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COLOR FLAT PANEL DISPL.4Y SUB-PI.YEL ARRANGEMENTS AND **LAYOUTS FOR SU&PIXEL RENDERING WITH INCRE.USED** MODULATION TR-ANSFER FUNCTION RESPONSE

Field of Classification Search .... 345/72, 345/83, 88, 92, 20J—205, 209, 96, 690, 694-696; 3J9/l0W109
See application file for complete search history.

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~~**COLOR FLAT PANEL DISPLAY SUB PIXEL** ARRANGEMENTS AND LAYOUTS **FOR SUB PIXEL RENDERING V'ITH SPLIT BLUE** SUB PIXELS~~

Related U.S. Application Data

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ABSTRACT

Various embodiments of a sub-pixel octal grouping are disclosed. The octal grouping may comprise three-color stb-pixels with one colored sub-pixel comprising twice the iumber of positions within the octal sub-pixel grouping as the other two colored sub-pixels. Various embodiments for per-

(Continued)

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ABSTRACT

Various embodiments of a sub-pixel octal grouping are disclosed. The octal grouping may comprise three-color (red, green and blue) sub-pixels with blue colored subpixel comprising twice the number of positions within the octal sub-pixel grouping as the red and green colored sub-pixels. Various embodiments for performing sub-pixel rendering on the sub-pixel groupings are disclosed.

37 Claims, 26 Drawing Sheets

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COLOR FLAT PANEL DISPLAY SUB-PIXEL ARRANGEMENTS AND LAYOUTS FOR SUB-PIXEL RENDERING ~~¥t'ITH SPLIT BLUE SUB PIXELS~~WITH INCRE.4SED MODULATION TRANSFER FUNCTION RESPONSE

RELATED APPLICATIONS

~~[0001]~~ This application claims priority to U.S. Provisional ~~Patent Application~~Appli- cation No. 60/~~346,738~~3J6,738 ("the '738 provisional application"), entitled "ARRANGEMENT OF ~~SUBPIXELS WITH~~ SUB-PIXELS \VITH DOUBLE BLUE STRIPES," filed on Jan. 7, 2002, which is hereby incorporated herein by reference. This application is also a continuation-in-part ofU.S. patent application Ser. No. 10/243,094, entitled "IMPROVED FOUR COLOR .ARRANGEMENTS OF EMITTERS FOR SUB-PIXEL RENDERING," filed on Sep. 13, 2002, now abandoned and published as United States Patent Publication No. 2004/ 0051724 ("the '724 application"). wliicli is hereby incorpo- rated herein by reference and is commonly owned by the same assignee of this application.

~~[0002]~~ This application is also related to United States Patent Publication No. 2003/0117J23 ("the 'J23 application") [U.S. patent application Ser. No. ~~___,~~10/278,3 28,] entitled "IMPROVEMENTS TO COLOR FLAT PANEL DISPLAY ~~SUB PI XEL ARRANGEMENTS AND LAYOUTS WITH~~SUB-PIXEL ARR.4NGEMENTS AND L.4YOUTS \VITH REDUCED BLUE ~~LUMINANCE~~LUMIN.4NCE WELL ~~VISIBALITY," filed on~~VISIBILITY," ~~___, U.S. patent application Ser. No. ___, entitled "COLOR DISPLAY HAVING HORIZONTAL SUB PI XEL ARRANGEMENTS AND LAYOUTS," filed on~~ filed on Oct. 22, 2002; United States Patent Publication No. 2003/0090581 ("the '581 application") [U.S. patent applica- tioiser. No. 10/278,393,] entitled"COLOR DISPLAY HAV- ING HORIZONTAL SUB-PIXEL .ARRANGEMENTS .AND L.4YOUTS," filed on Oct. 22, 2002; arid United States Patent Publication No. 2003/0128179 ("the '179 applica- tion") [U.S. patent application Ser. No. ~~_,~~10/278,352,] entitled "IMPROVEMENTS TO ~~COLOR FLAT PANEL DISPLAY SUB PI XEL~~ CDLOR FL.4T P.ANEL DISPL.4Y SUB-PIXEL .ARRANGEMENTS .AND LAYOUTS FOR ~~SUB PI XEL~~SUB-PIXEL RENDERING WITH ~~INCREASED MODU LATION TRANSFER FUNCTION RESPONSE," filed on~~SPLIT BLUE SUBPIX- ELS," filed on Oct. 22, 2002. which are all hereby ~~incorporated~~incorpo- rated herein by ~~refer ence~~reference and commonly owned by the same assignee of this application.

~~BACKGROUND~~B.4CKGROUND

~~[0003]~~ The present application relates to ~~improvements~~improveiiients to display layouts, and, ~~more~~iiiore particularly, to ~~improved~~irriproved color pixel arrangements, ~~means~~rrieans of addressing used in displays, and to data format conversion methods for these displays.

~~[0004]~~ Full color perception is produced in the eye by three-color receptor nerve cell types called cones. The three types are sensitive to different wavelengths of light: long, medium, and short ("red", "green", and "blue", ~~respec tively~~respectively). The relative density of the three differs significantly ~~from~~front one another. There are slightly ~~more~~iiiore red receptors than green receptors. There are very few blue receptors compared to red or green receptors.

~~[0005]~~ The human vision system processes the ~~informa tion~~information detected by the eye in several perceptual channels: ~~luminance, chromanance~~lurni- nance, cliroiiianance, and motion. Motion is only important for ~~hicker~~flicker threshold to the imaging ~~system~~systems designer. The ~~luminance~~liniinance channel takes the input ~~from~~front only the red and green receptors. In other ~~workds~~words, the ~~luminance~~luniinance channel is "color blind~~.~~".. It processes the information in such a manner that the contrast of edges is enhanced. The ~~chromanance~~clironianance channel does not have edge contrast ~~enhance ment~~enhancement. Since the ~~luminance~~ltuninance channel uses and enhances every red and green receptor, the resolution of the ~~luminance~~liiiiiinance channel is several times higher than the ~~chromanance chan nels~~cliroinanance channels. Consequently, the blue receptor contribution to ~~lumi- nance~~luminance perception is negligible. The ~~luminance~~ltuninance channel thus acts as a ~~resolution~~spatial frequency signal band pass filter. Its peak response is at 35 cycles per degree (cycles/°). It limits the response at 0 cycles/° and at ~~(0~~50 cycles/~~° 1 h~~° in the horizontal and vertical axis. This means that the luminance channel can only tell the relative brightness between two areas within the field of view. It cannot tell the absolute brightness. Further, if any detail is finer than 50 cycles/°, it simply blends together. The ~~limit~~menit in the horizontal axis is slightly higher than the vertical axis. The limit in the diagonal axes is ~~significantly~~somewhat lower.

~~[0006]~~ The ~~chromanance~~cllronianance channel is ~~further~~liirtlier subdivided into two sub-channels, to allow us to see ~~full~~fNl color. These channels are quite different from the luminance channel, acting as low pass filters. One can always tell what color an object is, no matter how big it is in our field of view. The red/green ~~chromanance~~cliroiiianance sub-channel resolution limit is at 8 cycles/°, while the yellow/ blue ~~chromanance~~cllromanance sub-channel resolution ~~limit~~liiiiit is at 4 cycles/ °~~.~~ Thus, the error introduced by lowering the red/green ~~resolution~~reso- lution or the yellow/blue ~~reso- lution~~resolution by one octave will be barely noticeable by the most perceptive viewer, if at all, as experiments at Xerox and ~~NASA, Ames~~N.4SA, Amies Research Center (see, e.g., R. Martin, J. Gille, J. Larimer, Detectability of Reduced Blue Pixel Count in Projection Displays, SID Digest 1993) have demonstrated.

~~[0007]~~ The luminance channel determines image details by ~~analyzing~~ana- lyzing the spatial frequency Fourier transform ~~com- ponents. From~~components. Front signal theory, any given signal can be ~~rep- resented~~represented as the ~~summation~~suniiiiation of a series of sine waves of varying amplitude and frequency. The process of teasing out, ~~mathematically~~iiiatlieiiiatically, these sine-wave-components of a given signal is called a Fourier Transform. The human vision system responds to these ~~sine-wave-components in the two-dimensional~~sire- wave-components in the two-dimensional image signal.

~~[0008]~~ Color perception is influenced by a process called "~~assimilation~~assimi- lation" or the Von Bezold color blending effect. This is what allows separate color pixels (also known as ~~sub- pixels~~sub-pixels or emitters) of a display to be perceived as a mixed color. This blending ~~eifect~~effect happens over a given angular distance in the field of view. Because of the relatively scarce blue receptors, this blending happens over a greater angle for blue than for red or green. This distance is approximately 0.25° for blue, while for red or green it is approximately 0.12°. At a viewing distance of twelve inches, 0.25° ~~sub- tends~~subtends 50 mils (~~1,270 y~~l,270{i) on a display. Thus, if the blue pixel pitch is less than half(~~625 p~~625tt) of this blending pitch, the colors will blend without loss of picture quality. This ~~blend- ing efiect~~blending effect is directly related to the ~~chromanance~~cllronianauce sub-channel resolution limits described above. Below the resolution limit, one sees separate colors, above the resolution limit, one sees the combined color.

BRIEF DESCRIPTION OF THE ~~DRAWINGS~~DRA\VINGS

~~[0009]~~ The accompanying drawings, which are ~~incorpo- rated~~incorporated in, and constitute a part of this specification illustrate various implementations and embodiments disclosed herein.

FIG. 1A shows an arrangement of four-color pixel ele- ments in an array, in a single plane, for a display device, having a repeat cell consisting of eight sub-pixels.

[0010] FIG. 1lB shows an arrangement of sub-pixel emitters comprising threes colors red, green, and blue n group ings that create a larger rectilinearly repeating cell groupthree-color pixel ele- ments in ari array, in a single plane, for a display device, having a repeat cell of consisting of eight sub-pixels wherein the bluegener- ated by selecting and defining four of the eight sub-pixels are "split"of FIG. 1A as the same color.

FIG. 1C shows an arrangeiiient of three-color pixel ele- ments in an array, in a single plane, for a display device, having a repeat cell of consisting of eight sub-pixels generated by selecting and defining four of the eight sub-pixels of FIG. lA as the sauce color and reducing their widths.

FIG. 2 shows a schematic of an electronic drive arrange- intent for the arrangement of sub-pixels shown in FIGS. 1A, 1B, and IC.

FIGS. 3A and 3B illustrate the relative polarities of active matrix dot inversion drive methods for a Liquid Crystal Dis- play using the arrangeiiient of color sub-pixels of FIG. IC and the drive arrangeiiient of FIG. 2.

[0011] FIGS. 24A, 34B, 4C, and 44D illustrate one embodiment of red,a set of green, and blue resample area arrays for the red, green and blue color planes respectively to match the sub-pixel, and red resample areas separately and overlaid, respectively, for the arrangement of sub-pixels of FIG. 11C.

[0012] FIGS. 5 **and** 6 illustrate the red and green resample area arrays of FIGS. 2 and 3 overlaid on the sub-pixel arrangement of **FIG.** 1 respectively.

FIGS. 5A, 5B, 5C, and 5D illustrate the set of green, blue, and red resaiiiple areas of FIGS. 4A, 4B, 4C, and 4D respec- tively, overlaid on the arrangement of sub-pixels of FIG. 1C to show their relative positions.

0013] FIG. 75E illustrates one particular inter color plane phase relationship between the red and green color resample areas overlaid on the sub-pixeltwo logical pixels displayed on the arrangement of FIG. 1lC, resulting from the sub-pixel render- ing operation of the resample areas of FIG. 4D.

FIG. 6A illustrates two logical pixels displayed on the arrangement of FIG. 1C, resulting from the sub-pixel render- ing operation of the resample areas of FIG. 6D.

FIGS. 6B, 6C, and 6D illustrate a set of blue and red resample areas separately, and overlaid along with the green resample areas illustrated in FIG. 4A on arrangement of stb- pixels of FIG. 1C, respectively.

[0014] FIGS. 8A and 8B illustrate two possible schemat- ics for a driver arrangement for the arrangement of color emitter sub-pixels in **FIG. 1.**

FIG. 7A illustrates the set of green, blue, and red resample areas of FIGS. 4A, 4B, and 4C respectively, overlaid show their relative positions.

~~[0015] **FIGS. 9 and 10** show two "dot inversion" schemes—commonly known as "2x1" and "1x1", respec- tively—matching **FIG.** 8A's schematic.~~

~~[0016] **FIGS. 11 and 13** depict alternative blue color plane resample area arrays to replace the one shown in **FIG.** 4.~~

~~[0017] **FIGS. 12 and 14** show how the respective blue color plane resample areas of **FIGS. 11 and 13** would map onto the sub pixel layout as shown in **FIG. 1.**~~

~~poorly **FIGS. is and 16** show two "dot inversion" schemes—commonly known as "2x1" and "1x1", respec- tively—matching **FIG.** 8B's schematic.~~

~~[0019]~~ FIG. ~~17~~7B illustrates the ~~results of turning on two full color incoming data pixels~~arrangement of resample areas of FIG. 7A overlaid on the arrangeiiient of sub-pixels of FIG. lC to show their relative positions.

~~[0020] FIcs. isA~~FIGS. 8A and ~~igB~~8B show other embodiments of the octal ~~subpixel~~stibpixel arrangement with various vertical ~~dis- placements~~displacements of the subpixels.

~~[0021]~~ FIGS. ~~19A~~9A and ~~19B~~9B show yet other ~~embodiments~~embodiiiients of the octal ~~subpixel arrangement~~siibpixel arrangeiiient of various displacements of the split majority subpixel within the subpixel grouping.

~~[0022]~~ FIG. ~~20~~10 depicts a system incorporating sub-pixel rendering ~~techniques~~tecluiiqties suitable to drive a panel made in accordance with the various embodiments described herein.

FIGS. 11A and 11B depict two particular embodiments of flowcliarts to perform software and hardware sub-pixel ren- dering on a suitable display.

FIG. 12 is one particular erribodiiiient of an irripleiiienta- tion of a display made in accordance with several embodi- ments herein disclosed.

DETAILED DESCRIPTION

~~[0023]~~ Reference will now be made in detail to ~~various implementations~~iiiplenientations and embodiments of the invention, examples of which are illustrated in the ~~accompanying~~accoiiipanying drawings. ~~Wherever~~\Vlierever pos- sible, the same ~~reference~~ref'erence numbers will be used throughout the drawings to refer to the same or like parts.

Sub-Pixel Arrangements

FIG. 1A shows an arrangement of sub-pixel emitters **100** having four color emitters in groupings 110 that is shifted down every other column group by one sub-pixel. This cre- ates a larger rectilinearly repeating cell group **120** of eight sub-pixels. This layout was introduced in the '724 application Also disclosed in the '724 application is the practice of setting a plurality of the sub-pixels within the repeat cell to the same color point, an example of which is illustrated in FIG. 1B, wherein four of the eiiiitters **106** in the eight eiiiitter repeat cell group **120** are set to the same color. For exarriple, these four emitters 106 may be set to be liiiuinance adjusted (i.e. balanced) green in color. For exarriple, the other sub-pixel emitters rriay be set to be red **104** and blue **102.** The luminance balanced green **106** sub-pixels have twice the area, i.e., "real- estate," per color as the red **104** and blue **102** sub-pixels, but being balanced to have the same ltiminance as the red **104** sub-pixels, the total green energy is balanced to produce a pleasing white point when all sub-pixels are illuminated frilly. The iiianner of balancing the luinінance of the green color sub-pixel was previously disclosed in the '724 application.

In FIG. lC, the four sub-pixel emitters **106** are reduced in size and aspect ratio compared to the other two sub-pixel emitters **104** and **102.** The minority sub-pixels **104** and **102** may also be adjusted in aspect ratio. In this exaiiiple, the relative size of sub-pixel **106** is adjusted to be one half of that of sub-pixels 104 or **102.** As before, the colors may be assigned as desired. It should also be noted that although the repeat octal grouping is shown such that the majority color sub-pixels occupy the second and fourth columns, it also suffices that the iiiajority sub-pixels could occupy the first and the third columns as well.

In another embodiment, the colors are assigned as red **104,** blue **102,** and non-luminance balanced green **106.** Since there are twice as many green **106** as there are of the other two colors, red **104** and blue **102,** the result is a pleasing white point when all sub-pixels are illuminated frilly.

In this or another color assignment embodiment, the stb- pixel aspect ratios may be adjusted so that the display array **100** consists of square repeat cell groups **120.** Tliis will put the majority color sub-pixel emitter 106 on a square grid. It will also put the minority color sub-pixel emitters **102** and 104 on, or nearly on, an idealized "checkerboard". For an example of another color assignment embodiment, sub-pixels **106** could be assigned the color red and sub-pixels **104** could be assigned the color green in FIGS. 1B and lC. Under tliis color assignment, the algorithms for sub-pixel rendering discussed below would work siiiiilarly.

Not only may the green or the red sub-pixels occupy the majority colored sub-pixels in octal octal grouping **120,** but the blue sub-pixels may also occupy the majority sub-pixels. Such an arrangement was previously disclosed in '738 pro- visional application. Thus, all three colors—red, green, and blue—may occupy the majority sub-pixel position in this grouping. Additionally, while the colors—red, green and blue—have been used for the purposes of illustrating the present embodiments, it should be appreciated that another suitable choice of three colors—representing a suitable color gamut for a display—may also suffice for the purposes of the present invention.

~~[0024] In **FIG. 1,** in the arrangement of sub-pixel emitters **100,** there are three color emitters in groupings **120** that create a larger rectilinearly repeating cell group of eight sub pixels. This layout was introduced in the~~

the '738 provisional application and included herein by reference. Grouping **120** comprises red sub pixels **104,** green sub- pixels **106** and lalue sub pixels **102.** As may be seen, blue sub pixels **102** are "split" i.e. having a smaller width along the horizontal axis than either red or green sub pixels but doubled in number per grouping or repeat cell. Such a "split" sub pixel can refer to a sub pixel having a smaller area than a non split sub pixel. Splitting the blue sub pixels helps in breaking up the noticeable effect of visible vertical blue stripes down the display, as further discussed in U.S. patent application Ser. No. ________________________ ("the ______ application"), entitled "IMPROVEMENTS TO COLOR FLAT PANEL DISPLAY SUBPIXEL ARRANGEMENTS AND LAY OUTS WITH REDUCED BLUE LUMINANCE WELL VISIBILITY," filed on _______, incorporated by reference.

[0025] As may additionally be seen in **FIG. 1,** the red and the green sub pixels are placed upon a "checkerboard" pattern with the repeat cell itself. As discussed further in the ______ application, it may be desirable to alter the repeat cell grouping **120** color assignments to have a split green sub pixel in position of sub pixels **102** and have the remain- ing red and blue sub pixels form the checkerboard pattern. Likewise, it might be desirable to have the red sub pixels split and the green and blue sub pixels on a checkerboard pattern. The alternating "checkerboard" of emitters is simi- lar to the red and green "checkerboard" that was disclosed in co pending and comonly assigned U.S. patent application Ser. No. 09/916,232, entitled "ARRANGEMENT OF COLOR PIXELS FOR FULL COLOR IMAGING DEVICES WITH SIMPLIFIED ADDRESSING," filed on Jul. 28, 2000, which is hereby incorporated herein by reference.

[0026] It should be appreciate that while **FIG. 1** depicts the "split" blue subpixel as narrower than either the red or the green subpixels, another embodiment of the present invention employs blue subpixels of equal area dimensions to the red and green subpixels. To achieve a pleasing white point with all subpixels on in a logical pixel, the relative intensities of the red, green and blue emitters can be changed appropriately as discussed in co pending and commonly assigned U.S. patent application Ser. No. 10/243,094, entitled "IMPROVED FOUR COLOR ARRANGEMENTS OF EMITTERS FOR SUBPIXEL RENDERING," filed Sep. 13, 2002, which is hereby incorpated herein by refer- ence.

[0027] As shown in **FIG**FIGS. **1**1A, 1B and lC, the subpixels appear to have a substantially rectangular appearance. It should be appre- ciatedappreciated that other shapes to the subpixelsstibpixels are also possiblepos- sible and are contemplated within the scope of the present invention. For example, a multitude of other regular or irregularirregu- lar shapes for the subpixels are possible and are desirable if manufac- turablemanufactiirable. It suffices only that there is an octal grouping of colored subpixels in the fashion herein described that may be addressable for the purposes of subpixel rendering (SPR).

[0028] As subpixel shapes may vary under the scope of the present invention, so too may the exact positions of the subpixels be varied under the scope of the present invention. For example, FIGS. 18A8A and **18B**8B depict a similar octal subpixel grouping wherein one or both of the majority stripes **102106** are onsetoffset (relatively or otherwise) from the other subpixels **102 and 104** and **106.** Other vertical offsets are also pos- siblepossible.

[0029] Other embodimentseiiibodiinents of the octal groupings are also possiblepos- sible. FIGS. **19A**9A and **19B**9B depict octal groupings wherein the majority iiiajority subpixels ~~102~~106 are interspersed within the ~~checkerboard~~checker- board of subpixels 102 and **104** ~~and **106**~~. Other ~~arrange- ments of majority subpixel~~arrangements of rriajority silbpixel placement within such a ~~check- erboard~~checkerboard are also possible and are contemplated within the scope of the present invention.

~~**[0030]**~~ FIGS. ~~**19A**~~9A and ~~**19B**~~9B may have column electrodes that zig-zag across the display. ~~Column~~Collinin driver savings should be one third when compared to the RGB stripe system with the ~~same~~sauce resolution and the ~~number~~inunber of subpixels are about two thirds of the number of subpixels when compared to the RGB stripe system.

~~**0031]**~~ Yet other embodiments of the present invention are ~~possible~~pos- sible. For example, ~~the entire~~tlieentire octal subpixel groupings may be rotated 90 degrees to reverse the roles of row and column driver ~~connections~~coiuiections to the grouping. Such a ~~horizon- tal arrangement for subpixels is further disclosed in the co pending and commonly assigned application~~horizontal arrangerrient for siibpixels is fiirtlierdisclosed in the co-pend- ing application United States Patent Publication No. 2003/ 0090581 ("the '581 application") entitled "COLOR ~~DISPLAY~~DIS- PLAY HAVING HORIZONTAL ~~SUB-PI-XEL~~ SUB-PIXEL ARRANGEMENTS .AND LAYOUTS~~,~~" and is incorporated by reference.

~~**[0032]**~~ The alternating "~~checkerboard~~clieckerboard" of emitters is ~~simi- lar~~similar to the red and green "~~checkerboard~~clieckerboard" that was disclosed in ~~co pending~~ co-pend- ing and conunonly assigned United States Patent Ptiblication No. 2002/0015110 ("the '110 application") [U.S. patent application Ser. No. 09/~~916,232 ("the '232 application"),~~916J32] entitled "~~ARRANGEMENT~~ARRANGE- MENT OF COLOR PIXELS FOR FULL COLOR ~~IMAGING~~IMAG- ING DEVICES WITH SIMPLIFIED ADDRESSING," filed ~~on Jul. 25, 2001 and hereby incorporated herein by reference.~~

[0033] With the display comprised substantially of repeat cell 120 having the blue sub pixel split as sub pixel 102, it is possible to performon Jul. 25, 2001, using sub-pixel rendering upon this display using the area resampling techniques assuch as that described in cop-ending United States Patent Publication No. 2003/0103058 ("the '058 application") [U.S. patent Applicationapplica- tion Ser. No. 10/150,355 ("the '355 application"),] entitled "METHODS AND SYSTEMSSYS- TEMS FOR SUB-PIXEL RENDERING WITH\VITH GAMMA ADJUSTMENT," filed on May 17, 2002. These co-pending applications are hereby incorporated herein by reference. The methods described in the above co-pending applications may be modified for the eiiibodiiiients disclosed herein.
May 17, 2002, which is hereby incorporated herein by reference and is commonly owned by the same assignee of this application. One such embodiment of area resampling is shown in **FIGS. 2 through 7.**

FIG. 2 illustrates a schematic for a driver arrangeiiient **200** for the arrangement of color emitter sub-pixels in FIGS. 1A, lB, and lC. For convenience, the example given has the same number of sub-p ixels illustrated as FIG. lC. This drive arrangement may be used for a number of display tecluiolo- gies, as the blocks **210** iiiay represent one or several electrical coiiiponents, which are not shown so as not to obscure the embodiments. In particular, they may represent the capacitive display cell element for passively addressed Liquid Crystal Display (LCD), or ElectroLumiuescent (EL) Display. They may represent the gaseous discharge element in a Plasma Display Panel (PDP). They may represent the semiconductor diode element of a passively addressed Inorganic Light Emit- ting Diode or an Organic Light Emitting Diode Display. They may also represent the transistor, storage capacitor, and capacitive cell element of an Active Matrix Liquid Crystal Display (.AMLCD). They may fhrther represent the multi- transistor, storage capacitor, and light emitting element of an .Active Matrix Organic Light Emitting Diode Display (AMOLED). The may also represent, in general, the color sub-pixel and its associated electronic eleiiients found in other known or yet to be developed display technologies.

The drive tinting and method iiiay be any of those known in the art for NxM drive matrices as those shown. However, there may be modifications needed due to the specific color assignments, particularly any clieckerboard across the panel or color alternations within a single column. For example, the technique known in the art as "Multi-Row Addressing" or "Multi-Line Addressing" for passive LCD iiiay be modified such that groupings of rows are restricted to odd and even row combinations. This will reduce potential color crosstalk since, within a column with two alternating color sub-pixels, only one color will be addressed at a time.

Inversion schemes, switching the electrical field polarity across the display cell to provide a time averaged zero net field and ion current across the cell, can be applied to the embodiments disclosed herein. FIGS. 3A and 3B show two "dot inversion" schemes **300** and **310,** referred to as "1xl" and "2x1", respectively, on Active Matrix Liquid Crystal Displays, both of which will perform satisfactorily. The scheme shown on FIG. 3B may performs better when slight imbalances of light transmission occur beMeen positive and negative polarities, especially when the eye is tracking the motion of displayed images moving across the screen. Each of the Figures shows the polarities during half of the display addressing fields. The polarities are reversed for the other half, alternating every field, resulting in a net zero current (zero DC bias), as is well known in the art.

Data Format Conversion

[0034] FIGS. 2, 3 and 4 illustrate red **200,** green **300,** and blue **400**For one embodiment of data format conversion using area resanipling tecluiiqies, FIGS. 4A, 4B, and 4C illustrate green **406,** blue **402,** and red **404** resample area arrays for the red, green and, blue, and red color planes, respectively. It should be notedNote that each color resample area array **200, 300, and 400** comprises of resa mple areas **206, 306** and **404406, 402,** and **404** consists of resample areas **426, 422,** and **424** and that each resample area has an associated resample point **202416, 302412,** and **402414,** respectively, associated with it. The resample points **202416, 302412,** and **402414** match the relative positions of the red **104,** green **106** and, blue **102,** and red **104** sub-pixel locations, respectively, within each color plane; but not necessarily their exact inter-color-plane-phase relationships. It should be appreciated that any number of phase relationships are also possible, a number of which have useful properties in given data format conver sion cases.

[0035] FIGS. 5 and 6 illustrate the red and green resample area arrays of **FIGS. 2 and 3** overlaid on the sub pixel arrangement **100** of **FIG. 1,** respectively. **FIG. 7**FIG. 4D illustrates one particular inter-color-plane-phase relationship between the red and green color resample areas overlaid on the sub pixel arrangement **100.** This particular intercolor plane phase**400.** This relationship depicts convertingmight be employed to convert the conventional fullyiiilly converged square grid red green blue RGB format which is to be displayed "one-to-one" with the square blue **102**green **106** sub-pixel grid of FIG. lC. In this inter color plane phaseinter-color-plaie- phase relationship **400,** the green **300406,** blue **400402,** and red **200404** resample area arrays are substantially positioned such that the red **202414** and green **302**blue **412** resample points overlap the blue **402**green **416** sample points. This treats the bluegreen sub-pixels **102106** as though they lay on top of, or intimately associated with, the red **104** and ~~green 106~~**blue 102** sub-pixel ~~checkerboard~~clieckerboard.

~~**[0036]**~~ FIGS. ~~**11 and 13** depict alternative blue color plane~~5A, 5B, and 5C illustrate the green **406,** blue **402,** and red **404** resample area arrays ~~to replace the one shown in **FIG.**~~
of FIGS. 4A, 4B, and 4C overlaid on the sub-pixel arrangement **100** of FIG. lC, respectively, with the inter-color-plane-phase relationship **400** of FIG. 4D. FIG. 5D illustrates the inter-color-plane- phase relationship **400** of FIG. 4D overlaid on the sub-pixel arrangeiiient **100** of FIG. 1C. ~~**4. FIGS. 12 and 14** show how these respective blue color plane resample area would map onto the sub pixel layout as shown in **FIG. 1. FIGS. 11 and 13** depict two different embodiments of resample areas **406** for blue with the phase shift shown. It should be appreciated that other phase shifts suffice for the purposes of the present invention. Addition- ally, other resample areas for the blue pixel data could be employed without departing from the scope of the present invention.~~

~~**[0037]**~~ These Figures are merely ~~illustrative~~illus- trative and only serve to provide an understanding of the relationship between the ~~resample~~resarriple points, ~~reconstruction~~reconstniction points, ~~resa- mple~~resample areas, and sub-pixel locations for this embodiment.

~~**[0038]**~~ The ~~sub pixel rendering techniques as described in the '355~~above referenced '058 patent application ~~can be~~describes the iiietliod used to convert the incoming data ~~format~~fonnat to that suitable for the display. In such a case, the ~~method proceeds~~iiietliodproceeds as follows: (1) determining implied sample areas for each data point of ~~incoming~~incorriing three-color pixel data; (2) determining ~~the~~a resample area for each color sub-pixel in the display; (~~.~~3) forming a set of ~~coedlcients~~coefficients for each ~~said~~ resample area, the ~~coefficients~~coef- ficients comprising fractions whose denominators are a ~~function of~~
ftnc- tioiof

the resample area and ~~the numerators~~whose nlirnerators are a function of an area of each ~~said~~ implied sample ~~areas~~area that may partially overlap the resample ~~areas~~area; (4) multiplying the incoming pixel data for each implied ~~sample~~sarriple area by the coefficient resulting in a product; and (5) adding each product to obtain ~~luminance~~luniinance values for each ~~resample~~resarriple area.

Exaiiiining a "one-to-one" format conversion case for the resample operation illustrated in FIG. 4D and 5D, the green plane conversion is a unity filter. The red and blue color planes use a 3x3 filter coefficient matrix, derived as explained in detail in the '058 application:

~~**[0039]** Other sub pixel rendering techniques are possible to employ with the various sub pixel arrangements as disclosed herein. For example, the techniques known as "adaptive filtering" may be employed in the same fashion as described in U.S. patent application Ser. No. 10/215,843, entitled "METHODS AND SYSTEMS FOR SUB PIXEL RENDERING WITH ADAPTIVE FILTERING," filed on Aug. 8, 2002, which is hereby incorporated herein by reference and commonly owned by the same assignee of this application. Adaptive filtering can be adopted so as not to require a 3x3 sample of input data, which uses a minimum of two lines of memory. The test may be based on a smaller sample of input data, for example 1x3 or 1x2 matrices. The input data is sampled to test for vertical or diagonal lines, dots and edges, or other high contrast features and then actions are taken, depending on the outcome of the tests.~~

~~[0040] Test masks may be used and compared to the image data~~

	0. l2i	
0.125		0.125
	0. l2i	

FIG. 5E illustrates the results of turning on two full color incoming data pixels. The two pixels are converted to two clusters of output sub-pixels, called "logical pixels" **500** and **501,** turned on at varying amplitudes. One of the logical pixels **500** is centered on or near a red sub-pixel **104.** The green sub-pixel **106** is set at 100% illumination. The red sub-pixel **104** is set to 50% illumination, while the four sur- rounding blue sub-pixels 102 are set to 12.5% each. The result is a white dot visible to the human eye, centered between the red 104 and the green 106 sub-pixels. The other logical pixel 501, centered on or near blue sub-pixel **102,** similarly has the green sub-pixel **106** set to **100%** and the near by blue stb- pixel **102** set to 50% with the four surrounding red sub-pixels **104** set at 12.5% each.

FIGS. 6B and 6C show an alternative blue color plane resaiiiple area array **602** and an alternative red color plane resample area array **604,** respectively,—shown herein as box filters ([0.5 0.5])—to replace the blue and red resample area arrays **402** and **404** of FIGS. 4B and 4C, respectively. FIG. 6D illustrates an inter-color-plane-phase relationship **610** using the green resample area array **406** of FIG. 4A, and blue and red resample area arrays **602** and **604.** FIG. 6A shows the logical pixels **600** and **601** that result front turning on two input data format pixels using the resample operation of the inter-color-plane-phase relationship **610** (FIG. 6D) front input data with a "one-to-one" pixel to green sub-pixel **106** mapping. These logical pixels **600** and **601** may be in the

same relative positions as the two logical pixels **500** and **501** in FIG. 5E. Also,

4.

6. 1

G>iiiax, then a register value is set to 1, otherwise the register value is set to 0; corripare the register values for three succes- sive green data points to test rriasks to see if an edge is detected; if detected then take an appropriate action to the red and/or blue data---e.g. apply gamma or apply a new value or different filter coefficient. ~~Otherwise, if no feature is detected, then no action may be taken.~~

The following table is illustrative of this embodiment:

Data (for 3 successive points	0.98	0.05	0.0
Low Test (G < 0 1)	0	1	1
High Test (G > 0.9)	1	0	0
Compare low and NOT high	Tue	Tn	Tne

For the example above, an edge has been detected and there is an array of options and/or actions to take at this point. For example, the gamma correction could be applied to the output of the box filter for red and/or blue; or a new fixed value representing the output required to balance color could be used; or use a new SPR filter.

The test for black lines, dots, edges and diagonal lines are siiiiilar in this case, since only three values are examined:

		Register Value		Binary no.
1.	1		1	5
2.	1	1		6
		1	1	

In the above table, the first row could represent a black pixel with white pixels on either side. The second row could represent an edge of a black line or dot. The third row could represent an edge o1 a black line in a different location. The binary numbers are used as an encoding for the test.

The test for white lines, dots, edges, and diagonal lines might be as follows:

Register vaJ ue			Binary no.
1			
	1		4

If the tests are true and the high and low tests are, for example, 240 and 16 (out of255) respectively, tlientlie output value for these edges using the box filter might be 128+/—4— or some other suitable value. The pattern matching is to the binary niiiiibers shown adjacent to the register values. A simple replacement of 128 raised to an appropriate lamina power could be output to the display. For exarriple, for gamma=2.2, the output value is approximately 186. Even though the input may vary, this is just an edge correction term so a fixed value can be used without noticeable error. Of course, for more precision, a gamma lookup table could like- wise be used. It should be appreciated that a different value, but possibly similar, of correction could be used for white and black edges. It should likewise be appreciated that as a result of detecting ari edge, the red and/or blue data could be acted on by a different set of filter coefficients---e.g. apply a [1 0] filter (i.e. unity filter) which would effectively turn off sub pixel rendering 1or that pixel value.

The above tests were primarily for a greentest, followed by action on red and blue. Alternatively, the red and blue can be tested separately and actions taken as needed. If one desired to only apply the correction for black and white edges, than all three color data sets can be tested and the result ANDed together.

A fi.irther simplification could be made as follows. If only two pixels in a row are tested for edges, then the test above is further simplified. High and low tliresliolding may still be accomplished. If [0 1] or [1 0] is detected, then a new value could be app1ied---otherwise the original value could be used. Yet another sirriplification could be accomplished as fol- lows (illustrated for the red): subtract the red data value, R,,, from the red value inliliediately to the left, R _,,; if the delta is greater than a predetermined number—say for example 240---then an edge is detected. If an edge is detected, one could substitute a new value, or apply ganiina, output the value R to the display, or apply new SPR filter coefficients; otherwise, if no edge is detected, output the results of the box filter to the display. As either R, or R,_, rriay be larger, the absolute value of the delta could be tested. The same simpli- fication could occur for the blue; but the green does not need to be tested or adjusted, il green is the split pixel in the grouping. .Alternatively, a different action could be taken for falling edges (i.e. R,—R,_,<0) and rising edges (i.e. R,—R,_,>0).

The results are logical pixels **600** and **601** that have only three sub-pixels each. For a white dot and using a box filter for red and blue data, the green sub-pixels **106** are set to 100% as before. The nearby red **104,** as well as the nearby blue **102,** could be all set to 50%. The resample operation of inter-color- plane-phase relationship **610** of FIG. 6D is very simple and inexpensive to inipleiiient, while still providing good image quality.

Both of the above data format conversion methods match the human eye by placing the center of logical pixels at the numerically superior green sub-pixels. The green sub-pixels are each seen as the same brightness as the red sub-pixel, even though half as wide. Each green sub-pixel **106** acts as though it were half the brightness of the associated logical pixel at every location, while the rest of the brightness is associated with the nearby red sub-pixel illuminated. Thus, the green serves to provide the bulk of the high resolution luminauce modulation, while the red and blue provide lower resolution color modulation, matching the human eye.

~~**[0041]**~~ FIG. ~~17~~7A illustrates ~~the results of turning on two full color incoming data pixels. The two pixels are converted to two clusters of sub pixels, called "logical pixels", turned on at varying amplitudes. The logical pixel on the left is centered on or near a green sub pixel **106.** The logical pixel on the right is centered on or near a red sub pixel **104.** In both logical pixels, the various sub pixels are turned on to the appropriate illumination such that a pleasing white color is formed and centered on the green and red sub pixels, respectively.~~an alternative inter-color-plane-phase relationship **700** using the green, blue, and red resaiiiple area arrays **406, 402** and **404** of FIGS. 4A, 4B, and 4C. Note that inter-color-plane-phaserelationsliip **700** has the same relative phase as color sub-pixel arrangement **100** of FIG. IC as illustrated in FIG. 7B. Note that the relative phases of the resample points of inter-color-plane-phase relationship **700** is the saiiie as that for inter-color-plane-phase relationship **610** of FIG. 6D. If this inter-color-plane-phase relationship **700** were used for the "one-to-one" data format conversion, the green would again be a unitary filter, while the red and blue would use 3x2 coefficient filter kernel:

~~**[0042]** Fics. EA and GB illustrate two possible schematics for a driver arrangement **800** for the arrangement of color emitter sub pixels in **FIG. 1. FIG. 8A** shows a one to one correspondence of column drivers to columns in the display; however, with the split blue sub pixels, it may be desirable to tie adjacent columns of split blue sub pixels via connec tions g2o. As may be seen in Flc. GB, this scheme has the advantage of saving on the number of column drivers.~~

~~**[0043]** For convenience, these examples given have the same number of sub pixels illustrated as **FIG. 1.** These drive arrangements may be used for a number of display tech nologies, as the blocks **810** may represent one or several electrical components. They may represent the capacitive display cell element for passively addressed Liquid Crystal Display (LCD), or ElectroLuminescent (EL) Display. It may represent the gaseous discharge element in a Plasma Display Panel (PDP). It may represent the semiconductor diode element of a passively Inorganic Light Emitting Diode or an Organic Light Emitting Diode Display. It may represent the transistor, storage capacitor, and capacitive cell element of an Active Matrix Liquid Crystal Display (AMLCD). It may represent the multi transistor, storage capacitor, and light emitting element of an Active Matrix Organic Light Emit ting Diode Display (AMOLED). It may represent, in gen eral, the color sub pixel and its associated electronic ele ments found in other known or yet to be invented display technologies.~~

~~[0044] Known drive timing and methods may be used for NxM drive matrices as those shown. However, there may be modifications needed due to the specific color assignments, particularly any checkerboard across the panel or color alternations within a single column. For example, the tech- nique known in the art as Multi Line Addressing for passive LCD may be modified such that groupings of rows are restricted to odd and even row combinations. This will reduce potential color cross talk since, within a column with two alternating color sub-pixels, only one color will be addressed at a time.~~

~~[0045] Inversion schemes, switching the electrical field polarity across the display cell to provide a time averaged zero net field and ion current across the cell can be used to the above unique sub-pixel arrangements. **FIGS. 9 and 10** (matching **FIG. 8A's** schematic) and **FIGS. 15 and 16** (matching FIG. GB's schematic) show two "dot inversion" schemes referred to as "2x1" and "1x1", respectively on Active Matrix Liquid Crystal Displays, both of which will perform satisfactorily. The scheme shown on **FIGS.** 9 **and** 15 may perform better when slight imbalances of light transmission occur between positive and negative polarities, especially when the eye is tracking the motion of displayed images moving across the screen. Each of the Figures shows the polarities during half of the display addressing fields. The polarities are reversed for the other half, alternating every field, resulting in a net zero current (zero DC bias), as is well known in the art.~~

0.0625	0.0625
0575	0.375
0.0625	0.0625

Note that the two columns add up to 0.5 each, similar to the coefficients for the red and blue resample filter operation for the inter-color-plane-phase relationship **610** of FIG. 6D.

This inter-color-plane-phase relationship **700** shown in FIG. 7A is usefiil for scaling, both up and down, of conven- tional format data sets. The area resample method of calcu- lation of the fitter coefficients and keeping track of the input and output data buffers was described in the referenced '058 application. However, according to another erribodiineiit, while the red and blue color planes may be area resanipled, it may be advantageous to calculate the filter coefficients for the square grid of green sub-pixels **106** using a novel implemen- tation of a bi-cubic interpolation algoritlun for scaling up data sets while converting them to be displayed on the arrange- ment of color sub-pixels **100** of FIG. lC.

~~[0046]~~ FIG. ~~**20**~~10 depicts a ~~system **2000**~~systems 1000 in which a display as ~~constructed~~con- structed in accordance with the various embodiments ~~disclosed~~dis- closed herein is driven by a sub-pixel rendering technique ~~**2004**~~**1004** which may be resident on a physical device ~~**2002**~~**1002.** An input image data stream ~~2oog~~**1008** may be input into the ~~sub pixel~~sub-pixel rendering ~~technique **2004**~~tecluiiqiie **1004** and converted in the ~~manner~~mariner herein disclosed. ~~An~~.ln output image data stream ~~**2010**~~**1010** is sent to the display device ~~**2006**~~**1006** in order to drive the various sub-pixels to form an image thereupon. .As discussed in several references incorporated herein, the sub-pixel ~~render- ing~~rendering (SPR) ~~technique **2004**~~tecluiiqtie **1004** may be implemented in either hardware and/or software or a combination thereof. For example, SPR techniques ~~**2004**~~**1004** could be resident as logic (either hardware or software) on the display itself or it could reside on a graphics controller chip or board.

FIGS. llA and HB depict two particular flowchart embodiments disclosing sub-pixel rendering in software and hardware respectively. In FIG. 11A, SPR may be accom- plished in advance on a PC or other processing system and/or means. Front there, the pre-rendered images could be down- loaded to a controller/interface and sent along to a drive running the display. In FIG. llB, image data rriay be input from many different sources—for example, a notebook PC with DVI output or a desktop with DVI output—to a hardware module doing SPR. Front there, the sub-pixel rendered data could be sent ultimately to the display via a controller/inter- face and a drive. Of course, other hardware and software implementations are possible and that FIGS. llA and 11B rrierely describe two possible such implementations.

FIG. 12 shows one particular display embodiment for a 320x320 STN display using the sub-pixel repeat cell as dis- closed herein. Although various sub-pixel dimensions are also disclosed in FIG. 12, it should be appreciated that other dimensions would also suffice and that FIG. 12 is merely offered for illustrative purposes for a single embodiment.

~~[0047] While~~\V1iile the invention has been described with ~~ref erence to exemplary~~reference to exeiiiplary embodiments, it will be understood ~~by those skilled in the art~~ that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings ~~without~~with- out departing from the ~~essen tial~~essential scope thereof. For example, ~~some~~sortie of the ~~embodiments~~eiiibodiinents above may be implemented in other display technologies such as Organic Light ~~Emitting~~Eiiiitting Diode (OLED), ~~ElectroLu- menscent~~ElectroLuinenscent (EL), Electrophoretic, Active Matrix Liquid ~~Crys- tal~~Crystal Display (.AMLCD), Passive Matrix Liquid Crystal ~~dis- play~~display (AMLCD), Incandescent, solid state Light Emitting Diode (LED), ~~Plasma~~Plasiiia Display Panel (PDP), and Iridescent. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode ~~con- templated~~conterriplated for carrying out this invention, but that the ~~inven- tion~~invention will include all ~~embodiments~~erribodiments falling within the scope of the appended claims.

~~What is~~The invention claimed is:

1. .A method of converting incoming three-color pixel data of a first format for rendering onto a display panel; said display panel comprising a plurality of a sub-pixel group; said sub-pixel group further ~~comprising~~corriprising eight ~~sulk pixels;~~sub-pixels; wherein

~~wherein~~ each said sub-pixel is one of a ~~red color sub-pixel, a green~~first color sub-pixel, a second color sub-pixel and a ~~blue~~third color ~~sub-pixel~~sub-pixel;

wherein said sub-pixel group ~~further comprises four sub-pixels of said blue color, two~~furthercoinprises four sub-pixels of said ~~red~~first color, two sub-p ixels of said second color and two sub-pixels of said ~~green~~third color; wherein ~~further~~fiirtlier said sub-pixels of said ~~red~~second color and said sub-pixels of said ~~green~~third color form substantially a ~~checkerboard pattern.~~clieckerboard patteni; the method comprising:

determining iiiiplied sample areas for each data point of said incoiiiing three-color pixel data;

determining a resample area for each color sub-pixel on said display panel;

forming a set of coefficients for each resample area, said coefficients comprising fractions whose denominators are a fiinction of the resample area and whose nlimera- tors are a function of an area ofeacli iiiiplied sample area that may partially overlap said resample area;

multiplying the incoming pixel data for each iiiiplied sample area by a coefficient resulting in a product; and adding each product to obtain a ltimiuauce value for said color sub-pixel on said display panel represented by each resample area.

2. The ~~display~~method as recited in claim 1 wherein ~~said sub-pixels of said blue color comprises a smaller area than said sub-pixels of said red color and said green color.~~a plurality of resample areas for each color sub-pixel in the display forints a resample area array, and wherein the iiietliod further con- prises:

determining a phase relationship among the resample area arrays for each color sub-pixel.

3. The methods as recited in claim 2 wherein determining a phase relationship fiirtlier comprises:

positioning resample points for each said color resaiiiple areas such that the resarriple points for said second color and said third color substantially overlay the resample points for said first color.

4. The method as recited in claim 1 wherein said first color is green, and said second and third colors are red and blue respectively;

wherein said set of coefficients for said resample areas for the green color comprises a unity filter; and

wherein said set of coelficents for said resample areas for the red and blue colors are each a 3x3 filter coefficient matrix.

5. The method as recited in claim 1 wherein said unity filter is centered to substantially iiiatcli an input pixel by adjusting said unity filter with respect to a sub-pixel grid.

~~3~~6. The ~~display~~iiietliod as recited in ~~claim~~claims 1 ~~where~~wherein said eight sub-pixels of said sub-pixel group ~~further comprises substantially~~are disposed in two rows ~~and~~of four ~~columns of~~ sub-pixels~~;~~, and

wherein ~~further a first set of two non-adjacent columns comprise four sub pixels of said blue color and a second set of two non-adjacent columns comprise~~ two sub-pixels of said ~~red color and two sub pixels of said green color~~first color, one sub-pixel of said second color and one sub-pixel of said third color are disposed in each of said two rows.

~~4. The display as recited in claim 3 wherein said two non-adjacent columns comprising four sub-pixels of said blue color are offset vertically from said two nonadjacent columns comprise two sub-pixels of said red color and two sub-pixels of said green color.~~

7. The method as recited in claim 1 wherein said eight sub-pixels of said sub-pixel group are disposed in two rows of four sub-pixels, and wherein said checkerboard patteni is formed by one of said sub-pixel of said second color follow- ing one of said sub-pixel of said third color in a first row, and one of said sub-pixel of said third color following one of said sub-pixel of said second color in a second row.

~~5~~8. The ~~display~~method as recited in claim 1 wherein ~~said sub pixels of said lalue color are interspersed said substantially formed checkerboard pattern of~~a coiiibined area of said two sub-pixels of said ~~red~~first color is substantially equal to the area of one of said sub-pixel of said second color and said ~~green~~sub-pixel of said third color.

~~6. The display as recited in claim 1 wherein said display is an active matrix liquid crystal display.~~

9. The method as recited in claim 1 wherein said eight sub-pixels of said sub-pixel group are disposed in two rows of four sub-pixels, and wherein said sub-pixels of said first color are disposed in coltunns in said sub-pixel group.

~~7~~10. The ~~display~~method as recited in claim ~~6~~9 wherein a first one of said ~~display applies a dot inversion scheme for driving the~~columns of said sub-pixels ~~in each sub pixel group.~~of said first color is offset

~~8. The display as recited in claim 7 wherein said dot inversion scheme is 1x1 dot inversion.~~

~~9. The display as recited in claim 7 wherein said dot inversion scheme is 2x1 dot inversion.~~

from a second one of said columns of said sub-pixels of said first color in said sub-pixel group.

11. The rriethod of claim 1 wherein said display panel is an element of a display system utilizing one of a group of display tecluiologies, said group of tecluiologies comprising pas- sively addressed Liquid Crystal Display (LCD), ElectroLu- minescent (EL) Display, Plasiiia Display, passively addressed Inorganic Light Emitting Diode, Organic Light Emitting Diode Display, Active Matrix Liquid Crystal Display (AM- LCD), and Active Matrix Organic Light Emitting Diode Dis- play (AMOLED).

12. A system comprising:

~~10.~~ ~~In~~ a display panel, said display panel comprising a plurality ~~of~~o1 a sub-pixel group; said sub-pixel group ~~further~~ comprising eight sub-pixels~~; wherein each said sub-pixel is one of a blue color sub-pixel, a red color sub-pixel and a green color sub-pixel; wherein said sub-pixel group further comprises~~ specifying an output data format; said stb- pixel group fhrtlier corripising four sub-pixels of ~~said blue~~a first color, two sub-pixels of ~~said red~~a second color and two ~~sub-pixels of said green color; wherein further~~stb- pixels of a third color; said sub-pixels of said ~~red~~second color and said sub-pixels of said ~~green~~third color ~~form~~ substantially ~~a checkerboard~~forming a clieckerboard pattern;

~~a method of converting a source pixel data of a first format for rendering onto said display comprising:~~

means for receiving input iiiiage data specified in an input data foriiiat different from said output data foriiiat; and means for subpixel rendering said input image data speci- fied in said input data foriiiat to said output data format of said plurality of sub-pixel groups on said display panel.

13. The system as recited in claim 12 wherein said means for slibpixel rendering input image data further coiiiprises:

~~determining~~means for deteniiining implied sample areas for each data point of ~~incoming three-color pixel~~said input iiiiage data;

rrleans for determining ~~the resample~~a resarriple area for each color ~~sub-pixel~~stb- pixel in the display;

means for forming a set of coefficients for each ~~the~~ resample area, said coefficients comprising fractions whose denominators are a ~~function of~~fi.inction o1 the resample area and ~~the numerators are a function~~whose ntiiiierators are a fiinction of an area of each ~~the~~ implied sample ~~areas~~area that may partially overlap said ~~resample areas~~resa- rriple area;

means for multiplying the ~~incoming pixel~~input image data for each implied sample area by ~~the~~a coefficient resulting in a ~~product~~prod- uct; and

means for adding each ~~the~~ product to obtain ~~luminance values~~a lliminance value for each ~~resample~~resaiiiple area.

~~11. The method as recited in claim 10 wherein determin- ing the resample area further comprises:~~

14. The systems as recited in claims 13 wherein a plurality of resarriple areas for each color sub-pixel in the display foniis a resample area array, and wherein the system further com- prises:

means for determining a phase relationship ~~between~~aiiiong the resample area armys for each color ~~subpixel~~sub-pixel.

~~12~~15. The ~~methods~~systems as recited in ~~claim 11~~claims 14 wherein ~~deter- iining~~means for detenninung a phase relationship ~~further~~flirtlier comprises:

iiieans for positioning ~~resample~~resarriple points for each said color ~~resample~~resarriple areas such that the resample points for said ~~red~~second color and said ~~green~~third color substantially overlay the resample points for said ~~blue~~first color.

~~13. In a display, said display comprising a plurality of a sub pixel group; said sub pixel group further comprising eight sub pixels; wherein each said sub pixel is one of a blue color sub-pixel, a red color sub-pixel and a green color sub pixel; wherein said sub pixel group further comprises four sub pixels of said lalue color, two sub-pixels of said red color and two sub pixels of said green color; wherein further said sub pixels of said red color and said sub pixels of said green color form substantially a checkerboard pattern;~~

~~a method of converting a source pixel data of a first format for rendering onto said display comprising:~~

~~inputting a set of color image data;~~

~~testing the input data for a plurality of conditions;~~

~~and taking appropriate actions in response to the outcome~~

~~of said testing of the input data.~~

~~14. The method as recited in claim 13 wherein said set of color image input data comprises a sample of a 1x3 matrix of input data.~~

~~15. The method as recited in claim 13 wherein said set of color image input data comprises a sample of a 1x2 matrix of input data.~~

16. The ~~method~~system as recited in claim 13 wherein ~~testing the input data for a plurality of conditions further comprises:~~said first color is green, and said second and third colors are red and blue respectively;

wherein said set of coefficients for said resample areas for the green color comprises a unity filter; and

wherein said set of coefficents for said resample areas for the red and blue colors are each a 3x3 filter coefficient matrix.

~~testing for the detection of a high contrast feature in the~~

~~input data.~~

17. The ~~method~~systems as recited in claim 16 wherein said ~~high contrast feature comprises one of a group, said group comprising an edge, a line, and a dot~~unity filter is centered to substantially iiiatcli an input pixel by adjusting said filter with respect to a sub-pixel grid.

~~18. The method as recited in claim 13 wherein taking appropriate actions in response to the outcome of said testing of the input data further comprises:~~

~~substituting a new color data value for the current color~~

~~data value.~~

~~19. The method as recited in claim 13 wherein taking appropriate actions in response to the outcome of said testing of the input data further comprises:~~

~~applying gamma correction to the current color data value.~~

~~20. The method as recited in claim 13 wherein taking appropriate actions in response to the outcome of said testing of the input data further comprises:~~

~~apply new sub pixel rendering filter coefficients to the input data.~~

~~21. A system comprising:~~

18. The system as recited in claim 12 wherein said eight sub-pixels of said sub-pixel group are disposed in two rows of foitr sub-pixels, and wherein two sub-pixels of said first color, one sub-pixel of said second color and one sub-pixel of said third color are disposed in each of said two rows.

19. The system as recited in claim 12 wherein said eight sub-pixels of said sub-pixel group are disposed in two rows of four sub-pixels, and wherein said clieckerboard pattern is donned by one of said sub-pixel of said second color follow- ing one of said sub-pixel of said third color in a first row, and one of said sub-pixel of said third color following one of said sub-pixel of said second color in a second row.

20. The system as recited in claim 12 wherein a combined area of said two sub-pixels of said first color is substantially equal to the area of one of said sub-pixel of said second color and said sub-pixel of said third color.

21. The system as recited in claim 12 wherein said eight sub-pixels of said sub-pixel group are disposed in two rows of four sub-pixels, and wherein said sub-pixels of said first color are disposed in columns in said sub-pixel group.

22. The system as recited in claim 21 wherein a first one of said columns of said sub-pixels of said first color is offset front a second one of said columns of said sub-pixels of said first color in said sub-pixel group.

23. The system as recited in claim 12 wherein said system utilizes one of a group of display technologies, said group of tecluiologies comprising passively addressed Liquid Crystal Display (LCD), ElectroLuminescent (EL) Display, Plasma Display, passively addressed Inorganic Light Eiiiitting Diode, Organic Light Erriitting Diode Display, Active Matrix Liquid Crystal Display (AMLCD), arid Active Matrix Organic Light Emitting Diode Display (AMOLED).

24. A method of rendering input image data specified in a first fonnat comprising first, second and third color data val- tes onto a display panel substantially coiiiprising a sub-pixel repeating group comprising eight sub-pixels of first, second and third colors disposed in two rows; said sub-pixel repeat- ing group filrtlier comprising two sub-pixels of said first color, one sub-pixel of said second color and one sub-pixel of said third color disposed in each of said two rows; the method comprising:

determining a plurality of input saiiiple areas for said input image data; each said input saiiiple area representing one input intake pixel indicating first, second and third color data values in said input image data;

determining a first color resample area array for said first color sub-pixels on the display panel; said first color resarriple area array comprising a plurality of first color resarriple areas each comprising a first color resample point such that one first color resarriple point represents one first color sub-pixel on the display panel;

for each first color resample point in said first color resa- mple area array, assigning said first color data value of said one input image pixel represented by a correspond- ing implied sample area to a first lurliinance value for said first color sub-pixel represented by said first color resarriple point;

determining a second color resarriple area array and a third color resample area array for said respective second color and third color sub-pixels on the display panel; each of said second color and third color resample area arrays comprising a plurality of respective second color and third color resarriple areas each comprising respec- tive second color and third color resarriple points such that one second color resarriple point represents one second color sub-pixel on the display panel and one third colorresarriple point represents one third color sub-pixel on the display panel;

computing a set of coefficients for each of said second color resample areas and said third color resample areas, said coefficients comprising fractions whose denomina- tors are a function of the respective resample area and whose niiiiierators are a fhnction of any partial area of each input sample area that may overlap said respective resample area when said respective resample area array overlays said input sample areas; and

producing a second luniinance value and a third luminance value for each respective second color sub-pixel and third color sub-pixel on the display panel by multiplying respective ones of said coefficients of a corresponding resample area by respective second color and third color data values of the input iiiiage data ior each input sample area overlaid by said resample area, and adding the resulting products.

~~a display, said display comprising a plurality of a sub pixel group~~25. The method as recited in claim 24 wherein said first color is green, said second color is red and said third color is blue; said sub-pixel repeating group ~~further~~ comprising ~~eight~~two green sub-pixels~~; wherein each said sub pixel is one of~~, one blue sub-pixel and one red sub-pixel disposed in each of said two rows.

26. The method as recited in claim 25 wherein a combined area of said two green sub-pixels disposed in each row is substantially equal to the area of one of said blue sub-pixel and said red sub-pixel.

~~a blue color sub pixel, a red color sub pixel and a green color sub pixel;~~27. The method as recited in claims 24 wherein said first color is green, and wherein said sub-pixel repeating group ~~further comprises~~corriprises four green sub-pixels ~~of said blue color, two sub~~disposed in columns in said sub-pixel repeating group.

28. The method as recited in claim 24 wherein said stb- pixels of said ~~red~~second color ~~and two sub pixels of said green color; wherein further said sub pixels of said red color~~ and said sub-pixels of said ~~green~~third color form ~~substan tially a checLerboard pattern; and~~substantially a clieckerboard pattern in said two rows such that a sub-pixel of said second color is followed by a sub-pixel of said third color in said first row, and a sub-pixel of said third color is followed by a sub-pixel of said second color in said second row.

29. The method as recited in claim 24 wherein each of said respective second color and third color resample areas over- laps at least two partial rows of input sample areas represent- ing input image pixels in said input iiiiage data.

30. The method as recited in claims 24 wherein each of said respective second color and third color resample areas over- laps at most one partial row of input sample areas represent- ing input image pixels in said input image data.

31. The method as recited in claim 24 wherein a plurality of said respective second color and third color resample areas has a diamond shape.

32. The method as recited in claims 24 flirtlier coiiiprising determining a phase relationship among said first, second and third resample area arrays.

33. The method as recited in claim 32 wherein determining a phase relationship among said first, second and third resa- mple area arrays comprises positioning said first, second and third color resample points for each respective first, second and third color resample area such that said first, second and third color resample points are substantially coincident.

34. The rriethod as recited in claim 32 wherein determining a phase relationship among said first, second and third resa- mple area arrays comprises positioning said first, second and third color resample points for each respective first, second and third color resample area such that none of said first, second and third color resample points are substantially coin- cident.

35. The method as recited in claim 24 wherein the step of corriputing a set of coefficients for each of said second color resample areas and said third color resarriple areas comprises computing a 3x3 filter coefficient matrix having the values

(Add 0.0625 0.0625 0.373 0.062 .

means for subpixel rendering input image data.

22. The system as recited in claim 21 wherein said means for subpixel rendering input data further comprises:

means for inputting a set of color image data;

means for testing the input data for a plurality of condi tions; and

means for taking appropriate actions in response to the outcome of said testing of the input data.

23. The system as recited in claim 22 wherein said set of color image input data comprises a sample of a 1x3 matrix of input data.

24. The system as recited in claim 22 wherein said set of color image input data comprises a sample of a 1x2 matrix of input data.

25. The system as recited in claim 22 wherein said means for testing the input data for a plurality of conditions further comprises:

means for testing for the detection of a high contrast feature in the input data.

26. The system as recited in claim 25 wherein said high contrast feature comprises one of a group, said group comprising an edge, a line, and a dot.

27. The system as recited in claim 22 wherein means for taking appropriate actions in response to the outcome of said testing of the input data further comprises:

means for substituting a new color data value for the current color data value.

28. The system as recited in claim 22 wherein means for taking appropriate actions in response to the outcome of said testing of the input data further comprises:

means for applying gamma correction to the current color data value.

29. The system as recited in claim 22 wherein means for taking appropriate actions in response to the outcome of said testing of the input data further comprises:

means for applying new sub-pixel rendering filter coef ficients to the input data.

30. The system as recited in claim 21 wherein said means for subpixel rendering input data further comprises:

means for determining implied sample areas for each data point of incoming three-color pixel data;

means for determining the resample area for each color sub-pixel in the display;

means for forming a set of coefficients for each the resample area, said coefficients comprising fractions whose denominators are a function of the resample area and the numerators are a function of an area of each the implied sample areas that may partially overlap said resample areas;

means for multiplying the incoming pixel data for each implied sample area by the coelficient resulting in a product; and

means for adding each the product to obtain luininance values for each resample area.

0.125 0.125 0

0.125 0.12 0.125

0.

37. The metliodof claini 24 wherein said display panel is an element ofa display system utilizing one of a group of display technologies, said group of

technologies comprising pas-sively addressed Liquid Crystal Display (LCD), ElectroLti-niinescent(EL) Display, Plasma Display, passively addressed Inorganic Light Emitting Diode, Organic Light Emitting Diode Display, Active Matrix Liquid Crystal Display (AM- LCD), and Active Matrix Organic Light Emitting Diode Dis- play (AMOLED).

36. The method as recited in claim 24 wherein the step of computing a set of coefficients for each of said second color resample areas and said third color resainple areas coiiiprises computing a 3x2 filter coefficient matrix having the values

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Embedded Excel	0
Format changes	0
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