known as image differencing. One non-limiting advantage of using image differencing is that the procedure is tolerant of the movement of the user relative to the front side surface **12**B of the screen **12**, and to gradual changes in ambient lighting. However, in another embodiment, where there is little change in the rear image of the screen **12** except when the user touches the screen, a methodology based on background subtraction could be used. In this case an image of the surface is taken in a situation where it is known that there is no user interaction (e.g., during a calibration phase). This reference image is then compared to each frame that is digitized by the camera **14**. When the user touches the surface **12**B, a strong light change occurs at the point of contact (as described above). In this case it is possible to track the movement of the user's hand in contact with the screen **12**, as well as to detect for how long the user touches the screen **12**. A similar approach may use a statistical technique to slowly update the reference image to accommodate changes in the environment and in the lighting conditions.

[**0033**] A further embodiment of this invention combines the translucent surface of the screen **12** with a projection system, such as a slide projector, a video projector, or lighting fixtures, transforming the surface to an interactive graphics display. In such an embodiment the foregoing operations are still effective, since if the front light source **18** is considerably brighter than the projected image, the image taken from the camera **14** of the rear side surface **12**A is substantially unaffected by the projection. Therefore, the point of contact of the user's hand still generates a strong silhouette, detectable by the data processor **20** vision system. However, if the rear projected-image is significantly brighter than the front light going through the surface **12**A, there may be situations where a change in the projected image could be mistakenly recognized as a user's contact with the surface **12**B. There are, however, solutions for this potential problem: a) the areas for interaction can be freed from projected imagery, and the computer vision system instructed to look for interaction only on those areas; b) the shape of the difference pattern can be analyzed by computer vision and pattern recognition methods (including statistical and learning based methods) and only those shapes that resemble a particular kind of user interaction (such as touching with a finger) are accepted. This latter solution can be used also to improve the detection performance in the general case described above with regard to **FIGS. 2 and 3**.

[**0034**] In another embodiment, multiple users can use the system **10** at the same time, or interact with both hands. As long as the points of contact are reasonably separated, the procedure described in **FIG. 3** detects multiple areas of contact with the front side surface **12**B of the screen **12**.

[**0035**] In another embodiment of this invention the data processor **20** is provided with at least one light sensor (LS) **24** to monitor the light source levels at the front side **12**B and/or the rear side **12**A of the screen **12** to determine an amount of the difference in the illumination between the two sides. This embodiment may further be enhanced by permitting the data processor **20** to control the intensity of one or both of the rear and front light source(s) **16** and **18**, so that the difference in brightness can be controlled. This light source control is indicated in **FIG. 1** by the line **26** from the data processor **20** to the rear light source(s) **16**.

[**0036**] In general, the LS **24** may be used to determine a difference in ambient light levels to ensure that the system **10** is usable, and/or as in input to the image processing algorithm as a scale factor or some other parameter. Preferably the LS **24** is coupled to the data processor **20**, or some other networked device, so that the image processing algorithm(s) can obtain the ambient light level(s) to automatically determine whether there is enough ambient light difference for the system **10** to operable with some expected level of performance. Preferably there may be an ability to increase or decrease the light level from the front and/or the rear sides of the translucent screen **12**. In this case the data processor **20** can be provided with the brightness control **26**. Preferably the LS **24** and the brightness control **26** can be used together in such a way that the data processor **20** is able to change the brightness level of the front or the rear sides of the screen **12**, or both.

[**0037**] In another embodiment a system with multiple screens **12** and a single camera **14** or projector/camera system can be used, assuming that the system is able to direct the camera **14** and/or the projector to attend each of the screens **12**. In this case the multiple screens **12** can be illuminated by a single light source or by multiple light sources, either sequentially or simultaneously.

[**0038**] Based on the foregoing description it can be appreciated that in one aspect thereof this invention provides input apparatus and methods for a screen **12** having a translucent surface that uses the camera **14** and the data processor **20** to process an image stream from the camera **14**. The camera **14** is positioned on the opposite side of screen **12** from the user or users of the system **10**. Because the surface is translucent, the image of the users and their hands can be severely blurred. However, when the user touches the surface **12**B, the image of the point of contact on the surface becomes either significantly brighter or significantly darker than the rest of the surface, according to the difference between the incident light from each side of the surface. If the incident light on the user's side is brighter than on the camera side, the point of contact is silhouetted, and therefore, significantly darker. If the incident light on the user's side is darker than on the camera side, the user's skin in contact with the surface reflects the light coming from the camera side, and therefore the point of contact is significantly brighter than the background. To detect when the user touches the surface, an image differencing technique maybe employed. In this non-limiting case consecutive frames are subtracted from one another such that when the user touches the surface, a significant difference in brightness at the point of contact can be readily detected by a thresholding mechanism, or by motion detection algorithms. The apparatus and method accommodates multiple and simultaneous interaction on different areas of the screen **12**, as long as they are reasonably apart from each other.

[**0039**] Note that in at least one embodiment of the invention only the rear light source(s) **16** may be provided, and the front light source(s) **18** maybe provided solely by environmental lighting (e.g., sun light during the day and street lighting at night). In this case it may be desirable to provide the automatic control **26** over the brightness of the rear light source(s) to accommodate the changing levels of illumination at the front side **12**B of the screen **12**.