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Chapter IX

Neural Networks and 3D Edge Genetic Template Matching for Real-Time Face Detection and Recognition

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Abstract

This chapter describes a novel system that can track and recognize faces in real-time using neural networks and genetic algorithms. The main feature of this system is a 3D facemask that, combined with a neural network-based face detector and adaptive template matching using genetic algorithms, is capable of detecting and recognizing faces in real-time. Neural network learning and template matching enable size and pose invariant face detection and recognition, while the genetic algorithm optimizes the searching algorithms, enabling real-time usage of the system. It is hoped that this chapter will show how and why neural networks and genetic algorithms are well suited to solve complex pattern recognition problems like the one presented in this chapter.

Introduction and Background

Given a real-time visual scene, the process of automatically detecting and recognizing faces can be very complex. This is because of the many factors that must be taken into account when attempting such a task. These factors range from scene characteristics (e.g., lighting, background, etc.) to facial factors (e.g., expression, size, orientation, and location). Other factors include system accuracy, speed, reliability, and the ability to easily change or upgrade the system to adapt to the ever-changing situations. However, if accomplished, real-time face tracking and recognition can find numerous application areas at home, in the office, in cars, security, surveillance, entertainment, computer interface, robotics, and so forth.

This chapter describes how genetic algorithms and neural networks can be used for real-time face detection and recognition. The basic face detector is a three-layered back propagation-trained neural network using frontal face images of a fixed size (40x40 pixels). Faces that are larger than this size and of other orientations can be searched for using a genetic algorithm-guided 3D face template matching. For the system to perform well on real-time images, genetic information inheritance is used to estimate the position, size, and pose of the face in the next frame. Genetic information inheritance aids the genetic algorithm in converging rapidly, allowing more time for face recognition. Face recognition is carried out using a hybrid system made up of a neural network and template matching methods.

The use of genetic information inheritance from frame to frame and robust searching using genetic algorithms are the main points in this chapter. The methods provide this system with high speed and detection rates. In addition, color information is only used mainly at the beginning of the search to initialize the genetic algorithm. Another strong point of this system is the use of similar methods and features for both face detection and recognition. At a rate of 60 milliseconds per frame, it is not easy to tune different methods to perform both functions effectively. Moreover, a random sampling method is used to increase the data used to train the neural networks, reducing the number of face samples that must be collected beforehand.

This work was carried out using a Sony IEEE1394 SDK FWLink-4001 digital camera at 15 frames per second. The selected image size was 320x240 pixels. The camera data is in YCrCb format, accessed using a MFC application. A Dell Precision 370 Pentium IV computer was used to perform computer simulations.

The rest of this chapter is organized as follows. The third section looks at other works related to this one. Face detection including all the processes required for size and pose invariance (e.g., genetic algorithms) are described in the fourth section. The next section is dedicated to face recognition where the neural network and template matching methods are explained. Results and discussions are in the sixth section and the seventh section concludes this chapter. The last section offers an insight on the future direction this research area is likely to go.

Related Work

A robust real-time object detector using an integral image is proposed by Viola and Jones (2004) that achieved good results. However, their system is rather complex because it involves