FIG. 4B. In yet a further variation, tilt direction is controlled by a fourth input (e.g., a fourth finger of the user's hand, or on the other hand), with the presence/absence of the fourth input or the particular location of the fourth input designating rotation direction.

[0060] In certain embodiments described herein, rotation is controlled by sensing additional pressure. In other embodiments, rotation is controlled by the duration of an input.

[0061] Rotation further may be controlled by utilizing input motion information. In particular, 3D object movement/scaling/rotation control in accordance with a further embodiment of the invention entails inputs A, B and C, with the new position of input C' relative to original position C designating the amount of rotation about axis r, defined by line segment AB That is, as input C moves closer or further away from line segment AB, the amount of rotation about axis R changes. The direction and magnitude of rotation is dependent on the direction and length of C-C'. The direction and length of the component of C-C' that is perpendicular to AB may also only be used to control direction and magnitude of rotation. During one-handed implementation, a user may opt to utilize his/her thumb and middle finger as inputs A and B, respectively, and the index finger as input C. Of course, other finger combinations may be employed, as well as multi-hand utilization.

[0062] 3D Globe View Control

[0063] While it is possible to navigate a 3D representation of the earth or other sphere-like body with a standard 6-DOF camera model (x, y, z position, and 3-axis orientation), the present invention provides various methods and techniques that advantageously enable users to more easily and intuitively navigate a globe. As used herein, the term "globe" shall include the earth or other orbital body, or other sphere-like or somewhat-sphere-like structure or body.

[0064] As further described herein, navigation of a globe in accordance with the present invention entails the following components: a 2 degree-of-freedom ("2 DOF") point of interest (POI) coordinate in units such as latitude and longitude, a distance (or range) to that point of interest, an azimuth angle (e.g., angle from north), and a tilt angle (e.g., angle from the surface normal), for a total of 5 degrees-of-freedom. Preferably, a roll angle is not included, as it is generally not useful for observing subjects on the surface of the globe, as humans naturally assume that the horizon is always horizontal, and it can be very disorienting to the user when it is not.

[0065] As is appreciated, while the herein described 5 DOF globe navigation process seemingly does not have the full flexibility of the 6-DOF free-space camera model, a reduction in the freedom of the camera provides various benefits to users, including ease of use and reduction in camera control distractions, as described herein.

[0066] In currently available systems and techniques, a user utilizes a computer mouse to provide for two-degrees of freedom of information, for example, to change the two parameters relating to POI coordinates. In order for the user to adjust another parameter, such as range, azimuth, or tilt, the user selects another tool or holds down another key (a "modifier key" such as Control or Shift) to indicate that the mouse should now manipulate an alternate set. Not only is such mode switching cumbersome, but it is impossible to simultaneously adjust more than any two at a time, forcing the user to decompose a view manipulation into a sequence of individual operations.

[0067] In accordance with the present invention, more that one set of 2D coordinates may be input at a time employing a multi-point input device, thus permitting more advanced ways of controlling the view of the globe than currently available.

[0068] In accordance with particular embodiments of the present invention, PZR control is applied to four of the five degrees of freedom of 3D globe navigation (latitude, longitude, range, azimuth, tilt). In particular, the four DOFs that correspond to PZR control are: 2D translation along the surface of the sphere (i.e., latitude, longitude); distance change (range); and rotation around the surface normal, more generally known in mapping as the " azimuth" angle. As used herein, the term "PZR-Globe" refers to such PZR control. But, however, as is appreciated, PZR-Globe control of the present invention does not have a one-to-one correspondence, that is, pure translation along the surface of the sphere may also cause a change in azimuth (e.g., if measured relative to the north pole of the globe). A quaternion representation of globe orientation may be used as an intermediary to perform these view changes robustly. Translation is preferably performed to visually correspond to the motion on the display screen plane.

[0069] Tilt, the fifth of the four degrees of freedom discussed above, in accordance with the present invention, is controlled by utilizing a third input. Referring to FIG. 5, the user makes contact with the input device (e.g., touches the multi-point input display) with a third input C (e.g., with a third finger) after the first two inputs A and B, and movement (or sliding) of the third input to a different position C' operates to control globe tilt. In one variation of the invention, tilt angle is a function of the vertical distance between the initial and final positions of the third input. In a variation, a rate of tilt rotation is a function of the distance traveled by the third input. In either of these variations, the tilt function may employ a minimum threshold distance away from the cluster of inputs used for PZR-Globe control, thus requiring the third input to be a set minimum distance away from the other inputs to control tilt.

[0070] PZR-Globe control and tilt control, in accordance with the invention, may be implemented with fingers from the same hand (e.g., thumb, index, middle), or with fingers from both hands. For example, the thumb and index finger of one hand provides PZR-Globe control, with the index finger of the other hand controlling tilt. Whether one or two hands are employed to carry out PZR-globe control and tilt control, all 5 degrees of freedom can be controlled simultaneously.

[0071] Referring to FIG. 6A, in accordance with another embodiment of the present invention, the user provides first and second inputs A and B (e.g., two finger contact) horizontally on the input device and maintains these two inputs in stationary positions, so that no PZR-Globe control is carried out. Upon receipt of the two inputs, a virtual axis is defined as the horizontal line on the input device contact surface extending between the two inputs A and B. The user effects a tilt by initiating a third input C on the input device surface, where direction and magnitude of tilt adjustment is a function of the distance d between the third input C and the virtual axis, as shown in FIG. 6B. For example, if input C is above and relatively far away from the virtual axis, the globe is controlled to tilt away from the vertical at a relatively quick rate. As another example, if input C is below and relatively close to the virtual axis, the view tilts towards the vertical at a relatively slow rate. In an alternative embodiment, rather than