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Section 6

Guidelines for Facial Comparison Methods

Purpose

The purpose of this document is to describe current methods for facial comparison and to provide guidelines for their appropriate use.

Introduction

Facial comparison is a manual process undertaken by a human. FISWG has identified two broad categories of facial comparison: facial review and facial examination. Facial review is a fast, less rigorous process conducted between an image and a subject or between (sets of) images. Facial examination involves a more time consuming rigorous process performed between (sets of) images (still, video capture, 3-D scan). FISWG recommends an independent technical review or check (verification or peer review) of all documented observations relating to facial examinations.

There are four main methods currently in use for facial comparison: holistic comparison, morphological analysis, photo-anthropometry, and superimposition. Selection of the appropriate method to use for a facial comparison depends on the image quality, the training and experience of the practitioner, and the purpose of the examination.

Regardless of the method chosen for comparison, the repeatability and accuracy of the conclusions that can be drawn from image comparison are directly related to the quality of the images. As a general rule, the lower the quality of the image being used in a comparison, the weaker the conclusion that can be drawn. Optimal images for facial comparison are high resolution and have sufficient focus to resolve features of interest, such as blemishes and wrinkles, with minimal compression artifacts or distortion, and show the subject(s) from the same viewpoint, in the same pose (orientation of the face), with the same lighting, same expression, with no obscuration of features. Generally, optimal images are taken under conditions where factors such as resolution, compression, and subject pose can be controlled and consistently repeated. When comparing subjects depicted in images, it is preferable to use those that were captured with a minimal time interval between them. Facial comparison can be undertaken using sub-optimal images, but only if the practitioner has been trained in the proper evaluation of such images[1].

As with any task, individuals performing facial comparisons should have training commensurate with their duties. Some facial comparison methods will require a greater amount of training than others, not only for the performer to develop competency in the specific processes of a given method, but to understand the strengths and weaknesses of

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[1] FISWG Section 3 "Guidelines and Recommendations for Facial Comparison Training to Competency"

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the various methods. As a result, the repeatability and accuracy of the conclusions that can be drawn from image comparison are directly related to the level of training achieved by the performer. Individuals conducting facial review will require less training than those who conduct facial examination[2].

Finally, it must be recognized that agencies (and individuals) perform facial comparison for a wide variety of purposes, often under operational conditions that do not allow for a great deal of time or effort to be expended (e.g., border crossing). Under such conditions a facial review is usually performed, and it is necessary to utilize a less rigorous method than FISWG would otherwise recommend. Agencies that choose to utilize such methods must recognize this fact and the associated risks (i.e., greater chance of error). Under such a scenario, the consideration of additional information outside the scope of facial comparison may be warranted.

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[2] FISWG Section 3 "Guidelines and Recommendations for Facial Comparison Training to Competency"

Holistic Comparison

FISWG recommends that holistic comparison be used only when time constraints do not permit a complete examination. Whenever feasible, holistic comparison should be extended toward a basic form of morphological comparison. Holistic comparison cannot be used for facial examination purposes.

Description

Holistic comparison exploits a basic human ability, where all facial features are assessed simultaneously and compared to another face or image of a face. Holistic comparison is common practice in facial review. It may occur that the individual assessing the facial features during review cannot explicitly explain the basis for his or her conclusion, therefore limiting the forensic value of this approach.

Advantages and Disadvantages of Holistic Comparison

Factors relating to holistic comparison are described in the table below.

Factor	Details	Pro	Con
Image	Can be attempted on any image	x	
	Does not require identical subject pose, angle and orientation	x	
Process	No contemporaneous documentation of the process is required for facial review	x	
	No contemporaneous documentation of the process is performed		x
Specialized Equipment	None	x	
Time for Examination	Fast	x	
Training	None	x	
Validation/ Accuracy	Studies show that holistic comparison has low and variable accuracy rates (Kemp et al., 1997; Bruce et al., 1999; Megreya and Burton, 2006; Butavicius et al., 2008)		x

FISWG Recommended Practices

Because of the low accuracy rates associated with using holistic comparison, FISWG recommends that holistic comparison should be limited to use when operational conditions preclude the use of other methods. Practitioners who are required to make quick assessments of identity based on facial comparisons should combine their holistic comparison conclusion with other readily available information when reaching a decision regarding identity.

Effect of Sub-optimal Images on Holistic Comparisons

Research results indicate that holistic face comparisons are negatively affected by sub-optimal images, specifically in relation to lighting (Hill and Bruce, 1996), expression (Bruce et al., 1999), view (Bruce et al., 1999), resolution (Lee et al., 2009) and feature

obscuration (Henderson et al., 2001; Lee et al., 2009). However, since the error rate for untrained holistic face comparison has repeatedly been shown to be high (at least 30%) even with optimal images (Bruce et al., 1999; Burton et al., 1999; Bruce et al., 2001; Kemp et al., 1997) the effect of sub-optimal images may be less significant than with other methods of comparison.

Morphological Analysis

FISWG recommends morphological analysis as the primary method of facial comparison.

Description

Morphological analysis as a comparison method is based on the assessment of correspondence of the shape, appearance, presence and/or location of facial features. These features include global (corresponding to the overall face), local (including anatomical structures such as nose or mouth and their components, e.g., nose bridge, nostrils, ear lobes) and discriminating characteristic facial marks such as scars or moles.

While efforts have been made to establish a classification scheme for facial features (Iscan, 1993; Penry, 1971; Ritz-Timme et al., 2010; Vanezis et al., 1996), a standard taxonomy has not yet been agreed upon. In addition, even when given a fixed classification schema, inter observer differences in classification of facial features has been observed in many studies (Ritz-Timme et al., 2010; Vanezis et al., 1996), indicating the difficulty of classifying individual features.

Morphological analysis is a systematic method of facial comparison in which the features of the face are described and compared. Conclusions in relation to similarity or difference are based on subjective assessment and interpretation of observations.

Advantages and Disadvantages of Morphological Analysis

Factors relating to morphological analysis are described below.

Factor	Details	Pro	Con
Image	Can, with appropriate training, be applied to lower quality images	x	
	Best results are obtained when images have similar pose, angle and orientation		x
Process	Easily explained to untrained individuals	x	
	Can be used to exclude a subject	x	
Specialized Equipment	Feature list (where process is documented)	x	
	There is no standardized set of features and/or feature components used in facial comparison		x
Time for Examination	Dependent on examiner training, image quality, and application:	x	x
	45 seconds – minutes for facial review	x	
	2+ hours for facial examination		x
Training	Requires- basic (facial review) –advanced (facial examination) training		x
Validation/ Accuracy	Considered to be more reliable than other methods	x	
	Only limited studies have been done on accuracy or reproducibility		x

FISWG Recommended Practices

Morphological analysis can be used both for facial review and for facial examination; for facial review the process is faster and less rigorous. Screening and access control applications require a more basic level of morphological analysis and at this level documentation of the decision-making process may not be required. When using morphological analysis for facial examination, FISWG recommends full documentation of the examination and decision making process and an independent technical review (verification or peer review) of this documentation.

Morphological analysis should be undertaken in a systematic manner and include a list of the features to be compared for every examination thereby allowing replication of the examination process. Although a variety of facial feature lists do exist, FISWG does not currently endorse any specific list.

The existing facial feature lists typically include:
- Face shape
- Forehead
- Eyes
- Ears
- Cheek area
- Nose
- Mouth
- Mouth area
- Jawline
- Chin
- Scars and blemishes

Some of these features can be subdivided. For example, the ear contains multiple components, including the helix, antihelix, tragus, antitragus, etc., which can be assessed individually or in combination. There is no agreement regarding the number or nomenclature of components that must be compared. Future FISWG documents will address the standardization of a feature list for morphological comparison.

Effect of Sub-optimal Images on Morphological Comparison

Morphological comparison is usually highly sensitive to image quality. Loss of image quality through blurring, compression artifacts or reduction in spatial resolution (e.g., pixels on target), can reduce or eliminate the visibility of fine details such as blemishes or creases on the face, and can also reduce the visibility of gross details such as the specific shape of the eyes, nose and mouth. As a result, the ability to detect similarities and differences between two or more images will be reduced and greater uncertainty will be introduced. The net effect is that one will be less able to either identify or eliminate a subject based on a comparison.

Photo-Anthropometry

FISWG recommends that photo-anthropometry NOT be used for facial comparison at this time.

Description

Photo-anthropometry is derived from facial anthropometry, the study of facial measurements of individuals using soft tissue landmarks and bone structure, as used in anthropological and clinical applications. Photo-anthropometry is the measurement of dimensions and angles of anthropologic landmarks and other facial features in order to quantify characteristics and proportions. The measurements taken from one image are then compared to the measurements taken from a separate facial image. Conclusions are based on subjective thresholds for acceptable differences between measurements.

Advantages and Disadvantages of Photo-Anthropometry

Factors relating to photo-anthropometry are described in the table below.

Factor	Details	Pro	Con
Image	The conditions under which one can achieve reliable results are very restrictive (see below) and are rarely encountered in forensic case work		x
Process	Potential to automate the process	x	
	There is no standardized set of landmarks used in facial comparison		x
	Visual detection, placement and marking of landmarks in single images is subjective and unreliable		x
Specialized Equipment	Utilizes an itemized feature list which assists with the repeatability and the documentation process	x	
Time for Examination	Hours, dependent on examiner training, image quality, and application		x
Training	Requires advanced training		x
Validation/ Accuracy	A potentially objective analysis that may permit statistical analysis	x	
	Lack of reliability shown in testing		x

FISWG Recommended Practices

Given the uncontrolled conditions under which many questioned images (e.g., CCTV images or surveillance images) are captured it is not possible to define a threshold boundary of similarity or dissimilarity in measurements to support a conclusion of identification or exclusion.

Large scale studies on the use of anthropometric comparison, based on approximately 30 landmarks and high resolution images, have shown that photo-anthropometry has limited discriminating power (Evison et al., 2010). In practice, a reduced form of this method using between 3 to 7 landmarks without taking actual measurements is undertaken on lower quality images, like CCTV. However, there is evidence that this reduced method is also unreliable for both identification and exclusion purposes (Kleinberg, 2007; Moreton and Morley, 2011). Additionally, the absence of photogrammetric control (scale) in the images dictates the use of ratios/proportions rather than absolute measurements. However, the use

of ratios will not overcome problems arising from subject distance to camera, subject pose or focal length of lens (Edmond et al., 2009).

The following imaging conditions must be met to get reliable results using photo-anthropometry:
- o Sufficient resolution and focus to resolve features and landmarks of interest
- o Minimal compression artifacts
- o Minimal distortion
- o Same viewpoint
- o Same lighting
- o Minimal obscuration
- o Known focal length
- o Known lens distortion
- o Known subject distance
- o Known angle of head tilt
- o Same aspect ratio
- o Same pose
- o Short time interval between photographs
- o Similar expression

A properly trained examiner[3] will benefit from knowledge of anthropometric landmarks for certain applications such as alignment of images, without implementing the metric application. However, due to the limitations described above regarding image requirements, the forensic application in facial comparison is mostly precluded. This technique should neither be used as an independent comparison method nor in conjunction with another method for positive identification or exclusion.

Effect of Sub-optimal Images on Photo-Anthropometry

Photo-Anthropometry is extremely sensitive to image quality. Loss of image quality through blurring, compression artifacts, reduction in spatial resolution (e.g., pixels on target), lens distortion or perspective distortion reduces the ability to determine the specific location of individual landmarks, which subsequently reduces the accuracy of all measurements. Furthermore, in sub-optimal images, the ability to determine the specific pose and expression of the subject can be greatly reduced, which can further introduce error and uncertainty. The net effect is a significant reduction in the accuracy of the analysis, with the potential to improperly include or exclude a subject from the population of potential suspects.

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[3] FISWG Section 3 "Guidelines and Recommendations for Facial Comparison Training to Competency"

Superimposition

FISWG recommends that superimposition only be used in conjunction with morphological analysis.

Description

Superimposition is the process of creating an overlay of two aligned images and comparing them visually with the assistance of image transitions. Using video techniques or digital image processing, image transitions can include wipes, fades, and toggles. In a wipe, a straight line passes across the screen gradually revealing the underlying image such that parts of both images at full opacity can be observed simultaneously. In a fade one image is progressively replaced by another image by gradually changing the transparency of the image layers such that the entirety of both images is observed at reduced transparency simultaneously. In a toggle each image is displayed for a short time period (fraction of a second) at full opacity. Superimposition is commonly used in conjunction with other methods.

Advantages and Disadvantages of Superimposition

Factors relating to Superimposition are described in the table below.

Factor	Details	Pro	Con
Image	The conditions under which one can achieve reliable results are very restrictive (see also photo-anthropometry) and are rarely encountered in forensic case work		x
Process	Superimposition can enhance morphological analysis when comparing the relative spatial distribution and shapes of features depicted	x	
	Superimposition should not be used as an independent comparison method		x
	There is a potential to distort images to bias a conclusion where none is warranted		x
	The use of some image transition features may be misleading to the inexperienced observer Agreement between two superimposed images could be inferred by the nature and speed of the transition tool used		x
Specialized Equipment	Requires specialized software or video editing equipment and appropriate knowledge of its use		x
Time for Examination	Dependent on examiner training, image quality, and application		x
Training	Requires advanced training		x
Validation/ Accuracy	Very dependent upon imaging conditions		x

FISWG Recommended Practices

The most appropriate use of superimposition is as an aid to visual comparison when two images are taken from the same viewpoint. Images may be photographs, frames or images from video, or images synthesized from 3D face or head models. Images must be registered (scaled, rotated, and translated) to one another for proper alignment. There should be a concordance between images in all aspects of angle and perspective to avoid distortion of the spatial distribution of landmarks and features. FISWG recommends only the use of rotations and scaling transformations when applying the superimposition method because these transformations preserve shapes. Image processing techniques such as skewing and perspective transformation should not be used. Unless there is reason to question the aspect ratio, aspect ratio must be maintained. Superimpositions are only suitable for image-to-image comparisons.

Unless both images are captured under the ideal imaging conditions described in the Photo-anthropometry section, most video superimpositions do not match exactly. However, a very slow fade may give the illusion of a perfect match as one image is almost imperceptibly replaced by another. In this practice, the human eye is led from one image to another blending the two together, reducing the ability to perceive differences. A fast fade may emphasize differences. In general, wipes and fades promote the appearance of similarities; whereas, toggling between images promotes the appearance of differences. It is for this reason that wipes, fades, and toggles can mislead naïve observers and even the improperly or untrained practitioner. If superimposition is used, these limitations must be fully understood and explained to any third parties.

Effect of Sub-optimal Images on Superimposition

Superimposition is sensitive to image quality. Loss of image quality through blurring, compression artifacts, reduction in spatial resolution (e.g., pixels on target), lens distortion, or perspective distortion reduces the ability to determine the specific location of individual features, which subsequently reduces the ability to generate an accurate overlay/superimposition. Furthermore, in sub-optimal images, the ability to determine the specific pose and expression of the subject can be greatly reduced, which can further introduce error and uncertainty. The net effect is a significant reduction in the accuracy of the analysis, with the potential to improperly include or exclude a subject from the population of potential suspects.

User Scenarios

Facial comparisons are performed for a number of reasons and the comparison method employed should be chosen based on the timeframe required for a decision and the level of confidence required. Comparisons that need to be immediate require the use of faster processes which will necessarily lead to a result with a lower confidence. In certain scenarios this lower confidence is an acceptable trade-off for the speed of the analysis. For example, in screening and access control, the examiner might be expected to evaluate hundreds of comparisons a day whereas forensic casework will require more time to be spent on a single comparison. To illustrate common applications of facial comparison, user scenarios for facial review and facial examination are described below.

Facial Review

Access control - To enter a government facility, an individual presents an access card with biographic information and a fairly old photo to a gate guard. The guard swipes it in his handheld device, which brings up the embedded information from the card, to include a photograph. The guard uses the holistic method to compare the photo on the card to the photo on his device. The guard then compares those photos to the individual at the gate. While holistically they match, the morphology of the blemishes and creases on the face is sufficiently different for the guard to request that the person provide a secondary form of identification. The photo on the second ID card is more recent and depicts some of the more aged characteristics the guard observed and the individual is allowed access.

Field Personnel – A law enforcement officer encounters an individual late at night on a dark road as a result of a traffic stop. The driver and sole occupant claims to have no driver's license or other identity documents. The driver is also unable to present any documentation for the vehicle. The officer attempts to gather information from the driver with the hope of establishing an identity and confirming the driving privilege status of the driver, via a database available through the radio or Mobile Digital Computer (MDC). After several unsuccessful attempts with fictitious names and birth dates, the officer takes a digital image of the driver with a device provided by his/her agency. The digital image is sent via the device to the MDC and transmitted to the agency mug shot database where it is searched against many images via a facial recognition program. The system returns five candidates to the MDC and the officer uses holistic comparison to conduct a facial review combined with his/her investigative training to identify the driver.

Border Security – A border control officer is assigned to a port of entry which allows pedestrian access to his/her country at the border with a neighboring nation. Pedestrians desiring access are funneled into a line which eventually allows only one person at a time to pass through a controlled space where digital images are captured and automatically searched against a database of known or suspected criminals/terrorists. If a match is determined by the system and that match is above a certain threshold, that pedestrian is removed from the line and taken to a secure area for further investigation. If the comparison score is close to a predetermined threshold, then the border control officer receives one or more candidate images for review. The officer makes a determination, based on a limited morphological analysis, of whether the pedestrian is removed to a secure area for further screening or is allowed to pass over the border.

Facial Examination

A robbery suspect is arrested by an investigator who has several cases believed to have been committed by the same individual. Based on eyewitness testimony of the bank tellers and surveillance images, the investigator is able to select a subset of images that could be submitted to a facial recognition system. The system returns a high match score for a

known individual already in the agency database from a previous arrest. The matter is coming to trial and the defense attorney requests a dismissal of the case based on an alibi that indicates the suspect was nowhere near the scene of the crimes. Since the investigator had no training in the area of facial comparison and was concerned that a defense attorney might use the "alibi" defense, he has already sent numerous evidentiary images and mug shots of the subject to the agency's crime lab. An examiner at the crime lab, trained in Morphological Analysis, examines the images and provides his opinion in a formal report that contradicts the alibi. Based on the facial examiner's evidence, the judge denies the motion and sets a trial date.

A police officer makes a routine traffic stop. The vehicle operator presents a driver license (DL) to the officer. The license is run and no warrants come up, so the officer prepares to release the subject with a ticket when she notices that while the DL photograph shows a person with very large ears, the vehicle operator appears to have small ears. As a result, she becomes suspicious, requests permission to search the vehicle, and discovers a large cache of illicit drugs in the process. The suspect is arrested. Subsequently, the suspect's defense attorney argues for a dismissal of the case based on the fact that the DL photograph actually depicts the suspect, so there was nothing suspicious and therefore no justification for the search, making the drug evidence inadmissible. The District Attorney requests that the local crime lab perform a facial comparison examination to determine if the suspect is, in fact, depicted in the DL photo. An examiner at the crime lab, trained in Morphological Analysis, requests additional photographs of the suspect in order to approximate the same conditions as the DL photo. Upon comparison with the additional photographs, the examiner identifies multiple inconsistencies between the suspect and the individual depicted in the DL photo. These include detailed differences in the ears and nose, as well as two small scars on the face in the DL photograph that are not present on the suspect's face. At a subsequent hearing, the examiner testifies to these results. Based on the facial examiner's evidence, the judge denies the motion and sets a trial date.

Summary of Recommendations

FISWG recommends that holistic comparison be used only when time constraints do not permit a more complete examination. Whenever feasible, holistic comparison should be extended toward a basic form of morphological comparison.

FISWG recommends morphological analysis by trained individuals as the primary method of comparison. When using morphological analysis for facial examination, full documentation of the examination and decision making process is required.

FISWG recommends that superimposition only be used in conjunction with morphological analysis. Only rotation and scaling transformations should be used when applying the superimposition method because these transformations preserve shapes.

FISWG recommends that photo-anthropometry NOT be used for facial comparison at this time.

FISWG recommends an independent technical review or check (verification or peer review) of all documented observations relating to facial examinations.

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