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*Journal homepage: <http://www.journalijar.com>***INTERNATIONAL JOURNAL
OF ADVANCED RESEARCH****RESEARCH ARTICLE****Envisaging Hand and Facial Features of Human Body using Topinard's Canon System****Manimala.S¹ and C.N.Ravi Kumar²****1.** Department of CS & E, SJCE, Mysore-570006, India.**2.** Department of CS & E, SJCE, Mysore-570006, India.**Manuscript Info****Manuscript History:**

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Key words:hand features, facial features,
topinard canon, estimation**Abstract**

The anatomy of the hand is complex, intricate, and fascinating. Hands may be affected by many disorders, most commonly traumatic injury. In treating hand problems, the mastery of anatomy is fundamental in order to provide the best quality of care. Topinard's canon is used to predict 8 features of left and right hand from height of a person. The geometric approach represents the face in terms of structural measurements and distinctive facial features that include distances and angles between the most characteristic face components such as eyes, nose, mouth or facial templates such as nose length and width, mouth position and chin type. In this paper, the focus is on predicting geometric features of face from height of a person. 12 Geometric features of face of 150 subjects are collected. The proposed method can be used to predict facial features like face length and width, nose length and width, eye length and width, lips height and width, distance between eyes using Topinard's canon system. All 28 features of hand and face are envisaged with an accuracy of more than 85% using only height of a person.

*Copy Right, IJAR, 2013.. All rights reserved.***Introduction**

Dimensional relationships between the body segments and the whole body have been of interest to artists, scientists, anatomists, anthropologists and medico-logistics for long time [36]. Examination of skeletal remains recovered from a scene of crime, have often been used by the forensic anthropologists to extract relevant information about the victim [37]. Personal identification is an integral part of the investigation in cases of mass disasters where disintegrated and amputated body organs are found very frequently in case of air accidents. If only height of a person is available, then the proposed method can be used to obtain complete knowledge of the damaged part. In medical science when it is necessary to replace any part of the human body like fingers, it can be constructed using the features estimated by our proposed method for perfection in the plastic surgery.

The hands play an important role in non-verbal communication. Hands often approach the face during social interaction. Human face varies from one person to another. It considers the race, gender, age, and other physical characteristics of an individual. Computer vision is the field in computer science that is concerned in applying theories and models to construct computer vision systems. It challenges programmers to emulate the functionalities of human vision systems. Human vision system has the ability to understand the organization of its surrounding [20], [21].

Faces are very specific objects whose most common appearance roughly looks alike. Some changes in the facial features make the faces different. Human face varies from one person to another.

Topinard's Canon

Canon proposed by Topinard is used widely by the artists to sketch the human structure. He defines the proportions of the human body. Human body is divided into 100 parts. All other features of the human body are computed as

number of parts. Height of the person is first divided by 100. Topinard says that his work is an essay in rational anthropometry and a very remarkable attempt for the period [38].

$$part = \frac{Height}{100} \dots (1)$$

Literature Evaluation of Hand and Facial Feature

Geometric measurements of the human hand have been used for identity authentication in a number of commercial systems. Anil K. Jain and others have worked extensively on hand geometry specifically for identification and verification systems [5,6,7]. There is not much open literature addressing the research issues underlying hand geometry-based identity authentication; much of the literature is in the form of patents [1,2, 3]. Hand geometry recognition systems may provide three kinds of services like verification, classification and identification [11]. A novel contact-free biometric identification system based on geometrical features of the human hand is developed by Aythami Morales and others [10]. A component-based hand verification system using palm-finger segmentation and fusion was developed by Gholamreza and others. The geometry of each component of the hand is represented using high order Zernike moments which is computed using an efficient methodology [14].

Windy and others have used geometric measurements to study the sexual orientation. The ratio of the length of the second digit (2D) to the length of the fourth digit (4D) is greater in women than in men. This ratio is stable from 2 years of age in humans [8,9]. Gender classification from hand images in computer vision is attempted by Gholamreza and others [15].

Issac Cohen and others have worked on 3D hand construction from silhouettes of 2D hands [12]. Digital and metacarpal formulae are morphological variables which may also have functional significance in the understanding of how certain hand forms may be ill-fitted for certain tasks [13].

T.F.Coates and others have worked on active shape models [16,17] which laid foundations for statistical shape analysis using Procrustes analysis, tangent space projection and Principal Component Analysis[18]. Geometric hand measurements are also used in hand gesture classification using a view-based approach for representation and Artificial Neural Network for classification [19].

Facial feature detection aims to detect and extract specific feature such as the eyes, lips and nose. [29] Many algorithms have been proposed for face detection in still images that are based on texture, depth, shape and color information. For example, face localization can be based on the observation that human faces are characterized by their oval shape and skin-color[30]

S.V.Cerez proposed a system that detects a human face in an image and extracts or bounds facial features using a geometrical face model [31]. Burl and others use multi-oriented, multi-scale Gaussian derivative filters to model the texture around key points on the face.[35] R. L. Hsu and others use color information to detect the face[32][15].

T.F.Coates and others have worked on active shape models [33] which laid foundations for statistical shape analysis using Procrustes analysis, tangent space projection and Principal Component Analysis[34]. Active Shape Model (ASM) for facial features extraction is also used by Mahoor and others. The enhancement in this method relied on three improvements: (a) initialization of the ASM model using the centers of the mouth and eyes (b) incorporation of RGB color information to represent the local structure of the feature points, and (c) application of 2D affine transformation in aligning the facial features that were perturbed by head pose variations [29].

Dataset Generation

153 subjects (78 males and 75 females) between the ages of 22 and 25 years with no obvious deformities or previous history of trauma to the hands were selected for the study. Anthropometry describes the dimensions of the human body. The name is derived from anthropos, meaning “human”, and metrikos, meaning “measuring” [27]. Classical anthropometric data provides information on static dimensions of the human body in standard postures. Most measurements of the subjects are taken in the most desirable position of standing.[28] 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.

Mathematical Model

One hundredth of height of a person is known as part. Most of the features are envisaged using part. Head length is computed as 13.2 times the part. Neck length is 6.6 parts.

Features of arms

Using Topinard's canon an attempt is made to estimate features of the human body. Middle finger width is computed using equation 2. Palm width is computed as 4 parts and palm length is estimated as 11.5 parts. Wrist width is computed as 3.5 times parts. The length of the hand from middle finger tip to elbow, elbow to shoulder, wrist to elbow and from middle finger tip to shoulder are predicted using equations 3 to 6 respectively.

$$\text{Middle Finger Width} = 0.925 * \text{part} \dots (2)$$

$$\text{Middle finger tip to Elbow} = 25 * \text{part} \dots (3)$$

$$\text{Elbow to Shoulder} = 18 * \text{part} \dots (4)$$

$$\text{Wrist to Elbow} = 14 * \text{part} \dots (5)$$

$$\text{Middle finger tip to Shoulder} = 43 * \text{part} \dots (6)$$

Features of Face

12 facial features are envisaged with accuracy of more than 90% using height of the person. Head is divided into four parts. Nose length is estimated as one fourth of the head i.e 13.2 divided by four is 3.3 parts. From root of the nose to bottom of the nose is 3.3 parts. Face length is estimated as in equation 8. Left and Right Eye width and height are predicted using equations 9 to 12.

$$\text{Face Length} = 11.5 * \text{part} \dots (8)$$

$$\text{Left Eye Width} = \frac{\text{Head Length}}{7} \dots (9)$$

$$\text{Left Eye Width} = \frac{\text{Head Length}}{7} \dots (10)$$

$$\text{Left Eye Height} = 1 * \text{part} \dots (11)$$

$$\text{Right Eye Height} = 1 * \text{part} \dots (12)$$

Left and right ear height is computed as in equation 13 and 14. Inner distance between eyes is estimated using equation 15. Nose length and width features are estimated with the help of equation 16 and 17. Lips width and height at the centre is estimated as shown in equation 18 and 19.

$$\text{Left Ear Height} = 2 * \frac{\text{Head Length}}{7} \dots (13)$$

$$\text{Left Ear Height} = 2 * \frac{\text{Head Length}}{7} \dots (14)$$

$$\text{Inner Distance between eyes} = \frac{\text{Head Length}}{7} \dots (15)$$

$$\text{Nose Length} = 3.3 * \text{part} \dots (16)$$

$$\text{Nose Width} = 2 * \text{part} \dots (17)$$

$$\text{Lips Width} = 3.4 * \text{part} \dots (18)$$

$$\text{Lips Height at Center} = 1.2 * \text{part} \dots (19)$$

Estimation Analysis

In statistics, the mean square error or MSE of an estimator is one of ways to quantify the difference between an estimator and the true value of the quantity being estimated. 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 (20). The mean absolute error is a quantity used to measure how close forecasts or predictions are to the eventual outcomes. The mean absolute error (MAE) is an average of the absolute errors computed as in (21), where f_i is the envisaged value and y_i is the true value.

$$MSE = \frac{1}{n} \sum_{i=1}^k (f_i - y_i)^2 \quad (20)$$

$$MAE = \frac{1}{n} \sum_{i=1}^k \text{abs}(f_i - y_i) \quad (21)$$

Table 1 : Statistical analysis of all the samples

Features of Human Body		Min	Max	Mean	STD	RMSE	MAE	Prediction Accuracy
Left Hand Features	Middle Finger Width	1.4	2.2	1.6464	0.16183	0.11616	0.087379	94.728
	Palm Width	6.3	9.75	8.0676	0.82439	0.54485	0.44951	94.487
	Palm Length	15.3	20	18.079	1.1037	1.1204	0.97681	94.9
	Wrist width	4.5	7.3	5.7301	0.59839	0.41396	0.33349	94.231
	Mid Finger tip to elbow	34.2	50.2	43.174	3.5019	2.5266	2.0208	95.173
	wrist to elbow	19	32	25.214	2.6227	2.6702	2.1612	90.806
	Elbow to Shoulder	24	37.1	29.916	2.6795	2.1334	1.6161	94.592
	Mid Finger tip to Shoulder	59.1	84.9	72.81	5.4314	3.4198	2.5974	96.51
Right Hand Features	Middle Finger Width	1.2	2.1	1.6941	0.21726	0.20495	0.16754	90.638
	Palm Width	6.7	9.75	8.0886	0.79311	0.51573	0.42395	94.815
	Palm Length	15.5	20.1	18.046	1.1085	1.1608	1.0167	94.689
	Wrist width	4.5	7.3	5.7337	0.60164	0.41802	0.33606	94.179
	Mid Finger tip to elbow	35.3	50.2	43.398	3.3112	2.6106	2.177	94.781
	wrist to elbow	19.9	31.5	25.483	2.4081	2.1475	1.7067	92.962
	Elbow to Shoulder	23.8	37.2	29.896	2.7135	2.2046	1.6518	94.491
	Mid Finger tip to Shoulder	61	84.9	73.131	5.2136	3.1511	2.3728	96.826
	Face Length	14.8	24	19.572	2.7393	2.0442	1.7548	90.848
	Left eye width	2.8	4.4	3.4565	0.42753	0.45394	0.35315	88.904
	Right eye width	2.8	4.4	3.4565	0.4263	0.45309	0.35185	88.945
	Left eye height	1.1	2	1.549	0.17589	0.22019	0.17747	89.335
	Right eye height	1.1	2	1.5503	0.17664	0.21995	0.17656	89.39

Face Features	Left Ear height	5	7.2	6.0013	0.45955	0.55083	0.45263	92.822
	Right Ear height	5	7.2	6.0284	0.45782	0.52734	0.43278	93.126
	Distance between eyes(inner)	2.3	3.7	3.0003	0.27604	0.33992	0.26221	91.756
	Nose length	3.8	6.2	4.8696	0.57638	0.52123	0.4209	91.193
	Nose Width at bottom	2.7	4.7	3.6683	0.48094	0.37851	0.30675	91.542
	Lips width	4.1	6.2	5.2369	0.47634	0.56791	0.45739	91.864
	Lips height at centre	1	2.7	1.7918	0.35091	0.3855	0.30139	84.309

In table 1 statistical features of all 153 samples are given. As illustrated all the features except eye width and height has an prediction accuracy of more than 91%.

Table 2 tabulates statistical features and analytical features of only 75 female samples. All 28 features of the human structure are estimated with an accuracy of more than 91%.

Table 2 : Statistical analysis of only Female samples

Features of Human Body		Min	Max	Mean	STD	RMSE	MAE	Prediction Accuracy
Left Hand Features	Middle Finger Width	1.4	1.7	1.5187	0.074785	0.090335	0.072228	95.004
	Palm Width	6.3	8.5	7.356	0.42625	0.63762	0.55633	92.949
	Palm Length	15.3	19.2	17.301	0.8229	0.98296	0.82802	95.428
	Wrist width	4.5	6	5.26	0.32962	0.40739	0.34298	93.802
	Mid Finger tip to elbow wrist to elbow	34.2	43.9	40.229	1.8428	1.4148	1.169	97.031
	Elbow to Shoulder	19	26.4	23.162	1.4063	1.5583	1.3029	94.098
	Mid Finger tip to Shoulder	24	32.2	28.596	1.8435	1.5138	1.1866	95.786
Right Hand Features	Middle Finger Width	59.1	74.6	68.823	3.269	2.8722	2.1279	96.986
	Middle Finger Width	1.2	1.8	1.516	0.12416	0.14166	0.10513	92.684
	Palm Width	6.7	8.5	7.4	0.38695	0.58801	0.51087	93.542
	Palm Length	15.5	19.2	17.289	0.86048	1.008	0.86365	95.227
	Wrist width	4.5	6	5.264	0.34313	0.41422	0.34569	93.745
	Mid Finger tip to elbow wrist to elbow	35.3	44	40.655	1.7461	1.6793	1.443	96.333
	Elbow to Shoulder	19.9	26.8	23.661	1.2846	1.9143	1.6992	92.284
Face Features	Elbow to Shoulder	23.8	32	28.632	1.8315	1.5019	1.1546	95.913
	Mid Finger tip to Shoulder	61	76	69.391	3.0284	2.1866	1.6873	97.612
	Face Length	14.8	19.8	17.031	0.92312	1.386	1.1819	93.488
	Left eye width	2.8	3.8	3.1387	0.21491	0.26587	0.20097	93.226
	Right eye width	2.8	3.8	3.1387	0.21491	0.26587	0.20097	93.226
	Left eye height	1.2	1.8	1.54	0.15939	0.17447	0.14337	90.885
	Right eye height	1.2	1.8	1.54	0.15939	0.17447	0.14337	90.885
	Left Ear height	5	6.7	5.7907	0.36987	0.49327	0.41894	93.001
	Right Ear height	5	6.7	5.788	0.37052	0.49644	0.42161	92.959
	Distance between eyes(inner)	2.3	3.6	2.944	0.24175	0.26071	0.19699	93.401
	Nose length	3.8	5.6	4.5653	0.3899	0.36595	0.28675	93.617
	Nose Width at bottom	2.7	4.3	3.3333	0.3481	0.36942	0.30734	91.15
Lips width	4.1	6	4.96	0.43434	0.60041	0.5073	90.567	
Lips height at center	1.3	2.3	1.824	0.21862	0.22235	0.19417	89.232	

In table 3 shows statistical analysis of all 28 features of only male samples of human structure. Some of the features have prediction accuracy of less than 90%. This indicates that estimation of hand and facial features of female samples have prediction accuracy more than male samples.

Table 3 : Statistical analysis of only Male samples

Features of Human Body		Min	Max	Mean	STD	RMSE	MAE	Prediction Accuracy
Left Hand Features	Middle Finger Width	1.5	2.2	1.7692	0.12306	0.1395	0.10333	93.968
	Palm Width	8	9.75	8.7519	0.44652	0.43747	0.34679	95.966
	Palm Length	17	20	18.828	0.77286	1.2383	1.1199	94.392
	Wrist width	5.6	7.3	6.1821	0.42457	0.42018	0.32436	94.643
	Mid Finger tip to elbow	41.2	50.2	46.005	2.0916	3.2554	2.8397	93.386
	wrist to elbow	24	32	27.187	1.9066	3.4134	2.9865	87.64
	Elbow to Shoulder	26	37.1	31.186	2.7526	2.5931	2.029	93.443
	Mid Finger tip to Shoulder	68.5	84.9	76.645	4.1928	3.874	3.0487	96.051
Right Hand Features	Middle Finger Width	1.5	2.1	1.8654	0.13322	0.14652	0.11087	94.165
	Palm Width	8	9.75	8.7506	0.43816	0.43504	0.34038	96.04
	Palm Length	17	20.1	18.774	0.78739	1.2907	1.1638	94.173
	Wrist width	5.6	7.3	6.1853	0.4242	0.42164	0.32679	94.596
	Mid Finger tip to elbow	41.2	50.2	46.035	2.0828	3.2645	2.8827	93.289
	wrist to elbow	24	31.5	27.235	1.8758	2.7198	2.289	90.84
	Elbow to Shoulder	26	37.2	31.112	2.8735	2.7138	2.1299	93.123
	Mid Finger tip to Shoulder	68.5	84.9	76.728	4.2555	3.8574	3.0321	96.071
Face Features	Face Length	18.5	24	22.015	1.2878	2.4885	2.2518	88.577
	Left eye width	2.9	4.4	3.7622	0.35127	0.57985	0.49949	84.747
	Right eye width	3	4.4	3.7622	0.3483	0.57855	0.49692	84.828
	Left eye height	1.1	2	1.5577	0.19105	0.25658	0.21026	87.844
	Right eye height	1.1	2	1.5603	0.19228	0.25618	0.20846	87.953
	Left Ear height	5.5	7.2	6.2038	0.44792	0.601	0.48503	92.649
	Right Ear height	5.5	7.2	6.2596	0.41397	0.55543	0.44351	93.287
	Distance between eyes(inner)	2.5	3.7	3.0545	0.29697	0.40162	0.32492	90.173
	Nose length	4	6.2	5.1622	0.57689	0.63572	0.5499	88.861
	Nose Width at bottom	3.3	4.7	3.9904	0.35466	0.38704	0.30618	91.918
	Lips width	4.8	6.2	5.5032	0.34654	0.5348	0.40941	93.111
	Lips height at center	1	2.7	1.7609	0.44178	0.49394	0.40447	79.575

Conclusion

The challenging task of envisaging hand and facial features is accomplished with the application of Topinard's canon. All the 8 features of left hand and right hand are estimated with an accuracy of more than 91% for male samples, female samples and all samples. 12 facial features are estimated with an accuracy of more than 85%. Only height of the person is used to estimate all 28 features of hand and face.

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