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(54) Title: METHOD AND APPARATUS FOR FILTERING AND ANALYZING A NOISE IN AN IMAGE

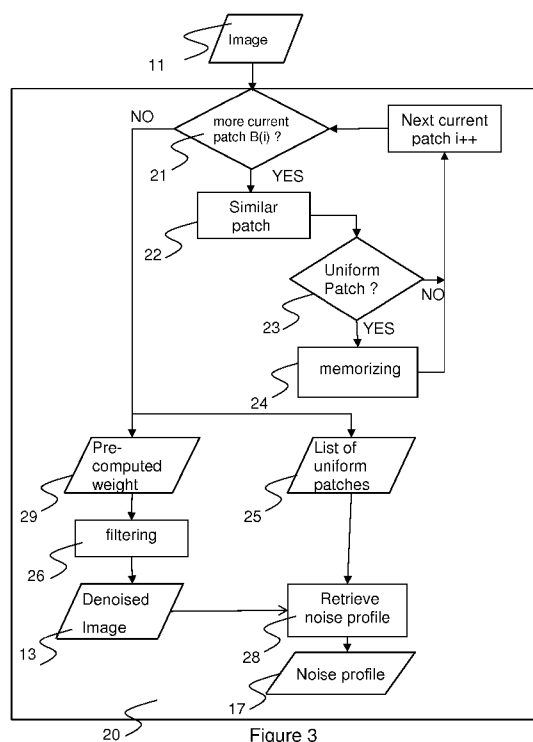


Figure 3

(57) Abstract: A method (20) for filtering and analyzing a noise in an image and an apparatus (100) configured to perform this method are described. The method comprises determining (21), for each pixel of the image, a current patch centered on the pixel; determining (22), for the current patch, similar patches in the image, a similar patch being a patch with similar content; determining (23), if the current patch is a uniform patch, a uniform patch being a patch with uniform content; memorizing (24) the current patch and similar patches determined for the current patch into a list (25) of uniform patches when the current patch is a uniform patch; and filtering (26) noise in the image using information obtained for the determination of the similar patches; retrieving (28) a noise profile for the image from the list (25) of uniform patches.



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METHOD AND APPARATUS FOR FILTERING AND ANALYZING A NOISE IN AN IMAGE

TECHNICAL FIELD

5 The present invention relates generally to the field of image processing. More precisely, the invention relates to a method and an apparatus for filtering and analyzing a noise, e.g. film grain noise, in an image of a sequence of images.

BACKGROUND

10 This section is intended to introduce the reader to various aspects of art, which may be related to various aspects of the present invention that are described and/or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present invention. Accordingly, it should be understood that these
15 statements are to be read in this light, and not as admissions of prior art.

A chemical film is made of color layers, e.g. one layer for a black-and-white film or three color layers for a color film. Each layer contains color particles or grains. If a film is scanned on a film scanner, the resulting digital signal contains film grain noise, which manifests as small-scale spatio-temporal noise artifacts caused by the
20 film grain. Since film grain noise has a relatively large energy level in the high-frequency region, it is more expensive to encode in the DCT domain. Besides, the underlying video suffers from inaccurate motion estimation. A natural idea to overcome this problem is to remove film grain noise as much as possible as a preprocessing step so as to achieve a higher coding gain.

25 However film grain noise enhances the natural appearance of pictures in high-definition video and should be preserved in coded video. **Figure 1** illustrates film grain management according to previous art. In previous art, it is proposed, after having enhanced the coding performance by extracting film grain noise 12 from the input image 11 to get a denoised image 13 for image processing 14 (such as up-

sampling, encoding), to re-synthesize 18 film grain and to add it back to the enhanced image 15 to get the final image 19. Such synthesis 18 film grain requires a grain analysis 16 from the input image 11 and from the denoised image 13. The denoising 12 and the film grain analysis 16 are processed sequentially.

5 In this regards, Buades et al. discloses in the paper "A non-local algorithm for image denoising" (in IEEE Computer Society Conference on Computer Vision and Pattern Recognition, Vol. 2, 2005) the non-local means (NL-means) method, based on a non-local averaging of all pixels in the image for denoising an image.

10 Besides, Schallauer et al. discloses in the paper "Rapid and reliable detection of film grain noise" (in IEEE International Conference on Image Processing, 2006) a detector for film grain properties. First, homogeneous blocks concerning intensity and texture are determined by a measure calculated in the frequency domain. Second, based on these blocks the signal-dependent grain noise level is estimated and an image region of pure film grain is detected.

15 However, both methods require a high computational power since statistics are computed at patches level or even at pixel levels. A highly desirable functionality is to be able to optimize the denoising and film grain management for real-time embedding of such methods in image processors.

20 SUMMARY OF INVENTION

It is an object of the invention to provide an enhanced solution for filtering noise, e.g. removing film grain noise, and retrieving a noise profile from an image of a sequence of images.

25 In a first aspect, the invention is directed to a method, performed by a processor, for filtering and analyzing a noise in an image. The method comprises, for each current patch in the image, obtaining similar patches to the current patch, a similar patch being a patch with similar content; and in the case where the current patch is a uniform patch, a uniform patch being a patch with uniform content; memorizing the current patch and similar patches to the current patch into a list of
30 uniform patches; obtaining a filtered image by filtering noise in the image from the

similar patches; and obtaining a noise profile for the image from the list of patches and optionally from the filtered image.

Each of the current patches in the image is obtained for a patch being centered on each of the pixels of the image. Indeed, the processed patches are defined at a pixel precision.

Advantageously, the method mutualizes the computation of local statistics in particular regarding patches similarity by performing jointly the denoising and the grain analysis. Indeed, the method advantageously determines homogenous area by considering a uniform patch and its associated similar patches. Besides, the grain analysis benefits from the pixel wise determining of patches of the denoising to drastically increase the number of patches considered for homogeneity. On the contrary, in the prior art implementation, grain analysis relies on disjoint patches to minimize the computation of local statistics. Advantageously, the method improves the noise profile estimation from a quality point of view since it relies on more patches.

According to a particular characteristic, obtaining, for the current patch, similar patches in the image comprises determining if a distance between the current patch and the similar patch is small, ie below a first threshold.

According to another particular characteristic, the current patch is a uniform patch if a variance of the current patch is low, ie below a second threshold.

According to an advantageous characteristic, memorizing a new uniform patch, ie among the current patch and similar patches determined for the current patch, into a list of uniform patches comprises adding, to the list of uniform patches, a patch among the current patch and the similar patches to the current patch that are not comprised in the list of uniform patches.

According to a first variant, the list of uniform patches comprises a location of a pixel wherein the current patch is centered on this pixel or the similar patches are centered on this pixel.

According to a second variant, the list of uniform patches further comprises the mean value of the current patch or of the similar patches.

According to a particular embodiment, the noise is film grain noise.

These functionalities can then be integrated into image processor or GPU.

In a second aspect, the invention is directed to an apparatus comprising at least one processor; and a memory coupled to the at least one processor, wherein the memory stores program instructions, wherein the program instructions are executable by the at least one processor to perform the disclosed method.

5

In a third aspect, the invention is directed to an apparatus comprising means for obtaining, for each current patch, similar patches to said current patch, a similar patch being a patch with similar content; means for memorizing the current patch and similar patches to the current patch into a list of uniform patches in the case
10 where the current patch is a uniform patch, a uniform patch being a patch with uniform content; and means for filtering noise in the image from the similar patches; means for obtaining a noise profile for the image from the list of uniform patches.

In a fourth aspect, the invention is directed to a computer program product
15 comprising program code instructions to execute of the steps of the disclosed method when this program is executed on a computer.

In a fifth aspect, the invention is directed to a computer-readable storage
20 medium storing program instructions computer-executable to perform the disclosed method.

Any characteristic or variant described for the method is compatible with the apparatus intended to process the disclosed methods and with a computer program product, a computer-readable storage medium storing program instructions.

25

BRIEF DESCRIPTION OF DRAWINGS

Preferred features of the present invention will now be described, by way of non-limiting example, with reference to the accompanying drawings, in which:

Figure 1 illustrates steps of the denoising, film grain management and image
30 processing according to prior art;

Figure 2 illustrates steps of the denoising, film grain management and image processing according to a particular embodiment of the invention;

Figure 3 illustrates steps of the method for filtering and analyzing a noise in an image according to a particular embodiment of the invention;

Figure 4 illustrates steps of the retrieving of a noise profile according to a particular embodiment of the invention; and

5 **Figure 5** illustrates an apparatus according to a particular embodiment of the invention.

DESCRIPTION OF EMBODIMENTS

10 In the following the invention shall be explained with reference to film grain noise as an example for noise in an image. Of course, the invention is not limited to this type of noise. The invention can be used for filtering and analysing any kind of noise or low-level signal component on a given image.

15 As illustrated on **Figure 1**, film grain management generally includes three steps. The first step is noise filtering 12, i.e. denoising or removal of noise, of an images sequence, wherein each image potentially shows different profiles of film grain noise. Noise filtering 12 is advantageously achieved by spatial and/or temporal filtering. The second step is noise analysis 16 to define noise profile. The third step is film grain noise synthesis 18 of unique strength throughout the complete sequence of images in order to achieve a common look and feel for the complete sequence.

20 A salient idea of the invention is to jointly perform film grain analysis along with the noise filtering. The described particular embodiment relies on the state-of-the-art technique called Non Local means (hereinafter NLmeans) and disclosed in the paper "A non-local algorithm for image denoising". However the invention is not limited to such embodiment and the invention is compatible with any noise filtering
25 method based on patches analysis. Advantageously, the invention allows reducing the global complexity compared to a sequential denoising and film grain analysis as presented on **Figure 1**. Indeed the computation of local statistics (patch distances are computed during NLmeans, hence providing a bound for corresponding image homogeneity) is mutualized when performing jointly the denoising and the grain
30 analysis. As, latter on explained, the invention further allows improving the result from a quality point of view.

Figure 2 illustrates steps of the denoising, film grain management and image processing according to a particular embodiment of the invention.

In a first step 20, a joint noise filtering and noise analysis is performed producing a denoised image 13, i.e. filtered image 13, and a noise profile 17. This first step 20 is latter on described with reference to **figure 3**. The remaining of the process remains almost unchanged. In particular, the second step 18, comprising the film grain noise synthesis on the enhanced image 15 from the noise profile issued from step 20 to generate the final image 19, remains unchanged even if the noise profile benefits from a better precision (for instance in term of quantification as detailed hereafter).

As previously discussed, the method is advantageously compatible with any state-of-the-art denoising technique based on patches. A patch or a block is a set of pixels, typically size 16x16 pixels or 8x8 pixels. A patch is defined by its size and the coordinates of a pixel representative of the location of the patch in the image. In a variant, the pixel at the center of the patch is used as representative of the coordinates of the patch. However, any other variant envisaged by the skilled in the art to determine a patch is compatible with the described embodiments.

Figure 3 illustrates steps of the method for filtering and analyzing a noise in an image according to a particular embodiment of the invention. The NL means algorithm comprises a linear weighted interpolation of pixels in the image wherein the weights w_{ij} are defined as the L2 distance between patches centered at the considered pixels i and j . Technically, the denoised value at pixel i is defined as:

$$NLmeans(i) = \frac{1}{Z_i} \sum_{j \in V(i)} w_{ij} I(j) \quad \text{with} \quad w_{ij} = e^{\frac{-||B(i)-B(j)||_2^2}{\sigma^2}} \quad (\text{equation 1})$$

Where $B(i)$ denotes the patch centered at pixel i and σ is some scale parameter. Z_i is some normalization factor computed as the sum of weights w_{ij} , $V(i)$ corresponds to a neighborhood of pixel i and $I(j)$ the original value for pixel j (for instance the luminance value of a pixel in the YCrCb format or a vector representing a (R,G,B) value of a pixel in the RGB format). The skilled in the art will notice that the weight w_{ij} drastically decreases with the L2 distance between the patch centered on pixel j

and the patch centered on pixel i wherein such distance is also used for patch similarity. In other words, the NL-means comprises determining similar patches centered on pixel j to the patch centered on pixel i to filter noise for each pixel i . Advantageously such determining of similar patches for denoising is re-used for noise analysis along with a determining of uniform or homogeneous patches.

In a first step 21, a current pixel i in the image is determined and for each current pixel i , a current patch $B(i)$ centered on the current pixel is obtained until each pixel i of the image 11 is processed i.e. there is no more patch $B(i)$ to process. Advantageously, the process is parallelisable for each pixel/patch of the image which speed up the processing. Indeed, for each pixel of the image, the steps 21 to 24 of the method are iterated either sequentially or in parallel. The steps 21 to 24 perform an exhaustive search of similar patches and of uniform patches in the image 11. At the output of the steps 21 to 24, a set 29 of pre-computed weights w_{ij} and a list 25 of uniform patches are obtained. Once the similar patches, and L2 distance, are determined for each pixel of the image, the filtering step 26 is processed. In a variant illustrated on figure 3, the noise profile retrieving step 28 is processed once the filtering step 26 is finished and the whole filtered image 13 available for noise profile retrieving. In another variant (not shown on figure 3), the noise profile retrieving step 28 uses the mean luminance value of a noisy uniform patch as an approximation of mean luminance value of the denoised patch and the step 28 can start before the whole filtered image 13 is available. Finally, figure 3 represents a sequential processing of step 22 followed by step 23 for a current patch/pixel, however according to various variants, since the steps 22 and 23 are not dependant; the steps 22 and 23 are either performed sequentially in any order or in parallel.

The steps 22 to 28 are now detailed, in the second step 22, similar patches to the current patch are determined in the image. A similar patch is a patch with similar content. According to a preferred embodiment, a distance between the current patch and each patch in the image are computed. In a non-limiting example L2 norm is advantageously used as the distance because it is compatible with the weights w_{ij} in the NL means as detailed above. The tested patch $B(j)$ and the current patch $B(i)$ are similar in the case where the distance between the tested patch and the current

patch is below a first threshold τ_1 . Let us note d_{ij} the distance between the two patches, for instance L2 norm between the two patches:

$$d_{ij} = \|B(i) - B(j)\|_2^2$$

Then if $d_{ij} < \tau_1$, the patches centered at pixel i and pixel j are similar. The similar patches are memorized for homogeneity analysis in step 23.

- 5 Advantageously, the weights w_{ij} are also computed between the patch centered at pixel i and pixel j at this step :

$$w_{ij} = e^{\frac{-d_{ij}}{\sigma^2}}$$

and memorized in a set 25 of pre-computed weights for the filtering step 26.

- 10 As described in the paper "Rapid and reliable detection of film grain noise", the grain noise analysis requires determining homogeneous blocks concerning intensity and texture. Then, based on these homogeneous blocks, the signal-dependent grain noise level is estimated. In the preferred embodiment, the grain noise is supposed to be uncolored and consequently applied only on the luminance component (Y layer) of a frame in the YCrCb format. The notation of the YCrCb
- 15 format is used in the following of the description. However the invention is not limited to YCrCb colorimetric coding scheme and the invention is compatible with any colorimetric coding scheme wherein the luminance is coded in separate layer. Thus the invention is compatible with LAB, HSV or HSL format. The grain model is defined in the DCT domain. A 16x16 patch of grain in the luminance spatial domain follows a
- 20 model based on a random Gaussian noise in a subpart of the 16x16 patch in the DCT domain. The 3 features that model the grain in the DCT domain are the variance σ^2 of the noise and two cutoff frequencies that limit the area where the noise is present. The cutoff frequencies define the grain shape. For instance, if they are equal, the grain is circular. The DC component is set to a null value in order to
- 25 obtain a centered patch grain in the spatial domain. The value of σ^2 depends on the mean luminance value of the patch $B(i)$ to which the grain has to be added. Cutoff frequency values are supposed to be constant.

- 30 Thus in the third step 23, the uniformity, i.e. homogeneity, of the current patch is tested. A uniform patch is a patch with uniform content. According to a preferred embodiment, the variance of the current patch $B(i)$ is computed. A patch is

considered as a uniform patch when the variance of the current patch is low, for instance below a second threshold τ_2 :

$$\text{Var}(B_i) < \tau_2$$

If the test is successful, ie the above comparison is true YES, the current patch is uniform and is thus aggregated for grain analysis in step 24. If the test failed, ie the above comparison is false NO, the current patch is not uniform, the current patch is thus discarded for grain analysis.

Besides, regarding similar patches of a current uniform patch obtained in step 22, their variance is also bounded. Indeed if $d_{ij} < \tau_1$, then the variance of patch $B(j)$ is bounded by $\tau_1 + \tau_2$. Depending on the thresholds τ_1 and τ_2 , patch $B(j)$ can also be aggregated for grain analysis. Advantageously the threshold τ_1 is adjusted to define uniform patches variance. Advantageously the threshold τ_2 is adjusted as small as needed so that patches with variance below $\tau_1 + \tau_2$ are also considered as uniform.

Then, in the case where the current patch is a uniform patch, in a fourth step 24, the current patch $B(i)$ and similar patches $B(j)$ for the current patch are memorized into a list of uniform patches. According to an advantageous characteristic, a patch is only present once in the list. Accordingly, a patch, among the current uniform patch and associated similar patches, is added to the list when such patch is not already comprised in the list of uniform patches. According to a first variant, the list comprises a location (coordinates) of a pixel i in the image such that the current uniform patch is centered on the pixel i or such that an associated similar patch is centered on the pixel i . According to a second variant, the list of uniform patches further comprises the mean luminance value of the uniform patch. In a refinement of this second variant, the mean luminance value of a patch is used as an index in the list and the uniform current patch or the uniform similar patches to be added are stored according to their mean luminance value. Advantageously, the mean luminance value is quantified and the number of indexes reduced. This second variant is particularly advantageous with regards to the variant where an approximation of the denoised mean value is used for the noise retrieving step 28.

Finally the steps 21 to 24 are iterated for the next current patch until all current patches in the image are processed. At the end of the iterations, a set of pre-computed weights w_{ij} and a list of uniform patches are obtained.

In a fifth step 26, each pixel of the image 11 is filtered for noise according to equation 1. To that end, the noise filtering step 26 uses the set 29 of pre-computed weight of step 22. Any variant envisaged in by the skilled in the art (size of the neighbourhood $V(i)$ of i , weight set to 0 when too low..) is compatible with those pre-computed weights. At the output of the noise filtering step 26, the denoised image 13 is available for each component YCrCb.

In a sixth step 28, the noise profile is retrieved for the image from the list 25 of patches and from the filtered image 13.

Figure 4 illustrates sub-steps of the retrieving of a noise profile step 28 according to a particular embodiment of the invention. According to a preferred variant the grain profile is assumed to be constant over the sequence of images. Accordingly the grain features (variance and cutoff frequencies as detailed above) are computed for each image independently, on an image by image basis. In order to get unbiased values for those features, the grain analysis must be done only on the uniform areas of the filtered frame. In a nutshell, an accumulation process is followed by a grain patch located in a uniform area of the filtered luminance image 13. Advantageously, such processing is performed only for element of the list uniform patches.

The grain analysis requires patches from the input image 11 comprising grain noise and patches from the same filtered image 13 in order to extract the grain noise. The grain layer of patch is extracted by subtracting the filtered patch to the original one.

In a step 282, the intensity $\hat{Y}_{filt}$ is computed for the filtered patch B_i . According to a variant, an approximation of the intensity $\hat{Y}_{filt}$ for the filtered patch B_i is stored in the list of uniform patches and such step 282 is optional.

In a step 283, the intensity range [0;255] is uniformly quantized in R sub ranges. In a variant wherein the modeling of the noise is continuous, the whole intensity range [0;255] is kept and R is set to 256. The goal of the analysis is to extract, for every intensity sub range, the value of the variance σ^2 and for the global image sequence the cutoff frequency values. The analysis is done on a frame by frame basis, accumulating results up to convergence. The quantized value acts as a selector to switch the mean intensity value on a given accumulator.

In a step 284, the DCT of the grain is computed. In a step 285, every element is squared and the result is accumulated into a 16x16 accumulator selected according to the quantized mean intensity value. One scalar and one 16x16 accumulator are needed per intensity sub range.

5 The prior art method aggregates patches that are disjoint. Advantageously, in the invention, all patches that compose the image are considered. Thus, the number of patches is tremendously larger, resulting in two benefits, depending on the use case. Firstly, since more patches are considered, the thresholds τ_1, τ_2 that are used to consider a patch as uniform can be modified to be stricter. That would lead to
10 more uniform blocks and a more accurate grain model. Secondly, since more patches are considered, it is not necessary to quantify the levels of luminance Y as previously envisaged. In other words, in a variant, a continuous modeling of grain model can be performed since a much larger number of blocks are used. Both factors, the thresholds level and continuous modeling, contribute the enhancement
15 of the estimation of the noise profile from the quality point of view.

According to a particular characteristic, all the accumulators must be reset before processing the first frame of a new image sequence. For every accumulator, the number of accumulated values must be stored all along the sequence for
20 allowing the computation of the average values when a new image has been processed.

Then the grain standard deviation is estimated from the accumulators' value. Within the r^{th} intensity sub range, if more than N_{min} grain patches have been accumulated, the averaged intensity mean $\tilde{Y}_r$ and the grain standard deviation $\tilde{\sigma}_r$ are
25 estimated, in a non-limiting example, as follow:

$$\tilde{Y}_r = \frac{1}{N_r} \sum_{k=1}^{N_r} \hat{Y}_{filt}^{r,k} \quad \tilde{\sigma}_r = \sqrt{\frac{1}{9} \sum_{i=2}^4 \sum_{j=2}^4 \frac{1}{N_r} \sum_{k=1}^{N_r} \Gamma_k^r(i,j)}$$

Where N_r is the number of accumulated grain patch since the beginning of the shot for the r^{th} intensity sub range and Γ is the 16x16 DCT of a grain patch. The sum over k is continuously stored in the corresponding accumulators. The invention is however compatible with any other algorithm known by the skilled in the art for
30 computing a variance and a DCT. The N_{min} threshold is almost always reached

since the number of patches drastically increases with the disclosed method. If standard deviation has been estimated within more than 4 intensity sub ranges, a 3rd order polynomial regression is computed after adding an extra point corresponding to a null standard deviation for the maximum intensity. The resulting polynomial is used for modeling the variation of the grain standard deviation with respect to the intensity.

The cutoff frequencies are further estimated from the accumulators' value. Let's call Ω_r the averaged squared DCT matrix corresponding to the r^{th} intensity sub range:

$$\Omega_r = \frac{1}{N_r} \sum_{k=1}^{N_r} \Gamma_k^r$$

For every rows and columns of Ω_r the mean value is computed. For the first row and the first column, the DC component is discarded from that computation.

$$L_k^r = \frac{1}{15 + (k > 0) ? 1 : 0} \sum_{i=(k>0)0:1}^{15} \Omega_r(k, i)$$

$$C_k^r = \frac{1}{15 + (k > 0) ? 1 : 0} \sum_{i=(k>0)0:1}^{15} \Omega_r(i, k)$$

$\hat{L}_k^r$ and $\hat{C}_k^r$ are obtained by filtering respectively L_k^r and C_k^r with the simple lowpass filter (0.25 ; 0.5 ; 0.25). Finally, for the r^{th} intensity sub range, the vertical and horizontal cutoff frequencies $F_{cut}^{r,V}$ and $F_{cut}^{r,H}$ are obtained as follow :

$$F_{cut}^{r,V} = \operatorname{argmin}_k \left(\left| \hat{L}_k^r - \frac{1}{6} \sum_{n=3}^5 \hat{L}_n^r \right| \right)$$

$$F_{cut}^{r,H} = \operatorname{argmin}_k \left(\left| \hat{C}_k^r - \frac{1}{6} \sum_{n=3}^5 \hat{C}_n^r \right| \right)$$

The cutoff frequencies associated to the current image are computed by averaging the set of frequencies obtained in the R intensity sub ranges.

Thus at the end of noise retrieving step 28, a noise profile 17 comprising the value of the variance σ^2 as a function of the mean value of a patch and for the global image sequence the cutoff frequency values are determined.

Figure 5 represents an exemplary architecture of an apparatus 100 configured to filter noise and analyze noise in an image according to an exemplary embodiment of the invention. The apparatus 100 comprises one or more processor(s) 110, which is (are), for example, a CPU, a GPU and/or a DSP (English acronym of Digital Signal Processor), along with internal memory 120 (e.g. RAM, ROM, EPROM). The apparatus 100 comprises one or several Input/Output interface(s) 130 adapted to display output information and/or allow a user to enter commands and/or data (e.g. a keyboard, a mouse, a touchpad, a webcam); and a power source 140 which may be external to the apparatus 100. The apparatus 100 may also comprise network interface(s) (not shown). The image may be obtained from a source. According to different embodiments of the invention, the source belongs to a set comprising:

- a local memory, e.g. a video memory, a RAM, a flash memory, a hard disk ;
- a storage interface, e.g. an interface with a mass storage, a ROM, an optical disc or a magnetic support;
- a communication interface, e.g. a wireline interface (for example a bus interface, a wide area network interface, a local area network interface) or a wireless interface (such as a IEEE 802.11 interface or a Bluetooth interface); and
- an image capturing circuit (e.g. a sensor such as, for example, a CCD (or Charge-Coupled Device) or CMOS (or Complementary Metal-Oxide-Semiconductor)).

According to different embodiments of the invention, the filtered image and the noise profile may be sent to a destination. As an example, the filtered image and the noise profile are stored in a remote or in a local memory, e.g. a video memory or a RAM, a hard disk. In a variant, the image, the enhanced image and the noise profile are sent to a storage interface, e.g. an interface with a mass storage, a ROM, a flash memory, an optical disc or a magnetic support and/or transmitted over a communication interface, e.g. an interface to a point to point link, a communication bus, a point to multipoint link or a broadcast network.

According to an exemplary and non-limitative embodiment of the invention, the apparatus 100 further comprises a computer program stored in the memory 120. The computer program comprises instructions which, when executed by the

apparatus 100, in particular by the processor 110, make the apparatus 100 carry out the method described with reference to figure 4. According to a variant, the computer program is stored externally to the apparatus 100 on a non-transitory digital data support, e.g. on an external storage medium such as a HDD, CD-ROM, DVD, a read-only and/or DVD drive and/or a DVD Read/Write drive, all known in the art. The apparatus 100 thus comprises an interface to read the computer program. Further, the apparatus 100 could access one or more Universal Serial Bus (USB)-type storage devices (e.g., "memory sticks.") through corresponding USB ports (not shown).

According to exemplary and non-limitative embodiments, the apparatus 100 is a device, which belongs to a set comprising:

- a mobile device ;
- a communication device ;
- a game device ;
- a tablet (or tablet computer) ;
- a laptop ;
- a still image camera;
- a video camera ;
- an encoding chip;
- a still image server
- a video server (e.g. a broadcast server, a video-on-demand server or a web server) ; and
- an up-scaling, a display or a decoding chip.

The implementations described herein may be implemented in, for example, a method or a process, an apparatus, a software program, a data stream, or a signal. Even if only discussed in the context of a single form of implementation (for example, discussed only as a method or a device), the implementation of features discussed may also be implemented in other forms (for example a program). An apparatus may be implemented in, for example, appropriate hardware, software, and firmware. The methods may be implemented in, for example, an apparatus such as, for example, a processor, which refers to processing devices in general, including, for example, a computer, a microprocessor, an integrated circuit, or a programmable logic device. Processors also include communication devices, such as, for example, computers,

cell phones, portable/personal digital assistants ("PDAs"), and other devices that facilitate communication of information between end-users.

Implementations of the various processes and features described herein may be embodied in a variety of different equipment or applications, particularly, for example, equipment or applications. Examples of such equipment include an encoder, a decoder, a post-processor processing output from a decoder, a pre-processor providing input to an encoder, a video coder, a video decoder, a video codec, a web server, a set-top box, a laptop, a personal computer, a cell phone, a PDA, and other communication devices. As should be clear, the equipment may be mobile and even installed in a mobile vehicle.

Additionally, the methods may be implemented by instructions being performed by a processor, and such instructions (and/or data values produced by an implementation) may be stored on a processor-readable medium such as, for example, an integrated circuit, a software carrier or other storage device such as, for example, a hard disk, a compact diskette ("CD"), an optical disc (such as, for example, a DVD, often referred to as a digital versatile disc or a digital video disc), a random access memory ("RAM"), or a read-only memory ("ROM"). The instructions may form an application program tangibly embodied on a processor-readable medium. Instructions may be, for example, in hardware, firmware, software, or a combination. Instructions may be found in, for example, an operating system, a separate application, or a combination of the two. A processor may be characterized, therefore, as, for example, both a device configured to carry out a process and a device that includes a processor-readable medium (such as a storage device) having instructions for carrying out a process. Further, a processor-readable medium may store, in addition to or in lieu of instructions, data values produced by an implementation.

As will be evident to one of skill in the art, implementations may produce a variety of signals formatted to carry information that may be, for example, stored or transmitted. The information may include, for example, instructions for performing a method, or data produced by one of the described implementations. For example, a signal may be formatted to carry as data the rules for writing or reading the syntax of a described embodiment, or to carry as data the actual syntax-values written by a described embodiment. Such a signal may be formatted, for example, as an electromagnetic wave (for example, using a radio frequency portion of spectrum) or

as a baseband signal. The formatting may include, for example, encoding a data stream and modulating a carrier with the encoded data stream. The information that the signal carries may be, for example, analog or digital information. The signal may be transmitted over a variety of different wired or wireless links, as is known. The

5 The signal may be stored on a processor-readable medium.

A number of implementations have been described. Nevertheless, it will be understood that various modifications may be made. For example, elements of different implementations may be combined, supplemented, modified, or removed to produce other implementations. Additionally, one of ordinary skill will understand that

10 other structures and processes may be substituted for those disclosed and the resulting implementations will perform at least substantially the same function(s), in at least substantially the same way(s), to achieve at least substantially the same result(s) as the implementations disclosed. Accordingly, these and other implementations are contemplated by this application.

15 The invention finds its interest in all domains concerned with the noise in an image notably film grain noise. Applications related to video compression and representations of videos are concerned.

CLAIMS

1. A method (20) for filtering and analyzing a noise in an image (11), the method comprises:
 - for each current patch in said image, obtaining (22) similar patches to said
5 current patch, a similar patch being a patch with similar content and in the case where said current patch is a uniform patch, a uniform patch being a patch with uniform content, memorizing (24) said current patch and similar patches to said current patch into a list (25) of uniform patches; and
 - obtaining a filtered image (13) by filtering (26) noise in said image from said
10 obtained similar patches;
 - obtaining (28) a noise profile for said image from said list (25) of uniform patches.
2. The method according to claim 1 wherein obtaining (22) similar patches to said
15 current patch in the image comprises determining if a distance between said current patch and said similar patch is small..
3. The method according to any of claims 1 to 2 wherein said current patch is a
20 uniform patch in the case where a variance of said current patch is low.
4. The method according to any of claims 1 to 3, wherein memorizing (24) said
current patch and similar patches to said current patch into a list (25) of uniform
patches comprises adding, to said list of uniform patches, a patch among said
25 current patch and said similar patches to said current patch that is not comprised in said list of uniform patches.
5. The method according to any of claims 1 to 4 wherein said list (25) of uniform
patches comprises a location of a pixel such that a uniform patch is centered on
30 said pixel.
6. The method according to any of claims 1 to 5 wherein said list (25) of uniform
patches further comprises the mean value of a uniform patch.

7. The method according to any of claims 1 to 6, wherein the noise is film grain noise.

8. The method according to any of claims 1 to 7, wherein each current patch of said image is obtained for a patch being centered on each pixel of the pixels of said image.

9. An apparatus (100) configured to filter and analyze a noise in an image, the apparatus (100) comprising at least one processor (110) and a memory (120) coupled to the at least one processor, the at least one processor being configured to:

- Obtain, for each current patch in said image, similar patches in said image, a similar patch being a patch with similar content; and memorize in the case where said current patch is a uniform patch, a uniform patch being a patch with uniform content, said current patch and similar patches to said current patch into a list of uniform patches in said memory (120); and
- obtain a filtered image by filtering noise in said image from said similar patches;
- obtain a noise profile for said image from said list of uniform patches.

10. An apparatus (100) configured to filter and analyze a noise in an image, the apparatus (100) comprising:

- means for obtaining, for each current patch in said image, similar patches in the image to said current patch, a similar patch being a patch with similar content and means for memorizing said current patch and similar patches to said current patch into a list of uniform patches in the case where said current patch is a uniform patch, a uniform patch being a patch with uniform content; and
- means for filtering noise in said image from said similar patches resulting in a filtered image;
- means for obtaining a noise profile for said image from said list of patches.

11. A computer program product comprising program code instructions to execute of the steps of the method according to any of claims 1 to 8 when this program is executed on a computer.
- 5 12. A processor readable medium having stored therein instructions for causing a processor to perform at least the steps of the method according to any of claims 1 to 8.

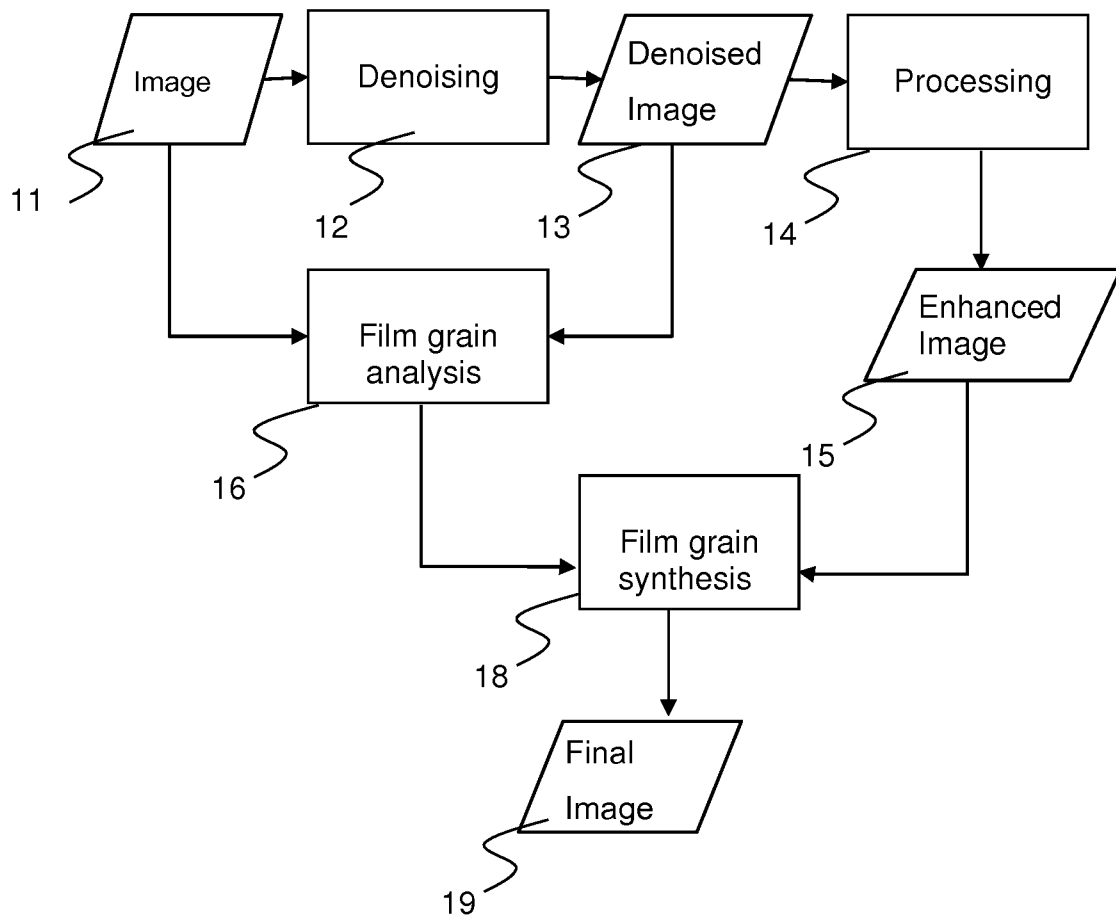


Figure 1

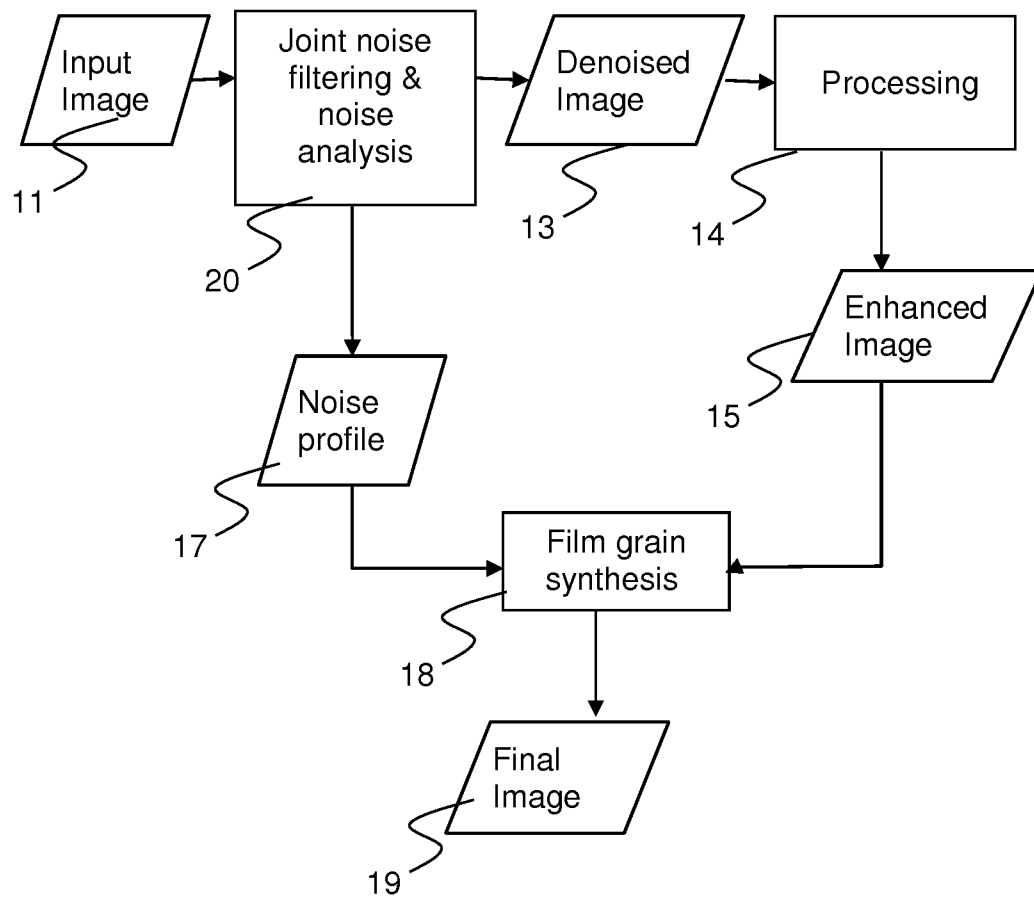


Figure 2

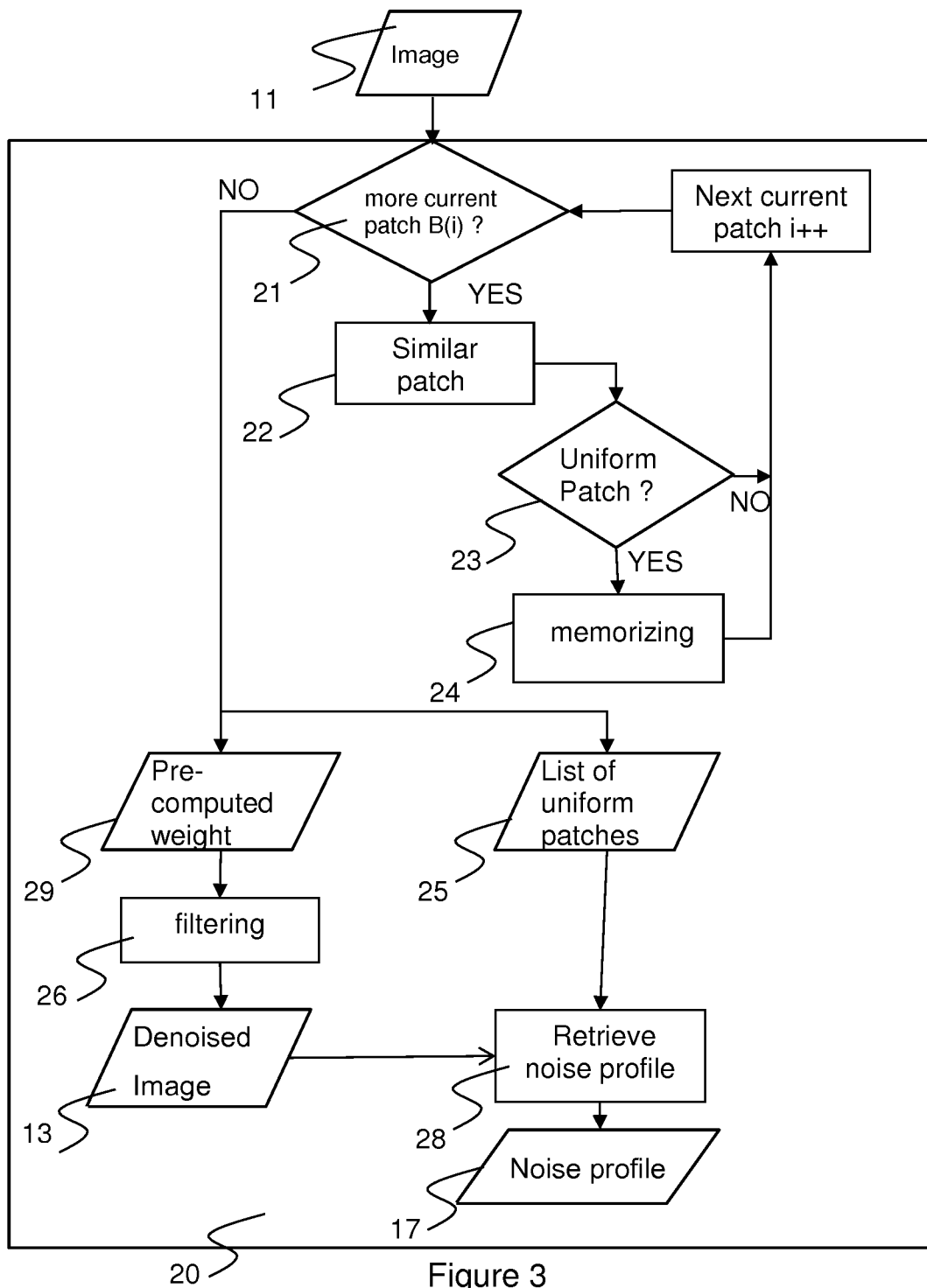
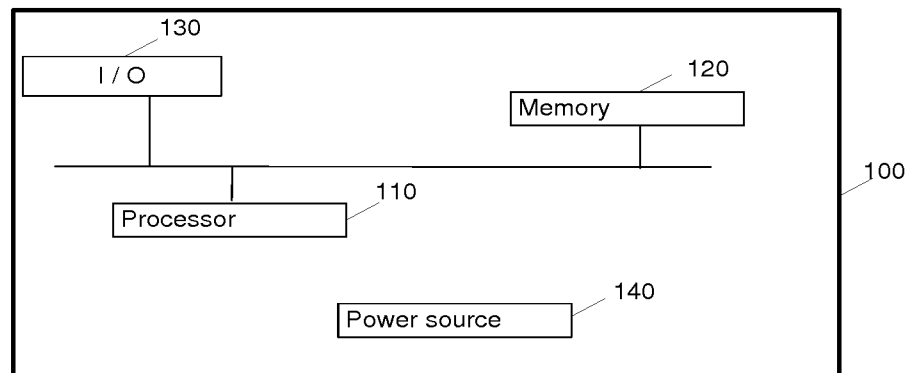
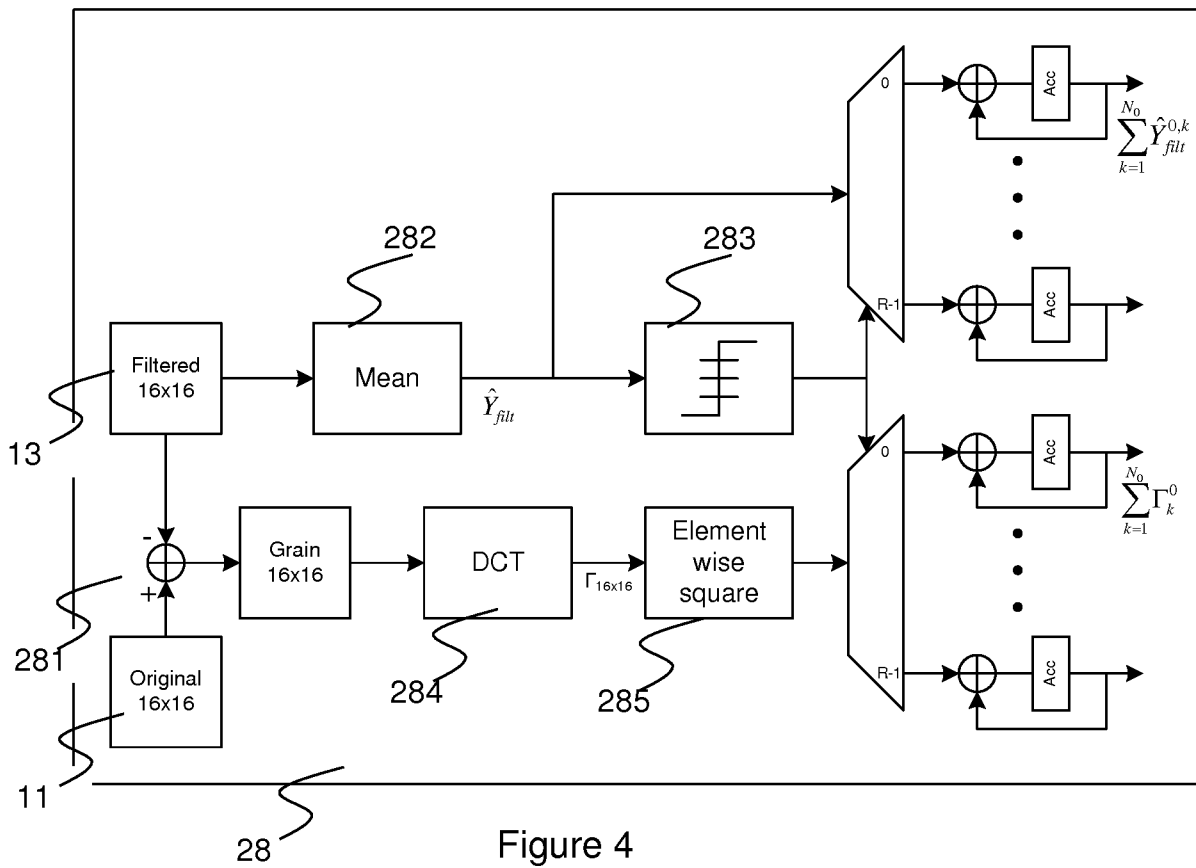


Figure 3



INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2015/053775

A. CLASSIFICATION OF SUBJECT MATTER

INV. G06T5/00 G06T7/40 H04N19/85
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G06T H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CHIRAG JAIN ET AL: "A low-complexity, motion-robust, spatio-temporally adaptive video de-noiser with in-loop noise estimation", 15TH IEEE INTERNATIONAL CONFERENCE ON IMAGE PROCESSING : ICIP 2008 ; SAN DIEGO, CALIFORNIA, USA, 12 - 15 OCTOBER 2008, IEEE, PISCATAWAY, NJ, USA, 12 October 2008 (2008-10-12), pages 557-560, XP031374062, ISBN: 978-1-4244-1765-0 abstract Page 557, right column, second paragraph ("In this effort ..." - "filter") Section 2; figures 1, 2 ----- -/--	1-12



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

18 May 2015

Date of mailing of the international search report

06/07/2015

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Kessler, Cordula

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2015/053775

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	YUNTAO QIAN ET AL: "3-D nonlocal means filter with noise estimation for hyperspectral imagery denoising", GEOSCIENCE AND REMOTE SENSING SYMPOSIUM (IGARSS), 2012 IEEE INTERNATIONAL, IEEE, 22 July 2012 (2012-07-22), pages 1345-1348, XP032469095, DOI: 10.1109/IGARSS.2012.6351287 ISBN: 978-1-4673-1160-1 abstract Section 1. Introduction: the second-to-last paragraph Section 3. NLM FILTER FOR SD AND SI NOISE REDUCTION -----	1-12
A	BHUJLE HEMALATA ET AL: "Novel Speed-Up Strategies for Non-Local Means Denoising With Patch and Edge Patch Based Dictionaries", IEEE TRANSACTIONS ON IMAGE PROCESSING, IEEE SERVICE CENTER, PISCATAWAY, NJ, US, vol. 23, no. 1, 1 January 2014 (2014-01-01), pages 356-365, XP011532816, ISSN: 1057-7149, DOI: 10.1109/TIP.2013.2290871 [retrieved on 2013-11-26] abstract Section II. NLM THROUGH DICTIONARY BUILDING -----	1,4,9-12
A	US 2006/215767 A1 (GOMILA CRISTINA [US] ET AL) 28 September 2006 (2006-09-28) abstract paragraphs [0009], [0018] -----	7
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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2015/053775

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2015/053775

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