ner demonstrates the use of his system with a calculator that blurs the boundaries between the digital and physical world by taking a printed number and transferring it into an electronic calculator. Interactive Paper (11) provides a framework for three prototypes. Ariel (11) merges the use of engineering drawings with electronic information by projecting digital drawings on real paper laid out on a planar surface. In Video Mosaic (11), a paper storyboard is used to edit video segments. Users annotate and organize video clips by spreading augmented paper over a large tabletop. Caméléon (11) simulates the use of paper flight strips by air traffic controllers, merging them with the digital world. Users interact with a tablet and touch sensitive screen to annotate and obtain data from the flight strips. Paper Augmented Digital Documents (3) are digital documents that are modified on a computer screen or on paper. Digital copies of a document are maintained in a central database and if needed, printed to paper using IR transparent ink. This is used to track annotations to documents using a special pen. Insight Lab (9) is an immersive environment that seamlessly supports collaboration and creation of design requirement documents. Paper documents and whiteboards allow group members to sketch, annotate, and share work. The system uses bar code scanners to maintain the link between paper, whiteboard printouts, and digital information.

[0013] Xlibris (19) uses a tablet display and paper-like interface to include the affordances of paper while reading. Users can read a scanned image of a page and annotate it with digital ink. Annotations are captured and used to organize information. Scrolling has been removed from the system: pages are turned using a pressure sensor on the tablet. Users can also examine a thumbnail overview to select pages. Pages can be navigated by locating similar annotations across multiple documents. Fishkin et al. (2) describe embodied user interfaces that allow users to use physical gestures like page turning, card flipping, and pen annotation for interacting with documents. The system uses physical sensors to recognize these gestures. Due to space limitations we limit our review: other systems exist that link the digital and physical world through paper. Examples include Freestyle (10), Designers' Outpost (8), Collaborage (12), and Xax (6). One feature common to prior work in this area is the restriction of the use of physical paper to a flat surface. Many project onto or sense interaction in a coordinate system based on a rigid 2D surface only. In our system, by contrast, we use as many of the three dimensional affordances of flexible displays as possible.

[0014] In Illuminating Digital Clay (15), Piper et al. proposed the use of a laser scanner to determine the deformation of a clay mass. This deformation was in turn used to alter images projected upon the clay mass through a projection apparatus. The techniques presented in this patent are different in a number of ways. Firstly, our display unit is completely flexible, can be duplicated to work in unison with other displays of the same type and move freely in three-dimensional space. They can be folded 180 degrees around any axis or sub-axes, and as such completely implement the functionality of two-sided flexible displays. Secondly, rather than determining the overall shape of the object as a point cloud, our input techniques rely on determining the 3D location of specific marker points on the display. We subsequently determine the shape of the display by approximating a Bezier curve with control points that coincide with these marker locations, providing superior resolution. Thirdly, unlike Piper (15), we propose specific interaction techniques based on the 3D manipulation and folding of the display unit.

[0015] The advantages of regular paper over the windowed display units used in standard desktop computing are manifold (21). In the Myth of the Paperless Office (21) Sellen analyzes the use of physical paper. She proposed a set of design principles for incorporating affordances of paper documents in the design of digital devices, such as 1) Support for Flexible Navigation, 2) Cross Document Use, 3) Annotation While Reading and 4) Interweaving of Reading and Writing.

[0016] Documents presented on paper can be moved in and out of work contexts with much greater ease than with current displays. Unlike GUI windows or rigid LCD displays, paper can be folded, rotated and stacked along many degrees of freedom (7). It can be annotated, navigated and shared using extremely simple gestural interaction techniques. Paper allows for greater flexibility in the way information is represented and stored, with a richer set of input techniques than currently possible with desktop displays. Conversely, display systems currently support properties unavailable in physical paper, such as easy distribution, archiving, querying and updating of documents. By merging the digital world of computing with the physical world of flexible displays we increase value of both technologies.

SUMMARY OF THE INVENTION

[0017] The present invention relates to a set of interaction techniques for obtaining input to a computer system based on methods and apparatus for detecting properties of the shape, location and orientation of flexible display surfaces, as determined through manual or gestural interactions of a user with said display surfaces. Such input may be used to alter graphical content and functionality displayed on said surfaces or some other display or computing system.

[0018] The present invention also relates to a food or beverage container with a curved interactive electronic display surface, and methods for obtaining input to a computer system associated with said container or some curved display, through multi-finger and gestural interactions of a user with a curved touch screen disposed on said display. Such input may be used to alter graphical content and functionality rendered on said display. The invention also pertains to a number of context-aware applications associated with the use of an electronic food or beverage container, and a refilling station.

[0019] One aspect of the invention is a set of interaction techniques for manipulating graphical content and functionality displayed on flexible displays based on methods for detecting the shape, location and orientation of said displays in 3 dimensions and along 6 degrees of freedom, as determined through manual or gestural interaction by a user with said display.

[0020] Another aspect of the invention is a capture and projection system, used to simulate or otherwise implement a flexible display. Projecting computer graphics onto physical flexible materials allows for a seamless integration between images and multiple 3D surfaces of any shape or form, one that measures and corrects for 3D skew in real time.

[0021] Another aspect of the invention is the measurement of the deformation, orientation and/or location of flexible display surfaces, for the purpose of using said shape as input to the computer system associated with said display. In one embodiment of the invention, a Vicon Motion Capturing System (23) or equivalent computer vision system is used to