user (**7**) are tracked by augmenting them with 3 IR reflective markers (**3**). Sensors are placed evenly from the tip of the finger up to the base knuckle. Pens are tracked similarly throughout the environment. The intersection of a finger or pen with a flexible display surface is calculated using planar geometry. When the pen or finger is sufficiently close, its tip is projected onto the plane of the flexible display surface. The position of the tip is then related to the length and width of the display. The x and y position of the point on the display (**1**) is calculated using simple trigonometry. When the pen or finger touches the display, the input device is engaged.

Imaging

[0076] In the embodiment of a projected flexible display, computer images or windows are rendered onto the paper by a digital projector (**5**) positioned above the workspace. The projector is placed such that it allows a clear line of sight with the flexible display surface between zero and forty-five degrees of visual angle. Using one projector introduces a set of tradeoffs. For example, positioning the projector close to the scene improves the image quality but reduces the overall usable space, and vice versa. Alternatively a set of multiple projectors can be used to render onto the flexible display surface as it travels throughout the environment of the user.

[0077] Initially, a calibration procedure is required to pair the physical position of the flexible display surface and the digital output of the projector. This is accomplished by adjusting the position, rotation, and size of the projector output until it matches the dimensions of the physical display surface.

Gesture Analysis

[0078] In the following section, the term "marker" is interchangeable with the term "accelerometer". Understanding the physical motion of paper and other materials in the system requires a combination of approaches. For gestures such as stapling, it is relatively easy to recognize when two flexible displays are rapidly moved towards each other. However, flipping requires knowledge of a flexible display surface's prior state. To recognize this event, the z location of markers at the top and bottom of the page is tracked. During a vertical or horizontal half-rotation, the relative location on the z dimension is exchanged between markers. The movement of the markers is compared to their previous position to determine the direction of the flip, fold or bend.

[0079] To detect more advanced gestures, like rubbing, marker data is recorded over multiple trials and then isolated in the data. Once located, the gesture is normalized and is used to calculate a distance vector for each component of the fingertip's movement. The system uses this distance vector to establish a confidence value. If this value passes a predetermined threshold the system recognizes the gesture, and if such gesture occurs near the display surface, a rubbing event is issued to the application.

EXAMPLES

Example 1

Photo Collage

[0080] There are many usage scenarios that would benefit from the functionality provided by the invention. One such non-limiting example is the selection of photos for printout from a digital photo database containing raw footage. Our design was inspired by the use of contact sheets by professional photographers. Users can compose a photo collage using two flexible displays, selecting a photo on one overview display and then rubbing it onto the second display with a rubbing gesture. This scenario shows the use of flexible display input as a focus and context technique, with one display providing a thumbnail overview of the database, and the other display offering a more detailed view.

[0081] Users can select thumbnails by pointing at the source page, or by selecting rows through producing a foldline with a bend gesture. By crossing two fold lines, a single photo or object may be selected. Thumbnails that appear rotated can be turned using a simple pivoting action of the index finger. After selection, thumbnails are transferred to the destination page through a rubbing gesture. After the copy, thumbnails may resize to fit the destination page. When done, the content of the destination flexible display can be printed by performing a rubbing gesture onto a printer. The printer location is tracked similarly to that of the flexible display, and is known to the system. Gestures supported by the invention can also be used to edit photos prior to selection. For example, photos are cropped by selecting part of the image with a two-handed gesture, and then rubbing the selection onto a destination flexible display. Photos can be enlarged by rubbing them onto a larger flexible display.

Example 2

Flexible Cardboard Game

[0082] In this non-limiting embodiment, the invention is used to implement a computer game that displays its graphic animations onto physical game board pieces. Said pieces may consist of cardboard that is tracked and projected upon using the apparatus described in this invention, or electronic paper, LCD, e-ink, OLED or other forms of thin, or thin-film displays. The well-known board game Settlers of Catan consists of a game board design in which hexagonal pieces with printed functionality can be placed differently in each game, allowing for a game board that is different each game. Each hexagonal piece, or hex, represents a raw material or good that can be used to build roads or settlements, which is the purpose of the game. In this application, each hex is replaced by a flexible display of the same shape, the position and orientation of which is tracked through the hexes such that a board is formed. A computer algorithm then renders the functionality onto each flexible display hex. This is done through a computer algorithm that calculates and randomizes the board design each time, but within and according to the rules of the game. The graphics on the hexes is animated with computer graphics that track and represent the state of the game. All physical objects in the game are tracked by the apparatus of our invention and can potentially be used as display surfaces. For example, when a user rolls a die, the outcome of said roll is known to the game. Alternatively, the system may roll the die for the user, representing the outcome on a cube-shaped flexible display that represents the cast die. In the game, the number provided by said die indicates the hex that is to produce goods for the users. As an example of an animation presented on a hex during this state of the game, when the hex indicates woodland, a