Indonesian Journal of Electrical Engineering and Computer Science
Vol. 18, No. 1, April 2020, pp. 268~275
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v18.i1.pp268-275

Segmentation of the human body based on frequency of human electromagnetic radiation

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Article Info

Article history:

Received Aug 22, 2019
Revised Oct 15, 2019
Accepted Oct 29, 2019

Keywords:

Frequency
Human body segment
Human electromagnetic radiation
k-NN
ROC

ABSTRACT

This paper discusses the body segment recognition based on human electromagnetic radiation frequency. Twenty-three points of human electromagnetic radiation are studied experimentally from thirty-three healthy human subjects. Three human body segments are considered, namely Left, Right and Chakra. For the purpose of recognition, k-Nearest Neighbor (KNN) algorithm is used to classify the segments of the human body. Then, the performances of classification are determined based on the accuracy and Receiving Operating Characteristic (ROC) analysis. It is found that the proposed technique accurately classifies the body segments with 100% accuracy, thus suggest that the proposed technique is significant to classify human body segments.

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1. INTRODUCTION

In general, research on segmentation of human body is focused on image-based techniques and has become a promising area of research [1, 2]. Human body segmentation is essential in numerous applications including surveillance, content-based image retrieval and etc. However, studies show that there are many challenging issues in the human image segmentation due to body posture variations and confusing background. Thus, a new technique is proposed in this study to identify the human body segmentation using human electromagnetic radiation analysis. Human electromagnetic radiation refers to the signal emitted by a human body and exist close to the physical body. It is described as the endogenous electromagnetic fields that generated associated to electrical properties of the human body [3, 4].

In biomechanic studies, segmentation of human body was determined by center of mass for each body segment using the Zatsiorsky and de Lava segmentation methods [5]. The segment includes head, trunk, upper trunk, mid trunk, lower trunk, upper arm, forearm, hand, thigh, shank and foot. Recently, analyzing of human body in three-dimensional (3D) models had received attention as it enables detection of many different body segments [6]. Such segments include head, torso, left and right arm, and left and right leg. Apart of this, the human body could have segmented into planes that comprise frontal, sagittal and horizontal planes, as shown in Figure 1 [7], where their identification is based on anatomical position. In this study, the body is segmented into three segments namely Left, Right and Chakra. The Left and Right segment is referred to sagittal plane, where the left and right sides of the body is also divided and splitting the center of the head, torso and between the legs. For Chakra, is an energy center in human being and can be described as the focal points for the reception, absorption and transmission of human electromagnetic radiation in the human body.

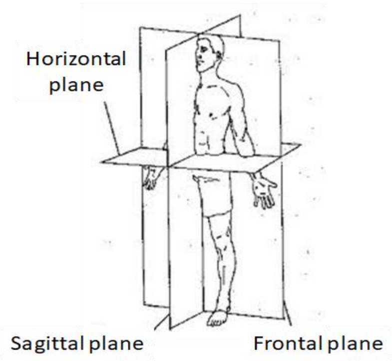


Figure 1. Planes of the human body

Previously, research works on the human electromagnetic radiation has found male and female distinction on several body segments [8, 9], and a significant result also has shown in classifying body segment on Upper body, Torso, Arm and Lower body [10]. Therefore, further examination on distinguishing characteristic of body segments on Left, Right and Chakra are proposed.

For the purpose of pattern recognition, k-nearest neighbor (KNN) technique is engaged to classify human body segments. KNN is one of the most fundamental and simple classification methods and have been successfully applied in numerous areas [11-13]. In evaluating a classifier performance, there are a number of ways to compute and assess the performance of a classifier [14], and one of the widely used methods is Receiving Operating Characteristic (ROC) [15]. ROC has been used in several studies and it provides an abundant measure of classification performance [16-18]. ROC is a useful tool for evaluating performance of binary classification.

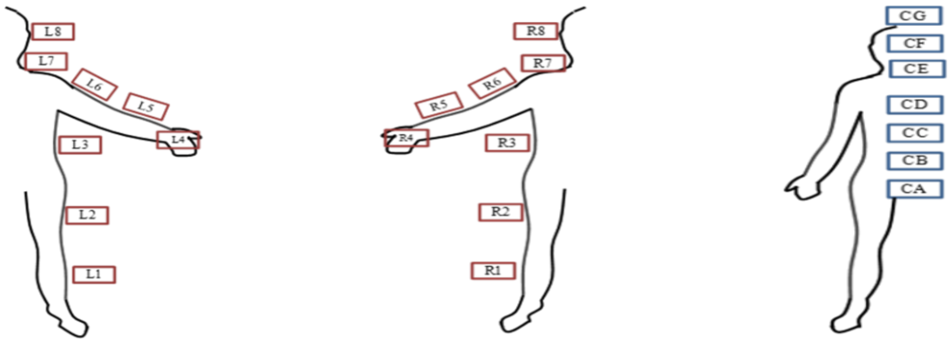
2. RESEARCH METHOD

The segmentation of human body studied in this paper is comprised of three parts. The first part is acquisition of human electromagnetic radiation frequency data. Based on quantitative measure of frequency radiation, the second part of the following is the classification techniques for human body segmentation, herein the KNN algorithm is employed to classify between genders. The third part is the performance evaluation techniques, which is based on the ROC analysis.

2.1. Experimental Setup

The human electromagnetic radiation frequency is taken on twenty-tree points around the body as shown in Figure 2, which represents as the segments of Left, Right and Chakra. It consists of eight points on the Left and Right segments, respectively and seven points of chakra located along the central plane of body. The frequencies are obtained via a hand-held frequency meter with a telescopic whip antenna that operated at a range of Mega Hertz. The frequency meter is equipped with a filter unit to scrutinize interference that could exist and to evade display of random noises. Further, the meter is also fitted with ultrasensitive synchronous detector that used to indicate the relative field strength of electromagnetic waves interacting with the antenna. During the measurement, the antenna is set on the 6th segment length and placed in horizontal position to the human body. The frequencies are taken remotely at a distances of 1 to 5 cm above the body on twenty-three points of the human body as shown in Figure 3 [19].

In this study, thirty-three of healthy human subjects are participated from seventeen males and sixteen females. All the measurements are conducted in controlled environment in an anechoic chamber and measured at the same location and stand on a ferrite floor at fixed and relax positions. The subjects are also informed to limit their body part movement during measurement to reduce variation of reading frequency. Moreover, to enhance the data reliability, the ambient frequencies are measured immediately before and after experiment [20].



(a) Left (b) Right (c) Chakra

Figure 2. 23 points of human body [21]

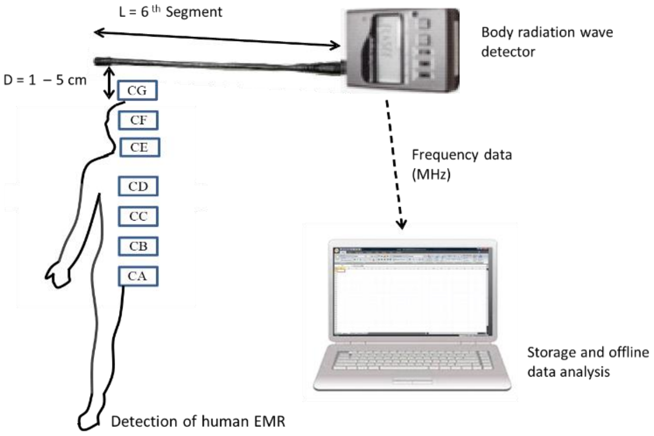


Figure 3. Frequency acquisition procedure

2.2. KNN Classification

The KNN algorithm is one of the preferred classification algorithms because it's simple and robust characteristics. It is a method for classifying samples based on closest distance in the feature space and a new sample is classified according to a majority vote of its neighbor. When a new sample is appeared, KNN classifier determines the k according to most similar class with the closest neighbor of training samples. For the criterion of distance metric, the default neighborhood setting of Euclidean is used to find closest neighbors. The Euclidean compute the root of square differences between two coordinates of test sample and training set sample. The Euclidean distance between two samples of testing, x_i and training, x_j is defined as (1) or the absolute distance between them is given in (2),

$$d_E(x_i, x_j) = \sqrt{\sum_{r=1}^{n}\left(x_{ir} - x_{jr}\right)^2} \quad (1)$$

$$d_A(x_i, x_j) = \sum_{r=1}^{n}\left|x_{ir} - x_{jr}\right| \quad (2)$$

where x_i, x_j are samples composed of n features, such that $x_i = \{x_{i1},\ldots,x_{in})$, $x_j = \{x_{j1},\ldots,x_{jn}\}$. The value of k determines the optimal number of closest neighbor, and typically k = 1 is considered as closest neighbor [22].

A method of data randomization is used for the classification where the datasets are randomly organized into training and testing sets and assessed at ratio of 7:3 [23]. For each training set, different values of k range from 1 to 15 are used to determine the optimum value of k that gives the best classification results. In this study, two classifiers for human body segments are studied, namely Classifier 1 and Classifier 2 to classify on male subjects and female subjects, respectively. Synthetic data is applied in the analysis to improve the number of samples and classify efficiently [24]. The synthetic data is generated randomly by modifying the original dataset for not more than 10%.

2.3. Evaluation of Classifier Performance

Various techniques could be used to compute and assess the performance of a classifier [14]. One of the widely used methods is ROC. ROC is a graphical plot of sensitivity and (1- specificity) and used to measure the performance of binary classification, which yields two discrete results such as positive and negative. In addition to classification accuracy, the primary measure of ROC is sensitivity and specificity. Sensitivity is the measure of actual positives that are correctly identified, while specificity is the measure of negatives that are correctly identified. Ideally, the optimal classification should yield 100% sensitivity and specificity, denoting that the classification for all samples is positive and negative in positive group and negative group, respectively. In the ROC plot, a single point on a ROC space designates the potential combination of sensitivity and specificity and could be used to evaluate the possible sensitivity and specificity for predictors.

Figure 4 shows an assessment of ROC plot demonstrating the regions of liberal and conservative. The diagonal line divides the ROC plot from the lower left hand to the top right hand corners known as line of reference. Good classification results are shown as points above the diagonal line, while points below the diagonal line produce worst results [15]. The regions of interest in ROC plot is recognized as conservative and liberal region [15, 25].

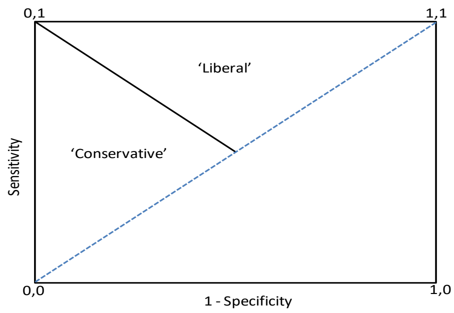


Figure 4. Assessment of ROC Plot [10]

3. RESULTS AND ANALYSIS

The results for the classification of body segment using KNN algorithm are discussed. Two classifiers are studied, namely, Classifier 1 and Classifier 2. The KNN classifier is trained for best value k which ranges from 1 to 15 to compare the results. Then, the accuracy, sensitivity and false positive rate are calculated for each value k. The performances of classification for each classifier are determined based on accuracy and ROC analysis. Note that in the ROC plot, the point is labeled only with the smallest number k value for any given point that overlaps in the same point at the ROC space.

3.1. Classifier 1

Figure 5 demonstrates the KNN classification results of classifier 1. The classifier achieves its best performance of correct classification when k = 1, which yields a 100% accuracy. The classifier also produced 100% classification for k = 2, while other values of k have an accuracy that varies from 50% to 85.714%, the lowest is found at k = 13.

When the points are located close to the top left corner of the ROC space, this indicates that the screening has reliably distinguishes the different body segments. In Figure 6, it is observed the classifier achieves its best performance and reliably distinguish body segments of Chakra, Left and Right at k = 1 and k = 2, where sensitivity is maximum and false positive rate is minimum. Hence, the classifier could be considered as ideal at k = 1 and k = 2. The results in Figure 6 also show the characteristic difference of classifying body segments for Chakra, Left and Right. The classifier is deemed as conservative when classifying Chakra and Right segments because all of the ROC space is found close to the top left corner as shown in Figure 6(a) and Figure 6(c). Referring to Figure 6(c), five of the ROC space are close to the top left corner of the space while the other ROC space are located in the middle of the left corner. Thus, positive classifications with strong evidence are obtained for Chakra and Right segment. However, in classifying Left segment, the classifier can be thought as conservative and liberal, as shown in Figure 6(b), because some of the ROC space are located in the middle of the left corner, while the other ROC space are located towards the top right-hand corner. In liberal region, it makes positive classification with weak evidence as it makes some false positive error.

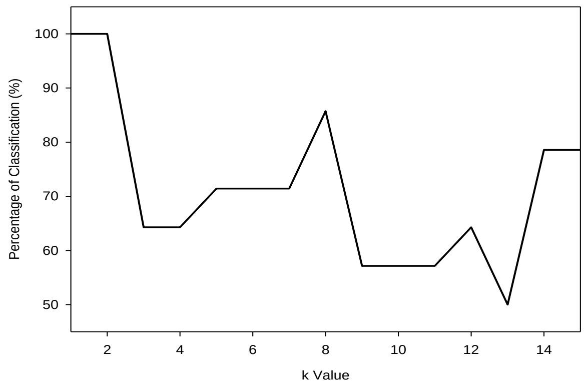
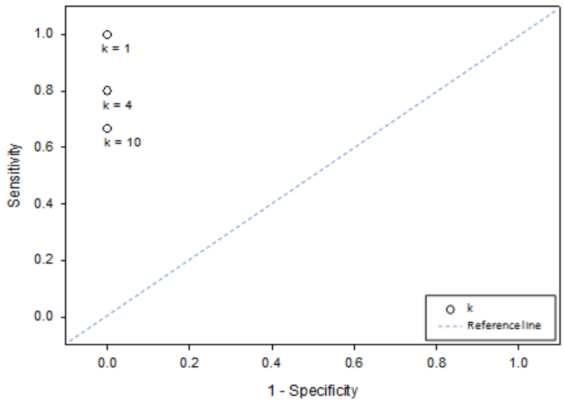
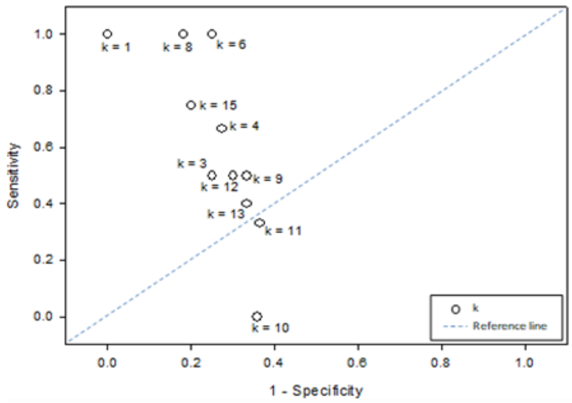


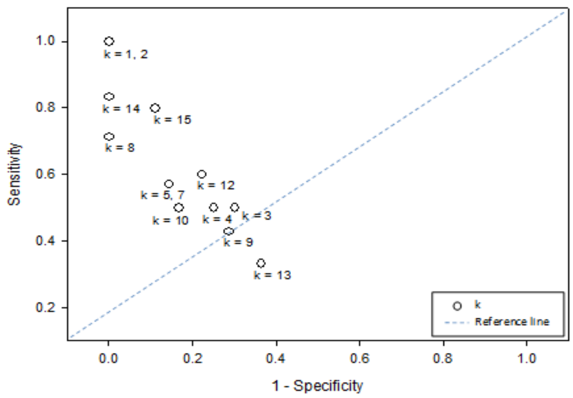
Figure 5. Percentage accuracy of classifier 1



(a) Chakra



(b) Left



(c) Right

Figure 6. ROC Plot of Classifier 1

3.2. Classifier 2

The classification results of the KNN on Classifier 2 are given in Figure 7. From the graph, it is observed that the KNN classifier achieves its best performance of correct classification when k = 1, which yields an accuracy of 100%. Also, the classifier produced 100% classification for k = 2. Other values of k produced an accuracy ranging from 57.14% to 85.71%, and the lowest accuracy are found at k = 5, 7, 11 and 13.

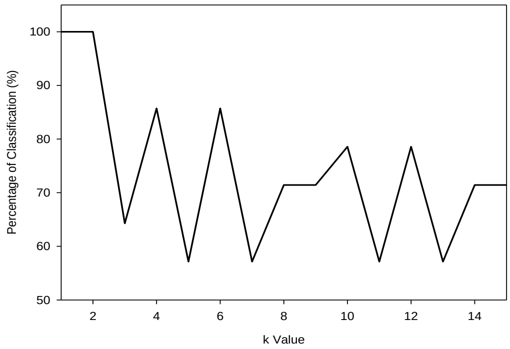
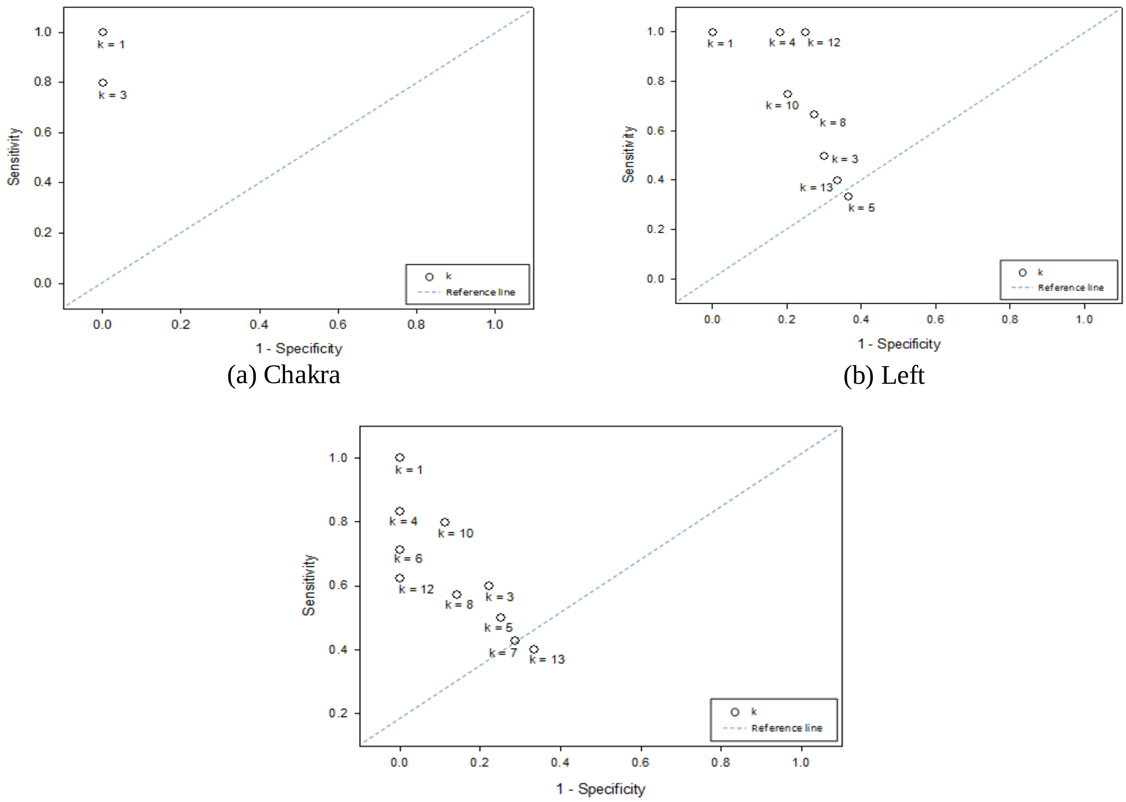


Figure 7. Percentage accuracy of Classifier 2

As noted in Figure 8, the classifier achieves its best performance and reliably distinguish body segments of Chakra, Left and Right at k = 1 and k = 2, with maximum sensitivity and minimum false positive rate. Hence, the classifier is considered as ideal at k = 1 and k = 2. The results also show the characteristic differences of body segment classifications for Chakra, Left and Right. For the Chakra, as shown in Figure 8(a), all of the ROC space are found close to the top of the left corner; for the Right segment, as shown in Figure 8(c), most of the ROC space are in the left corner, where seven of the ROC space are close to the top of the left corner and the other ROC space are in the middle of left corner. Hence, the classifier is conservative when classifying Chakra and Right segments as they make positive classification with strong evidence. However, in classifying the Left segment, the classifier is conservative and liberal, as shown in Figure 8(b), because some of the ROC space are in the middle of the left corner, while the other ROC space are in the top tending towards the right corner. In liberal region, it makes positive classification with weak evidence as it makes some false positive error.



(a) Chakra

(b) Left

(c) Right

Figure 8. ROC Plot of Classifier 2

The overall analysis for the values of k from 1 to 15, both classifiers are found to have higher specificity in most of the segments that indicates it able to differentiate their own segment better than others.

4. CONCLUSION

In this study, the KNN algorithm has been used to efficiently classify of human body segments among genders of Classifier 1 and Classifier 2, and the performance of classifications was evaluated based on accuracy and ROC analysis. The performance of Classifier 1 and Classifier 2 in each segment of the human body is examined. Both classifiers are shown produce almost similar results. Classifier 1 and Classifier 2 achieve their best performance for body segment classification at 100% accuracy, which suggests an ideal classification. All three human body segments of Chakra, Left, and Right were accurately identified which suggest that the KNN classifiers are capable of discriminating between segments. The finding indicates the frequency of human electromagnetic radiation can be used for human body segmentation. This approach has the potential to complement the existing techniques of human image segmentation for use in future surveillance applications.

ACKNOWLEDGEMENTS

The authors wish to express their appreciation to Universiti Teknologi Malaysia for supporting the research.

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