direction of the finger using the knowledge of the wrist gained from the datums. This allows the left hand finger **50** to alternatively point at a point (or touch a point) to be determined on the object **30** held in the right hand as well.

[0127] **FIG. 1***c*

[0128] **FIG. 1***c* illustrates another version of the embodiments of **FIGS. 1***a* and *b,* in which two camera "binocular" stereo cameras **60** and **61** processed by computer **64** are used to image artificial target (in this case a triangle, see also **FIG. 2**), **65**, on the end of pencil **66**, and optionally to improve pointing resolution, target **67** on the tip end of the pencil, typically a known small distance from the tip. (the user and his hand holding the pencil is not shown for clarity. This imaging allows one to track the pencil tip position in order to determine where on the paper (or tv screen, in the case of a touch screen) the pencil is contacting. (see also **FIG. 2**, and **FIG. 12**).

[0129] For best results it is often desirable to have independently controllable near coaxial light sources **62** and **63** are shown controlled by computer **64** to provide illumination of retroreflective targets for each camera independently. This is because at different approach angles the retroreflector reflects differently, and since the cameras are often angularly spaced (eg by non-zero angle A), they do not see a target the same.

[0130] Numerous other camera arrangements, processing, computation, and other issues are discussed in general relative to accurate determination of object positions using two or more camera stereo vision systems in the S. F. El Hakim paper referenced above and the additional references referred to therein.

[0131] The computer can also acquire the stereo image of the paper and the targets in its four corners, **71-74**. Solution of the photogrammetric equation allows the position of the paper in space relative to the cameras to be determined, and thence the position of the pencil, and particularly its tip, to the paper, which is passed to display means **75** or another computer program. Even with out the target on the end, the pointing direction can be determined from target **65** and knowing the length of the pencil the tip position calculated

[0132] A line target **76** can also be useful on the pencil, or a plurality of line targets spaced circumferentially, can also be of use in defining the pencil pointing direction from the stereo image pair.

[0133] A working volume of the measurement system is shown in dotted lines **79**—that is the region on and above the desk top in this case where the sensor system can operate effectively. Typically this is more than satisfactory for the work at hand.

[0134] It is noted that the dual (Stereo pair) camera system of **FIG. 1** has been extensively tested and can provide highly accurate position and orientation information in up to 6 degrees of freedom. One particular version using commercial CCD Black and white cameras and a Matrox "Genesis" framegrabber and image processing board, and suitable stereo photogrammetry software running in an Intel Pentium 300 MHZ based computer, has characteristics well suited to input from a large desktop CAD station for example. This provides 30 Hz updates of all 6 axes (x y z roll pitch and yaw) data over a working volume of 0.5 meter×0.5 meter in x and y (the desktop, where cameras are directly overhead pointing down at the desk) and 0.35 meters in z above the desk, all to an accuracy of 0.1 mm or better, when used with clearly visible round retroreflective (scotchlite 7615 based) datums approx. 5-15 mm in diameter on an object for example. This is accurate enough for precision tasks such as designing objects in 3D cad systems, a major goal of the invention

[0135] The cameras in this example are mounted overhead. If mounted to the side or front, or at an angle such as 45 degrees to the desktop, the z axis becomes the direction outward from the cameras.

[0136] **FIG. 1***c* additionally illustrates **2** camera stereo arrangement, used in this case to determine the position and orientation of an object having a line target, and a datum on a portion of the user. Here, cameras **60** and **61** are positioned to view a retro-reflective line target **80** in this case running part of the length of a toy sword blade **81**. The line target in this case is made as part of the plastic sword, and is formed of molded in corner cube reflectors similar to those in a tail light reflector on a car. It may also made to be one unique color relative to the rest of the sword, and the combination of the two gives an unmistakable indication.

[0137] There are typically no other bright lines in any typical image when viewed retroreflectively. This also illustrates how target shape (ie a line) can be used to discriminate against unwanted other glints and reflections which might comprise a few bright pixels worth in the image. It is noted that a line type of target can be cylindrical in shape if wrapped around a cylindrical object, which can be viewed then from multiple angles.

[0138] Matching of the two camera images and solution of the photogrammetric equations gives the line target pointing direction. If an additional point is used, such as **82** the full 6 degree of freedom solution of the sword is available. Also shown here is yet another point, **83**, which serves two purposes, in that it allows an improved photogrammetric solution, and it serves as a redundant target in case **82** cant be seen, due to obscuration, obliteration, or what have you.

[0139] This data is calculated in computer **64**, and used to modify a display on screen **75** as desired, and further described in **FIG. 15**.

[0140] In one embodiment a matrox genesis frame processor card on an IBM 300 mhz PC was used to read both cameras, and process the information at the camera frame rate of 30 HZ. Such line targets are very useful on sleeves of clothing, seams of gloves for pointing, rims of hats, and other decorative and practical purposes for example for example outlining the edges of objects or portions thereof, such as holes and openings.

[0141] Typically the cameras **60** and **61** have magnifications and fields of view which are equal, and overlap in the volume of measurement desired. The axes of the cameras can be parallel, but for operation at ranges of a few meters or less, are often inclined at an acute angle A with respect to each other, so as to increase the overlap of their field of view—particularly if larger baseline distances d are used for increased accuracy (albeit with less z range capability.). For example for a cad drawing application, A can be 30-45 degrees, with a base line of 0.5 to 1 meter. Where as for a