Kinship verification between two people by photos

The goal of kinship verification between two people by photos is to automatically determine whether two selected individuals are members of the same family or not based on their photographs. Recently, kinship verification has attracted the interest of researchers and is actively used in various fields. This is due to the remarkable progress of deep learning in extracting deep features for face image analysis over the past 10 years, particularly in kinship verification [4, 5].

There are a number of reasons explaining why this area of research has become trendy. The first is due to the variety of potential applications of kinship verification. For example, in the fields of anthropology and genetics, kinship verification can help study hereditary characteristics that unite close relatives [6]. Additionally, kinship verification can be applied in social security to find relatives of a found child [7]. Furthermore, kinship verification can be used in smart home systems for recognizing family members' faces and in other applications related to personalization in the Internet of Things [8]. The second reason is that the human eye has a low sensory perception for quantitatively evaluating two images of different people [9]. Therefore, there is a need for a tool capable of assessing multiple facial image characteristics, such as the distance between the eyes, forehead height, the shape and size of facial parts. The third point is that kinship verification provides grounds for new interdisciplinary research as it attracts the attention of researchers from various fields, such as machine learning, computer vision, psychology, anthropology, genetics, and pattern recognition.

In computer vision, kinship recognition is the task of training a machine to recognize genetically related and unrelated people based on features extracted from digital images. An important component for research in the field of kinship verification is a database with photographs of people and descriptions of their kinship. The volume and quality of the collected photographs determine the accuracy of identifying kinship or non-kinship. The photographs should be of the same size, and the faces depicted should be in a similar frontal position. Deep learning algorithms designed for image classification tasks are most often used for analyzing the initial data. Simple algorithms have low data analysis accuracy but consume few computational resources, so they can be run on a Central Processing Unit (CPU). For more accurate data analysis and in larger quantities, complex machine learning algorithms are usually used. Some deep learning algorithms have complex architectures and require higher performance equipment, so they are most often executed on a Graphics processing unit (GPU) or Neural Processing Unit (NPU).

When looking at recent research in kinship verification, a trend towards the use of deep neural networks can be noted. For example, in a 2019 study [2], the author attempted to predict the kinship of two individuals based on photographs of their faces using the Families in the Wild dataset [3] and the VGGFACE2 neural network. The database was initially divided into families. For training the neural network, a pair of images was fed into the input, and the output was 1 if they were relatives, and 0 if they were not. However, this neural network didn’t analyze the common external characteristics of each individual family. It simply learned to analyze images based on some quantitative characteristics, such as eye color, head shape, forehead height. At the same time, it didn’t associate anyone with a specific family. It only looked at the overall similarity, but might has missed such an important characteristic as, for example, a particular nose shape that prevails in a specific family. In other words, the algorithm works by comparing one person to another, whereas it could compare one person to an entire family. This conclusion is drawn from the fact that the information about belonging to a specific family wasn’t used in training this neural network.

In another study from 2013 [1], the Family101 database divided into families was used. Unlike the previous study, this one included the analysis of the appearance of each family member. The goal was to determine which family a person belongs to. For this, the researchers used an algorithm that reconstructed the query face from a sparse set of samples among the candidate families. The resulting faces were compared with the original, and the face with the least difference indicated that its parts most likely belong to the relatives of the person being sought, thus identifying the family. However, despite the interesting concept, this study did not use modern machine learning algorithms, which are more efficient and provide greater accuracy.

The aim of this thesis is threefold. It aims to assess the feasibility of using neural networks for kinship verification. Second, it aims to evaluate the impact of additional information about belonging to a specific family on the model's performance and accuracy. Third, it aims to identify possible limitations of the model in determining kinship.

In this work, a proof-of-concept application for determining kinship based on photographs developed, considering data about family memberships. The developed program is compared with a similar program that does not take family memberships into account. Both unrelated individuals and various close relatives are tested to identify the model's limitations.

The thesis is limited by the inability to determine kinship in cases where, for example, a mother and daughter are tested, but the mother's parents are not listed in the family, and there is only one child. In this case, the mother has no kinship with any family members, neither with her husband nor with his relatives, nor with other children, as there are none. The mother is likely to be mistakenly identified as belonging to a different family, and as a result, the mother and daughter will be identified as unrelated.

The thesis is also limited by the fact that the neural networks will search for kinship within a limited set of families on which they were trained. That is, there is no possibility to test new individuals; they must be members of one of the families in the dataset.

Finally, there are limitations regarding the format of the photos. All photographs must be of the same size, and the people depicted in them must be looking directly at the camera.

This thesis is organized as follows. Chapter 1 describes the dataset structure and the work done on it. Chapter 2 describes the architecture of the first neural network. It also contains information about testing the neural network both with and without consideration of family memberships. Next, it compares and analyzes the obtained results as well as identifies the model's limitations. Chapter 3 describes the architecture of the second neural network. It also contains information about testing the neural network both with and without consideration of family memberships. Next, it compares and analyzes the obtained results as well as identifies the model's limitations. Chapter 4 describes the architecture of the third neural network. It also contains information about testing the neural network both with and without consideration of family memberships. Next, it compares and analyzes the obtained results as well as identifies the model's limitations. Chapter 5 compares three models and analyzes the obtained results. Chapter 6 concludes on feasibility of using neural networks, particularly with consideration of family memberships, for the kinship verification problem.

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