SENSOMOTORIC INSTRUMENTS Attorney's file: 49238

Patent application

Head mounted system and method to compute and render a stream of digital images using a head mounted display

CLAIMS:

1. A head mounted system (10) comprising:
   a) a binocular eye tracking system (14a, 14b) comprising:
      - at least a first camera (14a) arranged for acquiring a user's left eye (16a);
      - at least a second camera (14b) arranged for acquiring a user's right eye (16b);
   b) a head mounted display (10) comprising:
      - a first displaying means (18a) for presenting an image to a user's left eye (16a);
      - a second displaying means (18b) for presenting an image to a user's right eye (16b);
   c) a processing unit (24, 24a, 24b) designed to
      - process images from the eye tracking system (14a, 14b) and calculate at least an orientation vector of the left (16a) and the right eye (16b);

   characterized in that

   the processing unit (24, 24a, 24b) is further designed to
      - calculate a 3D position of the left (16a) and the right eye (16b);
      - compute and render a stream of digital images to be projected onto the user's left and right eye (16a, 16b) by means of the head mounted display; and

- consider the 3D position of the left and the right eye (16a, 16b) and the orientation of the left and the right eye (16a, 16b) when computing and rendering the stream of digital images for positioning a virtual camera when rendering a virtual 3D scene and/or to determine which part of a virtual scene is rendered in focus.

2. The head mounted system (10) according to claim 1, characterized in that the head mounted system (10) comprises wearing means (12) and the processing unit (24, 24a, 24b) is mechanically coupled to those wearing means (12).

3. The head mounted system (10) according to claim 1, characterized in that the head mounted system (10) comprises wearing means (12) and a data interface mechanically coupled to those wearing means (12), the processing unit (24, 24a, 24b) being coupled with said data interface, especially wired or wireless.

4. The head mounted system (10) according to one of the preceding claims, characterized in that the head mounted system (10) comprises light guide means for projecting images onto said user's eyes (16a, 16b), which follow a substantially separate optical path as the optical path used by the eye tracking system (14a, 14b).

5. The head mounted system (10) according to one of the preceding claims, characterized in that the processing unit (24, 24a, 24b) is designed to calculate the 3D position of a point of regard (POR), in particular the 3D position of the point of regard (POR) and the distances to each of the eyes (16a, 16b), that the user is fixating using the 3D eye position of the left and the right eye (16a, 16b) and the orientation vectors of the left and the right eye (16a, 16b).

6. The head mounted system (10) according to one of the preceding claims,

characterized in that
the processing unit (24, 24a, 24b) is designed to estimate the 3D position of the point of regard (POR) as the closest point between the left and the right direction rays defined by the calculated 3D positions and orientation vectors of the left and the right eye (16a, 16b), if the left and the right direction rays do not intersect.

~~7. The head-mounted system (10) according to claim 6,~~
characterized in that
the processing unit (24, 24a, 24b) is designed to filter the left and the right eye direction rays and positions through a mapping function, especially by applying an offset, a linear or a non-linear transformation.

8. The head mounted system (10) according to claim 7,
characterized in that
the processing unit is designed to carry out a calibration procedure calibrating the head mounted system (10) for a specific user, wherein the mapping function is the result of the calibration procedure.

9. The head mounted system (10) according to claim 8,
characterized in that
the processing unit (24, 24a, 24b) is designed to carry out the calibration procedure by showing through the head mounted display to the user virtual stimuli (28), in particular virtual targets, to be fixated and determining the difference between the point of regard (POR) calculated by the 3D positions and orientation vectors of the left and the right eye (16a, 16b) on the one side and the location of said virtual stimuli (28).

10. The head mounted system (10) according to claim 9,
characterized in that
the processing unit (24, 24a, 24b) is designed to provide said virtual targets (and/or stimuli (28)) moving along a predetermined or random path.

11. The head mounted system (10) according to claim 9,
characterized in that

the processing unit (24, 24a, 24b) is designed to carry out the calibration procedure by continuously calculating over time the difference between the point of regard (POR) calculated by the 3D positions and orientation vectors of the left and the right eye (16a, 16b) on the one side and frequent objects of interest and/or visual anchors in the images projected on the head mounted display.

12. The head mounted system (10) according to claim 5, characterized in that the processing unit (24, 24a, 24b) is designed to calculate the intra-ocular distance and is further designed to calculate based on the intra-ocular distance and the 3D positions of the left and the right eye (16a, 16b) the virtual points of view and to use these virtual points of view when rendering a pair of images for the left and the right eye (16a, 16b) for simulating a 3D virtual scene.

13. The head mounted system (10) according to claim 5, characterized in that the processing unit (24, 24a, 24b) is designed to determine based on the distance of the point of regard (POR) a region which is to be shown in focus in the rendered virtual image, wherein the processing unit (24, 24a, 24b) is further designed to render the virtual images accordingly to simulate the depth of focus for the whole image which a human eye would observe if it were seeing a real object at the same 3D coordinates as the point of regard (POR) in a real scene.

14. The head mounted system (10) according to claim 13, characterized in that the processing unit (24, 24a, 24b) is designed to render based on the 3D positions of the left and the right eye (16a, 16b) on the one side and the distance to said point of regard (POR) on the other side at least one augmented reality element which blends in with the scene as seen by a user wearing the head mounted system (10).

15. The head mounted system (10) according to one of the preceding claims, characterized in that

the processing unit (24, 24a, 24b) is designed to render at least one virtual activation element (30) to be shown in the images, especially the images of a scene, projected onto the user's eyes (16a, 16b), the processing unit (24, 24a, 24b) being further designed to activate a predetermined function associated with the virtual activation element (30) if a predetermined activation condition is met.

16. The head mounted system (10) according to one of the preceding claims, characterized in that
the processing unit (24, 24a, 24b) is designed to render said at least one virtual activation element (30) as a finite, polygonal, 3D shape positioned at a predetermined position with a predetermined 3D orientation for a certain time in the scene.

17. The head mounted system (10) according to claim 15 or 16, characterized in that
the processing unit (24, 24a, 24b) is designed to render said at least one virtual activation element (30) with a predetermined colour and/or containing text and/or an image in itself and/or with varying degrees of transparency between none and fully transparent.

18. The head mounted system (10) according to claim 15 or 16, characterized in that
the processing unit (24, 24a, 24b) is designed to render said at least one virtual activation element (30) with varying degrees of transparency between none and fully transparent dependent on a distance of a focused gaze of the user.

19. The head mounted system (10) according to one of claims 15 to 18, characterized in that
the processing unit (24, 24a, 24b) is designed such that the activation condition consists in the 3D point of regard (POR) entering a virtual space region defined by the activation element (30).

20. The head mounted system (10) according to one of claims 15 or 19, characterized in that

the processing unit (24, 24a, 24b) is designed such that the activation condition consists in the 3D point of regard (POR) dwelling in the virtual space region defined by the activation element (30) for a predetermined amount of time.

21. The head mounted system (10) according to one of claims 15 to 20, characterized in that
the processing unit (24, 24a, 24b) is designed such that the activation condition consists in the 3D point of regard (POR) entering and exiting the virtual space region defined by the activation element (30) within a predetermined amount of time.

22. The head mounted system (10) according to one of claims 15 to 21, characterized in that
the processing unit (24, 24a, 24b) is designed such that the activation condition consists in the 3D point of regard (POR) entering the virtual space region defined by the activation element (30) and a subsequent blink within a predetermined time window being detected by the eye tracking system (14a, 14b).

23. The head mounted system (10) according to one of claims 15 to 22, characterized in that
the processing unit (24, 24a, 24b) is designed such that the activation condition consists in the 3D point of regard (POR) entering the virtual space region defined by the activation element (30) and a subsequent trigger event from an external interface is being activated.

24. The head mounted system (10) according to claim 23, characterized in that
the trigger event from an external interface being:

- the pushing of a mechanical trigger, button or touch sensitive surface;
- the detection of a change in an electromyographic interface connected to the body of the user;
- the issuing of a voice command;

- a biological monitoring function reaching a threshold level, the biological monitoring function especially consisting in pulse/heart rate, blood pressure, a channel in an EEG interface; and/or
- a finger, hand or arm gesture detected by a gesture sensor.

25. The head mounted system (10) according to one of the preceding claims, characterized in that
the processing unit (24, 24a, 24b) is designed to highlight and/or pre-activate a group of activation elements (30a to 30d) which lie at the same virtual distance based on an image disparity and a simulated depth of focus calculated from the 3D positions of the left eye (16a), the right eye (16b) and the point of regard (POR).

26. The head mounted system (10) according to one of the preceding claims, characterized in that
the processing unit (24, 24a, 24b) is designed to highlight and/or pre-activate a group of all activation elements (30a to 30d) which lie at the same virtual distance based on an image disparity and a simulated depth of focus calculated from the 3D positions of the left eye (16a), the right eye (16b) and the point of regard (POR).

27. The head mounted system (10) according to claim 25 or 26, characterized in that
the processing unit (24, 24a, 24b) is designed to highlight a certain group of activation elements (30a to 30d) by substantially focussing all its elements, while all other activation elements (30_{i-2}, 30_{i-1}, 30_i) in other groups are being rendered out of focus.

28. The head mounted (10) system according to claim 27, characterized in that
the processing unit (24, 24a, 24b) is designed to further render all other activation elements (30_{i-2}, 30_{i-1}, 30_i) in other groups partially or completely transparent.

29. The head mounted system (10) according to one of the preceding claims, characterized in that
the processing unit (24, 24a, 24b) is designed to calculate the 3D position of the left (16a) and the right eye (16b) with respect to the respective camera (14a; 14b), wherein a distance of the respective camera (14a; 14b) to the respective eye (16a; 16b) is calculated from the dimensions in the image of eye features which do not change dynamically.

30. A method to compute and render a stream of digital images using a head mounted system (10) comprising a binocular eye tracking system (14a, 14b) with at least a first camera (14a) arranged for acquiring a user's left eye (16a) and at least a second camera (14b) arranged for acquiring a user's right eye (16b); a head mounted display with a first displaying means (18a) for presenting an image to a user's left eye (16a) and a second displaying means (18b) for presenting an image to a user's right eye (16b); and a processing unit (24, 24a, 24b) designed to process images from the eye tracking system (14a, 14b) and calculate at least an orientation vector of the left and the right eye (16a, 16b);
characterized by the following steps:

- the processing unit (24, 24a, 24b) calculates a 3D position of the left and the right eye (16a, 16b);
- the processing unit (24, 24a, 24b) computes and renders a stream of digital images to be projected onto the user's left and right eye (16a, 16b) by means of the head mounted display; and
- considering the 3D position of the left and the right eye (16a, 16b) and the orientation of the left and the right eye (16a, 16b) when computing and rendering the stream of digital images for positioning a virtual camera when rendering a virtual 3D scene and/or to determine which part of a virtual scene is rendered in focus.