thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Among other things, the present invention may be embodied as methods or devices. Accordingly, the present invention may take the form of an entirely hardware embodiment, an entirely software embodiment or an embodiment combining software and hardware aspects. The following detailed description is, therefore, not to be taken in a limiting sense.

[0022] Throughout the specification and claims, the following terms take the meanings explicitly associated herein, unless the context clearly dictates otherwise. The phrase "in one embodiment" as used herein does not necessarily refer to the same embodiment, though it may. As used herein, the term "or" is an inclusive "or" operator, and is equivalent to the term "and/or," unless the context clearly dictates otherwise. The term "based on" is not exclusive and allows for being based on additional factors not described, unless the context clearly dictates otherwise. In addition, throughout the specification, the meaning of "a," "an," and "the" include plural references. The meaning of "in" includes "in" and "on."

[0023] The term "pseudorandom" as used herein, indicates a statistically random process, which appears to be random as distinguished from a truly random process, which lacks predictability. Pseudorandom processes may be generated using some deterministic elements combined with some non-repeating patterns. For example, a timestamp may be combined with the changing contents of a predetermined memory location to generate a pseudorandom number. Furthermore, this term as used herein, indicates lack of a predefined scanning organization, for example, an array of pixels (picture elements), parallel scanlines, or any other arrangement having a temporal or spatial relationship between scanlines.

[0024] The term "corresponding" as used herein, may indicate a one-to-one, one-to-many, or many-to-one mapping. For example, an image pixel corresponding to a display position may indicate that the image pixel corresponds to more than one display position, when adjacent display positions are resolvable at a higher resolution in comparison with the resolution of the image associated with the image pixel. In such a case, a single image pixel may be interpolated or resolved to cover more than one display position, and thus, the single image pixel corresponds to more that one display position and indicates a one-to-many mapping. In another case where the image pixels and the display positions have substantially equal resolutions, the correspondence there between can be a one-to-one mapping. Furthermore, if a plurality of adjacent pixels have substantially equal values, they may be projected as a line to form the image instead of a series of individual positions on a display.

[0025] The following briefly describes the embodiments of the invention in order to provide a basic understanding of some aspects of the invention. This brief description is not intended as an extensive overview. It is not intended to identify key or critical elements, or to delineate or otherwise narrow the scope. Its purpose is merely to present some concepts in a simplified form as a prelude to the more detailed description that is presented later.

[0026] Briefly described, the invention is directed to an image projection device for displaying an image onto a remote surface. The image projection device employs a scanner to project image beams of visible light and tracer beams of light onto a remote surface to form a display of the image. The device also employs a light detector to sense at least the reflections of light from the tracer beams incident on the remote surface. The device employs the sensed tracer beam light to predict the trajectory of the beam and subsequent image beams that form a display of the image on the remote surface. Additionally, in at least one embodiment, the light detector can also sense the reflections of visible light that form the projected image incident on the remote surface. And the device can employ the sensed reflections of this visible light to effect adjustments to subsequent image beams that form the display of the image on the remote surface.

[0027] The trajectory of the projected image beams can be observed so that the image is displayed from a point of view that can be selected by, or automatically adjusted for, a viewer of the displayed image. Also, the image beams and tracer beams that form the projected image can be projected onto the remote surface in a pseudo random pattern that is primarily based on the projected image itself rather than a predefined pattern, such as an array or grid.

[0028] To display the projected image on a remote surface, the image projection device projects pulses of visible light onto the remote surface and also projects other pulses of tracer beam light onto the same remote surface. These pulses can be generated by modulating the output of light sources or shuttering the detector of the reflected light from the remote surface. The light from the image beam and the tracer beam can be combined and projected onto the same location at the remote surface, or they may be projected onto two adjacent locations where the distance between the two locations is predetermined. The image beam light typically has a wavelength in the visible spectrum. Also, the tracer beam light can have a wavelength in either the visible wavelength or another wavelength in the visible light spectrum. If visible light is employed for the tracer beam pulses, the frequency of the pulses is typically so fast that the tracer beam pulses are undetectable to the typical viewer. Also, if non-visible light is employed for the tracer beam pulses, the light wavelength can be in one or more non-visible spectrums, e.g., infrared, ultraviolet, or the like.

[0029] Furthermore, in at least one embodiment, the image projection device enables one or more safety interlocks between the image projection device and the remote surface. For example, a determination is made as to whether or not the scanner is properly moving, and if not, the image beam pulses and tracer beam pulses are disabled until the scanner is properly moving again. Also, in at least one embodiment, if a moving object is detected between the image projection device and the projection of the image on the remote surface, the image beam pulses and tracer beam pulses are disabled until the moving object is no longer present.

[0030] In at least one embodiment, the tracer beam non-visible light pulses are IR (Infra-Red) light that is projected by a scanner, such as an oscillating MEMS scanner, onto particular positions in a pseudorandom scanline trajectory that sweeps across the remote surface. A light detector, such as a camera, coupled with a processing unit, tracks the tracer beam light pulses to obtain data for detecting N consecutive preceding positions of the pseudorandom scanline trajectory and estimating the subsequent consecutive M positions of the scanline trajectory with respect to a current screen position. Multiple component image beams of visible light, for example, RGB (Red-Green-Blue) colors, are modulated, based on a corresponding M pixels of an image in a memory (memory image), and combined to create discrete combined image beam pulses. The combined image beam pulses are projected onto the remote surface at the subsequent estimated