Stating Comparison Score Uncertainty and Verification Decision Confidence Towards Transparent Face Recognition

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Abstract

Face Recognition (FR) is increasingly used in critical verification decisions and thus, there is a need for **assessing the trustworthiness** of such decisions. The confidence of a decision is often based on the overall performance of the model or on the image quality. We propose to **propagate model uncertainties to scores and decisions in an effort to increase the transparency of verification decisions**. This work presents two contributions. First, we propose an approach to **estimate the uncertainty of face comparison scores**. Second, we introduce a **confidence measure of the system's decision** to provide insights into the verification decision. The suitability of the comparison scores uncertainties and the verification decision confidences have been experimentally proven on three face recognition models on two datasets.

Introduction

- Human operators can intuitively state how sure they are about their decisions and may even conclude that they cannot make a meaningful, justifiable decision
- Current state-of-the-art face recognition models do not offer this confidence or uncertainty estimates

Definitions [1]

Uncertainty: the belief about the variability of possible outcomes
Confidence: the belief that a given prediction is correct

Score Uncertainty Estimation

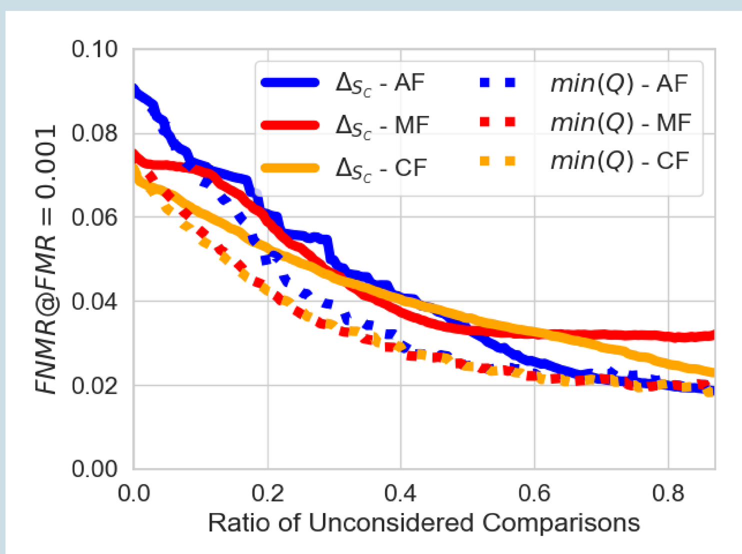
- To estimate the model uncertainty, we apply multiple stochastic forward passes with different dropout patterns being applied as proven by [2] and calculate the embedding uncertainty as the standard deviation of this set of stochastic embeddings
- To decide whether two embeddings represent the same identity or not, we use the cosine similarity **(a)**. We then apply the formula of the propagation of uncertainty **(c)** [2] to obtain the score uncertainty based on the embedding uncertainties.

Decision Confidence Estimation

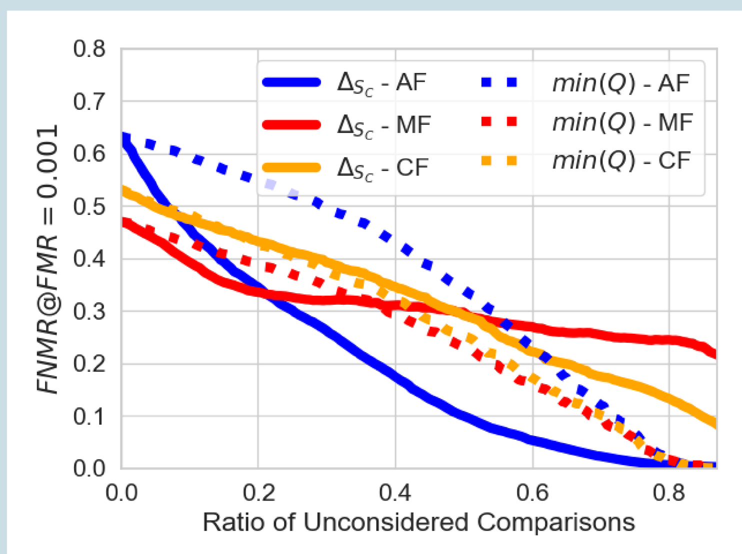
- The score uncertainty only indicates how certain the system is about the score, not how reliable the decision is
- To obtain a decision confidence **(g)** , we also apply the formula of the propagation of unceraintY **(c)** on a modified sigmoid function **(e)** that approximate the decision function and takes the decision threshold *d* into account

Results

Adience

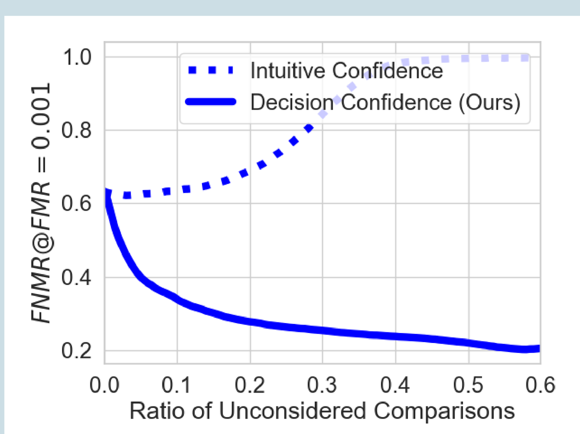


XQLFW

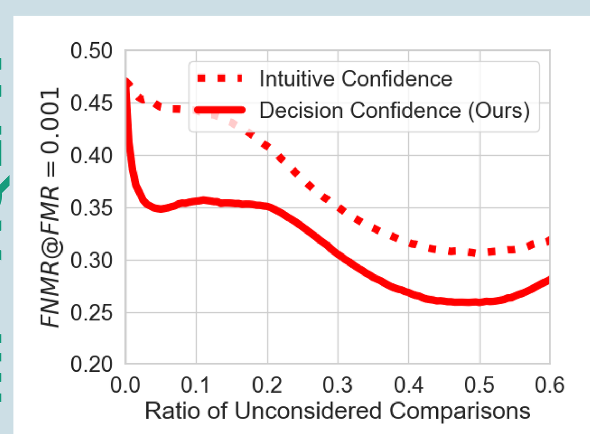


Score Uncertainty Evaluation based on ERC curves: With a higher score uncertainty (Δ_{S_C}), more wrong decisions are made. Evaluated on three FR models, ArcFace (AF), MagFace (MF) and CurricularFace (CF).

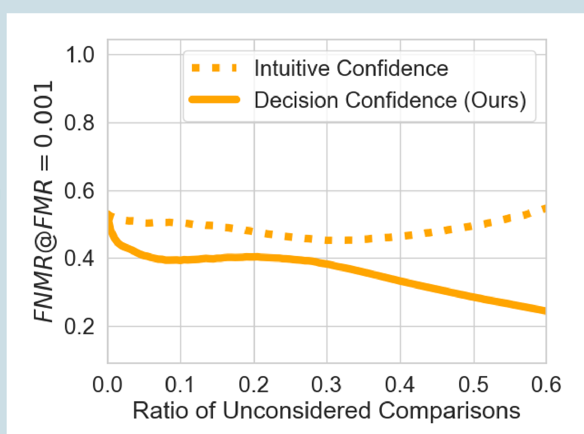
AF - XQLFW



MF - XQLFW

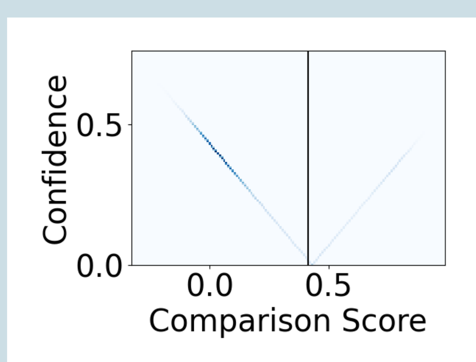


CF - XQLFW

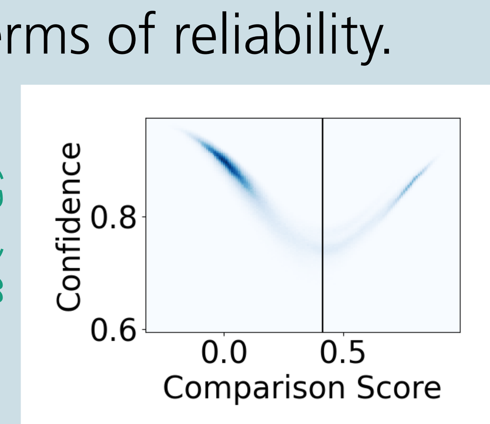


Decision Confidence Evaluation based on ERC curves: The proposed confidence outperforms the intuitive confidence in terms of reliability.

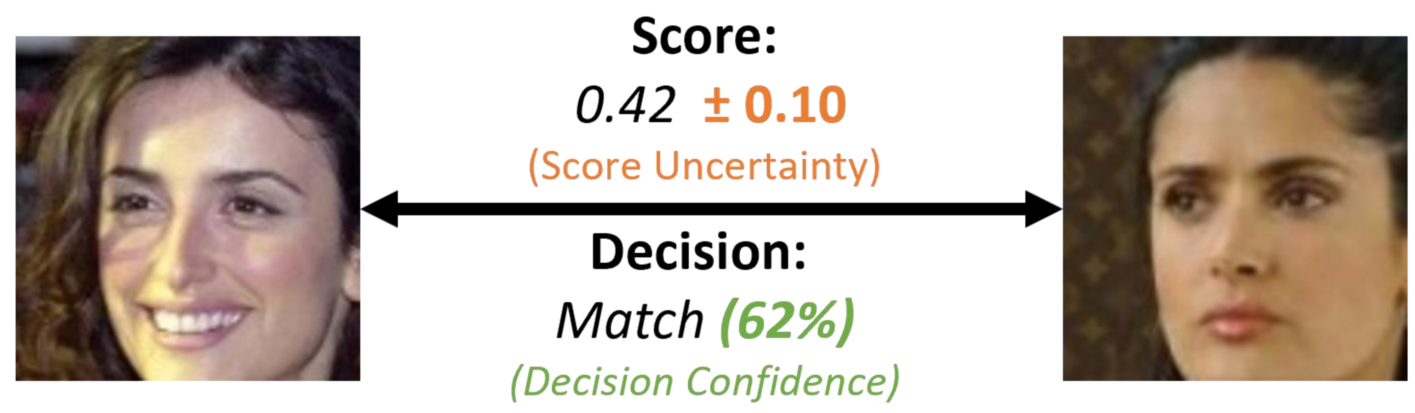
Λ_{Int}



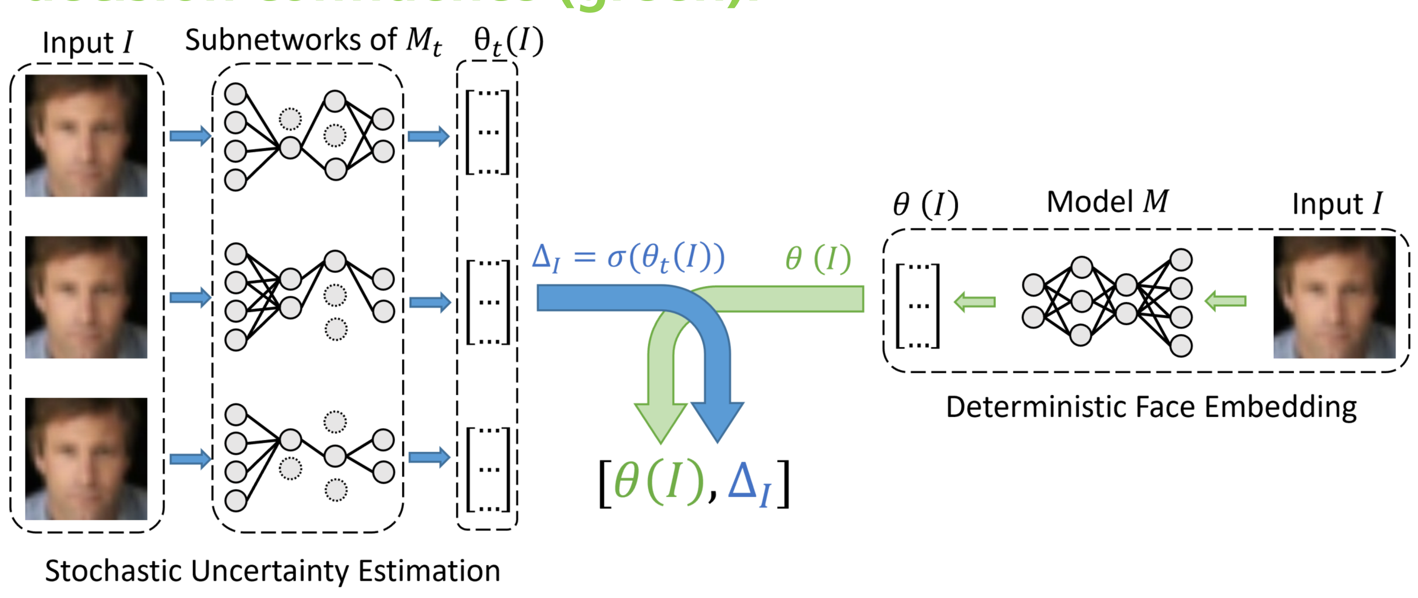
$\Lambda_d(S_C)$



Comparison of the Confidence Measures: The proposed confidence provides a more natural understanding of confidence than the intuitive confidence.



Transparent Face Verification: In addition to the usual information, such as the score and the decisions made, we propose the following to increase the transparency of the FR system: **the score uncertainty (orange)** and the **decision confidence (green).**



Uncertainty Estimation of the Embedding: A deterministic and a set of stochastic embeddings are created using different dropout patterns. The uncertainty is calculated as the standard deviation of the stochastic embeddings.

$$S_C(X,Y) = \frac{X \cdot Y}{||X||\,||Y||} \quad \textbf{(a)} \qquad S_C(X,Y) = \sum_{n=1}^{N} x_n \cdot y_n \quad \textbf{(b)}$$

$$\Delta_E = \sqrt{\left(\frac{\partial f}{\partial x}\right)^2 \cdot \Delta^2} \quad \textbf{(c)} \qquad \Delta_{S_C} = \sqrt{\sum_{i=1}^{n} y^2 \cdot \Delta_{x_i}^2 + \sum_{i=1}^{n} x^2 \cdot \Delta_{y_i}^2} \quad \textbf{(d)}$$

Uncertainty Estimation of the Comparison Score: the cosine similarity **(a)** simplifies to **(b)** when normalized. The formula of propagation of uncertainty [2] **(c)** applied to **(b)** leads to **(d)**, which allows the calculation of the comparison score uncertainty.

$$\textbf{(e)} \quad \delta(S_C) = \frac{1}{1 + e^{-\alpha(S_C - d)}} \qquad \textbf{(f)} \quad \Lambda_{Int}(s) = |s - D_{th}|$$

$$\textbf{(g)} \quad \Lambda_d(S_C) = 1 - \left[\begin{array}{l} \sum^N \delta(S_C) \cdot (1 - \delta(S_C)) \cdot \alpha x_n \cdot \Delta_{y_n}^2 + \\ \sum^N \delta(S_C) \cdot (1 - \delta(S_C)) \cdot \alpha y_n \cdot \Delta_{x_n}^2 \end{array}\right]^{\frac{1}{2}}$$

Confidence Estimation of the Decision: the decision step function is approximated with a modified sigmoid **(e)** to gain a derivable decision function. Then **(c)** is applied which leads to **(g)**, that allows the calculation of a confidence estimate. **(f)** shows the "intuitive confidence", where the confidence increases as the actual scores moves further away from the decision threshold.

[1] Dane K Peterson and Gordon F Pitz. Confidence, uncertainty and use of information. Journal of Experimental Psychology: Learning, Memory, and Cognition, 14(1): 85, 1988.

[2] H.H. Ku. Notes on the use of propagation of error formulas. Journal of Research of the National Bureau of Standards. Section C: Engineering and Instrumentation, 70C, 1966