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Description

TECHNICAL FIELD

The present invention pertains to ink-jet printing methods for controlling ink drop placement to improve the appearance of the printed image.

BACKGROUND INFORMATION

Ink-jet printers include one or more pens for delivering drops of ink to a printing medium, such as paper. An ink-jet pen typically includes a nozzle plate that has formed in it a plurality of nozzles. The nozzles are in fluid communication with an ink reservoir.

Any of a number of mechanisms may be employed for expelling ink through the nozzles of the pen. For instance, one mechanism, known as thermal-type ink-jet printing, includes a thin-film resistor mounted adjacent to each nozzle. To expel a drop of ink from a nozzle, a current pulse is applied to the resistor for heating the resistor. The heated resistor vaporizes a portion of the ink near the nozzle. The rapid expansion of the ink vapor forces a drop of ink through the nozzle. This "firing" of drops is controlled by a microprocessor in response to external data that is provided to the printer and that represents part of the desired image to be printed.

The ink-jet printer includes mechanisms for moving the pen and for advancing the paper relative to the pen. Typically, the pen is scanned across the paper one or more times, the paper is advanced, and the pen is again scanned across the paper. The microprocessor-controlled firing of selected nozzles at selected times during scanning of the pen produces on the paper an arrangement of ink dots in a resolution high enough to represent an image or textual information.

A measure of the quality of an ink-jet printed image is the uniformity of the printed ink density across the surface of the image. Preferably, individual ink drops will penetrate the permeable printing medium and diffuse evenly through the medium, joining with adjacently printed drops to form a continuous image element of substantially uniform ink density.

Unevenness in ink density causes an undesirable mottled appearance in the printed image. Uneven ink density may result in instances where adjacently printed ink drops randomly coalesce prior to penetration of the drops into the printing medium. This coalescence problem frequently occurs when the printing medium has low permeability, such as is characteristic of the clear films that are used for overhead projection displays.

Various methods have been used in the past to control ink drop placement for producing uniform, high-density images. For example, U.S. Patent No. 4,748,453, entitled "Spot Deposition for Liquid Ink Printing," discloses a method wherein drops of ink printed in one scan of the pen are placed on the medium in a pattern that is intended to prevent overlap of flowable ink drops, thereby eliminating coalescence. A subsequent scan of the pen (which scan is delayed until the previously deposited drops are sufficiently dry) prints new drops that overlap the previously printed drops. While this technique may be somewhat effective, the pattern in which the drops are printed during one scan results in diagonally adjacent drops being in tangential or perimeter contact. It has been found that this perimeter contact between simultaneously printed individual drops will cause coalescence of at least some of the diagonally adjacent drops. This uneven or random coalescence of ink drops will produce the mottled image mentioned earlier.

Placing drops on the printing medium in a manner that avoids any contact between simultaneously printed drops will eliminate the problem of drop coalescence; however, the overall ink density of the image will be reduced because of the corresponding increase in the amount of printing medium area that is exposed between drops, or more scans of the printhead over the printing medium will be required to achieve adequate ink density.

SUMMARY OF THE INVENTION

The present invention is directed to an ink drop placement method for applying ink to a printing medium to produce a high-density image without mottling, and as specified in claims 1, 3 and 5 hereinafter. The placement method involves controlling a conventional ink-jet pen so that drops of ink are fired in clusters of two or more for covering selected portions or "pixels" of the printing medium. As the clusters are printed during a scan of the pen, pixels that are horizontally and vertically and diagonally adjacent to each printed cluster remain blank.

The drops that comprise each cluster overlap in the center of the cluster. This intentional overlapping of drops within the central region of the printed clusters results in a concentration of forces due to surface tension at the center of the cluster. Accordingly, during the period immediately following the instant a cluster is printed, the cluster-drops tend to coalesce toward the center of the printed cluster.

The coalescence that occurs within the printed clusters (which coalescence is attributable to the overlapped arrangement of the ink drops in each cluster) does not produce observable mottling be-

cause this coalescence is present in all printed clusters, thereby producing a substantially uniform appearance across the entire printed image.

The method for placing drops in accordance with the present invention may be employed to produce a 25% coverage pattern in one scan. The 25% coverage pattern is particularly useful in instances where the ink drop size cannot be controlled to prevent excessive cluster to cluster overlap (hence, coalescence) with a 50% coverage pattern

EP-A-0 420 399 (cited under Art. 54(3) & (4) EPC) discloses ink jet printing with clusters covering, in one scan, 50% of the print medium, with the pixels which are horizontally and vertically adjacent remaining blank; contact between clusters is limited to tangential or perimeter contact between drops of diagonally-adjacent clusters.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram of an ink-jet printer that is suitable for carrying out the ink drop placement method of the present invention.

Fig. 2 is a diagram showing a medium printed with an arrangement of two-drop clusters covering 25% of the printing medium surface.

Fig. 3 is a diagram showing a medium printed with another arrangement of two-drop clusters covering 25% of the printing medium surface.

Fig. 4 is a diagram showing a medium printed with another arrangement of four-drop clusters covering 25% of the printing medium.

DETAILED DESCRIPTION

The diagram of Fig. 1 illustrates an ink-jet printer 20 having known mechanisms for securing and advancing relative to the printer a printing medium, such as a sheet of film 22 used with an overhead projector.

The film 22 is advanced relative to, and in close proximity with, an ink-jet pen 24. The pen 24 is mounted to a slide mechanism 26. As is known in the art, the pen 24 is reciprocally driven along the slide mechanism 26 between the side edges 28 of the film 22. The film 22 is advanced in a direction 30 that is perpendicular to the direction 32 in which the pen 24 is reciprocated. The movement of the pen 24 from one edge 28 to another is hereafter referred to as a scan. All ink drops printed by the pen 24 during a single scan will be referred to as being simultaneously printed.

The pen 24 includes a conventional nozzle plate (not shown) that has formed in it a plurality of nozzles through which drops of ink are expelled by mechanisms such as the thermal-type system described above. As the pen 24 is scanned across

the film 22, it "covers" a single swath 34. A single swath 34 is illustrated in Fig. 1 as the space between the dashed reference lines 36 that extend between the film edges 28. By "covered" is meant that the pen 24 may be controlled during the scan for firing ink drops through the nozzles to cover any selected area within the swath 34. A new swath is defined as the film 22 is advanced. Each new swath is immediately adjacent to the prior swath to ensure printing continuity from the top to the bottom of the film 22.

It is convenient to consider each swath 34, hence, the entire film surface, as being defined as a continuous matrix of discrete elements, or pixels.

Fig. 2 depicts a 25% coverage pattern printed with two-drop clusters 60. Each two-drop cluster 60 comprises two ink drops 60a, 60b arranged to overlap about the horizontal centerline H of the pixel group 65. The centers of drops 60a, 60b are vertically aligned. The 25% pattern is printed so that every fourth pixel group 65 in a row of pixel groups, and every other pixel group 65 in a column of pixel groups, is printed with a two-drop cluster 60.

Fig. 3 depicts an alternative arrangement of a two-drop cluster 70 for printing a 25% coverage pattern. In Fig. 3, the two-drop cluster 70 is arranged so that the drops 70a, 70b overlap about the vertical centerline V of the pixel group 75. The centers of the drops 70a, 70b are horizontally aligned. The pixel groups 75 are oriented to correspond with the orientation of the drop cluster 70. Accordingly, the rectangular-shaped pixel groups 75, are oriented with long axes in the horizontal direction. The 25% pattern depicted in Fig. 3 is printed so that every other pixel group 75 in a row of pixel groups, and every fourth pixel group in a column of pixel groups is printed with a two-drop cluster 70.

Fig. 4 depicts another alternative arrangement for printing a 25% coverage pattern, using four-drop clusters 80. The individual drops 80a, 80b, 80c, 80d overlap along the vertical V and horizontal H centerlines of the pixel groups 85. The 25% pattern depicted in Fig. 4 is printed so that every other pixel group 85 in a row of pixel groups 85, and every other pixel group in a column of pixel groups is simultaneously printed with the four-drop cluster 80.

It may be useful to employ the 25% coverage pattern described with respect to Figs. 2 - 4 in instances where the size of the ink drops cannot be sufficiently controlled to produce 50% coverage patterns that have no significant overlap between diagonally adjacent pixel groups. The 25% coverage pattern (Figs. 2 - 4) is advantageous in this regard because the minimum distance between any two simultaneously printed clusters 60, 70, 80

is increased compared to clusters printed in a 50% coverage pattern. Accordingly, there is no tangential contact between simultaneously printed pixel groups 60, 70, 80, and the distance provided between the simultaneously printed pixel groups accommodates oversize ink drops that would otherwise overlap with diagonally adjacent printed clusters.

A 100% coverage pattern may be produced from the 25% patterns of Figs. 2 - 4 by repeating three times the pen scan across a single swath with the pen fired so that the uncovered pixel groups are covered with the drop clusters.

While the present invention has been described in accordance with preferred embodiments, it is to be understood that certain substitutions and alterations may be made thereto without departing from the scope of the appended claims.

Claims

1. A method for controlling a scannable pen that is operable for placing ink drops on a medium (22) that has a surface definable by a matrix of adjacent pixel groups (65) that are arranged in horizontal rows and vertical columns, the method comprising the steps of:

directing, during a first scan of the pen, clusters (60) of at least two overlapping ink drops to substantially cover every fourth pixel group (65) of a row of pixel groups (65); and

directing, during the first scan of the pen, clusters (60) of at least two overlapping ink drops to substantially cover every other pixel group (65) in every other column of pixel groups.

2. The method of claim 1 wherein the cluster (60) comprises two overlapping ink drops having centers that are vertically aligned.

3. A method for controlling a scannable pen that is operable for placing ink drops on a medium (22) that has a surface definable by a matrix of adjacent pixel groups (75) that are arranged in horizontal rows and vertical columns, the method comprising the steps of:

directing, during a first scan of the pen, clusters (70) of at least two overlapping ink drops to substantially cover every other pixel group (75) in every other row of pixel groups (75); and

directing, during the first scan of the pen, clusters (70) of at least two overlapping ink drops to substantially cover every fourth pixel group (75) of a column of pixel groups (75).

4. The method of claim 3 wherein the cluster (70) comprises two overlapping ink drops having centers that are horizontally aligned.

5. A method for controlling a scannable pen that is operable for placing ink drops on a medium (22) that has a surface definable by a matrix of adjacent pixel groups (85) that are arranged in horizontal rows and vertical columns, the method comprising the steps of:

directing, during a first scan of the pen, clusters (80) of four overlapping ink drops to substantially cover every other pixel group (85) in every other row of pixel groups and every other pixel group in every other column of pixel groups.

Patentansprüche

1. Ein Verfahren zum Steuern eines bewegbaren Stifts, der wirksam ist, um Tintentropfen auf einem Medium (22) zu platzieren, das eine durch eine Matrix von benachbarten Pixelgruppen (65), die in horizontalen Reihen und vertikalen Spalten angeordnet sind, definierbare Oberfläche besitzt, wobei das Verfahren folgende Schritte aufweist:

Richten von Gruppen (60) von mindestens zwei sich überlappenden Tintentropfen während eines ersten Durchlaufs des Stifts, um im wesentlichen jede vierte Pixelgruppe (65) einer Reihe von Pixelgruppen (65) zu bedecken; und
Richten von Gruppen (60) von mindestens zwei sich überlappenden Tintentropfen während des ersten Durchlaufs des Stifts, um im wesentlichen jede zweite Pixelgruppe (65) in jeder zweiten Spalte der Pixelgruppen zu bedecken.

2. Das Verfahren gemäß Anspruch 1, bei dem die Gruppe (60) zwei sich überlappende Tintentropfen mit Mittelpunkten aufweist, welche vertikal ausgerichtet sind.

3. Ein Verfahren zum Steuern eines bewegbaren Stifts, der wirksam ist, um Tintentropfen auf ein Medium (22) zu platzieren, das eine durch eine Matrix von benachbarten Pixelgruppen (75), die in horizontalen Reihen und vertikalen Spalten angeordnet sind, definierbare Oberfläche besitzt, wobei das Verfahren folgende Schritte aufweist:

Richten von Gruppen (70) von mindestens zwei sich überlappenden Tintentropfen während eines ersten Durchlaufs des Stifts, um im wesentlichen jede zweite Pixelgruppe (75) in jeder zweiten Reihe von Pixelgruppen (75) zu bedecken; und

Richten von Gruppen (70) von mindestens zwei sich überlappenden Tintentropfen während des ersten Durchlaufs des Stifts, um im wesentlichen jede vierte Pixelgruppe (75) einer Spalte von Pixelgruppen (75) zu bedecken.

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4. Das Verfahren gemäß Anspruch 3, bei dem die Gruppe (70) zwei sich überlappende Tintentropfen mit Mittelpunkten aufweist, welche horizontal ausgerichtet sind.

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5. Ein Verfahren zum Steuern eines bewegbaren Stifts, der wirksam ist, um Tintentropfen auf ein Medium (22) zu plazieren, das eine durch eine Matrix von benachbarten Pixelgruppen (85), die in horizontalen Reihen und vertikalen Spalten angeordnet sind, definierbare Oberfläche besitzt, wobei das Verfahren folgenden Schritt aufweist:

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Richten von Gruppen (80) von vier sich überlappenden Tintentropfen, während eines ersten Durchlaufs des Stifts um im wesentlichen jede zweite Pixelgruppe (85) in jeder zweiten Reihe von Pixelgruppen und jede zweite Pixelgruppe in jeder zweiten Spalte von Pixelgruppen zu bedecken.

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Revendications

1. Procédé de commande d'un stylet balayable qui peut être activé pour placer des gouttes d'encre sur un support (22) qui comporte une surface qui peut être définie par une matrice de groupes de pixels adjacents (65) qui sont agencés selon des rangées horizontales et des colonnes verticales, le procédé comprenant les étapes consistant à :

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diriger, pendant un premier balayage du stylet, des grappes (60) d'au moins deux gouttes d'encre en chevauchement de manière à recouvrir sensiblement chaque groupe de quatre pixels (65) d'une rangée de groupes de pixels (65) ; et

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diriger, pendant le premier balayage du stylet, des grappes (60) d'au moins deux gouttes d'encre en chevauchement de manière à recouvrir sensiblement chaque groupe d'autres pixels (65) dans chaque autre colonne de groupes de pixels.

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2. Procédé selon la revendication 1, dans lequel la grappe (60) comprend deux gouttes d'encre en chevauchement comportant des centres qui sont alignés verticalement.

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3. Procédé de commande d'un stylet balayable qui peut être activé pour placer des gouttes d'encre sur un support (22) qui comporte une

surface qui peut être définie par une matrice de groupes de pixels adjacents (75) qui sont agencés suivant des rangées horizontales et des colonnes verticales, le procédé comprenant les étapes consistant à :

diriger, pendant un premier balayage du stylet, des grappes (70) d'au moins deux gouttes d'encre en chevauchement de manière à recouvrir sensiblement chaque groupe d'autres pixels (75) dans chaque autre rangée de groupes de pixels (75) ; et

diriger, pendant le premier balayage du stylet, des grappes (70) d'au moins deux gouttes d'encre en chevauchement de manière à recouvrir sensiblement chaque groupe de quatre pixels (75) d'une colonne de groupes de pixels (75).

4. Procédé selon la revendication 3, dans lequel la grappe (70) comprend deux gouttes d'encre en chevauchement comportant des centres qui sont alignés horizontalement.

5. Procédé de commande d'un stylet balayable qui peut être activé pour placer des gouttes d'encre sur un support (22) qui comporte une surface qui peut être définie par une matrice de groupes de pixels adjacents (85) qui sont agencés selon des rangées horizontales et des colonnes verticales, le procédé comprenant les étapes consistant à :

diriger, pendant un premier balayage du stylet, des grappes (80) de quatre gouttes d'encre en chevauchement de manière à recouvrir sensiblement chaque groupe d'autres pixels (85) dans chaque autre rangée de groupes de pixels et chaque groupe d'autres pixels dans chaque autre colonne de groupes de pixels.

FIG. 1



