Digital Characterization of Observers Using Computer Vision in Real-Time

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1 Introduction

We present implementation of a system for digital characterization. The term *digital characterization* is used to describe the functions of an intelligent system for displaying selected visual information on a computer screen. The system tracks and characterizes the viewers by analyzing the images of their faces taken by the camera attached to the screen, using the real-time computer vision methods. Non-contact interaction between system and observer is performed according to observer's characteristics (e.g. gender, age group), estimation of observer's distance and location relative to the camera. The system also performs logging and visualization of recorded data. The system is designed for real time application using standard computer hardware.

2 Digital characterization

Digital characterization system is an intelligent system for displaying visual information. It consists of the main server and a set of "players". Players are computers that display content on screens and are usually networked to the main server. The scheme of a digital characterization system is displayed in Figure 1.

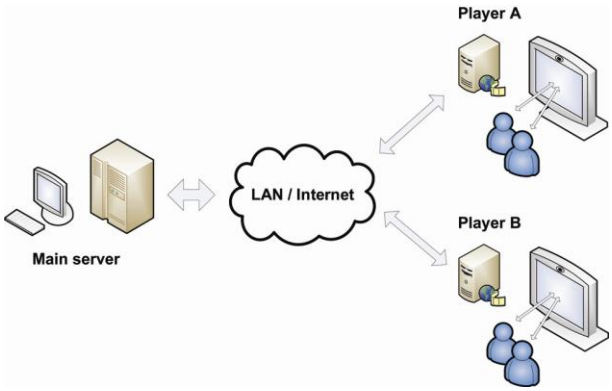

Figure 1. Scheme of digital characterization system.

By deploying an inexpensive video camera on the top of the screen and taking advantage of the extra, unused computing power of the associated player computer, we make the system intelligent by measuring and adapting to the actual audience in real time [2, 8]. System comprises four components:

- face detection and face tracking,
- face characterization,
- interaction module and
- web application for visualization of recorded data.

3 Face detection and face tracking

First system component detects and tracks several faces in real-time. Faces are found with Viola & Jones face detector [6]. The problem of tracking is solved by applying optical flow method Lucas-Kanade with time and spatial locality of detection (Figure 2). Detector and tracker are implemented in C++, using libraries Boost and Intel's OpenCV [1].

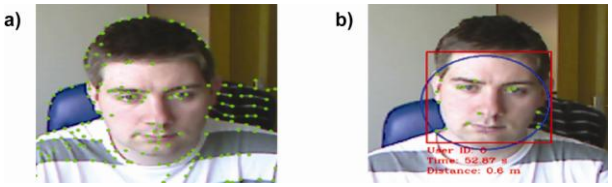

Figure 2. Good points to track. b) Tracking face with Lucas-Kanade optical flow.

4 Face characterization

Computer vision methods are used to determine observer's characteristics such as gender, age group and expression, based on facial image. Feature extraction is based on the Principal Component Analysis (PCA) method [6, 9]. We use the data mining environment Orange for machine learning [3].

Characterization of the observer's gender from their face is specially treated. The following methods of machine learning are applied and inter-compared: naive Bayes, K-nearest neighbors, classification tree and random forest [5]. A part of FERET face image library is used as learning and test sets [7]. Comparison of different methods used for learning is shown in Table 1.

Table 1. Best classification accuracy of machine learning methods.

Learning method	Classification accuracy [%]
Naïve Bayes	77,5
K-nearest neighbors	85,0
Classification tree	72,9
Random forest	83,3

Gender of an observer can be typically determined in 17.9 ms with 85% reliability. PCA method is implemented in C++ using OpenCV library, gender classifier is realized in Python.

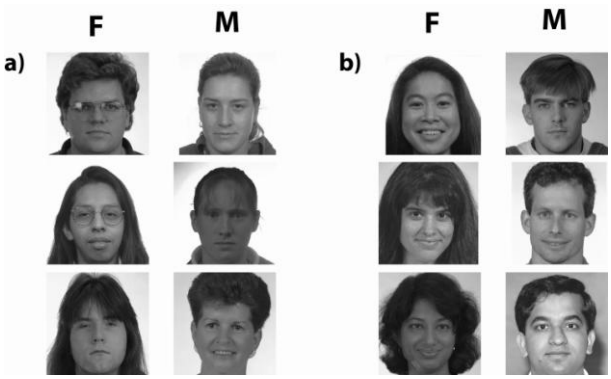

Figure 3. Gender classification. a) Typical faces that were not correctly characterized by the system. b) Typical faces that were correctly classified by the system.

5 Interaction with the observer

The interaction is based on the observer's position and characteristics. Displayed contents dynamically adapt when the observer changes the location. Virtual 3D environment is developed for this purpose. The projection on the screen is adjusted to the observer's position relative to the camera. Distance between the observer and the screen is determined. Using only one camera we calculate the distance from the relative size of the observer's face. The projection angle is estimated from the position of the face in the captured image. By determining the distance and the angle we gain all information of the position of the observer. Implementation of interaction component is written in C++ and uses 3D graphical environment Ogre3D [4].

6 Data visualization

Tracking, characterization and interaction statistics are stored in relational database for further analysis. A web application is developed for system management, statistical reports generation and visualization of the audience data (Figure 4). The database used is PostgreSQL, the application is implemented in PHP and the charting performed with Adobe Flex technology.

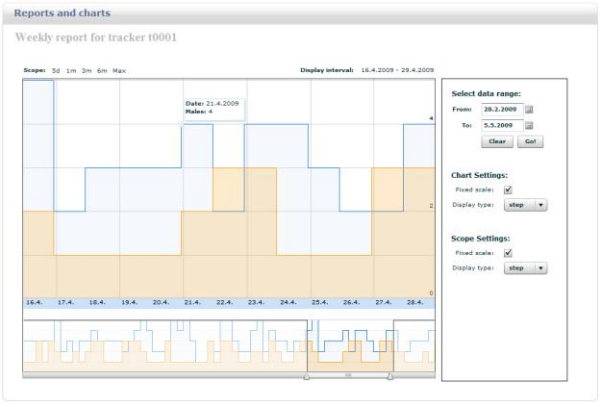

Figure 4. Web application for visualization of statistical data of the viewers.

The source code used in the project is platform independent and developed for real-time execution on a computer with standard hardware.

7 Acknowledgement

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References

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