Biometric Identification from Human Aesthetic Preferences

In recent years, human–machine interactions encompass many avenues of life, ranging from personal communications to professional activities. This trend has allowed for person identification based on behavior rather than physical traits to emerge as a growing research domain, which spans areas such as online education, e-commerce, e-communication, and biometric security. The expression of opinions is an example of online behavior that is commonly shared through the liking of online images. Visual aesthetic is a behavioral biometric that involves using a person’s sense of fondness for images. The identification of individuals using their visual aesthetic values as discriminatory features is an emerging domain of research. This paper introduces a novel method for aesthetic feature dimensionality reduction using gene expression programming. The proposed system is capable of using a tree-based genetic approach for feature recombination. Reducing feature dimensionality improves classifier accuracy, reduces computation runtime, and minimizes required storage. The results obtained on a dataset of 200 Flickr users evaluating 40,000 images demonstrate a 95% accuracy of identity recognition based solely on users’ aesthetic preferences.

Human–machine interactions rely on human behavior [1]. Behavioral biometrics can prove effective in situations where a person’s mood, emotions, or intent are to be identified. While the majority of biometric research focuses on behavioral biometrics such as voice and gait [2], as well as the enhancement of accuracy through information fusion [3-4], this article presents the most comprehensive study to date on the use of aesthetic-based human traits expressed through human–machine interaction for biometric identification. In the domain of behavioral biometrics, social-behavioral biometrics utilizes a person’s interpersonal interactions, dispositions, and attitudes expressed through online media and communications as features [5-8]. Social network users exhibit many unique features through daily communications [2]. One such feature includes an individual’s visual aesthetic preference, which can be described as the principles or criteria which represent one’s judgment of visual beauty [5]. Research on the identification of individuals based on their visual aesthetics, essentially their visual preferences, emerged very recently [9-11]. With knowledge of an individual’s visual preference from a selection of images, corresponding features can be retrieved, which forms the person’s specific visual aesthetic authentication template. This is the basis of visual aesthetic identification. The present research is a significantly extended version of conference paper [12].

As a relatively new domain of research, visual aesthetic identification shows very high potential. Human–machine interaction often includes not only work-related tasks but also online social activities, interactions with family members, recreation and more. Among them, sharing photographs, discussing art, and expressing the liking of posted images are common expressions of human behavior. However, understanding these behaviors has been notoriously difficult due to the numerous visual features that are present in the images. During the creation of user authentication templates, it is important to use the most discriminatory features for classification. In pattern recognition, a feature is a characteristic that represents some data of an observation. Although what are considered good feature characteristics depends heavily on the problem domain, many common techniques aim to improve the efficacy of feature data such as normalization, selection, extraction, and expansion. Highly correlated or otherwise non-discriminatory features can decrease the accuracy and speed of the classifier, with intensity varying depending on the model. The most recent work [11] used 861 original features, reduced to 700 Principal Components (PC) using Principal Component Analysis (PCA). Although the accuracy obtained was higher than in the previous works, a further increase in accuracy and reduction of template generation time were outlined as future challenges. A reduced feature set can lower these times, which is typically done through feature selection or extraction techniques [13].

In this paper, we apply Gene Expression Programming (GEP) to reduce feature dimensionality and increase classifier accuracy in a new identification model for visual aesthetic identification. Gene expression programming is a stochastic, meta-heuristic approach that utilizes structured gene trees to represent generated candidate solutions. The general structure of a GEP model follows other genetic approaches that use the fundamental principles of evolution: selection, mutation, and crossover (also called recombination). Through the use of program generations, unique candidates are generated based on random mutation and crossover with the previous generation to maintain a population of programs
A modified GEP-based approach to feature extraction is proposed in this paper to improve aesthetic-based person identification accuracy and reduce enrollment times. This approach transforms the original feature set into a smaller set of complex features through structured program evolution. We establish that these complex features can increase accuracy due to the reduction of noise introduced into the classifier system. A smaller feature vector with higher discriminatory ability also results in fewer computations during classification and a lower amount of memory required to store an authentication template. The proposed approach can be applied to other domains and lead to integration into more complex systems. In proposing such a model, the paper aims to improve the current state-of-the-art visual aesthetic identification and test the efficacy of a GEP approach given a large feature set in this domain. Results surpass the state-of-the-art methods for visual aesthetic identification.

Very preliminary research on this topic has been published as a conference paper [12]. In the current work, additional extensive experimentations on model hyperparameters and analysis have been provided. An adaptive mutation behavior was implemented, which increases the robustness and growth of the overall accuracy of the system. Model performance comparisons between different machine learning algorithms have also been added. Thus, this paper makes the following contributions:

- A novel visual aesthetic-based identification model is introduced that achieves higher accuracy over the most recently reported results.
- The investigation of utilizing gene expression programming to construct complex features is conducted for the first time in the aesthetic research domain.
- The proposed model reduces the dimensionality of the feature data required for identification, which achieves an improvement in both computation speed and system robustness of the visual aesthetic-based identification system.
- A comparison with the proposed model and previous works is performed on the benchmark dataset.

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Keywords

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