the computer, with the second morpheme input converting the normally triggered first default action to a second action. The first and second morphemes (and any subsequent morphemes) together form a sentence that can be interpreted as a command to implement a computer controlled action, whether it be to unlock an electronically controlled door, display a graphical image on a computer display, or begin logging on to a computer network. Advantageously, such a user interface system is well suited for interaction with small computer devices, and may even be cross-cultural to a limited extent, with ability to squeeze or pinch being universal human attributes.

[0010] The present invention is particularly useful for portable computers that can be held in the palm of a hand. If the portable computer is partially or completely surrounded with a deformable material having embedded or contact pressure/deformation sensors, a user is able to gesture with or manipulate the whole computer in order to achieve some desired result. Material deformation can be implemented at various scales. For instance, a computer and connected deformation sensors mounted inside a flexible tube could respond to right angle bending of the tube, or even complex knotting or looping of the tube. In practice however, only minute surface deformations are required, being just sufficient to provide tactile feedback to pressing, pinching, or bending type manipulations. In either case, however, the measurement of location and pressure applied to a surface is sufficient to characterize the mode of interaction (distinguishing a pinch from a prod).

[0011] One particularly preferred embodiment of a handheld portable computer that responds to a physical manipulatory grammar in accordance with the present invention includes a computer, a feedback module to provide visual, auditory, or tactile feedback to a user (e.g., processor connected LCD display, audio speaker, or tactile display to present Braille or other conventional touch interface), and co-mounted graspable, deformable piece partially or completely surrounding the feedback module. In addition, various thermal or pressure sensors are mounted to detect handedness of a user, with the grasping hand generally being the non-dominant hand for the user. Depending on the handedness of the user (which can be considered as a morpheme), the displayed data structure is modified. For example, text displayed on an LCD display screen may be automatically shifted rightward on the screen to allow pen based annotation on the left side of the screen, thereby aiding left handed users.

[0012] Physically manipulatable user interfaces additionally provide an opportunity for multiple devices to interact in a user friendly manner. For example, a tileable display system having multiple displays with touch sensitive deformable pieces surrounding the display can be used to organize documents based on relative position of contact of each display. For example, if two displays initially showing separate data structures (e.g two different pages from two different electronic books) are brought together in side by side touching contact, the displayed visual information can alter (e.g. by displaying adjacent pages of a single electronic book). As will be appreciated, one can also use multiple computers connected to physically manipulatable control elements to construct complex commands for organizing data structures.

[0013] Additional functions, objects, advantages, and features of the present invention will become apparent from consideration of the following description and drawings of preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] **FIG. 1** is a schematic diagram of an approximately spherical hand holdable portable computer having a deformable surface, a status display, and a pressure sensor array for detecting surface deformations;

[0015] **FIG. 2** is a graphical diagram illustrating various physical manipulation morphemes, with axes respectively illustrating complexity of senseme tuples required to form a morpheme, and plasticity of a device required to support the physical manipulation;

[0016] FIGS. **3-16** schematically illustrate various preferred classes of physical manipulation morphemes;

[0017] **FIG. 17** is a graphical diagram illustrating various spatial morphemes, with a first axis illustrating complexity of senseme tuples required to form a morpheme, and a second axis illustrating the degree of positional information needed to support the physical manipulation (moving along a continuum from relative local measurement along a single specified dimension to absolute global measurement with six degrees of freedom determined);

[0018] FIGS. **18-26** schematically illustrate various preferred spatial manipulation morphemes;

[0019] **FIG. 27** is a graphical illustration showing increasing degrees of sensor system complexity that can be used to detect various categories of environmental stimuli, including light effects, thermal effects, the electromagnetic environment, and the vibratory/acoustic environment;

[0020] **FIG. 28** is a graphical diagram illustrating various physical manipulation morphemes for multiple interacting devices, with axes respectively illustrating the complexity of senseme tuples required to form a morpheme, and increasing level of physical contact;

[0021] FIGS. **29-34** schematically illustrate various preferred manipulation morphemes for multiple interacting devices;

[0022] **FIGS. 35 and 36** are schematic diagrams illustrating "squeeze", and "tilt" morphemes applicable to a portable computer;

[0023] **FIG. 37** is a schematic diagram illustrating tilt and squeeze morphemes used to control view of large two dimensional data sets with a relatively small display of a portable computer;

[0024] **FIG. 38** is a schematic illustration representing a portable computer having a display ready to receive annotations from a right handed user;

[0025] **FIG. 39** is a schematic illustration representing a portable computer having a display ready to receive annotations from a left handed user;

[0026] **FIG. 40** is an electronic schematic illustrating components of the pressure and tilt sensitive modules of a portable computer such as illustrated in FIGS. **35-39**.