CLAIMS

1. A method of setting up non-randomly positioned markers in a field of view of a camera bar, and tracking a pose of the camera bar, the method including the steps of:

(i) a camera bar viewing a field of view, the camera bar in fixed attachment with a video camera;

(ii) displaying the camera bar's view of the field of view on a display of a computer system;

(iii) the computer system generating a pattern of non-random marker positions, including positions in the field of view, and displaying the pattern of non-random marker positions in the field of view on the display of the computer system together with the camera bar's view of the field of view;

(iv) the computer system detecting in the view of the camera bar, that a marker has been placed in a position of a non-random marker position, generated in step (iii);

(v) the computer system recording a marker and a respective position of the marker in the field of view, in response to the computer system detecting in the view of the camera bar, that a marker has been placed in a position of a non-random marker position, in step (iv);

(vi) repeating steps (iv) and (v) until a predetermined number of different markers and respective marker positions have been recorded;

(vii) the computer system matching markers detected in the field of view of the camera bar with the recorded markers and their respective marker positions, to obtain a pose of the camera bar;

(viii) repeating step (vii), to track the pose of the camera bar.

2. The method of Claim 1, including the step of storing the recorded predetermined number of different markers and respective marker positions.

3. The method of Claims 1 or 2, wherein the generated pattern of non-random marker positions in the field of view starts from an initial indicator which is detected in the field of view by the computer system.

4. The method of any previous Claim, wherein the generated pattern of non-random marker positions in the field of view is generated using a path represented by

a continuously differentiable (C1) continuous path or function~~.~~

~~5. The method of any previous Claim~~, or wherein the generated pattern of non-random marker positions in the field of view is generated using a path represented by a smooth continuous path or function.

~~6~~5. The method of Claim~~s~~ 4 ~~or 5~~, wherein the markers positions are equidistantly spaced along the path.

~~7~~6. The method of any previous Claim, wherein the generated pattern of non-random marker positions in the field of view is generated from a set of parameters which are passed into one or more well-defined, deterministic formulas.

~~8~~7. The method of Claim ~~7~~6, wherein a formula generates a spiral pattern and the parameters include the position of an initial marker, the camera bar height above the floor and the orientation angle(s) of the camera bar.

~~9~~8. The method of any previous Claim, wherein the generated pattern of non-random marker positions in the field of view is a spiral pattern.

~~10~~9. The method of any of Claims 1 to 3, wherein the generated pattern of non-random marker positions in the field of view is a quasicrystal pattern~~.~~

~~11. The method of any of Claims 1 to 3, ~~; or wherein the generated pattern of non-random marker positions in the field of view is on a non-periodic grid, or on a periodic grid, or on a non-periodic lattice, or on a periodic lattice~~.~~

~~12. The method of any of Claims 1 to 3, ~~; or wherein the generated pattern of non-random marker positions in the field of view is on a set of non-intersecting closed curves, e.g. on a set of concentric circles~~.~~

~~13. The method of any of Claims 1 to 3, ~~; or wherein the generated pattern of non-random marker positions in the field of view is on a set of non-intersecting open curves, e.g. on a set of concentric semicircles.

~~14~~10. The method of any previous Claim, wherein in step (iii), the pattern of non-random marker positions in the field of view are overlaid on the camera bar's view of the field of view.

~~15~~11. The method of any previous Claim, wherein in step (iv), the computer system displays in the display that it has detected in the view of the camera bar that a marker has been placed in a position of a non-random marker position, e.g. by changing a displayed colour of the non-random marker position, e.g. from red to green.

~~16~~12. The method of any previous Claim, wherein the camera bar is a monoscopic camera bar.

~~17~~13. The method of Claim ~~16~~12, wherein step (vii) includes

(a) detecting markers' 2D positions in a sequence of images viewed by the camera bar using a marker extraction algorithm, where the first image and the last image of the sequence are taken from different camera bar positions, and labelling markers through the sequence using nearest neighbour matching;

(b) extracting matrices using a robust extractor to extract rotation and translation, in which a scale factor is unknown, from the first frame of the sequence to the last frame of the sequence;

(c) computing 3D marker positions, in which the scale factor is unknown, using the detected 2D marker positions, using camera bar calibration data;

(d1) matching the computed 3D marker scaled positions to a 3D path of the markers, where the 3D path in a world coordinate system is known, including fitting the set of computed 3D marker positions to the 3D path of the markers, including deriving the scale factor; or

(d2) matching the computed 3D marker scaled positions to the 3D positions of the markers, where the 3D positions of the markers in a world coordinate system are known, including fitting the set of computed 3D marker positions to the 3D positions of the markers, including deriving the scale factor;

(e) modelling the matching solution as a SIM(3) of the Lie Group, to represent camera bar pose, the matching solution including a scale, and

(f) extracting the camera bar pose from the matching solution, in the world

coordinate system.

~~18~~14. The method of Claim ~~17~~13, wherein steps (d1) or (d2) are performed by using Iterative closest point (ICP) fitting, or curve fitting or using a non-linear minimization technique such as a Levenberg–Marquardt algorithm (LMA or just LM); or using a Gauss Newton algorithm~~.~~

~~19. The method of Claims 17 or 18~~, or wherein in step (b), Random sample consensus, RANSAC, is used.

~~20~~15. The method of any of Claims 1 to ~~15~~11, wherein the Camera bar is a stereoscopic camera bar, including two cameras mounted a fixed distance apart in a stereoscopic configuration~~.~~

~~21. The method of any of Claims 1 to 15~~, or wherein the camera bar includes three cameras, arranged in a triangle (e.g. an equilateral triangle), at fixed distances from each other.

~~22. The method of any of Claims 1 to 15, wherein the camera bar includes a plurality of cameras.~~

~~23~~16. The method of ~~any of~~ Claim~~s~~ ~~15~~20 ~~to 22~~, wherein step (vii) includes:

(a) detecting markers' 2D positions on images viewed by the camera bar using a marker extraction algorithm;

(b) computing 3D marker positions using the detected 2D marker positions, using camera bar calibration data, and using a camera bar coordinate system;

(c1) matching the computed 3D marker positions to a 3D path of the markers, where the 3D path in a world coordinate system is known, including fitting the set of computed 3D marker positions to the 3D path of the markers; or

(c2) matching the computed 3D marker positions to the 3D positions of the markers, where the 3D positions of the markers in a world coordinate system are known, including fitting the set of computed 3D marker positions to the 3D positions of the markers;

(d) modelling the matching solution as a SE(3) of the Lie Group, to represent

camera bar pose, and

(e) extracting the camera bar pose from the matching solution, in the world coordinate system.

~~24~~17. The method of Claim ~~23~~16, wherein steps (c1) or (c2) are performed by using Iterative closest point (ICP) fitting, or curve fitting or using a non-linear minimization technique such as a Levenberg–Marquardt algorithm (LMA or just LM); or using a Gauss Newton algorithm.

~~25. The methods of Claims 23 or 24, wherein the camera bar pose is provided instantaneously.~~

~~26~~18. The method of any previous Claim, in which the field of view of the camera bar does not coincide at all with the field of view of the video camera.

~~27~~19. The method of any of Claims 1 to ~~25~~17, in which the field of view of the camera bar partially overlaps with the field of view of the video camera~~.~~

~~28. The method of any of Claims 1 to 25~~, or in which the field of view of the camera bar includes the whole of the field of view of the video camera.

~~29. The method of any previous Claim, in which the markers have specific shapes, and/or colours and/or are made of specific materials.~~

~~30. The method of any previous Claim, in which the markers used do not differ from each other significantly in appearance.~~

~~31. The method of any previous Claim, in which the markers used are approximately spherical, or approximately circular.~~

~~32. The method of any previous Claim, in which the camera bar pose comprises camera bar rotation and camera bar translation i.e. six degrees of freedom.~~

~~33. The method of any previous Claim, in which the computer system is a laptop~~

~~computer, a desktop computer, a tablet computer, or a smartphone.~~

~~34. The method of any previous Claim, in which the camera bar is moved to display a new field of view partly overlapping with a previous field of view, after the camera pose is tracked for the first time, and then the pattern of non-random marker positions in the new field of view is displayed on the display of the computer system together with the camera bar's view of the new field of view, and then steps (iv) and (v) are performed.~~

~~35. The method of any previous Claim, including repeating steps (iv) and (v), together with performing step (viii).~~

~~36. The method of any previous Claim, including, when performing step (viii), the number of different markers and respective marker positions that have been recorded is at least ten, or is in the range of 10 to 1000, or is in the range of 20 to 500.~~

~~37~~20. A system including a video camera, a camera bar in fixed attachment with the video camera, and a computer system including a display, wherein the computer system is configured to:

(i) display the camera bar's view of a field of view on the display of the computer system;

(ii) generate a pattern of non-random marker positions, including positions in the field of view, and display the pattern of non-random marker positions in the field of view on the display of the computer system together with the camera bar's view of the field of view;

(iii) detect in the view of the camera bar, that a marker has been placed in a position of a non-random marker position, generated in (ii);

(iv) record a marker and a respective position of the marker in the field of view, in response to detecting in the view of the camera bar, that a marker has been placed in a position of a non-random marker position, in (iii);

(v) repeat (iii) and (iv) until a predetermined number of different markers and respective marker positions have been recorded;

(vi) match markers detected in the field of view of the camera bar with the recorded markers and their respective marker positions, to obtain a pose of the camera

bar;

(vii) repeat (vi), to track the pose of the camera bar.

~~38. The system of Claim 37, configured to perform a method of any of Claims 1 to 36.~~

~~39~~21. A computer program product, the computer program product executable on a computer system including a display to:

(i) display a camera bar's view of a field of view on the display of the computer system;

(ii) generate a pattern of non-random marker positions, including positions in the field of view, and display the pattern of non-random marker positions in the field of view on the display of the computer system together with the camera bar's view of the field of view;

(iii) detect in the view of the camera bar, that a marker has been placed in a position of a non-random marker position, generated in (ii);

(iv) record a marker and a respective position of the marker in the field of view, in response to detecting in the view of the camera bar, that a marker has been placed in a position of a non-random marker position, in (iii);

(v) repeat (iii) and (iv) until a predetermined number of different markers and respective marker positions have been recorded;

(vi) match markers detected in the field of view of the camera bar with the recorded markers and their respective marker positions, to obtain a pose of the camera bar;

(vii) repeat (vi), to track the pose of the camera bar.

~~40. The computer program product of Claim 39, executable on the computer system to perform a method of any of Claims 1 to 36.~~

~~41. A method for mixing or compositing computer generated 3D objects and a video feed from a video camera, to generate augmented reality video in real-time, in which:~~

~~(a) the body of the video camera can be moved in 3D and sensors, including an accelerometer and a gyro sensing over six degrees of freedom, in or attached directly~~

or indirectly to the video camera provide real-time positioning data enabling the 3D position and 3D orientation of the video camera to be calculated;

(b) a camera bar, for example including two cameras forming a stereoscopic system, is fixed directly or indirectly to the video camera;

(c) that real-time positioning data is then automatically used to create, recall, render or modify computer generated 3D objects;

(d) the resulting computer generated 3D objects are then mixed in or composited with the video feed from the video camera in real-time to provide augmented reality video for example for TV broadcast, cinema or video games;

and in which:

(e) the 3D position and orientation of the video camera is determined with reference to a 3D map of the real-world, by using the real-time 3D positioning data from the sensors plus a video flow in which the camera bar, for example including two cameras forming a stereoscopic system, surveys a field of view, and software running on a processor is used to detect non-randomly positioned markers in the field of view, the markers and their non-random positions being previously recorded at the processor and included in the 3D map of the real-world, wherein the markers have been previously manually or artificially added to that field of view.

42. The method of Claim 41, the method including a method of any of Claims 1 to 36.

43. A mixing or compositing system, the mixing or compositing system including:

(i) a video camera;

(ii) sensors including an accelerometer and a gyro sensing over six degrees of freedom;

(iii) a camera bar, for example including two cameras forming a stereoscopic system; and

(iv) a processor;

for mixing or compositing computer generated 3D objects and a video feed from the video camera in real-time, to generate augmented reality video in real-time for example for TV broadcast, cinema or video games, in which:

(a) the body of the video camera can be moved in 3D and the sensors in or attached directly or indirectly to the video camera provide real-time positioning data

enabling the 3D position and 3D orientation of the video camera to be calculated;

(b) the camera bar, for example including two cameras forming a stereoscopic system, is fixed directly or indirectly to the video camera;

(c) the system is configured to use that real-time positioning data automatically to create, recall, render or modify computer generated 3D objects;

(d) the system is configured to mix in or to composite the resulting computer generated 3D objects with the video feed from the video camera in real-time to provide augmented reality video in real-time for example for TV broadcast, cinema or video games;

and in which:

(e) the system is configured to determine the 3D position and orientation of the video camera with reference to a 3D map of the real-world, by using the real-time 3D positioning data from the sensors plus a video flow in which the camera bar, for example including two cameras forming a stereoscopic system, surveys a field of view, and in which software running on the processor is configured to detect non-randomly positioned markers in the field of view, the markers and their non-random positions being previously recorded at the processor and included in the 3D map of the real-world, wherein the markers have been previously manually or artificially added to that field of view.

44. The system of Claim 43, the system including a system of Claims 37 or 38.

45. A video file of a video produced using a method of any of Claims 41 to 42.

46. A video stream of a video produced using a method of any of Claims 41 to 42.