A Genetic Type – 2 Fuzzy Logic System for Human Identification in Craniofacial Superimposition

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Abstract—One of the most research areas in forensic science is human identification, because now a day’s identification of missing person is a very challenging issue. For that reason we introduce the Craniofacial superimposition is a forensic identification technique which identifiy the person from the photographs or video shots are compared with the skull for accurate identification of person. Our proposed work identifies the person by the craniofacial superimposition technique. Here we implement the skull - face overlay process for human identification. Our proposed work performs the skull - face overlay process by the Enhanced-Robust 3D Point Matching [ER-3DPM] algorithm which identify the person by the matching the points in skull with the photograph of person. For accurate identification of person our proposed method performs the validation process by the genetic algorithm and type 2 fuzzy set. Finally our proposed work analyses the performance with the parameters of accuracy and execution time.

Keywords—Human Identification, Skull-Face over lay, Validation , Type 2 fuzzy sets.

I. INTRODUCTION

The methods used to identify the missing person from the skull information have been under continuous investigation in forensic medicine field. Cranioface superimposition is the one of the approach for identify the cranioface. Craniofacial superimposition which performs the super imposes the skull on to the image and analyses the morphological features. Several craniofacial superimposition methods have been proposed [1, 4, and 5]. Paper [1] was proposed the craniofacial superimposition method which solves the many global optimization problems and which have more interesting properties for faster reconstruction. This approach performs the skull overlay process for human identification. In paper [4] introduce the two new variant for automatic skull face overlay process for craniofacial superimposition method. here we have modeled the imprecision associated with facial soft tissues depth in cranial and facial landmarks by using these landmark points identify the person. Computer aided craniofacial superimposition method which identifies the human by using the computer aided technique. Here craniofacial superimposition involves the two fold process, such as landmark setting and skull-face overlay process. In computer aided technique landmarks setting and overlay process of skull and face both are done by automatically. Here skull overlay process is repeated until process the all photographs in dataset which is adjust the size and orientation of skull physically [5]. Real code genetic algorithm introduces the fast automatic super imposition method. This approach considers the time consuming of overlay process of 3D skull to 2D photographs. Here synthetic data are used for validate the method. for fast super imposition process we implement enhancing of three methods such as improvement of registration transformation, use of real code scheme and design the better GA components [2]. Soft computing means combination of emerging problem solving technology which includes the fuzzy logic, probabilistic reasoning, neural networks and genetic algorithm. These soft computing technologies were used for the cranio face super imposition method. Here fuzzy controls the genetic algorithm and neural networks for this we identify the missing human [3].

Image registration is the one of the process of super imposition method. Image registration is the overlaying the two or more image which is same scene taken from different views at different times here author focus the image registration by classify the image. Here we classify the image area based and feature based. Four basic steps for image registration such as feature detection, feature matching, mapping function designing and image transformation [6]. More over all techniques leads to high complexity and proposed more difficult for super imposition method. Summary of key contributions, craniofacial superimposition method is one of the complex forensic techniques that aims to identify the missing person from the photograph and the skull found.
Our proposed work provides the craniofacial superimposition method which has two step of process for human identification.

2. We first implement the skull overlay process by using the Enhanced- Robust 3D Pointing Matching [ER-3DPM] algorithm which overlay the 3D skull to 2D photographs

3. Second our proposed work implement the validation process by using the genetic algorithm and type 2 fuzzy sets

4. Finally our proposed work analyses the accuracy and execution time of craniofacial superimposition method.

In the following section we discuss about section 2 related work, section 3 gives the problem formulation section 4 illustrates the proposed method, section 5 explains the experimental results, and finally in section 6 we conclude the our proposed work.

II. RELATED WORK

In recent years several craniofacial superimposition techniques are introduced, in this section we discuss about the previous work related to the craniofacial superimposition method. Morpho-analytical approach was an arthroscopic method which evaluating the shape correlation between the skull and photographs. Here when applied the conjoint of skull we implement the superimposition which increase the reliability [10]. In [9] author was proposed three methods for superimposition such as basic landmark matching, morphological matching and combining of both approaches. By these methods identify the human. David garrido et al [16] was proposed the two human identification methods that is developed by the skull template. This approach achieves accuracy only 80%. Advanced 3D computer based cranio superimposition method consists of three consecutive steps for identification of human, they are face enhancement and skull modeling, and skull face overlay process and decision making. We implement the face enhancement and skull modeling by the acquisition and processing of anti-mortem of photographs which together the landmark points of skull and face. Second this method develops the skull-face overlay process by using the adjustment of size and orientation of skull. This process focuses to identify the single ante-mortem missing person. Finally we implement the decision making process which finds the degree of similarity in skull and photographs. This phase shows the identified person missing person or not [4]. Author [5] was proposed the computer aid craniofacial superimposition method. Here craniofacial superimposition method comprise the three fold, first digital model of skull and enhance the face by using the computer vision technology which model the skull and enhance the image automatically. Second automatic skull-face overlay method which finds the optimum superimposition between the 3D model of skull and 2D face photographs by using computer programs. Finally we take the decision of resulting image whether its correct person or not. LSSVR is the novel frame work which develops the statistical model for skin and skull. This model involves the cross validation process for each parameter selection. Here statistical model designed by PCA [Principal Component Analysis]. In PCA process we evaluate the variation of minor and major modes of shape in skin and skull images. Finally LSSVR achieves the 99% accuracy but here the error rate and time consuming of identification of person is too high. Here deviation between the reconstructed image and original image also high [19].

Oscar ibanez et al [7] was proposed the new approach for craniofacial superimposition method. Here we identify the human by using the fuzzy location of cephalometric landmarks. Author focuses the some significant features between the different nationalities. craniofacial superimposition method uses the two land mark points such as cephalometric and craniometric because it tackles the inherent matching of uncertainty problems, fuzzy sets are improves the performance of skull overlay process by 20 sec. This process not performs the any validation process [9]. Image registration is the one of the process of skull face overlay process [6] here image registered by the four step of process. First we detect the feature by using the distinctive the salient features of object such as closed-boundary regions, edges, contours, line intersections and then we matching the feature in this step matching the feature detection image to reference image, third we implement the transform model estimation, here we align the image correspondence to the reference image. Finally we develop the resampling and transformation which compute the non-integer values by using some interpolation techniques by using these four step of process we detect the missing person.

III. PROBLEM FORMULATION

Most of the previous approaches have focused the determining the missing person in craniofacial superimposition method which identifies the person from the 2D photographs and skull found. In all existing approach process the skull-face overlay by manually.ie physically moving the skull until the real face found. In [4] author introduces the craniofacial superimposition method by using the four step of process for achieves the minimum error rate. But this method increases the high execution time. Because it impose the skull –face process by using the traditional adjustment method which adjust the skull physically until the original image found since it leads the high execution time.
The above equation shows the distance between the fuzzy landmark points, which is found during the skull overlay process for matching the skull image. It leads to high execution time. In [2] authors have introduced the soft computing techniques which includes the genetic algorithm and neural networks for craniofacial superimposition method. Here, author uses the two sets of landmark points such as cranial and facial from these points construct the transformation model and matching the image. The equation shows the final results of the system

\[ F = C \cdot (A, D_1, D_2, D_3^{-1}, A^{-1}), S, T, M, P \]  

In this process, two sets of landmark sets and transformation model was used for superimposition method which leads to high calculation time more than 12 sec. To overcome the above problems, we have to propose the novel algorithms for craniofacial superimposition method.

IV. PROPOSED WORK

3D craniofacial superimposition is the forensic process in which photograph a missing person is identify by using the comparison with the skull found. Our proposed work identifies the human from the skull and 2D photographs. Here we identify the number of reference points in both skull and 2D face. Our method uses the various components for human identification process; the components are shown in below figure 1. Here we required the 3D target skull image, 2D unknown photographs and 13 set of reference points in skull image which are stored in morph database. It is craniofacial longitudinal Morphological Face Database which is presently comprises 55,134 images of 13,000 individuals.

Our proposed work has the various stages for craniofacial superimposition method such as 3D homographic module, matching module, and feature extraction and validation process. In our proposed work inserts the 13 reference points in skull manually and 2D photograph we insert the 13 reference points by using the feature extraction. By using the feature extraction we apply the 2D-3D registration because here the photograph is 2D and the skull is 3D. For that reason we apply the 2D-3D registration here the reference image taken from the morph database. Our proposed work performs the 2D-3D registration by the following three steps,

1. We get the input 2D image from MORPH database.
2. Inserts the points on 2D image
3. We register the 2D-3D image by using the local features such as nose, eyes, lips and forehead points,
Figure 2 illustrates the stages of feature extraction. We detect the points from 2D face to 3D skull image, and the figure shows the 13 reference points of the 2D photographs.

The location of the face features such as eyes, nose, lips and forehead points. Here we shows the areas of where the eyes and nose are located is used to estimate the position of the 13 points. For example, landmark A is calculated by taking the middle point between A1 and A2. Point B is calculated by taking B3 and B7. Point C is the midpoint between C5, C6, C12 and C8. D is calculated by taking the mid pits of the D9, D10 and D11 and D13, and finally E is considered by taking the E4 and C5.

A. 3D Homographic Module

Our proposed work has the first stage homographic module which estimating the points of the skull and photograph. The estimation of points on skull and photograph is necessary because the calculation of correlation between them. If face of the photograph is not in a correct position correlate the 3D points of the skull with the 3D points of the human face. The homographic module performs the correlation between the skull and skin with 13 reference points.

Let 3D points of cranial landmarks is defined as the $C = \{C_1, C_2, C_3, ..., C_n\}$ and 3D points of 2D photograph face is defined as $F_h = \{F_1, F_2, F_3, ..., F_n\}$. From that points we constructed the homographic module [HM] and correlate the points on 3D skull and face.

$$X_I = \frac{C - m(C)}{s(C)} \quad (3)$$

Equation (3) shows the 3D skull image, here $m(C)$ represents the mean values of the image and $s(C)$ is the variance of the image.
\[ Y_i = \frac{F_i - m(F)}{s(F)} \quad (4) \]

The above equation illustrates the 3D skin image here \( m(F) \) represents the mean values of the image and \( s(F) \) is the variance of the image.

The mean equation are shown below,

\[ m(C) = \frac{1}{n} \sum_{i=1}^{n} C_i \quad (5) \]

The above equation shows the mean cranial points for the skull image, similarly we calculate the mean value for face image.

\[ s^2(C) = \frac{1}{n-1} \sum_{i=1}^{n}[C_i - m(C)]^2 \quad (6) \]

\[ \sqrt{s^2(C)} = s(C) \quad (7) \]

Equation 6 and 7 shows the variance of the cranial skull image. Similarly we calculate the variance in skin image points.

Figure 4 shows the correlation of 3D cranial and skin points in homographic module which correlate the face and skull.

**B. Matching Module**

Our proposed method deals the matching problem in different way. Here we solve the problem of matching in two point’s sets in surface. Matching process is use the common algorithm for solving this problem we provides the solution of 3D point matching. Our proposed work matching module calculates the degree of correspondence which means how similarity between the 3d skull and face points. The degree of correspondence calculated by using the points of homographic module.
Algorithm 1 for Enhanced Robust 3D Point

Algorithm 1 shows the Enhanced robust-3D point matching [ER-3DPM], here we detect the matching degree of the 3D skull and facial points in photographs. Our proposed work matching the points by using the skull overlay process which uses the ER-3D algorithm.

C. Validation Process of Skull and Face

Our proposed work performs the validation process by using the genetic algorithm with type 2 fuzzy sets. Here we implement the global population based optimizers by using the genetic algorithm. After initializing the genes present in chromosomes Genetic algorithm has the four step of process. Estimating the fitness level for each membership function which is calculated for all chromosomes. Here select the best fuzzy output which means select the best chromosomes based on best fitness function. Perform the crossover and mutation function for select for the selected chromosomes. Finally we select the best chromosomes.

The purpose of this work is to utilize the high capability of T2FISs which is achieved by the combination of genetic algorithm with the type 2 fuzzy sets. This algorithm provides solution for low accuracy and uncertainty error issues. Because our proposed work combines the two soft computing techniques includes as the fuzzy and genetic algorithm. The figure shows the architecture of type 2 fuzzy sets.

Type 2 fuzzy interference system uses the three important components first fuzzifier which is interference engine and fuzzy rules finally output is the type reducer and defuzzifier. In type 2 fuzzy process fuzzifier convert the crisp input into fuzzy set input and fuzzy set characterized by the μa(x) membership function. Here x is the primary member function. Here we calculate the uncertainty in the primary memberships of a type-1 fuzzy set, which consists of a bounded region that we call the “Footprint of Uncertainty” [FOU].
From this footprint value we evaluate the upper and lower membership function of type 2 fuzzy sets as given below

\[ \tilde{\mu}_A = \frac{F_OU(A)}{\forall x \in X} \]  
\[ \mu_A = \frac{F_OC(A)}{\forall x \in X} \]

The type 2 fuzzy sets Mamdani IF-Then rule is shown below

Rule Ri: If \( X_1 \) is \( A_{i1} \) and \( X_n \) is \( A_{in} \) then \( Y \) is \( B_i \)

Here \( R_i \) represent the fuzzy rules for each points in \( n \) dimensional, \( A_{i1} \)…..\( A_{in} \) are the ascending fuzzy sets. In type 2 fuzzy sets are compares the size of each output, which estimate the smaller medium and larger these linguistic terms are presented in type 2 fuzzy set rules. Here we predict the fuzzy set from chromosomes which is estimated by the genetic algorithm.

![Type 2 fuzzy systems](image)

**Fig. 6 Type 2 fuzzy systems**

Figure 6 shows the typical fuzzy set systems which contains the basic components of fuzzy. Here we reduce the fuzzy set by using fuzzy type reducer which reduce the fuzzy set and gives to the defuzzier which produce the output set of fuzzy.

<table>
<thead>
<tr>
<th>Membership function input parameter 1</th>
<th>Membership Function input parameter 2</th>
<th>Membership function input parameter n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Membership function</td>
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</tr>
<tr>
<td>input parameter 1</td>
<td>input parameter 2</td>
<td>input parameter n</td>
</tr>
</tbody>
</table>

**Fig. 7 Chromosome structure**

Figure 7 illustrates the chromosome structure of fuzzy set which is take the input from the fuzzy set. The below graph shows the membership ascending order values.

![Membership function of fuzzy set](image)

**Fig. 8 Membership function of fuzzy set**
Figure 9 shows the structure for type 2 fuzzy set which is used the mamdani rule, our prosed work use the mamdani rule for validation process.

V. EXPERIMENTAL RESULTS

Our proposed method implemented by using the mat lab software, this paper proposes the cranio face super imposition technique for human identification from 3D skull to 2D face. In following sections we discuss about our proposed work evaluation results.

A. Craniofacial Superimposition

Our proposed work evaluate the accuracy and execution time of the validation process which proves our proposed work efficient than the other methods.

B. Experimental Setup

Our proposed work use the MORPH data base which consists of numerous image that means which contains the meta data for each person such as age, gender, height, race, eye coordinates etc., MORPH data base which contains the 55,134 images of 13,000 individuals.

C. Evaluation Results

<table>
<thead>
<tr>
<th>Methods</th>
<th>Accuracy Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>David Garrido et al [16]</td>
<td>80</td>
</tr>
<tr>
<td>Fuqing Duan et al [17]</td>
<td>94</td>
</tr>
<tr>
<td>Proposed work</td>
<td>97</td>
</tr>
</tbody>
</table>

Above table 1 shows the accuracy results for our proposed work. Here we compare the accuracy results of our proposed work with the previous work.
The figure 10 illustrates the accuracy comparison results; our proposed work provides the better accuracy [97] compared with the other methods.

### Table 2: Analysis results for the execution time

<table>
<thead>
<tr>
<th>Methods</th>
<th>Execution Time [sec]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuzzy Logic [7]</td>
<td>2-4 minutes</td>
</tr>
<tr>
<td>Genetic Algorithm [7]</td>
<td>20-40 seconds</td>
</tr>
<tr>
<td>CMA-ES [14]</td>
<td>15-17 seconds</td>
</tr>
<tr>
<td>Proposed method</td>
<td><strong>8-10 seconds</strong></td>
</tr>
</tbody>
</table>

Table 2 shows the analysis results for the execution time, our proposed work provides the 8-10 seconds for identify the human by using the craniofacial superimposition method.

![Fig. 11 3 Comparative results for execution time](image)

Figure 11 explains the execution time analysis, here our proposed work provides the minimum execution time for human identification compared than the previous works.

### Table 3: Results of our proposed work

<table>
<thead>
<tr>
<th>Method</th>
<th>Accuracy</th>
<th>Execution time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Craniofacial Superimposition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matched Accuracy</td>
<td>97</td>
<td>Matched</td>
</tr>
<tr>
<td>Not Matched Accuracy</td>
<td>47</td>
<td>Not Matched</td>
</tr>
<tr>
<td>Matched</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Not Matched</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Above table shows the overall results of the our proposed work which shows the accuracy and execution time for matched and not matched process.

### VI. CONCLUSION

The main focus in forensic anthropology is the identify the human from skull information. Craniofacial superimposition is the one of the approach for identify the cranioface which identify the human by using the superimposition of a skull compares on a number of ante mortem images of a missing person morphological correspondence. Our proposed work identifies the human by using the skull - face overlay process. Here we super imposition the skull over the face by using the Enhanced Robust 3D Point Matching algorithm [ER-3DPM] which correlates the morphological points in 3D skull with 2D face.

We implement the validation process for the accurate identification of person; here we apply the genetic algorithm with the type 2 fuzzy set. For this combined process of validation we achieve the maximum accuracy for human identification. Finally our proposed work analysis the performance of craniofacial superimposition with the parameter of accuracy and execution time. In future direction we have planned for investigate the more number of morphological features for skull overlay process. In addition we design the validation process with the one soft computing technique.
REFERENCES


