International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-4, November 2019

2D Cam Capture: An Optimal Real-Time Dimension Measurement System

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Abstract: ***In the textile industry, dimension measurement of patterns plays a major role to obtain a perfect fit for a garment. The process of obtaining the measurements must be fast enough with high accuracy to avoid wastage of materials and also to ensure customer satisfaction. Currently digitizer is used to do the measurements of industrial patterns in textile industries. The existing digitizer has certain disadvantages which include high investment and less accuracy due to manual intervention for coordinate mapping. In recent trends image processing is a growing tool to analyse and process the image captured by a camera, which plays the major role in quality control system and material inspection system in various industries. The proposed method acts as a pinch-hitting to the conventional processes by providing a 2D Cam Capture algorithm using sequence of image processing techniques. This eases the measuring process by providing accurate dimensions of multi shapes without any distortion. This computer vision-based system involves capturing the image, processing and shape analysis using pixel calculation algorithm thereby providing accurate measurements. 2D Cam Capture provides an accuracy of 98.6% obtained from 245 samples at a minimum rate of 189.90 ms per iteration.It is cost effective by using a camera and it ease the process of capturing multi shapes without any shape distortion. This method increases accuracy and let the user to achieve their time schedule by way of increasing the productivity.***

Keywords: ***Digitization, image processing, image analysis and pixel count, dimension measurement.***

I. INTRODUCTION

Textile Industries normally produce manual patterns for the desired product. These manually created pattern shapes by the experts of the concerned field are taken to a computer using a device called digitizer which is available in various sizes. The conventional process of clicking the buttons by many numbers of times on the outline of the shapes to be captured leads to less accuracy in its defined procedure. Moreover, it consumes a large amount of time.

Manuscript published on November 30, 2019.
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These digitizers are being imported from various countries and are not manufactured in our country which is very expensive, carry high maintenance cost along with very high dependency value. The 2D Cam Capture has all intelligence
in covering up the difficulties encountered in prevailing digitizing and camera capturing methods. Moreover, it provides a greater level of comfort by doing away with the cumbersome process of digitizing especially bigger and complicated polygonal shapes.
It is cost-effective because of camera usage and the software which eases the process of capturing multiple shapes without any shape distortion. It also increases accuracy and let the user achieve their schedule by way of increasing productivity[1].In the existing manual method, the dimension is calculated one by one using a pattern template. The pattern master needs to make marking around the pattern. The pattern dimensions are then calculated by marking coordinates along the edges and curves. Later the coordinates are joined together as an enlarged pattern. This process of manual digitization consumes more time and also the resultant values are less accurate. The exact process of manual measurement is shown in Figure 1[2]**Error! Reference source not found.**.

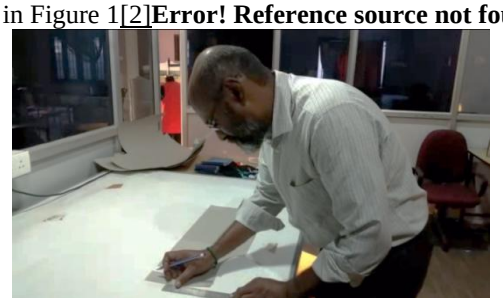

Figure 1. Manual Digitization

Digitizer tablets are generally input devices that are used to select or to draw an image using stylus or puck. Stylus is a special type of pen for marking. Puck consists of buttons and lens that are used to select the images. Initially the pattern is placed in the work table which consists of wirelines (as that of graph sheet). The wirelines along with the puck gives the dimension of the pattern. The puck consists of two hairlines on the glass. The intersection of the two edges is placed on the pattern line and by clicking action the x and y coordinates are marked and these points are logged by the computer thereby providing the dimensions. The digitizer requires high investment and it gets compounded if the tablet gets damaged. The digitizer table is shown in Figure 2.

Figure 2. Digitizer Table

Ongoing through the detailed study on the literature it is proposed to develop a system that acquires an image and produces a virtual scaled image. The proposed system replaces the present manual digitizing systems and fetches complete measurement details about the objects with minimal time consumption and high accuracy[3]**Error! Reference source not found.**.

Adopted ideologies in the development of 2D Cam Capture from the expertized literatures are discussed as follows:

Importance of Digitization Process in Textiles R. Anil Kumar and R.I. Sathya (2015) has given an introduction to the fundamental principles involved in the digitization process. It has outlined key concepts and themes such as defining digitization, examining pathways, introducing the notion of 'fit for purpose' and assessing archival concerns and dissemination compression techniques. It provides recommendations applicable to the strategic planning level, the policy which is derived from the strategy should include principles that serve as the conceptual foundation as well as helping to prioritize projects.

Ding, Choo Ming (2000) has elaborated on the works of Getz, Line and Mckinley on the advantages of digitization. It was inferred that

1. Digitization does not require new building blocks; information sharing can be enhanced and redundancy of collections reduced.
2. Digital materials can be sorted, transmitted and retrieved easily and quickly.
3. Access to electronic information is cheaper than its print counterpart when all the files are stored in an electronic warehouse with compatible facilities and equipment.
4. Digital texts can be linked, thus made interactive; besides, it enhances the retrieval of more information. In the light of the following advantages, it is natural today to find more information being digitized.

Huang (2015), presented an inspection system for quality control and production line automation for a semiconductor industry. To improve the yield rate and reduce manufacturing costs, the inspection devices were installed in the design, layout, fabrication, assembly and testing processes of production lines. This paper discusses the various state of the art visual inspection algorithms such as image processing, computer vision and machine learning systems that have been applied in the semiconductor manufacturing industry. They presented a system to inspect the defects of SMD LEDs and obtained 95% accuracy.R. Greco, M. Materazzi and M. Pampaloni (2002), The technology-based digitization encourages preservation by limiting the handling of original records, access strategy and impact of a digitization program on the institution's other public service activities has been discussed by the Preservation Committee of the Canadian Council of Archives (2002). It also discussed the cost and complexities inherent in the development of a digitization program. The capabilities of digital technology and its importance of various steps involved in the digitization process, efforts to preserve, manage and provide access to scholarly information, digitization pre-requisites and the practical experience of digitization.

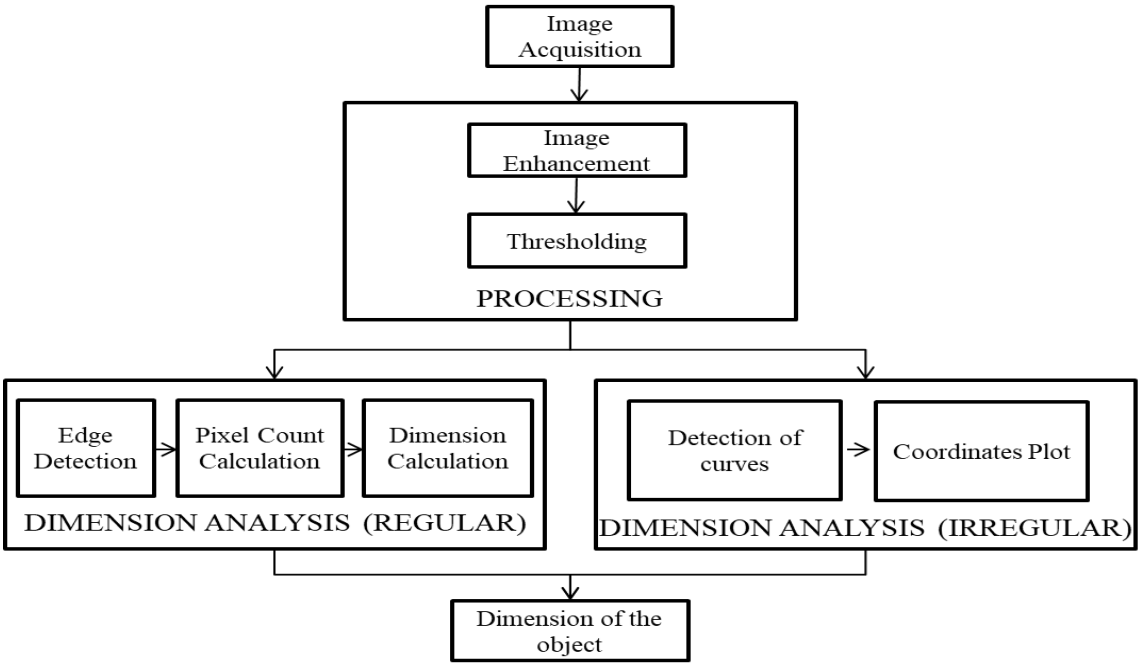

Figure 3. Process Flow of 2D Cam Capture

II. METHODOLOGY

Figure 3 depicts the process involved in 2D Cam Capture which includes acquisition, processing, and dimension analysis which are explained below.

A. *Image Acquisition:*

Virtual image retrieval from the source is the foremost step in image processing. The process of image acquisition deals with various parameters. Image Acquisition involves capturing an image from the source using a camera based on the application. This should be equipped with a proper lighting system to provide the exact result. The obtained optical image is transformed into an array of data which is later manipulated and processed by the computer[4].

B. *Processing:*

Processing is to be performed with some operations on an image to obtain an enhanced image or to extract some useful information from the captured image. Here the input is an image and output may be image or characteristics/features associated with that image which enables the system to perform with better precision. The proposed pre-processing includes the following two steps:

STEP 1: Image Enhancement

Image enhancement techniques are aimed at realizing improvement in the quality of the captured image. The result is another image that demonstrates certain features in a manner to have a better appearance when compared to the original image. Advanced techniques that are optimized concerning certain specific requirements which are used[5].

STEP 2: Thresholding

It is a non-linear operation that converts an image with grey tones to black and white or separates pixels on a greyscale value[6]. It is useful in discriminating the foreground from the background. The grey level image is converted to a binary image that has essential information about the position and shape of the object. This conversion to a binary image has a greater advantage of reduced complexity[7]. From the following mathematical equation, it can be explained as the distribution of the data. The threshold value is assigned from the variance calculated. The higher the value of variance, the data is more dispersed [8].

$$\sigma^2 = \frac{\sum_{i-0}^{N}(x_i-\mu)^2}{N} \quad \text{---------- (4)}$$

Where

N – Total number of pixels in one image
x_i – Pixel value
μ – Mean

C. *Dimension Analysis (Regular)*

In dimension analysis, the shape acquired is pre-processed like RGB to HSL (Hue Saturation Luminance) manipulation. The values of Hue, Saturation and Luminance are determined as follows:

$$R' = R/255 \text{---------- (5)}$$

$$G' = G/255 \text{---------- (6)}$$

$$B' = B/255 \text{---------- (7)}$$

The values are divided by 255 for conversion of the range from 0 - 255 to 0 – 1.

$$C_{max} = max\,(R', G', B') \text{---------- (8)}$$

$$C_{min} = min\,(R', G', B') \text{---------- (9)}$$

$$\Delta = C_{max} - C_{min} \text{--------- (10)}$$

Hue Value:

$$H = \begin{cases} 0^{\circ}, \Delta = 0 \\ 60^{\circ} \times \left(\frac{G'-B'}{\Delta} mod6\right), C_{max} = R' \\ 60^{\circ} \times \left(\frac{B'-R'}{\Delta} + 2\right), C_{max} = G' \\ 60^{\circ} \times \left(\frac{R'-G'}{\Delta} + 4\right), C_{max} = B' \end{cases} \text{--------(11)}$$

Saturation Value:

$$S = \begin{cases} 0^{\circ}, \Delta = 0 \\ \frac{\Delta}{1-|2L-1|}, \Delta \neq 0 \end{cases} \text{--------- (12)}$$

Luminance Calculation:

$$L = (C_{max} - C_{min})/2 \text{---------- (13)}$$

With the contouring and edge detection algorithm, classification of each shape is categorized. Normally two important aspects related to the shape analysis is done which includes:

- Edge detection
- Pixel Counting
- Dimension Calculation

STEP 1:Edge Detection

It is the process of identifying edges in an image which is to be used as a fundamental asset in image analysis along with locating areas with strong intensity contrasts and extracting the following important feature of an image:

- Corners
- Lines
- Curves

The Laplace operator is a differential operator given by the divergence of the gradient of a function on Euclidean space. The Euclidean space specifies a void which is equalized with a processed image here[9].This approach to segmentation groups of pixels or subregions into larger regions is based on predefined criteria. A set of points is selected based on the acquired shape like pixels in a specific grayscale range. Then the regions are selected from these pixels to neighbouring pixels according to a region membership criterion like pixel intensity or colour or grayscale texture[10].The detection of curve in the object along with deviation of straight line is shown in figure

4. Laplacian operator of an image f(x,y) is defined as

$$\nabla^2 f(x,y)=\partial^2 f(x,y)/\partial x^2+\partial^2 f(x,y)/\partial y^2 \nabla^2 \quad \text{---------- (14)}$$

$$\partial^2 f(x,y)/\partial x^2=f(x+1,y)+f(x-1,y)-2f(x,y)\partial^2 \quad \text{---------- (15)}$$

$$\partial^2 f(x,y)/\partial y^2=f(x,y+1)+f(x,y-1)-2f(x,y)\partial^2 fxy\partial y^2 \quad \text{---- (16)}$$

$$\nabla^2 f(x,y)=[f(x+1,y)+f(x-1,y)+f(x,y+1)+f(x,y-1)]-4f(x,y) \quad \text{---------- (17)}$$

STEP 2: Pixel Counting and Dimension Calculation

The number of pixels which are encountered between the edges in the object are detected through the image information and are counted. The number of pixels obtained using this cam capturing algorithm the length of the image is fetched.

$$\text{Dimension in cm} = \left(\sqrt{\frac{A1}{A2}}\right) * D1 \text{---------- (18)}$$

A1 – Pixels covered by the camera
A2 – Area covered by the camera
D1 – Dimension in pixels

D. Dimension Analysis (Irregular)

From the processed segment of image, the curves are found with the angle of deviation from the actual line of straightened angular line segment present in the contoured image [11]**Error! Reference source not found.**. Then the coordinates are plotted where ever the angular deviation occurs. The detection of curve in the object along with deviation of straight line is shown in Figure 4. Figure 5 denotes the overall flow of 2D Cam Capture as discussed above.

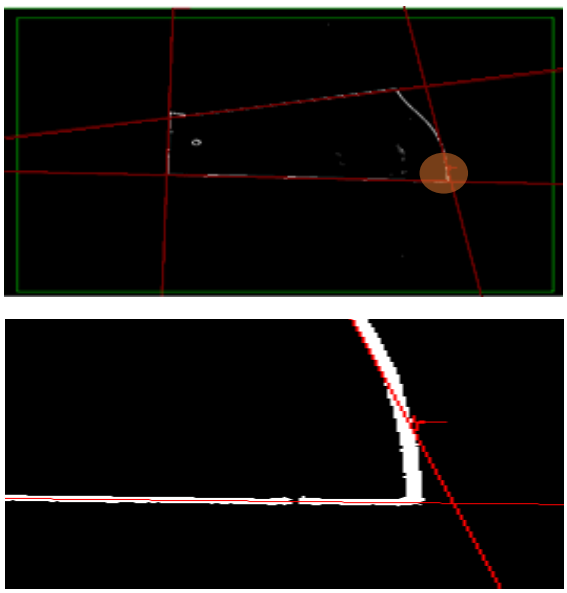

Figure 4. Curve Detection

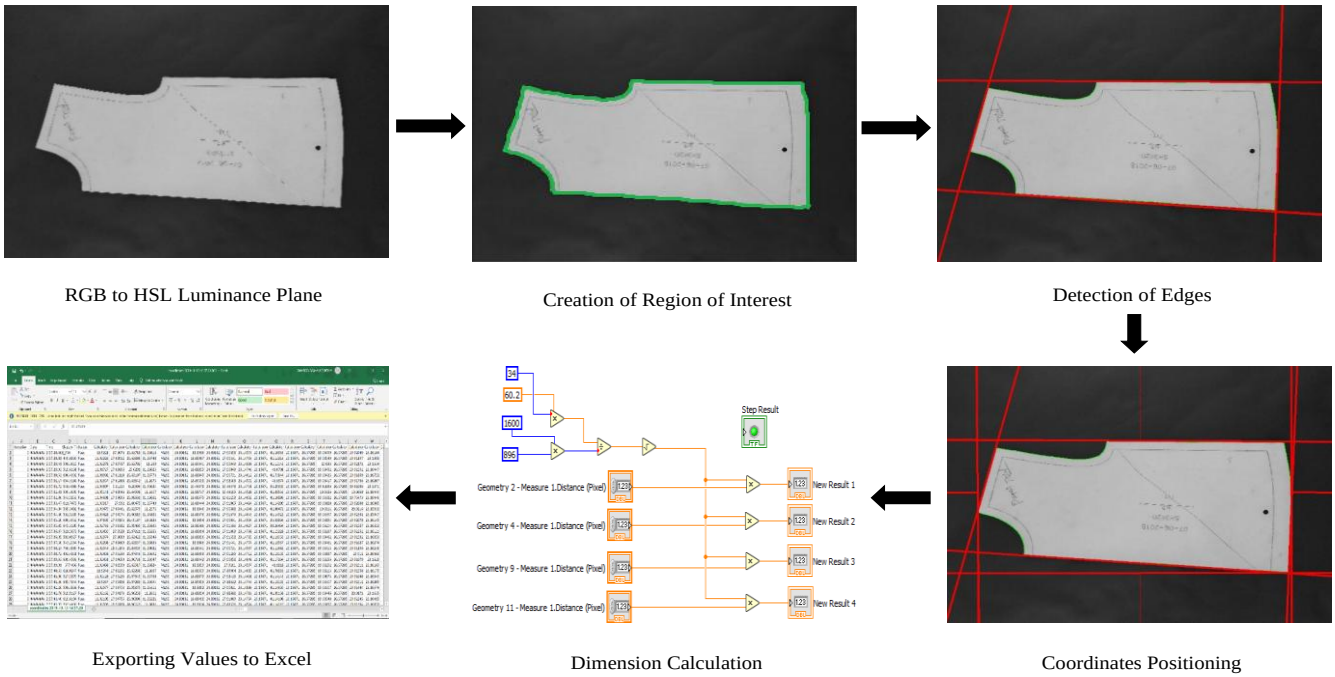

Figure 5.Result of Coordinates Along with Edges

III. RESULTS AND DISCUSSION

Results are obtained for both regular and irregular objects. The procedure for measuring the dimensions differ for regular and irregular shapes. Regular shapes have measurable dimensions whereas irregular shapes do not. Thus, for irregular shapes coordinates are marked and used for processing.

Table 1 shows the comparison of results of quadrilateral and Table 2 shows the comparison of error obtained in 2D Cam Capture and digitizer with actual measurement. (The lowest error value is highlighted).

Table 1. Comparison of Results of Quadrilateral

S.No	Manual Measurement				Results of 2D Cam Capture				Results of Digitizer			
	L1 (cm)	B1 (cm)	L2 (cm)	B2 (cm)	L1 (cm)	B1 (cm)	L2 (cm)	B2 (cm)	L1 (cm)	B1 (cm)	L2 (cm)	B2 (cm)
1	26.9	8	23	9.3	26.9	8.18	22.9	9.3	26.8	8.1	22.9	9.2
2	19.4	4.2	27	14	19.4	4.2	26.9	14	19.5	4.2	27.1	14.3
3	18.8	12.6	16.4	12.7	18.8	12.6	16.4	12.7	18.1	12.5	16.4	12.8
4	6.5	5.9	6.9	5	6.5	5.89	6.87	5	6.6	5.8	6.8	5.1
5	20.2	20.5	18	20.6	20.2	20.5	18.1	20.6	20.1	20.5	18.1	20.6

Table 2. Error Comparison of Quadrilateral

Error comparison between Manual and 2D Capture					Error comparison between Manual and Digitizer				
L1 (%)	B1 (%)	L2 (%)	B2 (%)	Gross Error (%)	L1 (%)	B1 (%)	L2 (%)	B2 (%)	Gross Error (%)
1.9	**0.2**	0.7	**0**	**0.7**	2.7	1.2	**0.4**	1	1.325
0.4	**0**	**0.3**	**1.6**	**0.575**	0.5	0	0.3	2.1	0.725
0.2	**0.4**	**0**	**0**	**0.15**	3.7	0.7	0	0.7	1.275
0.1	**0.1**	0.04	**0**	**0.06**	0.1	0.1	**0.1**	0.02	0.08
0	**0**	**0**	**0**	**0**	0.4	0	0.5	0	0.225

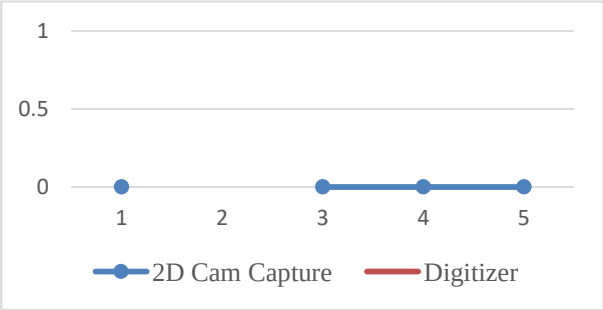

Figure 6 Error Comparison - Quadrilateral

The comparison chart depicting the error values between the dimensions of quadrilateral shape is shown in Figure 6. It is clear that the error value of 2D Cam Capture is very minimum compared to the digitizer.

The comparison between the results computed manually and the results obtained using 2DCam Capture algorithm is shown below. Table 3 shows the comparison of results obtained for a quadrilateral. Similarly, Table 4 shows the error comparison between the results obtained. (The lowest error value is highlighted)

Table 3. Comparison of Results of Circle

S.No.	Manual Measurement Radius (cm)	Results of 2D Cam Capture Radius (cm)	Results of Digitizer Radius (cm)
1	6.9	6.91	6.8
2	1.45	1.48	1.5
3	8	8.18	7.9
4	6.5	6.5	6.4
5	2.2	2.23	2.4

Table 4. Error Comparison of Circle

S.NO.	Error comparison between Manual and 2D Cam Capture (%)	Error comparison between Manual and Digitizer (%)
1	**0.1**	1.4
2	**2**	3.4
3	**2.2**	1.2
4	**0**	1.5
5	1.3	**0**

Similar to quadrilateral shapes the comparison chart depicting the error values between the dimensions of quadrilateral shape is shown in Figure 7. The error value of 2D Cam Capture is very minimum compared to the digitizer as that of quadrilateral shown in Figure 6.

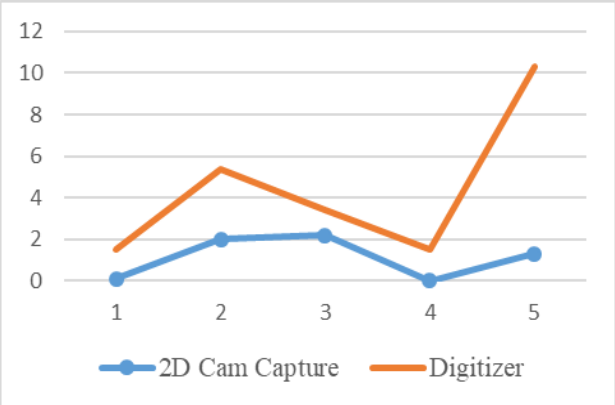

Figure 7. Error Comparison – Circle

The results for irregular shapes differ a bit compared to that of irregular shapes. The irregular shapes may have curves in it. In such cases proper dimensions cannot be given because the curve does not have any specified dimension. Thus, for such kind of objects the coordinates are extracted and using the obtained coordinates further processing can be done. Initially Table 5 shows the final output obtained (only four coordinates are shown)

The representation in the Table 5 is given as follows:

L1, L2 – Length of the object
B1, B2 – Breadth of the object
X1, X2, X3, X4 – X Coordinates
Y1, Y2, Y3, Y4 – Y Coordinates

The figure depicts the representation given in the Table 5.

Table 5. Result of coordinates along with edges

S.NO.	L1	L2	B1	B2	X1	Y1	X2	Y2	X3	Y3	X4	Y4
1	10.66	20.73	20.93	6.38	30.27	24.73	25.19	44.94	25.19	30.11	22.16	30.15
2	2.88	2.65	1.31	1.58	18.47	33.65	19.45	33.65	27.74	19.24	20.15	10.33
3	6.62	5.87	6.87	5.14	42.51	21.18	42.51	28.15	27.84	43.67	44.06	43.67
4	9.67	11.91	7.77	10.98	24.39	28.55	51.11	28.55	38.97	18.15	38.97	29.11
5	12.04	27.44	26.08	11.29	30.27	24.73	25.19	44.94	25.19	30.11	22.16	30.11

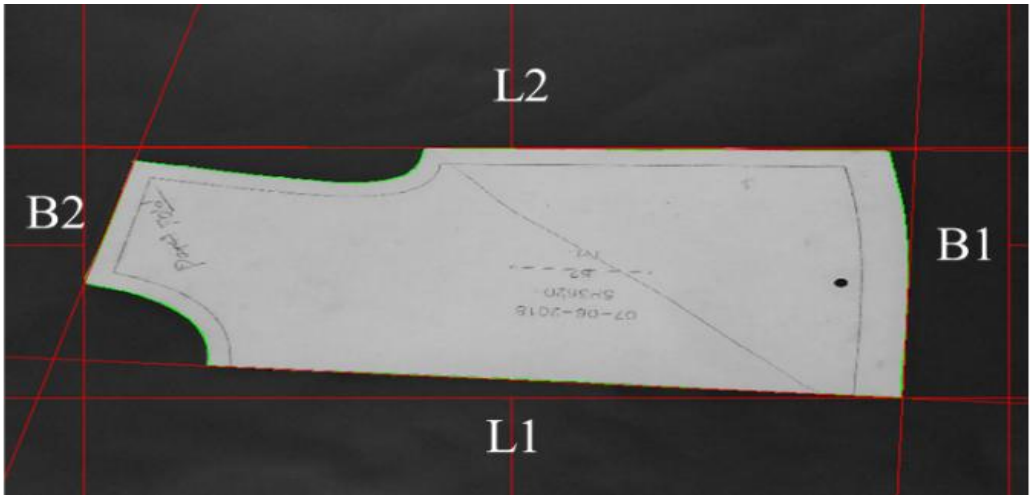

Figure 8. Image of Irregular Objects

IV. CONCLUSION AND FUTURE SCOPE

It is clearly shown in the results that the conventional manual measurement process and digitizing tablets are to be replaced with the innovative method, 2D Cam Capture.The proposed work eases the entire process with minimum time consumption and increased accuracy.

This method is tested against square, circle, rectangle, triangle and irregular shapes.

The irregular shapes are given by the experts in the field of textile industry.The 2D Cam Capture provides an accuracy of **98.6%** obtained from **1200** readings with **245 samples.** It produces results at the minimum rate of **189.90 ms** per iteration where other measurement techniques take hours (varies based on different patterns), consecutively which increases the production rate in the textile industries. It is made cost-effective by using a web camera and a suitable lighting arrangement which ease the process of capturing multi shapes without any shape distortion. To increase the accuracy, high resolution camera need to be utilized for image acquisition. In the future, the proposed system can be further developed to 3D models and also to identify other details of the given object.

ACKNOWLEGEMENT

We would like to express our gratitude towards Mr.L.B.Thiyagarajan, Proprietor, ESSDi Infotech Corporation for sharing the problem ideology prevailing in the Garment and Textile industry.

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