systems available from Nintendo, Sega, Sony, or Microsoft. In other embodiments, host computer system **14** can be a "set top box" which can be used, for example, to provide interactive television functions to users, or a "network-" or "internet-computer" which allows users to interact with a local or global network using standard connections and protocols such as used for the Internet and World Wide Web. In other implementations, the host computer can be an appliance or electronic device, vehicle computer, etc.

[0057] Host computer **14** preferably implements a host application program with which a user is interacting via interface device **12** which includes haptic feedback functionality. For example, the host application program can be a video game, word processor or spreadsheet, Web page or browser that implements HTML or VRML instructions, scientific analysis program, virtual reality training program or application, or other application program that utilizes input of mouse **12** and outputs force feedback commands to the device **12**. Herein, for simplicity, operating systems such as Windows™, MS-DOS, MacOS, Linux, Be, etc. are also referred to as "application programs." Herein, computer **14** may be referred as providing a "graphical environment,", which can be a graphical user interface, game, simulation, or other visual environment. The computer displays "graphical objects" or "computer objects," which are not physical objects, but are logical software unit collections of data and/or procedures that may be displayed as images by computer **14** on display screen **26**, as is well known to those skilled in the art. Suitable software drivers which interface such software with computer input/output (I/O) devices are available from Immersion Corporation of San Jose, Calif.

[0058] Display device **26** can be included in host computer **14** and can be a standard display screen (LCD, CRT, flat panel, etc.), 3-D goggles, or any other visual output device. Typically, the host application provides images to be displayed on display device **26** and/or other feedback, such as auditory signals. Audio output device **104**, such as speakers, is preferably coupled to host microprocessor **100** via amplifiers, filters, and other circuitry well known to those skilled in the art and provides sound output to user when an "audio event" occurs during the implementation of the host application program. Other types of peripherals can also be coupled to host processor **100**, such as storage devices (hard disk drive, CD ROM drive, floppy disk drive, etc.), printers, and other input and output devices.

[0059] Interface device **12** is coupled to the computer **14** by a bus **20**, which communicates signals between device **12** and computer **14** and may also, in some embodiments, provide power to the device **12**. In other embodiments, signals can be sent between device **12** and computer **14** by wireless transmission/reception. In some embodiments, the power for the actuator can be supplemented or solely supplied by a power storage device provided on the device, such as a capacitor or one or more batteries. The bus **20** is preferably bi-directional to send signals in either direction between host **14** and device **12**. Bus **20** can be a serial interface bus, such as an RS232 serial interface, RS-422, Universal Serial Bus (USB), MIDI, or other protocols well known to those skilled in the art; or a parallel bus or wireless link.

[0060] Device **12** can include a local microprocessor **110**. Local microprocessor **110** can optionally be included within the housing of device **12** to allow efficient communication with other components of the device. Processor **110** is considered local to device **12**, where "local" herein refers to processor **110** being a separate microprocessor from any processors in host computer system **14**. "Local" also preferably refers to processor **110** being dedicated to haptic feedback and sensor I/O of device **12**. Microprocessor **110** can be provided with software instructions (e.g., firmware) to wait for commands or requests from computer host **14**, decode the command or request, and handle/control input and output signals according to the command or request. In addition, processor **110** can operate independently of host computer **14** by reading sensor signals and calculating appropriate forces from those sensor signals, time signals, and stored or relayed instructions selected in accordance with a host command. Suitable microprocessors for use as local microprocessor **110** include lower-end microprocessors as well as more sophisticated force feedback processors such as the Immersion Touchsense Processor. Microprocessor **110** can include one microprocessor chip, multiple processors and/or co-processor chips, and/or digital signal processor (DSP) capability.

[0061] Microprocessor **110** can receive signals from sensor **112** and provide signals to actuator **18** in accordance with instructions provided by host computer **14** over bus **20**. For example, in a local control embodiment, host computer **14** provides high level supervisory commands to microprocessor **110** over bus **20**, and microprocessor **110** decodes the commands and manages low level force control loops to sensors and the actuator in accordance with the high level commands and independently of the host computer **14**. This operation is described in greater detail in U.S. Pat. Nos. 5,739,811 and 5,734,373. In the host control loop, force commands are output from the host computer to microprocessor **110** and instruct the microprocessor to output a force or force sensation having specified characteristics. The local microprocessor **110** reports data to the host computer, such as locative data that describes the position of the device in one or more provided degrees of freedom. The data can also describe the states of buttons, switches, etc. The host computer uses the locative data to update executed programs. In the local control loop, actuator signals are provided from the microprocessor **110** to an actuator **18** and sensor signals are provided from the sensor **112** and other input devices **118** to the microprocessor **110**. Herein, the term "tactile sensation" refers to either a single force or a sequence of forces output by the actuator **18** which provide a sensation to the user. For example, vibrations, a single jolt, or a texture sensation are all considered tactile sensations. The microprocessor **110** can process inputted sensor signals to determine appropriate output actuator signals by following stored instructions. The microprocessor may use sensor signals in the local determination of forces to be output on the user object, as well as reporting locative data derived from the sensor signals to the host computer.

[0062] In yet other embodiments, other hardware can be provided locally to device **12** to provide functionality similar to microprocessor **110**. For example, a hardware state machine incorporating fixed logic can be used to provide signals to the actuator **18** and receive sensor signals from sensors **112**, and to output tactile signals.

[0063] In a different, host-controlled embodiment, host computer **14** can provide low-level force commands over bus **20**, which are directly transmitted to the actuator **18** via microprocessor **110** or other circuitry. Host computer **14** thus directly controls and processes all signals to and from the device **12**, e.g. the host computer directly controls the forces output by actuator **18** and directly receives sensor signals from sensor **112** and input devices **118**. Other embodiments