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FACIAL COMPOSITE SYSTEM USING GENETIC ALGORITHM

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ABSTRACT

The article deals with genetic algorithms and their application in face identification. The purpose of the research is to develop a free and open-source facial composite system using evolutionary algorithms, primarily processes of selection and breeding. The initial testing proved higher quality of the final composites and massive reduction in the composites processing time. System requirements were specified and future research orientation was proposed in order to improve the results.

KEY WORDS

Genetic algorithm, facial composite, breeding, crossover

INTRODUCTION

Facial composites are images of human faces constructed from the victims' and witnesses' description of a suspects' face. Traditionally, composites are made by a police artist using specialized software such as Electronic-Facial Identification Technique (E-FIT), Pro-Fit, Identikit or Faces, which are enabling pasting individual facial features such as eyes, eyebrow, mouth, chin, hair, etc. together in order to form a whole face.

According to psychologists, exact selecting of facial features by recalling a person's face can be a very difficult task 1. Moreover, composing identikits by a third party (a forensic artist) reduces the precision of results. Therefore, composites constructed using conventional software are recognised only in 20% of cases 2.

Our research aims at simplifying the whole process by developing a system enabling witnesses to find the most suitable image within the set of automatically generated facial composites.

RELATED WORK

One of the systems relying on the human ability of face recognition rather than single facial features recalling is EVOFIT. It is a system developed at the University of Stirling (3) incorporating shape and texture face model gained by employing Principal Component Analysis (PCA) and an evolutionary algorithm (EA). The EA starts with generating a random

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population of 18 faces. The population is shown to a witness who is asked to select six faces most resembling the suspect and also to propose the best individual. The best individual is copied to the next generation without a change. The other 17 faces of the new generation are composed by recombining the genes of the selected 6 faces, with all having the same probability to be chosen for the process of crossover, except of the best individual which was awarded doubled influence for the breeding process. The mutation rate was set to 0.1.

System using Active Appearance Model (4), statistical model based on the PCA, in combination with evolutionary techniques was developed at the Istanbul Technical University. This system was developed to test more different Interactive Nature-Inspired Heuristics (INIH) in obtaining the facial composite:

- Interactive Generational Genetic Algorithm (IGGA): New generation is created through selection and recombination with parents being chosen by binary tournament according to their fitness score (4).
- Interactive Steady-State Genetic Algorithm (ISSGA): ISSGA is a strategy based on replacing the worst parent. In each iteration only one child is produced. The population then consists of three members: two parents and one offspring. The user is supposed to choose directly parents for the next recombination without evaluating or rating them (4).
- Interactive Evolutionary Strategy: New individuals are generated from a number of individuals from an old generation through crossover with parents being selected randomly (4).

First commercially used system based on evolutionary algorithms in this field was originally developed as a research project at the University of Kent under the name EigenFIT (5) and was introduced to the market in 2006 as EFIT-V 6. The EFIT-V system combines the usage of statistical appearance model of a face with Interactive Evolutionary Algorithm (IEA). The IEA works with the population of nine faces which is displayed to a witness who is supposed to choose the face most resembling the suspect. The best face selected is copied directly to the new generation. No fitness function is then calculated. Instead, new generation consists of eight mutated clones of the selected individual with the mutation rate being set to 0.001 (6).

Research on implementing evolutionary techniques in simulations of complex graphic textures and structures reaches to the 1991 (7). Several programs based on different strategies imitating natural processes have been developed since then but as the databases consist of a very specific group of faces, they cannot be widely used. Due to the subjectivity of a composite evaluation it is also difficult to choose the most suitable technique as the best solution must adapt a combination of various evolutionary strategies.

METHODS

The present paper introduces a software solution providing a witness with a series of images depicting a whole face instead of individual features. The faces are generated by a program based on an evolutionary algorithm. The study carried out at the University of Central Lancashire (8) indicates the importance of choosing accurate hair at the beginning of the session. A user is therefore asked to choose hair, moustache and beard from the dataset. Those parts do not take part in further breeding, but are important for the final appearance. The proposed evolutionary algorithm includes several steps:

- The initial population of 100 faces is generated using random numbers for the model parameters with 16 being offered to a witness.
- The best result is selected by a witness.
- Individual chromosomes representing the facial features are evaluated by the system. Fitness function of an individual represents the individual's deviation from the best

individual chosen by a user. It is calculated as a sum of absolute differences for all the genes, where n stands for the number of genes.

$$\sum_{i=1}^{n} |a_{best,i} - a_{m,i}|$$

- In order not to lose the best individuals by muting and recombining the genes, the elite, 20 best ranked individuals, are always preserved for the next generation without a change.
- A weighted roulette wheel is applied to select more capable parents as candidates to undergo crossover, with fitness function values being used as a criteria for parents evaluating. The crossover rate was set on 1 which means that each child is being created by recombining genes of two parents.
- With a certain probability process of mutation is applied on new individuals. The genes are muted with a mutation rate of 0.01. Hair, moustache and beard as external features are excluded from the mutation process.
- After crossover and mutation a new generation of 100 faces is evolved with 16 best individuals being displayed to a witness.

Each generation is evolved with the aim of gradual convergence towards the target face.

RESULTS

The proposed facial composite system was developed and tested with a testing dataset consisting of 12 facial features in each category.

We proved the convergence towards the desired target for the system based on an ordered database. However, the convergence time of the initial system was too short with a minimum change after the third generation. Continuing the recombination does not seem to be useful then. Therefore, generating several random individuals for ensuring the variability was proposed.

The results imply the hypothesis that the full functionality of the system can be ensured only when the system is based on a suitable database. The database requirements include the size of the database, file type of images and most important of all the parameters is the order of individual elements. Evaluation of feature similarity of bigger datasets might become an exhaustive task. Therefore, the Principal Component Analysis was proposed for the facial features extraction. Since it has been derived from the pixel resolution of an image, the change in any parameter corresponds to the change in an image.

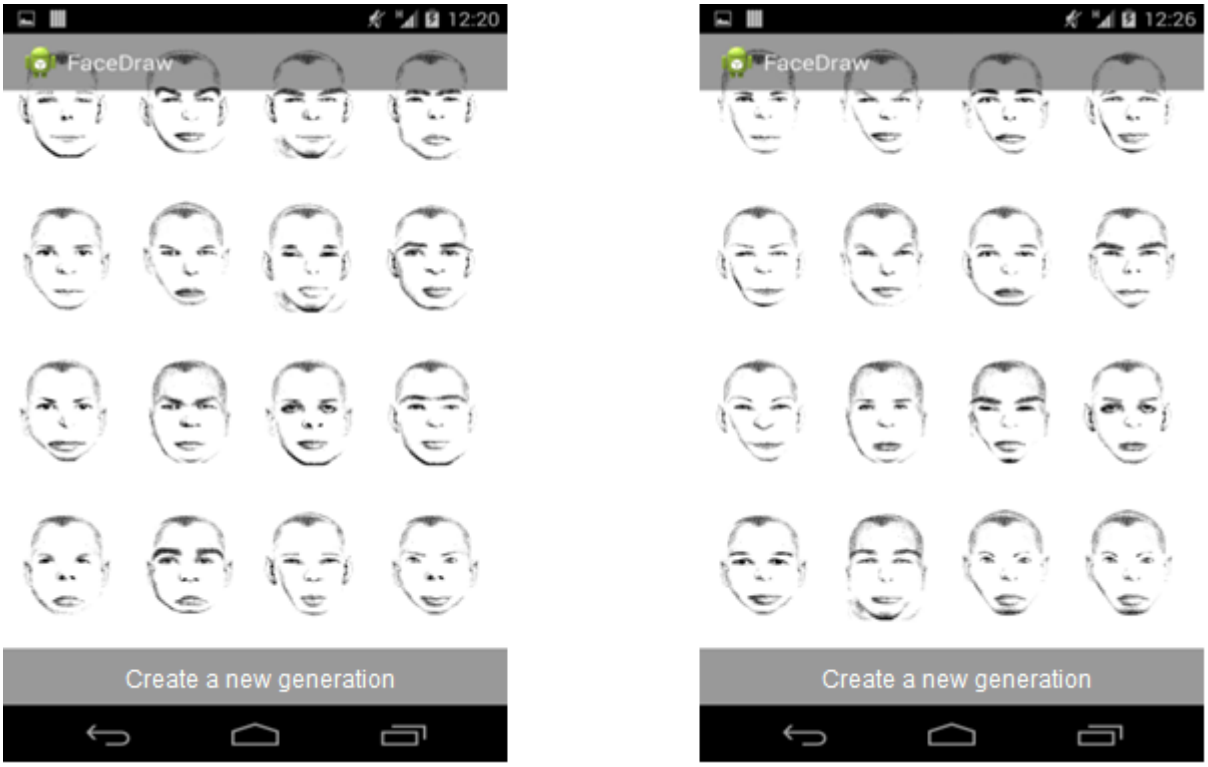

Fig. 1 *Comparison of the initial population and the 4th generation*

CONCLUSION AND FUTURE WORK

This paper presents a preliminary reserach. It is oriented on introducing the research and proposing methods for the future research.

The facial composite system based on an evolutionary algorithm and running on a free platform (OS Android) was developed and analysed. The initial system verification confirmed the hypothesis that the composite processing time can be markedly decreased and convergence towards the target can be ensured using EA. However, further research in the field might lead to improved results. Therefore, proposing the appearance model based on real photographs and enhancing the database are the key tasks for the future work. Also, employing other evolutionary strategies would result in improved performance of the system. Additionally, implementing holistic tools enabling user external adjusting are necessary for full functionality of the system.

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