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Report

Survey About Facial Image Quality

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Contents

List of Tables

List of Figures

1 Introduction

International Civil Aviation Organization (ICAO) New Technologies Working Group (NTWG) accepted in the Berlin Resolution in June 2002 [6] that there are many advantages in favor of facial image. It is already socially and culturally accepted internationally, photographs do not disclose information that the person does not routinely disclose to the general public, the facial image is non intrusive and does not require new and costly enrolment procedures to be introduced, many states have a legacy database of facial images captured as part of the digitized production of passport photographs which can be encoded into facial templates.
Since that resolution the facial image is the mandatory biometric identifier to be included in digital identity documents. There has been much effort with the objective to warrant the quality of facial images for digital data interchange, right printing and to give facilities for face recognition.

At the Department for IT Security of the Fraunhofer Institute for Computer Graphics Research (Fraunhofer IGD) there is a particular interest in the implementation of the standard requirements for digital passports. They are specified in ICAO-MRTD document "Biometrics Deployment of Machine Readable Travel Documents" [6] and in its Annex D, better known as ISO/IEC 19794-5 [1], to design a metric for facial images. In this document both documents are called "international standards". The project "Two Dimensional Facial Image Quality" (2DFIQ)is the initiative of the Fraunhofer IGD to propose a model to measure the quality of digital passport photos based on the specifications of the international standards referred to [6], [1]. In the analysis and design phase of the project, some problems to assign a precedence and relevance of attributes of a passport photo occured. Since these international standards play an important role in the maturation process of security assurance in some countries, a survey to ask the experts from Germany and from other countries about their opinion and perception of quality, facial image quality, perception and use of both international standards was designed.

2 Identification of ICAO/MRTD and ISO 19794-5 Quality Requirements

In the earliest phase of the project 2DFIQ an analysis of requirements related to facial image from the international standards [6], [1], was performed; it is summarized in Table 4. The first column includes the attributes identified and classified according to common characteristics and correlation in the quality perception, the second and third columns contain the requirement sentences related to the attribute identified and the fourth column describes restrictions or constraints and/or comments associated to the attribute. The results of that analysis were not at all satisfactory for the required needs thus a deeper analysis of quality requirements for passport photos based in the ICAO "Biometrics Deployment of Machine Readable Travel Documents" specifications [6], and its annexes: "Annex A. Photograph Guidelines", "Annex B. Facial Image Size Study 1", "Annex C. Facial Image Size Study 2", "Annex D. Face Image Data Interchange" better known as "ISO/IEC CD 19794-5" [1] was done.
A method called *Achto Cualli*[1] was designed by the author of this document for the 2DFIQ project. The *Achto Cualli* method which is composed of the following precepts:

1. Identification of conformance requirements
2. Identification of requirements, rules, laws, standards or politics related
3. Qualification of requirements

[1] Achto means firstly, Cualli means the best, in Nahuatl, an ancient Mexican language

4. Integration of fulfillment of requirements into an algorithm

For the purposes of the survey and as part of that project, the first precept of the *Achto Cualli* method was applied to identify the quality conformance requirements to be fulfilled. Three main groups of requirements were identified:

- Photograph requirements. Implies the previous preparation of the scenario to be used; this accomplishes the requirements of background uniformity, color, type, reflection and illumination of the scene.
- Image requirements. Including all attributes that have the main influence in the perception, this criteria considers those attributes that have a big impact on visual perception such as brightness and contrast which are common requirements specified in all ICAO Annexes previously mentioned.
- Biometric Content. The classification of elements in this group obeys the specifications of head pose angle, face features and shoulders visibility and position.

A matrix called *Achto Cualli matrix* for each main group of requirements is generated a result of applying this method, every matrix includes seven columns, the first column corresponds to the attribute identificador, the second column corresponds to the name of the attribute, the third column corresponds to the conformance requirement sentence or sentences. The first matrix presented in Table. 1 contains specifications of photograph requirements. Table. 2 represents the second matrix for image requirements, Table. 3 shows the biometric requirements identified. There are in total twenty six attributes identified from which fourteen are photograph requirements, five are image attributes and seven are biometric attributes.

3 Facial Image Quality

Problem Definition After the analysis of the standard requirements specified in ICAO-MRTD and ISO/IEC 19794-5, the most complex problem found is the subjective specification of photograph guidelines from Appendix A from ICAO MRTD [5], it complicates the objective quality interpretation of a facial image, for example sentences like

- The photograph must be in sharp focus and clear
- The photograph must show your skin tones naturally
- The photograph must have an appropriate brightness and contrast
- The photograph must be color neutral
- The photograph must show your eyes open and clearly visible (no hair across your eyes)
- The photograph must be taken with a plain light colored background
- The photograph must be taken with uniform lighting and not show shadows or flash reflections on your face and no red eye effect

are subjective, how to quantify or measure "appropriate" and "clearly"? or how to qualify "color neutral"? Another problem identified for designing the metric are the different biometric attributes referred to the specifications of ICAO MRTD and ISO 19794-5 [6], [1], how to evaluate the different features of a face?

Tab. 1: Achto Cualli matrix of Photograph Requirements

ID	**Attribute**	**Constraint**
AOF	Antiquity	must be no more than 6 months old
SPH	Size	must be 35-40mm in width-height
FOS	Focus	must be in sharp focus and clear
LGS	Lighting Scene	must be taken with uniform ligthing, must not show shadows
SKT	Dermis	must show the natural individual's skin tone
BGD	Background	must be taken with a plain light-colored background
EYS	Eyes	the individual's eyes must be open and clearly visible -no hair across the eyes
FCG	Facing	individual's facing square on to the camera, not looking over one shoulder (portrait style) or tilted, and showing both edges of the face clearly
HCV	Head	head coverings are not permitted except for religious reasons, but the facial features from bottom of chin to top of forehead and both edges of the individual's face must be clearly shown
PRG	Percentage	the face must takes up 70-80 % of the photograph
EXP	Exposure	must not be over or under exposure
EXS	Expression	must show the individual's face alone with neutral expression
MCD	Mouth	must show the individual's face with mouth closed
NFR	No Flash Reflection	There shall be no lighting artefacts or flash reflections on glasses

Tab. 2: Achto Cualli matrix of Image Requirements

ID	Attribute	Constraint
BNS	Brightness	must have the appropriate brightness
CST	Contrast	must have the appropriate contrast
CLR	Color	must be color neutral
NRE	Red eye	must not show red eye
FLT	File	the file type should be in a compressed format such as JPEG2000

Tab. 3: Achto Cualli matrix of Biometric Requirements

ID	Attribute	Constraint
APA	Head pose angle	the individual's pose angle should be less than +/- 5 degree
WAH	Width of head	the head must be greater than 5/7 of width of image
LOH	Length of head	must be no more than 80% of the vertical length
NRF	Number of face	only one is accepted
HCF	Horizontally centered face	the face should lies on the vertical line and horizontal center
VP	Vertical position	the vertical position of the face should be between 50% and 70%
RSL	Resolution	at least 180 pixels of resolution for the width of the head or rougly 90 pixels from eye center to eye center

Tab. 4: Photograph taking guidelines for travel documents

Attribute	**Requirement 1**	**Requirement 2**	**Comment/Constraint**
Hair	Without hair	With hair with different hair color	For persons with voluminous hair overriding it is the priority to pay attention keep the requirements mentioned in the large conditions of the image
Head	Without headgear	With headgear (allowed for religious reasons only)	For persons who wear headgear, the face region (from chin to forehead must be visible)
Face	Without Make-up,without piercing	with make-up, with piercing	None under- or overexposed, no covers on the face, neutral face expression (no smile, both eyes normally opened, mouth closed), line of vision directly to the camera
Eyes region	Without eyeglasses (of persons with different eye colors)	With eyeglasses (of persons with different eye colors)	For eyeglasses the eyeglass frame may not cover the eyes, no reflections on eyeglass lenses, pupil and iris must be recognizable, no perceptible distortions (e.g. fish eye effect), no "red eye" effect
Eye (left or right)	No eye flap (of persons with different eye colors)	With eye flap (of persons with different eye colors)	Pupil and iris of both eyes must be recognizable, no perceptible distortions, no "red eye" effect
Mouth	Without beard	With beard (upper lip beard, chin and/or cheek beard)	The mouth must be closed
Shoulders			Shoulders must be visibly

4 Methodology of the Survey and Data Compilation

This survey addresses to people who have experience in working directly or indirectly with facial images. Two kinds of user-experts were identified: practical user experts and technical user experts. In the first group people can be included whose main activities are one or more of the following: control, testing, inspection, certification of identity documents with a facial image like passport, visa, driver's license etc. In the second group people can be included who have made research in digital facial image, biometrics, standardization, face recognition, passport photos evaluation, facial image, IT security, software development, etc. The framework of this survey consists of the analysis of results of two basic frames, the first frame is compound of practical user-experts and the second frame is compound of technical user-experts. These frames are characterized by the use of facial image in the daily activities of both groups of user-experts. Figure 1 shows the survey framework design in which the main activities of each group of experts can be included and, as a common factor, the use of facial images.

Survey Objective. The main purposes of this survey are

- Evaluation of the perception of the definition of quality in a general sense
- Evaluation of the perception of the facial image quality concept
- Identification of a relative state of the art of the relationship between security and the use of ICAO-MRTD and ISO 19794-5 [6], [1] as international standard to control the quality of facial image
- Evaluation of the perception, classification, relevance, and precedence of quality requirements specified in ICAO-MRTD and ISO 19794-5 [6], [1]
- Identification of facial image working groups around the world
- Comparison between the opinions of practial and technical user-experts to find convergences and divergences between both groups.

Obtaining Survey Data. For practical user-experts an on-site survey was supplied. The experts have been visited and applied the questionnaire directly in their work places. The questionnaires were applied at the following locations: Frankfurt airport at the check-in zone and border police as well as Office of Order in Darmstadt, Germany. For the the technical user-experts the advantages of the Internet for data collection were used. They were invited through a personalized email. An online survey was designed, directed to contact technical user-experts from different countries within a relatively short time. For this online survey a web-based application in a three-layer platform (web and applications server, database server, and a web-browser as client) was created. The identification of the technical user-experts group was done through an on-line research strategy using different data sources to obtain the email addresses and professional profiles:

- Lists of participants in specialized conferences (Biometrics Quality, Face Recognition)
- Internet search engines such as Google, Yahoo, Altavista, WebCrawler and Windows Live, with the keywords facial image, face recognition, face research, personal identity, face image standardization, biometrics

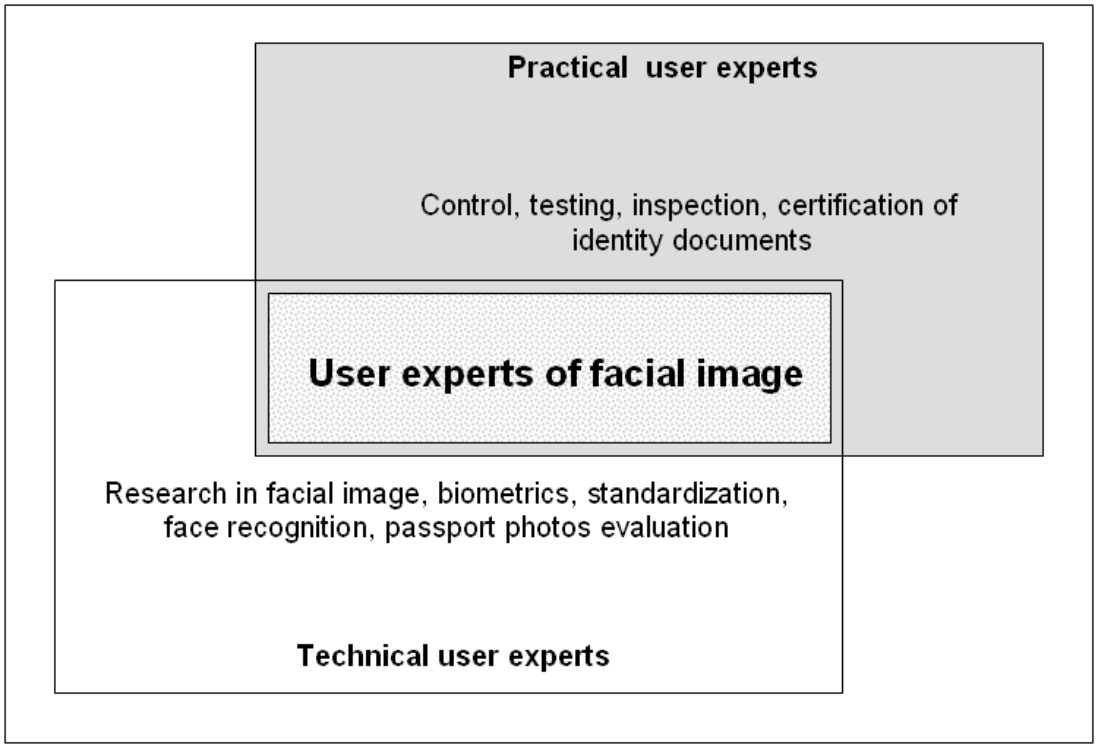

Fig. 1: 2DFIQ Survey Framework

- One-to-one referencing, this strategy consisted in asking colleagues or friends to invite colleagues or friends who have the user-expert profile to answer the survey

Size of the Population. A total of 400 experts from 25 countries was invited, 30 practical user-experts and 370 technical user-experts. The practical user-experts were invited personally in different sessions and work times.

User expert profile. A person to be qualified as expert should cover the requirement of working directly or indirectly with facial image in his/her daily activities and the use of some kind of normative document to perform their activities, the experts contacted can have one of these positions in a organization, university or company:

- Account Manager
- Application Security Architect
- Application Security Engineer
- Associate Software Engineer
- Auditor Cert Security Consultant
- Certification & Accreditation Engineer
- Channel/Business Development

- Check-in Agent
- Chief Scientist
- Chief Security Officer (CSO)
- Compliance Officer
- Customer Service
- Customer Support
- Database Security Architect
- Database Security Engineer
- Developer
- Director of Privacy and Security
- Disaster Recovery Coordinator
- Forensics Engineer
- Identification Document Controler
- Incident Handler
- Information Assurance Analyst
- Information Assurance Engineer
- Instructor
- Jr. Security Analyst
- Junior Researcher
- Management
- Manager
- Information Security
- Penetration Engineer
- Personal Identification Controller
- Physical Access Controller
- Principal Software Engineer
- Privacy Officer
- Product Strategist
- Quality Assurance Specialist

- Regional Channel Manager
- Research Engineer
- Sales Engineer
- Sales Representative
- Security Analyst
- Security Architect
- Security Auditor
- Security Consultant
- Security Director
- Security Engineer
- Security Evangelist
- Security Product Manager
- Security Product Marketing Manager
- Security Researcher
- Security System Administrator
- Senior Product Manager
- Senior Researcher
- Senior Security Engineer
- Senior Software Engineer
- Software Engineer
- Technical Editor
- Technical Marketing Engineer
- Technical Support Engineer
- Technical Writer
- Technology Risk Consultant
- Threat Analyst
- Training/Awareness Specialist
- VP Information Security
- VP of Marketing

- VP of Regional Sales

Results expected. According to the objective of this survey, the results to be obtained are specified in Table. 5, the first column shows the variable name, the second column shows the expected value.

Tab. 5: Results Expected from the Facial Image Quality Survey

Result	**Description**	**Value expected**
Quality	Definition of quality in a general sense	qualitative: list of terms that compound the quality definition according to user-experts opinion
Facial image quality	Definition of facial image quality concept	qualitative: list of terms that compound the facial image quality definition according to user-experts opinion
Relationship between security and facial image control	State of the art of the relationship between security and the use of ICAO-MRTD and ISO 19794-5 [6], [1] as international standard to control the quality of facial image	qualitative: list of terms associated in the relationship
Quality requirements perception	Coincidence of user-experts opinions with the requirements specified in ICAO-MRTD and ISO 19794-5 [6], [1]	quantitative: percentage of coincidences
Precedence order of quality attributes	Classification of quality requirements specified in ICAO-MRTD and ISO 19794-5 [6], [1] in ascendent order according to user-experts opinion	qualitative: list of attributes
Relevance order of quality attributes	Quality attribute occurrence in the user-experts opinion and comments	qualitative: list of attributes
Facial image working groups	Identification of facial image working groups around the world	qualitative: list of working groups founded
Opinion convergence	Opinion convergences between practical and technical user-experts	quantitative: percentage of convergences
Opinion divergence	Opinion divergences between practial and technical user-experts	quantitative: percentage of divergences

5 Profiles of Participants

International standards play an important role in the maturation process of security control in its different variations. In many countries the iniciatives to stablish a standarized process of personal identity documents especially for the control of travel documents has been supported in the last four years with a high priority. In this section of the survey the information about those who have answered this survey is presented; in order to compile information of the greater number of potential facial image user experts from different countries, the on-line survey has been addressed to people from 25 different countries. This demographic information can be a reference guide of detecting the adoption of the standards referred to the previous section.
This section includes the country name, type of organization, company or university, position, activities related to facial images and normative documents used. Most of technical user-experts are people who have between one and eleven years of experience working with facial images, while the practical user-experts are people who have from two days to fourthteen years of experience working in controlling identity documents.

Size of the population. A total of 400 persons was invited, 362 people from 24 different countries were invited by email to answer the on-line survey and 38 people from Germany were invited to answer the on-site survey.

Participation in the survey. A total of 20 persons answered the survey on-site. From people invited by email to answer the on-line survey, 5 emails were answered automatically as out of office messages, 75 emails were rejected because of a problem with the email account of the addressees, 175 emails were not answered, and 66 people participated in answering the on-line survey. Table 6 shows the distribution of invited people and participating people segregated by country.

Type of institution of the participants. From a total of 59 different types of institutions of participants, 34% are universities, 14% are research institutes, 25% are specialized companies, 20% are government agencies, 3% are airlines, 3% have not answered this question. Figure 2 shows the percentage distributions of the participants organizations.
Position of participants. There were 81 people who answered this question, the position of the participants are distributed as follows:
Activities related to facial image quality. The main activities performed by the participants are:

- Face recognition development
- Passport control
- Visa control
- Personal identification control
- Research in face detection and recognition
- Research and development management in face recognition and related files
- Research in computer vision
- Research work on facial image processing and analysis

Tab. 6: Invited People and Participating People Segregated by Countries

Country of Origin	**Invited People**	**Participating People**
Afghanistan	0	1
Australia	4	0
Austria	6	2
Brazil	5	1
Canada	8	1
Chile	4	1
China	23	4
Croatia	1	2
Denmark	13	4
Finland	12	2
France	3	1
Germany	68	40
Israel	2	0
Italy	5	1
Japan	2	1
Korea	5	0
Mexico	9	1
Netherlands	5	1
Norway	0	1
Singapore	2	0
Slovenia	10	0
Spain	4	1
Sweden	1	0
Switzerland	1	0
Turkey	1	1
United Kingdom	41	5
United Sates of America	165	15
Total	370	86

Tab. 7: Distribution of Participants Segregated by Position

Position	**Percentage**
Chief Scientist	16%
Check-in Agent	12%
Research Engineer	11%
Senior Researcher	9%
Developer	7%
Instructor	5%
Security Researcher	5%
Software Engineer	5%
Account Manager	4%
Junior Researcher	4%
Senior Software Engineer	4%
Management	3%
Personal Identification Controller	2%
Security Engineer	2%
Application Security Architect	1%
Forensics Engineer	1%
Identification Document Controller	1%
Manager Information Security	1%
Principal Software Engineer	1%
Sales Representative	1%
Security Analyst	1%
Security Architect	1%
Security Consultant	1%

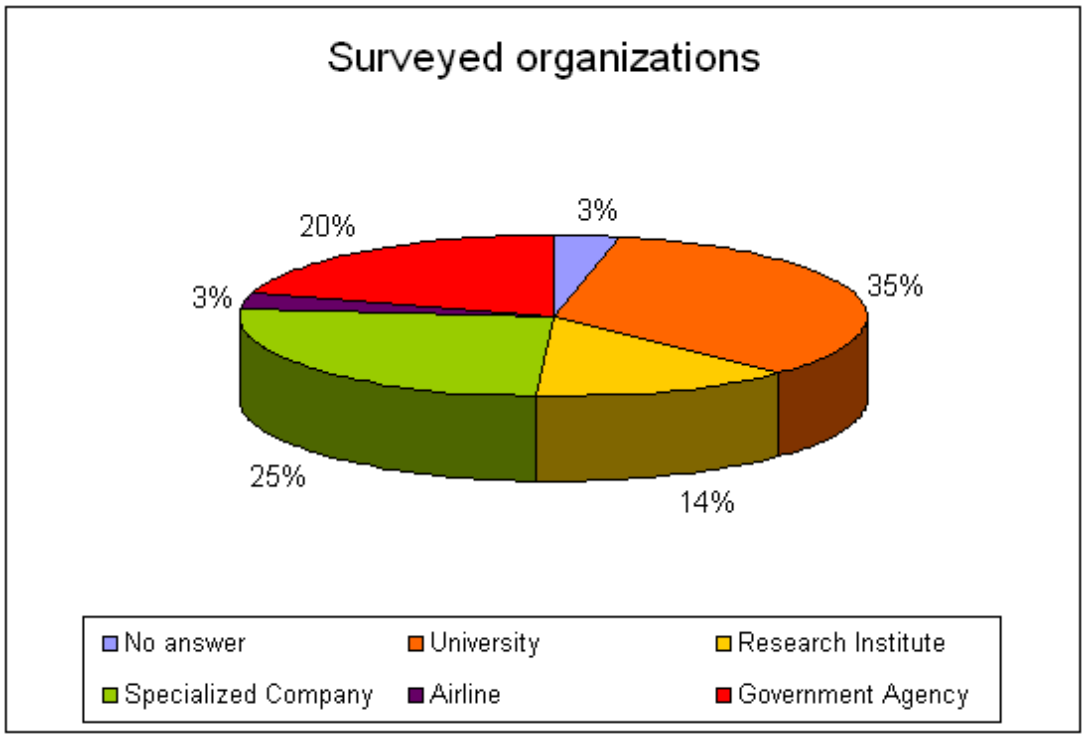

Fig. 2: Surveyed Organizations

- Research in neurosciences
- Research into 2D/3D face recognition
- Research and standardization of facial images
- Research in integration of identification-based systems
- Analysis of face recognition algorithms performance
- Analysis of biometrics
- ICAO portrait control (ISO quality assessment of facial images)
- Advising government agencies
- Advising the government regarding all questions of facial quality software for passport applications
- Development of face recognition systems
- Development of biometric software
- Development of ID related solutions
- Development of projects to evaluate face recognition
- Development of projects for automatic image analysis (recognition and detection)

- Testing of biometric systems
- Exploring image compression effects on face recognition and developing fully compressed domain facial recognition system
- Development of standards
- Development of modern facial recognition techniques (SVM, recognition by parts as well as common discriminators)
- Development for 3D face recognition
- Development of projects related to smart cards
- Consulting in IT security and biometrics
- Development of projects for electronic passport
- Implementation of face finding algorithms, face image quality assessment and enhancement
- Enrolment and quality assurance

Use of normative documents. With this question the participants were asked to select a type of normative document used in their daily activities. Three kind of normative documents were offered: best practices, law related and standard. As alternative answer a field was included to write an alternative document not listed previously. This question was answered by 81 persons, a total of 77 recognize the use of one of the documents listed to perform the daily activities related to facial image quality, while the rest declared to use other types of normative documents. Table 8 shows the distribution of normative documents used segregated by group of participants. Most of people who specified as main activity the control of passports, visa or personal identity answered that the control of a facial image is based on corporate documents and on experience, not necessarily on an international standard. The participants declared to use the following documents as normative documents in the performance of their daily activities related to facial images:

- Corporate manual
- ICAO and SC37 documents
- Papers in the leading academic journals
- Laws depending on the country to be visited (check-in agent answer)
- ISO/IEC 19794-5
- Academic surveys
- ISO/IEC 19794-1 and 2
- ISO/IEC JTC 1/SC 37 Documents
- NIST-ITL-1-2001/2006
- Directives of the Federal Ministry

Tab. 8: Types of Normative Documents Used, Segregated by Group of Participants

Type of Document	**Practical user experts**	**Technical user experts**
Best practices	7	6
Law related	7	5
Other document	6	16
Standard	0	30
Total	20	57

- EU directives
- ICAO, DIN, ISO
- Tutorials published on the www, blogs
- Guidelines of the Federal Print Office

6 Definition of Quality

The concept quality has different meanings. It can be interpreted according to the point of view or according to the needs of the user. The participants were asked to select a phrase that defines quality best. Purpose of this question is to compare the interpretation of the quality concept from both groups of experts and to identify which concepts can be mixed to form an integrated quality concept considering the opinions of the participants. This section includes the analysis of the use and interpretation of different concepts of quality. Some different definitions of quality in its general concept were included to evaluate which one was the term most frequently used by the user-experts to develop their activities related to facial image quality.

Quality Concept. According to the dictionary of English language [2] quality is an inherent or distinguishing characteristic; Philip Crosby, considered as one of the great brains of the quality revolution in [3], specifies that quality is the conformance of requirements. The best known International Quality Standard: ISO 9000 in its quality definition [4] determines that quality is the degree with that a set of inherent characteristics fulfils requirements. Figure 3 compares opinions of technical and practical user-experts. It can be estimated that for the majority (39%) of technical user-experts the meaning of Quality is: *an inherent or distinguishing characteristics property* while for the majority(45%) of practical user-experts, Quality means: *fulfilment of legal and regulatory requirements*, as second meaning of quality for technical user-experts the *conformance of requirements* was chosen having 32% of opinions. For practical user-experts the second meaning selected having 30% is the degree or grade of excellence.

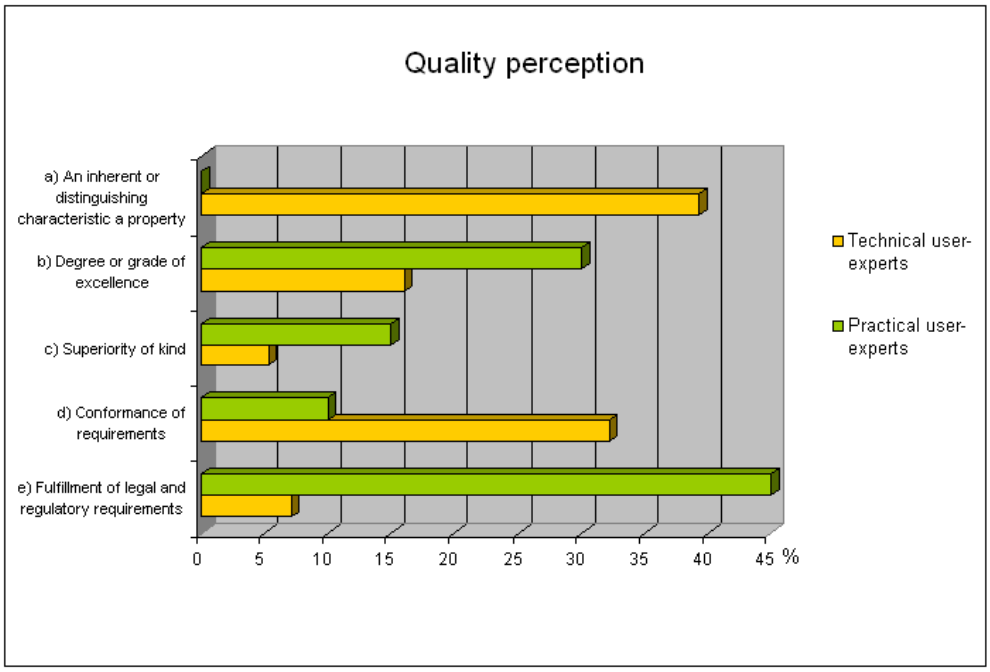

Fig. 3: Quality Perception of User-Experts

7 Perception of Facial Image Quality

Facial Image Quality Perception. The concept of Facial Image Quality as the quality concept by itself can be interpreted depending on its use and dependig on the normative documents to be used.
The objective of this question is to compare the interpretation of the quality concept of both expert groups and to identify which concepts can be mixed to form an integrated facial image quality concept considering the opinion of the participants and the specifications of the ICAO MRTD and ISO 19794-5 [6], [1]. This perception was evaluated asking the participants which of the following sentences describes best the good quality of a facial image:

1. The image has a good resolution.
2. The face is recognizable.
3. The color is neutral.
4. The image fulfils the specifications established.

These sentences refer to requirements related specifically to facial image of the standards mentioned previously and using a quality concept in a general sense. A total of 76 people answered this question of which 56 are technical user-experts and 20 are practical user-experts. Figure 4 shows a graphic of the results obtained, while Table 9 shows the results segregated by group of experts.

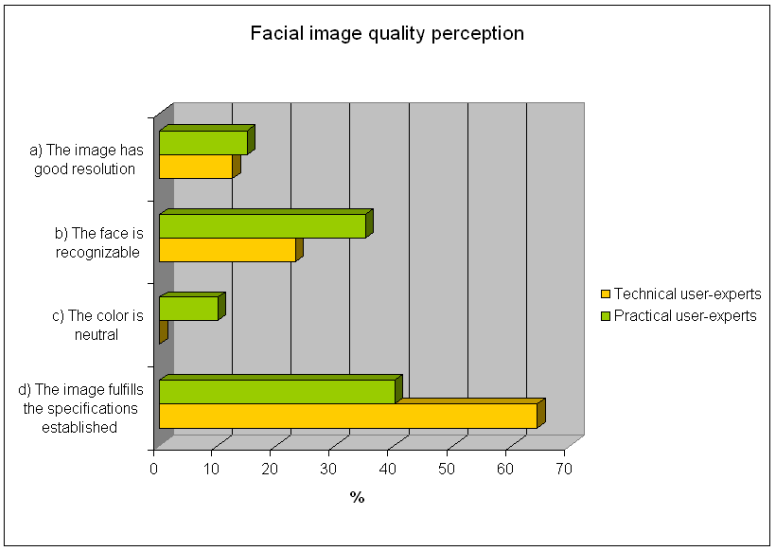

Fig. 4: A Facial Image Quality Perception of user-experts

Tab. 9: A Facial Image Quality Perception of user-experts

Quality sentence	**Practical user experts (%)**	**Technical user experts (%)**
1	15	12
2	35	23
3	10	0
4	40	64

Digital Facial Image Quality Perception. This perception was evaluated based on the requirements related specifically to digital facial image stablished in [1]. The users were asked to select within the next sentences which defines best the quality of a digital facial image:

1. The image has a good resolution.
2. The face is recognizable.
3. The color is neutral.
4. The image fulfils the specifications established.
5. The image file permits good performance in the software I use.

The last sentence was included to evaluate how important the performance of a software is for each group of experts to evaluate the quality of a facial image .
A total of 75 people answered this question, of which 55 are technical user-experts and 20 are practical user-experts. Figure 5 represents a graphic of the results obtained, while Table 10 shows the results segregated by group of experts.

Tab. 10: A Digital Facial Image Quality Perception of user-experts

Quality sentence	**Practical user experts (%)**	**Technical user experts (%)**
1	25	11
2	30	16
3	0	0
4	35	46
5	10	25

For technical user-experts the most important criterion to evaluate the quality of a facial image is with 46% when the image fulfils the specifications established. This criterion is also the most important for practical user-experts having 35% of selections. The second one for practical user-experts with 30% is when the face is recognizable, while for technical user-experts it is when the image permits good performance in the software to use. With 25% this result is a big paradox between both groups, and calls attention to reflect on the results. The way the technical user-experts are conducting their work could be redirected to satisfy the needs of the practial user-experts.

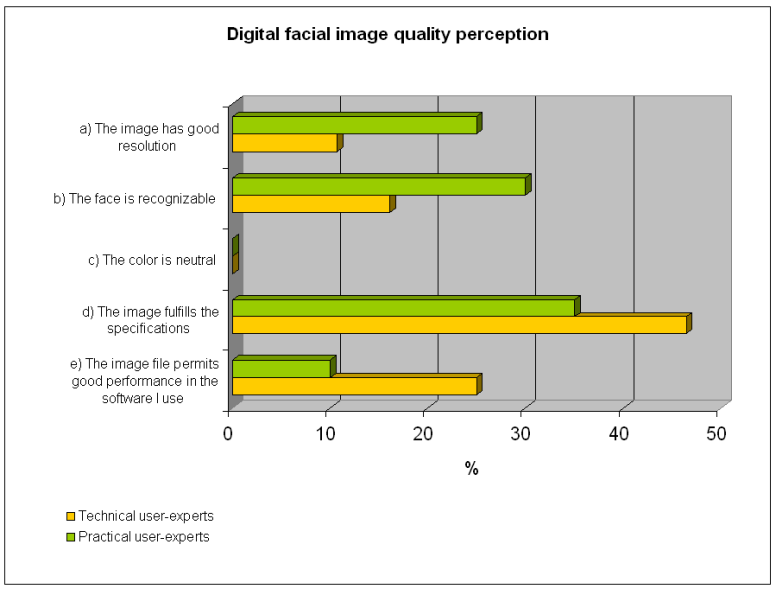

Fig. 5: Quality perception of user-experts of a digital facial image

8 Relevance of Facial Image Quality Attributes

In this section the theoric interpretation of relevance is evaluated in different ways, firstly the participants were shown five different groups of requirements extracted from section 2 Table

1, Table 2 and Table 3. The results are compared with each other, some groups as were being with one type of requirements and other created with a combination of different types of requirements. The following list shows the group organization:

1. Group A. Photograph Requirements
    - Size of photograph
    - Antiquity of the photograph
    - Background
    - Neutral expression
    - No flash reflection
2. Group B. Combination of Image and Photograph Requirements
    - Brightness
    - Contrast
    - No red eye
    - Eyes visibility
    - Mouth closed
3. Group C. Biometric Attributes
    - Head pose angle
    - Width and length of head
    - Distribution of head
    - Face features are recognizable
4. Group D. Combination of Photograph, Image and Biometric Requirements
    - Background
    - Head pose angle
    - Brightness
    - Contrast
    - Image resolution
5. Group E. Combination of Phograph and Biometric Attributes
    - Eyes visibility

- Image resolution
- Head distribution
- Head pose angle
- It must show just one face

This first evaluation was made asking to select one of two groups shown in four questions of the survey's questionnaire.

- Group A vs. Group B
- Group C vs. Group D
- Group A vs. Group E

The participants assigned a relevance for every group of photos which is measured as follows: for the on-line survey the order in which an attribute group was selected and saved in the database in real time at the moment when the survey was answered. The precedence was registered in the database; for the on-site survey an order of precedence, assigned by the participants, was indicated. The percentage of selections obtained for each group in each question was obtained according to the number of votes or selections obtained for each group. The groups were ordered in descendent order according to the percentage obtained for each group.
The relevance assigned by the technical user-experts is ordered as follows:

1. Group C, 71%
2. Group E, 70%
3. Group B, 53%
4. Group A, 46%
5. Group D, 58%

For practical user-experts the relevance is ordered as follows:

1. Group B, 65%
2. Group C, 60%
3. Group D and E, 40% each one
4. Group A, 35%

The second evaluation of attribute's relevance was conducted showing the same attributes together and asking the users to assign a number for their precedences where 1 represents the most important requirement and 14 the least important. The attributes are shown in Table 12; the first column corresponds to the precedence number, the second contains the attributes shown, the third column contains the order selected by the practical user experts and the fourth column contains the order selected by technical user experts.
The relevance order was obtained from a table of the survey database filled in by user experts. Every question obtained the highest value and corresponding attribute from every relevance number. Figure 6 shows the logic adhered to determine the relevance order for every attribute

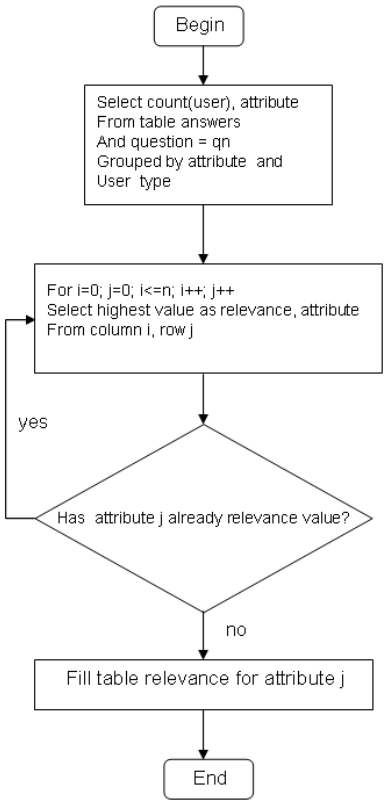

Fig. 6: Flowchart of relevance selection criteria

from both groups of experts. The evaluation process begins selecting the question qn in this case qn $\bar{1}4$, the quantity of user experts for attribute j, n is the total number of relevances to be evaluated, i is the actual relevance in evaluation. The highest relevance value and its corresponding attribute are obtained from column i before being saved. It is validated if there is already a value saved for that attribute, if not the values corresponding to user-expert type, relevance value and attribute name are saved. If there is a value previously saved for that attribute, the next highest value for the next attribute is obtained. Table 12 shows the results for the relevances obtained for every attribute and group of experts.

For technical user-experts the most important requirement is *neutral expression* with 34% of votes, the least important requirement is *contrast* with 27% of votes. For practical user-experts with 25% of preferences the most important requirement is *Size of head distribution* while *Size of photography* is the least important having 20% of preferences.

The third evaluation of attribute's relevance was conducted showing seven requirements together and asking the participants to assign a number for their precedence where 1 is the most important requirement and 7 is the least important; the requirements evaluated are presented in Table **??**. The order of relevance was obtained in the same way as the second evaluation explained above, the logic is shown in Figure 6, in this case question qn= 43 and n= 7. Table **??** shows the results of relevances obtained for every attribute and group of experts.

Another approach to evaluate the relevance of attributes was followed by the visual perception test. It consists in asking participants to select the one photo out of a group of five, that accomplishes or not accomplishes a specific quality requirement. A total of four group of photographs

Tab. 11: Second relevance evaluation of quality attributes

Order	Attribute presented	Practical user experts	Technical user experts
1	Size of the photography	Size of the head distribution	Neutral expression
2	Age of the photograph	Brightness	No Red eye
3	Brightness	Size of the photography	Size of the head distribution
4	Contrast Background	Contrast Antiquity of the photograph	Background Size of the photography
6	Neutral expression	Neutral expression	Age of the photograph
7	No flash reflection	Horizontally centered face	Vertical position
8	Size of the head distribution	Width of head	No flash reflection
9	Width of head	Background	Width of head
10	Red eye	Head pose angle	Horizontally centered face
11	Head pose angle	No flash reflection	Length of head
12	Horizontally centered face	Vertical position	Brightness
13	Vertical Position	No Red eye	Head pose angle
14	Length of head	Size of the photography	Contrast

Tab. 12: Second relevance evaluation of quality attributes

Order	Attribute presented	Practical user experts	Technical user experts
1	Background	Eyes	Shoulders
2	Mouth	Background	Head
3	Head	Mouth	Hair
4	Hair	Head	Eyes
5	Eyes	Hair	Background
6	Shoulders	Shoulders	Nose
7	Nose	Nose	Mouth

was selected for the visual test. In the following paragraphs will be explained, how the different attributes were evaluated.
It shall be emphasised that all the attributes referred to were analized and described in section 2. For more details of the international standards specifications that section might be consulted. The percentages to be presented in this part are the highest values obtained as results for each evaluation.

Photograph groups used For the following evaluations, the first group of photographs shown

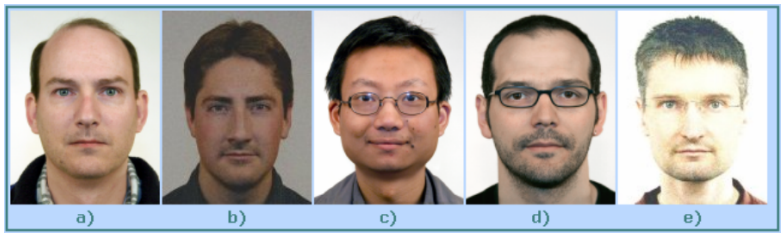

Fig. 7: First group of photographs for visual test

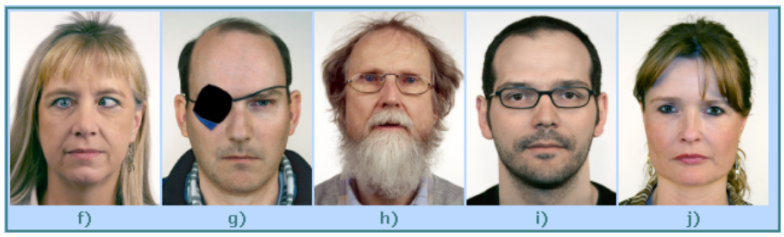

Fig. 8: Second group of photographs for visual test

Fig. 9: Third group of photographs for visual test

in Figure 7was used. This group contains five photographs; photograph b) has been altered adding 30% more contrast, and photograph e) has been altered adding 30% more brightness, photograph d) has been included because of the characteristics of eyeglass frames.

Evaluation of brightness. The first requirement tested was brightness. The participants were asked to select which photo does not have an appropriate brightness; the photographs selected were b) and e). Brightness is related to the luminance of an object, in this case e) would be the right answer. The percentage of correct answers for each user-experts group is:

- Technical user-experts: 54%

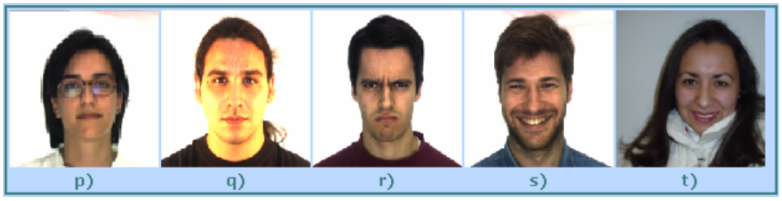

Fig. 10: Fourth group of photographs for visual test

- Practical user-experts: 35%

Evaluation of eyes region. It was asked to select the photograph that does not have good quality within the eyes region. The percentages obtained are:

- Technical user-experts: 74% selected photograph c) has bad quality because it has reflection on eyeglass lenses.
- Practical user-experts: 35% selected photograph d) because the eyeglass frame was not adequate.

Evaluation of contrast. For this attribute it was asked to select a photograph that does not have an adequate contrast.

- Technical user-experts: 48% vote that photograph e) does not have appropriate contrast and 47% think, that photograph b) is the correct answer.
- Practical user-experts: 50% vote that photograph e) does not have appropriate contrast while 35% answer correctly when selecting photograph b)

Evaluation of overexposure. As fourth requirement the participants had to select the photograph with overexposure.

- Technical user-experts: 91% mean that photograph e) is overexposed.
- Practical user-experts: 90% think, that photograph e) is overexposed.

Evaluation of color neutrality. The understanding of color neutrality was the fifth evaluated requirement. The participants had to select a photograph that is not color neutral.

- Technical user-experts: 34% think that photograph b) is not color neutral.
- Practical user-experts: 70% think that photograph b) is not color neutral.

Evaluation of automatic face recognition understanding. As last evaluation with this group of photographs, it was asked which photograph could complicate the face recognition through a software.

- Technical user-experts: 67% of technical user-experts selected photograph e).
- Practical user-experts: 53% of technical user-experts selected photograph e).

Photographs group used. For the following evaluation, the second group of photographs shown in Figure 8was used. In this group the photograph d) from the first group was included because of its characteristics mentioned. Photograph f) was included because the left eye of the individual has a cross-eyed problem and this is one of the exceptions not considered in the standard. However it does not mean that the photograph has a bad quality. Photograph g) was included because the individual is wearing a flap in the right eyes region. The standard permits an eye flap only because of health reasons. If someone is wearing an eye flap, how can the expert users know if that is because of health reasons without a software?.
Evaluation of line of sight. In this evaluation it was asked to select in which photograph the individual was not looking directly to the camera.

- Technical user-experts: 53% think that photograph f) does not fulfil that requirement
- Practical user-experts: 55% think that photograph f) does not fulfil that requirement

In the comments about this photograph it became obvious, that most of the people think the photograph was manipulated to obtain the eye effect. Many people think it does not fulfil the quality requirement because the person is not looking directly into the camera with both eyes. However it is a real photograph from someone who has a physical problem and it does not mean that the photograph has a bad quality.
Evaluation of eyes visibility. It was asked to indicate which photograph does not accomplish the sentence *the individual's eyes must be open and clearly visible*.

- Technical user-experts: 81% answered that photograph g) does not accomplish the requirement except the person uses the patch because of health reasons
- Practical user-experts: 80% answered that photograph g) does not accomplish the requirement except the person uses the patch because of health reasons

Evaluation of automatic face recognition understanding. As last evaluation with this group of photographs, it was asked which photograph could complicate the face recognition through a software

- Technical user-experts: 84% selected photograph g)
- Practical user-experts: 65% selected photograph g)

Photographs group used For the following evaluations, the third group of photographs shown in Figure 9 was used. This group of photographs has a variety of special characteristics; photograph k) is included because of the skin color of the individual, photograph l) is included because of the head cover and skin color of the individual, photograph m) is included because of the hair distribution and color, use of piercing of the individual and make-up.
Evaluation of automatic face recognition understanding. In the third group photographs were included which are considered having a good quality. The participants were asked which photograph would affect the face recognition.

- Technical user-experts: 50% selected photograph k) and 50% selected photograph l).
- Practical user-experts: 51% selected photograph k) and 49% selected photograph l).

Photograph k) has good quality nevertheless half of all users think that it does not have good quality because the skin color was too dark. A technical expert mentions, that *"dark complexions cause problems for some face recognition systems"*. For photograph l) the user-experts

think that it does not have good quality because of the head cover.
Photographs group used For the following evaluations, the fourth group of photographs shown in Figure 10was used. The fourth group is compound of photographs considered as having bad quality because none does accomplish the requirements specified for eyeglasses reflection, brightness, contrast, facial expression and head distribution. **Evaluation of automatic face recognition understanding.** Participants have been asked which photograph would affect the face recognition.

- Technical user-experts: 41% selected photograph p) and 30% selected photograph q)
- Practical user-experts: 35% selected photograph p) and 35% selected photograph t)

9 Conclusions

A total of 87 experts from 20 different countries participated in the survey. Technical and practical user-experts answered the survey according to their knowledge obtained through the experience. 38% of technical user-experts use a standard to develop activities related to facial image quality. Most of practical user-experts referred that the control of a facial image is based on corporative documents as well as on experience. For technical user-experts the most important criteria is with 46% to evaluate the quality of a facial image when the image fulfils the specifications established. This criteria is the most important for practical user-experts as well having 35% of votes. The second important criteria for practical user-experts with 30% is when the face is recognizable while for technical user-experts for with 25% is when the image permits good performance in the software to use. This result is a big paradox between both groups, and claims attention for reflecting about the results. It can be inferred that the technical user-experts are conducting their work - of whatever kind- related to facial images to produce results having as priority the performance of software when the priority or needings of final users is the face recognition.
The group of requirements which best describe the quality for technical user-experts are:

- Head pose angle
- Width and length of head
- Distribution of head
- Face features are recognizable

For practical user-experts they are:

- Brightness
- Contrast
- No red eye
- Eyes visibility
- Mouth closed

The visual evaluation of the requirements shows that the meaning of the specifications of the documents is not clear and that there are some variations related to physical defects of the individual face which should be included in the phrasing of requirements. Many participants assign a photography a bad quality just because of a physical defect of an individuals right eye. Most of the participants assigned another photograph a bad quality just because of the individuals skin color. About the evaluated quality scales some of the participants expressed that it would be better to know under which criteria a photo can be accepted or rejected.
The following list shows the organizations founded that have research groups in facial image and/or in biometrics.

- Fujitsu Laboratories, Japan
- Univ. of Bologna, Italy
- Nanjing University, China
- Mitretek Systems, USA
- University of Sao Paulo, Brazil
- Bogazi University, Turquia
- Technical University of Catalunya, Spain
- Cyberextruder, USA
- Queen Mary University, UK
- University of Kent, UK
- University of California, USA
- Siemens Austria, Austria
- Identity Solutions, UK
- Siemens, USA
- FBI, USA
- UNAM, Mexico
- Bundeskriminalamt, Germany
- Secunet Security Networks AG, Germany
- University of Zagreb, Croatia
- Image Ware System, USA
- University of Oulu, Finland
- Aalborg University, Denmark
- University of Ilinois at Urbana Champaign, USA

- Mitsubishi Electric Research Laboratories, USA
- ZGDV, Germany
- Aalborg University, Denmark
- Fraunhofer IGD, Germany
- University of Twente, Netherlands
- Universidad de Chile, Chile
- Gjovik University, Norway
- Steria Mummert Consulting, Germany
- Carnegie Mellon University, USA
- Bundesdruckerei, Germany
- Sagem DS, France
- Institute of Computing Technology, China

A Glossary

Frame A method providing categories and structure to thoughts.

Framework A hypothetical description of a complex entity or process; a structure for supporting or enclosing something else, especially a skeletal support used as the basis for something being constructed.

Measurable requirement Considered as requirement capable of being measured, requirement with a previously defined unit, system or standard of measurement.

Practical user expert Can be anyone whose daily activities are related to control, testing, inspection and certification of identity documents with a facial image (passport photo).

Technical user expert - Can be anyone who has experience working with facial images this group of experts include people whose main activities are related to research in facial image standardization, biometrics, face recognition, passport photos evaluation, facial image, IT security.

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