System for dynamically maximizing the contrast between the foreground and background in images and/or image sequences

The invention relates to a system for dynamically maximizing the contrast between foreground and background in images and/or image sequences.

For the smooth integration of virtual objects into real scenes (also called augmented reality), it is known that there are two problems to solve. On one hand, the transformation between camera coordinate system and scene coordinate system must be determined and, on the other hand, occlusions of virtual objects, which are usually displayed in the background, must be determined by real objects, which usually are in the foreground.

In the application area “television transmission” or “broadcasting”, one is interested in solving the two aforementioned problems preferably non-mechanically, i.e. without the additional use of markers or sensors. This allows for a shorter assembly time and reduces the complexity of a broadcast system on site to be assembled as a whole. Especially with live broadcasts, the majority of the equipment must be transported to the usage site and subsequently assembled and disassembled.

To solve the transformation problem, there are, on one hand, hardware-based solutions such as "encoded heads" (e.g. from vinten.com), and, on the other hand, software-based, visually working solutions. Both solutions provide a mapping x=M(X) which allows to map a 3D coordinate X of a virtual object in the 3D space in a camera coordinate x in the current camera image.

Previously known segmentation methods require so-called keying instructions, such as a specific background color (e.g., in the case of chroma keying or infrared keying). However, these mechanical solutions have the above-mentioned disadvantages, since the keying instructions must be installed at the transmission site.

Embodiments of the invention seek to avoid the above disadvantages.

According to a first aspect of the present invention, there is provided a system for dynamically maximizing the contrast between foreground and background in images and/or image sequences, including at least one image-recording device; at least one

analysis module connected to the at least one image-recording device and configured to determine a transformation between a two-dimensional coordinate system of the at least one image-recording device and a two-dimensional coordinate system of at least one display device, and carry out a segmentation to determine at least occlusions of background objects through foreground objects in an image; at least one control module connected to the at least one analysis module; and a database connected to the at least one control module and to the at least one display device, wherein the database is configured to store a sequence of display information to be displayed on the at least one display device one after the other, wherein the at least one display device is configured to display information, including video clips, wherein the at least one image-recording device is configured to record the display information displayed on the at least one display device, wherein the at least one analysis module is further configured to identify quality data on the segmentation and transmit the quality data to the at least one control module, wherein the at least one control module is configured to adjust the display information displayed on the at least one display device based on the quality data, wherein the at least one control module is configured to determine for remaining display information of the sequence, in which display information an expected probability distribution of the foreground and an expected probability distribution of the background of the image-recording device differ the most.

By taking into account quality data on the segmentation, it is possible to obtain information about whether foreground and background are in sufficient contrast to each other. In case of a non-sufficient contrast, the display information can be adjusted, so that in the case of an unchanged foreground, a high-contrast background can be generated.

The system can further include a database, which is connected to the control module and to the display device, wherein the database is configured to store a sequence of display information to be displayed on the display device one after the other. The database can, for example, be part of a media server. The media server transmits display information to be played, for example, video clips, to the display device.

In this connection, it is preferred that the control module is configured to change the stored sequence of the display information. In other words, the control module can instruct the media server to output or display a particular piece of display information

on the display device. To achieve optimum control by means of the control module, the display information output from the media server on the display device (video clip) can also be transmitted to the control module.

The analysis module can be configured to apply and minimize an energy function during the segmentation, wherein the energy function is based on probability distributions of foreground objects and background objects and/or on pixel-wise probability distributions. The segmentation into foreground and background (with intermediate values such as semi-occlusions or blurring being possible) is designated with Y.

Here segmentation methods are used that do not require keying instructions, but can separate arbitrary background and foreground objects. In this process, an energy function E(Y) is defined, which is to be minimized. E(Y) can correspond to the negative logarithm of the probability that an occlusion has been determined correctly. Methods of convex optimization permit to minimize the energy efficiently and optimally, taking into account each individual image point, i.e. to maximize the corresponding probability. However, for minimizing the energy function E(Y), a priori knowledge of the appearance of the background and of the foreground is required, in particular, in the form of probability distributions F (foreground) and B (background) or pixel-wise distributions f_i and b_i, wherein i designates a specific image point/pixel.

This a priori knowledge needs to be updated due to possible changes in brightness or changes of the appearance, which causes drifting (the progressive deviation of a model from reality). Due to the above-described feedback mechanism, in which quality data on the segmentation are transmitted to the control module, and the control module adjusts the display information based on the quality data, the drift problem can be counteracted. This allows therefore the use of current segmentation methods with enhanced performance. The feedback takes, in particular, place via the display device, preferably an LED system as it, for example, exists for banner advertising in many sporting events.

The control module can be further configured to determine for remaining display information of the sequence, in which display information an expected probability distribution of the foreground and an expected probability distribution of the

background of the image-recording device differ the most.

The control module can also be configured to calculate a probability mapping for a respective image-recording device, wherein the probability mapping describes which probability distribution exists in an image of the respective image-recording device if the display device displays any one of the remaining pieces of display information.

The control module can be further configured to determine the probability mapping based on the time-varying 2D-2D mapping x=F(d) between d in the coordinate system of the display device and x in the coordinate system of the image-recording device. This 2D-2D mapping F can, for example, be determined by applying x=M(X), wherein X is the physical position X of the display point d.

The control module can be configured to determine the probability mapping based on a radiometric calibration between the display device and the respective image-recording device.

On the display device a plurality of arbitrarily designed calibration marks can be arranged, which are detectable by the image-recording device, in order to facilitate the 2D-2D transformation F between the coordinate system of the display device and the coordinate system of the image-recording device. In order that such calibration marks need not be regularly assembled and disassembled, the display devices can have such calibration marks permanently. The calibration marks can also be designed in such a manner that a radiometric calibration between recording device and display is possible.

The control module can be further configured to insert calibration information into the sequence of display information, wherein the display device is configured to display the calibration information. In this process, the calibration information can comprise at least a single monochrome image, wherein the image has a display duration of at least one or precisely one frame, and wherein the image preferably has a color, which has a high contrast to a foreground object. If a piece of calibration information is displayed as a monochrome image for the duration of a frame on the display device only, the calibration information is not visible to a viewer of the display device with the naked eye. However, the calibration information displayed on the display device is recorded by the image-recording device, so that the respective frame can

be used to update knowledge of foreground objects and background objects, as it is known for this frame, which color the background has.

According to a second aspect of the present invention, there is provided a method for dynamically maximizing the contrast between the foreground and background in images and/or image sequences, the method including: detecting at least one image by at least one image-recording device; calculating a transformation between a two-dimensional coordinate system of the at least one image-recording device and a two-dimensional coordinate system of at least one display device; carrying out a segmentation to determine at least occlusions of background objects through foreground objects in an image; displaying display information, including video clips, on the at least one display device, wherein the display information displayed on the at least one display device is recorded by the at least one image-recording device; during the segmentation, identifying quality data on the segmentation and adjusting the display information displayed on the at least one display device based on the quality data; providing a stored sequence of display information to be displayed on the at least one display device one after the other; and determining for remaining display information of the sequence, in which display information an expected probability distribution of the foreground and an expected probability distribution of the background of the image-recording device differ the most.

This method can comprise further optional steps corresponding to the features described above for the system. Accordingly, further optional aspects of the method can be directly derived from these features.

In the following text, the invention is exemplarily and non-restrictingly described with reference to the accompanying figures.

Fig. 1 shows a schematic diagram of the system presented herein.

A system 10 for dynamically maximizing the contrast comprises a plurality of image-recording devices C1, C2, Ck (indicated by three black dots below C2) and a plurality of analysis modules A1, A2 to Ak (indicated by three black dots below A2). An analysis module A1, A2 is assigned to each camera C1, C2.

CLAIMS

1. A system for dynamically maximizing the contrast between foreground and background in images and/or image sequences, comprising

at least one image-recording device;

at least one analysis module connected to the at least one image-recording device and configured to determine a transformation between a two-dimensional coordinate system of the at least one image-recording device and a two-dimensional coordinate system of at least one display device, and carry out a segmentation to determine at least occlusions of background objects through foreground objects in an image;

at least one control module connected to the at least one analysis module; and

a database connected to the at least one control module and to the at least one display device,

wherein the database is configured to store a sequence of display information to be displayed on the at least one display device one after the other,

wherein the at least one display device is configured to display information, including video clips,

wherein the at least one image-recording device is configured to record the display information displayed on the at least one display device,

wherein the at least one analysis module is further configured to identify quality data on the segmentation and transmit the quality data to the at least one control module,

wherein the at least one control module is configured to adjust the display information displayed on the at least one display device based on the quality data,

wherein the at least one control module is configured to determine for remaining display information of the sequence, in which display information an expected probability distribution of the foreground and an expected probability distribution of the background of the image-recording device differ the most.

2. The system of claim 1, wherein the at least one control module is configured to change the stored sequence of the display information.

3. The system of claim 1, wherein the at least one control module is configured to calculate a probability mapping for a respective image-recording device, and wherein the probability mapping describes which probability distribution exists in an image of the respective image-recording device if the at least one display device displays any one of the remaining pieces of display information.

4. The system of claim 3, wherein the at least one control module is configured to determine the probability mapping based on a transformation between the coordinate system of the at least one display device and the coordinate system of the at least one image-recording device.

5. The system of claim 4, wherein the at least one control module is configured to determine the probability mapping based on a radiometric calibration between the at least one display device and the respective image-recording device.

6. The system of claim 4, wherein a plurality of calibration marks are arranged on the at least one display device, which are detectable by the at least one image-recording device to facilitate the transformation between the coordinate system of the at least one display device and the coordinate system of the at least one image-recording device.

7. The system of claim 1, wherein the at least one control module is configured to insert calibration information into the sequence of display information, and wherein the at least one display device is configured to display the calibration information.

8. The system of claim 7, wherein the calibration information comprises at least a single monochrome image, wherein the image has a display duration of at least one or precisely one frame, and wherein the image has a color having a high contrast to a foreground object.

9. The system of claim 1, wherein the at least one analysis module is configured to apply and minimize an energy function during segmentation, and wherein the energy function is based on probability distributions of foreground objects and background objects and/or on pixel-wise probability distributions.

10. The system of claim 9, wherein the at least one control module is configured to determine for remaining display information of the sequence, which display information an expected probability distribution of the foreground and an expected probability, distribution of the background of the image-recording device differ the most.

11. The system of claim 10, wherein the at least one control module is configured to calculate a probability mapping for a respective image-recording device, and wherein the probability mapping describes which probability distribution exists in an image of the respective image-recording device if the at least one display device displays any one of the remaining pieces of display information.

12. The system of claim 11, wherein the at leak one control module is configured to determine the probability mapping based on a transformation between the coordinate system of the at least one display device and the coordinate system of the at least one image-recording device.

13. The system of claim 12, wherein the at least one control module is configured to determine the probability mapping based on a radiometric calibration between the at least one display device and the respective image-recording device.

14. The system of claim 12, wherein a plurality of calibration marks are arranged on the at least one display device, which are detectable by the at least one image-recording device to facilitate the transformation between the coordinate system of the at least one display device and the coordinate system of the at least one image-recording device.

15. The system of claim 10, wherein the at least one control module is configured to insert calibration information into the sequence of display information, and wherein the at least one display device is configured to display the calibration information.

16. The system of claim 15, wherein the calibration information comprises at least a single monochrome image, wherein the image has a display duration of at least one or precisely one frame, and wherein the image has a color having a high

contrast to a foreground object.

17. A method for dynamically maximizing the contrast between the foreground and background in images and/or image sequences, the method comprising:

detecting at least one image by at least one image-recording device;

calculating a transformation between a two-dimensional coordinate system of the at least one image-recording device and a two-dimensional coordinate system of at least one display device;

carrying out a segmentation to determine at least occlusions of background objects through foreground objects in an image;

displaying display information, including video clips, on the at least one display device, wherein the display information displayed on the at least one display device is recorded by the at least one image-recording device;

during the segmentation, identifying quality data on the segmentation and adjusting the display information displayed on the at least one display device based on the quality data;

providing a stored sequence of display information to be displayed on the at least one display device one after the other; and

determining for remaining display information of the sequence, in which display information an expected probability distribution of the foreground and an expected probability distribution of the background of the image-recording device differ the most.