Human Identification using X-Ray Image Matching

Ryudo ISHIGAMI, Thi Thi Zin, Norihiro SHINKAWA and Ryuichi NISHII

Abstract—**Human identification both prior to death and after death is becoming one of the major worldwide issues nowadays for law enforcement aspect as well as social and security aspects. General identification prior to death is possible through comparison of many biometric identifiers. However identification after death is impossible using behavioral biometric such as speech and actions. Moreover, in many circumstances such as natural disasters, air plane crash or a case of identification a couple of weeks later, most of physical biometrics may not be useful for identification due to the decay of some soft tissues. A lot of research has been done in the field of different biometric modalities like Finger-print, Iris, Hand-Veins, Dental biometrics etc. to identify humans. However only a little has been known the chest X-Ray biometric which was very powerful method for identification especially during the mass disasters in which most of other biometrics are unidentifiable. Therefore in this paper, we propose a stochastic modelling approach for human identification after death by using chest X- Ray prior to death database. Some experimental results are shown based on real life dataset and confirmed.**

Index Terms— **Biometric identifier, Human behavior, Stochastic model, X-Ray image matching**

I. Introduction

IDENTIFICATION of human bodies is a key issue in today world. Legal forces and law firms are exploiting various types of biometrics such as fingerprints, DNA appraisal, dental treatment records, iris etc. to make postmortem identification.

According to the Code of Criminal Procedure, three of the available methods are considered to be reliable scientific procedures for identification: fingerprint analysis, dental record analysis, and genetic profiling. When reliable identification is impossible through these methods, others may be used to gain insight into it. Such cases may involve radiology as an essential tool throughout the identification process. For example, in the case of mass disasters such as big earthquakes, tsunami and fires unidentified human bodies are appeared in various forms in fronts of doctors and prosecutors. There include persons who never had a dental treatment, damage DNA records, invisible finger prints. For such cases, it is difficult to confirm one's identity. There have been a lot of evidences at the time of the crash of Japan Airlines 123 flight in 1985. Since the delaying discovery corruptions and damages were occurred so that identification of dental findings, fingerprint collation, DNA verification becomes difficult. Specifically, in the case of the Great East Japan Earthquake, about 500 hospitals, etc. were dispatched for doing an examination, etc. about 15,824. Among them, 15,749 entities have been identified for identity confirmation. According to statistics identity verification in case of being involved in an incident or accident, collation is carried out comprehensively judging tooth treatment medical record, fingerprint collation, DNA collation, clothing, a residue article and the like.

The identification systems at the time of the earthquakes disaster, include the followings:

(i) Confirm existence of blood donation facts, Confirm intention of offer request. Confirmed by the Japanese Red Cross Society that blood specimens are preserved. Receipt of blood specimens (if stored), and reconciliation.

(ii) Confirmation of documents directly related to himself, such as umbilical cord, diary, tooth treatment record etc., fingerprint detection, DNA type inspection, dental chart preparation.

(iii) Judgment in combination with other information such as collection of oral cavity cells, DNA type examination, physical characteristics, clothing, personal belongings etc.

However, more unidentified bodies needed for identification so that tremendous effort is required. Although it is necessary to allocate more personnel to rescue work to save as much as possible than to allocate personnel to verify identity immediately after the earthquake, as time goes on, identification work become more difficult to create more problems. Therefore, in this paper we propose a stochastic modeling method using radiograph and CT scan images for identifying human beings after death based on image processing technology. It is also reasonable for choosing an X - ray photograph as reference data before life, since one time or another everybody has been checked for their health with X-Ray images.

For almost all people, a chest X-Ray is taken admission to school and joining the company, every time a medical checkup or medical examination of a human is taken, and these data are obliged to be stored in a medical database. Also, it is bone which is the most robust and corruption-resistant part of the body that can be obtained with X-ray and CT scan

Manuscript received January 31, 2017; revised February 14, 2017. This work was supported by JSPS KAKENHI Grant Number 15K15457.

Ryudo Ishigami is with Department of Electrical and Systems Engineering, Graduate School of Engineering, University of Miyazaki, Miyazaki, JAPAN.

Thi Thi Zin is with Department of Electrical and Systems Engineering, Faculty of Engineering, University of Miyazaki, Miyazaki, JAPAN. (Corresponding author, phone: +81-985-58-7411; fax: +81-985-58-7411; e-mail: thithi@cc.miyazaki-u.ac.jp).

Norihiro Shinkawa is with Department of Radiology, Faculty of Medicine, University of Miyazaki, Miyazaki, JAPAN.

R. Nishii is with Department of Diagnostic Imaging Program, Molecular Imaging Center, National Institute of Radiological Sciences, Chiba, JAPAN.

images at the time of medical examination for the chest. Thus, identification of an identity becomes possible even if identity confirmation by tooth treatment record is impossible. It can also be expected to prevent human error when visually checking for a long time. As an operation method when this program is actually completed, a CT scan image is performed on the unknown body to obtain a query image. Then, using the obtained data, a database is created from a hospital within a range where it is considered that an unknown identity body had been living beforehand, and a matching process is performed between the database and the query.

The purpose of this paper is to develop an algorithm that creates a database using chest X - ray photograph and matches with CT scan image after death and creates ranking with similar chest radiograph. The processing here consists of three major processes: "feature extraction", "matching process" and "ranking". We organize the paper as follows. In section 2, we describe some related works. We present the system overview including feature extraction process, the contents of feature quantities and matching process in section 3. The experimental procedures and results are discussed in section 4 followed by conclusions in section 5.

II. Some Related Works

Several researchers have shown valuable methods in a variety of forensics applications including identification process when the common used methods have failed to perform good jobs [1, 2]. In this concern, radiology techniques such as X-Ray and CT images matching techniques have been played important roles. Chest x-ray images have also been studied for visual monitoring system and surveillance by other researchers [3]. Two of the prior studies relied on rule-based keyword search approaches. In another study, chest x-ray images are applied supervised classification to identify chest x-ray reports consistent with visual surveillance [4-5]. In our work, different from prior research, we proposed a fully statistical approach where (1) the content of chest x-ray images are represented by extracted features (2) statistical feature selection was applied to select the most informative features, and (3) matching analysis was used to enrich the extracted features.

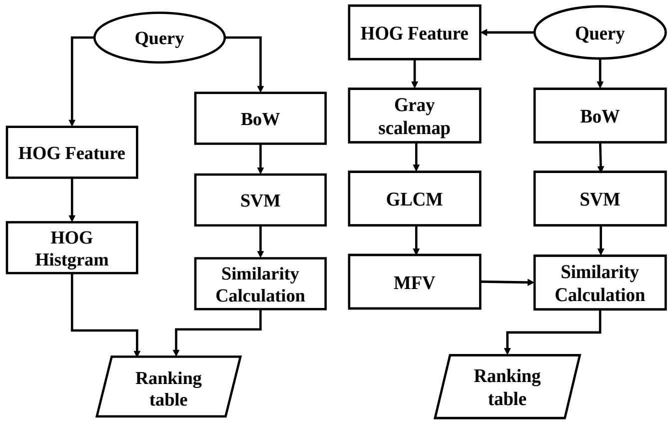
III. Overview of Proposed Method

The proposed method for human identification by using chest x-ray images consists of two level feature extraction process for both database and query x-ray images, computation of similarity measures and decision making process for ranking potential images. The overview of the proposed system is described in Figure 1 (a) and (b).

A. The Proposed System with Level 1 Feature Extraction

We first extract Histogram of Orientations of Gradients (HOG) feature and Bag of Words (BoW) feature from chest radiographs for all x-ray images in the database considered.

Similar features are also extracted for query image. Then a feature database for feature vectors are created for all images in the database. We then obtain similarity scores between query image and images in the database by using BoW



(a) (b)

Fig. 1. Overview of Proposed Method.

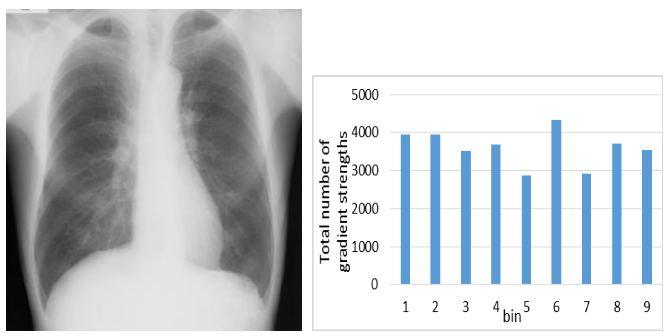
classifier. Finally, the ranking is performed by using Euclidean distance among the resultant scores.

It is worthwhile to note that during extracting the HOG features process due the use the brightness gradient, large noise occur if the entire photograph is whitish and blurred or shadows appear large. In addition, even when the blank area in which the human body does not show occupies a large area, the accuracy of matching is remarkably lowered. Figure 2 and 3 show examples in which the original image is actually blurred no feature appears in the histogram an example is shown in Figure 2 (a) and Figure 2 (b). In order to improve the Level 1 feature extraction process, we move forward to proceed to Level 2 process by adding Markov Feature Vector developed for object image retrieval [7].

B. The Proposed System with Level 2 Feature Extraction

In this level 2, after finding the HOG feature amount, a grayscale map of nine gradations (0 to 8) was generated using the maximum bin value in each block without obtaining the HOG histogram. Figure 2 (a) and (b) show examples of the original image and the HOG feature vector respectively. From the grayscale map, it can be seen that the shape of the original data is blurredly captured and then Markov Feature Vector (MFV) is generated as follows. An improved block diagram is shown in Figure 1(b).

Let P ($k \times k$) be the GLCM at an angle, then P in one direction is given by the equation.



(a) (b)

Fig. 2. (a) Bright overall and Light in ribs, (b) Example of HOG histogram

ISBN: 978-988-14047-3-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

$$C = C_{(i,j)} \quad (1)$$

$$P_{(i,j)} = \frac{C_{(i,j)}}{\sum_{j=1}^{K} C_{(i,j)}} \quad (2)$$

GLCM in all 8 directions can be expressed as π = πP where π is defined as MFV.

C. Euclidean Distance as Similarity Measure

We calculate similarity using Euclidean distances between features extracted from each chest radiograph stored in the database using MFV and BoW score obtained from the query image. In this paper, we used an expression where MFV of query image data is x_m, image data in database is y_m, BoW score of query image data is x_b, image data in database is y_b, and distance is D.

$$D = \sqrt{200(x_m - y_m)^2 + 50(x_b - y_b)^2} \quad (3)$$

Now we will describe the ranking evaluation method of the matching result which includes a method of finding the Bull's eye score and relevance rate, a method of finding the recall rate, etc. However, due to the characteristics of this experiment, multiple chest radiographs and CT scan images are collected per person.

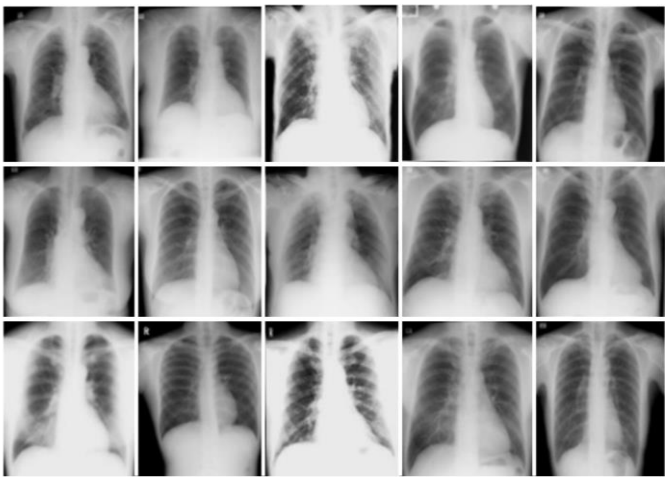
IV. Experiment and Experimental Results

In order to perform the experiment for the proposed method 27 subjects who had preserved pre-mortem data and post-mortem data were collected from data stored in the database of Miyazaki University School of Medicine. The data of each subject before and after death was used. Experimental data was saved in DICOM format, and processing was performed on captured images of each data. Figures 3 (a) and (b) contain the actual images of before and after death. The chest radiographs were all 2470 × 2470 in resolution, and the CT scanned images were all 256 × 256 in resolution. ID1 and ID2 are orderly allocated from the upper left in Figure 1 and the IDs correspond to the same person before and after death, respectively.

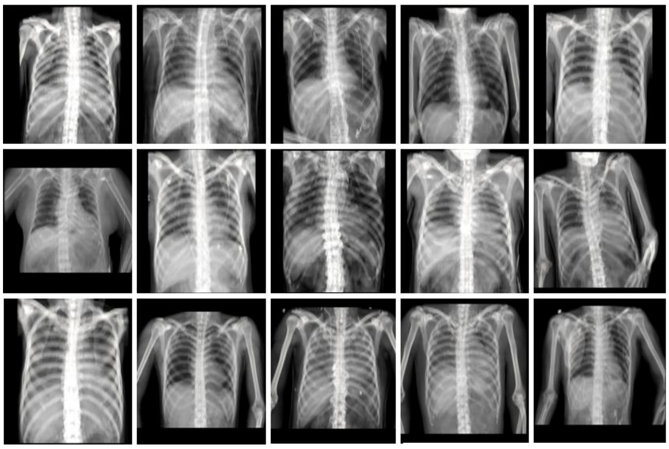
First of all, a database was created using all of the images in Figure 3(a). Subsequently, the image of Figure 3(b) was actually entered into the program as a query. As a result, 16 out of 27 people whose output result was in the 10^{th} rank were 16, and the average rank was 9.5. Although there was no example in which the correct answer image was displayed at the lowest position among all the data, the result with the lowest ranking was the 24^{th} in ID 9. In the output data, the top 15 scores of the 27 people are displayed in order, and the correct score is displayed as the True tag, while the calculated score is displayed for the incorrect score. Figure 4 (a) and Figure 4 (b) show examples in which the best ranking could be output, and Figure. 4 (c) shows an example in which the correct answer image could not be represented in the top 15 places. In addition, as a stable part in the same way, the experiment using only the part of the sixth rib and above was performed, and the average ranking was 10.6 and 15 was in the top 10 within 15^{th} place. Table I shows the accuracy of the correct answer image within the top 10 of each method.

Table. I. Experimental accuracy

Method	First feature (%)	Second feature (%)	Accuracy (%)
[HOG histogram, BoW]	18.5	51.9	44.4
[MFV, BoW]	48.1	51.9	59.3
[Steady MFV, Steady BoW]	59.3	40.7	59.3
[Steady MFV, BoW]	59.3	51.9	63.0



(a)

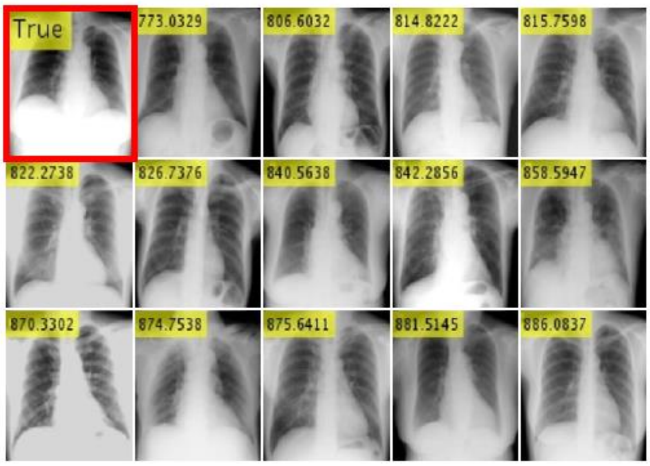


(b)

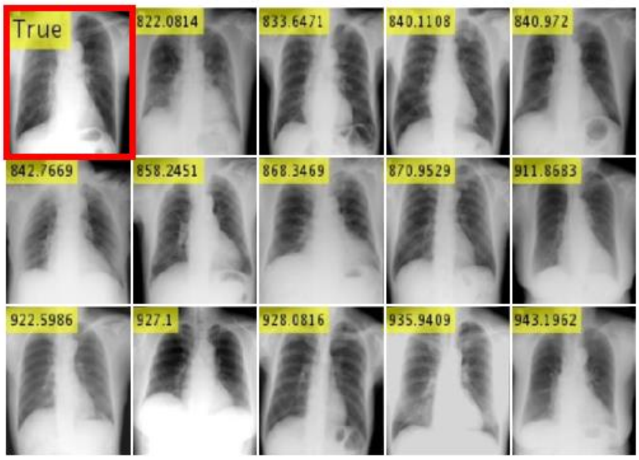
Fig. 3. (a) Old Chest X-ray Photograph. (b) CT Scan Image after Death

Also, as a feature of the data with low ranking, it is the case that an overall X-rayed X-ray picture is used as a database. In this case as well, it is considered that the feature amount used this time greatly depends on the luminance. The average ranking when ranking was carried out using each feature quantity alone was 11.2 in MFV stand alone and 11.1 in BoW alone. It turns out that combining these two leads to an improvement in the final ranking. Also, by using the stable part, we attempted to improve the ranking, but compared with using all parts, the ranking declined slightly but the ranking did not decrease greatly, the extracted part we have found that it has a big influence on ranking. However, since the current trimming is based on the basic skeleton and the coordinates are determined and all the images are mechanically cut out, there is a possibility that the part cut out for each image may

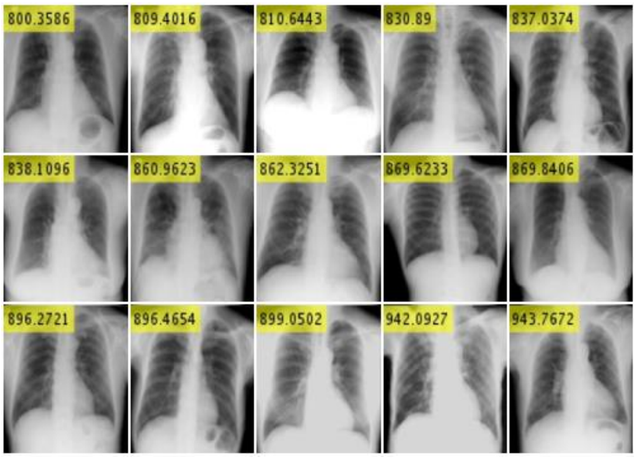
ISBN: 978-988-14047-3-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)



(a)



(b)



(c)

Fig. 4. (a) ID 23, (b) ID 27, (c) ID 19.

differ little by little, if it becomes possible to cut it for each part of the bone instead of the coordinate, the result may be changed greatly.

V. Conclusion and Discussion

In this paper, we have proposed a method to score and output the similarity score based on the chest X - ray photograph of the birth, using a CT scan image of the corpus as a query, and conducted an experiment to confirm its effectiveness. Since the DICOM format is a RAW image, it is possible to adjust the contrast and the brightness, so if the parameter adjustment can be automated, the variation in the result due to the contrast difference may be suppressed. Also, since the resizing performed at the beginning of the experiment is all currently done manually, there is a possibility that the order change may have occurred by resizing. Regarding this, we also plan to implement an automation of resizing. Because the purpose of resizing is due to the difference in resolution and scale between the CT scan image and the X-ray photograph, when CT scan of the corpse is performed, the pose and the size as the reference at the time of photographing such as the position of the arm and the size of the rib If it can be unified, we think that it will not be necessary to resize, which will lead to an improvement in accuracy.

Regarding the development of an algorithm to create a database using chest radiographs, matching with a CT scan image after death, and creating a ranking with similar chest radiographs, 27 subjects The average ranking of the experiments performed on the experiments was within 10th place, depending on future improvements such as increasing experiment data and using new features, in addition to means such as fingerprints, tooth treatment charts and DNA collation, It can be said that identity verification using the CT scanned image can be sufficiently realized.

Future prospects include automation of image resizing currently performed, automatic setting of parameters such as luminance contrast information, experiments using the proposed method for larger scale data, and extraction of new feature quantities. Therefore, if it is possible to find more extractable feature quantities and combine those with the current method, further improvement in ranking can be expected. Furthermore, by increasing the number of feature quantities, it is also expected that countermeasures can be taken in cases where the influence of noise is greatly influenced by one feature amount and the overall ranking is greatly lowered.

References

[1] Byard RW, Both K, Simpson E. The identification of submerged skeletonized remains. Am J Forensic Med Pathol. 29(1), pp. 69-71, Mar. 2008.

[2] Bilge Y, Kedici PS, Alakoç YD, et al. The identificatión of a dismembered human body: a multidisciplinary approach. Forensic Sci Int., 137:141-6, 2001.

[3] Guillermo Andrés Montes Loaiza, Andrés Felipe Otálora Daza, Guillermo Andrés Archila., Applications of conventional radiology in the medical forensic field. Rev Colomb Radiol., 24(4): 3805-17, 2003.

[4] Bejan CA, Vanderwende L, Xia F, Yetisgen-Yildiz M. Assertion Modeling and its role in clinical phenotype identification. J Biomed Inform., 46(1), pp. 68-74, 2003.

[5] Bejan CA, Xia F, Vanderwende L, Wurfel M, Yetisgen-Yildiz M. Pneumonia identification using statistical feature selection. J Am Med Inform Assoc., 19(5):817-23, 2012.

[6] M. Yetisgen-Yildiz, C.A. Bejan, M.M. Wurfel. Identification of Patients with Acute Lung Injury from Free-Text Chest X-ray Reports. Proceeding of BioNLP Workshop of ACL'2013, 2013.

[7] Thi Thi Zin, Pyke Tin, T. Toriu, H. Hama. Dominant color embedded Markov chain model for object image retrieval, Proc. of 2009 Fifth Intl. Conf. on Intelligent Information Hiding and Multimedia Signal Processing (IIH-MSP 2009), pp.186-189, Kyoto, Japan, 2009.