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*Vor Ablauf der für Änderungen der Ansprüche zugelassenen
Frist. Veröffentlichung wird wiederholt falls Änderungen
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(54) Title: PROCESS FOR DETECTING AND CHECKING THE GENUINENESS OF BANK NOTES AND DEVICE FOR IMPLEMENTING IT

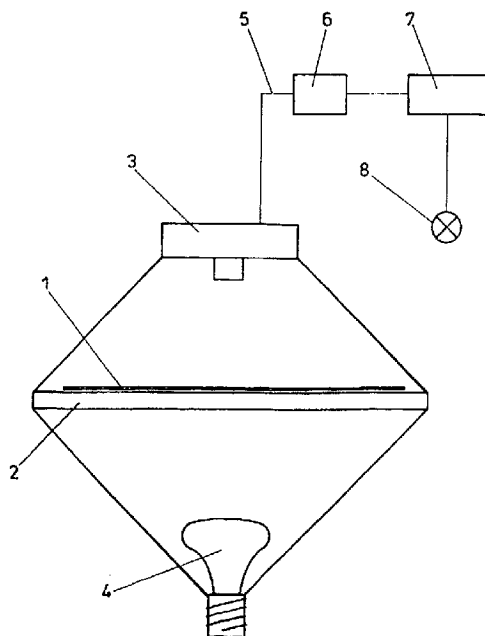
(54) Bezeichnung: VERFAHREN ZUR ERKENNUNG UND ZUM ÜBERPRÜFEN DER ECHTHEIT VON BANKNOTEN SOWIE EINRICHTUNG ZUR DURCHFÜHRUNG DIESES VERFAHRENS

(57) Abstract

In order to check and detect the genuineness of bank notes (1), light from a radiation source (4) is passed through them and a monochrome image with at least 32 grey gradations is made by means of a digital camera (3). The signal from said digital camera (3) is taken to a computer (7) for the evaluation of the number, frequency and/or surface distribution of the grey gradations detected.

(57) Zusammenfassung

Zur Erkennung und zur Erfassung der Echtheit von Banknoten (1) werden diese durch eine Strahlenquelle (4) durchleuchtet, wobei ein Schwarzweiß-Bild mit wenigstens 32 erfaßten Graustufen von einer digitalen Kamera (3) aufgenommen wird. Das Signal der Digitalkamera (3) wird einem Rechner (7) für die Auswertung der Anzahl, Häufigkeit und/oder flächenmäßigen Verteilung der erfaßten Graustufen zugeführt.



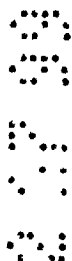
ABSTRACT

A METHOD OF IDENTIFYING AND AUTHENTICATING BANKNOTES AS WELL
AS A DEVICE FOR CARRYING OUT SAID METHOD

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To identify and authenticate banknotes (1), the latter are illuminated by a radiation
source (4) with a black-and-white image having at least 32 detected grey levels
being taken by a digital camera (3). The signal of the digital camera (3) is fed to a
computer (7) for evaluating the number, frequency and/or spacial distribution of

10 the grey levels detected.



**A METHOD OF IDENTIFYING AND AUTHENTICATING BANKNOTES AS
WELL AS A DEVICE FOR CARRYING OUT SAID METHOD**

The present invention relates to a method of identifying and authenticating banknotes by a means of an electromagnetic radiation source as well as apparatus for identifying and authenticating banknotes, in which a banknote is illuminated by a source of electromagnetic radiation, such as, e.g., light exhibiting short wavelength.

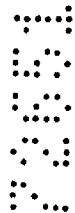
10 Devices are known, in which banknotes are illuminated from above, for instance, by means of a source of ultraviolet light to enable visual checking of the same. Evaluation in such cases relies on the viewer's experience, his or her attention being directed to certain characteristic items of the banknote which are suitable for evaluation as a function of the banknote. To evaluate banknotes
15 automatically, a number of devices are known in which the banknote is passed below a scanner. As a rule, special evaluation in those cases comprises a number of criteria directed to a particular banknote and is effected according to a predetermined scheme in a manner that requires separate preadjustment for each banknote. Such devices, as a rule, are only applicable to a relatively small
20 number of different banknotes, if expenditures involved in evaluation are not to become too high.

The present invention may provide a method and apparatus of the abovementioned kind, which may facilitate simple adaptation of identification to
25 different banknotes. Taking into consideration the ever decreasing interval between reintroductions of banknotes for reasons of security, the invention may minimize identification expenditures by means of relatively simple procedures. These procedures may be realized without complex computers such that quick and secure evaluation of a great number of banknotes that differ from one
30 another may be feasible.



According to one aspect of the present invention there is provided a method of identifying and authenticating banknotes using a source of electromagnetic radiation, including the steps of:

- 5 a) passing a banknote to a location between said source and a digital camera;
- b) illuminating the banknote from one side thereof with said radiation;
- c) capturing a monochrome image of the illuminated banknote with the digital camera located on an opposite side of the banknote;
- d) detecting between 32 and 128 grey levels in the image; and
- 10 e) evaluating the frequency and/or spatial distribution of said 32-128 grey levels detected.



15 Because a monochrome or black-and-white image of the illuminated banknote is captured, information relating to both the front and the back of a banknote may be evaluated in the form of an accumulated summation signal. Computing resources may be minimized by limiting detection to a black-and-white image having at least 32 grey levels. At the same time, accuracy of the evaluation may be readily increased by detecting 32 mutually different grey levels so that nearly all banknotes can be reliably differentiated from one another and the security criteria required for each banknote, with a view to deciding its authenticity, can be reliably met. Notwithstanding that evaluation of a black-and-white image involves relatively high computing resources, these can be readily met by today's computers at favourable cost-performance ratios such that the method according to the invention may be securely realized even with non-highly specialized

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25 computers.



According to a further aspect of the present invention there is provided an apparatus for identifying and authenticating banknotes including a source of electromagnetic radiation for illuminating a banknote; a digital camera for capturing a monochrome image of the banknote illuminated by the electromagnetic radiation; a computer capable of evaluating at least 128 grey levels in respect of their relative arrangement, frequency and/or spatial

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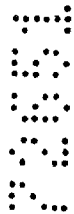


distribution in the image; means for locating the banknote between said source and the digital camera; means for transferring an authenticity evaluation signal from said computer to a display or control device, wherein said authenticity evaluation signal is based on an evaluation of between 32 and 128 grey levels.

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By detecting a banknote passed between a digital camera and a light source, a still image can be taken, with the video signal from the camera representing the image optionally being subjected to conventional data compression, in particular video data compression, prior to further processing. The signals to be utilized

10 subsequently may contain at least 32 grey levels on the image-taking side, wherein the video signal may be subjected to an appropriate computing operation



which may increase the significance of the subsequent evaluation at correspondingly reduced computing resources. Evaluation of the number of grey levels in that case may also be effected by departing from compressed signals

15 with the further option of subsequently further evaluating respectively coded signals, such as, for instance, summation signals of each individual video point information. By virtue of the fact that either the relative arrangement or the



20 frequency or the spacial distribution of the grey levels in the picture is subjected to evaluation in the original form of the video signal or in an appropriately modified compressed or coded form, an authenticity evaluation signal may be transmitted to a display and/or to a control device for passing on the banknote, within an extremely short period of time.



25 In order to ensure an optimum degree of reproducibility of the data detected, the configuration may be advantageously devised such that the banknote is held immobilized on an illuminated plate while being photographed. Such a still image may allow for any desired compressions and encodings prior to further processing, the reproducibility becoming independent of the feed transport speed or other mechanical parameters in any event.

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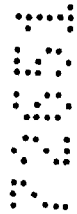
A further increase in the precision of the evaluation and the safe differentiation of an even greater number of different banknotes may be obtained by providing that



evaluation comprises at least 64, preferably 128 grey levels, the grey level signal advantageously being compared to reference signals in order to obtain suitable results in rapid succession.

- 5 With such an arrangement, the reference signals may be fed externally to the respective computer in the form of data.

- Alternatively, the arrangement may be devised such that the computer comprises an adaptive learning circuit, in particular an iteration circuit for calibration to a
 10 given banknote, thereby enabling the formation of reference signals by iteration. In order to reduce the time of evaluation and the amount of data to be processed, the arrangement advantageously may be devised such that a differential signal of the video signal and reference signal is fed to the evaluation circuit.



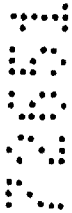
- 15 In a particularly advantageous manner, the configuration may be devised such that the source of electromagnetic radiation is constituted of light exhibiting a short-wavelength such as a source of U.V. or X-ray radiation, whereby a maximum of evaluable signals may be obtained even with relatively tightly imprinted banknotes. In addition to the option of simply evaluating statistical data relating to the grey levels detected in each case, a more complex evaluation may
 20 also be effected with correspondingly higher computing resources, in which case the configuration preferably is devised such that the black-and-white image of the banknote is subjected to picture element evaluation, such as, e.g. pattern recognition. Image evaluation programs of this kind are used, for instance, in
 25 connection with the evaluation of satellite photography, wherein high degrees of fault tolerances may be achieved in such cases because possibly misread data or failures may be compensated for by computation as an image is taken.



- 30 A preferred embodiment of the present invention will now be described with reference to the accompanying drawing.



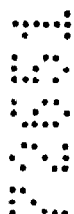
In the drawing a banknote 1 placed on a transparent support 2 is visible, the banknote being held immobilized as an image thereof is captured by a digital camera 3. The banknote 1 is illuminated by means of a radiation source 4 constituted by a light source. The signal from the digital camera 3 reaches a computer 7, in which the respective evaluation takes place via data lines 5 and a data compressor or data concentrator 6. The digital camera 3 detects at least 32 grey levels, wherein an appropriate signal 8 may be triggered for indicating authenticity if the latter has been confirmed by evaluation. As an alternative, an appropriate gate or a further transport mechanism may be actuated to enable a banknote recognized as authentic, to be deposited in a suitable shaft intended to receive said banknote. The light source may be adapted to the respective type of banknote 1 to be investigated. In principle, energy-rich electromagnetic radiation sources are particularly advantageous with tightly imprinted banknotes. For quick and safe detection, the digital camera 3 should be able to take at least five frame pictures per second at the desired resolution. The transparent plate 2 may be replaced with a perforated plate able to provide secure immobilization by sucking air through suitable bores in the plate, in particular with a view to immobilizing the banknote while capturing an image thereof.



The claims defining the invention are as follows:

1. A method of identifying and authenticating banknotes using a source of electromagnetic radiation, including the steps of:

- 5 a) passing a banknote to a location between said source and a digital camera;
- b) illuminating the banknote from one side thereof with said radiation;
- c) capturing a monochrome image of the illuminated banknote with the digital camera located on an opposite side of the banknote;
- d) detecting between 32 and 128 grey levels in the image; and
- 10 e) evaluating the frequency and/or spatial distribution of said 32-128 grey levels detected.



- 15 2. Apparatus for identifying and authenticating banknotes including a source of electromagnetic radiation for illuminating a banknote; a digital camera for capturing a monochrome image of the banknote illuminated by the electromagnetic radiation; a computer capable of evaluating at least 128 grey levels in respect of their relative arrangement, frequency and/or spatial distribution in the image; means for locating the banknote between said source and the digital camera; means for transferring an authenticity evaluation signal from said computer to a display or control device, wherein said authenticity evaluation signal is based on an evaluation of between 32 and 128 grey levels.



- 20 3. Apparatus according to claim 2, wherein a video signal representing said image is fed to the computer via a data compression device.



4. Apparatus according to claim 2 or 3 and further including a plate on which said banknote is held immobilized while capturing said image.



- 25 5. Apparatus according to any one of claims 2 to 4, wherein the computer compares a signal representing the grey levels to one or more reference signals.

6. Apparatus according to claim 5, wherein a differential signal of the video signal and the or each reference signal is fed to the evaluation circuit.

- 30 7. Apparatus according to any one of claims 2 to 6, wherein the computer comprises an adaptive learning circuit, in particular an iteration circuit suitable for being calibrated to a given banknote.



8. Apparatus according to any one of claims 2 to 7, wherein the source of electromagnetic radiation includes light exhibiting a short-wavelength such as U.V. or X-ray radiation.

9. Apparatus according to any one of claims 2 to 8, wherein the computer is
5 capable of evaluating the image by means of pattern recognition.

10. A method of identifying and authenticating banknotes substantially as hereinbefore described with reference to the accompanying drawing.

11. Apparatus for identifying and authenticating banknotes substantially as hereinbefore described with reference to the accompanying drawing.

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