

# International Journal of Engineering Research and Science & Technology



ISSN : 2319-5991

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## USING ARTIFICIAL INTELLIGENCE TO TAKE BODY MEASUREMENTS AND EXTRACT CLOTHING PATTERNS

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### Article Info

Received: 04-01-2023 Revised: 06-02-2023 Accepted: 18-03-2023

### ABSTRACT

Technology and artificial intelligence have been widely used in many fields because of their advantages such as increasing production, saving time, effort and money, beside increasing the accuracy. This study presents the use of artificial intelligence represented by (OpenCv) technology and (Python) language in designing an (E-tailor) program to extract body measurements by entering the length of the body and taking two front and side images of it, and then taking these measurements and converting them by applying (Dfx2 code) to (G-code) and then draw a digital diagram of the pattern. The results of using the (E-tailor) program to extract the measurements of a number of people with different lengths and sizes showed that the program extracted the measurements effectively comparing to manual measurements and it was possible to convert them into a digital pattern. It was found that the (E-tailor) program has the ability to extract body measurements effectively, with a high accuracy and it was possible to convert them into a digital pattern. Therefore, it is recommended to try the program and introduce it on a large scale in the field of clothing industry.

**Keywords:** Artificial intelligence, Human Body Measurements, digital pattern, Garment industry.

### 1. Introduction:

With the continuous technological progress and the rapid development of the

technologies used in the ready-made garment industry, it was necessary to take advantage of this technological

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development to serve two important and essential stages in the ready-made garment industry; It is the stage of taking measurements for the body, and the stage of designing the pattern, which is a basic building block for the design stages, as the pattern is the template through which parts of the garment are traced on fabrics before cutting and assembling (wikipedia 2022). The design of the pattern depends mainly on taking accurate measurements of the body, while international companies and fashion houses compete with each other to gain the trust of customers by producing high-quality clothing products that suit their sizes and bodies, and there is no doubt that consumers always seek those who achieve the highest levels of satisfaction with clothes, And these goals can only be achieved through the production of clothes of accurate sizes that provide comfort in wearing and the appropriate shape, and hence research in this scope comes decisively and important to contribute to achieving those goals. The manufacturing system of the modern garment industry reacts in a short time to frequent changes (fashion trends, customer requirements, quantities, fabrics, etc.), the apparel industry is labor intensive and energy intensive. Because of the special nature of the garment industry, the methods of ensuring efficiency are of great importance (Gries & Lutz, 2018).

Body measurements refer to measuring the actual person (or people) who will wear a garment. These are different from garment measurements and can be taken manually or purchased from different body data services (Nayak, Nguyen, Panwar, George, & Ulhaq, 2020), As the traditional method of body

measurement takes a long time, and there are chances of human error, in addition to inaccurate measurements (George, 2020), Also, the person who takes measurements in the traditional way faces difficulties and difficulties in taking measurements frequently, as he is forced to stand, sit, bend and turn around in order to take measurements, which is physically exhausting and takes a long time (Bititci, Garengo, Dörfler, & Nudurupati, 2012). Also, the process of taking manual measurements may include touching the body of the person to take measurements and this may cause some embarrassment, especially when the sexes differ.

The traditional method of taking body measurements for tailoring involves having a tailor measure a person's body with a measuring tape, and the manual method of taking body measurements does not provide accurate readings of the various measurements of the body (Krause, Hinke, Perryman, Goebel, & LeRoi, 2017), which negatively and directly affects model building, and this method is also time consuming and can be inaccurate It depends on the skill of the tailor. In addition, people with disabilities may be difficult to measure, as they may not be able to stand in the same

position as a non-disabled person, hence this project highlights the use of artificial intelligence in extracting and analyzing body measurements and then extracting pattern sizes based on It can be relied upon quickly and efficiently in the future in building a new system that helps in developing local standards for different body sizes in the future.

## 2. Leterure Review :

Bol et al [6], use software tools were developed to automate data collection, analyze the collected data, and improve interpretation of the results, and then an innovative study was initiated to evaluate the potential application of this technology to measure animal body shapes. A preliminary study was carried out, including the development and testing of a modified laser scanning platform that can measure 3D shapes (including a life-size animal model) and evaluation of the accuracy achieved, the results enabled the determination of the best positioning and optimal setup of the laser measurement system for shape determination/ irregular size, creating a set of measurements that can be compared with the actual sizes of scanned objects.

Wang et al. [7], created a new predictive model for estimating body dimensions related to clothing style, based on artificial

neural networks (ANNs) of the radial basis function (RBF). Detailed body dimensions related to pattern making can be obtained by entering four easy-to-measure key dimensions.

Bartol et al. [8], investigated body measurement using 3D surface scanning techniques and found that it was faster and more convenient than measurement with traditional methods and at the same time provided more data that required automatic processing, and they described several 3D scanning methods and processing pipelines in their literature. Also, they show that over the past decade, larger public 3D human scan datasets have been released. The methods they describe in their literature are discussed within the newly proposed framework of five common processing stages: preparation, scanning, feature extraction, model fitting, and measurement extraction. Finally, they gave an overview of about 80 currently available 3D scanners made by about 50 companies.

Ruchay et al. [9], concluded that manually measuring animals is time-consuming, expensive, and cumbersome and that recent advances in 3D sensing technology provide innovative tools for designing automated, contactless systems for animal body condition assessment. So an automated

computer vision system capable of generating an accurate 3D model of live cattle was designed. Their system relies on reconstructing a non-rigid 3D shape using data from depth cameras.

Bansal and Garg [10], Using a regular webcam, they showed that the device could detect and recognize a person's face from a pre-stored database of faces, and provided a set of detection algorithms that could later be packaged into a file without difficulty in a portable framework between specific processor architectures.

### **3. The Objectives:**

- i.** Develop an AI-based system to take body measurements for tailoring purposes.
- ii.** Investigate the accuracy of the AI-based system compared to traditional method of body measurement.
- iii-** Investigate the capability of making pattern due to the extracted measure

### **4. Materials and Method :**

In this present, creating (E-tailor) application to extract body measurements via analysing camera pictures, beside extracting pattern layout all together through using the following tools:

#### **4.1 The Tools of Taking Measurements:**

High quality Camera (Webcam or phone camera).

#### **4.2 The Tools of Making The Application:**

##### **i. Python language for programing the application.**

The Python interpreter and the extensive standard library are available in source or binary form free of charge for all major platforms, and can be freely distributed (PythonTM, 2023).

##### **ii. OpenCV via computer :**

(Open Source Computer Vision Library) is an open source computer vision and machine learning software library. OpenCV was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in the commercial products. Being an Apache 2 licensed product, OpenCV makes it easy for businesses to utilize and modify the code.

The library has more than 2500 optimized algorithms, which includes a comprehensive set of both classic and state-of-the-art computer vision and machine learning algorithms. These algorithms can be used to detect and recognize faces, identify objects, classify human actions in videos, track camera movements, track moving objects, extract 3D models of objects, produce 3D point clouds from stereo cameras, stitch images together to produce a high resolution image of an entire scene, find similar images from an image database, remove red eyes

from images taken using flash, follow eye movements, recognize scenery and establish markers to overlay it with augmented reality (OpenCV team, 2023).

### **iii. measuring tape:**

for taking manual measurements and comparing it with the application extracted measurements.

## **4.3 The Tools of Making Pattern:**

### **i. Tailornova: for drawing personal pattern:**

Tailornova is a patent-pending online fashion design software that helps to create unlimited designs easier and faster than ever. Visualize your creations in 3D and get custom-fitted patterns in seconds (Wambui josphine, 2023).

### **ii. Dfx to g-code converter :**

This software (dxf2gcode) lets us convert a variety of two-dimensional drawings (2D) to a G-code that is compatible with many CNC machines (soft radar, 2019).

### **iii. G-code to CNC printer:**

Mach 3 CNC control software is a platform that turns most windows PCs into a CNC machine controller that manages the motions of motors and generators.

Through an importing process called LazyCam, Mach 3 CNC control software processes a CNC programming language called geometric code (G-code) that tells the

CNC machine what type of action to perform.

The third version of the software, the Mach 3 is reviewed as the most user-friendly and reliable — from DIY projects to industrial machining.

The field of mechatronics aims to produce a design solution to make more intelligent and streamlined system processes for difficult or time-consuming tasks.

## **4.4. The Methodology:**

### **4.4.1 Creating The (E-tailor )**

#### **Application:**

Open-cv technology had been used for creating (E-tailor) application which has been used for extracting body measurements via camera .

Open CV cannot directly measure body measurements. However, it can be used to detect body parts and then measure the distance between them. For example, Open CV can be used to detect the eyes, nose, and mouth of a person and then measure the distance between them to calculate the face width. Similarly, Open CV can be used to detect the shoulders, hips, and waist of a person and then measure the distance between them to calculate the body measurements.

### **4.4.2 Open CV Detect Joints:**

Open CV can detect joints using a technique called skeletonization. This technique involves thinning an image until only the lines representing the joints remain. This is done by applying a series of morphological operations to the image, such as erosion and dilation. Once the image has been thinned, the joints can be detected by finding the intersections of the lines.

#### 4.4.3 Get Distance Between Body Open CV:

#### 4.4.4 The Process of Deteting The Ditances:

To get the distance between two bodies in Open CV, you can use the `cv2.norm()` function. This function takes two points as input and returns the Euclidean distance between them. For example, if you have two points  $(x_1, y_1)$  and  $(x_2, y_2)$ , you can calculate the distance between them using the following code:

```
distance = cv2.norm(np. array(x1, y1), np.  
array(x2, y2)).
```

Detecting Body-Round on a Front Body Picture by OpenCv Technology Represented in Coloured Lines as show in figure 1.



**Fig 1 Detecting Body-Measurements Distances on a Front Body Picture by OpenCv Technology Represented in Coloured Lines.**

**Figure Error! No text of specified style in document.. Detecting Body-Round on a Front Body Picture by OpenCv Technology Represented in Coloured Lines.**

-The interpretation of the colourere-lines in figure1:

- a. **Yellow:** neck width.
- b. **Blue:** shoulder line.
- c. **Sky blue:** arm length.
- d. **Red:** waist girth.
- e. **Green:** hip girth.
- f. **Orange:** wrist girth.
- g. Vertical light green: Shoulder to feet.



**Figure Error! No text of specified style in document.. Detecting Body-Round on a Side Body Picture by OpenCv Technology Represented in Coloured Lines.**

Detecting Body-Round on a Side Body Picture by OpenCv Technology Represented in Coloured Lines as in figure 2.

-The interpretation of the colourered-lines in figure 2:

- a. **Blue:** Chest girth.



- b. Sky blue:** Arm length.
- c. Red:** Waist girth.
- d. Green:** Hip girth.
- e. Orange:** Wrist girth.
- f. Vertical light green:** Shoulder to feet.

#### 4.4.5 The Steps of Creating The Pattern:

- a. Create an Account:** To get started with Tailornova, you will need to create an account. You can do this by visiting the Tailornova website and clicking on the “Sign Up” button.
- b. Choose a Pattern:** Once you have created an account, you can choose from a variety of patterns available on the Tailornova website. You can also upload your own patterns if you have them.
- c. Customize Your Pattern:** Once you have chosen a pattern, you can customize it to your liking. You can adjust the size, shape, and other details of the pattern to make it unique.

- d. Generate the Pattern:** Once you have customized your pattern, you can generate it by clicking the “Generate” button. This will generate a PDF file of your pattern that you can print out and use.
- e. Cut and Sew:** Finally, you can cut out the pattern pieces and sew them together to create your garment.

#### 4.4.6 Converting Dfx File to Gcode:

- a-** Open the software and select the file you want to convert.
- b-** Select the output format you want to use.
- c-** Adjust the settings for the output file.
- d.** Click the “Convert” button to start the conversion process.
- e-** Once the conversion is complete as in figure3, you can save the output file to your computer.
- f-** Open the output file in your preferred CAM software to generate the gcode.



**Fig 3 The Process of Converting Distance-lines into Bulk-Sizes Through OpenCv Technology Within a Mediator Application .**

#### 4.4.7 Operating the CNC Machine to Cut the Garment Parts Due to Pattern Layout:

G-code is a programming language used to control CNC (Computer Numerical Control) machines. It is used to create instructions for the machine to follow, such as cutting, drilling, and milling.

##### The Steps :

1. Load the G-code file into the CNC

machine.

2. Set the machine parameters, such as the feed rate, spindle speed, and tool selection.

3. Check the G-code file for errors.

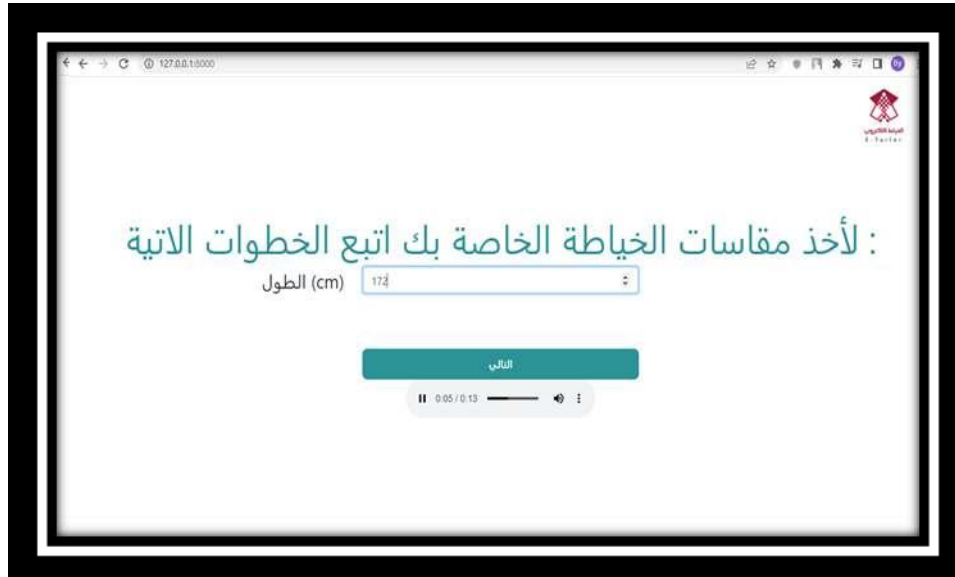
4. Start the machine and monitor the progress.

5. Stop the machine when the job is complete.

6. Unload the finished product.

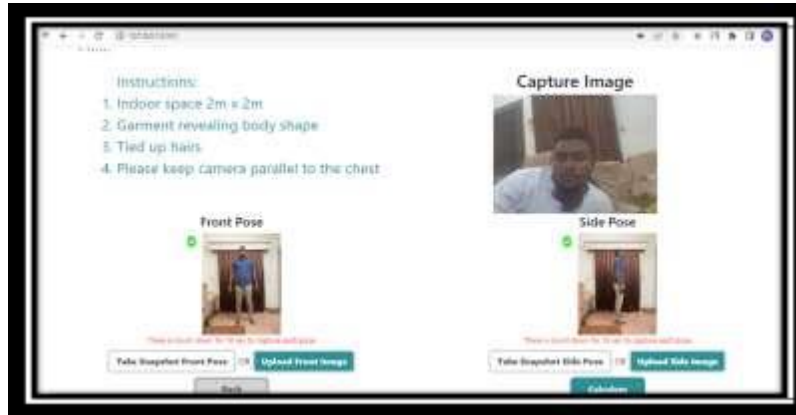
E-tailor WepApp application were created based on AI represented in OpenCv technology fun

ctioned and extracted measuremnts as the following steps :



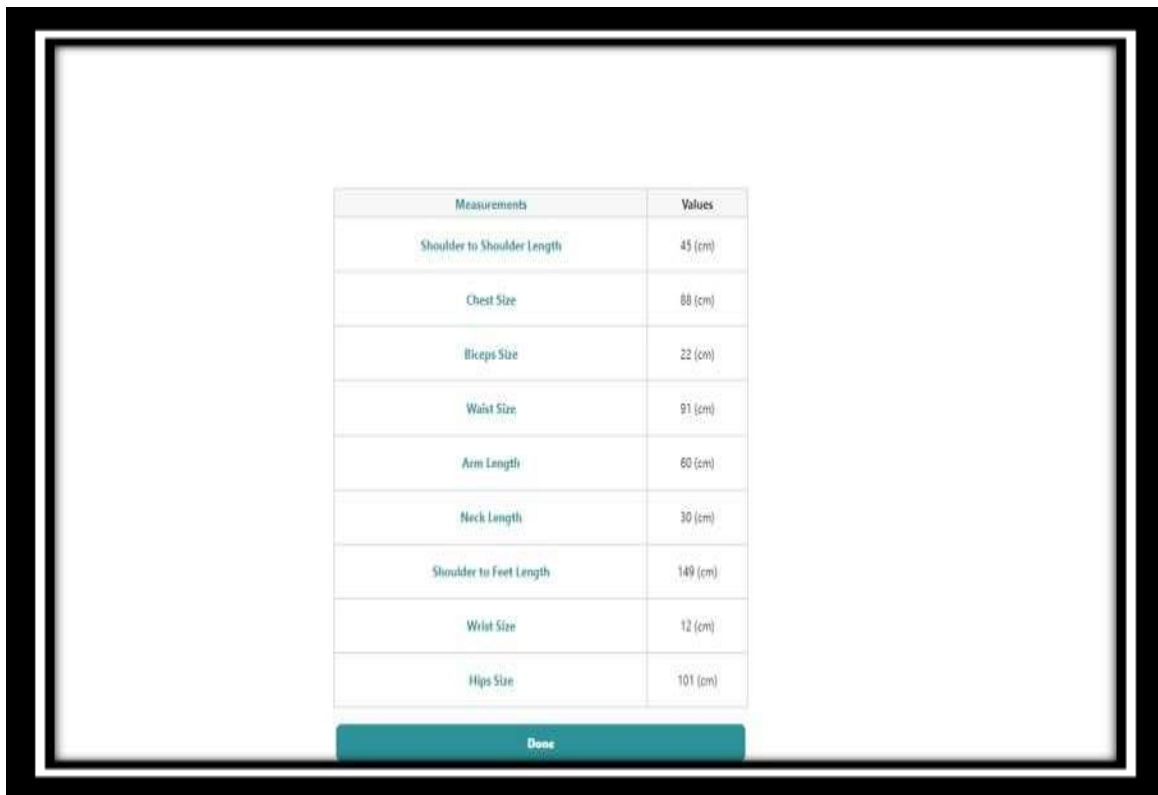
**Figure 4 The Application Asks for Inserting The Height of The Body.**

- i- **The first step:** The application asks for inserting the height of the body figure 4 .
- ii- **The second step :** Two images front and side were taken as in figure 5.



**Figure 5 Two Images Front and Side Were Taken.**

**4.4.6 The Final Step :** The program analyzed and treated the inputs then extracted the measurements as in figure 6.



Measurements	Values
Shoulder to Shoulder Length	45 (cm)
Chest Size	88 (cm)
Biceps Size	22 (cm)
Waist Size	91 (cm)
Arm Length	60 (cm)
Neck Length	30 (cm)
Shoulder to Feet Length	149 (cm)
Wrist Size	12 (cm)
Hips Size	101 (cm)

**Figure 6 The Program Analyzed and Treated The Inputs Then Extracted The Measurements .**

**5. The Results and Discution :**

**5.1 The Results of Manual Measurements and Application Measurements and The Comparison Between Them:**

**5.1.1 In A Single Specimen:**

This dataset was collected from a sample of an individuals sample as in Table 1.

**Table 1. Comparison Between Data of Individul Measuremnts and The Manual Methods Respectively .**

Size	Tape	App	Accurate
Shoulder to Shoulder Length	50	50	100%
Chest	99	104	86.8%
Biceps	27	27	100%
Waist	88	104	84.6%
Arm Length	68	68	100%
Neck Length	38	43	88.3%
Wrist Size	17	17	100%
Hip Size	110	114	96.4%
Shoulder to Feet Length	160	162	98.7%

**5.1.2 In A Set of Specimens:**

The dataset was colected from a several individuals with variation in heights and body measurements in the Sudan and is intended to be used for research purposes.

**i. The manual-based measurement as in table 2.**

**Table 1. Datadet of Several Individuls Measuremnts With The Manual Method.**

No	height	Shoulder Length	Chest	Biceps	Waist	Arm Length	Neck	Wrist	Hips	shoulder to feet
1	188	50	99	27	88	68	38	17	104	162
2	172	45	86	25	79	65	37	16	99	156
3	171	47	89	25	82	67	36	16	105	151
4	166	42	79	22	75	62	37	15	94	144

5	176	49	93	26	85	60	38	17	95	155
6	175	44	85	24	80	60	38	16	107	154
7	167	40	80	23	72	58	36	15	99	143
8	186	48	91	26	83	68	35	19	111	160
9	169	44	88	25	80	57	36	16	110	149
10	169	44	87	25	79	55	34	15	99	150
11	164	42	83	23	74	53	37	16	114	144
12	163	42	84	25	76	53	38	16	99	143
13	187	48	97	27	88	67	38	17	119	161
14	184	46	89	26	80	67	36	18	117	160
15	179	44	87	26	77	64	36	16	102	161
16	186	50	99	28	89	69	36	18	100	158
17	185	47	90	27	88	67	35	17	117	161
18	181	51	100	28	91	62	40	18	122	159
19	180	46	88	25	79	65	35	16	98	160
20	182	45	92	26	81	67	36	16	124	158
21	190	51	101	27	92	70	39	20	107	156
22	180	42	80	22	70	68	34	17	112	164
23	177	44	87	24	79	65	36	16	108	160
24	176	43	84	24	73	61	37	16	96	155
25	180	45	87	25	76	60	38	16	111	152
26	185	49	98	26	88	68	38	17	121	159
27	180	46	92	27	84	66	38	17	118	160
28	175	41	81	24	70	59	35	15	101	154
29	177	43	84	24	71	60	35	16	98	153
30	181	46	94	26	83	66	37	16	120	158
total	5331	1364	2674	758	2412	1897	1099	496	3227	4660
average	177.7	45.467	89.13	25.267	80.4	63.23	36.63	16.53	107.56	155.3
								7		

**ii. The application-based measurements table 3:**

**Table 2 . Datadet of Several Individuls Measurmnts Extracted With The Application.**

No	height	Shoulder Length	Chest	Biceps	Waist	Arm Length	Neck	Wrist	Hips	shoulder to feet
1	188	50	99	27	95	68	39	17	108	163
2	172	46	92	27	88	65	38	16	104	165
3	171	47	85	26	86	67	39	16	107	160
4	166	44	84	22	50	62	40	15	98	148
5	176	48	93	26	91	60	40	17	100	158
6	175	43	95	25	85	60	43	16	111	157
7	167	46	85	25	79	58	40	15	103	147
8	186	47	97	26	88	68	39	19	116	163
9	169	45	94	26	85	57	38	16	112	152
10	169	48	92	25	80	55	37	15	101	155
11	164	41	90	25	84	55	43	16	117	148
12	163	42	88	25	81	54	42	16	103	148
13	187	50	105	26	94	65	42	18	123	164
14	184	45	96	27	85	64	41	19	119	163
15	179	43	97	26	83	64	40	18	106	163
16	186	48	106	26	94	67	39	20	104	165
17	185	46	98	26	93	69	38	18	121	165
18	181	49	108	26	97	63	42	18	126	162
19	180	44	88	26	84	67	37	19	104	164
20	182	47	95	25	86	68	35	17	127	162
21	190	46	109	26	99	73	37	22	110	160
22	180	48	88	25	77	68	36	19	115	162
23	177	47	94	24	82	64	42	18	112	164
24	176	42	95	25	77	63	41	16	111	157
25	180	45	91	26	79	63	45	16	116	156
26	185	47	104	27	92	70	44	18	125	160
27	180	44	96	27	88	68	42	16	122	164
28	175	40	87	25	74	60	36	16	105	158
29	177	45	90	24	75	63	39	16	103	156
30	181	46	97	25	87	68	40	17	126	160
Total	5331	1369	2838	767	2538	1916	1194	515	3355	4769
Average	177.7	45.63	94.6	25.57	84.6	63.87	39.8	17.167	111.83	158.97

**5.2 The Processing, Analyzing and Comparing of The Several-Individuals Measurements:**

**5.2.1 Data Preprocessing:**

The data was preprocessed to ensure that it was in a usable format for the project. This included removing any records with missing values, normalizing the data, and converting the categorical variables into numerical values.

**5.2.2 Data Analysis :**

The data was analyzed using descriptive

statistics and visualizations and compared with app results in table 4. Descriptive statistics were used to summarize the data and identify any patterns or trends. Visualizations were used to explore the relationships between the different variables and to identify any outliers as in table 4 which show the comparison between the manual and application methods of taking measurements, and the accuracy of the application in

percentage

Size	average by Tape	average by App	Accuracy
Shoulder to Shoulder Length	45.46	45.63	99.6%
Chest	89.13	94.60	94.2%
Biceps	25.26	25.56	98.8%
Waist	80.40	84.60	95%
Arm Length	63.23	63.86	99%
Neck Length	36.63	39.80	92%
Wrist size	16.53	17.16	96.3%
Hip Size	107.56	111.83	96.1%
Shoulder to Feet Length	155.33	158.96	97.7%
Average			96.52%



**Table 4 The Comparison Between The Manual and Application Methods of Taking Measurements.**

### 6. Conclusion:

The results of the analysis showed that the measurements taken from the sample images, compared to the measurements taken manually, gave an accuracy of up to 96.52%, and it may increase depending on the environment for taking the image such as light, distance, background, shadow, wear.

### 7. Recommendations:

- i-** Use CNC Machine Laser to cut the fabric directly depending on the extracted measurements.
- ii-** Influence the following Engineers and Researchers to use Artificial Intelligence in Garment designing and industry.
- iii-** Create a MobileApp version of our WebApp for an easy access and use.

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