display scenes corresponding to many different positions and attitudes, a large memory capacity is needed.

[0013] What is needed is a synthetic vision system that is small and light enough to be easily hand held for personal use or compactly mounted in a vehicle. Desirable attributes of such a system would include precise positioning, reduced registration errors and graphics rendering at 20 Hz or greater frame rates. Ideally the system should include compact attitude and heading sensing devices.

[0014] In addition it would be desirable to extend synthetic vision to include display of actual and/or digitally created scenes from arbitrary view points. For example, it would be useful for a construction engineer to be able to see a proposed building or a buried water pipe from a variety of perspectives: his current location, from overhead, from 45 degrees off to one side, etc.

[0015] It would also be desirable for the system to use a modern graphics rendering scheme in which data is culled from a database of objects according to their spatial locations and the extent of a computed view frustum. Culling allows the computer to quickly identify large blocks of data that can be ignored for a particular scene. In contrast to a planoptic approach, objects need only appear in a database once.

SUMMARY

[0016] According to an aspect of the invention a synthetic vision system includes a display, a sensor suite and a computer all housed in a handheld unit. The display is in communication with the computer and shows actual or digitally created scenes. The sensor suite comprises position and attitude sensors in communication with the computer and the computer uses position and attitude data reported by the sensor suite to calculate a view frustum and renders in three dimensional perspective on the display stored objects in a database that lie wholly or partially within the frustum.

[0017] According to an aspect of the invention a synthetic vision devices comprises a display, a position sensor and an attitude sensor each in communication with a computer, wherein the computer executes a software routine comprising the steps of: loading geospatial data into memory and geo-registering it to a common reference frame, gathering and processing user inputs, reading measurements from navigation and tracking sensors, combining measurements into a filtered estimate of user state, updating scene content data, calculating positions and orientations of graphics viewpoints based on updated state data, and, drawing an updated graphic scene to video hardware based on updated state data.

[0018] According to an aspect of the invention a synthetic vision system includes a display, a position sensor and an attitude sensor each in communication with a computer wherein the position sensor is a WAAS enabled GPS receiver and the attitude sensor comprises gyroscopic rate sensors or accelerometers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The drawings are heuristic for clarity. The foregoing and other features, aspects and advantages of the invention will become better understood with regard to the following descriptions, appended claims and accompanying drawings in which:

[0020] FIG. **1** shows a synthetic vision device used in a construction application to visualize the spatial relationship between a piece of machinery and an underground object.

[0021] FIG. **2** shows a synthetic vision device used to visualize a direct real world view from a user's actual position augmented by computer generated objects from a database.

[0022] FIG. **3** shows a synthetic vision device used to visualize the view of FIG. **2** from a different perspective not corresponding to the viewer's actual position.

[0023] FIG. **4** shows a schematic block diagram of the major subsystems of a synthetic vision device.

[0024] FIG. **5** shows a flow chart of the major steps in a software routine for a synthetic vision device.

[0025] FIG. **6** shows a view frustum used in rendering computer graphics.

[0026] FIG. **7** shows a top view of a user holding a synthetic vision device and illustrates two different possible fields of view that may be displayed by the device.

[0027] FIG. **8** shows a person using a synthetic vision device to look at an object behind an opaque wall. A close up view of the display of the device is also shown.

[0028] FIG. **9** shows a person using a synthetic vision device to look at an object that is in front of a wall. A close up view of the display of the device is also shown.

[0029] FIG. **10** shows views of a scene from different perspectives as displayed on a synthetic vision device.

[0030] FIG. **11** shows a synthetic vision device used to visualize a direct real world view from a user's actual position. A reticle symbol is used to designate an object in the view.

[0031] FIG. **12** shows a synthetic vision device used to visualize a direct real world view from a user's actual position. An arrow symbol is used to designate the direction in which the device must be pointed to see the reticle which was visible in the view shown in FIG. **11**.

DETAILED DESCRIPTION

[0032] Synthetic vision is an improvement upon natural vision. It helps one see objects and information that would otherwise be imperceptible. According to an aspect of the invention, a person holding a handheld synthetic vision device is able to aim it in any direction and see real world objects in that direction displayed on its screen even when those objects are hidden by darkness, fog or other obstructions. Further, the synthetic vision device may display information pertaining to displayed objects. For example, the voltage on a wire, the weight of a vehicle or name of the owner of a shipping container might all be displayed near their respective objects.

[0033] According to an aspect of the invention, a synthetic vision device may display scenes as viewed from perspectives other than that of the person holding the device. The user of the device may select a top-down map view, a side view or a view from an arbitrary viewpoint. In this way the user can look at objects from all sides without having to personally move around the objects.

[0034] The fundamental features of a synthetic vision device are therefore that it has a means of determining its position (all but the simplest synthetic vision devices also include a means of determining spatial orientation), that it has a graphics display and that it has access to information about objects that are shown on its display. The information may be the size, shape and position of objects, but could also include additional parameters of interest such as temperature, radioactivity, price or any number of other possible attributes.

[0035] Objects shown on a synthetic vision device may be actual video images, digitally created computer graphics, or a