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A Novel Method of Anticipating Torso and Leg Features using Taalamana System

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Abstract— Human body is composed of structures like head, neck, torso, two arms and two legs. The organs are proportional in nature. In this paper, an attempt is made to anticipate the features of torso and leg of the human body. Geometric features of both the torso and leg from 75 female and 78 male subjects were extracted using anthropometric method. The proposed method of taalamana system can be used to anticipate various features like throat to navel length, navel to knee top, knee length, beneath of knee to ankle, ankle to floor, navel to floor, hip to floor, body width near elbow, waist width, thigh width, knee width, calf width, ankle width and shoulder width. All 20 features of torso and leg are estimated with an accuracy of more than 87% using only middle finger width of a person.

Keywords—Taalamana system, torso features, leg features, human structure, prediction

I. Introduction

Human body is made up of head, neck, torso, two arms and two legs. Human torso is the central part of the human body from which neck and limbs extend. An attempt to anticipate the torso and leg features of human being using middle finger width of a person is done with the assistance of Taalamana System.

Taalamana System

Iconography is the branch of art history which studies the identification, description, and the interpretation of the content of images. The word iconography literally means "image writing". The idea of constructing human structure is derived from Silpa Shastra. It has developed its own norms of measures and proportions. It is a complex system of iconography that defines rigid definitions [1],[4]. The shilpa shastra normally employ divisions on a scale of one (eka tala) to ten (dasa tala). Each tala is subdivided into 12 angulas. It is called Taalamana paddathi or Taalamana system, the system of measurements by Tala, the palm length of hand i.e. from the tip of the middle finger to the wrist as shown in fig 1 labeled as 2 .

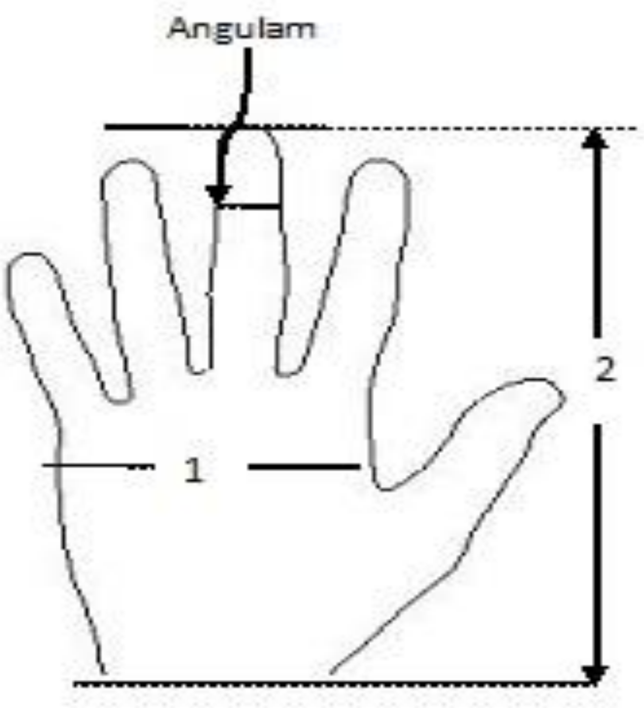


Fig 1: Computation of Middle finger length

Organization of paper

The paper is organized into five sections. Introduction to taalamana system is given in first section. Literature review is done in the second section. Dataset generation is discussed in section 3. Mathematical model is presented in section 4 and the estimation analysis is illustrated in section 5

II. LITERATURE REVIEW

Takahashi and others investigated human body posture estimation method based on back projection of human silhouette images extracted from multi-camera images [8,9]. To extract human silhouettes from color images accurately, a real-time background subtraction method that utilized the brightness and chromaticity in RGB color system for each pixel of the color image is proposed by them [9].

Mousa Mojarrad and others have proposed an algorithm for detection and recognition of the Human Body Composition and extraction of their measures like width and length of human body in images. Finding people and extraction of their features in images are particularly important problem of object recognition, because people can have high variability in the appearance.[10] Li, Jing-Feng and others proposed a real-time system for 3D human upper body tracking and modeling. The system uses multiple cameras to recover the depth maps in real-time, then integrates both color and depth information to track the human body, head, and hands, and finally recovers the 3D upper body model parameters from the tracking results.[11] An attempt is made by Sasaki and others to describe an approach to estimate human hand posture using 3-dimensional range data. The approach employs an approximation of the human hand with a plane in the 3-dimensional space.[12]

Yamauchi and others present a method for 3D human body modeling using range data. In this approach the entire human body is first decomposed into major body parts by a parts-based image segmentation method, and then a kinematics model is fitted to the segmented body parts in an optimized manner [13]. Werghi and others addresses the problem of recognizing human body posture from a cloud of 3D points acquired by a human body scanner. Motivated by finding a representation that embodies a high discriminatory power between posture classes, a new type of feature is suggested, namely the wavelet transform coefficients (WTC) of the 3D data-point distribution projected on to the space of spherical harmonics [14]. Marasamy and others proposed a method that includes a development over classical LDA (i.e. LDA using wavelets transform approach) that enhances performance such as accuracy and time complexity [15].

Pinto and others proposed a methodology based on 2D and 3D wavelet transforms, which are used to estimate multi-scale features from a real face acquired by a 3D scanner. The proposed methodology starts by considering a dataset composed by faces displaying seven different facial expressions [16]. Powar and others proposed an approach to use initial expression classification research using Hidden Markov Models (HMM) on 2D texture facial data [17]. Dan Luo and others present an appearance-based multimodal gesture recognition framework, which combines the different groups of features such as facial expression features and hand motion features which are extracted from image frames captured by a single web camera [18]. Spinello and others present a novel human detection method based on a Bayesian fusion approach using laser range data and camera images [19]. Wang and others proposed a method which consists of three major components: depth image acquisition, mean shift based preprocessing, and HMM-based gesture recognition [20].

The human legs are conspicuous in erotic contexts, but few studies have experimentally tested preferences for longer legs. The authors examined the utility of the human leg-to-body ratio (LBR) as a specific aesthetic criterion among 71 British undergraduates. The results showed that a longer LBR was preferred as maximally attractive in women, whereas a shorter LBR was preferred in men [5]. Leong and others have proposed a novel method of body feature extraction from a marker-less scanned body. The semantic definitions of body features found in ISO 8559 were interpreted into a series of mathematical definitions [7]. A total of 21 feature points and 35 feature lines on the human torso were identified. Each feature stands for an important landmark for garment making or the ergonomics industry. [6]

Manimala and Ravi Kumar have proposed a novel method to estimate the features of hand and face using only middle finger width [23, 24].

III. GEOMETRICAL FEATURE DATASET

Anthropometry describes the dimensions of the human body. The name is derived from anthropos, meaning *human*, and metrikos, meaning *measuring* [21]. Classical anthropometric data provides information on static dimensions of the human body in standard postures. Most measurements of the subject are taken in the most desirable position of standing [22]. The data collection is based on Traditional Anthropometric methods. The equipments used are Calipers, Scales and Tapes. Data is measured in cms with precision up to 2 decimal places. Figure 2 illustrates various torso and leg features. 78 Male and 75 female subject data are collected for the present study.

Fig 2 illustrates the feature extraction from human structure. Label 1 indicates body width at the position of elbow. Label 2 is the length of the body from throat to navel. Length of the human body from navel to knee top is labeled as 6. Knee length, length of the human body from knee to floor, navel to floor and hip to floor are labeled as 9, 12, 14 and 15 respectively. Label 20 shows the shoulder width. Features like ankle width, calf width, knee width and thigh width are drawn on left leg as shown in the figure. Other features like body width at elbow from side, ankle width from side, thigh width from side are not shown in the figure.

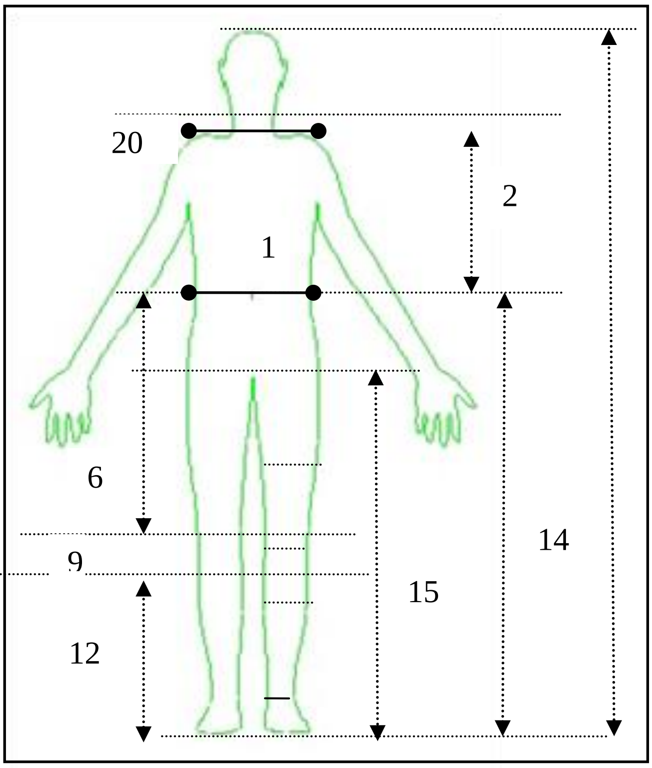


Fig 2 : Extraction of torso and leg features

IV. MATHEMATICAL MODEL

Middle finger width is called as an angulam. One tala is equal to twelve angula. One eighth of an angulam is called as yuva. Using Tala, Angula and Yuva all the features of the human torso and leg are estimated.

Body width is estimated from front and side at elbow using equation 1 and 2. Length of the body from throat to navel is computed using equation 3. Waist width is anticipated from front and side with the help of equation 4 and 5.

$$Body\ Width\ at\ Elbow(front) = 18 * angula - 3 * yuva \cdots (1)$$
$$Body\ Width\ at\ Elbow(side) = 12 * angula + 4 * yuva \cdots (2)$$
$$Throat\ to\ Navel = 25 * angula \cdots (3)$$
$$Waist\ Width\ (front) = 20 * angula - 3 * yuva \cdots (4)$$
$$Waist\ Width\ (side) = 13 * angula + 5 * yuva \cdots (5)$$

Length of the human body from navel to knee top is calculated as shown in equation 6. Using equation 7 and 8 thigh width from frontal and side pose is computed. Knee length and width are estimated with the help of equations from 9 to 11.

$$Navel\ to\ Knee\ Top = 34 * angula - 5 * yuva \cdots (6)$$
$$Thigh\ Width\ (front) = 9 * angula \cdots (7)$$
$$Thigh\ Width\ (side) = 9 * angula - 3 * yuva \cdots (8)$$
$$Knee\ Length = 5 * angula \cdots (9)$$
$$Knee\ Width\ (front) = 7 * angula \cdots (10)$$
$$Knee\ Width\ (side) = 7 * angula + 1 * yuva \cdots (11)$$

Length of the human body from knee to ankle, knee to floor, navel to floor, hip to floor are predicted using equations 12 to 15 respectively. Calf width is estimated using equation 16 and 17. Ankle width from front and side computed using equation 18 and 19. Shoulder width is anticipated using equation 20.

$$Knee\ to\ Ankle = 23 * angula + 4 * yuva \cdots (12)$$
$$Knee\ to\ Floor = 30 * angula \cdots (13)$$
$$Navel\ to\ Floor = 63 * angula + 2 * yuva \cdots (14)$$
$$Hip\ to\ Floor = 60 * angula - 1 * yuva \cdots (15)$$
$$Calf\ Width\ (front) = 5 * angula + 5 * yuva \cdots (16)$$
$$Calf\ Width\ (side) = 5 * angula + 5 * yuva \cdots (17)$$
$$Ankle\ Width\ (front) = 4 * angula + 3 * yuva \cdots (18)$$
$$Ankle\ Width\ (side) = 5 * angula + 5 * yuva \cdots (19)$$
$$Shoulder\ Width\ = 26 * angula \cdots (20)$$

V. ESTIMATION ANALYSIS

One of ways to quantify the difference between an estimator and the true value of the quantity being estimated in statistics is Mean Square Error or MSE of an estimator. MSE is a risk function, corresponding to the expected value of the squared error loss or quadratic loss. MSE measures the average of the square of the "error." The error is the amount by which the estimator differs from the quantity to be estimated. The difference occurs because of randomness or because the estimator doesn't account for information that could produce a more accurate estimate. The square root of MSE yields the root mean squared error or RMSE(21).

The Mean Absolute Error is a quantity used to measure how close forecasts or predictions are to the eventual outcomes or actual values. The mean absolute error (MAE) is an average of the absolute errors computed as in (22), where f_i is the predicted value and y_i is the true value.

$$MSE = \frac{1}{n}\sum_{i=1}^{k}(f_i - y_i)^2 \quad (21)$$

$$MAE = \frac{1}{n}\sum_{i=1}^{k} abs\left(f_i - y_i\right) \quad (22)$$

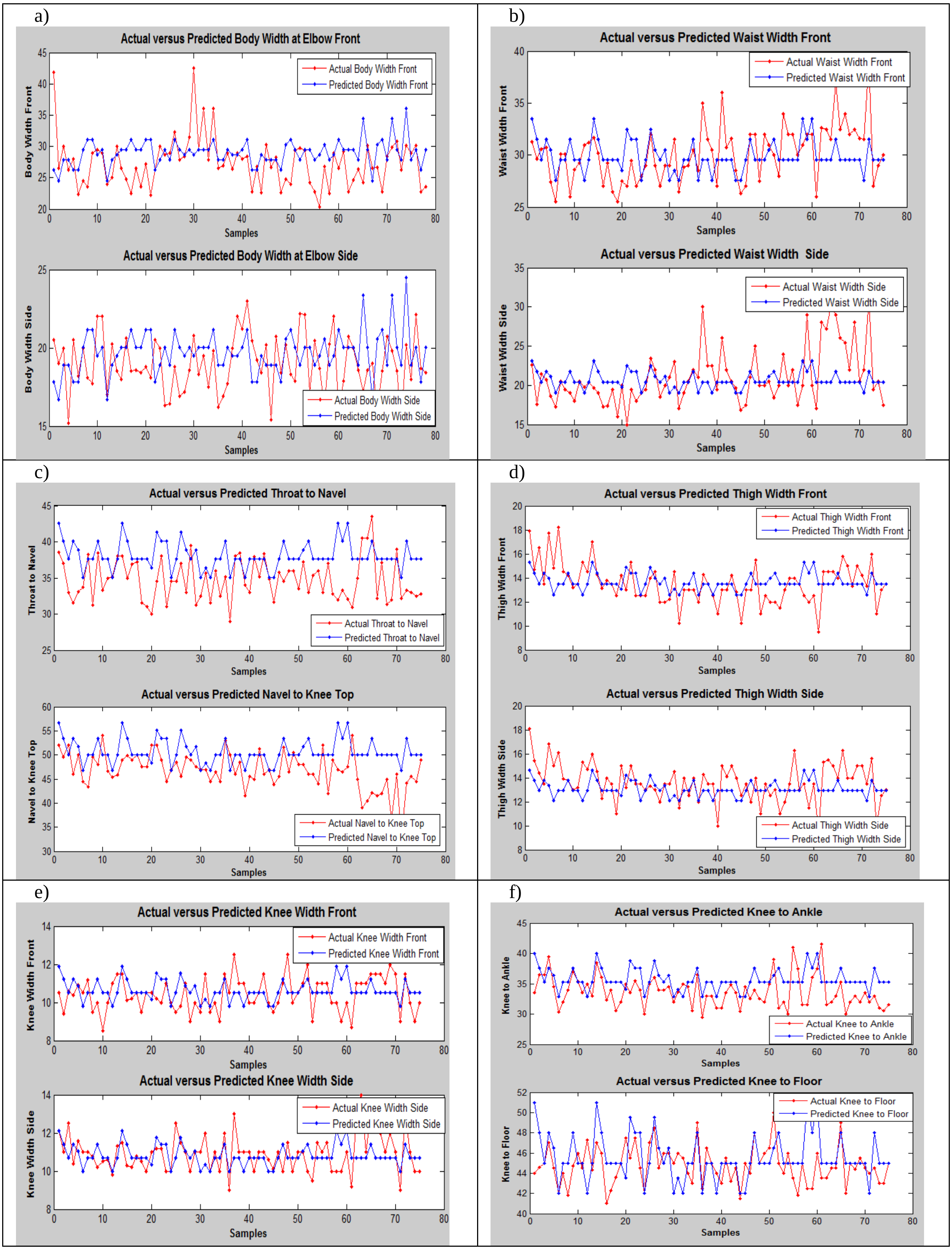
Table 1 shows the statistical features like Minimum value, Maximum Value, Mean, Standard deviation, Prediction Accuracy, RMSE and MAE of all 20 features of the torso and leg that are estimated using only middle finger width. All the features have estimation accuracy of more than 87%.

TABLE I

ESTIMATION ANALYSIS OF TORSO AND LEG

Features	**Min**	**Max**	**Mean**	**STD**	**RMSE**	**MAE**	**Prediction Accuracy**
Body width at elbow (front)	20	31	25.229	2.9099	3.2524	2.7997	89.557
Body width at elbow (side)	13	25	18.719	2.8852	2.9091	2.3693	87.554
Throat to Navel	29	43.5	34.752	2.8851	4.5327	3.7382	90.318
Waist width (front)	25.5	39	30.113	2.6639	2.703	2.2054	92.634
Waist width (side)	15	31	21.081	3.5348	3.6034	2.6492	87.27
Navel to Top of knee	32.5	54	46.784	3.777	5.5087	4.4623	91.277
Thigh width (front)	9.5	18.2	13.556	1.6771	1.6381	1.2667	90.776
Thigh width (side)	1.5	18.1	13.539	2.1055	2.087	1.5118	88.308
Knee length	6	10	7.8107	0.6697	0.7869	0.648	91.253
Knee width (front)	5.5	12.5	10.4	1.0378	1.1309	0.8506	92.044
Knee width (side)	9	14	10.93	0.9945	1.0339	0.7966	92.654
Lower of knee to ankle	29.5	41.5	33.68	2.5836	3.183	2.7167	92.43
Knee to floor	41	55.3	47.27	3.7823	4.701	3.3356	93.554
Navel to Floor	86	102.5	95.1	3.7432	4.5781	3.577	96.315
Hip to Floor	83	100	92.06	3.848	4.8389	3.9832	95.612
Calf width (front)	6	11	8.364	1.0243	0.9905	0.8188	90.449
Calf width (side)	6.6	11.5	8.590	0.9663	0.9541	0.7176	91.59
Ankle width (front)	5	8	6.553	0.4688	0.4664	0.3338	95.049
Ankle width (side)	6.2	9.1	7.9	0.5856	0.8548	0.7061	91.809

In fig 3, actual and anticipated features of torso and leg are plotted. Red line in the plot shows the actual value of a feature and blue line indicates the anticipated or estimated value of the feature. Overlap of red and blue lines in the plot is a clear indication of how close is the predicted value to the actual value of the feature. Figure 3a shows body width at elbow feature from front and side view. Similarly waist width, throat to navel and navel to knee top are shown in figure 3b and 3c. Thigh width and knee width are depicted in figure 3d and 3e. Figure 3f shows the predicted and actual value of knee to ankle and knee to floor length of the human body. Figure 3g depicts the length from navel to floor and hip to floor. Figure 3h and 3i are displaying the actual and predicted width of calf and ankle. And in figure 3j knee length and shoulder width are shown.



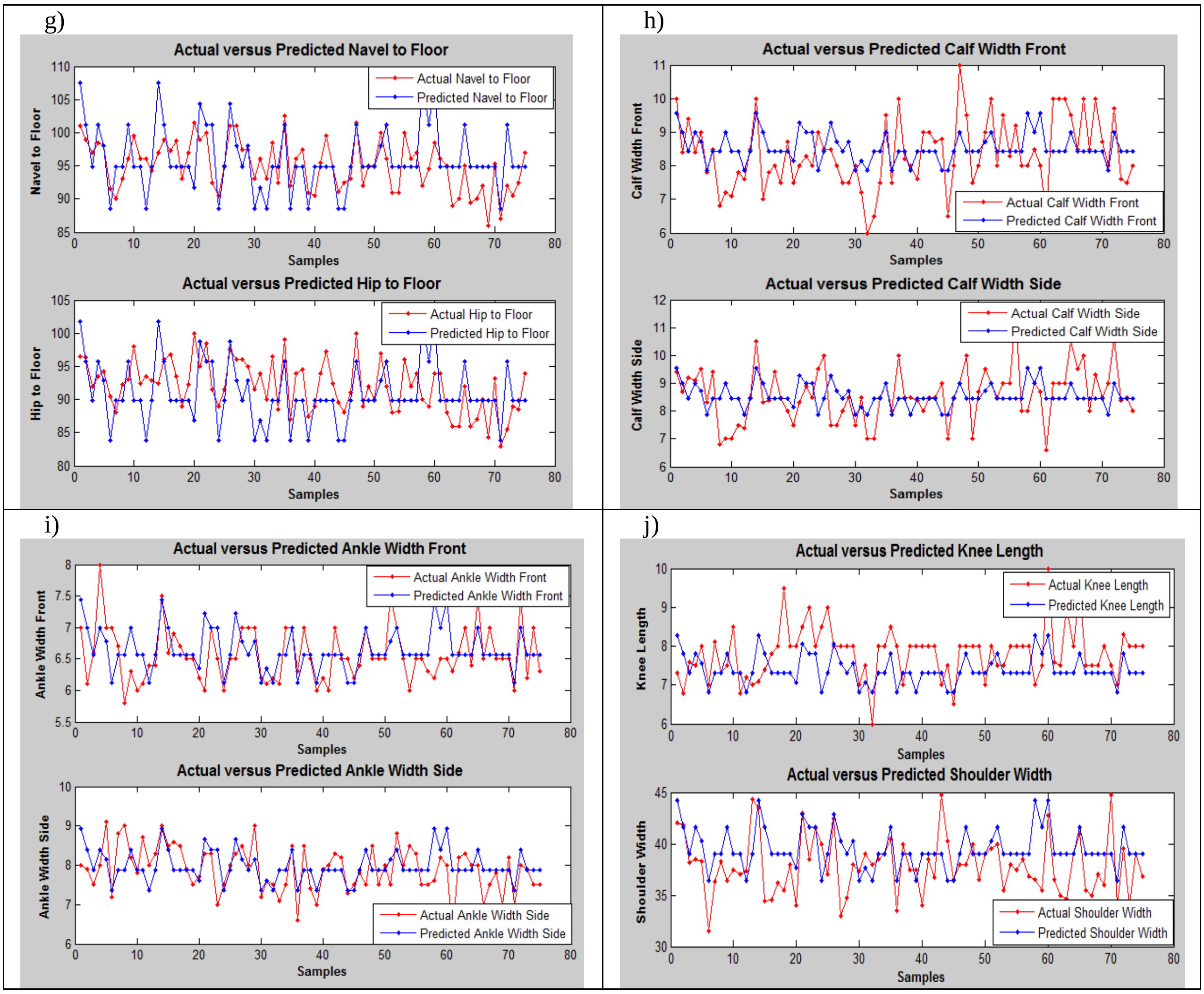


Fig 3(a-j) Actual and Estimated Features of Torso and Leg

VI. Conclusion

The task of anticipating torso and leg features of human body is accomplished with the help of Taalamana System. All 20 features of torso and leg are estimated with an accuracy of more than 87% using only middle finger width. It is evident that all length features are predicted with more accuracy than width features. Width of the human body varies significantly from person to person where as length of the human body is proportional in nature.

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