APPARATUS AND METHODS FOR ACQUIRING AN IMAGE OF A GOODS PACKAGE

Use of a laser as a light source for illumination of an object is known. In many circumstances, laser illumination is an attractive proposition for a number of reasons. For instance, lasing devices tend to be compact in size, do not require excessive amounts of energy from their power sources, and are a good solution in situations where the illumination light must be polarised. This is a particularly advantageous feature in situations where the light source must penetrate a material such as a transparent or partially transparent film thereby allowing illumination of an object under the material. For instance, details of the object under the film may be read by a reading device or, say, have an image of the object captured by an imaging device such as a camera and the use of polarised light in such circumstances leads to a reduction in excessive glare from the film.

A significant downside to the use of lasing devices is that when high output power of the laser emitter is required, the greater the output power of the laser emitter, the greater and brighter is the speckle. Speckle is a random intensity pattern produced by the mutual interference of a set of wave fronts. It is observed when radio waves are scattered. It is a result of the interference of many waves, having different phases, which add together to produce a resultant wave whose amplitude, and therefore intensity, varies randomly. Thus, speckle is a random pattern created when a laser beam is scattered off a rough surface. Speckle is not normally an issue in light beams of low coherence -- made up of many different wavelengths -- because the speckle patterns produced by individual wavelengths have different dimensions and will normally average one another out. However, in applications requiring polarised light, it becomes a significant issue. This is especially true in high-power laser applications where the lasing device is provided to illuminate an object enclosed or wrapped in a transparent or partially transparent material such as shrink wrap film, where an image of the object under the film is to be acquired. In such applications, illumination of the object will normally require a few hundred milliwatts of laser

emitter output, thereby causing a significant amount of speckle. Speckle effect may become so severe, that it causes distortion of the image acquired by the imaging device (as high-contrast, large speckle “kernels” are very difficult to distinguish from target items – i.e. those items which it is desired to capture an image of – like text, labels, barcodes, etc.), thereby leading to spurious results and possibly rendering any results unusable.

There have been significant efforts in the field of reducing speckle effect. One approach, as utilised by the system disclosed in United States Patent Application Publication 2010/0080253 A1, provides an imaging system which includes a plurality of laser sources configured to produce a plurality of light beams. One or more optical alignment devices orient the light beams into a collimated light beam. A light modulator modulates the collimated light beam such that images can be presented on a display surface. Speckle is reduced with an optical feedback device that causes the laser sources to operate in a coherent collapsed state. Examples of optical feedback devices include partially reflective mirrors and beam splitter-mirror combinations.

However, such arrangements are limited in the range of applications where they are applicable and, in any event, offer a relatively complex solution. For instance, collimation of the light beam requires careful calibration and commissioning is just one aspect of the above disclosure which can be considered a complex solution. Further, these approaches are generally too complex and expensive for some applications, such as logistics applications where the target items are items such as goods cartons and packages such as are normally shipped on pallets. Yet further, system specifications in these applications require relatively high-level illumination levels and corresponding laser emitter power, but with reduced speckle.

The invention is defined in the independent claims. Some optional features of the invention are defined in the appended claims.

Significant technical advantages may be realised when applying the techniques disclosed herein. For instance, use of an apparatus where the laser devices are arranged to project an illumination laser at a projection angle to illuminate a surface of a goods package (or other object), where the projection angle is oriented at the predetermined angle relative to a principal axis of view of a linescan camera, offers a convenient and cost-effective solution to reduce speckle effect. Thus, an imaging device for capturing an image of an object having a rough surface may capture an image with reduced interference and noise caused by speckle reflection from the rough surface.

In another arrangement, provision of an array of low-intensity lasers to project a composite laser beam to illuminate a portion of a rough surface of the goods package (for example, shrink wrap film), allows for a uniform, or substantially uniform, laser beam of resultant higher intensity. Using individual laser devices which, respectively, project laser beams onto adjacent portions of the object allows for a composite laser beam of higher intensity to be produced, without the attendant disadvantage of increased speckle caused by the use of a high-powered emitter.

For instance, acceptable results for reduced speckle can be achieved using low-intensity lasers of around, say, 5 mW or 7 mW, to produce a composite laser beam with an intensity level of the order of 20,000 lux or above for image acquisition of a large load, such as a pallet of goods. Using the techniques disclosed herein, a substantially uniform beam may be achieved using smaller, individual low-intensity lasers. For the purposes of the present disclosure, the term "substantially uniform" in the context of a composite laser beam includes a laser beam which has no readily perceivable bright or dark spots when viewed by an imaging device such as a linescan camera. Thus, a relatively inexpensive source of illumination is provided, having a uniform or substantially uniform beam width up to the typical width of

pallet, say around 1.4m, with intensity of the order of 20,000 lux or more, with reduced reflection and low speckle.

The invention will now be described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 is a series of block diagrams illustrating views of a first apparatus for acquiring an image of a surface of a goods package;

Figure 2 is a block diagram illustrating an elevational view of a second apparatus for acquiring an image of a surface of a goods package; and

Figure 3 is a series of block diagrams illustrating a plan view and enlarged part thereof of a third apparatus for acquiring an image of a surface of a goods package.

Referring now to Figure 1, a first apparatus for acquiring an image of a surface of a goods package is illustrated. Apparatus 100 comprises a linescan camera 102 capable of capturing an image in an optical plane 104. That is, the field of view of linescan camera 102 is in the optical plane 104. Apparatus 100 also comprises a first laser device 106a which, in this example, is arranged to emitter a laser beam in an axis which is coplanar with optical plane 104. In the example of Figure 1, apparatus 100 also has a second laser device 106b, but this is omitted from the view of Figure 1A for the sake of simplicity. However, this can be seen in Figure 1B which will be discussed shortly. Linescan camera 102 and the or each laser devices 106a, 106b are mounted on supports 108 mounted on base 110 disposed on floor surface 112. In the example of Figure 1A, the linescan camera 102 is arranged for movement in a movement plane 114, as will be explained shortly. Apparatus 100 is provided to capture an image of goods package 118 disposed upon a pallet 116 which, in turn, is also disposed upon floor surface 112. In the example of Figure 1A, goods package 118 has a surface 120, the surface which apparatus 100 is to acquire an image of. Goods package 118 has a material 122 thereon which is partially transparent to laser light. One exemplary material 122 is shrink wrap film such as is commonly used for the wrapping of goods packages or stacks of goods packages. It will be appreciated

that, in the view of Figure 1A, the spacing between shrink wrap 122 and goods package 118 has been exaggerated for the sake of illustration and, in practice, one would expect shrink wrap 122 to be wrapped tightly around goods package 118.

Turning now to Figure 1B, apparatus 100 and goods package 118 is illustrated in plan view. In the example of Figure 1B, both the laser devices 106a and 106b are illustrated. Linescan camera 102 and laser devices 106a, 106b are retained on a frame support 111.

Now that the optical plane (field of view) 104 of linescan camera 102 can be seen in plan view Figure 1B, it can be seen that the field of view fans out from the aperture 103 of linescan camera 102. The optical plane is a principal axis of view 124 of optical plane 104 and can be thought of as a line extending along the major axis of linescan camera 102 about which the field of view is symmetrical in the optical plane 104. In the example of Figure 1B, principal axis of view 124 is parallel to a normal N of surface 120 of goods package 118.

Laser device 106b projects a laser beam 126. In the example of Figure 1B, laser beam 126 is a line laser. The line laser may have a Gaussian intensity distribution in which case line 126 is representative of the centre of intensity of the beam, but with laser light being projected on the sides of line 126 as well. This provides the technical benefit that, with a fan angle about 15 degrees, a relatively uniform image may be acquired. Laser 126 is projected at a projection angle 128 from the principal axis of view 124 of linescan camera 102. The angle 128 of projection of laser beam 126 is such that its reflections 130 as reflected from material 122 reflect at an angle away from the field of view and sensor matrix/aperture 103 of linescan camera 102. Similarly, laser device 106a projects a laser beam 132 also at an angle 128a from principal axis of view 124. As such, reflections 134 of laser beam 132 are also reflected from material 122 at an angle away from the field of view and sensor matrix/aperture 103 of linescan camera 102. As a consequence of this, any direct

reflections of the laser beams 126, 132 do not cause any interference in the acquisition by linescan camera 102 of an image of surface 120 of goods package 118.

It will be appreciated that the precise configuration of each of laser devices 106a 106b may take several variant forms. For instance, in the example of Figure 1B, only a single laser beam is illustrated for the sake of simplicity but it will be appreciated that the or each laser device 106a, 106b may emit more than one laser beam projected generally parallel with laser beam lines 126, 132. In such a situation, each of the laser beams 126, 132 can be considered representative of the plural laser beams.

As noted above, speckle may be caused by the projection of a laser on to any roughened surface. In the context of goods packages/pallet loads, these are often wrapped in a material 122 such as shrink wrap film.. Thus, in the context of this disclosure, the surface (for example, the external surface facing the camera device) of the shrink wrap film may be considered a surface of the goods package. The manner of the shrink wrapping of the film results in a surface which is not substantially flat and, therefore, is susceptible to causing speckling when the laser light is shone thereon.

Thus, it will be appreciated that Figure 1 illustrates an apparatus 100 for acquiring an image of a surface 120 of a goods package 118, the surface being a rough surface, in the context that it is capable of causing speckle.. Apparatus 100 comprises a linescan camera 102 for acquiring the image of the surface 120 of goods package 118 on an optical plane 104 having a principal axis of view 124. Further, a (the or each) laser device 106a, 106b projects a laser beam 132, 126 at a projection angle 128, 128a thereby to illuminate the surface 120 of goods package 118 on the optical plane (i.e. the field of view of laser camera 102 is incident upon surface 120 of goods package 118 in the optical plane 104). Projection angle 128, 128a is oriented at a predetermined angle relative to the principal axis of view 124.

In the example of Figure 1, linescan camera 102 is arranged for movement in a movement plate 114 to acquire the image of the surface 120 of the goods package 118 and does so one line at a time. The result is a complete hi-resolution (for example, approximately 160 Mpixel) image. Linescan camera 102 is arranged to move vertically in plane 114. In the example, linescan camera 102 is mounted for linear movement on supports 108 which may comprise of linear actuators, having suitable drivers as will be known to the skilled person, and these are arranged upon a support base 110. A suitable linescan camera is one which is set to grab about 6-10 lines per mm with a field of view 104 of a line being 1 pixel thick and 8000 pixel wide, but other, for example higher, resolutions are contemplated. In the example of Figure 1, the or each laser device 106a, 106b shares, as mentioned above, the support framework 111 upon which both the laser devices 106a, 106b and linescan camera 102 are supported. Thus, operation of the linear actuators may be such that the linescan camera 102 and the or each laser device 106a, 106b is moved in the movement plane 114.

As illustrated in Figure 1 the or each laser device 106a, 106b is arranged to project the laser beam 132, 126 in the optical plane 104. That is, the or each laser beam 132, 126 is projected in the optical plane 104 of linescan camera 102; the or each laser beam 132, 126 is coplanar with the optical plane 104. While it is desirable that the or each laser beam 132, 126 is incident upon surface 120 to illuminate the surface 120 of goods package 118 for linescan camera 102 to acquire an image thereof, it is not essential that the or each laser beam 132, 126 actually be projected in a plane which is coplanar with optical plane 104. An alternative arrangement is illustrated in Figure 2.

A projection angle 128 may be selected dependent upon certain design parameters of the apparatus 100. For instance, if a "working distance" between linescan camera 102 and surface 120 is 1.8 m, then a suitable angle of projection of the laser beam (or a principal axis of a composite laser beam) is 65.2°.

While in the example of Figure 1, principal axis of view 124 of linescan camera 102 is coaxial with a normal N of surface 120, it will be appreciated that this is not essential. For example, principal axis 124 may be arranged at an angle to normal N or surface 120. However, in such an arrangement, the or each laser beam 132, 126 is still projected at an angle 128 from principal axis of view 124. Thus, any reflections of the laser light on shrink wrap 122 are reflected away from the sensor matrix of linescan camera 102.

In the example of Figure 1, it is the linescan camera and the or each laser device are moved while the goods package remains stationary. As a further option, the camera may be moved and the laser device held stationery, as long as the laser beam I capable of moving to illuminate the field of view of the linescan camera as it scans. However, the techniques disclosed herein have broader application than that and may also be used in a conveyor application wherein the linescan camera (and perhaps the laser device) are stationary and goods are moved past the linescan camera (and perhaps the laser device) on a conveyor system. What is significant is that the relative movement is effected between the goods package and the linescan camera. In conveyor system applications, any goods package may have a material thereon -- such as a reflective label -- which may cause glare/reflection and/or speckle, and which might otherwise cause interference in the image acquisition device when acquiring the image of the goods package. However, it is likely that increased benefit of the techniques disclosed herein may be realised in a situation where it is a goods package stationary (upon a pallet load or similar) and the linescan camera arranged to move to acquire the image. In such situations, a goods package has a high likelihood of being wrapped in a reflective and speckle-inducing material such as shrink wrap. A shrink-wrapped film may be considered a particularly rough surface of the goods package in the context of laser illumination and speckle.

In Figure 2, a second apparatus for acquiring an image of a rough surface of a goods package is illustrated. In Figure 2, parts of apparatus 200 which are similar to the parts of apparatus 100 are given like numerals. Thus, apparatus 200 comprises a linescan camera 102 having an optical plane 104 (the plane in which the camera's field of view is) and one or more laser devices 106. Again, linescan camera 102 and the or each laser device 106 are mounted for linear movement on supports 108 which may comprise of linear actuators with suitable supports 108 arranged upon a support base 110. Again, apparatus 200 operates to capture an image of a surface 120 of goods package 118, which, in this example, is wrapped in shrink wrap film 122. In the example of Figure 2, the or each laser device 106 is not mounted to project the or each laser beam 204 in the optical plane. The or each laser device 106 is mounted above a linescan camera 102 but arranged to project laser beam 204 at an angle 206 from the horizontal plane (in the example of Figure 2 the optical plane 104 is in the horizontal plane). However, laser beam 204 is co-incident on surface 120 of goods package 118. Thus, the field of view 104 of linescan camera 102 is illuminated by laser beam 204 as it moves in movement plane 114 to capture the image of surface 120.

It is not illustrated in Figure 2, but laser beam 204 is also projected at a projection angle 128 relative to the principal axis of view of optical plane 104 to ensure that any reflections (for example, caused by speckling of the laser on the surface of material 122) reflect away from the sensing matrix of linescan camera 102, as is illustrated in Figure 1B.

It will be appreciated that other arrangements defining a relative displacement between the or each laser device 106 and linescan camera 102 are contemplated. A significant feature of the example of Figure 2 is that the laser beam 204 is coincident on surface 120 with field of view 104 of linescan camera 102.

Turning now to Figure 3, a third apparatus for acquiring an image of a rough surface of a goods package is illustrated in plan view in Figure 3A, and an enlarged part thereof is illustrated in Figure 3B.

Apparatus 300 comprises a linescan camera 302 for acquiring the image of the surface 304 of goods package 306. Goods package 306 has thereon a material 316 -- such as shrink wrap film. Goods package 306 is disposed upon pallet 318.

Apparatus 300 further comprises one or more laser devices 308 comprising an array 310 of low-intensity line lasers, 310a, 310b, etc, for projecting a composite laser beam 312 to illuminate a portion 314 of the surface 304 of goods package 306. Suitable values of power for the low-intensity lasers include powers in the range of 5 mW to 7 mW, although other power values are contemplated. Array 310 comprises a first low-intensity line laser 310a for projecting a first laser beam 312a on to a first portion 314a (see Figure 3B) and a second low-intensity line laser 310b for projecting a second laser beam 312b onto a second portion 314b (see Figure 3B) of the surface 304. As illustrated in Figure 3B, second portion 314b is adjacent first portion 314a, thereby to reduce the speckling 318 caused by reflections of laser light from the material 316.

An example of a laser array 400 is shown in Figure 4A. In this example, the lasers 402a, 402b, … 402n are arranged in a linear array. In this example, this means that each of the lasers 402a, 402b, … 402n are arranged upon a common axis 404 of array 400. Such an arrangement facilitates simple projection of the lasers in the optical plane 104, as illustrated in Figure 1A, assuming with lasers are oriented in a plane normal to axis 404. In another example, as illustrated in Figure 4B, the lasers 402a, 402b, … 402n are not arranged on a common line 404, and as such, may be considered to be in a non-linear array. However, in the example of Figure 4B, the lasers 402a, 402b, … 402n are arranged such that their individual beams are incident upon the surface of the goods package to project a composite laser line. That is, the

individual lasers produce a composite beam and, in a manner similar to that of Figure 2, are co-incident upon the field of view/optical plane 104 of linescan camera 102.

Another non-linear array 400 is illustrated in Figure 4C were the individual lasers 402a, 402b, … 402n are arranged in an irregular array and, as in Figure 4B, the individual beams are arranged to be incident upon the surface of the goods package to project a composite laser line.

It will be appreciated that the invention has been described by way of example only. Various modifications may be made to the techniques described herein without departing from the spirit and scope of the appended claims. The disclosed techniques comprise techniques which may be provided in a stand-alone manner, or in combination with one another. Therefore, features described with respect to one technique may also be presented in combination with another technique.

Claims

1. An apparatus for acquiring an image of a surface of a goods package , the surface being a rough surface, the apparatus comprising:

a linescan camera for acquiring the image of the surface of the goods package on an optical plane having a principal axis of view;

a laser device for projecting a laser beam at a projection angle, thereby to illuminate the surface of the goods package on the optical plane; wherein

the projection angle is oriented at a predetermined angle relative to the principal axis of view.

2. The apparatus of claim 1, wherein the laser device is arranged to project the laser beam in the optical plane.

3. The apparatus of claim 1 or claim 2, wherein the laser device comprises an array of low-intensity lasers and the laser beam is a composite laser beam comprised of laser beams from the lasers in the array.

4. The apparatus of any preceding claim, wherein the linescan camera is arranged for movement in a movement plane to acquire the image of the surface of the goods package.

5. An apparatus for acquiring an image of a surface, the surface being a rough surface, the apparatus comprising:

a linescan camera for acquiring the image of the surface of the goods package; and

a laser device comprising an array of low-intensity lasers for projecting a composite laser beam, thereby to illuminate a portion of the surface of the goods package, the array comprising a first low-intensity laser for projecting a first laser beam onto a first portion of the surface of the goods package and a second low-

intensity laser for projecting a second laser beam onto a second portion of the surface of the goods package adjacent the first portion, wherein

the linescan camera is arranged for movement in a movement plane to acquire the image of the surface of the goods package.

6. The apparatus of claim 4 or claim 5, wherein the laser device is arranged for movement in the movement plane with the linescan camera.

7. The apparatus of any preceding claim, wherein the lasers in the array are arranged in a linear array.

8. A method for acquiring an image of a surface of a goods package, the surface being a rough surface, the method comprising:

acquiring the image of the surface of the goods package using a linescan camera, acquisition of the image being on an optical plane having a principal axis of view;

projecting a laser beam at a projection angle from a laser device to illuminate the surface of the goods package on the optical plane; wherein

the projection angle is oriented at a predetermined angle relative to the principal axis of view.

9. A method for acquiring an image of a surface of a goods package , the surface being a rough surface, the method comprising:

acquiring the image of the surface of the goods package using a linescan camera by moving the linescan camera in a movement plane; and

projecting a laser beam from a laser device comprising an array of low-intensity lasers, the laser beam being a composite laser beam, the array comprising a first low-intensity laser projecting a first laser beam onto a first portion of the surface of the goods package and a second low-intensity laser projecting a second

laser beam onto a second portion of the surface of the goods package adjacent to the first portion.