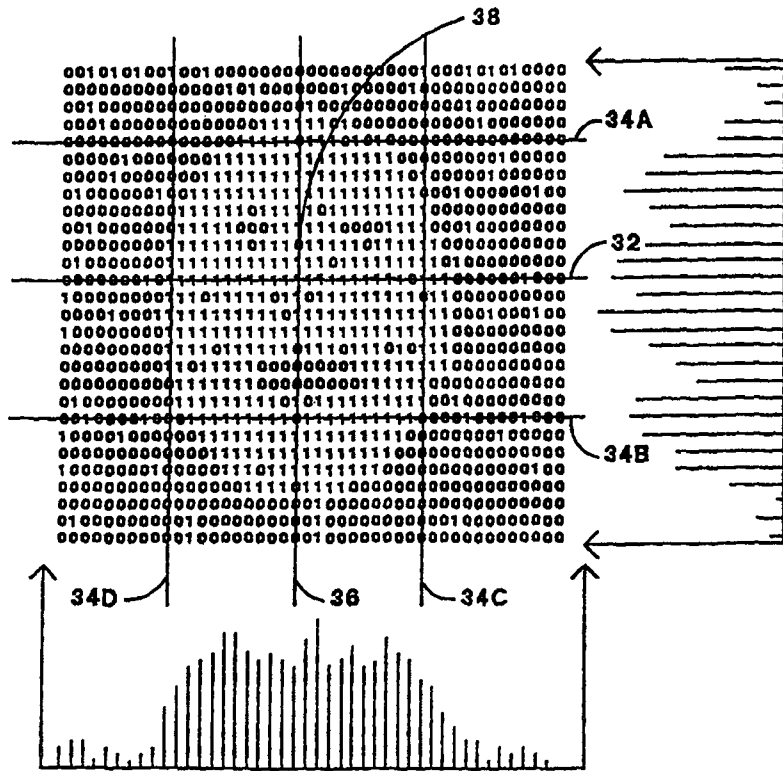# PCT

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : **G06K 9/00** **A1**	(11) International Publication Number: **WO 99/35606** (43) International Publication Date: 15 July 1999 (15.07.99)

(21) International Application Number: PCT/JP99/00010

(22) International Filing Date: 6 January 1999 (06.01.99)

(30) Priority Data:
09/004,539   8 January 1998 (08.01.98)   US

(71) Applicant: SHARP KABUSHIKI KAISHA [JP/JP]; 22–22, Nagaike–cho, Abeno–ku, Osaka–shi, Osaka 545–0013 (JP).

(72) Inventor: QIAN, Richard, Jungiang; Apartment 152, 501 S.E. 23rd Avenue, Vancouver, WA 98683 (US).

(74) Agent: TAKANO, Akichika; Salute Building, 9th floor, 72, Yoshida–cho, Naka–ku, Yokohama–shi, Kanagawa 231–0041 (JP).

(81) Designated States: JP, KR, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

(54) Title: SYSTEM FOR HUMAN FACE TRACKING

(57) Abstract

A system detects a face within an image by receiving the image which includes a plurality of pixels, where a plurality of the pixels of the image is represented by respective groups of at least three values. The image is filtered by transforming a plurality of the respective groups of the at least three values to respective groups of less than three values, where the respective groups of the less than three values have less dependency on brightness than the respective groups of the at least three values. Regions of the image representative of skin–tones are determinded based on the filtering. A first distribution of the regions of the image representative of the skin–tones in a first direction is calculated. A second distribution of the regions of the image representative of the skin–tones in a second direction is calculated, where the first direction and the second direction are different. The face within the image is located based on the first distribution and the second distribution. The estimated face location may also be used for tracking the face between frames of a video.

DESCRIPTION

SYSTEM FOR HUMAN FACE TRACKING

BACKGROUND OF THE INVENTION

5   The present invention relates to a system for
locating a human face within an image, and more
particularly to a system suitable for real-time tracking
of a human face in video sequences.

Numerous systems have been developed for the
detection of a target with an input image. In
10   particular, human face detection within an image is of
considerable importance. Numerous devices benefit from
automatic determination of whether an image (or video
frame) contains a human face, and if so where the human
face is in the image. Such devices may be, for example,
15   a video phone or a human computer interface. A human
computer interface identifies the location of a face, if
any, identifies the particular face, and understands
facial expressions and gestures.

Traditionally, face detection has been
20   performed using correlation template based techniques
which compute similarity measurements between a fixed
target pattern and multiple candidate image locations.
If any of the similarity measurements exceed a threshold
value then a "match" is declared indicating that a face
25   has been detected and its location thereof. Multiple
correlation templates may be employed to detect major
facial sub-features. A related technique is known as
"view-based eigen-spaces," and defines a distance metric
based on a parameterizable sub-space of the original
30   image vector space. If the distance metric is below a
threshold value then the system indicates that a face has
been detected.

An alternative face detection technique
involves using spatial image invariants which rely on
35   compiling a set of image invariants particular to facial
images. The input image is then scanned for positive

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occurrences of these invariants at all possible locations
to identify human faces.

Yang et al. in a paper entitled A Real-Time
Face Tracker discloses a real-time face tracking system.
5   The system acquires a red-green-blue (RGB) image and
filters it to obtain chromatic colors (r and g) known as
"pure" colors, in the absence of brightness. The
transformation of red-green-blue to chromatic colors is a
transformation from a three dimensional space (RGB) to a
10   two dimensional space (rg). The distribution of facial
colors within the chromatic color space is primarily
clustered in a small region. Yang et al. determined
after a detailed analysis of skin-color distributions
that the skin color of different people under different
15   lighting conditions in the chromatic color space have
similar Guassian distributions. To determine whether a
particular red-green-blue pixel maps onto the region of
the chromatic color space indicative of a facial color,
Yang et al. teaches the use of a two-dimensional Guassian
20   model. Based on the results of the two-dimensional
Guassian model for each pixel within the RGB image, the
facial region of the image is determined. Unfortunately,
the two-dimensional Guassian model is computationally
intensive and thus unsuitable for inexpensive real-time
25   systems. Moreover, the system taught by Yang et al. uses
a simple tracking mechanism which results in the position
of the tracked face being susceptible to jittering.

Eleftheriadis et al., in a paper entitled
"Automatic Face Location Detection and Tracking for
30   Model-Assisted Coding of Video Teleconferencing Sequences
at Low Bit-Rate," teaches a system for face location
detection and tracking. The system is particularly
designed for video data that includes head-and-shoulder
sequences of people which are modeled as elliptical
35   regions of interest. The system presumes that the
outline of people's heads are generally elliptical and
have high temporal correlation from frame to frame.

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Based on this premise, the system calculates the difference between consecutive frames and thresholds the result to identify regions of significant movement, which are indicated as non-zero. Elliptical non-zero regions

5   are located and identified as facial regions. Unfortunately, the system taught by Eleftheriadis et al. is computationally intensive and is not suitable for real-time applications. Moreover, shadows or partial occlusions of the person's face results in non-zero

10   regions that are not elliptical and therefore the system may fail to identify such regions as a face. In addition, if the orientation of the person's face is away from the camera then the resulting outline of the person's head will not be elliptical and therefore the

15   system may fail to identify the person's head. Also, if there is substantial movement within the background of the image the facial region may be obscured.

            Hager et al. in a paper entitled, Real-Time Tracking of Image Regions with Changes in Geometry and

20   Illumination, discloses a face tracking system that analyzes the brightness of an image within a window. The pattern of the brightness within the window is used to track the face between frames. The system taught by Hager et al. is sensitive to face orientation changes and

25   partial occlusions and shadows which obscure the pattern of the image. The system is incapable of initially determining the position of the face(s).

            What is desired, therefore, is a face tracking system that is insensitive to partial occlusions and

30   shadows, insensitive to face orientation and/or scale changes, insensitive to changes in lighting conditions, easy to calibrate, and can determine the initial position of the face(s). In addition, the system should be computationally simple so that it is suitable for

35   real-time applications.

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