University of Houston

MUG FILE PROJECT REPORT NUMBER UHMUG-11

Forgery Application of a Pattern Recognition Algorithm for Facial Images

B. T. Rhodes and K. Prasertchuang

This project was supported by Grant Number 76-NI-99-012 awarded by the Law Enforcement Assistance Administration, U. S. Department of Justice, under the Omnibus Crime Control and Safe Streets Act of 1968, as amended. Points of view or opinions stated in this document are those of the authors and do not necessarily represent the official position or policies of the U. S. Department of Justice.

MUG FILE PROJECT REPORTS

UHMUG-1 Summary report for a Research Project *"A Man-Computer System for Solution of the Mug File Problem"*.
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UHMUG-2 *An Analysis of Procedures for Generating Facial Images*
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UHMUG-3 *Factors Affecting Facial Recognition*
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UHMUG - 11

FORGERY APPLICATION OF A PATTERN RECOGNITION ALGORITHM FOR FACIAL IMAGES

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Houston, Texas

June 1977

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ABSTRACT

This report considers the application of a pattern recognition algorithm to the problem of matching photographs of the same individual in a set of photographs that are available to Forgery investigators. Some of these photographs will not be in the standard mug shot position required for the algorithms in UHMFS. A rotation procedure is presented which standardizes the needed distances to the mug shot position. Empirical results are presented which indicate the amount of rotation of the head permitted before a non-standard photograph could not be used and an estimate of the percent of these photos a Forgery unit would have is made.

This is predicted to be a promising area of application and a brief description of future possibilities is included.

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ACKNOWLEDGEMENTS

Detective John Baxter of the Houston Police Department Forgery Division has been a constant source of help during this study. Other members of HPD have also helped. Sharon Neyland and Verla Malik took the measurements in HPD's Forgery file. Kimball Sumney and Janet Parker did the computer work and Ken Zingrebe served as contact with HPD during our field trial. We are grateful for the good work done by all.

Ben T. Rhodes
Project Director
June 1977

SUMMARY

The problem considered in this report arises in forgery cases in law enforcement and in other identification situations that depend on photographs of faces. In forgery cases a photograph of the person who cashed the forged check is often available. Over a period of time the forgery unit of a large police department will accumulate a sizeable set of these photographs and may receive 15-50 new photographs each week. The objective of this part of our research has been to attempt to develop a computer-aided system which could match the individuals shown in new photographs coming into a forgery department with other photographs of that same individual which are already in the department's file. This may help the investigating officer establish a pattern of operation for an individual which may assist in identification and collection of materials for prosecution.

The approach taken here makes use of a mug shot retrieval system described in UHMUG-1 which uses a pattern recognition algorithm to determine the similarity of facial images in the standard mug shot position. There are two fundamental differences in this type of application:

(1) A photograph is available so we do not have to depend on the memory of the witness for a facial image.

(2) The photographs in this application may be taken with the camera in a different position than the standard mug shot position.

It is usually an advantage to have a photograph and not have to depend on the memory of a witness, the skill of the sketch artist,

and the other variables which contribute "noise" to the generation of a facial image of the suspect. However, if the camera angles are very different from the standard mug shot position, the photograph may not contain enough information for a successful application of the pattern recognition algorithm. Although the results to this point are preliminary, it appears that the pattern recognition algorithm of the UHMFS can be applied to a large percentage of the photographs obtained by forgery departments.

The major research problem in this application is to develop a procedure to handle the photographs which are taken from a non-standard (relative to the straight-on front bust view used in mug shots) position. Prasertchuang[1] developed a procedure to estimate the nine distances on a standard photograph using the corresponding distance on a non-standard photograph and the approximate distance from the target person to the camera. It is estimated that this procedure will provide estimates with 5-10% accuracy for about 90% of the photographs in a forgery application.

Other factors which are important in forgery cases include (1) individuals who are successful in forgery tend to repeat that offense, (2) they often use disguises, their hands or other objects to hide their face at the time they cash a forged check. This tactic may make it impossible to use certain photographs. The algorithm, as designed, attempts to minimize the effect of disguises by using only measurements below the eyebrows, but these may be difficult to obtain when beards are present. This leads to the major practical problem associated with the forgery application,

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[1] Master's thesis entitled "A Procedure to Estimate the Distance Between Two Facial Features On a Standard Mug-Shot Photograph"

measuring the photographs and maintaining a data base which permits rapid retrieval of the photos for viewing by a human judge.

Rotation of the head makes it difficult to select the points on the photograph to use for measurements. In addition, beards and other items may hide points that should be used. The only approach we have used for this problem is for the person making the measurements to make a subjective estimate of where the points should appear in the photograph. An alternative procedure which may be considered in future research is to develop a pattern recognition algorithm which could function with a variety of input measures. This system would then sort for look-alikes based on the measurements which could be made on a particular photograph.

With the Townes algorithm (currently in UHMFS) the pattern that defines a face is the ratio of certain distances. Because of this, the Prasertchuang rotation procedure has very little effect on the performance of the algorithm. At this stage in our research, it is impossible to tell if the rotation procedure would be cost-effective. It is an involved procedure that would add to the expense of a forgery application, and it has little effect on the Townes algorithm for most pictures.

For this reason, the first attempt at a field trial with the Houston, Texas Police Department did not use the rotate procedure, but simply used measurements from all photographs as though they were taken in the standard position. This brief field trial had to be aborted because of the difficulty of retrieving photographs of look-alikes from the file, and it furnished no information about the performance of the algorithm. This trial did point out the importance of having an efficient storage and retrieval system for the photographs if this system is to be successful.

Discussions with law-enforcement professionals indicate the number and frequency of forgery cases is expected to increase more rapidly than other crimes. One reason for this is it appears to be a relatively easy way to support a drug habit, with none of the physical danger associated with crimes like robbery. The combination of a pattern recognition procedure for handwriting and fingerprint retrieval with photograph retrieval is certainly a possibility.

The forgery application appears to be a very promising area of application for a system like UHMFS, but there would also be advantages to a new system designed strictly for forgery cases.

THE ROTATE PROCEDURE

A schematic of this approach is indicated in Figure 1. A non-standard photo is given to a technician who performs the measurements required for a computer program called ROTATE. The ROTATE program then calculates an estimate of the values that would have been obtained if the photo had been taken in the standard mug file position. Only measurements standardized by this procedure are stored in the computer file. The pattern recognition algorithm uses these standardized values to search for look-alikes in the file and displays a list in order of their "similarity." Then one or more humans view the pictures to decide if there are any matches to the photo currently being entered in the file.

The major contribution of the computer system is to enable humans to view and examine a small set of the photographs on file by selecting those which have a high probability of being a match to the new photograph. The computer also stores the standardized records and can be used to control a device which displays the photos automatically to the human viewer.

The difference between standard and non-standard photographs is illustrated in Figure 2. These tracings were made from photographs of the same person taken under the same condition except for a "rotation" of the head.

Figure 2(b) shows the nine distances required by the pattern recognition algorithm ($M_1, \ldots M_9$). Note that M_1 through M_6 are horizontal dimensions and M_7, M_8, and M_9 are vertical dimensions. For any algorithm which uses ratios of these values, any vector which is a scalar multiple of these values can be used as the par-

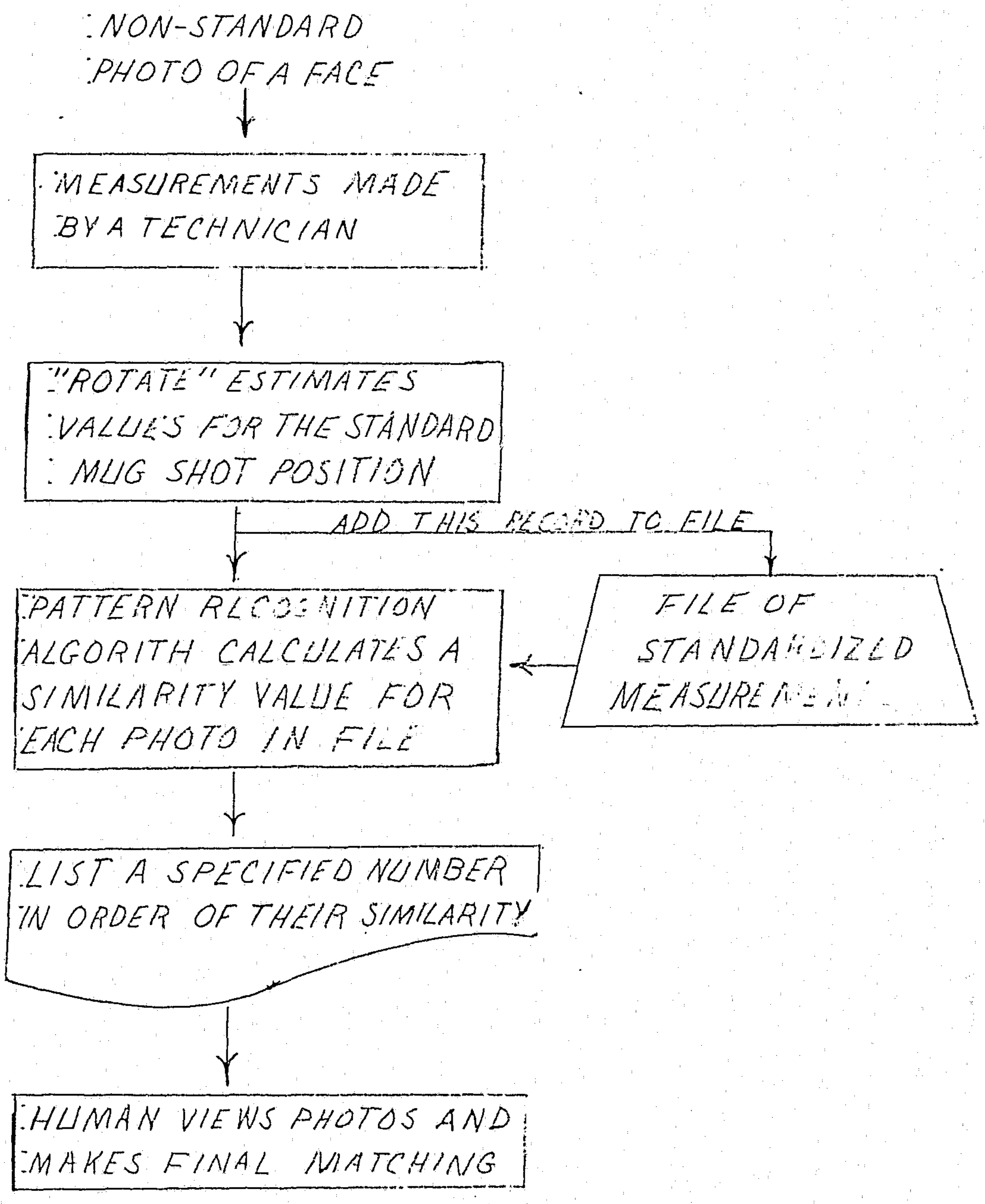

NON-STANDARD PHOTO OF A FACE
MEASUREMENTS MADE BY A TECHNICIAN
"ROTATE" ESTIMATES VALUES FOR THE STANDARD MUG SHOT POSITION
ADD THIS RECORD TO FILE
PATTERN RECOGNITION ALGORITH CALCULATES A SIMILARITY VALUE FOR EACH PHOTO IN FILE
FILE OF STANDARDIZED
LIST A SPECIFIED NUMBER IN ORDER OF THEIR SIMILARITY
HUMAN VIEWS PHOTOS AND MAKES FINAL MATCHING

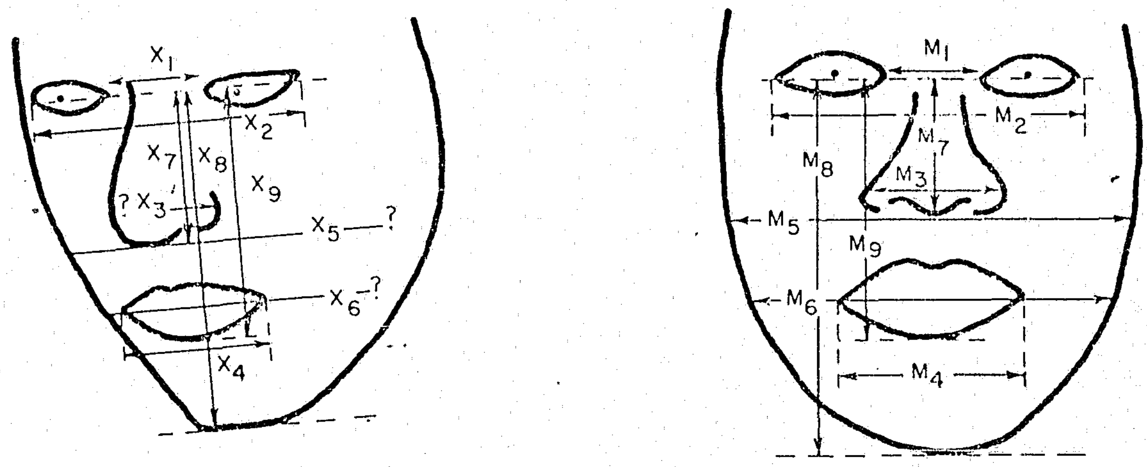
FIGURE 1

ameters of an individual's face. To determine a standard record from a non-standard photograph like Figure 2(a), we must estimate $(kM_1,...kM_9)$ for any $k > 0$ using information we can obtain from the non-standard photograph.

Two distinct problems arise when we try to estimate $(kM_1,..,kM_9)$. One problem is that it is often difficult to see the same features in the non-standard photograph. For example in Figure 2(a) the question marks indicate problems such as we see one side of the nose, and it is difficult to judge where the side of the face should be. If we denote the distances between the same features on a non-standard photograph as $(X_1,X_2,..,X_9)$, then it is difficult for a technician to measure X_3,X_5, and X_6. The problem is discussed in greater detail below.

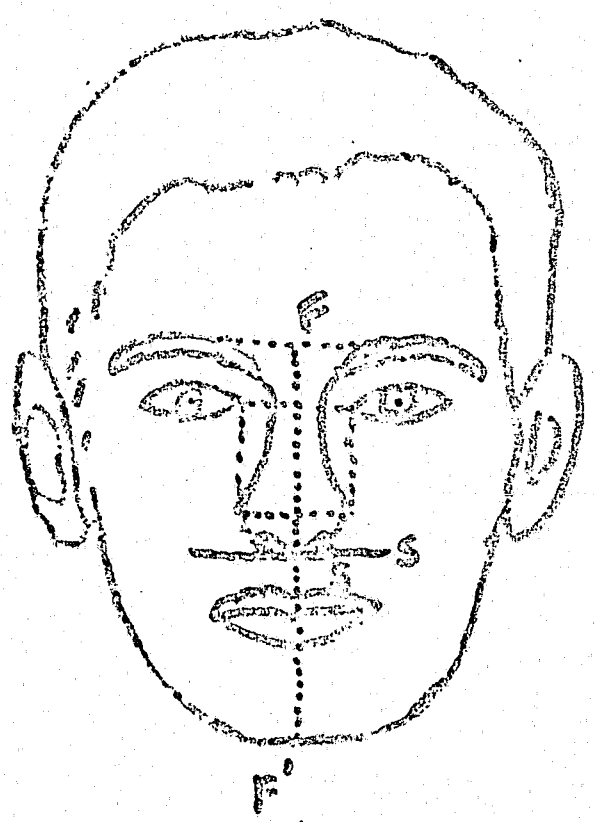
The second problem is that the mathematical relation between the values $(X_1,...,X_9)$ and $(kM_1,...,kM_9)$ depends on the orientation of the face and the camera, the distance from the camera to the face, the type of lens in the camera, and the topography of the individual face. All of these values cannot be determined from a non-standard photograph. Prasertchuang has used a combination of assumptions and mathematical approximations to develop a procedure to estimate $(M_1,...,M_9)$. The primary assumption, which is based on empirical work, is that the individual in the non-standard photograph has a "proportional standard face." The key elements of this assumption as shown in Figure 3 are:

1. The internal biocular distance (M_1) is approximately equal to the nose width (M_3).
2. The distance from a line drawn across the top of the eye-



(a) NON-STANDARD (b) STANDARD

TRACINGS OF PHOTOGRAPHS
FIGURE 2



PROPORTIONAL STANDARD FACE

FIGURE 3

brows to the base of the nose (FS) is approximately equal to the distance from the base of the nose to the chin line (SF').

The other assumption, required when there is rotation in the horizontal plane, is that horizontal distances are symmetric about the centerline of the face (F F'). This provides a basis to estimate the orientation of the face to the camera in terms of the horizontal rotation ϕ and the vertical rotation ω from the standard mug shot position.

The mathematical relation used to calculate the standardized measurements assumes a value for the distance from the pupils of the eyes to the axis of rotation of the head (effective axis of rotation $r = 5.5$ inches) and the angle formed by the pupil and the nasion point with the axis of rotation, $\xi = 13^{o}$. These values are averages based on small samples but they appear to be adequate when the camera distance is greater than three feet.

Estimation of the Angles of Rotation

The basic idea for estimating rotation of the head in the horizontal plane is indicated in Figure 4, which is a tracing made from a photograph of a life size mannequin. (A mannequin was used because the angles of rotation can be controlled better than with human subjects.) In this case the horizontal rotation is $\phi = 30^{o}$ and the vertical rotation is $\omega = 25^{o}$ down. One source of information about the angle ϕ is given by the fact that the distance from the right pupil to the center of the nose (P'A) is less than the distance from the left pupil to the center of the nose (AP). These values would be equal if there were no horizontal rotation.

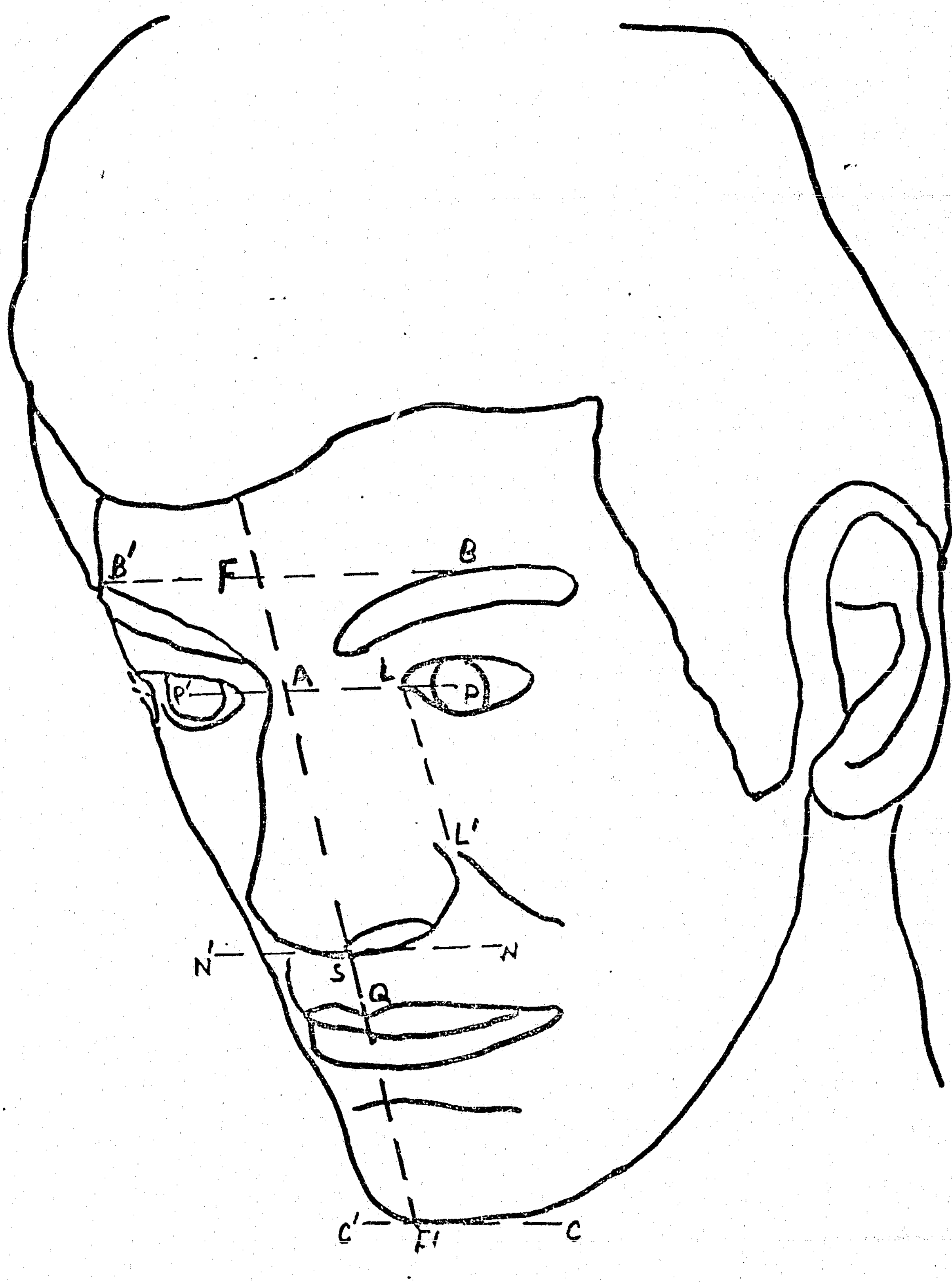


FIGURE 4

As ϕ increases, one of the pupil distances will increase and the other will decrease. An estimate of ϕ can be calculated using the distances P'A and P'P. The details of the procedure are given in the section below.

<u>Details of the Measurements Required for the Rotation Procedure:</u>

For these steps follow Figure 4:

1. Draw the line between the pupils, P'P, then draw the eyebrow level line B'B, the line of nose, N'N, at septum S, and line at chin contour C'C, all parallel to pupil line P'P.
2. On the side of the face that can be seen, draw a line (L'L or R'R) from inner corner of eye (inner canthus) to the wing of the nose (alar furrow). In Figure 4 this is L'L.
3. From the base of nose at septum S, draw the line through S and the middle point of philtrum on the upper lip Q, this line PS should be parallel to the line LL' or RR' obtained in step 2, and intersect pupil line P'P at A, eyebrow level line B'B at F, and chin line C'C at F'.
4. Measure the smaller distance (either P'A or AP) and P'P, then compute $\hat{\phi}$ using the relation

   $$\cos \hat{\phi} = [(P'A)\cdot(P'P)/2]^{1/2}/(P'P)/2.$$

5. To estimate the vertical facial angle ω, measure the distance FF' and the shorter distance of FS, SF', then compute $\hat{\omega}$ using the relation

   $$\cos \hat{\omega} = [(F'S)(F'F)/2]^{1/2}/(F'F)/2.$$

Calculation of the Standardized Values:

Let $\hat{M}_i$ be the standardized estimate of measurement i using the rotate procedure. Let X_i be the value of measurement i obtained from the non-standard photograph, then for horizontal measures

$$\hat{M}_i = \frac{X_i \cos \lambda}{\cos(\hat{\phi}-\lambda)}, \quad i = 1,\dots 6$$

where λ is determined from

$$\tan \lambda = \gamma \cdot \sin(\hat{\phi} - \xi)/[d + r(1 - \cos(\hat{\phi} - \xi))]$$

and

d = camera distance

r = effective radius of rotation (assumed at 5.5 inches)

ξ = angle formed by a pupil, the center of rotation of the skull and the nasion point (assumed at 13°).

When the camera distance is large relative to the radius of the skull, both λ and cosλ are small and $\hat{M}_i$ is approximately $X_i/\cos\hat{\phi}$. A similar procedure is used for vertical measurements using $\hat{\omega}$ instead of $\hat{\phi}$.

Prasertchuang has made a sensitivity analysis of this procedure. The most important variables are camera distance and effective radius of rotation of the pupil, and the actual angles of rotation, ϕ and ω. His results show a greater percentage error with larger values of ϕ and ω.

Table 1 gives the results of Prasertchuang's application of this procedure to horizontal measurement on a mannequin. In this case the largest error occurred with ϕ = 40° and ω = 20°, this was only 2.84%. The average error for the five combinations of rotations was only 1.19%.

Table 2 gives results when applied to one white male. The

Table 1

Set		10°	20°	30°	40°	50°	Mean
	Φ	10°	20°	30°	40°	50°	
	ω	20°	20°	20°	20°	20°	
Estimate	Φ	12.22°	21.46°	33.10°	42.61°	51.05°	
	ω	18.76°	17.42°	17.55°	17.55°	17.02°	
Error	Φ	2.12°	1.46°	3.10°	2.61°	1.08°	
	ω	-1.24°	-2.58°	-2.45°	-2.45°	-2.98°	
Estimated value of selected distance (cm.)		7.04	6.99	7.22	7.25	7.17	7.13
Error %		-.14	-.85	2.41	2.84	1.70	Average Error = 1.19

Results of estimation of a selected horizontal distance which has a value of 7.05 cm. on a standard photograph of the mannequin.

Table 2

Set							Mean
	Φ	30°	45°	30°	45°	60°	
	ω	0°	0°	22.5°	22.5°	22.5°	
Estimate	Φ	32.24°	43.75°	33.85°	50.77°	52.63°	
	ω	6.15°	0°	22.21°	22.20°	18.76°	
Error	Φ	2.24°	-1.25°	3.85°	5.77°	-7.37°	
	ω	6.15°	0	.29°	.30°	-3.74°	
Estimated value of selected distance (cm.)		7.51	6.87	7.49	7.60	7.58	7.41
Error %		4.27	-4.58	4.03	5.56	5.21	Average Error =2.90

Results of estimation of a selected horizontal distance which has an actual value of 7.20 cm. on a standard photograph of a white male.

percent errors are greater, but this could be explained by the difficulty in controlling the orientation of the face for a human subject.

In either case, the results for a horizontal measurement appear to be very good for pattern recognition purposes. The procedure may not be as accurate for vertical measurements due to the non-symmetry of the face about N'N.

A problem arises in using the rotation procedure for an algorithm which uses ratios of horizontal and vertical measurements, for example M_5/M_8. If the rotation procedure produces $\hat{M}_5 = k_H M_5$ and $\hat{M}_8 = k_v M_6$, it is necessary that k_H be approximately equal to k_v. This has not been established at this time and will require further research.

Measurement of Non-Standard Photographs

The difficulty in trying to measure the values $(x_1 \ldots, x_9)$ from a non-standard photograph was illustrated in Figure 2(a). Some of the features (such as one side of the nose) are not visable from the camera position and do not appear in the photograph. Other features (such as the side of the face) are visable, but they are difficult to distinguish on the non-standard photograph. The photographs in Figure 5 illustrate the problems. Photo number 1, in the standard position, has five black dots which mark the line used to measure M_5. Photo number 2 in a non-standard position shows only four of the black dots. Without the black dots, the person measuring X_5 has to make a judgment where to make the measurement on the side of the face nearer the camera. In many photos this is a difficult judgment to make.

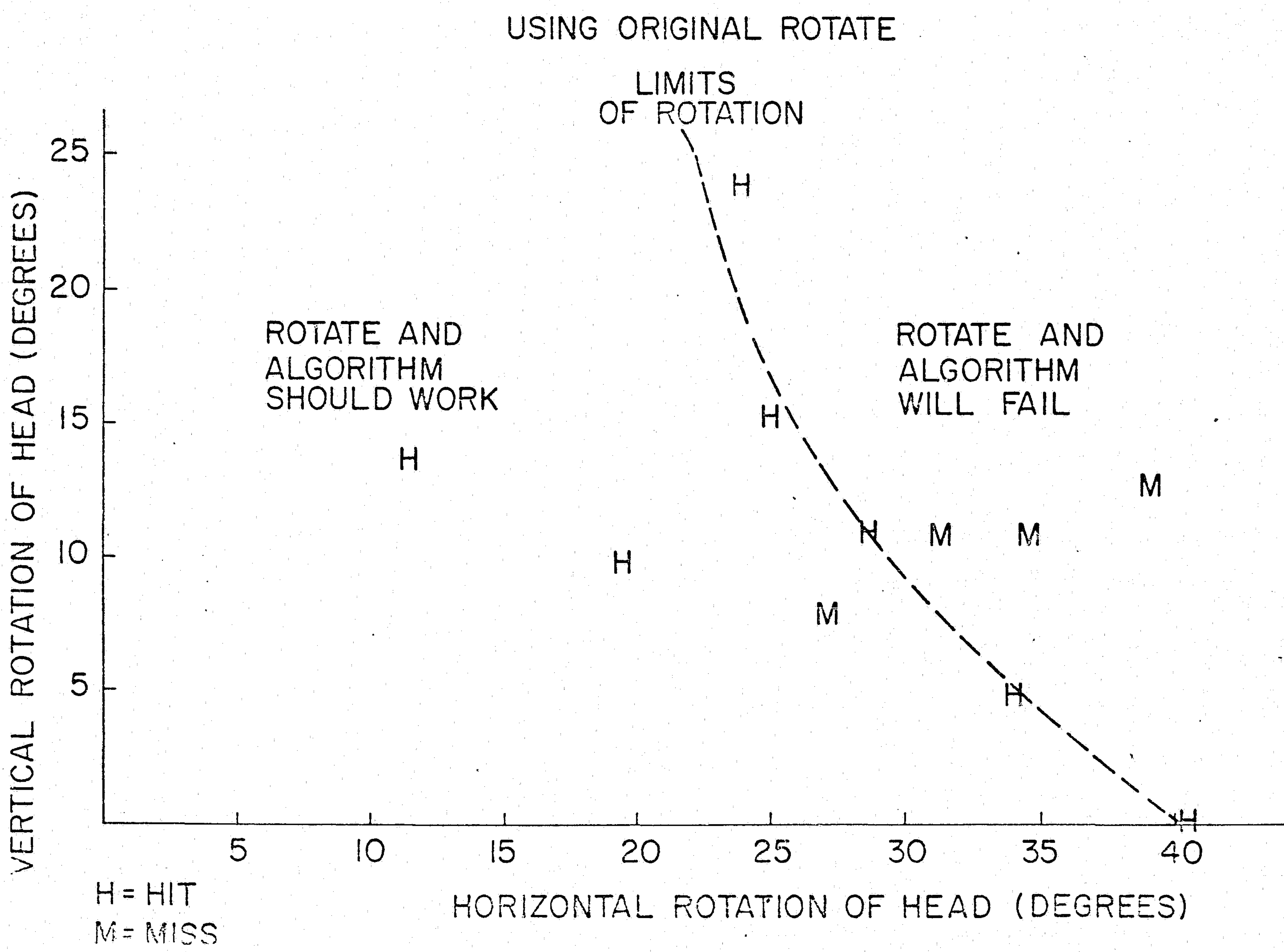
Since most faces are approximately symmetric about the vertical axis, some alternatives can be considered for horizontal measurements. Estimates for half of the distance can be developed using the side of the face nearer the camera, then these values can be multiplied by two. Good judgment of where to measure is still required to obtain the corresponding value and research will be required to determine how well this task can be performed.

EXPERIMENTAL RESULTS

A set of eleven individuals were photographed in the standard mug-shot position. The measurements taken from the standard photographs of these eleven individuals were combined with the measurements of 549 randomly chosen mug shots from the Oakland, California Police Department. This set of 560 measurements was the mug file data base for the experiment.

The eleven individuals were also photographed in a non-standard position. The actual angles of rotation are unknown but they are large deviations from the standard position as can be seen in the tracings of some of the photographs included in Appendix 1. The angles of rotation (ϕ, ω) were estimated using the Prasertchuang procedure. The results obtained with the pattern recognition algorithm are shown in Figure 6. This shows four misses out of eleven tries where a miss is defined as failure to rank the actual target in the top 10% of the look-alikes, in this case that means the top 56 since there are 560 in the test. The dotted line is an estimate of the limits of rotation in terms of ϕ and ω that can be handled by ROTATE based on this data.

A tabulation of 258 photographs from the files of the Houston Police Department Forgery files indicates that about 50% of these are in approximately the standard position and less than 10% have enough rotation to be outside the dotted line in Figure 6.


USING ORIGINAL ROTATE
LIMITS
OF ROTATION
ROTATE AND
ALGORITHM
SHOULD WORK
ROTATE AND
ALGORITHM
WILL FAIL
VERTICAL ROTATION OF HEAD (DEGREES)
HORIZONTAL ROTATION OF HEAD (DEGREES)
H = HIT
M = MISS

FIELD TRIAL

During the Summer of 1976 a proposal was made to the Houston Police Department to conduct a field trial. A copy of this proposal is included in Appendix 2. The proposal was accepted and we began measuring the photos in the forgery file in the fall of 1976 on a part-time basis. Once the file was measured, the data was key-punched and loaded on our computer. Attempts to locate suspects began in the Spring of 1977. Everything worked reasonably well except for the extreme difficulty of retrieval of a selected look-alike photograph to compare to the current suspect. The following description of this problem is taken from a report prepared by the graduate student who worked with H.P.D., Ken Zingrebe.

"Several Dubl-Check photos of current interest by the HPD were measured and a run made for possible look-alikes from the files in the computer.

The list of possibilities for each photo was taken to the HPD. The list referenced the photos of interest by a four-place number which was the number assigned by the project personnel to each photo in the initial file. The following steps were then necessary:

1. The project number had to be cross referenced to the HPD master number.

2. Either the picture, or the name of the individual who corresponded to the number had to be obtained from the mug shot office or through the remote terminal from the Department of Public Safety Driver's License Division (name only in this case).

3. If a photo was obtained, then comparison between the

mug shot and the target photo was made. If the name was obtained then the card file in Forgery had to be searched for that name and the folders which might contain that person's photo.

4. If possible folders were recorded then a search of the folders had to be made to locate the photos in them, and a comparison made between those photos contained in the folders and the target photo.

The name, only, can be obtained if the number on the master list is a Texas Driver's License. Then the search through the card and folder files has to be made. The driver's license photo can be obtained from Austin in a time period of 4 to 14 days.

From the efforts made as described above, the following problems were discovered:

1. Cross reference had to be made between the project's number and the HPD's number.
2. There was a delay in obtaining photos or names from the mug shot office and there was an unwillingness of same to look up several possibles at one time.
3. Long delay to obtain photos from Austin.
4. There was always the need to go to the card file before the search of the folders could be made.
5. A need to look in several folders on some of the possibles, after the card file search.
6. The searches are time consuming and therefore, the detectives on duty do not want to search.
7. Folders are purged and there may not be any picture available other than through the mug shot office or TDL office in Austin.

Some interesting and encouraging items found in this attempt to implement these procedures into a smooth system are:

1. Some photos were found to have been measured and entered on the computer list twice, but both listings were in the list of possibles. This shows that measurements by different individuals or at different times are reasonably close.
2. In one case it was discovered that the HPD had two mug shots of the same person; one under the true name and another under an alias. Both of these listings appeared on the list of possibles for a target photo.

Any system which would make retrieval of the original photos easier and faster would be an improvement. A master file of mug-shots filed by number either at the HPD Forgery Division or where they can be compared as soon as a computer listing of possibles is obtained would be of great help. This would eliminate much lost time and effort in searching out photos once needed. Preferably, a microfiche of the photos would be best. Space would be saved and the search easier on a fiche. Photos could easily be added to the list as they were required.

All of the problems mentioned can be overcome with this suggestion; except the first one, and that has been solved by changing the computer program to give the HPD number."

It is clear that Ken has identified the problem and the solution. The photos in the forgery file will have to be stored so that rapid retrieval and inspection can be made. A device such as used in the UHMFS system would be ideal. The field trial had to be aborted because it was too difficult to retrieve the number of photos needed to be examined.

FUTURE POSSIBILITIES

The future possibilities for forgery applications look promising. It should be possible to develop systems which combine retrieval of photos, fingerprints and handwriting. Because of the relatively small number of forgery cases (as opposed to all types of crimes) it is possible for a single mini-computer system like the current installation in Oakland, California to handle an entire state or area of the country for this type of application. This would be desireable since individuals who practice forgery tend to move from place to place.

The design of this type of system could take advantage of the fact that a witness is not involved. A person would be trained to match photographs in much the same way people are trained in matching handwriting and fingerprints. The computer system would be a tool to support these trained specialist. Only a few, perhaps one, installation would be required to service the entire United States. This should permit rapid tracking of an individual who moves from city to city. It looks like a very promising area to develop.

APPENDIX ONE

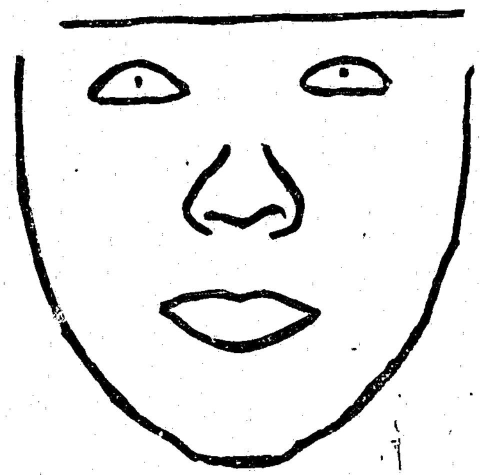
TRACINGS OF STANDARD

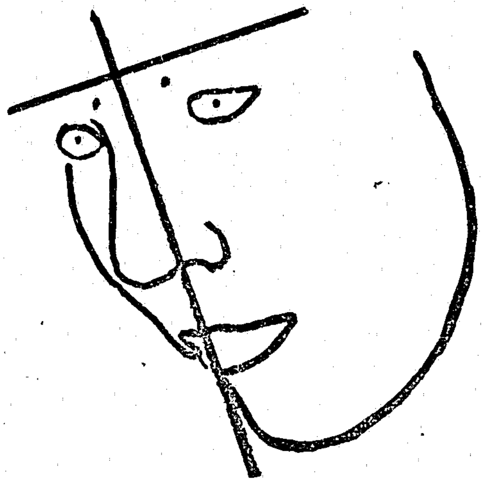
AND NON-STANDARD PHOTOGRAPHS

INCLUDED ARE ALL

FOUR MISSES AND

TWO HITS

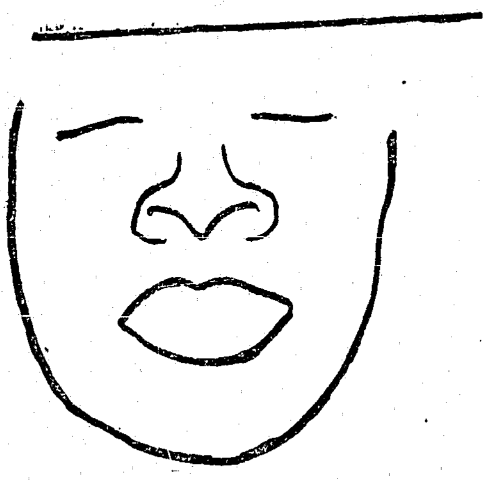


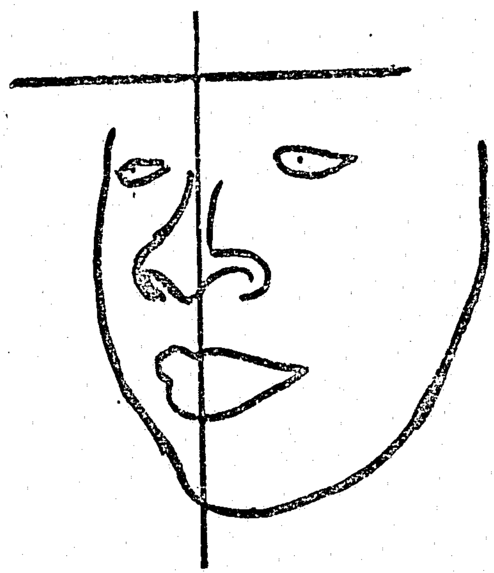


STANDARD

MISS
WITNESS 322

NON-STANDARD

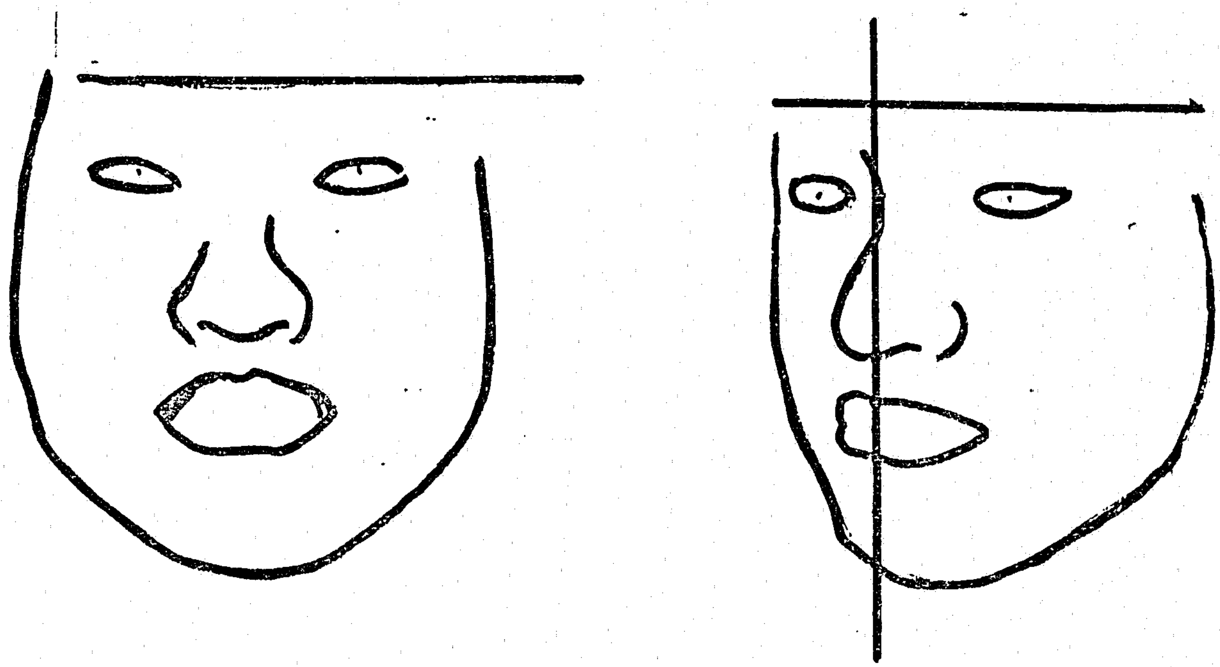




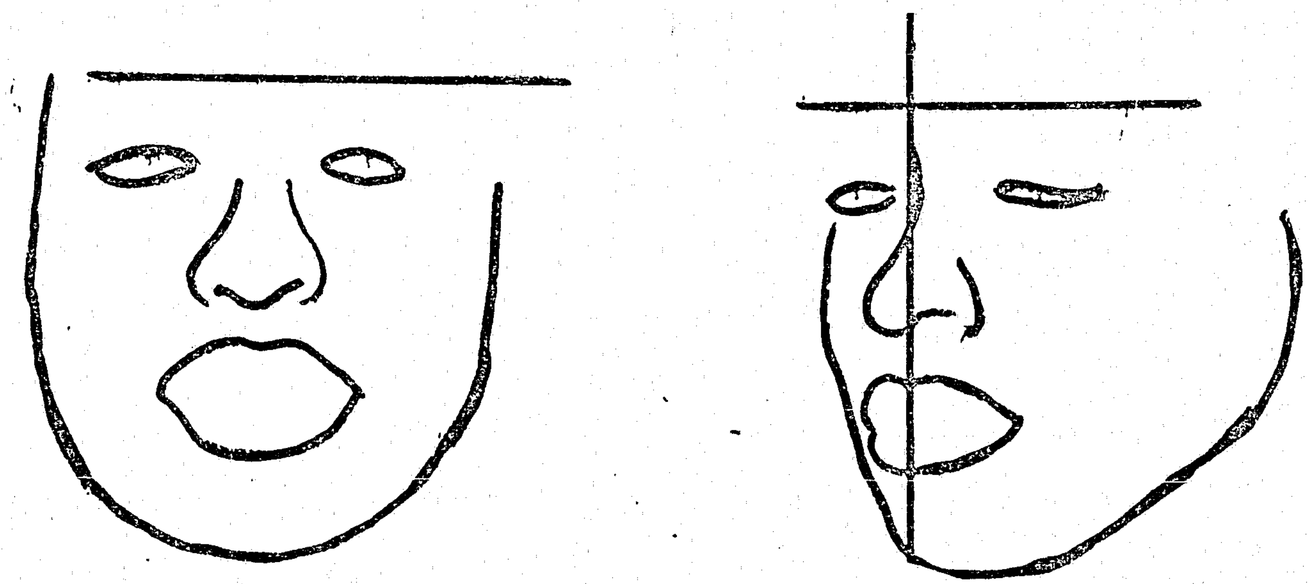
STANDARD

MISS
WITNESS. 323

NON-STANDARD



STANDARD — MISS WITNESS 330 — NON-STANDARD



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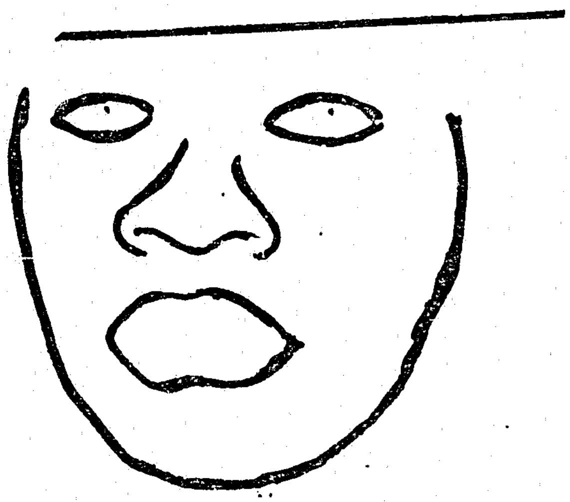

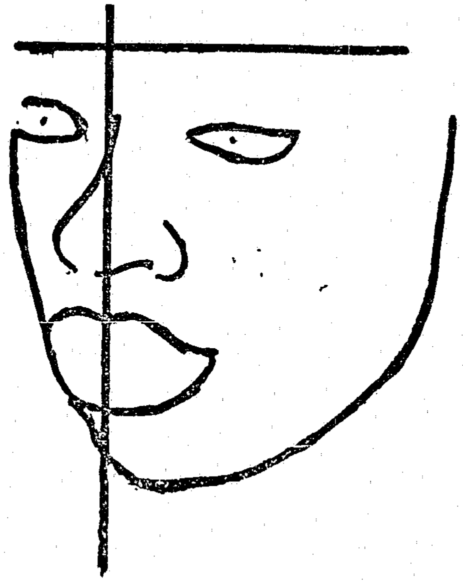

STANDARD

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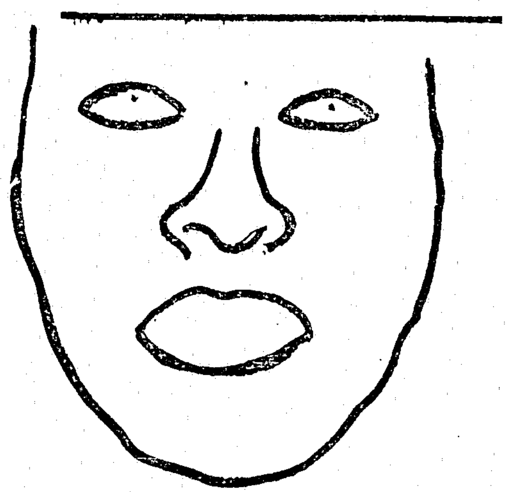

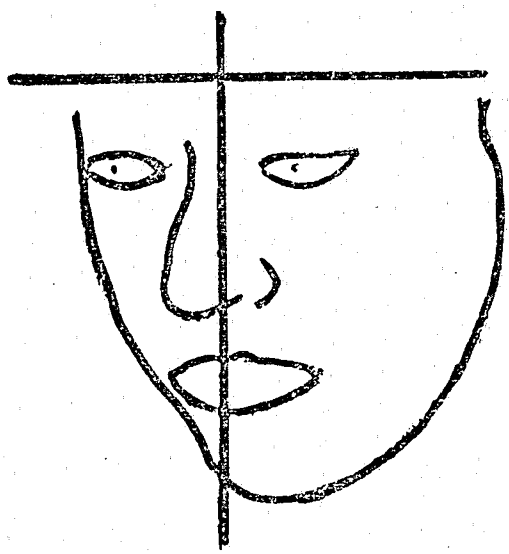

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Appendix Two

Proposal for a Field Trial of

"Computer Search for Look-alikes"

for Forgery Cases of the Houston Police Department

Ben T. Rhodes, Jr.

Industrial Engineering Department

University of Houston

June 1976

Statement of Agreement

The University of Houston personnel involved in the Field Trial of "Computer Search for Look-alikes" with the Houston Police Department agree to maintain proper security of any information obtained and not to violate the civil rights of any individual.

The only information which will be removed from HPD to the University of Houston will be numbers and codes which can only be associated with individuals through HPD records.

This research is supported by LEAA grant (76-NI-99-0012). The nature of the system will be discussed with members of the law-enforcement community who have a legitimate interest in our research.

Ben T. Rhodes, Jr.
Project Director

Field Trial of "Computer Search for Look-alikes" for Forgery Cases

Background: During the past two years, a team at the University of Houston has been working to develop an efficient method of using the information obtained from a witness about the suspect's face to help determine whether the suspect is in the mugfile. Four steps are applied in this procedure: (1) obtain information about the suspect's face from the witness and generate an image (by sketch artist or Identi-kit device), (2) measure certain distances on the image obtained from the witness and enter these into a computer, (3) the computer program (pattern recognition algorithm) searches ratios of the facial distances in the mugfile and determines which mugshots are "look alikes" to the image supplied by the witness, (4) the investigator and witness examine the selected "look alikes" to determine if one or more of these individuals should be considered a suspect.

At the suggestion of members of the Houston Police Department we began working on a special version of this procedure for forgery cases about one year ago. The special features of the forgery problem which make it an attractive area to consider are:

(a) A photograph of the face of the person who cashed the forged check is often available. This eliminates dependence on the memory of the witness and the skill of the sketch artist or Identi-kit technician.

(b) The population of forgery suspects is small relative to the entire mugfile and there is usually a history of repeated offenses.

The major research problem created by the forgery application is that the computer is trained to select look-alikes based on measurements made in the standard "mug shot" position. It has been necessary to develop procedures to "rotate" a face so that measurements from photographs (such as Dubl-Chek) can be used. This problem has been solved and we are now ready to begin a field trial.

Purpose: The purpose of this field trial is to determine the usefulness of the system to officers working on forgery cases in a large metropolitan area. It is expected that a trial will establish that this "tool for the investigator" is cost-effective. In addition we expect that H.P.D. officers will suggest additions and modifications which can be added to the system to make it more effective for forgery cases. Possible examples include handwriting codes and partial finger-prints.

Typical Application: Once the field trial system is set up, a typical application will involve the following steps:

1. A company or individual brings a forged check and a photograph of the person who cashed the check to the H.P.D. (This is usually 2-4 weeks after the check was cashed.)
2. The photograph will be assigned a number for identification purposes, and a technician (initially a University of Houston student) will take measurements of facial features.

3. Only the identification number and the numerical values of these measurements (to protect the rights of the individual) will be taken to the University of Houston and entered into a computer data file. A description of this "forgery file" is given below.
4. The computer will "rotate" the facial measurements to a standard "mug shot position", then it will search the forgery file for look-alikes.
5. The identification number of the new photograph and a list of the identification numbers of all "look-alikes" in the current file will be returned to H.P.D.

Personnel in H.P.D. can compare these "look-alikes" to the new photograph and judge if it is the same individual. Thus the system is a tool which helps an officer associate individual violations in the file with a single individual, and to collect all the information about that individual.

A Procedure for a Field Trial with the Forgery Department of H.P.D.: One possible procedure which can be used for a field trial here in Houston is to set up the "forgery file" on one of the University of Houston computers. The nature of this file and the procedures employed should guarantee the security of all H.P.D. information and the civil rights of all individuals involved.

Content of the Computer Forgery File: This file would consist of a set of numbers and letter codes which could not be associated with any individual except through records maintained in the Forgery Department at H.P.D. The initial version of the file will contain an identification number assigned by H.P.D. and measurements taken from photographs. At a later time additional codes such as check numbers or handwriting codes may be added.

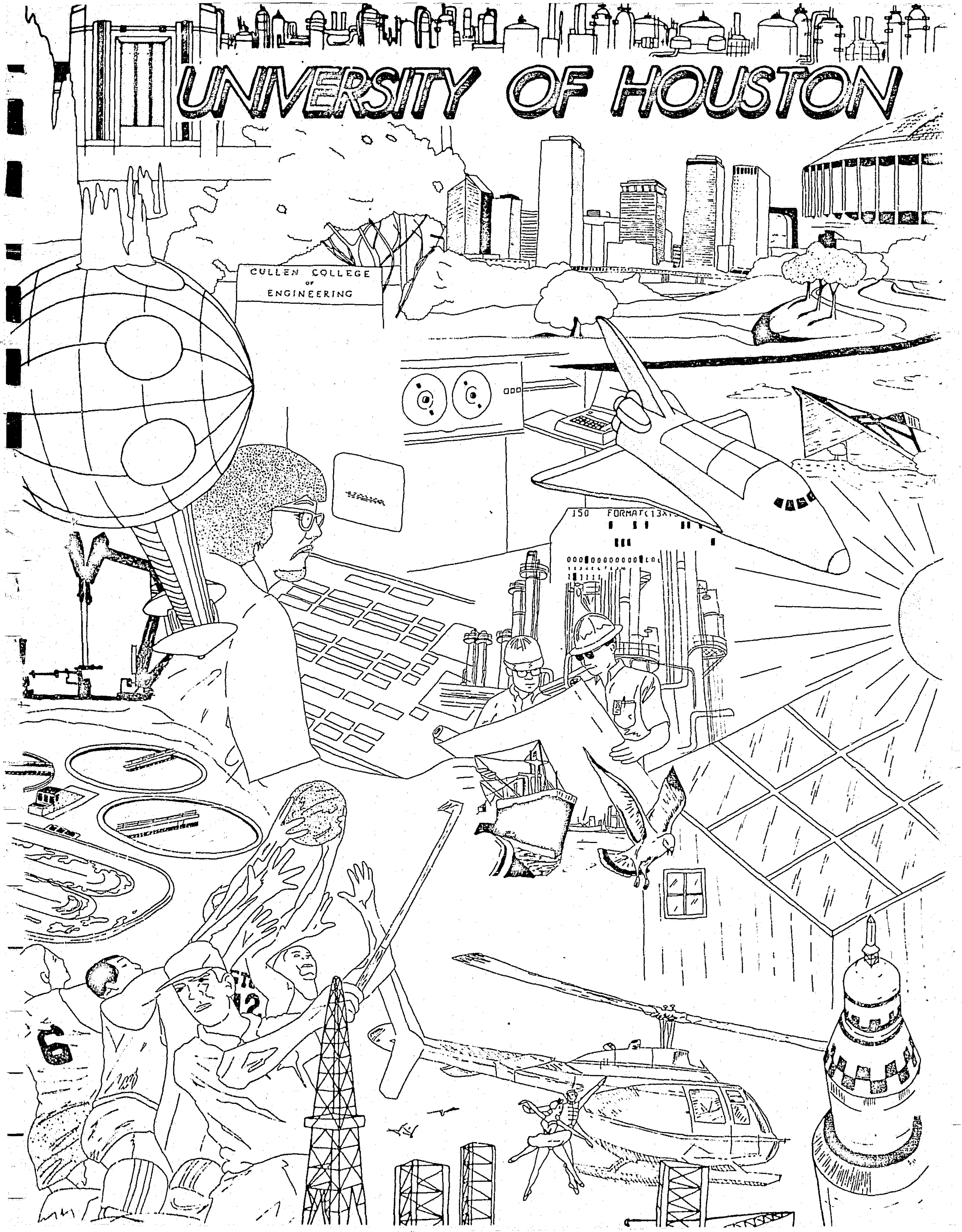
Forgery Department personnel will select the photographs to be included in the file and assign an identification number to each photo. University of Houston students will come to the Forgery Department and measure the photographs. The ID number and the numerical measurements will be recorded on the data form. The only other information on the data forms will be comments about the quality of the photograph and the difficulty of making certain measurements, a copy of the data form is attached. These data forms are the only materials which will be removed from the Forgery Department.

Schedule: We hope to have the "forgery file" constructed and on the computer by the end of the summer (1976). We can begin searches for look-alikes as soon as enough pictures are in the file to justify a search. Application of the system should continue until H.P.D. personnel are convinced it is a useful tool (at which time it can be moved to H.P.D. computers) or further research is needed before H.P.D. would want the system. Hopefully this judgment can be made in 6-9 months.

This research is currently supported by a grant from LEAA (76-NI-99-0012). No additional support is needed at this time.

DATA FORM FOR FORGERY FILE

I.D. NUMBER	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	Angles		Horizontal		Vertical		Comments on Photo
										ϕ	ω	Pupil	Small	Brow Chin	Shorter	
361453	0.70	2.05	0.85	1.35	2.85	2.65	0.80	2.50	1.80	20° Left	10° Up	1.45	.65	3.00	1.28	Good Quality Dubl-Chek
117881	0.39	.88	.46	.64	1.32	1.28	0.40	1.10	0.75	0°	20°	.62	.31	1.35	0.60	Mug-Shot Quality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CULLEN COLLEGE OF ENGINEERING


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END