Measuring Object Dimensions and its Distances Based on Image Processing Technique by Analysis the Image Using Sony Camera

Working Paper · December 2017

2 authors:

Huda M. Jawad
Al-Mustansiriyah University
30 PUBLICATIONS   **17** CITATIONS

SEE PROFILE

Tahseen A. Husain
University of Raparin
2 PUBLICATIONS   **5** CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:

Measuring Object Dimensions and its Distances Based on Image Processing Technique by Analysis the Image Using Sony Camera View project

thin film View project

Measuring Object Dimensions and its Distances Based on Image Processing Technique by Analysis the Image Using Sony Camera

Huda M. Jawad[1] & Tahseen A. Husain[2]

[1]Al-Mustansiriyah University, College of Science, Department of Physics, Baghdad, Iraq
[2] University of Raparin, College of Science, Department of Physics, Soleimani, Iraq
Correspondence: Tahseen A. Husain, University of Raparin, Soleimani, Iraq.
E-mail: tahseen.ahmed@raparinuni.org

Abstract: The measurement of object dimensions and its distance is essential for many technical applications. The purpose of this study was to find a suitable mathematical model in order to find an easy and accurate way to determine the object dimensions and its distance. This study was divided into two parts: the first one was to determine the dimensions of objects using a digital camera and a single laser pointer by placing those objects on black screen at different distances away from the camera then the second step was to determine the ranges of the objects using the images of two laser spots. Results show there is a relationship between different zoom and scale factor, and there is convergence and similarity between the experimental and theoretical values.

Keywords: Image Processing, Object Range, Sony Camera, Laser Pointer

1. Introduction

Over recent decades, the importance of determination the extent and dimensions of objects remotely has been increased especially in the regulations robot and control systems industry. The traditional direct distance measurement, which is the comparison of the distance with a calibrated ruler directly, is the oldest and most obvious method, but it cannot be applied in many cases. Therefore, several indirect distance measurement processes were developed throughout the centuries; here the distance is derived of any distance depending measure which is easier to access than the distance itself (Ertico, 2007). The importance of the indirect distance measurement is the non-contact distance measurement, which many applications require distance measurement without any physical contact between the distances meter and the measured object. Therefore, many procedures have been developed since the beginning of the last century in which different kind of methods were used such as sound waves and electromagnetic waves to obtain distance information (Mengel & Wertheimer, 2007).

In the early days, this projection was made on paper facilitating an artist to copy the image. As one can see, the step from human vision to imaging and to image processing is not that big. In principle, the following analogy can be made; our eyes play the role of a camera with the retina as imaging sensor and the virtual cortex as processing device. If our eyes would not be connected to our brain,

we would not be able to remember the things we see and therefore we will not be able to recognize things, reason and make decisions based on the perceived visual information. This completes the sense-think-act loop. The same applies to imaging and image processing; imaging without image processing (including recording) seems to be of no use (Van Eekeren et al., 2006).

In comparison to the pinhole imaging of a camera obscure, modern cameras make use of lenses (optics). This permits the collection of more light/radiation while keeping the scene in focus. Nowadays, there exist a wide range of different optical imaging devices; high-resolution mega pixel cameras for digital photography, infrared cameras for night-vision, microscopes for biological research, etc. Application of Super-resolution (SR) reconstruction is especially effective for imaging devices which have a coarse sampling grid and therefore tend to under-sample the data. Infrared cameras belong to this class due to the relatively large wavelength of infrared light in comparison to visible light (Dijk et al., 2007).

A laser pointer is a device emitting a narrow low-powered laser beam of visible light which used to highlight something of interest by illuminating it with a bright spot of colored light. The laser pointer with power less than (5mw) are safe to use, but those with power of (100 mw) or more have recently caused permanent eye damage (Burger & Burge, 2016). Those laser pointers with narrow beam and low power of typical laser pointer is invisible in a clean atmosphere, showing a spot of light when hit an object surface. Some higher –powered laser pointer gives a visible beam through scattering from dust particles or fog droplets on the way of the beam path. Because of the Rayleigh scattering from air molecules higher power and higher frequency laser (green or blue color) have a visible beam even if they are used in clean air, especially when they are used in dark places (Duarte, 2008).

The factors in which the brightness of a laser spot depends on are the optical power of the laser, the reflectance of the surface and the chromatic response of the human eye. The green laser seems brighter than other colors because the human eye is more sensitive at low light levels in the green region of the spectrum at the wavelength of (520 to 570 nm), for the same optical power. But sensitivity of the human eye decreases for red or blue wavelengths. The laser pointer power is usually measured in (milliwatt) (Herald, 2008). Brief papers are shown in references (Rahi, 2010; Song & Tang, 2000). The objective of this research is to determine the objects distances and the dimensions using computer techniques for image processing, then can be performed by analyzing the digital images of the laser spots distant targets and building systems process based on the use of laser pointers, and developed mathematical models to estimate object ranges.

2. Theoretical Approach

The most direct ways to capture an image is by using a digital camera. Digital cameras use a semiconductor chip known as a Charge Coupled Device (CCD) which it converts the incident light from an object to electrical signals right at the image plane. The number of pixels the CCD that can capture will decide the quality of the images in this camera. Cheap digital cameras have relatively low resolution, limited range, and low International Standards Organization (ISO) film speed equivalent, and that will make their images have poor quality. To obtain images that have quality agreeing to film Photography currently requires very expensive digital cameras (Sachs, 1996).

Digital image can be defined as a light intensity of 2-D function I (x, y), where x and y are spatial

coordinates and the value of (I) at any point is proportional to the brightness of the image at that point. The image represents the function I (x, y) over two spatial coordinates of a plane to obtain digital data for digital processing: sampling (spatially) and quantizing the luminance values, can be done by single chip (i.e. Charge-coupled Device (CCD)) (Burger & Burge, 2016). Digital images are consisted of pixels (short for picture elements). Each pixel forms the color (or gray level) at a single point in that image, so a pixel is the smallest discrete constituent of an image of a particular color. A digital image can be created by measuring the color of an image at a large number of points, from which a copy of the original can be reconstructed. Pixels are arranged in a regular form of rows and columns, they store information somewhat differently. A digital image is a rectangular array of pixels sometimes called a bitmap (Burger & Burge, 2016).

A camera is an instrument that can be used as an eye tracker. Other technical solutions are mainly determined by the choice of a camera. The performance of the employed algorithms depends on the properties of the camera. Moreover, the influence of some other conditions, e.g. lighting conditions, can be minimized by a proper choice. The aim of the this section is to share information between partners about good practice and provide criteria for camera selection (Lymperis et al., 2007).

Cameras have to be calibrated so that all real-lens projection distortion on the image can be compensated in the image processing software which will give the best measurements on the allergy reactions. The Calibration of the camera is the process that is used to figure the intrinsic and extrinsic parameters of the camera. In most cases the reliability and the output of a machine vision system depends on the accurate definition of the parameters. The calibration of the camera can be performed once and after the camera parameters are estimated they can be used again in the calculations, since the optical system remains invariant (Oggier et al., 2005).

The estimation of the intrinsic camera parameters is performed by presenting printed checker board images of known dimensions to the camera. The model of the camera can be iterated from these images, until the parameters are estimated to good accuracy. Extrinsic camera parameters can be figured by changing the distance and angle of the presented patterns to the camera. After performing the camera calibration, images acquired with the cameras can be compensated for the lens distortions and the measured image distances can be correlated to the real-world distances (Nedev and Ivanova, 2006). Intrinsic parameters are used to exhibit as they are the point projections into the ultimate image. That is the transformation of the camera coordinates system into a new image coordinate system. The four intrinsic camera parameters: Focal length, Principal Point Skew coefficient and Distortions Intrinsic camera parameters are all used to correct the distortion position of the point in 2-D image of scene. This distortion is caused by the defect camera optics (Oggier et al., 2005).

Sonar (originally an acronym for sound navigation and ranging) systems gain the distance between the sonar device and an object through time of flight (TOF) measurement (Forster, 2005). A sonic measuring impulse is emitted by the sender and Transmit through the supporting medium (air, water, etc.) with the according propagation speed (v). If the sound waves meet objects on their course of propagation, the waves are partly reflected back. These reflections can be observed by the sender/receiver device, which enables a measurement of the time TOF elapsed between the sending and the receiving of the sound impulse. Inserting TOF and (v) in the TOF equation gets finding the searched distance of the object (Modrow et al., 2007).

$$d = v \cdot \frac{(TOF)}{2} \ldots\ldots\ldots\ldots(1)$$

Where

(d) is the computed object distance from the measurement device, (*v*) the velocity of propagation of the used wave and TOF the time measured between sending and receiving of the measurement signal. The use of several sonar sensors in parallel or scanning of a single sensor in horizontal and/or vertical direction enables the acquisition of 3-dimensional distance images (Modrow et al., 2007).

Non-contact distance measurement methods that are based on light waves are common techniques for many different distance measuring applications. In the following the most important ones are introduced: Interferometry, (3D) Scanning, time-of-flight, triangulation, image-matching techniques, laser scanning technique, projection method, stereo vision, object space information, and (3D) straight-line constraints. Every camera, which in real time can be connected to a computer, has the following elements: Optical system, Image sensor, Interface circuit.

(Scf) is the scale factor which it can be measure from equation (5):

The first location is (x_1, y_1) for the first point in laser spot image plane

The second location is (x_2, y_2) for the second point in laser spot

Let $dx = x_2 - x_1$ ……………. (2)

Let $dy = y_2 - y_1$ ……………. (3)

To compute the distance in pixels between point (1) (x_1, y_1) and point (2) (x_2, y_2) we use

$R_d = \sqrt{dx^2 + dy^2}$ ………… (4)

Two laser spots have a separation from center to center ($D_L = 8cm$) in real world. While in image world the separation will be (R_d) which is the distance measured in number of pixels between two spots. So, we can be analysis image (I) to estimate object dimensions. The scaling factor (Scf) for the capture images have been used to transform from image world to real world.

The scale factor (Scf) can be computed from the following equation:

$$Scf = \frac{D_L}{R_d} \qquad \ldots\ldots\ldots\ldots (5)$$

Machine vision cameras are developed for video data transfer to computer for further data analysis by machine vision algorithms. There is a big variety of machine vision cameras because of different frame rate, connectivity, image, resolution, sensor type, spectral response. The most suitable cameras for eye tracking are functionally machine vision cameras, as they transfer uncompressed digital data, but these kinds of cameras are expensive (Van Eekeren & Schutte, 2008).

3. Experimental Approach

In this work, we took a square of side length (5 cm) and a circle with radius (5 cm) and placed them

on black screen as shown in Figure (1) then we put a screen (2 m) away from the camera and picked a picture when the zoom of the camera was on (¼), then we increased the zoom of the camera to (½) and picked another picture and increased the zoom of the camera again to (3/4) then to (1) and picked another picture, see Figure (2). Then we put the screen (3 m) away from the camera and did the same previous steps, and then we increased the distance between the screen and the camera (1 m) each time and did the same process for the four steps by changing the zoom of the camera each time until we reach (7 m). After that we cut the image and measured the self-factor from SCF, and then we measured the square of the side length and the area of the circle from the program.
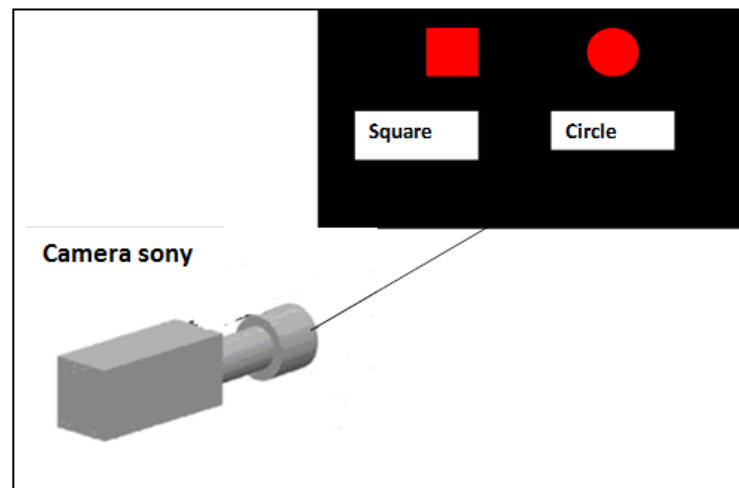

Figure 1: The suggested system design

4. Results and Discussion

Figure (2) shows images for the square and circle at different zoom up to the distance of (3 m). When we draw a graph between the distance on the x-axis and the scale factor (Scf) on the y-axis we find a mathematical equation of (TABLE CURVE) program for each distance. Table (1) shows experiment values for distance (m) and Scf. Figure (3) collects all the graphics in one chart. Then we find (a and b) values from each mathematical equation in the (TABLE CURVE) program. See the equation below (6 and 7).
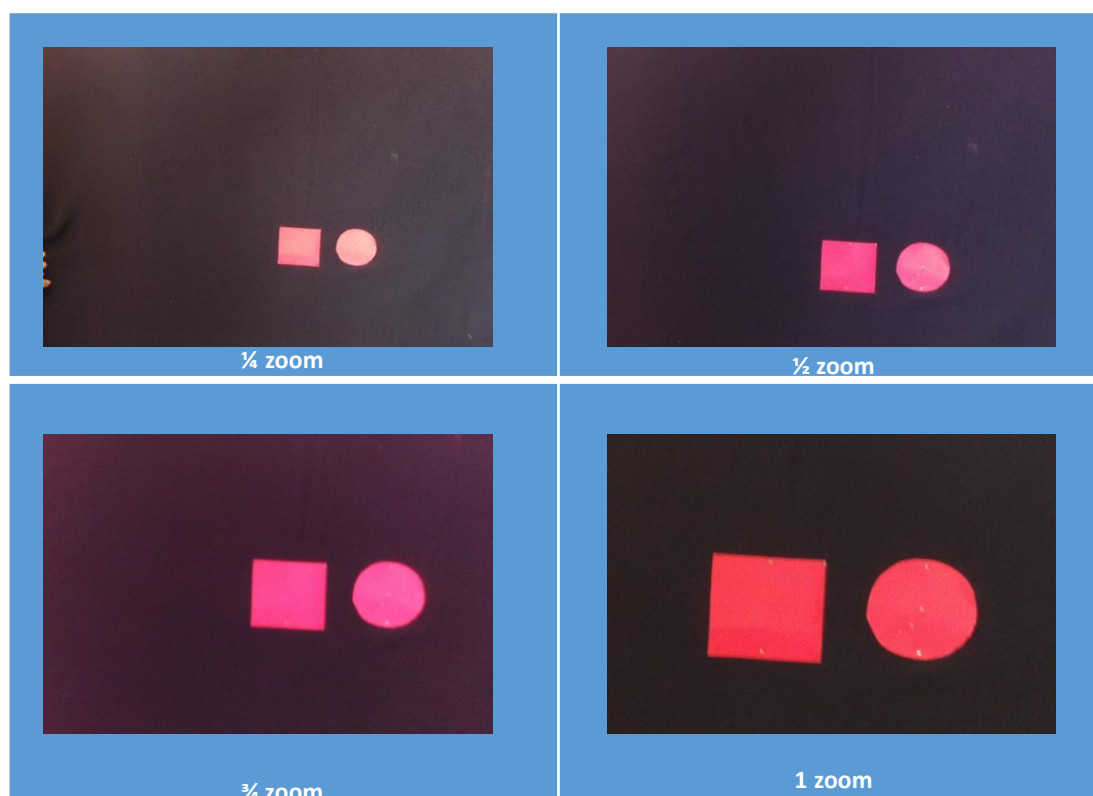
Figure 2: Images for square and circle at different zoom at distance (3m)

Table 1: Experiment values for distance (m) and Scf

d(m)	Scf.(cm/pixel) at 0.25 zoom	Scf.(cm/pixel) at 0.50 zoom	Scf.(cm/pixel)at 0.75 zoom	Scf.(cm/pixel) at 1 zoom
3	0.2496	0.169	0.152	0.058
4	0.2921	0.1961	0.1599	0.1249
5	0.3535	0.2155	0.202	0.149
6	0.3862	0.242	0.21	0.184
7	0.453	0.2739	0.262	0.191
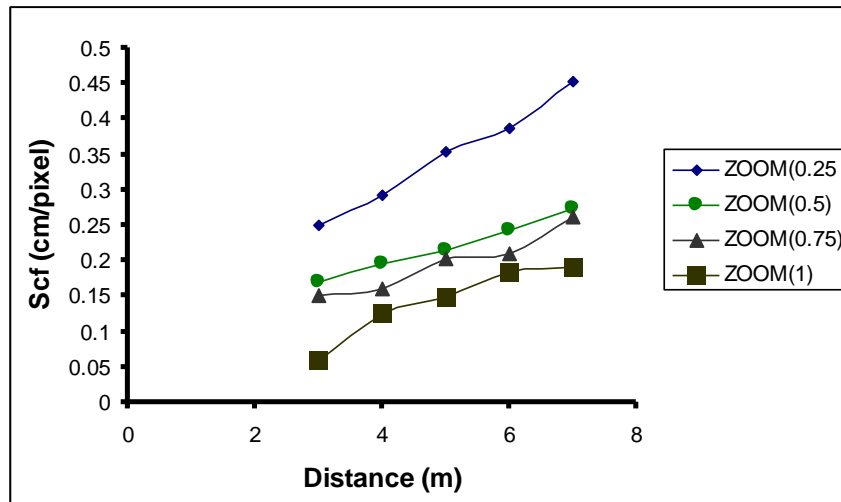
Figure 3: Experiment values for each distance from 3 to 7m

$Y = a + b X$ .... (6)

a = − 1.6

b = 1

Zoom = 1

a = - 1.6 +1 (zoom)

a = - 1.6 +1x1

a = - 0.6

$Y = a + b*\exp(x)$ ………. (7)

A = - 0.233

b = 7.7x10^ (-5) = 0

Zoom = 1

b = 0.233 + (0) exp (zoom)

b = 0.233

Figures (4-a and 4-b) show theoretical values of (a and b) respectively for each distance. Table (2) shows the theoretical values of (a & b) and the distance (m)**.**

Table 2: Theoretical (a and b) values and distance (m)

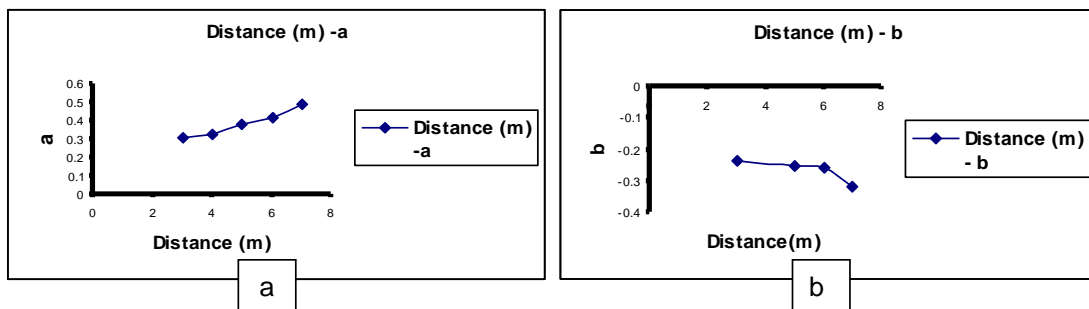| Distance (m) = d	a	b
3	0.305	- 0.236
4	0.327	- 0.215
5	0.386	- 0.250
6	0.415	- 0.255
7	0.494	- 0.319

Figure 4: Theoretical values of (a) increase with distance (b) decrease with distance

Table 3: Theoretical values for distance (m) and Scf

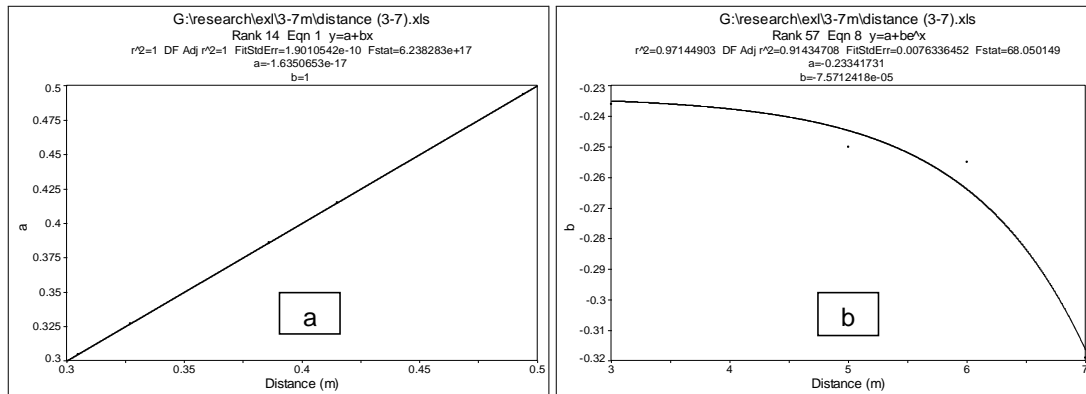| d(m)	Scf.at 0.25 zoom	Scf.at 0.50zoom	Scf.at 0.75 zoom	Scf.at 1 zoom
3	0.246	0.166	0.143	0.075
4	0.296	0.191	0.17	0.107
5	0.346	0.216	0.197	0.139
6	0.396	0.241	0.224	0.171
7	0.446	0.266	0.251	0.203

Figure 5: (a) values increase with distance, (b) values decreased with distance in (Table curve)

Figure (6) shows all the value of Scf in (Table Curve) for different power zoom for the distance of 3 (m) up to 7 (m), then from the data we got and by using equation (8) we can estimate the distances of objects and it is clearly seen that there is convergence and similarity between the experimental and the theoretical values.
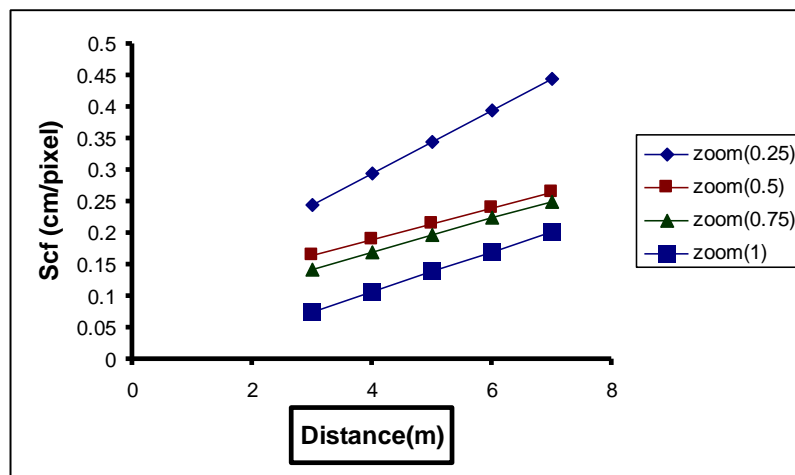

Figure 6: Theoretical values for each distance from 3 to 7(m)

$Y = - 0.6 + 0.233X$ ……… (8)

$SCF = - 0.6 + 0.233(distance)$

$0.075 + 0.6 = 0.233$

$X = 2.89 M$

Real distance (3m)

Equation (8) can estimate the objects ranges if we know Scf.

$Y = a + bX$

SCF = 0.17   ZOOM = 0.75

X = 4.4M

Real distance (4m)

Scf = 0.197   zoom 0.75   a =- 0.6   b = 0.233

X =4. 688M

Real distance (5m)

Scf = 0.25   zoom 0.5   a =- 0.6   b = 0.233

X = 6.5M

Real distance (6m)

Scf = 0.26   zoom 0.5   a =- 0.6   b = 0.233

X = 7.4M

Real distance (7m)

Note there is convergence and similarity between the experimental and the theoretical values, and then we have a standard equation from which we can estimate the objects ranges.

5. Conclusion

1 - The Scf increased with distance.

2 - Note that theoretical values of (a) increase with distance.

3 - Note that theoretical values of (b) decrease with distance.

4 - We got standard equation to estimate object range from (Table Curve) program.

5 – Note that there is convergence and similarity between the values of the experiment and the theoretical values, and then we have the standard equation from which we can estimate the objects ranges.

References

Burger, W., & Burge, M.J. (2016). Digital image processing: an algorithmic introduction using Java. Springer.

Dijk, J., van Eekeren, A.W., Schutte, K., & de Lange, D.J.J. (2007). Point target detection using super-resolution reconstruction, Proc. of SPIE Vol, pp. 65660U-65661.

Duarte, F.J. (2008). *Tunable Laser Applications*. CRC press.

Ertico (2007). PReVENT project homepage. Retrieved from http://www.prevent-ip.org/status.

Forster, F. (2005). Real-time range imaging for human-machine interfaces. Retrieved from https://mediatum.ub.tum.de/doc/601625/601625.pdf

Herald, S.M. (2008). Laser pointers restricted after attacks. Sydney Morning Herald.

Lymperis, D., Diamantis, A., Syrcos, G., & Karagiannis, S. (2007). Image processing algorithms for a computer assisted allergy testing system. 3rd International Conference on Computational Intelligence in Medicine and Healthcare, CIMED.

Mengel, P., & Wertheimer, R. (2007). D52.300.1 camera requirements and specifications. User Cams project deliverable. Retrieved from http://www.prevent-ip.org/en/public documents/deliverables/d523001 usercams general specifications.htm

Modrow, D., Laloni, C., Doemens, G., & Rigoll, G. (2007). 3d face scanning systems based on invisible infrared coded light. *Advances in Visual Computing,* 521-530.

Nedev, S., & Ivanova, V.C. (2006). Web camera as a measuring tool in the undergraduate physics laboratory. *European Journal of Physics* 27, 1213.

Oggier, T., Kaufmann, R., Lehmann, M., Buttgen, B., Neukom, S., Richter, M., Schweizer, M., Metzler, P., Lustenberger, F., & Blanc, N. (2005). Novel pixel architecture with inherent background suppression for 3 D time-of-flight imaging, Proc. SPIE, pp. 1-8.

Rahi, M.F. (2010). Driver circuit construction using visible semiconductor laser for distance measuremen. Al- Mustansiriyah University, College of Science, Dep. Physics.

Sachs, J. (1996). Digital image basics. Digital Light & Color. Retrieved from http://www.dl-c.com/Temp/downloads/Whitepapers/Basics.pdf

Song, K.T., & Tang, W.H. (2000). Driver circuit construction using visible semiconductor laser for distance measuremen. Graduate School of Information Systems" The University of Electro-Communications Choufu-shi, Tokyo, JAPAN 182-8585, 2000. fukuchi@megaUI.net.

Van Eekeren, A., Schutte, K., Dijk, J., De Lange, D., & Van Vliet, L. (2006). Super-resolution on moving objects and background, Image Processing, 2006 IEEE International Conference on. IEEE, pp. 2709-2712.

Van Eekeren, A.W.M., & Schutte, K. (2008). Apparatus and method for producingimproved quality signals. nr. 08161222.