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Automatic validation of ICAO compliance regarding head coverings: an inclusive approach concerning religious circumstances

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Abstract: This paper contributes with a dataset and an algorithm that automatically verifies the compliance with the ICAO requirements related to the use of head coverings on facial images used on machine-readable travel documents. All the methods found in the literature ignore that some coverings might be accepted because of religious or cultural reasons, and basically only look for the presence of hats/caps. Our approach specifically includes the religious cases and distinguishes the head coverings that might be considered compliant. We built a dataset composed by facial images of 500 identities to accommodate these type of accessories. That data was used to fine-tune and train a classification model based on the YOLOv8 framework and we achieved state of the art results with an accuracy of 99.1% and EER of 5.7%.

Keywords: Facial Images, ICAO, ISO/IEC 19794-5, Head Covering Detection, Deep Learning

1 Introduction

Photographs used in identification documents must comply with certain requirements that guarantee standardization, in addition to allowing the person represented in the portrait to be properly identified through this image. Compliance with these requirements is based on quality metrics that measure, for example, the framing of the head in the photograph, the contrast with an homogeneous background, the restriction on the use of sunglasses or glasses whose lenses or frames partially or completely cover the eyes, among many others.

Two of the most relevant and extended public documents related to quality assessment in biometrics are the ISO/IEC 19794-5 standard [IS] and Doc 9030 [IC], created by the International Civil Aviation Organization (ICAO) based on that standard. These documents are actually a series of guidelines for the acquisition of high quality images, i.e., portrait-like images, for their inclusion in machine-readable travel documents like passports and ID cards. These guidelines are based on the typical impact that certain features like blur, occlusions, and resolution have in the quality of facial images and are intended to preserve the performance of Facial Recognition Systems (FRS). However, these reports do not specify the method to measure each of the features. In order to implement their recommended

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guidelines it becomes necessary to develop algorithms to automatically verify the compliance with the requirements. All of them can be verified using image processing techniques, combined with geometric measurements of elements detected in the photograph or with more sophisticated methods including deep learning.

In this work we focus on a specific requirement related to the use of head coverings in the photograph. Head coverings should not be accepted except in circumstances specifically approved by the Issuing State of the Machine Readable Travel Document (MRTD). Such circumstances may be religious, medical or cultural.

However, the work already found in the literature regarding this requirement ignores the case when veils, scarves or head coverings cannot be removed for religious reasons. Basically, it just looks for the presence of hats or caps.

Our main contribution in this paper is, thus, the proposal of an algorithm that automatically verifies the compliance with the requirements related to the use of head coverings, specifically considering religious cases.

To do so we built our own dataset for training and testing the algorithm, given the fact that none of the public dataset found on the literature considers the relevant particularities needed to verify ICAO compliance when in the presence of religious coverings.

We reached a very satisfactory performance, with an accuracy of 99.1% and an Equal Error Rate (EER) of 5.7%, which competes with the state of the art results.

2 Related Work

The University of Bologna's Biolab group played a significant role in popularizing methods adhering to the ISO/IEC 19794-5 standard. In 2009, they introduced the Biolab-ICAO framework [Ma09], which served as a benchmark tool for assessing the compliance of face images with ICAO requirements. Subsequently, in 2012, the benchmark underwent further refinement, leading to the presentation of an official database and testing protocol [Fe12]. Additionally, the authors proposed the BioLabSDK, the first documented method in the literature capable of evaluating 23 scene requirements.

Today, the Biolab-ICAO framework is used to evaluate algorithms via an online public competition called Face Image ISO Compliance Verification (FICV), hosted at the FVC-onGoing website [FV]. The FICV is considered the official evaluation tool for ISO/IEC 19794-5 standard and is used by most relevant works presented in the literature or commercial products. 23 scene requirements are evaluated individually in terms of EER. The EER is a standard metric to evaluate the performance of biometric systems and can be defined as the point where the False Acceptance Rate (FAR) and False Rejection Rate (FRR) curves intercept each other. Therefore, the EER represents the rate at which both acceptance and rejections errors are equal, i.e., FAR = FRR.

Notice that out of those 23, we focus particularly on the 'Hat/Cap' requirement which is a reduced version of what we called in this work 'Head Coverings' to accomodate many more options, including religious cases that should be treated in a different way than just hat and caps.

To date, there are four published algorithms in the FVC-onGoing platform regarding the ’Hat/Cap’ requirement: BioTest, BioPass Face, id3, and ICAONet [eSGB22]. Their results are summarized on Table 1.

Algorithm	EER
ICAONet	5.7%
id3	6.8%
BioPass Face	9.8%
BioTest	16.5%

Tab. 1: Published results on the FVC-onGoing platform regarding the ’Hat/Cap’ ICAO Requirement.

Three of the algorithms are own by private companies, therefore there is no detailed explanation about their methods. ICAO Net makes use of the significant advancements observed in deep learning over the past decade, which have notably improved accuracy compared to traditional hand-crafted methods. This progress has prompted researchers in the field of ICAO compliance verification to adopt deep learning techniques with remarkable success.

We point also the recent work by Hernandez-Ortega et. al [He22], who proposed the algorithm FaceQvec for evaluating the conformity of facial images with the same 23 algorithms defined by BioLab plus two regarding white-noise estimation and expression. The one regarding the head coverings in particular, also only considering Hats/Caps and no religious circumstances that might be considered compliant, looks for pixels with unnatural colour in the upper forehead region. However, the authors do not show results regarding that requirement in particular because of the lack on negative samples for the development and testing.

What we conclude is that there is some work already on the head coverings requirements but there is the need to extend these methods to consider more than just hats/caps. Also, facial images that can be used to train and test algorithms considering these particular concerns are lacking.

3 Data

To overcome the lack of available datasets to train and test algorithms to validate the compliance with ICAO requirements and, in particular, the ’Head Coverings’ requirement, we built our own dataset. We collected facial images from people in controlled conditions, using many different accessories on the head, including religious options that could be considered compliant or not.

ICAO states that if head coverings are allowed, they shall be firm fitting and of a plain uniform colour with no pattern or no visible perforations and the region between hair lines, both forwards of the ears and chin including cheeks, mouth, eyes, and eyebrows shall be visible without any distortion or shadows [Wo18].

Our dataset is composed by 3500 images of 500 subjects gathered across volunteers from different ages, genders and origins. Table 2 shows the demographic distribution of identities.

	Caucasian		African		Asian	
	Female	Male	Female	Male	Female	Male
Children/Teen [0,20]	62	61	11	14	2	1
Young Adult]20-35]	61	61	13	14	17	17
Adult]35-50]	25	45	4	2	3	1
Senior Adult]50-65]	16	26	1	0	0	1
Senior]65-inf]	17	25	0	0	0	0

Tab. 2: Demographic distribution of identities in the built dataset.

Each volunteers takes 7 pictures:

- 2 with no head coverings at all;
- 3 with non-compliant head coverings (hat, caps, ribbons, etc);
- 1 with religious coverings that might be considered compliant;
- 1 with non-compliant religious coverings.

Samples of each picture taken can be seen in Figure 1.

Fig. 1: Samples of the pictures taken by each identity on the dataset. Top 3 are compliant, the bottom 4 are non-compliant.

In total, 1500 images are (potentially) compliant and 2000 images have one or more requirements that are non-compliant in terms of head coverings. We divided the dataset into training, validation and testing samples, randomly chosen.

4 Methods

In the field of object detection, the YOLO (You Only Look Once) network model [Re16] is well known for having the capability of detecting multiple objects in real-time. Therefore, we use YOLOv8 as our framework and we fine-tune the network parameters to achieve real-time performance and high accuracy on classifying facial images into ICAO compliant or non-compliant.

YOLOv8 was released on January 2023 by ultralytics and gives better results than its predecessor versions [To].

It has two parts: Head and Backbone. Backbone is responsible for generating feature pyramids after feature extraction. Head is responsible for identification and displaying bounding boxes along with objectness score [TCE23].

We trained our YOLOv8 model with the dataset specifically created for this purpose by us. The parameters chosen for training were:

- Model: yolov8s-cls.pt;
- Epochs: 10;
- Batch Size: 64;
- Image Size: 224 (pixels);
- Workers: 8;
- PreTrained: True;
- Optimizer: Adam;
- Initial Learning Rate: 0.001;
- Weight Decay: $5x10^-5$;
- Label Soothing Epsilon: 0.1;
- Model Layer Cutoff: None;
- Dropout (fraction): None.

Furthermore, YOLOv8 employs image augmentation techniques during training to enhance its performance. In each epoch, the model encounters slightly varied versions of the provided images. Notably, YOLOv8 utilizes mosaic augmentation, which involves

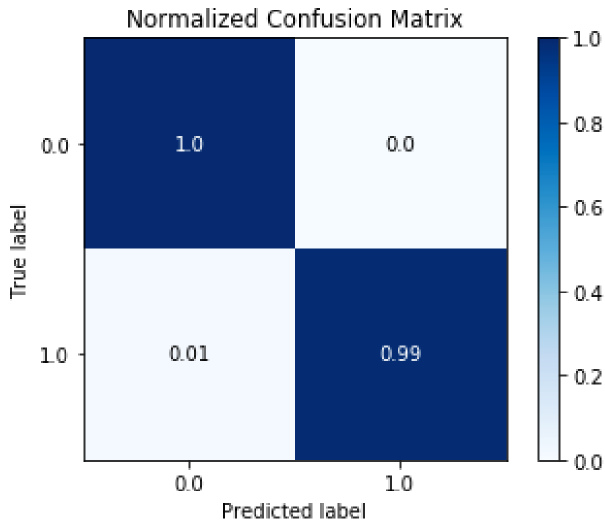

Fig. 2: Resulting confusion matrix. Class 0 stands for 'Non-compliant' and class 1 stand for 'Compliant'.

stitching together four training images to create a new composite image. This augmentation technique significantly contributes to the model's efficiency and learning capabilities [HZ20]. Compared to previous iterations, YOLOv8 demonstrates superior efficiency, thanks to its use of a larger feature map and a better optimized convolutional network [To]. For a deeper understanding of YOLOv8's functioning and detailed insights into its architecture, comprehensive information can be found in [Ro].

5 Results

The results obtained have shown that our method to automatically verify the compliance with the head coverings requirements can achieve very high accuracy levels (99.1%), failing only on 0.9% of the compliant samples - see Figure 2. The resulting loss curves during train and validation stages are shown in Figure 3. The tests were performed over a set of randomly chosen samples that represent 20% of dataset, making sure that all categories of images are balanced. The corresponding EER equals 5.7%, which is the same as the best performing algorithm already present in the literature, but now extended to be able to distinguish when a head covering might be considered compliant because of religious circumstances, which per se is an improvement.

6 Conclusions and Future Work

This work makes significant contributions in the form of a dataset and an algorithm aimed at automating the verification of compliance with ICAO requirements concercing the pres-

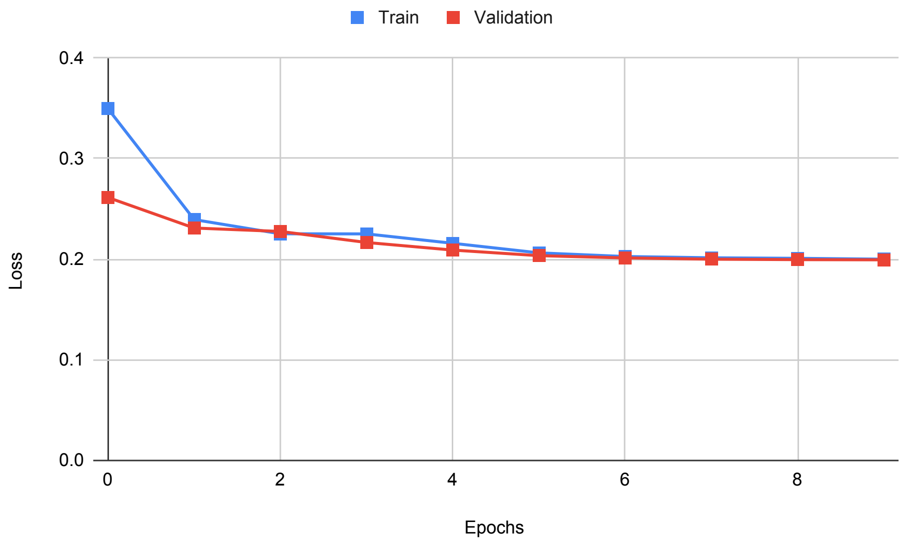

Fig. 3: Train and validation loss curves along the epochs.

ence of head coverings in facial images used in machine-readable travel documents. The existing methods fails to consider the acceptance of certain head coverings based on religious or cultural reasons, focusing primarily on the detection of hats or caps. In contrast, our approach specifically extends these considerations to include cases of religious coverings that can be accepted. To support our approach, we created a dataset consisting of 500 facial images representing diverse identities and accommodating the inclusion of more accessory types such as compliant and non-compliant religious coverings. Using this dataset, we fine-tuned and trained a classification model based on the YOLOv8 framework, resulting in a state-of-the-art performance with 99.1% of accuracy and an Equal Error Rate (EER) of 5.7%. These work highlights the lack of inclusion of religious factors when verifying compliance with head covering requirements, and demonstrates the efficacy of our approach in accurately identifying compliant head coverings. In the future we would like to consider also the case when there is a head covering that cannot be removed because of medical reasons, extending our dataset to include examples of it.

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