CLAIMS

1. A headset for displaying a virtual image of a building information model (BIM) to a user that is positioned and oriented to an extrinsic site coordinate system of a construction site; the headset comprising:

an article of headwear that is configured to be worn by the user and has one or more position-tracking sensors mounted thereon which are configured to output sensor data representing responses of the one or more sensors to one or more signals emitted by a position tracking system at the construction site from which the position and orientation of the article of headwear can be determined;

an augmented reality display system that includes a display assembly having an in-use position within the user's field of view that is fixed relative to the position-tracking sensors; the display assembly including at least one display and being capable of displaying the virtual image to the user while allowing the user to view his or her surroundings through the display assembly; wherein the augmented reality display system is configured to receive image data representing the virtual image of the building information model and to display the virtual image on the display; and

an electronic control system;

wherein the electronic control system comprises a headset tracking system configured to determine from the sensor data the location and orientation of the article of headwear on the construction site in an intrinsic coordinate system defined by the position tracking system and to output headset tracking data representing the same; and a coordinate conversion engine configured to convert, on the basis of a transformation, between the intrinsic coordinate system and the extrinsic coordinate system; the transformation being derived by relating the coordinates of one or more control points of known location in the extrinsic coordinate system to their corresponding coordinates in the intrinsic coordinate system; the coordinates of the one or more control points in the intrinsic coordinate system being derived from sensor data received from at least one sensor using the position tracking system; and

wherein the electronic control system is configured to receive the headset tracking data, and model data representing the building information model defined in the extrinsic coordinate system; process the model data using the coordinate conversion engine to produce derived model data defined in the intrinsic coordinate system; and use the headset tracking data to render a virtual image of the building information model relative to the position and orientation of the article of headwear on the construction site, generate the image data representing the virtual image and transmit the image data to the augmented reality display system for viewing by the user on the display.

2. A headset according to claim 1, wherein the headset further comprises a display position sensor for detecting the position of the display relative to the user's head and for outputting display position data representing the same; and wherein the electronic control system is configured to receive the display position data and to use it with the headset tracking data to render the virtual image of the building information model relative to the position and orientation of the article of headwear on the construction site.

3. A headset according to claim 2, wherein the display position sensor comprises at least one eye-tracking device.

4. A headset according to any preceding claim, wherein the one or more signals consist of electromagnetic radiation, e.g. optical or radio waves.

5. A headset according to any preceding claim, wherein the position-tracking system comprises a sweep-beam optical tracking system.

6. A headset according to any of claims 1 to 4, wherein the position-tracking system comprises a WiFi tracking system.

7. A headset according to any of claims 1 to 3, wherein the one or more signals consist of acoustic waves, e.g. ultrasound.

8. A headset according to any preceding claim, wherein the position tracking system comprises at least one source of electromagnetic radiation that is stationary at the construction site and at least one of the one or more sensors is configured to detect or measure a property of the electromagnetic radiation that is indicative of an angular distance from the at least one sensor to the stationary source.

9. A headset according to any preceding claim, wherein the headset tracking system is further configured to track the position of the headset for locating reference points at the construction site.

10. A method of displaying a virtual image of a building information model (BIM) that is positioned and oriented with reference to an extrinsic site coordinate system of a construction site in a headset; the headset comprising an article of headwear that is configured to be worn by a user and has one or more position-tracking sensors mounted thereon; an augmented reality display system that includes a display assembly having an in-use position within the user's field of view that is fixed relative to the position-tracking sensors, the display assembly including at least one display and being capable of displaying the virtual image to the user while allowing the user to

view his or her surroundings through the display assembly; and an electronic control system; the method comprising:

at a headset tracking system, on the basis of sensor data representing responses of the one or more sensors to one or more signals emitted by a position tracking system at the construction site, determining the location and orientation of the article of headwear on the construction site in an intrinsic coordinate system defined by the position tracking system;

at a coordinate conversion engine, converting between the intrinsic coordinate system and the extrinsic coordinate system on the basis of a transformation derived by relating the coordinates of one or more control points of known location in the extrinsic coordinate system to their corresponding coordinates in the intrinsic coordinate system; the coordinates of the one or more control points in the intrinsic coordinate system being determined on the basis of sensor data received from at least one sensor; and

at the electronic control system receiving headset tracking data from the headset tracking system and receiving model data representing the building information model defined in the extrinsic coordinate system, processing the model data using the coordinate conversion engine to produce derived model data defined in the intrinsic coordinate system, and using the headset tracking data and to render a virtual image of the building information model relative to the position and orientation of the article of headwear, generate image data representing the virtual image and transmit the image data to the augmented reality display system for viewing by the user as a virtual image of the building information model.

11. A method according to claim 10 wherein the headset comprises at least one display position sensor for detecting the position of the display relative to the user's head and wherein the method comprises at the electronic control system receiving display position data from the display position sensor and using the headset tracking data and the display position data to render the virtual image of the building information model relative to the position and orientation of the article of headwear relative to the headset user's eye.

12. A method according to claim 11, wherein the display position sensor comprises an eye-tracking device.

13. A method according to any of claims 10 to 12, wherein the one or more signals consist of electromagnetic radiation, e.g. optical or radio waves.

14. A method according to any of claims 10 to 13, wherein the position-tracking system comprises a sweep-beam optical tracking system.

15. A method according to any of claims 10 to 13, wherein the position-tracking system comprises a WiFi tracking system.

16. A method according to any of claims 10 to 12, wherein the one or more signals consist of acoustic waves, e.g. ultrasound.

17. A method according to any of claims 10 to 16, which further comprises downloading the BIM data to the electronic control system on the headset from a remote server.

18. A method according to any of claims 10 to 17, which further comprises downloading the transformation from a remote server and storing the same on the headset.

19. A method according to any of claims 10 to 18, wherein the position tracking system comprises at least one source of electromagnetic radiation that is stationary at the construction site and at least one of the one or more sensors is configured to detect or measure a property of the electromagnetic radiation that is indicative of an angular distance from the at least one sensor to the stationary source.

20. A computer program comprising a set of instructions, which, when executed by a computerised device, cause the computerised device to perform a method as claimed in any of claims 10 to 19.

21. A headset for use in validation of a construction task or setting out a construction site which comprises an article of headwear having a plurality of sensors mounted thereon, augmented reality glasses incorporating one or more displays for displaying a virtual image of a building information model (BIM) when viewed by a user and an electronic control system comprising:
a model positioning engine for receiving and processing model data representing the building information model defined in an extrinsic, real-world coordinate system and using a transformation between the extrinsic coordinate system and an intrinsic coordinate system for positioning and orienting the model in the intrinsic coordinate system; and
an image rendering engine for receiving tracking data representing the position and orientation of the article of headwear on the construction site in the intrinsic coordinate system, rendering a virtual image of the model relative to the position and orientation of the article of headwear and transmitting the image to the one or more displays where it is viewable by a user as a virtual image of the model;

wherein the tracking data is derived from sensor data representing the responses of a plurality of sensors on the article of headwear to electromagnetic radiation emitted by one or more

base stations at the construction site, wherein the electromagnetic radiation is modulated in a manner that is related to the angular distance to the one or more respected base stations;

and the transformation is derived by relating the coordinates of one or more control points of known location in the extrinsic coordinate system to their corresponding coordinates in the intrinsic coordinate system, the coordinates of the one or more control points in the intrinsic coordinate system being derived from sensor data representing the responses of one or more sensors positioned at the one or more control points to the modulated electromagnetic radiation.

22. A headset as claimed in claim 21, wherein the electronic control system further comprises a tracking engine for processing sensor data received from the sensors on the article of headwear to calculate the position and orientation of the article of headwear at the construction site in the intrinsic coordinate system.

23. A headset as claimed in either of claims 21 or 22, wherein the electronic control system comprises one or more processors, one or more memory units and at least one data storage device storing software comprising a model positioning module that is executable by the one or more processors to process the model data for positioning and orienting the model in the intrinsic coordinate system using the transformation, and an image rendering module that is executable by the one or more processors to process the tracking data and model data for rendering the virtual image of the BIM model relative to the position and orientation of the article of headwear.

24. A headset as claimed in claim 23, wherein the software further comprises a tracking module that is executable by the one or more processors to process the sensor data received from the sensors on the headset to calculate the position and orientation of the article of headwear at the construction site in the intrinsic coordinate system.

25. Calibration software for calibrating an inside-out positional tracking system for use in validation of a construction task or setting out a construction site comprising machine code that is executable by a processor for (i) receiving control point location data representing the positions of a plurality of control points at the construction site in an extrinsic, real world coordinate system, (ii) receiving control point tracking data representing the positions of the control points in an intrinsic coordinate system used by the tracking system, and (iii) relating the positions of the control points in the intrinsic and extrinsic coordinate systems to derive a transformation between the coordinate systems, wherein the calibration software comprises machine code that is executable by a processor to receive and process sensor data representing the response of a sensor at each control point to electromagnetic radiation emitted by at least one base station at the

construction site, which has at least one property that is indicative of an angular distance to the base station, to calculate the positions of the control points in the intrinsic coordinate system.

26. Calibration software as claimed in claim 25, wherein the machine code is executable to repeat steps (i) to (iii) periodically to refresh the transformation.

27. A method of construction which comprises using a headset as claimed in any of claims 1 to 9 or claims 21 to 24.

28. A method of construction which comprises a method according to any of claims 10 to 19.