[0168] D. If light insufficient, change light or other light gathering parameter such as integration time

[0169] E. Identify target(S)

[0170] F. If not identifiable, add other processing steps such as a screen for target color, shape, or size

[0171] G. Determine centroid or other characteristic of target point (in this case a retro dot on finger)

[0172] H. Perform auxiliary matching step if required

[0173] I. Compare location in stereo pair to determine range z and x y location of target (s)

[0174] J. Auxiliary step of determining location of targets on screen if screen position not known to computer program. Determine via targets on screen housing or projected on to screen for example

[0175] K. Determine location of target relative to screen

[0176] L. Determine point in display program indicated

[0177] M. Modify display and program as desired.

[0178] The simple version of the invention here disclosed answers several problems experienced in previous attempts to implement such inputs to computers

[0179] 1. Computationally intensive

[0180] 2. Latency (frequency response, time to get position or orientation answer)

[0181] 3. Noise (unreliability caused by ambient electronic, processing, or other conditions)

[0182] 4. Lighting (unreliability caused by ambient illumination, processing, or other conditions)

[0183] 5. Initialization

[0184] 6. Background problems, where the situation background cannot be staged, as in a cad system input on a desk.

[0185] It particularly achieves this simply and at low cost because of the function of the retroreflector targets used, which help answer all 6 needs above. When combined with color and/or shape detection, the system can be highly reliable fast and low cost. In some more controlled cases, having slower movements and more uniform backgrounds for example, retro material is not needed.

[0186] **FIG. 1*e***

[0187] The following is a multi-degree of freedom image processing description of a triangular shaped color target (disclosed itself in several embodiments of the invention herein) which can be found optically using one or more cameras to obtain the 3 dimensional location and orientation of the target using a computer based method described below. It uses color processing to advantage, as well as a large number of pixels for highest resolution, and is best for targets that are defined by a large number of pixels in the image plane, typically because the target is large, or the cameras are close to the target, or the camera field is composed of a very large number of pixels. The method is simple but unique in that it can be applied 1) in a variety of degrees to increase the accuracy (albeit at the expense of speed), 2) with 1 or more cameras (more cameras increase accuracy), 3) it can utilize the combination of the targets colors and triangles, (1 or more) to identify the tool or object. It utilizes the edges of the triangles to obtain accurate subpixel accruacy. A triangle edge can even have a gentle curve and the method will still function well. The method is based on accurately finding the 3 vertices (F**0**,G**0**,F**1**,G**1**,F**2**, G**2**) of each triangle in the camera field by accurately defining the edges and then computing the intersection of these edge curves rather than finding 3 or 4 points from spot centroids.

[0188] The preferred implementation uses 1 or more color cameras to capture a target composed of a brightly colored right triangle on a rectangle of different brightly colored background material. The background color and the triangle color must be two colors that are easily distinguished from the rest of the image. For purposes of exposition we will describe the background color as a bright orange and the triangle as aqua.

[0189] By using the differences between the background color and the triangle color, the vertices of the triangle can be found very accurately. If there are more than one triangle on a target, a weighted average of location and orientation information can be used to increase accuracy. The method starts searching for a pixel with the color of the background or of the triangle beginning with the pixel location of the center of the triangle from the last frame. Once a pixel with the triangle "aqua" color is found, the program marches in four opposite directions until each march detects a color change indicative of an edge dividing the triangle and the "orange" background. Next, the method extrends the edges to define three edge lines of the triangle with a least squares method. The intersection points of the resulting three lines are found, and serve as rough estimates of the triangle vertices. These can serve as input for applications that don't require high accuracy.

[0190] If better accuracy is desired, these provisional lines are then used as a starting point for the subpixel refinement process. Each of these 3 lines is checked to see if it is mainly horizontal. If a line is mainly horizontal, then a new line will be determined by fiting a best fit of a curve through the pixel in each column that straddles the provisional line. If a line is mainly vertical, then the same process proceeds on rows of pixels.

[0191] The color of each pixel crossed by a line is translated into a corresponding numeric value. A completely aqua pixel is would receive the value 0, while a completely orange pixel would receive the value 1. All others colors produce a number between 0 and 1, based on their relative amounts of aqua and orange. This numeric value, V, assigned to a pixel is a weighted average of the color components (such as the R, G, B values) of the pixel. If the components of the calibrated aqua are AR, AG, AB and those of orange are OR, OG, OB, and the pixel components are PR, PG, PB, then the numeric value V is:

$$V=WR*CR+WG*CG+WB*CB$$

[0192] With WR, WG, WB being weighting constants between 0 and 1 and CR is defined as:

[0193] A flow chart is shown in **FIG. 2*a***

[0194] The same process can be used to define CG and CB.