invention can be adjusted by means of distance as illustrated in Figure 6 or rotation as illustrated in Figure 7.

Distance

The field of view is varied by means of distance by

a. adjusting the height between the lens and the mirror

In the first embodiment, the height between the lens and the mirror is adjusted by increasing or decreasing the height of the two moveable rods, which act as the vertical adjustment means.

In the second embodiment, the height between the lens and the mirror is adjusted by increasing or decreasing the position of the rotational means along the height of the vertical adjustment means.

b. adjusting the height between the apparatus and horizontal plane.

In both the first and second embodiment, the height between the apparatus and horizontal plane is varied by means of increasing or decreasing the height of the support means, which is a tripod or a desktop stand.

Rotation

The field of view is varied by means of rotation by

a. titling the mirror.

In the first embodiment the height of the two vertical adjustment means are set differently i.e. setting the rods at different level to create a tilting effect of the mirror in order to vary the field of view. This is illustrated in Figure 7

b. titling the apparatus

In the second embodiment the apparatus is set at different angle along its horizontal axis within the range of , in order to vary the field of view as illustrated in Figure 8.

In the present invention, the image is produced through the reflection from the mirror and the

image reflected non-linearly from a flat reflective surface. The light reflected from the mirror is collected by the wide-angle lens. Full reflection can be redirected to camera by adjusting the mirror.

Claims

1. An imaging apparatus comprising
an image-capturing device
a wide-angle lens
a reflective surface
a vertical adjustment means
a support means
an illumination means; and
a sound detection means.

2. An imaging apparatus according to claim 1, wherein the image capturing device is a video camera
3. An imaging apparatus according to claim 1, wherein the reflective surface is a mirror
4. An imaging apparatus according to claim 1, wherein the vertical adjustment means is at least one rod.
5. An imaging apparatus according to claim 1, wherein the support means is a tripod or a desktop stand.
6. An imaging apparatus according to claim 1, wherein the illumination means is a LED ring
7. An imaging apparatus according to claim 1, wherein the sound detection means is a microphone ring.
8. An imaging apparatus according to claim 1 and 4, wherein the height of the vertical adjustment means is variable.
9. An imaging apparatus according to claim 1 and 5, wherein the height of the support means is variable.
10. An imaging apparatus according to claim 1, wherein the apparatus is used in a surveillance system.
11. An imaging apparatus according to claim 1, wherein the apparatus is used in a video teleconferencing system
12. An imaging apparatus according to claim 1, wherein the apparatus is used in a vehicle imaging system.
13. An imaging apparatus according to claim 12, wherein the vehicle imaging system is

used for a vehicle audit trail system.

14. An imaging apparatus according to claim 12, wherein the vehicle imaging system is used in a vehicle parking system.

15. An imaging apparatus according to claim 1, wherein the illumination means and sound detection means are detachable from the apparatus.

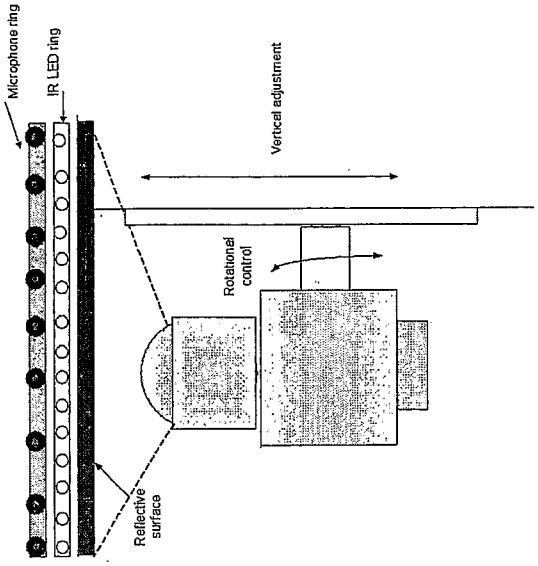


Figure 1 (b)

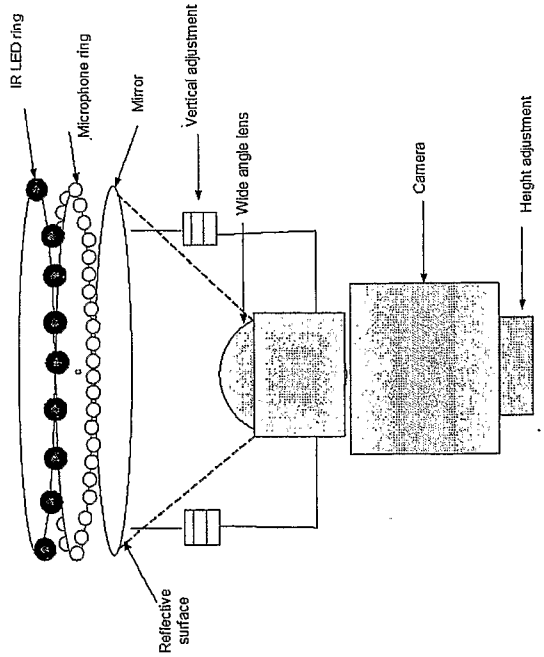
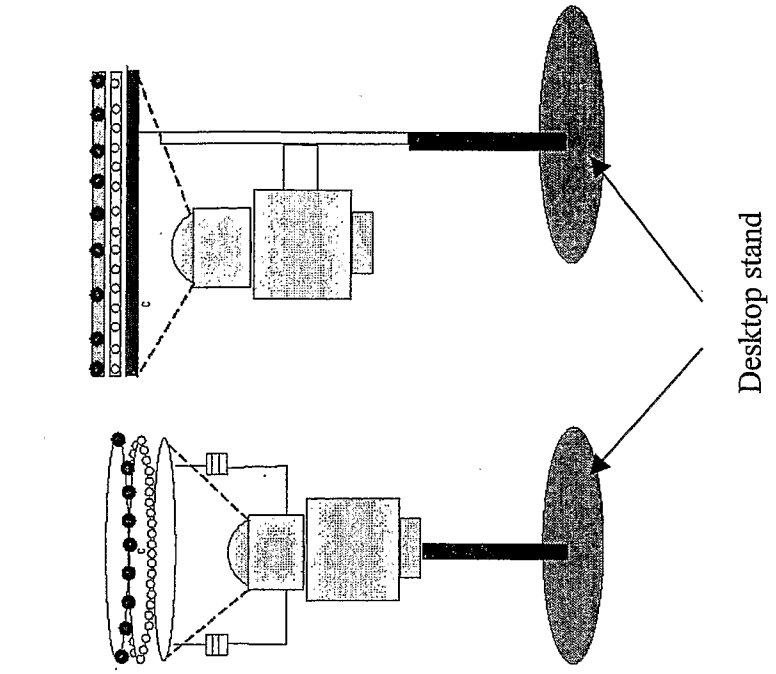


Figure 1 (a)



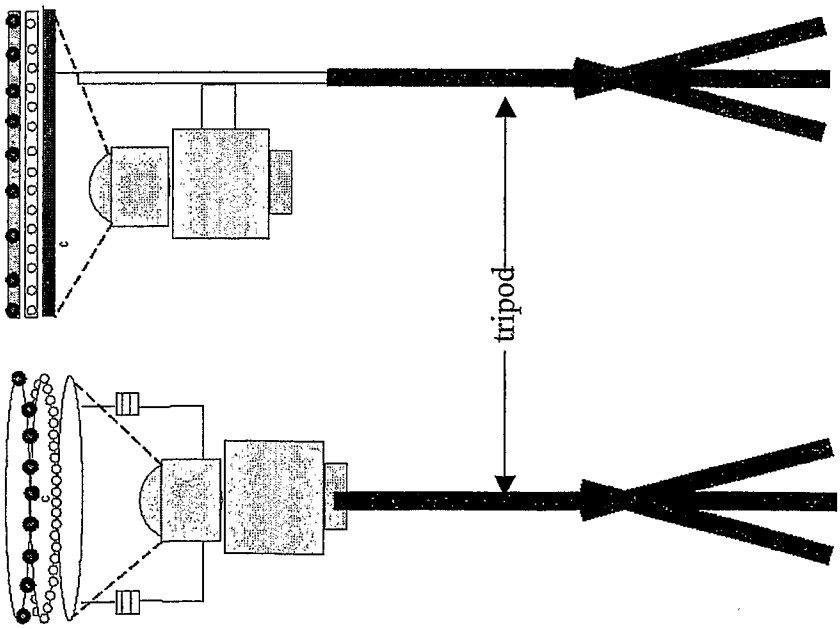


Figure 2

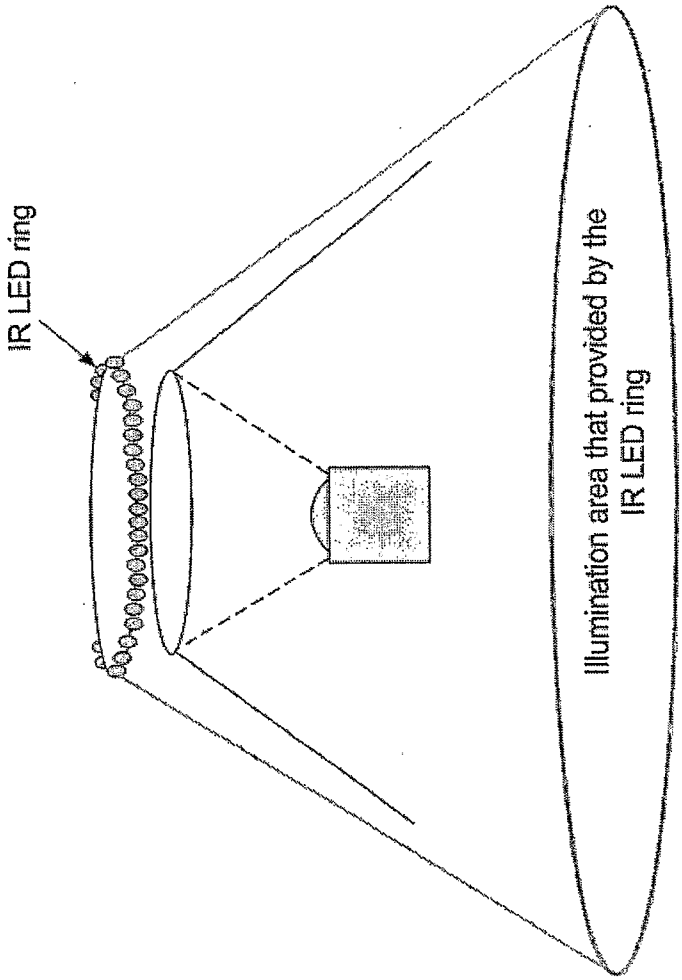


Figure 4

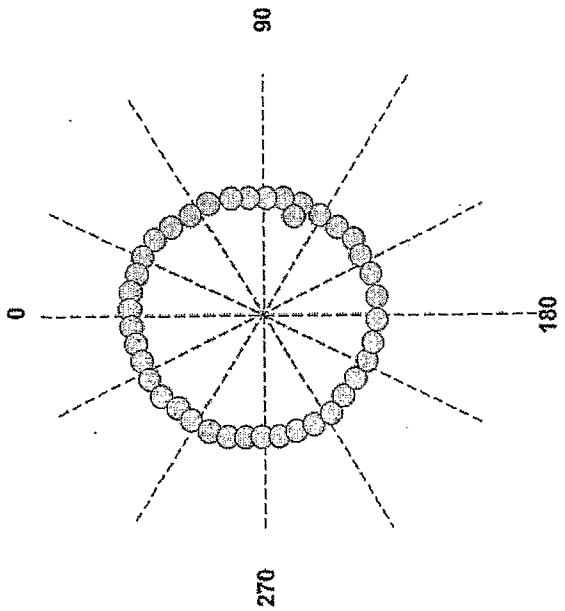


Figure 3

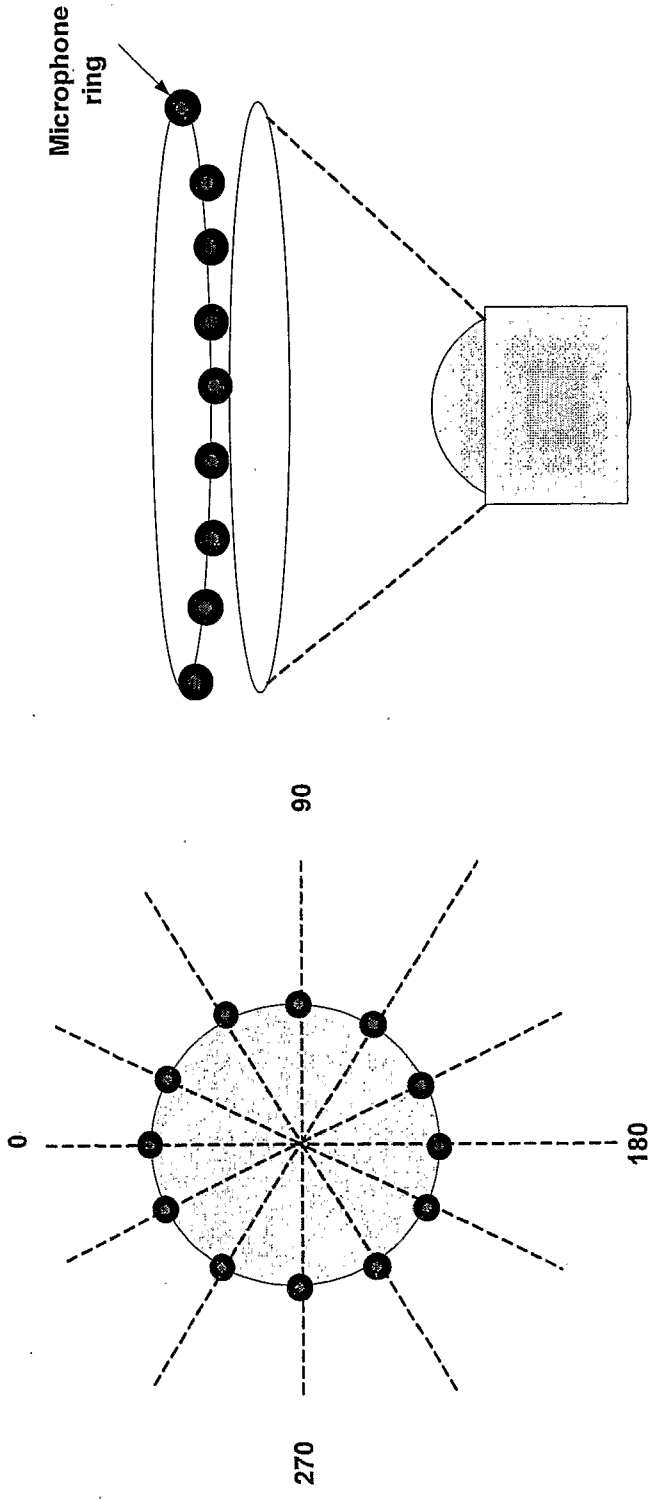


Figure 5

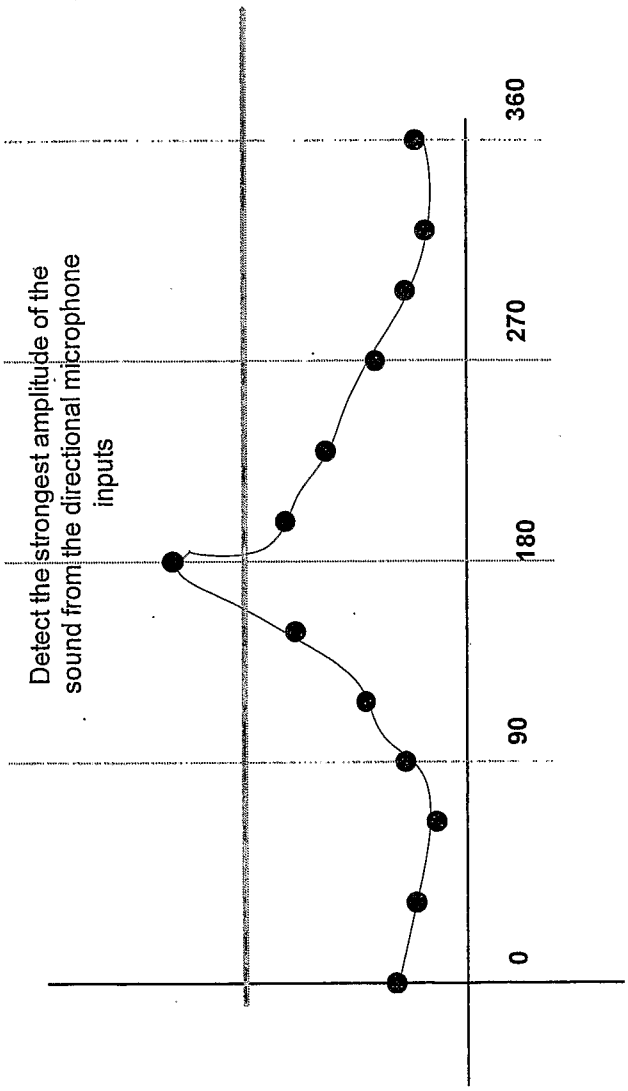
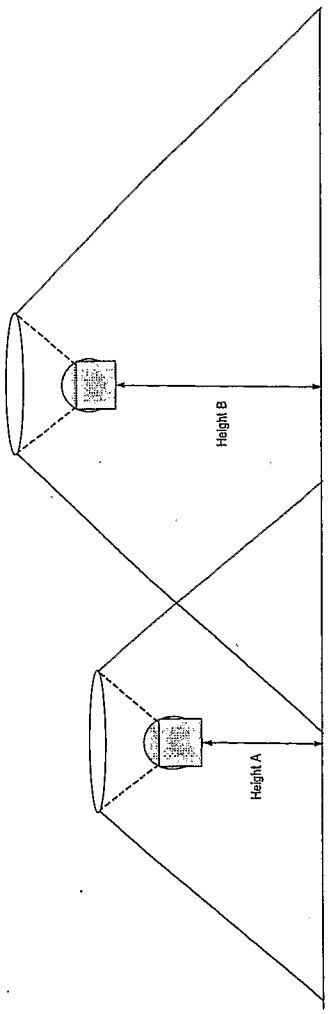
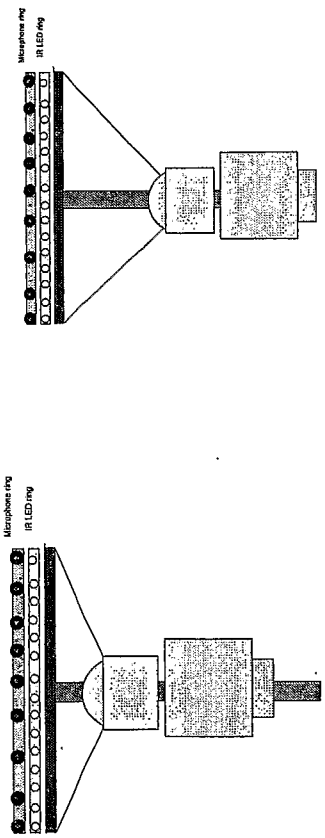

Detect the strongest amplitude of the sound from the directional microphone inputs
360
270
180
90
0

Figure 6



Varying distance between apparatus and horizontal plane



Varying distance between lens and mirror

Figure 7

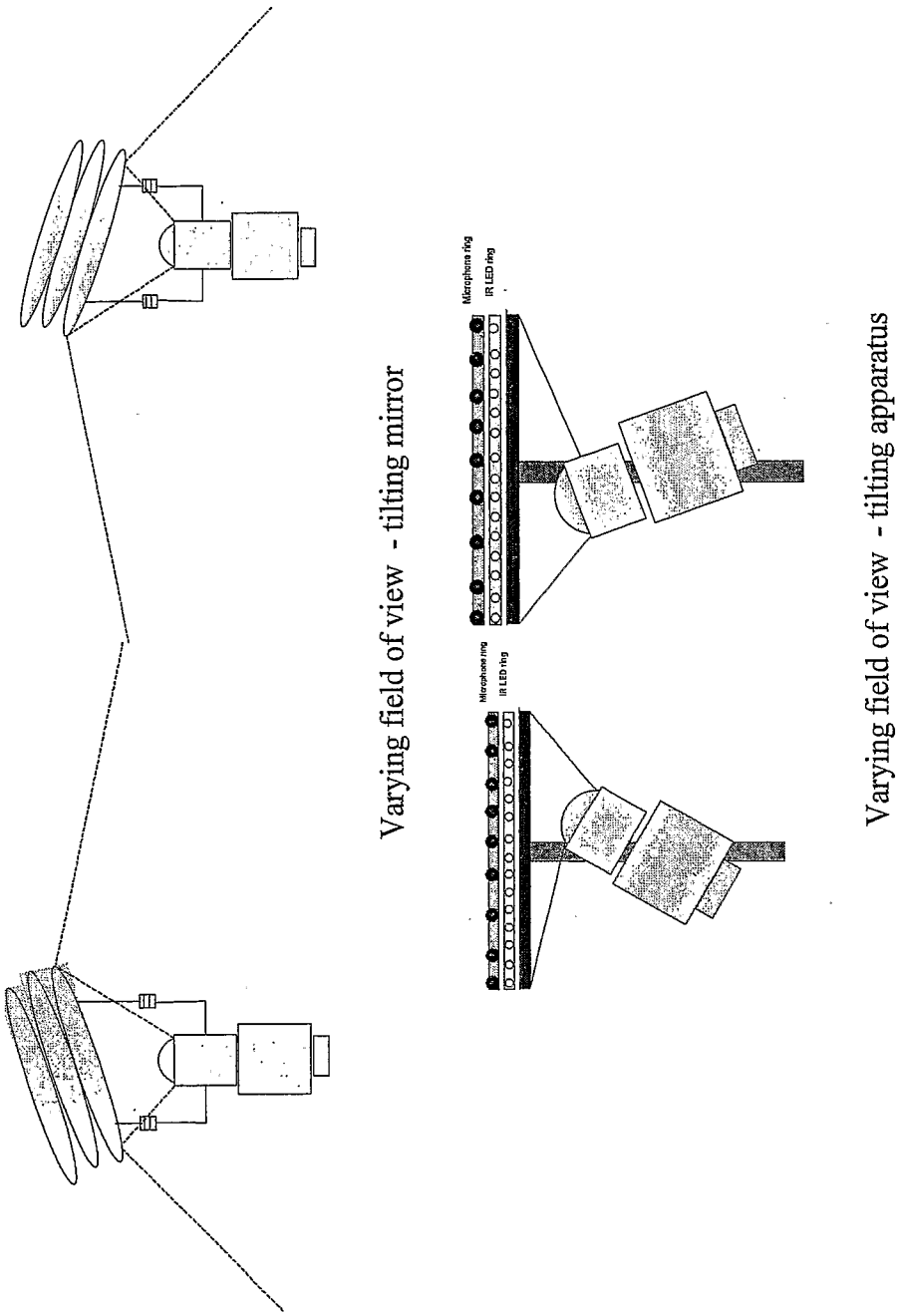

Varying field of view - tilting mirror
Varying field of view - tilting apparatus

Figure 8