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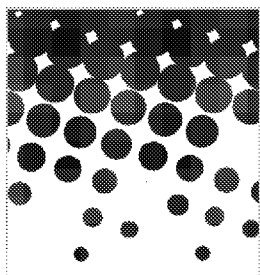


Fig. 10G

(57) Abstract: Methods for compensating for dot gain are provided. The methods combine a source image with a dithered image generated from the source image in order to compensate for dot gain. The methods provided operate on grey scale as well as multi channel colour images.

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TITLE: Halftoning method

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Background of the Invention**Field of the invention**

10 The present invention generally relates to reproduction and print industry, and more specifically to digital imaging and halftoning for print processes characterised by significant level of dot gain, such as flexo print and gravure print etc.

Background artShort introduction to flexo print industry

15 Flexo print is a large global industry widely used for printing on among various types of food packaging and labelling etc. Flexo print is used for printing on almost any type of material including various type of carton, paper, plastic materials and metal. Total global annual turnover is more than one hundred billion Euro, market trend is growing. Flexo print is characterised by print plates made of rubber and is popular for different reasons, among them low cost and short lead time.

20 The industry has an overall problem: lightest end of tonal range cannot be reproduced due to technical limitations in print process. This set strict limitations to print quality. To avoid random unwanted sharp transitions to white, the industry solves the problem by adding the colour that is missing/cannot be reproduced, or by completely removing the specific print colour. This causes light tonal areas in photographs and other design elements to become dark, colour changes known as colour cast occur, colours become unnaturally dirty and/or unnaturally intense, and details in bright areas become less visible or disappear.

30 Short introduction to general print principles

A conventional printing press cannot reproduce colour nuances, each colour is printed with 100% darkness. Black ink will become completely black without nuances, the same applies to all other print colours. That is how it was when Gutenberg invented his print process in the 14th century, and it is still the same today. Fundamentally, it is not possible to print a photo or other motives with different nuances of a print colour.

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Various methods have been developed to overcome this limitation. Prior to the invention of the halftone raster in 1882, different hatching techniques were used to produce an illusion of tonal range. Motives were hand drawn into a metal plate or a wooden board. Woodcut/xylography (drawing cut into a wooden board) and etching/metal cut (drawing engraved into a metal plate) are examples of this. The basic principle is that short distance between lines gives dark nuances, and long distance gives bright nuances. Variations in line thickness are also used to create dark and bright nuances.

Following the invention and widespread of photography, the need to reproduce photos in newspapers and other printed publications occurred. In 1833, William Fox Talbot was the first to describe the idea of a raster technique. Forty years later, in 1873, the first successfully reproduction of a full tone photo was printed, using a primitive precursor of the halftone raster. In 1882, the German inventor Georg Meisenbach patented the modern halftone raster, which until this day is still the industry standard in graphic industry. The basic principle is that the motive is separated into many single elements, in practice, small circular dots of different sizes placed in an imaginary square grid. The size of the dots and the space between them creates an illusion of nuances. This principle is used in all modern print processes to reproduce photos and other motives built of nuances. Modern halftone raster can be described as an advanced and strictly mathematic hatching technique.

In early days halftone raster was cut by hand with ruler and knife, later photographic methods were developed to streamline and standardize the process. When computers took over in graphic industry the raster processing became digital, but the basic principle is the same as in 1880: the motives are separated into small elements/dots to create an illusion of nuances. In the beginning halftone raster was used only on single colour motives, normally black/white photos. By the time the technique was refined and standardized to a level where it was possible to mix different print colours with high precision, it was possible to reproduce full colour photos with natural colours.

Factors that affect photo reproduction and print quality:

Paper quality:

Paper quality is determined by several factors, such as whiteness/purity, fibre size, density/weight, surface gloss/texture, and porosity/ability to soak ink.

Raster frequency/screen frequency:

Raster frequency is also referred to as screen frequency. Both refer to the number of dots per unit length. This are normally stated as lines per cm or lines per inch. If the raster frequency is 34 lines per cm, it means there will be 34 dots per length cm. Newspaper print normally use 34 lines per cm, high-end print as brochures and magazines normally use 48 or 54 lines per cm or higher, for example 60 lines per cm for specifically high quality.

Printing plates:

In order to print a motive, the motive must first be engraved into a thin print plate witch later are attached to the outside of a print cylinder. Separate print plates are made for each print colour, each print colour is applied using a separate print cylinder, usually referred to as a colour-unit. Prints containing full colour photos always require four print plates, one unique plate for each print colour (cyan, magenta, yellow and black). Print plates are consumables, unique printing plates must be made for each new print job. Various printing techniques use printing plates of various materials, as metal, rubber, wood and stone. Flexo print uses print plates made of rubber, hence the name (flexible). Motives can also be engraved directly into the print cylinder (referred to as gravure print), but due to high cost and time consume it is only used for special productions.

Dot gain and the factors that affect it:

1) Absorbing effect: A drop of water that hits a paper will soak into the paper and absorb outward, the stain will grow bigger. The same happens when printing ink hits the paper. The degree of dot gain is determined by the paper's ability to absorb ink, from almost invisible to highly visible.

2) Mechanical strength/level of details: In flexo print the print plates are made of rubber. Rubber is a weaker material than metal and requires larger dimensions on smallest details to withstand mechanical strain in the printing process. It is simply not possible to make as small details in rubber as in metal. This factor is an additional problem that causes dot gain in flexo print to be particularly high, which normally makes it impossible to reproduce nuances below approximately 10-20%.

The sum of these two factors are referred to as dot gain.

For example, if an area in the original photo is 2% black and dot gain in the printing process is 14 %, then the lightest area will be reproduced as about 16% black on final print.

More ink colours enhance the effect of dot gain. If the starting point is a multi-colour mix, for example 2% cyan, 2% magenta, 4% yellow and 3% black, final print will increase to 16% cyan, 16% magenta, 18% yellow and 17% black. When these colours are placed on top of each other, the sum of the colours will be perceived as very dark compared to the original design solution. The total perceived darkness will be slightly lighter than the sum of cyan, magenta and black, in this example close to 40% black (yellow affects the darkness so little that it is excluded in this example).

Problems related to high level of dot gain in printing processes can be summarized as follows:

- The impact of high level of dot gain are not predictable for designer/client. Therefore, they often choose solutions that end up with unwanted surprises and deviations from the presented design, or at worst, are not technically feasible.
- Colour proofs that visualise the dot gain problem is the last task in a design process that often extends over many months. Problems are only noticeable long after design solution is chosen and approved by designer/client, and long after the entire design process has been completed. Choosing other solutions at this stage is usually not a topic, although most design agencies have experienced such negative surprises that they have been left with no other choice but to start the whole process over again.
- Technical constraints, time pressure and costs often force designer and client to accept adjustments made by repro suppliers, which often imply significant deviations from the approved solution.
- Displeasure and frustration at the client/designer because they do not understand why final print differs from approved design.
- Lack of technical insight often make the designer/client waste a lot of time "quarrelling" with repro suppliers regarding adjustments that are not technically feasible to implement. For the same reason they often do not see opportunities that actually exist.
- Repro suppliers spend a lot of time and energy explaining to customers why it is not technically possible to get the result they want.
- Long and low efficiency processes due to much back and forth with corrections (usually done by physical post).

From prior art one should refer to the following:

US5892588A which discloses a digital halftoning method that combines dot size modulation halftone (AM halftone) with dot frequency modulation halftone (FM halftone) within a single image. The method includes creating a dot frequency modulation in lighter areas which otherwise would require a dot size which is below user definable "dot size limit". This dot frequency modulation randomly deletes dots from the dot area modulation screen in these lighter areas. The percentage of frequency modulation is graduated over the range of grey values which reduces objectionable visual transitions.

Although combining AM and FM halftoning represent an improvement for anticipating dot gain and improve image fidelity and colour reproduction, especially in the highlights, it introduces other challenges. A particular challenge is to handle the transition area between AM-halftoned and FM-halftoned parts of the resulting image. For grayscale image it is fairly simple as only one colour channel needs to be handle, but for colour images it is more challenging as all colour channels needs to be taken into account. Other challenges relates to defining the starting point of FM halftoning in different colour channels and the effects of introducing angles in each of the colour channels.

Given the industry limitations presented above, there is a need for new halftoning methods that improve image fidelity and colour reproduction, increase image details - especially in the highlights - and provide for higher tonal resolution and range. Preferably, these methods should be used on existing printing equipment, thereby avoiding the need for costly equipment upgrades.

EP1558017 discloses a method and system for converting a digital image into a halftone. The method considers a digital image (image source) made up of a matrix of pixels, wherein each pixel has an intensity value. The method comprises a dot cluster look-up table, a dot density look-up table, and a dot size look-up table. Each look-up table includes a number of entries with entry corresponding to a pixel intensity value. Each pixels making up the digital image are examined sequentially. For each pixels, the method disclosed retrieves a cluster factor, a dot density factor and a dot size factor from the corresponding look-up tables and for the corresponding intensity value for that pixel. Using the cluster factor and dot density factor the method determines whether a dot is to be placed or not in the halftone cell corresponding to the given pixel. This determination is represented by a dot placement indicator. The dot placement indicator can have a value of zero (no dot to be placed) or one (dot to be placed). Using the dot size factor and the dot placement indicator, the method then determines the size of the dot to be placed. This output is

referred to as halftone print code. This code is then sent to a print engine of an image forming device (such as a printer) for printing.

JP2004066614 and JP2004066566 disclose substantially similar methods for converting a digital image into a halftone. The method comprises the steps of
5 converting a digital image into a FM halftone and converting the same digital image into an AM halftone. The digital information of only the screen lines of the darkest portion of the AM halftone are then used as a mask onto the FM halftone. The output of this step produces the final halftone according to the method disclosed.

US6760126 discloses a method for converting a digital image into a halftone
10 based on an activity index of the area being halftone. A low frequency halftone is applied to the digital image to generate low frequency halftone data. A high frequency halftone screen is applied to the image source to generate high frequency halftone data. The final halftone of the image source is then computed as a weighted average of the low and high frequency halftone data based on the activity index.

US2006/0170974 discloses a method for producing or detecting watermark
15 (hidden words or patterns) with hybrid halftone dots that is suitable for a printed shadow image. The watermark patterns are composed of AM and FM dots. This is done through outputting the density-calibration chart to choose the proper density parameters, which are applied to the manufacture process of watermark with hybrid
20 halftone dots. D1 method comprises the step of producing two gray-scale images. One gray-scale image is an AM halftone performed using a threshold matrix, and wherein the AM halftone dot have been calibrated in density. The other gray-scale image is a FM halftone image produced using error diffusion, wherein the FM dots are calibrated in density. The AM halftone dot density is decided first, then a
25 calibration chart is used to choose a corresponding density for the FM halftone dot. The AM and FM halftones are then combined with a hidden- pattern mask to produce a final hybrid halftone.

Summary of the Invention

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Problem to be solved by the invention

Therefore, the main object of the invention is to provide a halftoning method for reproducing details in the highlights and compensate for dot gain.

Means of solving the problem

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The present invention provides a method to solve the problems described to flexographic printing and other print techniques having high level of dot gain, by

producing an optical illusion which camouflages the impact of dot gain. The present invention solves the problems discussed above by making it possible to reproduce soft gradients from dark to white (zero percent). The present invention provides high contrasts and maximum quality on all photos and other design elements, even soft light motives. This is achieved by controlling light and ink with high precision using combinations of different masking and raster techniques.

The objective is achieved according to the invention by a method for compensating for dot gain in a single channel as defined in the preamble of claim 1, and a method for compensating for dot gain in a multi-channel image as defined in the preamble of claim 2.

For the purpose of the present invention, the term 'image' refers to both images and motives,

A number of non-exhaustive embodiments, variants or alternatives of the invention are defined by the dependent claims.

In a first aspect of the invention a method is provided for compensating for dot gain in a single channel image comprising: receiving a source image, in the form a grey tone image, comprises an array of pixels; wherein each pixel having a binary value that corresponds to a grey level; generating a dithered image from said grey tone image wherein said dithered image comprises an array of same size and shape as the source image, wherein each pixel having a single bit binary value that corresponds to a dithered grey level; forming an output image having the same size and shape as the source image by applying the dithered image as a mask to the source image; wherein if a pixel value in the dithered image is 0 the grey level in the source image pixel is copied to a corresponding pixel in the output image; wherein if a pixel value in the dithered image is 1 a maximum value corresponding to maximum white is copied to a corresponding pixel in the output image; wherein a halftone raster is applied to the output image; and wherein the output image is used to make a printing plate.

In a second aspect of the invention a method is provided for compensating for dot gain in a multi-channel image comprising: receiving a source image, comprises: a plurality of channel images, each channel comprising an array of pixels, wherein each pixel having a binary value that corresponds to a brightness level; generating a dithered image from at least part of a channel image wherein said dithered image comprises an array of same size and shape as the source image, wherein each pixel having a single bit binary value that corresponds to a brightness level of the channel image, where 0 is dark and 1 is maximum brightness; forming an output image channel having the same size and shape as the channel image by applying the

dithered image as a mask to the channel image; wherein if a pixel value in the dithered image is 0 the brightness level in the channel image pixel is copied to a corresponding pixel in the output channel image; wherein if a pixel value in the dithered image is 1 a maximum value corresponding to maximum brightness level is copied to a corresponding pixel in the output channel image; wherein a halftone raster is applied to the output image; and wherein the output channel images are used to make a printing plate.

In one embodiment the dithered image is generated separately from each channel and applied as a mask to each respective output channel image.

10 In one embodiment the dithered image is generated from at least one channel and applied as a mask to all output channel image.

In one embodiment the dithered image represents a weighted brightness of the at least one channel.

15 **Effects of the Invention**

The present invention comprises a technology advantage over known methods in that it uses frequency modulation screening during the image source digital preparation stage by combining multi-bit bitmaps and 1-bit bitmap techniques as a preparation before amplitude modulation screening is applied when print plates are produced. Hence, only one AM-raster is used on final print.

This process results in large numbers of tiny dots in the flexographic printing plates being deleted, in a way that improves the visual quality of the final motive.

The present invention differentiates from US5892588A in that it only make use of FM raster technology during the image source digital preparation stage before an AM raster is applied. After the AM raster is applied on the digitally manipulated image source, the resulting image is used on the final print. Hence, the invention FM raster is not physically printed. The present invention requires only one digital output file, and only use AM raster on print. Therefore, the present invention can reproduce any colour value and is relevant for all kind of motives, also full colour photos.

30 In contrast, US5892588A makes use of two separate digital output files, one multi-bit digital file, and one binary 1-bit FM rastered file. Both output files are used on print, the first file is printed with AM raster, the second file is printed as a FM raster with square pixels. This is different from the present invention which only uses one output file printed with AM raster only. The downside of the US5892588A method is that when round raster dots are combined with square raster on print, there will be a visible edge in the border where the two rasters meet each other. This

technique can only reproduce 100% colour values, and is in practice limited to mono-colour or duo-colour. The method comes with strict limitations and is rarely used.

The present invention provides several further advantageous effects:

- 5 • It makes it possible to provide an illusion of light nuances in flexographic print and other print techniques, and in particular light nuance in the range of 0%-10% which are not in general possible to reproduce with current available flexographic techniques.
- 10 • It anticipates and compensate for dot gain in printing processes, such as flexographic and gravure print, by making it possible to reproduce smooth transitions to white and thereby keeping contrasts, colour brightness and highlights and maintaining details in highlights.
- 15 • It removes the problems of handling the transition area between AM-raster and FM-raster parts and defining a starting point of the FM screen, which are usually observed in prior art method that combine AM and FM raster on print, as for example described in the US5892588A
- It makes it possible to use existing printing equipment, thereby avoiding the need for costly equipment upgrades.

20 In a further surprising effect of the invention, it has been found that flexographic plates last longer in printing when prepared according to an embodiment of the present compared to traditional preparations. The reason is that the smallest raster dots on plate have a significantly larger diameter than without processing according to the present invention.

Brief Description of the Drawings

25 The above and further features of the invention are set forth with particularity in the appended claims and together with advantages thereof will become clearer from consideration of the following detailed description of an [exemplary] embodiment of the invention given with reference to the accompanying drawings.

30 The invention will be further described below in connection with exemplary embodiments which are schematically shown in the drawings, wherein:

- Fig. 1A Etching / hatching,
- Fig. 1B Photo of person,
- Fig. 1C Detail of photo 1B,

Fig. 2A	Raster principle 1: Amplitude modulated raster (AM). Keyword: fixed distance, variable size,
Fig. 2B	Raster principle 2: Frequency modulated raster (FM). Keywords: fixed size, variable distance,
Fig. 2C	Combined raster in the present invention,
Fig. 3A	Example of AM raster,
Fig. 3B	Example of multi-bit grayscale motive,
Fig. 3C	Example of binary FM raster,
Fig. 4A	Embodiment example starting point in full tone multi-bit motive,
Fig. 4B	Embodiment example Fig. 4A combined with binary FM rastered white mask,
Fig. 4C	Embodiment example Fig. 4B rasterized with AM half-tone raster according to current invention,
Fig. 4D	Embodiment example 3B, 3C and 3A in real size,
Fig. 5A	Embodiment example original photo,
Fig. 5B	Embodiment example with prior art flexographic process,
Fig. 5C	Embodiment example printed in flexo process according to present invention,
Fig. 6A & 6B	Correlation between colour systems and colour channels,
Fig. 7	Embodiment of system implementation of the present invention,
Fig. 8	Example of value chain in the printing process,
Fig. 9	Columns in print plate, side and top view,
Fig. 10A	Shows an exemplary grey tone image,
Fig. 10B	Shows a dithered image generated from the grey tone source image of Fig. 10A,
Fig. 10C	Shows the dithered image applied as white pixels to the source image in order to mask out non-critical areas,
Fig. 10D	Shows the result, hereafter referred to as the output image, of masking the source image of Fig. 10A with the dithered image of Fig. 10B,

- Fig. 10E Illustrates a standard halftone raster, typically an AM halftone raster, superimposed on the output image of Fig. 10D,
- Fig. 10F Shows the footprint of the standard halftone raster onto the output image,
- Fig. 10G Shows the final AM halftone raster, suitable for print, consisting of 100% black / solid circular dots (shown greatly enlarged), and
- Fig. 11 Shows an overview of data flow between various process steps in several embodiments.

Description of the Reference Signs

The following reference numbers and signs refer to the drawings:

801	A customer
802	Design agency/process
803	Repro provider/process
804	Print provider
805	The method according to the present invention
901	Side view of printing plates columns of different diameters
902	From above view of printing plates columns of different diameters
I	Image
RC	Red channel
GC	Green channel
BC	Blue channel
RL	Red light
GL	Green light
BL	Blue light
SI	Summed image
CC	Cyan channel
MC	Magenta channel
YC	Yellow channel
KC	Black channel
CPC	Cyan print colour
MPC	Magenta print colour
YPC	Yellow print colour
KPC	Black print colour

P	Paper
BP	Back pressure rollers

Detailed Description of the Invention

Various aspects of the disclosure are described more fully hereinafter with reference to the accompanying drawings. This disclosure may, however, be embodied in many different forms and should not be construed as limited to any specific structure or function presented throughout this disclosure. Rather, these aspects are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art. Based on the teachings herein one skilled in the art should appreciate that the scope of the disclosure is intended to cover any aspect of the disclosure disclosed herein, whether implemented independently of or combined with any other aspect of the disclosure. For example, an apparatus may be implemented or a method may be practiced using any number of the aspects set forth herein. In addition, the scope of the disclosure is intended to cover such an apparatus or method which is practiced using other structure, functionality, or structure and functionality in addition to or other than the various aspects of the disclosure set forth herein. It should be understood that any aspect of the disclosure disclosed herein may be embodied by one or more elements of a claim.

Fig. 1A shows an example of early day's etching and hatching techniques which give an impression of tonal nuances.

Fig. 1B shows a typical photo of person and in Fig. 1C, a detail of the same photo printed with halftone raster according to a raster principle of variable dot size with identical center spacing between dots.

Fig. 9 shows that when the printing plate is engraved, the motive will stand up as tiny circular columns having various diameters. The upper view show such columns of different diameters seen from side (901), while the lower view show the same columns seen from above (902).

Large diameter results in dark areas, small diameter results in bright areas. Areas that are not to be printed are engraved into the disc so that they are physically lower than the subject. When printing ink (marked in light grey in Fig. 9 illustration 901) is applied, it makes contact with only the top of the columns.

Engraving techniques may include:

- Flexographic print plates made of rubber are engraved by photochemical processes characterized by: fast and low cost process, print plates can be produced within minutes.
- Metal print plates in competing printing techniques are engraved with wax and acid and are characterized by: time consuming and expensive process, delivery of print plates can take several days / weeks.

In digital context light-based colour systems are used, normally the RGB colour system. The RGB colour system consists of red, green and blue light, which can be mixed together to produce any colour value. A digital photo consists of red, green and blue light, and the sum of the mixing ratio forms the final photo, as shown in Fig. 6A. Other light-based colour systems as LAB also exists, but are rarely in use and therefore not described here.

Fig. 6B shows that to print a photo, colours must first be converted to CMYK colours, which is the standard pigment-based colour system used in print processes. Colours are split into separate colour channels corresponding to each print colour comprising for example: cyan, magenta, yellow and black (key colour).

The present invention is principally about raster screening. Existing raster techniques use one of two physical principles to reproduce different nuances:

Fig. 2A shows raster principle 1: AM-raster. Variable size of the dots with identical center spacing between the dots. Large dots give dark tonal nuances, small dots give light tonal nuances. This is the principle behind halftone raster.

Fig. 2B shows raster principle 2: FM-raster. Variable spacing between dots / pixels of identical size and shape. Short spacing gives dark tonal nuances, wide spacing provides light tonal nuances. Note that in order to clarify the basic difference between the two principles, circular dots are used in Fig. 2B as an example. FM raster is normally executed with square dots / pixels, as in Fig. 3C.

What is unique with the present invention is that BOTH these principles are combined to overcome the industrial problem of dot gain, printed only with ordinary halftone raster (AM), as exemplified in Fig. 2C.

Fig. 3A shows a typical AM halftone raster, which is the industry standard in printed context; it is used in most contexts involving colour photos and in most other contexts where tonal gradients are reproduced. Halftone raster is not relevant in digital context, including digital print, except as a pure graphic effect. Halftone raster is characterized by raster dots of variable sizes arranged with identical center distances. Large dots creates dark tonal nuances, small dots creates light tonal nuances. Circular dots are most common, other raster dot shapes are also available

such as elliptical or diamond shaped, but these are rarely in use. To reproduce a motive on print it must first be converted to halftone raster, this process is normally done by a repro provider. Dark and light tonal nuances are converted to circular dots of variable sizes, which are then transferred and engraved into print plates.

5 Fig. 3B shows a typical multi-bit motive, which is the industry standard for reproducing tonal nuances in digital context, such as digital photo, computer screen or TV. Multi-bit is characterized by square pixels (dots) placed in an exact square pattern, all pixels are the same size and are arranged edge-to-edge without space between. Tonal nuances are created by placing square pixels on top of each other
10 with variable density and colour. Multi-bit is named in different ways, depending on the number of layers of nuances that can be placed on top of each other in one stack, 8-bit, 16-bit, 32-bit, etc. The higher the numbers, the more colour nuances can be reproduced.

Fig. 3C shows a typical 1-bit binary bitmap FM halftone raster motive
15 consisting only of black and white without tonal nuances. 1-bit bitmap is characterized by black or white square pixels located in an imaginary square grid. Pixels are apparently randomly placed, but are actually placed in an exact square grid. All pixels has the same size, an illusion of nuances are created by variable spacing between each pixel. Each space has the shape and size of one pixel, either
20 black or white. In dark areas the distance between pixels are short; in light areas the distance is wide. Fig. 3C is a digital 1-bit binary version of Fig. 2B.

1-bit is useful in monocolour / non-tonal context to avoid rasterisation, and such ensure maximum sharpness and maximum colour density. Typical examples are text, lines and logotypes. 1-bit bitmap can also be useful to reproduce photos or
25 other elements containing tonal range, without other rasterisation. This is useful in certain situations to overcome limitations in printing process related to halftone raster. For example to achieve higher resolution than halftone raster can offer to ensure maximum sharpness on small details, or the need to reproduce photos or other tonal range in primitive printing techniques where halftone raster is not an
30 option. 1-bit bitmap has strict colour limitations, only 100% of each colour can be mixed, without nuances. 1-bit bitmap is therefore normally used for mono-colour motives, such as black and white photos. 1-bit bitmap is not suitable for multi-colour nuances, for example colour photos. 1-bit binary bitmap requires high effective resolution to prevent visible square pixels on print, 1200 dpi or higher are normally
35 used.

The raster in Fig. 3A - 3C are greatly enlarged to clarify the differences between the principles, the same figures are shown in real size in Fig. 4D. The way

the raster technologies of Fig. 3A – 3C are put together in the present invention provides additional means in the toolbox that provides improved control over the print result. The present invention combines 1-bit binary digital image FM raster technology with multi-bit tone digital image technology before applying an AM halftone raster, and forces the final AM raster dots to be skipped in an apparently random manner. This camouflages the optical impact of dot gain.

A further example is shown in Fig. 4A-4C, which illustrates how the present invention uses and combines these basic raster technologies.

Fig. 4A shows the starting point of the example with an image with multi-bit gray tone motive. Then a white 1-bit binary mask is placed on top of the multi-bit image as shown in Fig. 4B, where the remaining tonal nuances have their original value, that is, they are not 100% black as in a regular 1-bit bitmap image.

Fig. 4C shows the result in accordance to the present invention, where the image is rasterized with an AM halftone raster, where the pixels are converted to round dots, and the dots are apparently randomly spread. The illustration in Fig. 4C is a simulation of ordinary AM halftone raster. For technical reasons, digital simulation does not provide an accurate representation of the final printed raster dots, but the Fig. shows the principle. On final print, the raster dots will be precise and circular.

The examples shown in Fig. 5A - 5C are a further example of how the present invention improves image reproduction in, for example, flexographic printing context. Fig. 5A shows the original photo from the photographer; Fig. 5B shows the same photo printed in flexographic print process according to current industry standard. By processing the original image according to the present invention, results as shown in Fig. 5C are obtained. The photo is printed with standard halftone raster, and shows that the dot gain problem is camouflaged, and the final flexo print appears close to identical to the original photo.

Fig. 8 shows a typical printing process value chain. Such a process usually starts with a customer (801) specifying and assigning an assignment. Design agency (802) creates the basis for the print process, such as images and text compilation, while the repro provider (803) customizes the design and photo according to technical specifications of the current print technique, produces the physical print plates the chosen print provider (804) needs to perform final printing. The method according to present invention (805) may be performed as a final step in design process (802) or as first step in repro process (803).

Dot gain is a reality that cannot be eliminated with prior art technology. The present invention therefore does not remove dot gain, but creates an optical illusion that camouflages the impact of it. The present invention processes the motive in a manner that forces the final halftone raster dots to be skipped in an apparently random manner. This way, the best of two different physical raster principles, AM raster and FM raster, are combined into a new hybrid raster, performed only by use of ordinary AM halftone raster. The effect can remind of the principle behind stochastic raster, but are performed only with ordinary AM halftone raster.

When final treated digital file are converted to AM raster (halftone raster) to prepare for print, the AM raster are forced to skip dots randomly, the regularity characterised by AM raster break up in a way that does not reduce the visual qualities on final print. The present invention adds new features and qualities to AM raster which can be described as similar to stochastic raster, but without the downsides associated to this method.

The method of the present invention can be performed manually, but can be advantageously done in a modern digital tool.

The present invention may be utilized in a manual imaging process, but may advantageously be implemented using digital tools which assume that a digital imaging tool such as Adobe Photoshop, Serif Affinity Photo and ACDSee Pro 7, or equivalent is used.

The present invention utilizes known physical laws and principles from the science of light, colour, photography, digital imaging, reproduction and printing.

The uniqueness of the present invention is the way the principles are put together, and that the purpose of putting them together in this way is to solve a specific print-sensitive problem.

The present invention solves the problem of significant dot gain by controlling light and ink with high precision, using combinations of different masking and raster techniques. The present invention can be performed manually, but it will be very time consuming, costly and technically demanding. For practical reasons, the present invention is used as a modern digital tool.

Using digital tools means that all the sub processes of the present invention are built up in a time and cost effective manner.

Principles Forming the Basis of the Invention

The inventor has realized that it is possible to combine 1-bit binary digital image FM raster technology with multi-bit tone digital image technology before

applying an AM halftone raster, to force the final AM raster dots to be skipped in an apparently random manner. This camouflages the optical impact of dot gain.

Fig. 10A shows an exemplary grey tone image. This represents a source image for the process described herein.

5 In a single channel embodiment for a grey tone image, the image, called the source image, comprises an array of pixels, each pixel having a binary value that corresponds to the grey level. The value has a bit depth of typically 8 or 16 bits and thus take on a value of 0 – 255 or 0 – 65535 respectively. For this disclosure, 0 corresponds to completely black pixel and 255 is a white pixel with no ink.

10 Fig. 10B shows a dithered image generated from the grey tone source image of Fig. 10A. This dithered image comprises an array of same size and shape as the source image. Typically, this dithered image is a single bit binary image. The dithering can be based on random dithering or pseudo random dithering as known from prior art. Dithering can also comprise error diffusion.

15 For this exemplary embodiment, 0 corresponds to completely black pixel and 1 corresponds to a white pixel. A light grey area in the source image leads to few dark pixels (pixel value 0) and many light pixels (pixel value 1).

Fig. 10C shows the dithered image is used as a mask applied to the source image in order to mask out non-critical areas. In practice, this is done by forming an
20 output image having the same size and shape as the source image. Typically, the bit depth is also the same as for the source image. For each position in the output image, the pixel value is a result of the grey tone value in the source image and the pixel value in the dithered image. If the dithered pixel value is 0 the grey level in the source image pixel is copied to the output pixel. If the dithered pixel value is 1 a
25 maximum value corresponding to maximum white is copied to the output pixel.

Fig. 10D shows the result, hereafter referred to as the output image, of masking the source image of Fig. 10A with the dithered image of Fig. 10B.

This process results in large numbers of tiny dots in the flexographic printing plates being deleted, as shown in Fig. 10G.

30 Fig. 10E illustrates a standard halftone raster, typically an AM halftone raster, superimposed on the output image. For illustration purpose, the standard halftone raster is shown (in a greatly enlarged view) as an imaginary black mask showing through the output image.

Fig. 10F shows the footprint of the standard halftone raster onto the output
35 image. Behind the raster dots are different halftone values, which are also broken by white pixels. The total value / darkness behind each raster dots provides the basis

for the calculation of how large the raster dot is. If the sum falls below a given value or if no information at all, the raster dot will be deleted.

Fig. 10G shows the final halftone raster, suitable for print, consisting of 100% black / solid dots (shown greatly enlarged). The output image of the present invention has forced the halftone raster to delete dots in a random pattern. Thus, fractures occur in the array of raster dots at the brightest end of the tonal scale, meaning black dots are deleted in the array of raster dots, which in turn is perceived as a random pattern. The fractures in the series of raster dots make it possible to reproduce smooth transitions from dark to white in printing techniques where otherwise it is not possible, for example in flexo print and gravure print.

Fig. 11 shows an exemplary colour image. This represents a source image for the process described herein.

For colour images, the principle is similar, the difference being the colour images comprise more than one channel. Typical cases are Red, Green and Blue channels called RGB, or Cyan, Magenta, Yellow and Black, called CMYK, having 3 and 4 channels respectively. Other colour spaces exist.

The principle is substantially the same as for grey scale images wherein each layer is processed in turn. However, the masking can be performed in two different ways, either using a mask layer formed from the layer being processed and then the processed output for each layer combined at the end to form a new colour image, or creating one single mask layer to be applied to each colour channel in turn and then combining each layer at the end to form a new colour image.

In the first case, taking a CMYK image as an example, the image called the source image, comprises an array of pixels, each pixel having three binary values that corresponds to the red, green and blue colour channel levels respectively. The colour channel levels have bit depths of typically 8 or 16 bits and thus take on a value of 0 – 255 or 0 – 65535 respectively. For this exemplary embodiment, 0 corresponds to completely dark colour level and 255 is a maximum colour level.

Fig. 11 shows an exemplary separate colour channel image derived from the source image of Fig. 11. This represents a single colour with a brightness level in the range 0 – 255. This separate colour channel image comprises an array of same size and shape as the source image, thus having same width and height.

Fig. 11 shows a dithered image generated from said colour channel image of Fig. 11. This dithered image comprises an array of same size and shape as the source image, thus having same width and height. Typically, this dithered image is a single bit image. The dithering can be based on random dithering or pseudo random dithering as known from prior art. Dithering can also comprise error diffusion.

For this disclosure, 0 corresponds to completely black pixel and 1 corresponds to a bright pixel. A light area in the source image leads to few dark pixels (pixel value 0) and many light pixels (pixel value 1).

Next, the dithered image is used as a mask applied to the colour channel image in order to mask out non-critical light areas. In practice, this is done by forming an output colour channel image having the same size and shape as the source image. Typically, the bit depth is also the same as for the source image. For each position in the output image, the pixel value is a result of the brightness level in the colour channel image and the pixel value in the dithered image. If the dithered pixel value is 0 the brightness level in the colour channel image pixel is copied to the output pixel. If the dithered pixel value is 1 a maximum value corresponding to maximum white is copied to the output pixel.

Fig. 11 shows the result of masking the colour channel image of Fig. 11 with the dithered image of Fig. 11.

This then is performed for the red, green and blue colour channel images and the respective output colour channel images are then combined to the output colour image.

When an AM raster is applied, this process results in large numbers of tiny dots in the flexographic printing plates being deleted.

Surprisingly the visual appearance if the output colour image is very close to the source image even though the three masks are normally all different.

In an alternative to colour channel specific mask layers, or dithered images, a global dithered layer for masking can be generated. This dithered image can be extracted using any one of the channels. A brightness image is typically generated using a mathematical processing of the input channels and the brightness image should therefore have sufficient bit depth compared to the inputs to avoid rounding errors. So if the input has three or four channels, where each value has a bit depth of typically 8 or 16 bits, the brightness image can have a bit depth of typically 16 or 24 bits and thus take on a value of 0 – 65535 or 0 – 16777215 respectively. For this disclosure, 0 corresponds to completely black pixel and 65535 is a white pixel with no ink.

Next, a dithered image is generated from said brightness image. This dithered image comprises an array of same size and shape as the source image. Typically, this dithered image is a single bit image. The dithering can be based on random dithering or pseudo random dithering as know known from prior art. Dithering can also comprise error diffusion.

For this exemplary embodiment, 0 corresponds to completely black pixel and 1 corresponds to a bright pixel. A light area in the source image leads to few dark pixels (pixel value 0) and many light pixels (pixel value 1).

Next, the dithered image is applied as white pixels to each of the separate colour channel images in order to mask out non-critical light areas. In practice, this is done by forming each separate output colour channel image having the same size and shape as the source image. Typically, the bit depth is also the same as for the source image. For each position in the output image, the pixel value is a result of the brightness level in the source image and the pixel value in the dithered image. If the dithered pixel value is 0 the brightness level in the colour channel image pixel is copied to the output pixel. If the dithered pixel value is 1 a maximum value corresponding to maximum white is copied to the output pixel.

When AM raster is applied, this process results in large numbers of tiny dots in the flexographic printing plates being deleted.

Each of the separate output colour channel images are then combined to a final output colour image.

Fig. 11 summarises the above wherein a multi-tone, single or multi-channel motive, where each channel is sent to a separate box shown in dashed line. Within each box each channel is used to form a dithered FM (frequency modulated) mask. The multi-tone channel is then completed by adding the FM modulated white pixels. Each channel in the motive is processed the same way, For multichannel motive each channel are combined into a final motive. Note that the FM dithered white pixels can be formed entering the boxes, either from the global motive or from individual channels.

It will be appreciated that for printing processes the output can be separate colour channel images rather than a combined colour image. The output is typically used to generate printing plates, in particular flexographic printing plates.

The method can be applied to both single and multi-colour motives:

Approach:

- 1) Digital multi-bits grayscale motive
- 2) Duplicate of multi-bit grayscale motive is converted to a binary FM raster
- 3) Multi-bits grayscale motive (1) is combined with FM raster motive (2), by adding white pixels from binary FM raster motive in the grayscale motive. This can be done via a separate mask or other suitable way.

Method of operation:

When the subject is reshaped to AM raster (halftone raster) when preparing for print, the AM raster will be forced to behave in a new way that solves the global industrial problem. White pixels from FM raster force the AM raster to exclude raster points in a random pattern, the regularity of the halftone raster is broken. The method adds to the AM raster to the positive properties of FM raster and stochastic raster, without the negative attributes associated with these methods. The method creates a random spreading effect only by using ordinary halftone (AM) raster. In practice, it combines the best AM raster, FM raster and stochastic raster combines in a new hybrid raster.

Purpose:

On final print, an optical illusion occurs which eliminates the visual effect of dot gain.

Bests Modes of Carrying out the Invention

Presently it appears that the best process is to use dithered mask layers generated for each separate channel as opposed to using a global mask layer.

For printing processes, the CMYK colour model is clearly preferred.

Alternatives Embodiments

It has been found that flexographic printing plates processed from present invention lasts significant longer. Research show that print plates used for repeated large volume productions show no damage or tear or wear at all, which is not normal. It has been found that the reason for this is that smallest dot on print plates processed with present invention has up to triple diameter of normal, which leads to significant more mechanical strength. In use the difference between traditional method and the present invention is not apparent for the viewer of the end products.

It has been found that for digital monitors; such as TV, screen computers and monitors; a process as described herein can also be applied to RGB images. This helps in overcoming technical shortcomings in projectors and again provides projected images with no apparent degradation.

While the method described lends itself well to automation it can also be undertaken using image editing tools, preferably based on editable layers.

Industrial Applicability

The method finds its use in preparation for printing processes, typically processes using flexographic printing plates.

Claims

1. A method for compensating for dot gain in a single channel image comprising:
receiving a source image, in the form a grey tone image, comprises an array
5 of pixels, wherein each pixel having a binary value that corresponds to a grey level;
generating a dithered image from said grey tone image wherein said dithered
image comprises an array of same size and shape as the source image, wherein
each pixel having a single bit binary value that corresponds to a dithered grey level;
forming an output image having the same size and shape as the source
10 image by applying the dithered image as a mask to the source image;
wherein if a pixel value in the dithered image is 0 the grey level in the source
image pixel is copied to a corresponding pixel in the output image;
wherein if a pixel value in the dithered image is 1 a maximum value
corresponding to maximum white is copied to a corresponding pixel in the output
15 image;
wherein a halftone raster is applied to the output image; and
wherein the output image is used to make a printing plate.
2. A method for compensating for dot gain in a multi-channel image comprising:
20 receiving a source image, comprises a plurality of channel images, each
channel comprising an array of pixels, wherein each pixel having a binary value that
corresponds to a brightness level;
generating a dithered image from at least part of a channel image wherein
said dithered image comprises an array of same size and shape as the source
25 image, wherein each pixel having a single bit binary value that corresponds to a
brightness level of the channel image, where 0 is dark and 1 is maximum brightness;
forming an output image channel having the same size and shape as the
channel image by applying the dithered image as a mask to the channel image;
wherein if a pixel value in the dithered image is 0 the brightness level in the
30 channel image pixel is copied to a corresponding pixel in the output channel image;

wherein if a pixel value in the dithered image is 1 a maximum value corresponding to maximum brightness level is copied to a corresponding pixel in the output channel image;

wherein a halftone raster is applied to the output image; and

5 wherein the output channel images are used to make a printing plate.

3. The method according to claim 2, wherein the dithered image is generated separately from each channel and applied as a mask to each respective output channel image.

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4. The method according to claim 2, wherein the dithered image is generated from at least one channel and applied as a mask to all output channel image.

5. The method according to claim 4, wherein the dithered image represents a
15 weighted brightness of the at least one channel.

20

25



Fig. 1A



Fig. 1B

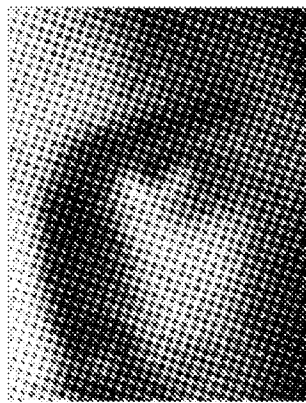


Fig. 1C

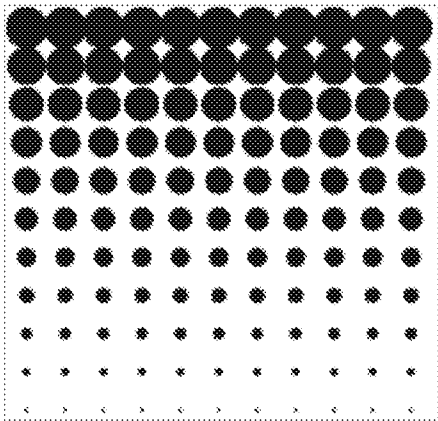


Fig. 2A

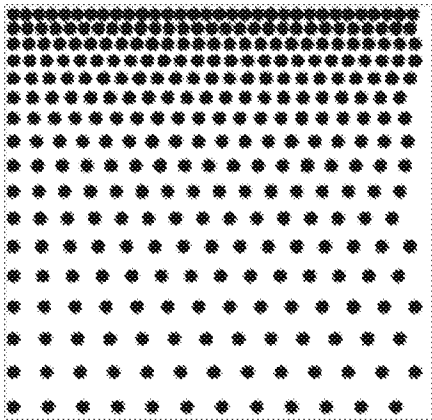


Fig. 2B

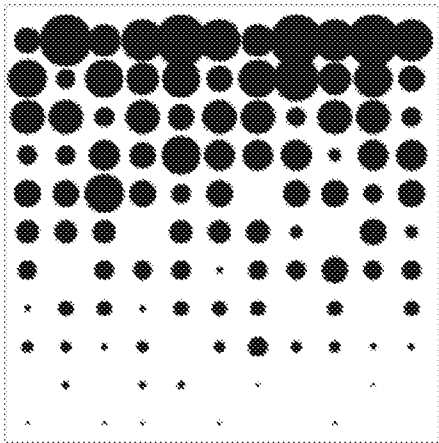


Fig. 2C

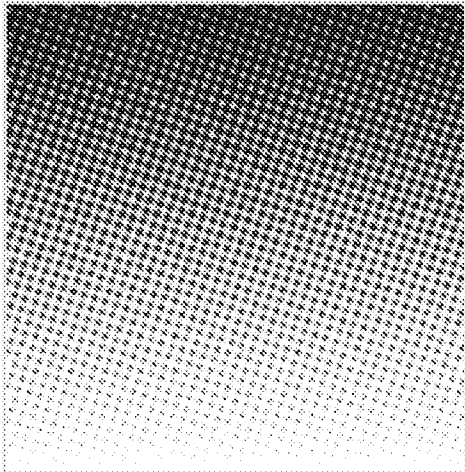


Fig. 3A

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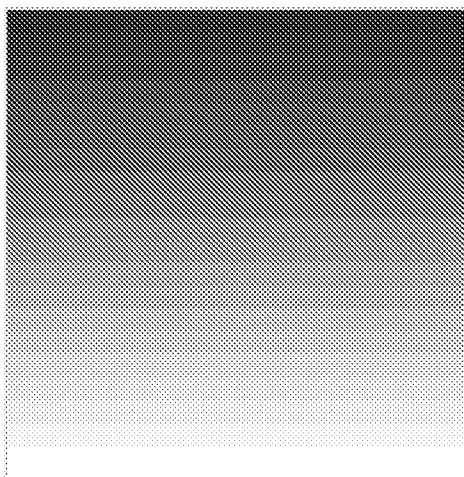


Fig. 3B

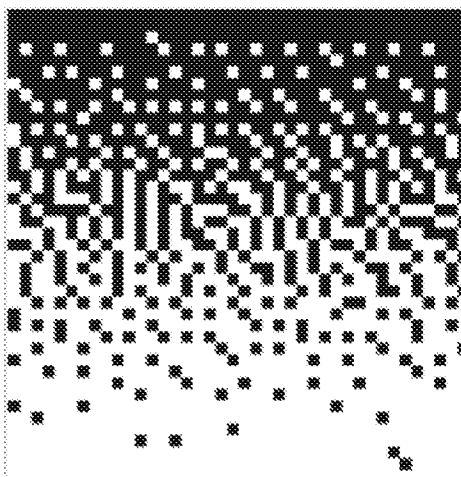


Fig. 3C

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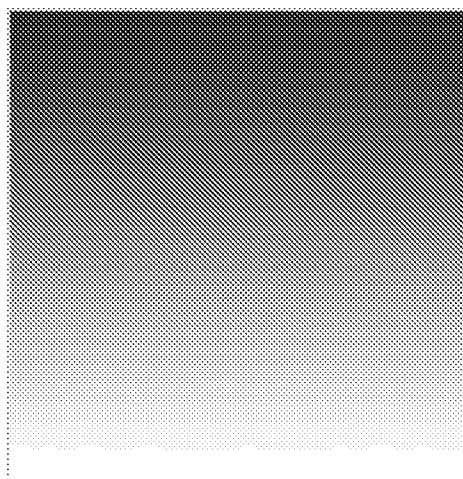


Fig. 4A

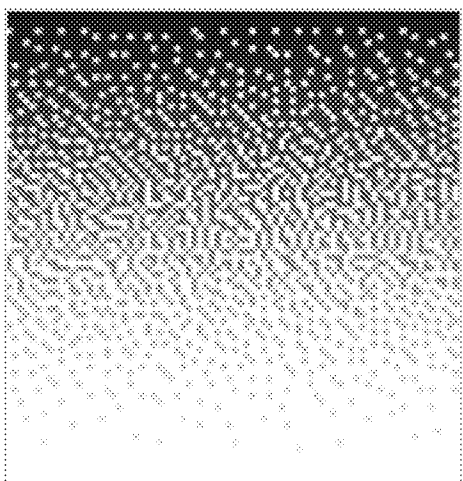


Fig. 4B

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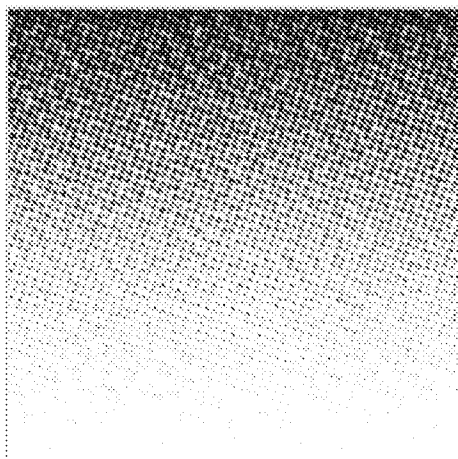


Fig. 4C



Fig. 4D



Fig. 5A



Fig. 5B

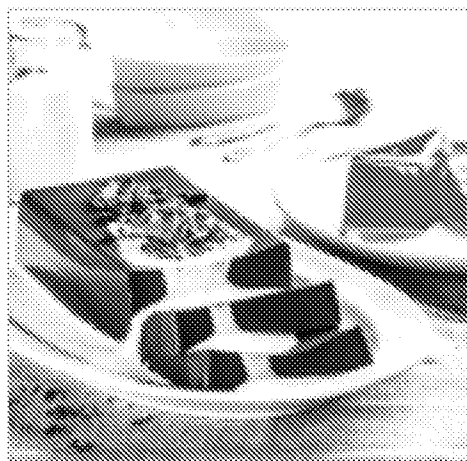


Fig. 5C

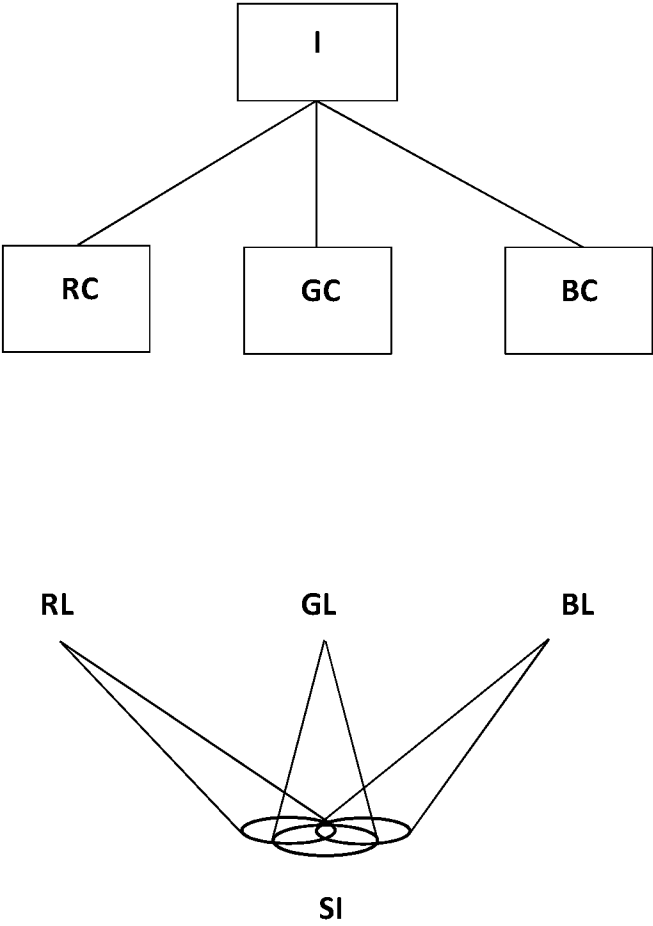


Fig. 6A

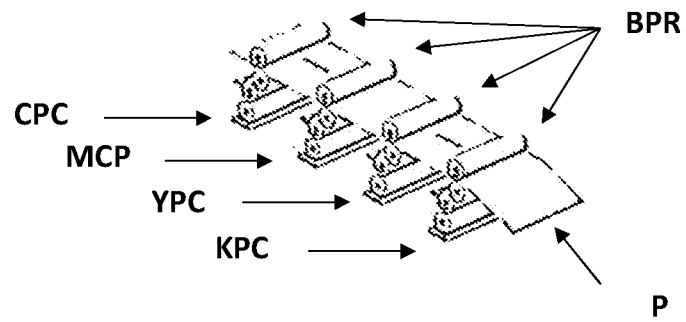
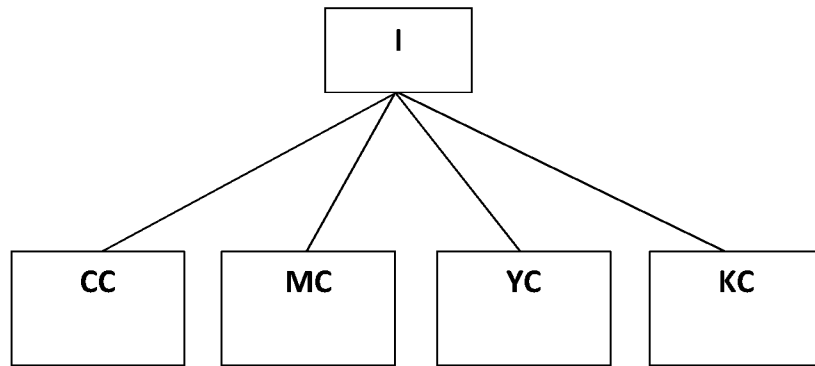


Fig. 6B

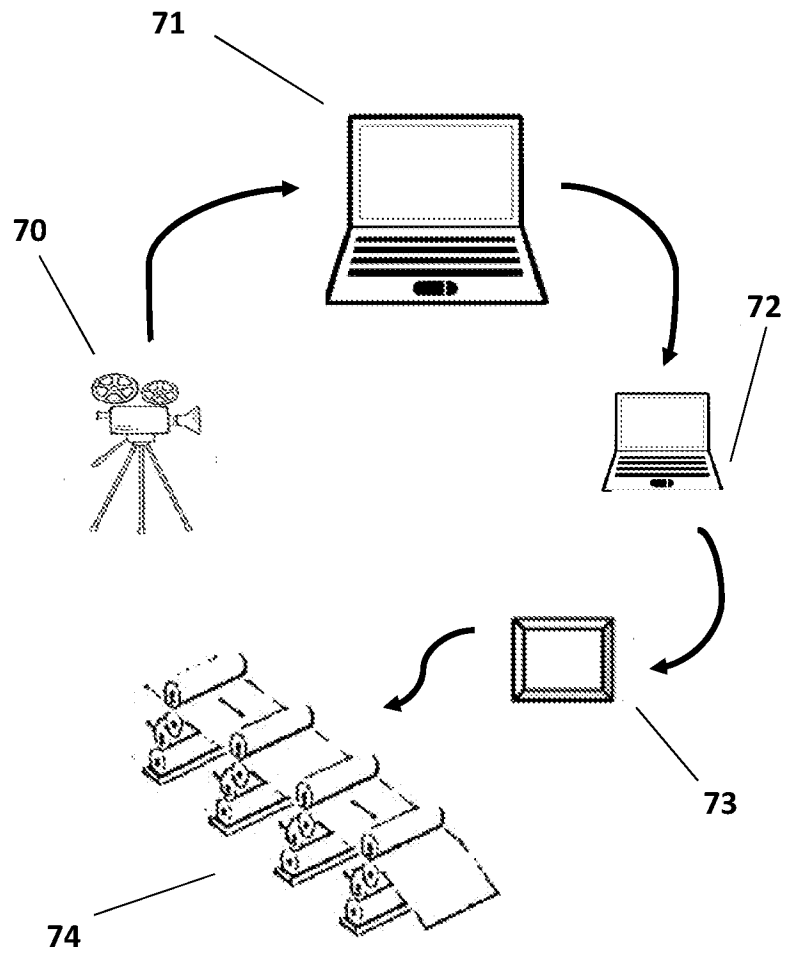


Fig. 7

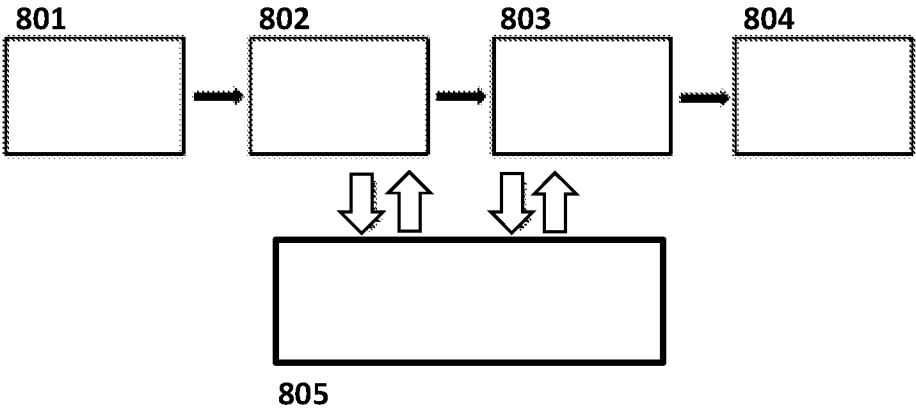


Fig. 8

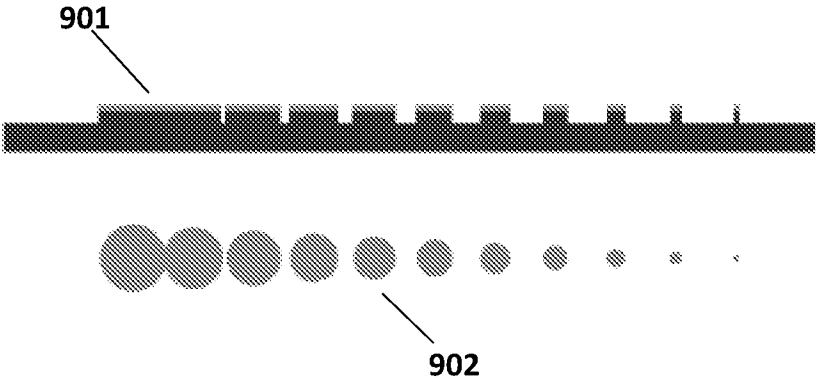


Fig. 9

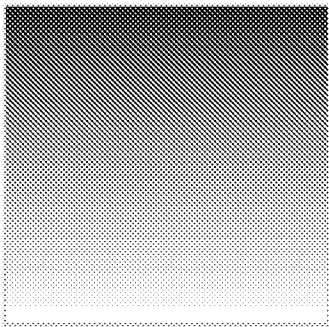


Fig. 10A

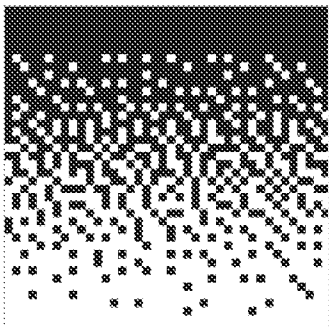


Fig. 10B

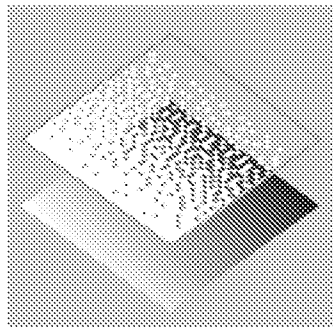


Fig. 10C

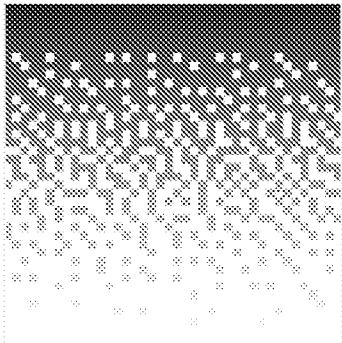


Fig. 10D

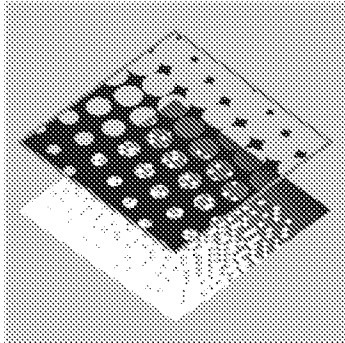


Fig. 10E

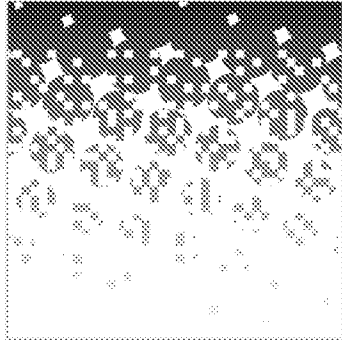


Fig. 10F

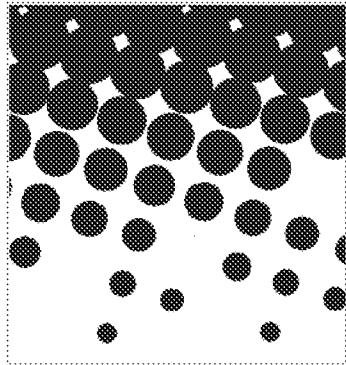


Fig. 10G

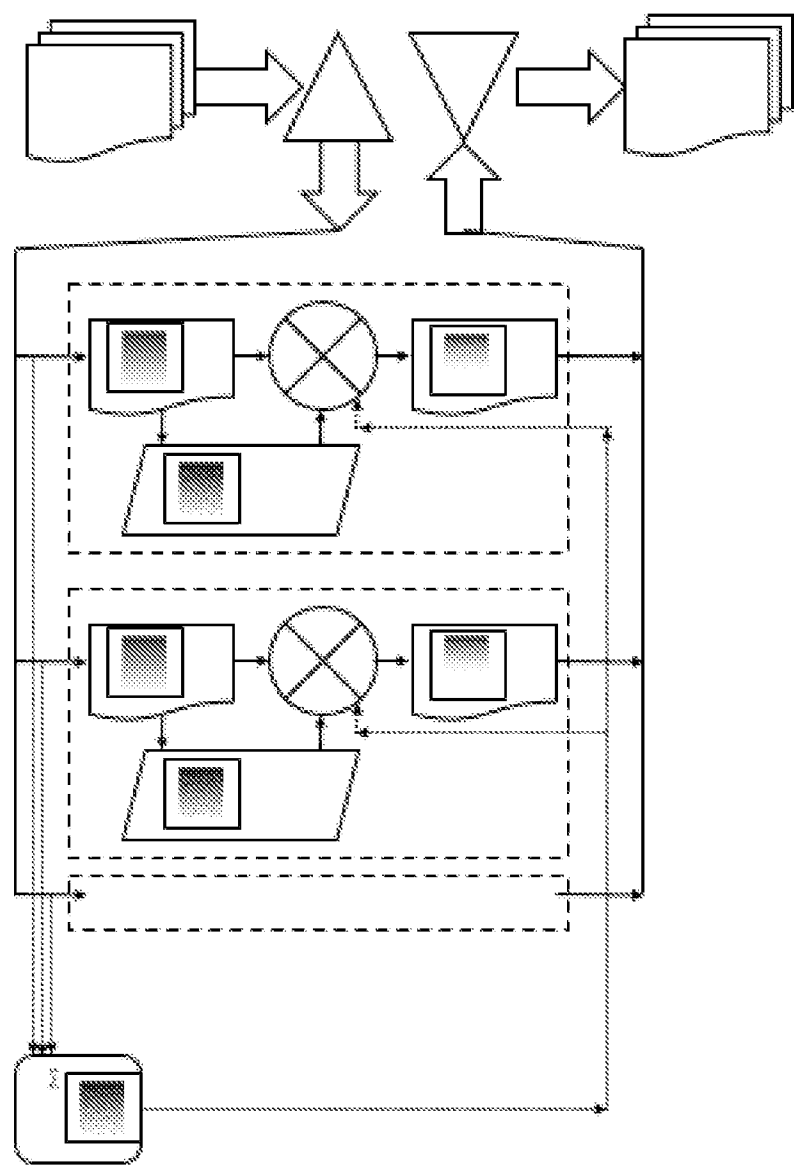


Fig. 11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO2019/050159

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: B41M, G06K, H04N

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20040218221 A1 (HIRANO MASANORI ET AL), 4 November 2004 (2004-11-04); whole document --	1-5
A	US 5568572 A (SHU JOSEPH S), 22 October 1996 (1996-10-22); whole document --	1-5
A	US 20070121137 A1 (KAKUTANI TOSHIAKI), 31 May 2007 (2007-05-31); whole document --	1-5
D, A	US 5892588 A (SAMWORTH MARK R), 6 April 1999 (1999-04-06); whole document --	1-5

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"D" document cited by the applicant in the international application	"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
"E" earlier application or patent but published on or after the international filing date	"&" document member of the same patent family
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	
"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	

Date of the actual completion of the international search

12-11-2019

Date of mailing of the international search report

12-11-2019

Name and mailing address of the ISA/SE

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO2019/050159

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DANIEL L LAU; GONZALO R ARCE; NEAL C GALLAGHER, "Green-Noise Digital Halftoning", PROCEEDINGS OF THE IEEE, 19981201, IEEE, NEW YORK, US, (1998-12-01), ISSN 0018-9219, VOL 86, NR 12; whole document -- -----	1-5

Continuation of: second sheet

International Patent Classification (IPC)

H04N 1/405 (2006.01)

G06K 15/00 (2006.01)

B41M 1/04 (2006.01)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/NO2019/050159

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			EP	1433307 A4	02/05/2007
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US	20070121137 A1	31/05/2007	JP	2007142848 A	07/06/2007
			JP	4534963 B2	01/09/2010
			US	7957031 B2	07/06/2011
US	5892588 A	06/04/1999	NONE		