



US005825308A

United States Patent [19]

[11] Patent Number: **5,825,308**

Rosenberg

[45] Date of Patent: **Oct. 20, 1998**

- [54] **FORCE FEEDBACK INTERFACE HAVING ISOTONIC AND ISOMETRIC FUNCTIONALITY**
- [75] Inventor: **Louis B. Rosenberg**, Pleasanton, Calif.
- [73] Assignee: **Immersion Human Interface Corporation**, San Jose, Calif.
- [21] Appl. No.: **756,745**
- [22] Filed: **Nov. 26, 1996**
- [51] Int. Cl.⁶ **G09G 3/02**
- [52] U.S. Cl. **341/20; 345/163; 345/167; 345/145; 341/27; 364/709.01**
- [58] **Field of Search** **341/20, 34, 35, 341/27; 345/179, 161, 156, 157, 158, 163, 167, 164, 165, 166, 184; 74/471 XY**

OTHER PUBLICATIONS

Rosenberg, Louis B., "Virtual fixtures as tools to enhance operator performance in telepresence environments", Stanford University, Center for Design Research, Stanford, CA 94305, SPIE Telemanipulator Technology, 1993.

Rosenberg, Louis B., "Virtual haptic overlays enhance performance in telepresence tasks", Stanford University, Center for Mechanical Engineering, Stanford, CA 94305.

Colgate, J. Edward et al., "Implementation of Stiff Virtual Walls in Force-Reflecting Interfaces," 1993, pp. 1-9.

Adlestein, Bernard D. et al., "Design and Implementation of a Force Reflecting Manipulandum for Manual Control Research," 1992, pp. 1-24.

(List continued on next page.)

Primary Examiner—Brian Zimmerman
Assistant Examiner—Albert K. Wong
Attorney, Agent, or Firm—James R. Riegel; Hickman & Martine, LLP

[56] References Cited

U.S. PATENT DOCUMENTS

3,944,798	3/1976	Eaton	.....	235/151.3
4,125,800	11/1978	Jones	.....	318/681
4,148,014	4/1979	Burson	.....	340/709
4,477,043	10/1984	Repperger	.....	244/223
4,654,648	3/1987	Herrington et al.	.....	340/710
4,734,685	3/1988	Watanabe	.....	340/710
4,775,289	10/1988	Kazerooni	.....	414/735
4,787,051	11/1988	Olson	.....	364/518
4,798,919	1/1989	Miessler et al.	.....	178/18

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

WO95/02233	1/1995	WIPO .
WO95/20787	8/1995	WIPO .
WO95/20788	8/1995	WIPO .
WO95/32459	11/1995	WIPO .
WO96/16397	5/1996	WIPO .
WO95/22591	7/1996	WIPO .
WO96/42078	12/1996	WIPO .
WO97/12357	4/1997	WIPO .
WO97/19440	5/1997	WIPO .

[57] ABSTRACT

A force feedback interface having isotonic and isometric control capability coupled to a host computer that displays a graphical environment such as a GUI. The interface includes a user manipulatable physical object movable in physical space, such as a mouse or puck. A sensor detects the object's movement and an actuator applies output force on the physical object. A mode selector selects isotonic and isometric control modes of the interface from an input device such as a physical button or from an interaction between graphical objects. Isotonic mode provides input to the host computer based on a position of the physical object and updates a position of a cursor, and force sensations can be applied to the physical object based on movement of the cursor. Isometric mode provides input to the host computer based on an input force applied by the user to the physical object, where the input force is determined from a sensed deviation of the physical object in space. The input force opposes an output force applied by the actuator and is used to control a function of an application program, such as scrolling a document or panning or zooming a displayed view. An overlay force, such as a jolt or vibration, can be added to the output force in isometric mode to indicate an event or condition in the graphical environment.

64 Claims, 16 Drawing Sheets

