

## Description

This invention relates to a method for increasing the throughput of a scanning head printer.

### Background Art

Scanning head printers are printers wherein a printhead moves across a page one line at a time. For example, a printhead may scan from left to right or right to left across a page, printing as it advances.

A printhead is the part of a printer which causes an image to be imprinted on the page. Often, a printhead includes a vertical array of print elements which form dots on a page. Different images are printed by different print elements being fired at different times and in different locations. Each element is capable of printing one row of dots across the page.

If the vertical dimension of the image to be printed is less than the vertical height of the printhead, then the image can be printed in one printhead pass. An example of such an image includes 9- to 12-point text characters, when printed by a 1/6th-inch high printhead. However, images to be printed are often bigger than the printhead, especially when printing computer graphics. Accordingly, the printer may print part of the image in one pass of the printhead and the remaining part in subsequent passes.

When images are printed in more than one pass of the printhead, the problem of print misregistration may occur. Print misregistration is a misalignment of dots resulting in poor print quality. It is caused by printing two vertically adjacent dots in different passes of the printhead moving in opposite directions. Misregistration is caused by a backlash from the changed motion of the printhead.

By printing unidirectionally, print misregistration is avoided, but printer speed is limited. Accordingly, scanning head printers generally print small images such as text characters which are smaller than or equal to the height of the printhead bidirectionally, and larger text characters and graphics unidirectionally. Alternatively, to maintain print quality, all images may be printed unidirectionally.

In short, the throughput of a scanning head printer is generally decreased when large images or graphics are printed, because unidirectional printing is necessary to maintain print quality.

The problem to be remedied by the present invention is to increase the throughput, i.e. the printing speed, of a scanning head printer. This problem is accomplished by claim 1.

The method steps of the present invention increase the throughput of a scanning head printer by controlling the steps of the printer in a manner

that, under proper circumstances, allows some graphic images to be printed bidirectionally.

### Disclosure of the Invention

The invented bidirectional graphics printing method includes software which first receives data describing at least part of an image to be printed, and then looks for vertical breaks in the image. If a break is detected, bidirectional printing is allowed. If no break is detected, the next printhead pass is in the same direction as the previous pass.

### Brief Description of the Drawings

Figure 1 is a block diagram outlining the invented method.

Figures 2A and 2B are enlarged images of the number "5" printed in two passes of a scanning printhead, Figure 2A showing the alignment of dots when both passes of the printhead are in the same direction, and Figure 2B showing vertical misalignment caused by bidirectional printing.

Figures 3A-D depict examples of how graphics images could be printed with a scanning head printer, Figures 3A and 3C illustrating conventional unidirectional printing, and Figures 3B and 3D illustrating accurate bidirectional printing made possible by the method of the present invention.

### Best Mode for Carrying Out the Invention

Figure 1 shows generally at 10 a block diagram outlining the steps of the invented method. Initially, a printer receives data defining part of the image to be printed, such step being symbolized by block 12. The received data should be sufficient to define a part of the image at least as high as the printhead.

The received data may be any data conveyed on a graphics-bit-map format, including text. When a page of text is conveyed on such a format, the invented method may allow bidirectional printing and thereby increase printer throughput.

Received data is then scanned to determine whether there are any breaks in the image. A break is a vertical separation of at least one blank dot row between elements of the image. For example, in a printhead with fifty print elements arranged vertically, each element is capable of printing one row or dots. If the image is such that one element is not required to print any dots in the row, then there is a break in the image. Block 14 signifies the step of finding such dot-row breaks.

If desired, the software can be programmed to perform a second scan of the data, the choice being shown by step 16, and the scan being shown by block 18. A second scan finds vertical alignment

breaks in the image by determining whether two consecutive dot-rows of the image have any dots in near vertical alignment. In other words, for every dot in the first row, there must not be a dot directly under it, or at a 45-degree angle relative to it, in the next row. If that test is met, the software identifies a break between the rows. However, this second scan is time consuming and detects only a small number of breaks. Accordingly, the second scan may be deleted from the invented method or a user may choose not to run the second scan. Put another way, with "second-scan" action not to be employed, Figure 1 can be re-viewed with blocks 16, 18 missing, and with process flow indicated by an arrow extending down from block 14 to the block (20) immediately below block 16.

In either case, the next step 20 is to determine whether time is minimized by printing a whole printhead height of data unidirectionally, or by printing less than a whole printhead height of data and then allowing bidirectional printing.

Experimentation has shown that time is minimized by printing a whole printhead height of data unidirectionally when there are no breaks in the image at or beyond 3/4 of the printhead height. If a break appears beyond 3/4 of the printhead height, time is minimized by printing the smaller band of data up to the break, and by then allowing the next printhead pass to be printed in either direction.

For example, in a printhead having a height of fifty nozzles, each nozzle capable of printing one row of dots, if nozzle thirty-seven (counting the nozzles from the top of the printhead down) is not required to print any dots, then a break appears in row thirty-seven. Time would be minimized by printing the image up to the break, and by then allowing for bidirectional printing.

In this example, row thirty-seven is the row at 3/4 of the printhead height. Similarly, this analysis applies to any break detected in rows thirty-seven through fifty. Accordingly, step 20 determines where the breaks occur in relation to the printhead height.

Because the 3/4 printhead height dimension was found to work well in certain applications, it is explained herein. However, the dimension is not mandatory and may be changed for other applications.

If a dashed-line is oriented vertically on a page, step will recognize the breaks in the dashed-line beyond 3/4 of the printhead height. In such a case, if bidirectional printing is allowed, the dashed-line may not be straight. Accordingly, step 21 determines whether there is more than one solid image within the printhead height.

A solid image is one without breaks. In a 50-print element printhead, if rows two through fifty all print, then there is one solid image. If there is a

break at row thirty-eight, then rows two through thirty-seven constitute one solid image and rows thirty-nine through fifty constitute a second solid image. The break at row thirty-eight, between the two solid images, is a solid image break.

If, as determined at step 21, two or more solid images appear within the printhead height, then the method proceeds to block 28. If only one solid image appears within the printhead height, then the method proceeds to block 22.

Step 21 is useful when text may be confused with vertical dashed lines. If desired, step 21 may be deleted from the invented method, and Figure 1 viewed as proceeding directly from step 20 to either step 22 or 28.

If the software has detected breaks at or beyond 3/4 of the printhead height, and, if applicable, only one solid image appears within the printhead height, then the printer will print, the portion of the image corresponding to the height of the printhead up to the detected break, and will allow the next pass to be printed in either direction, as symbolized by box 22. In this case, the elements in the printhead below the break in the image will not print dots. If step 21 is deleted and several breaks exist beyond 3/4 of the printhead height, only the image up to the first break is printed.

Step 24 then determines whether the printing task is complete. If not, further data defining the image to be printed is collected, and the dot row immediately beneath the previously detected break now becomes the top row. The process then repeats until printing is complete, at which time the method ends as shown in step 26.

If no breaks appear at or beyond 3/4 of the printhead height, or, if applicable, more than one solid image appears within the printhead height, the invented method prints a part of the image equal to the height of the entire printhead, and requires that the next pass be printed in the same direction, as illustrated by block 28.

The software next determines whether printing is complete, as shown in step 24. If not, the data defining the next part of the image is collected, and the process is repeated. If printing is complete, the task is ended as shown by box 26.

Figures 2A and 2B, by comparison, illustrate possible dot misalignment caused by bidirectional printing. Specifically, Figure 2A is an enlarged view of the number "5" printed by a scanning head printer in two unidirectional passes of a printhead. Figure 2A shows the proper alignment between dots 40, 42.

Figure 2B shows the same image printed bidirectionally, or in passes of the printhead moving in different directions. The vertical offset between dots 44, 46, which correspond, in relative positions, to dots 40, 42, respectively in Fig. 2A,

illustrates the misalignment problems connected with printing large characters and graphics images unidirectionally. Such misalignment, when noticeable, results in poor print quality. Noticeable misalignment is an offset between dots which does not result in the desired, predetermined quality of output.

Figures 3A and 3B depict how graphic images could be printed with a scanning head printer. In Figure 3A, rectangles 64a-c depict different passes of a printhead, all printed unidirectionally from left to right. The height of the printhead corresponds to the height of the rectangles, and is shown at 66. It is evident that the height 68 of each image to be printed is less than printhead height 66. Additionally, vertical breaks in the image are shown at 70a-c.

Figure 3B shows the same image printed according to the invented method. Rectangles 72a-d illustrate different passes of the printhead. The difference between Figure 3A and Figure 3B is that Figure 3B was printed bidirectionally. Rectangle 72a was printed left to right, then rectangle 72b was printed right to left, and so on. The invented method detected breaks 74a-c in the image, printed less than a full printhead height of the image, and allowed bidirectional printing.

Figure 3C depicts graphics images printed in four unidirectional passes of a printhead. Rectangles 76a-d represent such passes. Again, the height of the printhead corresponds to the height of the rectangles and is shown at 78.

Figure 3D shows the same images as in Figure 3C printed according to the invented method. Rectangles 80a-d illustrate different passes of the printhead. Rectangle 80a was printed left to right, no break was detected beyond 3/4 of the printhead height, and therefore rectangle 80b was also printed left to right.

When the data defining the image contained in rectangle 80b was scanned, break 82 was found. Accordingly, only the portion of the image corresponding to the height of the printhead up to the detected break was printed, resulting in rectangle 80b having a smaller vertical dimension than rectangle 80a.

Because of break 82, bidirectional printing was allowed, and rectangle 80c was printed right to left. In scanning the data defining the image within rectangle 80c, break 84 was detected. Accordingly, rectangle 80c printed only the part of the image up to break 84. Bidirectional printing was allowed because of the break, and rectangle 80d was printed left to right.

A simple model of the time ("T") required to print Figures 3A-D is calculated as follows, assuming that the non-printing slew speed of the printhead is twice as fast as the printing speed:

Figure 3A: (3 passes at time T) + (3 printhead returns at time 0.5T) = 4.5T

Figure 3B: (4 passes at time T) = 4T

Figure 3C: (4 passes at time T) + (4 printhead returns at time 0.5T) = 6T

Figure 3D: (4 passes at time T) + (1 printhead return at time 0.5T) = 4.5T

As shown, the invented bidirectional graphics printing method printed faster without any degradation in print quality.

#### Industrial Applicability

The invented bidirectional graphics printing method is applicable to any scanning head printer. Its application increases the throughput of such a printer by allowing graphics to be printed bidirectionally when doing so would not degrade print quality.

While the best mode or preferred embodiment of the invention has been described herein, variations and changes may be made without departing from the scope of the claims.

#### Claims

1. A method for increasing the throughput of a scanning-head printer having a print head with a vertical array of print elements adapted to print images which cannot be printed completely in one printing pass, comprising: receiving (12) data defining at least part of an image to be printed; analyzing such received data to determine when printing in opposite directions could cause noticeable print misregistration between vertically adjacent parts of the image; a second printing pass in a direction opposite to that of the first printing pass if there are vertical alignment breaks or solid breaks in the image to be printed whereas the second printing pass is performed in the same direction as the first printing pass if there are no such breaks.
2. The method of claim 1, wherein the step of analyzing includes detecting dot-row or vertical alignment breaks (14,18) between vertically adjacent parts of the image.
3. The method of claim 2, wherein the step of printing includes printing passes of the image unidirectionally (28) when no such breaks are detected, and printing passes of the image bidirectionally (22) when there are such breaks.

illustrates the misalignment problems connected with printing large characters and graphics images unidirectionally. Such misalignment, when noticeable, results in poor print quality. Noticeable misalignment is an offset between dots which does not result in the desired, predetermined quality of output.

Figures 3A and 3B depict how graphic images could be printed with a scanning head printer. In Figure 3A, rectangles 64a-c depict different passes of a printhead, all printed unidirectionally from left to right. The height of the printhead corresponds to the height of the rectangles, and is shown at 66. It is evident that the height 68 of each image to be printed is less than printhead height 66. Additionally, vertical breaks in the image are shown at 70a-c.

Figure 3B shows the same image printed according to the invented method. Rectangles 72a-d illustrate different passes of the printhead. The difference between Figure 3A and Figure 3B is that Figure 3B was printed bidirectionally. Rectangle 72a was printed left to right, then rectangle 72b was printed right to left, and so on. The invented method detected breaks 74a-c in the image, printed less than a full printhead height of the image, and allowed bidirectional printing.

Figure 3C depicts graphics images printed in four unidirectional passes of a printhead. Rectangles 76a-d represent such passes. Again, the height of the printhead corresponds to the height of the rectangles and is shown at 78.

Figure 3D shows the same images as in Figure 3C printed according to the invented method. Rectangles 80a-d illustrate different passes of the printhead. Rectangle 80a was printed left to right, no break was detected beyond 3/4 of the printhead height, and therefore rectangle 80b was also printed left to right.

When the data defining the image contained in rectangle 80b was scanned, break 82 was found. Accordingly, only the portion of the image corresponding to the height of the printhead up to the detected break was printed, resulting in rectangle 80b having a smaller vertical dimension than rectangle 80a.

Because of break 82, bidirectional printing was allowed, and rectangle 80c was printed right to left. In scanning the data defining the image within rectangle 80c, break 84 was detected. Accordingly, rectangle 80c printed only the part of the image up to break 84. Bidirectional printing was allowed because of the break, and rectangle 80d was printed left to right.

A simple model of the time ("T") required to print Figures 3A-D is calculated as follows, assuming that the non-printing slew speed of the printhead is twice as fast as the printing speed:

Figure 3A:  $(3 \text{ passes at time } T) + (3 \text{ printhead returns at time } 0.5T) = 4.5T$

Figure 3B:  $(4 \text{ passes at time } T) = 4T$

Figure 3C:  $(4 \text{ passes at time } T) + (4 \text{ printhead returns at time } 0.5T) = 6T$

Figure 3D:  $(4 \text{ passes at time } T) + (1 \text{ printhead return at time } 0.5T) = 4.5T$

As shown, the invented bidirectional graphics printing method printed faster without any degradation in print quality.

#### Industrial Applicability

The invented bidirectional graphics printing method is applicable to any scanning head printer. Its application increases the throughput of such a printer by allowing graphics to be printed bidirectionally when doing so would not degrade print quality.

While the best mode or preferred embodiment of the invention has been described herein, variations and changes may be made without departing from the scope of the claims.

#### Claims

1. A method for increasing the throughput of a scanning-head printer having a print head with a vertical array of print elements adapted to print images which cannot be printed completely in one printing pass, comprising: receiving (12) data defining at least part of an image to be printed; analyzing such received data to determine when printing in opposite directions could cause noticeable print misregistration between vertically adjacent parts of the image; a second printing pass in a direction opposite to that of the first printing pass if there are vertical alignment breaks or solid breaks in the image to be printed whereas the second printing pass is performed in the same direction as the first printing pass if there are no such breaks.
2. The method of claim 1, wherein the step of analyzing includes detecting dot-row or vertical alignment breaks (14,18) between vertically adjacent parts of the image.
3. The method of claim 2, wherein the step of printing includes printing passes of the image unidirectionally (28) when no such breaks are detected, and printing passes of the image bidirectionally (22) when there are such breaks.



4. The method of claim 1, wherein the step of analyzing includes detecting (21) solid image breaks within each printhead pass of the image. 5
5. The method of claim 4, wherein the step of printing includes printing (22) the passes of the image which immediately follow the passes in which no more than one such break is detected bidirectionally, and printing (28) other passes of the image unidirectionally. 10
6. The method of claim 1, wherein the step of analyzing includes detecting dot-row breaks (14) between vertically adjacent parts of the image, and detecting solid image breaks (21) within each printhead pass of the image. 15
7. The method of claim 6, wherein the step of printing further includes printing (22) the passes of the image which immediately follow the passes in which such dot-row breaks are detected, and no more than one such solid image break is detected, bidirectionally, and printing (28) other passes of the image unidirectionally. 20
8. A method according to one of claims 1 to 7 wherein each print element is capable of printing a row of dots comprising:
  - analyzing (14,18) such received data to detect any dot-row breaks; 25
  - determining (20) the location of such dot-row breaks in relation to the printhead height;
  - detecting solid image breaks (21) within each printhead pass of the image; 30
  - printing (28) the entire print pass and requiring the next print pass to be printed in the same direction as the previous print pass if no such dot-row breaks occur in the dot rows at or beyond 3/4 of the printhead height, or if more than one solid image break was detected within the previous print pass; and 35
  - printing (22) the dot rows up to the break only and allowing the next print pass to be printed in the opposite direction from the previous print pass if a break occurs at or beyond 3/4 of the printhead height and no more than one solid image break was detected within the previous print pass. 40

#### Patentansprüche

1. Verfahren zum Erhöhen des Durchsatzes eines Abtastkopf-Druckers, der einen Druckkopf mit einer vertikalen Anordnung von Druckelementen aufweist, welche Bilder drucken können, die in einem Druckdurchgang nicht vollständig 55

gedruckt werden können, mit den Verfahrensschritten:

Empfangen (12) von Daten, welche mindestens einen Teil eines zu druckenden Bildes definieren, Analysieren dieser empfangenen Daten, um zu bestimmen, wann das Drucken in entgegengesetzten Richtungen eine merkliche Druck-Fehljustierung zwischen vertikal benachbarten Teilen des Bildes bewirken kann, Ausführen eines zweiten Druckdurchgangs in einer zu der Richtung des ersten Druckdurchgangs entgegengesetzten Richtung, wenn vertikale Unterbrechungen der Ausrichtung oder durchgehende Unterbrechungen in dem zu druckenden Bild existieren, wobei der zweite Druckdurchgang in derselben Richtung wie der erste Druckdurchgang ausgeführt wird, wenn es keine solchen Unterbrechungen gibt.

2. Verfahren nach Anspruch 1, bei dem der Analyseschritt das Erfassen von Unterbrechungen (14, 18) von Punktreihen oder Unterbrechungen der vertikalen Ausrichtung zwischen vertikal benachbarten Teilen des Bildes umfaßt.
3. Verfahren nach Anspruch 2, bei dem beim Druckschritt Bilddurchgänge in einer Richtung (28) gedruckt werden, wenn keine solche Unterbrechungen erfaßt werden, und Bilddurchgänge in zwei Richtungen (22) gedruckt werden, wenn solche Unterbrechungen vorhanden sind.
4. Verfahren nach Anspruch 1, bei dem beim Analyseschritt durchgehende Bildunterbrechungen innerhalb jedes Druckkopf-Bilddurchganges erfaßt werden (21).
5. Verfahren nach Anspruch 4, bei dem beim Druckschritt solche Bilddurchgänge, die den Durchgängen, bei welchen nicht mehr als eine solche Unterbrechung erfaßt wurde, unmittelbar folgen, bidirektional gedruckt werden (22), und andere Bilddurchgänge unidirektional gedruckt werden (28).
6. Verfahren nach Anspruch 1, bei dem beim Analyseschritt Punktreihenunterbrechungen (14) zwischen vertikal benachbarten Teilen des Bildes und durchgehende Bildunterbrechungen (21) innerhalb jedes Druckkopf-Bilddurchganges erfaßt werden.

7. Verfahren nach Anspruch 6, bei dem beim Druckschritt ferner die Bilddurchgänge, welche unmittelbar auf Durchgänge folgen, in denen keine solchen Punktreihenunterbrechungen und nicht mehr als eine solche durchgehende



Bildunterbrechung erfaßt wurden, in einer Richtung gedruckt werden (22), und die anderen Bilddurchgänge in zwei Richtungen gedruckt werden (28).

8. Verfahren nach einem der Ansprüche 1 bis 7, bei dem jedes Druckelement eine Reihe von Punkten drucken kann, mit den Verfahrensschritten:

Analysieren (14, 18) der empfangenen Daten, um Punktreihenunterbrechungen zu erfassen, Bestimmen (20) des Ortes derartiger Punktreihenunterbrechungen im Verhältnis zur Druckkopfhöhe,

Erfassen von durchgehenden Bildunterbrechungen (21) innerhalb jedes Druckkopf-Bilddurchganges,

Drucken (28) des gesamten Druckdurchgangs und Fordern, daß der nächste zu druckende Druckdurchgang in derselben Richtung wie der vorherige Druckdurchgang gedruckt wird, wenn keine solchen Punktreihenunterbrechungen in den Punktreihen bei oder über 3/4 der Druckkopfhöhe auftreten, oder wenn mehr als eine durchgehende Bildunterbrechung innerhalb des vorhergehenden Druckdurchganges erfaßt wurde, und

Drucken (22) der Punktreihen nur bis zu der Unterbrechung und Erlauben, daß der nächste Druckdurchgang in der zum vorherigen Druckdurchgang entgegengesetzten Richtung gedruckt wird, wenn eine Unterbrechung bei oder über 3/4 der Druckkopfhöhe auftritt und nicht mehr als ein durchgehende Bildunterbrechung innerhalb des vorherigen Druckdurchgangs erfaßt wurde.

## Revendications

1. Procédé pour accroître le débit d'une imprimante à tête de balayage ayant une tête de balayage avec une matrice d'éléments d'impression adaptée pour imprimer des images qui ne peuvent pas être imprimées complètement en une seule passe d'impression, comprenant:

une réception (12) de données définissant au moins une partie d'une image à imprimer; une analyse des données reçues afin de déterminer lorsqu'une impression dans des directions opposées pourrait provoquer un défaut visible de repère d'impression entre des parties de l'image adjacentes verticalement;

une seconde passe d'impression dans une direction opposée à celle de la première passe d'impression dans le cas où l'image comprend des interruptions verticales de l'alignement ou des interruptions continues, et la seconde pas-

se d'impression étant réalisée dans la même direction que la première passe dans le cas où de telles interruptions n'interviennent pas.

2. Procédé conforme à la revendication 1, dans lequel l'étape d'analyse comprend une détection d'interruptions en rangée de points ou d'interruptions verticales d'alignement (14, 18) entre des parties de l'image adjacentes verticalement.

3. Procédé conforme à la revendication 2, dans lequel l'étape d'impression comprend des passes d'impression de l'image unidirectionnelles (28) lorsque de telles interruptions ne sont pas détectées, et des passes d'impression de l'image bidirectionnelles (22) lorsqu'il y a de telles interruptions.

4. Procédé conforme à la revendication 1, dans lequel l'étape d'analyse comprend une détection d'interruptions d'image continue pour chaque passe d'impression de l'image.

5. Procédé conforme à la revendication 4, dans lequel l'étape d'impression comprend une impression bidirectionnelle (22) des passes de l'image qui suivent immédiatement les passes pour lesquelles pas plus d'une seule interruption n'est détectée, et une impression unidirectionnelle (28) d'autres passes de l'image.

6. Procédé conforme à la revendication 1, dans lequel l'étape d'analyse comprend une détection d'interruptions en rangée de points (14) entre des parties de l'image adjacentes verticalement, et une détection d'interruptions d'image continue (21) pour chaque passe d'impression de l'image.

7. Procédé conforme à la revendication 6, dans lequel l'étape d'impression comprend également une impression bidirectionnelle (22) des passes de l'image qui suivent immédiatement les passes dans lesquelles de telles interruptions en rangée de points sont détectées, et dans lesquelles pas plus d'une seule interruption d'image continue n'est détectée, et une impression unidirectionnelle (28) d'autres passes de l'image.

8. Procédé conforme à l'une quelconque des revendications 1 à 7, dans lequel chaque élément d'impression peut imprimer une rangée de points, comprenant les étapes consistant à: analyser (14,18) les données reçues afin de détecter des interruptions quelconques en rangée de points;



déterminer (20) la position des interruptions en rangée de points relativement à la hauteur de la tête d'impression;

détecter des interruptions d'image continue (21) pour chaque passe d'image de la tête d'impression;

imprimer (28) la passe d'impression complète et demander que la passe d'impression suivante soit imprimée dans la même direction que la passe d'impression précédente si aucune interruption en rangée de points ne se produit dans les rangées de points à 3/4 de la hauteur de la tête d'impression ou au-dessus, ou si plus d'une seule interruption d'image continue a été détectée lors de la passe d'impression précédente; et

imprimer (22) les rangées de points au-dessus de l'interruption uniquement et autoriser une impression de la passe d'impression suivante dans la direction opposée à celle de la passe d'impression précédente s'il se produit une interruption à 3/4 de la hauteur de tête ou au-dessus, et que pas plus d'une seule interruption d'image continue n'a été détectée dans la passe d'impression précédente.

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