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ESTIMATING HUMAN BODY MEASUREMENT FROM 2D IMAGES USING COMPUTER VISION

[1]Daud Ibrahim Dewan , [2]Bikal Chapain, [3]Manishankar Prasad Jaiswal
[1]Dr. Sandeep kumar
[1] Department of Computer Science,
[1]Tula's Institute ,Dehradun, India.

Abstract : At the present scenario we cannot even imagine our daily life style without online means. Specially due to covid-19 we are inclined towards online shopping. People are preferring online means for every needs. But there are some sectors that are not getting as much attention as comparison to others. One of them is shirting and suiting/tailoring. Due to some limitation and requirement, this sector is being lagging behind. Proper measurement of the body of the customer is the major issue. Most of the research have been made on body measurement with 3D pictures using in depth camera. Practically it seems difficult to capture the images by every customer using in depth camera. so, we have purposed a model that uses 2D images for measuring the body measurement so that we can deliver the proper size shirting and suiting products.

IndexTerms **- Computer vision, edge detection, pose detection,**

I. INTRODUCTION

As we all know shopping is done for the fulfillment of the needs and requirement. Shopping online is the process of buying goods or getting services without visiting the supplier or service provider physically. when it comes under clothing, the main requirement is proper fitting of the clothes in the body. Building trust is one of the major issue in online shopping. Customer satisfaction and the requirement fulfillment is the key to success for online business. Most of the customer prefer online mode rather than visiting the shops physically. Due to the dependency on internet and communication people prefer online means for easy and fast services. Physical goods like books, gadgets, furniture, and appliances are can be ordered online but goods related to fashion like clothes need proper measurement and fitting. According to the recent study about 18% of the order are returned due to some reason. Clothing items occupies a huge percentage of around 70%. It is quite easier to estimate the size in readymade clothes but when we talk about tailoring we should know the precise measurement of the body. It is not possible for every customer to measure their body with measuring tape remotely. They even sometimes may not know what body measurement should I send for sewing which item. It is more complex in context of shirting and suiting. Business related to product like books, gadgets, furniture, and appliances are easy to do online. But there is some business that need a bit technical improvement to shift their business on online mode. yes, we are talking about the shirting and suiting. we should get the proper body measurement of the customer to provide the best fitting clothes. As I already mentioned that most of the research paper are based on 3D pictures. Some of the research have been done using 2D images but most of these research has focused only on upper body part. But in this research we are trying to get the full measurement of the body that is both upper and lower part.

This research has proposed a model by which we will be able to find the measurement of the body parts like length of the arm, shoulder, chest, stomach, waist, hips, length of legs, with the help of the 2D images. This model is web based application where the user can upload his/her images.

II. RELATED WORK

Only few of the researchers have shown their interest in measuring body measurement virtually/remotely using 2D images. Most of the research are based on 3D model and images from in depth camera. We are discussing some of the research done using 3D images and 2D images.Chang, et al. [1] has purposed a model of dynamic fitting room which utilize Microsoft Kinect and technology like augmented reality to allow the customer to visualize themselves in different clothing using real-time images. Here we are mainly focused on remote virtual measurement so the sophisticated hardware is not applicable. [2]They

have developed a model that can learn from examples to recognize indoor persons images. Different combination of support vector machine(SVM) is used to handle the recognition process. Shape and color based features is used to represent full body image of the person. This system works in real time. It has also strengthened the SVM based classifier to improve generalization and run time performance. (prosedia)Mojarrad & Kargar [3] has purposed a study that takes various images of people and process the image for estimating the size, measuring the body and finding the property of the body like: tall fat, short fat, tall thin, short thin using image segmentation, image registration, and object detection. They have only focused on upper body part which will not be sufficient for tailoring purpose. In this paper [4] they purposed an approach for body shape analysis using 2D images. For calculating the body parts, pixel number have been used. 2D pictorial information is the key information where the measurement is done by using the pixel value to find the measurement. Here [5] the size for T-shirt detection is done by assuming some condition: the sample must be in standing position with five segments i.e two hands, two legs and torso. They also used canny edge detection. The main important step is body measurement in garments or tailoring filed and to take measurement different methods are published. Among this method. Among all these method,[8,9] involves measurement, pattern making and sewing.Due to grow in technology , now a days body measurement can be done automatically and these are classified into several category including light laser,millimeter waves, modeling and image processing based system[[10, 11, 12, 14, 15, 17].In laser based technology,the body is exposed to laser beam so that reflection can be capture more that camera. A special software is required to control the beam of laser and timing and due to this reason this system is more expensive. The main problem of this method is that unintentional movements of body create noises [9, 12, 13, 14, 15, 16].

III. METHODOLOGY

For the determination of the human body measurement from the image provided, we complete definite steps. first of all, we need to detect the human body from given picture. The pictures provided will be 2D image taken from smartphone. After determining the human body from the picture we extract key points. In this purposed model we have classified the body measurement into two classes i) linear measurement

ii) circular measurement.

with the help of extracted key point, we were able to measure arm length, upper body length (for shirt), lower body length (for paint) and shoulder. As these measurements can be calculated by joint/key points, we placed these measurements in leaner measurement class. whereas measurement like chest, waist, thigh and heap cannot be calculated only with the help of key points as they need extra factor that is edge of the body so, we kept these measurements on circular measurement class. In these purposed model we applied different methods for each classes.

For the linear measurement we used pose estimation method. pose estimation is a computer vision technique which is used to predict the configuration of the body from an image. Human pose estimation localized body key points to accurately recognize the posture of the individual in the given picture. It includes two basic steps:

1. localizing human body joints/key points
2. grouping those points into valid human pose configuration

3.1 Linear measurement

For the linear measurement we used pose estimation method. pose estimation is a computer vision technique which is used to predict the configuration of the body from an image. Human pose estimation localized body key points to accurately recognize the posture of the individual in the given picture. It includes two basic steps

3. localizing human body joints/key points
4. grouping those points into valid human pose configuration

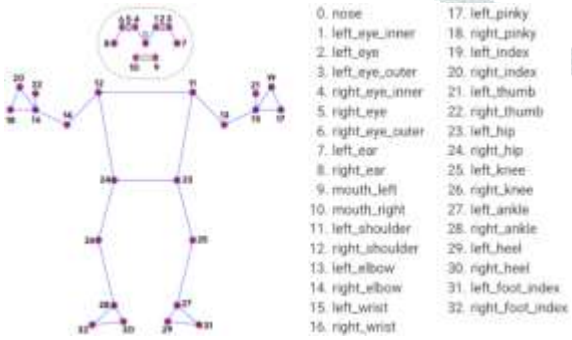

Fig.1Mediapipe pose detection with key/jointpoints.(https://google.github.io/mediapipe/images/mobile/pose_tracking full_body_landmarks.png)

Fig.2 Pose detection on sample input

In the first step the main focus is finding the key points of human beings example head, shoulder, arms, hand, knee and ankle. It then makes grouping of these joints into valid human pose configuration. With the help of the exact joints points we calculate the linear body measurement.

with the interest and advancement in the AI field some datasets have been released in these last years which ease the researchers to solve some real life problems with all their intellectual might. Some of the datasets are:

i) MPII human pose dataset

ii) coco key points dataset
iii) Media pipe

First we used pre-trained MPII human pose dataset to localize the key points of human body. During analyzing the key points obtained from MPII model we observed that some of the points were absent in most of the images. so, we were not able to continue with the less accuracy model.

Fig.3 Pose detection with MPII

Fig.4 Pose detection with Mediapipe

Then we tried coco key points model but the same problem was encountered. Then we use media pipe framework. With the use of media pipe framework we were then able to get the precise output.
This model detects the pose of the person in the image and draw all landmark points in the pose. Among the 33 points provided by the Media pipe we have used 13 points for this research. Description of the points are below:

0.Nose 12. Right shoulder 11. Left shoulder 14. Right elbow 16. Right wrist
23. Left hip 24. Right hip 26. Right knee 28. Right ankle

3.1.1 Image processing

Image preprocessing: For every accurate output the input should be presided. Here the data is image which may include complexity, inaccuracy and inadequacy due to this reason image preprocessing is essential to achieve high accuracy and desired result. First we converted the input image into grayscale and then resize into a fixed size (368*716).

3.1.2 Calculating the ratio(R)

As we mentioned above we had used mediapipe for the extracting key/joints point. After extracting the key/joints points we calculate ratio(R)
R = ratio that defines distance in centimeter(cm) in 1 pixel which is calculated as:
R=H/L where H= actual height of person-------(i)
L= length calculated between point 0 and point 28

In most of the research papers we found that [6] the researchers use the standard pixel ratio i.e 1pixel=0.02645cm. But the images provided may be of different dimension and taken from different distance which leads to in accuracy in results. So we calculated a ratio that provide how many cms are present in 1pixel in each images provided.
Finding the value of R. R = H/L
H=163cm(Provide height, differs to every person)
L=?
For L we have to calculate the distance between the two key points present in image. For that we have taken key(0) and key (28).
Co-ordinate of key(0) and key(28) obtained from image.
Distance(L)=$\sqrt{((X_2 - X_1)^2 + (Y_2 - Y_1)^2)}$
R=H/L in cm

3.1.2 Training dataset for linear measurement

Data set plays a vital role for the precise performance of the machine learning model. To build the robust model we took the data set that consists of individual's images along with their body measurement. In this research, we need a dataset that contains human body images and basic measurements for each body. All 21 Participants in the dataset are volunteers of gender male who are over the age of 12. The average male weight ranges between 45 and 98.5 kg and the length range between 5ft to 5.8ft We took the body's measurements of the participants manually using a measuring tape. For linear measurement we took measurement like length of Arm, Shirt length, Pant length and Shoulder. Participants were photographed in the different place concerning that the background should be plain. And the appeal of the participate should be in plain fabric We took the photos of volunteer in different light condition. Images were taken using smartphones because they are most widely used and easily available and can be afforded by everyone. The device used is Realme 7 pro with Android platform which has resolution of 1080 x 2400 pixels

Lenear Body measurement												
Actual Height	Shirt length			Arm length			Shoulder			Pant Length		
	Actual	Generated	Error(Actual-Generated)	Actual	Generated	Error	Actual	Generated	Error	Actual	Generated	Error
154	65	56.4	8.6	55	53.76	1.24	38	37.26	0.74	80	75.28	4.72
160	70	59.22	10.78	60	58.32	1.68	40	30.8	9.2	88	76.84	11.16
154	68	61.23	6.77	60	59.74	0.26	39	32.47	6.53	83	76.98	6.02
163	70	63.54	6.46	63	55.87	7.13	45	39.67	5.33	87	82.88	4.12
164	76	68.98	7.02	63	57.78	5.22	43	37.89	5.11	90	88.98	1.02
158	66	60.67	5.33	59	54.67	4.33	40	32.78	7.22	86	82.02	3.98
170	79	72.87	6.13	68	64.89	3.11	44	39.87	4.13	96	89.98	6.02
175	81	69.67	11.33	70	62.78	7.22	47	38.78	8.22	99	94.94	4.06
153	67	58.78	8.22	58	57.87	0.13	39	33.98	5.02	82	75.98	6.02
162	71	60.87	10.13	61	57.65	3.35	41	35.98	5.02	90	78.98	11.02
175	81	68.56	12.44	69	61.67	7.33	45	36.87	8.13	96	91.65	4.35
153	63	54.8	8.2	53	51.77	1.23	37	31.76	5.24	78	72.88	5.12
165	76	69.56	6.44	64	56.44	7.56	44	36.33	7.67	91	84.87	6.13
174	79	74.23	4.77	68	63.45	4.55	45	39.67	5.33	96	90.43	5.57
166	75	71.56	3.44	64	59.98	4.02	45	36.67	8.33	88	83.77	4.23
164	75	66.47	8.53	63	58.98	4.02	38	34.76	3.24	89	81.98	7.02
163	69	55.87	13.13	60	55.87	4.13	46	35.89	10.11	87	80.98	6.02
155	65	53.87	11.13	55	49.87	5.13	39	35.76	3.24	79	76.09	2.91
167	73	66.87	6.13	66	57.98	8.02	47	43.98	3.02	91	86.98	4.02
170	79	75.98	3.02	67	65.98	1.02	44	40.01	3.99	97	90.99	6.01
159	67	59.87	7.13	59	54.67	4.33	40	32.78	7.22	86	82.02	3.98
			7.863333333			4.048095			5.811429			5.404762

Table 1. Training data set for linear measurement to estimate the value of k

This training part is for finding the average of actual loss of the measurement that is k factor.

k=[$\sum_1^n(Actual - Generated)$]/n----------(ii)

where k=factor

Actual = Actual measurement of the volunteers

Generated= Generated measurement

To estimate the value of k, we generated the measurement from each images using Following equation:

Generated value = [{dist(A, B)}*R]

where A and B are key points/joint points.

Then we differentiate the actual length and generated length. The average of the generated Differences say loss now become the K factor. From the above table we observed different loss rate to different body parts so the value of k also differs with the different part which are mentioned below.

k1=Shirt length= 7.86

k2=Arm length=4.04

k3=Shoulder length=5.81

k4=Pant length=5.40

The value of k may differ according to the number of training dataset. More the training dataset more will be the accuracy. Due to limitation of resources we were not able to collect more training dataset. But in future we can increase the accuracy of this model simply by adding the training data set.

Final expression for finding the linear measurement:

measure = [{dist (A, B)}*R]+K_n----------(iii)

shirt length = [{dist(point12, point24)}*R]+K_1

Arm length = [{dist(point12, point16)}*R]+K_2

shoulder length = [{dist(point12, point11)}*R]+K_3

Pant length = [{dist(point24, point28)}*R]+K_4

3.2 Circular measurement

For the circular measurement we had implemented some further steps to achieve the high accuracy. For measuring circular measurement of body parts like: waist, hip, thigh. Through the human pose detection, we already knew the joint points but these points only are not sufficient for measuring the circular measurement. To measure the circular measurement, we needed the edge of the side of body. For this we have implemented the edge detection method. After analyzing most of the training images we obtained that size of images impacts the whole body measurement. So after, many hit and trial method we find closest dimension pattern. we divide it into two category such that if the width of the image is greater than 1500 px than it will be resized into

230px width whereas if the width of the image is less than 1500 px it will be resized into 330px keeping height of the image 718px for both.

3.2.1 Edge detection

Edge detection in an image processing is the technique to find the boundaries of the selected image. with the help of the edge detection we observed more accurate measurement in circular body part like stomach. For the edge detection we have used canny edge detection. By using the canny edge detection, the presence of Gaussian filter in algorithm remove any noise in the image.

With the help of edge detection, we obtained all the edges present in the image as shown in figure(Fig.5). For the measurements, edges only are not sufficient because we need exact coordinate of required edges from all the edges. For finding the position of the required parts edge, most of the researcher used different approach. In [6] researcher divide the whole body into 40 segments and observed in different dataset set. After analyzing all the data set manually, they conclude that the left focal point lies in between 11 and 16 and right focal point lies in between line 28 and 24. In our opinion this method will not be precise as the picture cannot be always taken from same distance and analyzing the raw lines will not result the exact focal points.

so, to resolve all the limitation and to obtain precise result we implement the method where we had use key/joints point and edges to find the exact coordinate of the required body parts which are essential for circular body measurement. This method can be achieved in the following ways.

Fig.5 Edge detection

3.2.2 Training dataset for Linear measurement

Circular Measurement											
Upper waist			Lower waist			Chest			Heap		
Actual	Generated	Error	Actual	Generated	Error	Actual	Generated	Error	Actual	Generated	Error
77	95.18	18.18	84	96.58	12.58	87	95.18	8.18	90	114.78	24.78
89	106.15	17.15	93	113.8	20.8	102	106.15	4.15	97	111.64	14.64
92	109.67	17.67	97	116.32	19.32	98	102.34	4.34	92	109.23	17.23
81	92.97	11.97	87	98.32	11.32	93	98.21	5.21	96	116.74	20.74
86	98.78	12.78	92	105.32	13.32	99	109.21	10.21	102	123.23	21.23
79	98.34	19.34	86	98.32	12.32	89	95.32	6.32	95	117.12	22.12
75	84.88	9.88	83	96.32	13.32	84	96.32	12.32	92	110.34	18.34
71	88.98	17.98	74	83.87	9.87	83	88.32	5.32	91	102.24	11.24
86	97.43	11.43	85	98.32	13.32	90	96.34	6.34	94	116.34	22.34
93	102.23	9.23	86	97.32	11.32	92	98.34	6.34	92	108.87	16.87
83	93.43	10.43	86	99.23	13.23	88	97.34	9.34	91	104.45	13.45
72	79.44	7.44	74	88.23	14.23	85	93.34	8.34	93	111.46	18.46
93	106.23	13.23	98	109.23	11.23	99	104.23	5.23	93	110.97	17.97
80	99.23	19.23	88	103.22	15.22	89	94.32	5.32	96	118.56	22.56
87	98.23	11.23	84	97.23	13.23	89	95.98	6.98	97	116.67	19.67
90	98.23	8.23	95	108.23	13.23	99	106.23	7.23	94	118.23	24.23
76	96.87	20.87	86	98.2	12.2	88	98.23	10.23	94	115.34	21.34
		13.89824			13.53294			7.141176			19.24765

Table 2. Training data set for Circular measurement to estimate the value of k

3.2.3 Calculating the upper body waist and lower body waist

Fig.6 Center point

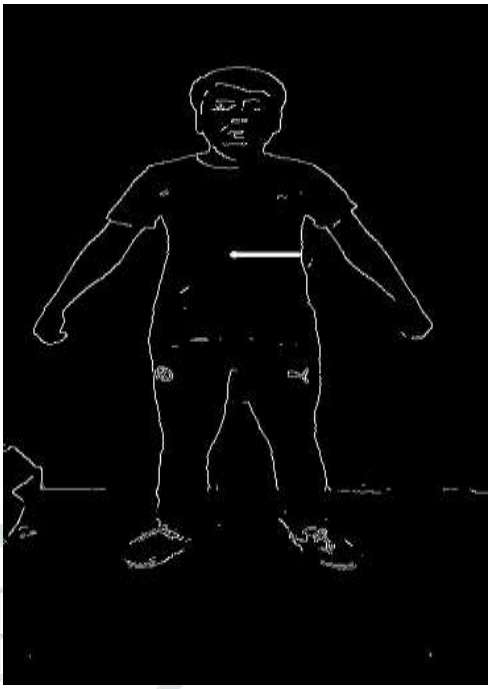

Fig.7 Line from center to desired edge.

For obtaining the exact coordinate on the edge of the body, first we find the center point inside the trapezium formed by key/joints detection say ABCD. For that, first we calculated the midpoint of line AB and line CD

After calculating the midpoint of both line(AB and CD) again we calculated the mid points[x,y] of line(EF), which is denoted by blue circle in the [figure.6].

After calculating the reference point [x,y] we, then move the point towards the x-coordinate of the center value until the y-coordinate is matched with the y-coordinate of the points of the edge. Which forms a straight line between the center [x,y] and co-ordinate[a,b] of the edge.

let the distance between [x,y] and [a,b] be X.

We than calculated the length using expression πx. Observing the calculated length and actual length ,we found that the calculated length is nearly close with actual length so, we use expression πx. Then we calculated the error in the generated measurement comparing with the actual measurement. After calculating the average Error (k) the final expression will be:

body waist= $\pi x*R - k_n$--------eq(ix)

Upper body waist=$\pi x*R - K_5$--------eq(x)

Lower body waist = $\pi x*R - K_6$--------eq(xi)

3.2.3 Calculating the chest

let the distance between the point A and B be x.

with the help of the eq--(i) we find the linear distance between these point.

X=x*R

After applying formula:

$2\pi X$ we got the closest value of the actual waist. Then we calculated the generated value and compare the actual value of the volunteer with the help of which we find the error factor K.

K=generated - actual

Final expression for calculating Chest measurement:

$2\pi X-K_7$-------eq(xii) where is average error factor for chest

3.2.4 Calculating the heap

To calculate heap we took joint/points 24 and 23[Fig.1] (C,D) [Fig.6] .As before, first we calculated the distance between these points with distance formula. We performed the same calculation as in **III.2.2.** using the same formula.

Then we observed the generated value and actual value and find the error factor (k) for heap.

Final expression to calculate heap:

$2\pi X-K_8$-------eq(xiii) where K is average error factor for chest

IV. RESULT AND ANALYSIS

Measuements										
	Sample1			Sample2			Sample3			RMSE
	Original	System Generated	Residuals(Error)	Original	System Generated	Residuals(Error)	Original	System Generated	Residuals(Error)	
Shirt length	65	64.27	0.73	70	67.08	2.92	68	69.09	-1.09	3.4158
Chest	87	88.04	-1.04	90	89.2	0.8	102	99.01	2.99	3.5539
Upper waist	77	81.29	-4.29	89	92.26	-3.26	89	92.26	-3.26	13.21977
Shoulder	38	43.07	-5.07	40	36.62	3.38	39	38.28	0.72	12.54923
Armlenght	55	57.8	-2.8	60	62.36	-2.36	60	62.76	-2.76	7.009067
Pant length	80	80.65	-0.65	88	84.67	3.33	83	82.38	0.62	3.965267
Lower Waist	84	83.05	0.95	93	96.34	-3.34	93	98.34	-5.34	13.52457
Heap	90	91.65	-1.65	97	92.4	4.6	95	92.4	2.6	10.21417

Table 3. Comparison of actual and predicted measurement with their RMSE values.(cms)

Here we present the results of the Comparison of actual and predicted measurement. We did not find any preexisting dataset so, we made our own data set. We have total 21 volunteer. We applied different algorithm to find the different body measurement. We have applied two different measuring model i) linear measurement ii) and circular measurement. Inside circular measurement we have applied different equations to different body parts. It is not a 100% accurate model so that, we have defined the value of error factor for each measurement class, so that after finding the average error rate we can add that error (either +ve or -ve) to the generated output. In future if we require more accurate results than we can increase the accuracy simply by increasing the sample data so that the value of k becomes more precise. Above table shows the Original measurement and generated measurement of three sample images. Due to the difference of picture dimension and distance form camera, the result is not accurate. If we want to increase the accuracy, we can also define the dimension of the image and applied special condition to maintain predefined distance from the camera. In the tailoring measurement we can consider the minimum cms difference. Here if we consider (+-)2 as the considerable measurement then we obtained 81.47% of accuracy in linear measurement. In comparison with the linear measurements the accuracy percentage of circular measurement is a bit low. The accuracy percentage of circular measurement we obtained is 72.18%.

Using root mean square error method(RMSE) we calculated deviation value between the system output and actual length. It measures how much error is there between two data set. SRMS is calculated using following equation.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (O_i - P_i)^2}{n}}$$

Here,
O = Original value
P = Predicted value of our system
n = Total number of sample data

Fig 8 Bar Graph

V. CONCLUSION

In this research, we proposed a model that targets to improve the approach of Tailoring industries in online sector. This experiment is conducted on a sample dataset where the measurement of the volunteer and the images are taken manually. To implement this research, we have used a pre trained pose detection algorithm to detect the joints/key on the body. We also have used edge detection algorithm finding the edges of the body. with the help of joint/key detection we calculated the linear measurement. With the help of both joints/key detection and edge detection we calculated the circular measurement. In comparison of linear measurement and circular measurement the accuracy of linear measurement is quite good. Due to the limitation of the resources we were not able to collect sufficient data. But we can increase the accuracy of this model by increasing the number in dataset so that the error factor in every measurement will be more precise.

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