MEMS SCANNING DISPLAY DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. patent application Ser. No. 15/624,477, filed Jun. 15, 2017, which claims priority to U.S. Provisional Patent Application Ser. No. 62/467,086 filed Mar. 3, 2017, the entireties of which are hereby incorporated by reference for all purposes.

BACKGROUND

[0001] Some display devices employ light source scanning to produce viewable images. In one example, laser light is reflected by a scanning mirror system at different angles to scan the laser across pixels of a projected image. Control of the light color and/or intensity at each pixel allows the image to be projected.

SUMMARY

[0002] Examples are disclosed that related to head-mounted scanning image display systems. In one example, a scanning head-mounted display system includes a light source, a motion sensor, a scanning mirror system configured to scan light from the light source along at least one dimension to form an image, and a controller configured to control the scanning mirror system to scan the light to form the image, receive head motion data from the motion sensor, and adjust one or more of a scan rate and a phase offset between a first frame and a second frame of the image based upon the head motion data. This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter. Furthermore, the claimed subject matter is not limited to implementations that solve any or all disadvantages noted in any part of this disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. 1 shows a block diagram of an example MEMS scanning head-mounted display device.

[0004] FIG. 2 shows an example laser trace diagram.

[0005] FIG. 3 shows another example laser trace diagram.

[0006] FIG. 4 shows an example laser die at a first rotational orientation.

[0007] FIG. 5 shows the example laser die of FIG. 4 at a second rotational orientation.

[0008] FIG. 6 shows another example laser trace diagram.

[0009] FIG. 7 shows another example laser trace diagram.

[0010] FIG. 8 shows a flow diagram illustrating an example method of dynamically adjusting one or more operating parameters of a scanning head-mounted display device.

[0011] FIG. 9 shows a block diagram of another example scanning head-mounted display device.

The invention claimed is:

1. A scanning head-mounted display system, comprising:

a light source;

a motion sensor;

a scanning mirror system configured to scan light from the light source along at least one dimension to form an image; and

a controller configured to

control the scanning mirror system to scan the light to form the image, receive head motion data from the motion sensor, and

adjust one or more of a scan rate and a phase offset between a first frame and a second frame of the image based upon the head motion data.

2. The scanning head-mounted display system of claim 1, wherein the scanning mirror system comprises a first mirror configured to scan the light in a first direction, and a second mirror configured to scan the light in a second direction.

3. The scanning head-mounted display system of claim 2, wherein the controller is configured to adjust the phase offset between the first frame and the second frame by adjusting a time at which the scanning mirror system initiates the scanning of the light in the second direction relative to the scanning of the light in the first direction.

4. The scanning head-mounted display system of claim 1, wherein the controller is configured to adjust the phase offset between the first frame and the second frame based on a desired line spacing at a region in the image.

5. The scanning head-mounted display system of claim 4, wherein the region is one of a plurality of regions in the image, and wherein the controller is configured to associate a respective phase offset with each of the plurality of regions.

6. The scanning head-mounted display system of claim 1, further comprising an eye tracking sensor configured to detect a gaze direction of a user, and wherein the controller is further configured to map the gaze direction to a region in the image, and to adjust one or more of the scan rate and the phase offset based on the region in the image.

7. The scanning head-mounted display system of claim 6, wherein the controller is further configured to adjust the phase offset in a first manner based on mapping the gaze direction to a first region in the image, and to adjust the phase offset in a second manner based on mapping the gaze direction to a second region in the image.

8. The scanning head-mounted display system of claim 6, wherein the region is a foveal region of the image, the image comprising a non-foveal region, and wherein the controller is further configured to increase the scan rate in the non-foveal region and to decrease the scan rate in the foveal region.

9. The scanning head-mounted display system of claim 6, wherein the phase offset between the first frame and the second frame comprises multiple phase offset adjustments,

and wherein the controller is configured to

determine a first phase offset adjustment based upon the region in the image,

determine a second phase offset adjustment based upon the head motion data, and

adjust the phase offset between the first frame and the second frame based upon a sum of the first phase offset adjustment determined and the second phase offset adjustment determined.

10. The scanning head-mounted display system of claim 1, wherein the light source is a laser light source comprising two or more offset lasers, and wherein the laser light source is configured to output light of multiple colors.

11. The scanning head-mounted display system of claim 1, further comprising an eye tracking sensor configured to detect eye movement, and wherein the controller is further configured to

map the eye movement, and

adjust the phase offset between the first frame and the second frame based upon the eye movement.

12. The scanning head-mounted display system of claim 1, wherein the scanning mirror system is configured to scan a horizontal line of the image in a half period of a micro-electromechanical actuator that drives the scanning mirror system.

13. The scanning head-mounted display system of claim 1, wherein the light source comprises a one dimensional array of light emitters.

14. The scanning head-mounted display system of claim 1, wherein the scanning mirror system comprises a same higher frequency scanning mirror and separate left-eye and right-eye lower frequency scanning mirrors for respectively scanning in a higher frequency scan direction and a lower frequency scan direction.

15. A method of displaying an image, comprising:

directing light from a light source toward a scanning mirror system;

scanning the light from the light source in a first direction at a higher frequency and in a second direction at a lower frequency to thereby scan the light in an interlaced pattern and form the image;

receiving head motion data from a motion sensor; and

based at least on the head motion data, adjusting one or more of a scan rate in the second direction and a phase offset between a first frame and a second frame of the interlaced pattern.

16. The method of claim 15, further comprising mapping a gaze direction determined via an eye tracking sensor to a region in the image, and adjusting one or more of the scan rate in the second direction and the phase offset based on the region in the image.

17. The method of claim 15, further comprising

mapping an eye movement across the image via an eye tracking sensor, and

based upon the eye movement, adjusting one or more of the scan rate in the second direction and the phase offset between the first frame and the second frame of the interlaced pattern.

18. The method of claim 15, wherein scanning the light from the light source comprises scanning the light to form the image at a resolution between 1440p and 2160p.

19. A scanning head-mounted display system, comprising :

a light source;

a motion sensor;

a scanning mirror system configured to scan light from the light source in a first direction at a higher frequency, and in a second direction at a lower frequency to form an image;

an eye tracking sensor; and

a controller configured to

control the scanning mirror system to scan the light in an interfaced pattern to form the image;

receive head motion data from the motion sensor,

receive data from the eye tracking sensor,

adjust one or more of a scan rate in the second direction and a phase offset between a first frame and a second frame of the interlaced pattern based at least on the head motion data and the data received from the eye tracking sensor.

20. The scanning head-mounted display system of claim 19, wherein receiving the data from the eye tracking sensor comprises receiving an indication of one or more of a gaze direction and an eye movement, and wherein the controller is further configured to

determine a first phase offset adjustment based upon the one or more of the gaze direction and the eye movement,

determine a second phase offset adjustment based upon the head motion data, and adjust the phase offset between the first frame and the second frame of the interlaced pattern based upon a sum of the first phase offset adjustment determined and the second phase offset adjustment determined.