Inertial Orientation Trackers With Drift Compensation

Invention could enable the paralyzed to control machines via head motions.

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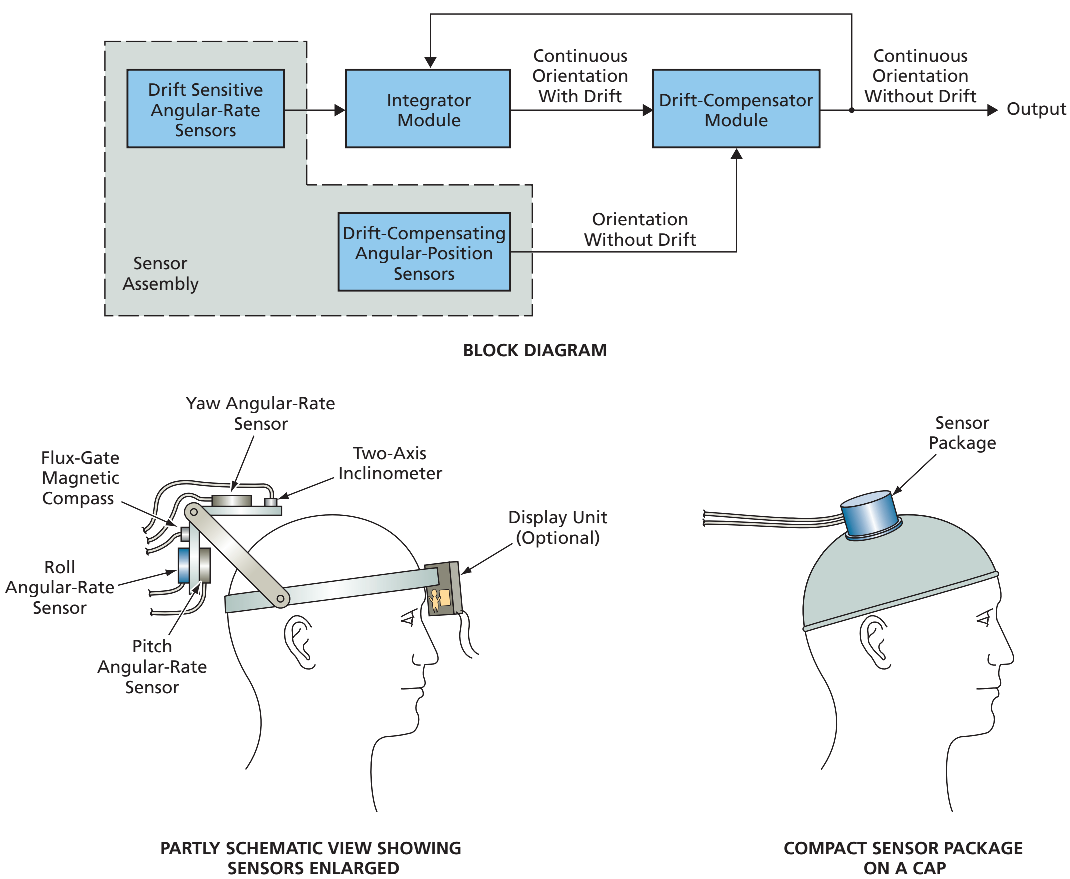
A class of inertial-sensor systems with drift compensation has been invented for use in measuring the orientations of human heads (and perhaps other, similarly sized objects). These systems can be designed to overcome some of the limitations of prior orientation-measuring systems that are based, variously, on magnetic, optical, mechanical-linkage, and acoustical principles. The orientation signals generated by the systems of this invention could be used for diverse purposes, including controlling head-orientation-dependent "virtual reality" visual displays or enabling persons whose limbs are paralyzed to control machinery by means of head motions.

The inventive concept admits to variations too numerous to describe here, making it necessary to limit this description to a typical system, the selected aspects of which are illustrated in the figure. A set of sensors is mounted on a bracket on a band or a cap that gently but firmly grips the wearer's head to be tracked. Among the sensors are three drift-sensitive rotation-rate sensors (e.g., integrated-circuit angular-rate-measuring gyroscopes), which put out DC voltages nominally proportional to the rates of rotation about their sensory axes. These sensors are mounted in mutually orthogonal orientations for measuring rates of rotation about the roll, pitch, and yaw axes of the wearer's head.

The outputs of these rate sensors are conditioned and digitized, and the resulting data are fed to an integrator module implemented in software in a digital computer. In the integrator module, the angular-rate signals are jointly integrated by any of several established methods to obtain a set of angles that represent approximately the orientation of the head in an external, inertial coordinate system. Because some drift is always present as a component of an angular position computed by integrating the outputs of angular-rate sensors, the orientation signal is processed further in a drift-compensator software module.



A **Sensor Assembly** contains angular-rate sensors, a two-axis inclinometer, and a magnetic compass, shown in enlarged, partially schematic form in the bottom left view. In a practical application, the assembly would fit in a compact package, as shown in the bottom right view.

Also mounted on the bracket are two drift-compensating angular-position sensors. One of these sensors is typically a two-axis bubble inclinometer that generates voltages proportional to tilts, relative to the gravitational field, about the roll and pitch axes. The other sensor is typically a flux-gate compass that measures the flux densities of the ambient magnetic field along the roll and pitch axes. In principle, the combination of the magnetic-field information and the tilt information can be used to determine the heading in the horizontal plane or, equivalently, the angular position in rotation about the vertical (gravitational) axis.

Because the bubble inclinometer gives accurate readings only when the head is motionless, success in its use depends on the fact that head motion ceases occasionally — on the average, about once every 10 seconds. Within about ¼ second after motion has ceased, the fluid in the inclinometer settles to a steady configuration and an inclinometer reading and the associated compass reading are taken at that time. These readings are digitized and fed to the drift-compensator module. The output of this module is a corrected angular-orientation signal, which both (1) constitutes the main orientation-signal output of the system and (2) is fed back to the integrator module for use in coordinate transformations needed to calculate angular velocities and angles.

In a simplistic approach, each set of drift-compensation readings can be used to reset the system, removing all the drift accumulated since the most recent prior reset. However, the abrupt removal of accumulated drift could jar the user or adversely affect external equipment that utilizes the orientation output. To prevent such jarring, the drift-compensator module removes the drift from the output gradually, rather than all at once. Thus, the drift compensator generates a set of angular-position signals that gradually approach the correct values over time.

This work was done by Eric M. Foxlin of Massachusetts Institute of Technology for Ames Research Center. Further information is contained in a TSP (see page 1).

This invention has been patented by NASA (U.S. Patent No. 6,361,507). Inquiries concerning rights for the commercial use of this invention should be addressed to the Ames Technology Partnerships Division at (650) 604-2954. Refer to ARC-14132-3.

Microstrip Yagi Antenna With Dual Aperture-Coupled Feed

This antenna would have a relatively simple, elegant, low-profile design.

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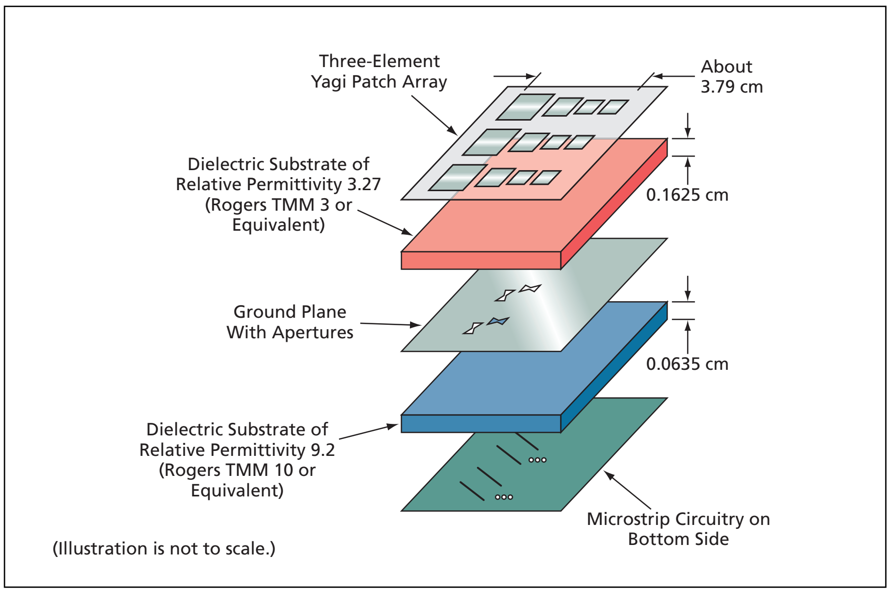
antenna is to combine features of a Yagi antenna with those of a microstrip patch to obtain an antenna that can be manufactured at low cost, has a low profile, and radiates a directive beam that, as plotted on an elevation plane perpendicular to the antenna plane, appears tilted away from the broadside. Such antennas are suitable for flush mounting on surfaces of diverse objects, including spacecraft, aircraft, land vehicles, and computers.

The design of the original version of the prior L-band microstrip Yagi antenna utilized a dual coaxial probe feed to generate circularly polarized radiation. (In some other versions of the prior antenna, a single aperture-coupled feed has been used to obtain linear polarization, but this would be of no help in contemplated applications in which circular polarization would be required.) The coaxial feed in the original circular-polarization version introduces electrical and mechanical complexities and difficulties. Electrically, it is difficult to match the impedance of the coaxial cable to that of the antenna because of the parasitics involved in the coaxial through-feed connections. Mechanically, the geometry of the coaxial feed makes it difficult to impart a low profile and predominantly planar character to both the antenna and its feed structure. In contrast, in the proposed X-band microstrip Yagi antenna, a dual aperture-coupled feed would be used to obtain circular polarization, simplifying both the electrical and mechanical aspects of design and imparting a predominantly planar character to the overall shape.



This **Simplified Exploded View** depicts the main components of the three-element microstrip Yagi antenna featuring dual offset aperture-coupled feed for each patch.

Stated somewhat more precisely, what has been proposed is a microstrip antenna comprising an array of three Yagi elements. Each element would include four microstrip-patch Yagi subelements: one reflector patch, one driven patch, and two director patches. To obtain circular polarization, each driven patch would be fed by use of a dual offset aperture-coupled feed featuring bow-tie-shaped apertures (see figure). The selection of the dual offset bow-tie aperture geometry is supported by results found in published literature that show that this geometry would enable matching of the impedances of the driven patches to the 50-Ω impedance of the mi-