Title: CONVERSION OF INPUT IMAGE DATA FOR DIFFERENT DISPLAY DEVICES

Abstract: A method, computer-readable medium and system for manipulating image data are disclosed. The method includes accessing first image data (3) configured for display using a first display device; accessing information associated with a manipulation of the first image data; and using the information and the first image data to generate second image data (101, 102) configured for display using a second display device. The first and second display devices may each include one of multilayer displays, stereoscopic displays, and 2D displays. Examples include the conversion of input data to multilayer display data comprising depth cues, and vice versa; and the conversion of input data to stereoscopic data configured for a multilayer display, via the display of interleaved image data on one screen (24a) and a parallax barrier on the other screen (24b).
CONVERSION OF INPUT IMAGE DATA FOR DIFFERENT DISPLAY DEVICES

RELATED APPLICATIONS
The present application claims the benefit of New Zealand Patent Application Number 576977, filed May 14, 2009, and assigned to the assignee of the present invention, and also claims the benefit of Japanese Patent Application Number 2009-127521, filed May 27, 2009, and assigned to the assignee of the present invention. Each of these applications is incorporated herein by reference in their entirety and for all purposes.

BACKGROUND OF THE INVENTION
Electronic display technology for displaying graphical images and/or text has evolved dramatically to meet the pervasive user demand for more realistic and interactive displays. A wide range of display technologies with differing capabilities are now available including: cathode ray tube (CRT); bistable display; electronic paper; nixie tube displays; vector display; flat panel display; vacuum fluorescent display (VF); light-emitting diode (LED) displays; ELD; plasma display panels (PDP); liquid crystal display (LCD) such as HPA display and thin-film transistor displays (TFT); organic light-emitting diode displays (OLED); surface-conduction electron-emitter display (SED) (experimental); laser TV (forthcoming); carbon nanotubes (experimental); and nanocrystal displays (experimental) which use quantum dots to make vibrant, flexible screens.

Further adaptations have been made to achieve enhanced visual effects using this technology, e.g. Stereoscopic and Multi-Layer Displays (MLD). Stereoscopic and auto stereoscopic displays provide the appearance of a 3D image by providing slightly different visual images to the left and right eyes of the viewer to utilize the binocular capabilities of the human visual system.

MLD systems use multiple layered screens aligned parallel with each other in a stacked arrangement with a physical separation between each screen.
Each screen is capable of displaying images. Thus, multiple images separated by a physical separation or "depth" can be displayed on one display. PCT Publication No. WO 99/42889 discloses such an MLD in which depth is created by displaying images on the background screen furthest from the viewer which will appear at some depth behind images displayed on the screen(s) closer to the user. The benefits of MLDs, in particular those utilizing the technology described in the PCT Publication Nos. WO 99/42889 and WO 99/44095 are gaining increasingly widespread recognition and acceptance due to their enhanced capabilities compared to conventional single focal plane displays (SLD).

The benefits of MLDs are especially germane to displays using liquid crystal displays (LCD), though MLDs can also be formed using other display technologies, e.g. an LCD front screen may be layered in front of an OLED rear screen.

There are two main types of Liquid Crystal Displays used in computer monitors, passive matrix and active matrix. Passive-matrix Liquid Crystal Displays use a simple grid to supply the charge to a particular pixel on the display. Creating the grid starts with two glass layers called substrates. One substrate is given columns and the other is given rows made from a transparent conductive material. This is usually indium tin oxide. The rows or columns are connected to integrated circuits that control when a charge is sent down a particular column or row. The liquid crystal material is sandwiched between the two glass substrates, and a polarizing film is added to the outer side of each substrate.

A pixel is defined as the smallest resolvable area of an image, either on a screen or stored in memory. Each pixel in a monochrome image has its own brightness, from 0 for black to the maximum value (e.g. 255 for an eight-bit pixel) for white. In a color image, each pixel has its own brightness and color, usually represented as a triple of red, green and blue intensities. To turn on a pixel, the
integrated circuit sends a charge down the correct column of one substrate and a
ground activated on the correct row of the other. The row and column intersect at
the designated pixel and that delivers the voltage to untwist the liquid crystals at
that pixel.

The passive matrix system has significant drawbacks, notably slow
response time and imprecise voltage control. Response time refers to the Liquid
Crystal Displays ability to refresh the image displayed. Imprecise voltage control
hinders the passive matrix's ability to influence only one pixel at a time. When
voltage is applied to untwist one pixel, the pixels around it also partially untwist,
which makes images appear fuzzy and lacking in contrast. Active-matrix Liquid
Crystal Displays depend on thin film transistors (TFT). Thin film transistors are
tiny switching transistors and capacitors. They are arranged in a matrix on a
glass substrate.

To address a particular pixel, the proper row is switched on, and then a
charge is sent down the correct column. Since all of the other rows that the
column intersects are turned off, only the capacitor at the designated pixel
receives a charge. The capacitor is able to hold the charge until the next refresh
cycle. And if the amount of voltage supplied to the crystal is carefully controlled, it
can be made to untwist only enough to allow some light through. By doing this in
very exact, very small increments, Liquid Crystal Displays can create a grey
scale.

Most displays today offer 256 levels of brightness per pixel. A Liquid
Crystal Display that can show colors must have three sub-pixels with red, green
and blue color filters to create each color pixel. Through the careful control and
variation of the voltage applied, the intensity of each sub-pixel can range over
256 shades. Combining the sub-pixel produces a possible palette of 16.8 million
colors (256 shades of red x 256 shades of green x 256 shades of blue). Liquid
Crystal Displays employ several variations of liquid crystal technology, including
super twisted nematics, dual scan twisted nematics, ferroelectric liquid crystal and surface stabilized ferroelectric liquid crystal. They can be lit using ambient light in which case they are termed as reflective, backlit and termed transmissive, or a combination of backlit and reflective and called transflective.

There are also emissive technologies such as Organic Light Emitting Diodes, and technologies which project an image directly onto the back of the retina which are addressed in the same manner as Liquid Crystal Displays. These devices are described hereafter as LCD panels.

However, the adoption of many display content types, including display content for stereoscopic and MLD displays has been hampered by the need to custom-build computer software applications and display controllers to suit the particular display-type. For example, a user that has an MLD may be limited to using custom designed software and hardware controllers as the MLD software and controllers may not be able to display other types of display content correctly. Conversely, the MLD software and controllers are purpose-built for the MLD and thus images designed for an MLD generally cannot be displayed correctly on SLDs or stereoscopic displays.
SUMMARY OF THE INVENTION

It would thus be advantageous to provide a display and corresponding software/hardware capable of displaying multiple different display content types. It would also be advantageous to provide an improved means for displaying images and visual effects designed for one display type on another display type.

It is an object of the present invention to address the foregoing problems or at least to provide the public with a useful choice.

It is acknowledged that the term 'comprise' may, under varying jurisdictions, be attributed with either an exclusive or an inclusive meaning. For the purpose of this specification, and unless otherwise noted, the term "comprise" shall have an inclusive meaning - i.e. that it will be taken to mean an inclusion of not only the listed components it directly references, but also other non-specified components or elements. This rationale will also be used when the term "comprised" or "comprising" is used in relation to one or more steps in a method or process.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.

The following terminology will be used throughout the specification and the intended meaning of each term is described below.

It will be appreciated that as used herein, the term "image" may refer to any visible effect, including a graphical image, object, text, pattern, symbol, design, shadow or other visible effect. The term "image data" may refer to any information or data specifying an aspect, facet or parameter of an image or part thereof, e.g. position, size, shape, orientation, color, contrast, brightness, intensity, hue, position, shading, depth, or any other aspect facet or parameter. The term "manipulating", "manipulate" and "manipulation" may include
conversion, duplication, interpretation, processing, deleting, copying, splicing, interlacing, transferring, transmitting, transposing and/or re-arranging of image data. The term "display content type" may refer to the type of display content which an image is displayed as, e.g., stereoscopic, 2D, 3D, 2D with depth cues, MLD effect, stereoscopic, auto-stereoscopic, holographic or any other type of display content. The term "display system" may refer to any display system including one or more electronic display layers capable of generating a visible image and may include, by way of example, one or more display layers formed from a: Cathode Ray Tube (CRT), Liquid Crystal Display (LCD), Organic Light Emitting Diode (OLED), Light Emitting Diode (LED), Plasma display panels (PDP), Surface-conduction electron-emitter display (SED), Laser TV, or any other known or future display technology.

It should be appreciated that herein a Multi Layered Display (MLD) may be referred to as having display "layers", "screens", "panels" or the like and these terms may be used interchangeably to refer to the different layers of the MLD that are capable of displaying an image.

According to one aspect of the present invention there is provided a method of manipulating input image data relating to an input image of a first display content type to generate an output image of a second display content type for display on a display system, the method including retrieving metadata specifying the second display content type, using a content engine to process the metadata and manipulate the input image data to generate the output image, and wherein the content engine outputs a data signal for generating the output image on the display system.

In one embodiment, the method can use a computer system which has a system memory coupled by a bus to a processor, and wherein the system memory stores computer readable instructions providing the content engine for manipulating the input image data and outputting the data signal.
The method may provide means for converting an input image of one display content type into an output image of another display content type by using metadata that specifies the second display content type and therefore how the image is intended to be displayed on the display system. The second display content type may be a visual effect applied to the first image (then displayed as the output image) to alter the visual appearance for entertainment, quality enhancement, information-conveyance or other purpose. Accordingly, the method may be used with one type of display system for viewing content designed for another type of display system, e.g. 2D images designed for a 2D display may be viewed as a multi layered image on an MLD.

Although the first and second display content types may be different in one embodiment, it should be appreciated that in some applications the first image may be displayed without alteration, e.g., the first image may be a stereoscopic image to be displayed as a stereoscopic image on the display system. In such applications, the content engine may be capable of manipulating the input image data such that the first and output images are of the same display content type, e.g., the first and second display content types are the same. Thus, in one embodiment, the content engine is configured such that no metadata is received and the content engine generates the output image in the first display content type. In one embodiment, the metadata may specify the output image is to be of the same display content type as the input image and the content engine is configured to generate the output image in the first display content type.

While reference herein has made to the input and output images in the singular, it should be appreciated that multiple input and output images may be used.
In one embodiment of the present invention, computer software includes a content engine for executing image data manipulation of input image data (e.g., relating to an input image of a first display content type) to generate an output image of a second display content type for display on a display system. The content engine may be embodied in computer-readable instructions including one or more image data manipulation algorithms which are executable to: process the input image data and metadata specifying the second display content type; and generate a data signal for generating the output image for display on the display system.

The metadata preferably specifies the second display content type such that the content engine can execute corresponding image data manipulation algorithms for generating a data signal with the output image. The metadata may "specify" the second display content type by including reference to a particular second display content type and/or a particular manipulation of the input image data. For example, in one embodiment, the metadata may designate pixels as being LEFT/RIGHT and/or FRONT/REAR pixels. The content engine can thus split the input image into LEFT/RIGHT and/or FRONT/REAR pixel groups and generate an output image data signal accordingly.

In one embodiment, the metadata may vary for each combination of the first and second display content types. For example, a 2D input image to be displayed as a multi-layered "output image" will be manipulated in a different way than a multi-layered input image to be displayed as a Stereoscopic output image.

In one embodiment, the first display content type may include one or more of the following display content types: 2D; 2D with depth map; 3D Object Data; multi-layered; stereoscopic; and enhanced color and/or contrast. In one embodiment, the second display content type may include one or more of the following display content types: 2D; 2D with depth map; 3D Object Data; multi-layered; stereoscopic; and enhanced color and/or contrast.
The content engine may include an image data manipulation algorithm for at least one combination of first and second display content types. Alternatively, the content engine may include an image data manipulation algorithm for a combination of first and second display content types. In one embodiment, the content engine may include a Hardware Identification Algorithm that automatically detects the type of display system and runs appropriate image data manipulation algorithms accordingly.

2D or two-dimensional images may be a conventional display content type which displays a 2D image on a display layer. The image data for forming a 2D image on a display layer may include the particular pixels forming the image and the visual characteristics, e.g., color, brightness etc. of those pixels.

2D images can also have "depth cues" applied to the image to give the appearance of depth. Such depth cues may include, by way of example, shading, perspective, motion parallax, relative size, occlusion (overlapping image blocking overlapped image), "distance fog," texture gradients or the like. A "2D depth cue" may be any 2D effect that provides a depth perception to a viewer and should not be seen to be limited to the examples provided herein. The depth cues applied to an image may form a "depth map" which provides a 2D map of the apparent depth of each part of the image.

The input image data may be provided in the form of 3D object data which may include not only the 2D information, e.g., x and/or y coordinate data, but also depth information (z-data), of particular image parts. The 3D object data may for example include voxel information of a 3D image. A 3D object can be displayed on a conventional 2D display screen using 3D simulation techniques such as depth cues as described above.
An MLD may include at least a first and second display layer, each capable of displaying an image using a first and second plurality of pixels, respectively. The first and second display layers may overlap and have at least a portion capable of being made substantially transparent such that a viewer can look through one of the display layers to view the other display layer.

In one embodiment, the first and second display layers may be referred to as "front" and "rear" display layers. However, it should be appreciated that the MLD may include more than two display layers and thus reference to "front" and "rear" should not be seen to be limiting. In one embodiment, the particular images displayed on the "front" and "rear" display layers may be interchangeable to achieve the same visual effect, e.g., the "front" and "rear" image (e.g., of enhanced color, enhanced contrast, stereoscopic display content type, etc. which is displayed using an MLD system) may be swapped while achieving a similar visual appearance.

The multi-layered display content type can therefore be used to show overlapping images on multiple overlapping layers. As the images displayed on the display layers are physically separated, images on the front display layer are closer to the viewer than images on the rear display layer. In addition to this multi-layered image effect, there are also numerous other visual effects achievable by using a MLD. For example, an MLD may be used to implement: a multi-layered Graphical User Interface (GUI) where different parts of the GUI are displayed on different display layers; Advanced White Silhouetting (AWS) as described in NZ patent application No. 570812; overall opacity control with alpha blending of back or front colored silhouette as described in PCT Publication No. WO 07/40413; 2D Gradient Blending which involves displaying parts of a 2D image on front and rear display layers to create an overlapping portion or "blending" of the image between the two display layers, where the ratio by which the image is split between front and rear display layers defines the gradient; 3D Gradient Blending which provides "Depth Fusion," e.g., a visual effect that uses
depth information (z-axis) to display a volume object that appears "fused" or continuously extends between the front and rear display layers, as described in PCT Publication No. WO 03/40820; "jumping" which involves moving an image from the rear to front layers and/or vice versa (and optionally repeating) to draw the users attention to the image as described in PCT Publication No. WO 03/23491; perspective "jumping" which involves moving images between layers on portions which do not directly overlap (e.g., the images move to the other layers at an angle to provide perspective to emphasize the depth between layers); clear split where images on different display layers do not overlap; separate image overlays where an annotation or other descriptor overlaps an image on another display layer; masking visible MLD Area which involves providing localized areas of multi-layered images on the display system to provide a visual appearance that these areas are "deeper" than the rest of the display; layered distortion effects including lens effects, fish eye lens, magnifying effects, reflections and shadowing, etc.; layered particle effects where small pixel images are dispersed across the front and/or rear display layers to provide an enhanced perceived volumetric appearance of the images displayed; suggestive volume techniques which involve using conventional depth cues (e.g., shading) in combination with layering to convey a greater perception of depth; enhanced color and/or contrast control as described in PCT Publication No. WO 04/002143; multi view where the images on the front and rear display layers are displayed such that they can only be viewed from different viewing angles as described in PCT Publication No. WO 04/036286.

The MLD technique referred to herein as "Depth Fusion," provides a visual effect that uses depth information (z-axis) of a 2D input image to display an output image that appears to show a volume object that appears "fused" or continuously extends between the front and rear display layers.

Thus, in one embodiment, an input image with input image data comprising color and/or brightness values and depth values may be converted to
display on an MLD as a depth fusion output image comprising front and rear images using data manipulation of the input image data, wherein said data manipulation may include:

processing said depth values to calculate a color and/or brightness split-ratio of at least one portion of the input image, said split-ratio specifying the first and second proportions of the color and/or brightness values of said input image portion that are to be respectively displayed as said front and rear images.

Preferably, the front and rear images are then respectively displayed on front and rear display layers.

Enhanced color and/or contrast (ECC) refers to techniques using an MLD system to achieve a color gamut and/or contrast that is higher than a comparable single image on a single display layer. For example, color of a first image may be improved by displaying a second image behind the first image, where the second image duplicates all or part of the first image. In one embodiment, the rear image may have no black pixels and/or may be "blurred" to reduce interference effects. The output image presented to the viewer thus appears to be a single image with an "enhanced" level of color since the light effectively travels through two pixels of the same color.

As another example, contrast of a first image may be improved by displaying a second image behind the first image, where the second image is essentially a grayscale duplicate of the first image. The resultant image thus appears to be a single image with an "enhanced" level of contrast.

As yet another example, both effects can be combined by displaying a second image behind a first image, where the second image is a combined grayscale and blurred color "copy" of the first image. Accordingly, the resultant image may have enhanced color an enhanced contrast.
Another example of an ECC technique is herein referred to as "Colorimetric ECC" and involves converting the input image data into the XYZ color space and applying a colorimetric color transformation to thereby display the image on the front panel with a more accurate reproduction of colors than with the aforementioned ECC technique. The colorimetric ECC technique takes into account the hardware profile of the display and thereby reduces the detrimental off-axis effects of 'haloing' which may be present when using the standard ECC technique above.

Typical display panels are capable of producing midtone colors accurately but may not accurately reproduce saturated colors of the source image. Thus, in another embodiment, an input image may be displayed on a front display layer of an MLD, wherein a rear image may also displayed on the rear display layer behind the input image on the front display layer, wherein pixels on the rear display layer in positions where the displayed output image (formed form front and rear images on respective display layers) is to have mid-tone colors are made white/transparent whereas pixels forming the rear image overlapped by front display layer pixels in positions where the displayed output image is to have saturated colors are displayed in color. Thus, the rear display layer can be used to enhance the color of saturated colors while maximizing light transfer to midtone colors which do not require enhancing.

It will be appreciated that black pixels may also be enhanced, though preferably, only the very dark shades are enhanced by displaying dark pixels on the overlapped rear display layer. This ECC technique may thus produce an output image with accurate reproduction of colors as the rear display layer minimizes interference with the front image by only displaying colored or black pixels behind predominantly only the saturated colors or darkest pixels.

Similarly, to improve contrast, an input image may be displayed on a front display layer of an MLD, wherein a rear image may also displayed on the rear
display layer behind the input image on the front display layer, wherein pixels on the rear display layer in positions where the displayed output image (formed from front and rear images) is to have mid-tone colors are made white/transparent whereas pixels forming the rear image overlapped by pixels in positions where the displayed output image is to have saturated colors are displayed in black or grayscale. Thus, the rear display layer can be used to enhance the contrast of the output image while maximizing light transfer to midtone colors which do not require enhancing.

In another embodiment, if the color of all the parts of the input image all fall within the gamut of a single panel of the MLD, then the overlapped pixels of the rear display layer may be made fully transparent/white.

Another technique for enhancing color is referred to herein Color Gamut Enhancement (CGE) and may compensate for display layers with a low color gamut. Color Gamut Enhancement may include in one embodiment, an input image displayed on a front display layer of an MLD, wherein a rear image may also displayed on the rear display layer behind the input image on the front display layer, wherein pixels on the rear display layer in positions where the displayed output image (formed from front and rear images on respective display layers) is to have mid-tone colors are made white/transparent whereas pixels forming the rear image overlapped by front display layer pixels in positions where the displayed output image is to have saturated colors are displayed as duplicates of the overlapping pixels of the front display layer.

Preferably each portion of the input image is converted from RGB to YUV color-space and Y is increased on the rear display layer until RGB is maximized. Thus, Color Gamut Enhancement may improve the color gamut by duplicating colors on both layers of the MLD, but luminance on rear panel is kept uniform and neutral to reduce interference between the display layers.
In some applications a multi layered display (MLD) may not include multiple color display layers and may instead include e.g. one color display layer overlapping a monochrome display layer. When a monochrome pixel is set to white it transmits ideally 100% of the light from the illumination source. In contrast, when a color pixel is set to white the three (R, G and B) coloured sub-pixels used only transmit about a third of the light from the illumination source, e.g. the R sub-pixel only lets through red, and blocks green and blue and similarly for the G and B sub-pixels. Thus, an MLD with a color display layer and a monochrome display layer may provide images with a higher light transmission and therefore, may require less power to display images at the same brightness levels as a comparable MLD with multiple color display layers.

In one embodiment, an input image that is an MLD color image comprising front and rear images may be converted to display on an MLD with a monochrome display layer and a color display layer using data manipulation of the input image data, wherein said data manipulation may include:

- calculating total color of at least a portion of the input image by multiplying color values of the front and rear images,
- calculating grayscale values of at least said portion of the front and/or rear input image.

Preferably, a first output image is displayed on said color display layer and a second output image is displayed on said monochrome display layer, wherein said first output image includes said input image with said calculated total color values divided by said grayscale values and said second output image is displayed with said grayscale values.

Preferably, said monochrome display layer is a rear display layer.

In an alternative embodiment, an input image that is an MLD color image comprising front and rear input images may be converted to display on an MLD
with a monochrome display layer and a color display layer using data manipulation of the input image data, wherein said data manipulation may include:

- converting said input image data into Hue, Saturation Value (HSV) color-space,
- calculating saturation values of at least a portion of said input image by adding saturation values of corresponding portions said front and rear images,
- converting said calculated saturation values to RGB color-space,
- calculating grayscale values of at least said portion of the front or rear input image.

Preferably, a first output image is displayed on said color display layer and a second output image is displayed on said monochrome display layer, wherein said first output image includes said input image with said calculated saturated RGB color values and said second output image is displayed with said grayscale values. Preferably, said monochrome display layer is a front display layer.

In a further embodiment, where said input image includes an MLD input image with Enhanced Color and/or Contrast (ECC) said data manipulation includes reducing said saturation values to 100% if said saturation values exceed 100%.

Another MLD display technique is referred to herein as "double frame rate" and can be used to display an output image that is an additive combination of front and rear input images. In one embodiment, an input MLD image comprising front and rear input images is converted to double-frame rate output images using data manipulation of input image data relating to said input MLD image, wherein said data manipulation includes assigning a temporal value to said front image that is different to a temporal value of said rear image.

Preferably, the double-frame rate output image is displayed by:
a) displaying the front image on said front display layer and
simultaneously making said rear display layer transparent, and then
b) sequentially displaying the rear image on said rear display layer
and simultaneously making said front display layer transparent, and
c) repeating steps a) and b).

It will be appreciated that steps a) and b) may be reversed.

The double frame rate technique of display may result in the images on
the front display layer appearing more opaque as there is no simultaneous
display of overlapping images. Furthermore, lighter objects may be displayed in
front of darker objects without interference.

Another MLD display technique is referred to herein as "occlusion" and
may be used to make an image on the front display layer appear more opaque.
In one embodiment, an input MLD image comprising front and rear input images
is converted to an output image using data manipulation of input image data
relating to said input MLD image, wherein said data manipulation includes:
copying said rear input image to create two said rear images, blurring or
sharpening one of said rear images and respectively sharpening or blurring the
other of said rear images to create a blurred copy of the rear image and a
sharpened copy of the rear image, and
copying said front input image to create two said front images, blurring or
sharpening one of said front images and respectively sharpening or blurring the
other of said front images to create a blurred copy of the front image and a
sharpened copy of the front image.

Preferably, the sharpened rear image is displayed on the rear display
layer and the blurred rear image is displayed on the front display layer.

Preferably, the sharpened front image is displayed on the front display layer and
the blurred front image is displayed on the rear display layer.
Preferably, the front image is masked in the alpha channel so the blurred copy can be projected onto the rear display layer.

As overlapping portions of the images on the front and rear display layers will multiply together to create the output image, some color values may need to be compensated for so that the output image has the same colors as the input image.

Thus, in one embodiment, the blurred copy of the front and/or rear images is created by manipulating the input image data by respectively blurring the front and/or image and then taking the square root of the blurred values to create blurred copy values.

In a further embodiment, the sharpened copy of the front and/or rear images is created by manipulating the input image data by respectively sharpening the front and/or image and then dividing by the square root of the blurred values to create sharpened copy values.

Another display technique is referred to herein as "occfusion" and combines the concepts of the "depth fusion" and "occlusion" techniques described above to convert a 2D input image into an MLD output image that appears to be more opaque and appears to be blended continuously between the display layers. The occfusion technique may include converting a 2D input image with depth information to an output image with front and rear images using the depth fusion method described above and then applying the occlusion method described above to the front and rear images. Alternatively, the front and rear images can be calculated based on the depth information and the occlusion method applied before the depth fusion.
Thus, the pixels forming the front and rear images can by "displayed" at
intermediate depths (i.e. between the front and rear display layers of the MLD) by
blending the sharpened and blurred pixels at each location of the input image,
proportional to the depth values of that portion.

However, as there is only one color input image, there is no color
information for regions of the rear image which are occluded by parts of the front
image. This color information is required by MLD Occlusion and so preferably,
the missing color information is provided manually.

In one embodiment, an MLD using LCD panels may have a rear display
panel having front and rear polarizers while the front display panel only has a
front polarizer. This configuration can reduce light loss through the display
relative to where the front display layer also has a rear polarizer but produces a
negative of the output image. To compensate, the display controller may feed a
negative of the output image to the front display panel, the resultant image
therefore being a positive image. However, negative images generated for such
a display may not display correctly on other MLD systems that do have such a
rear polarizer on the front screen.

Therefore, the content engine may include an "image inversion" image
data manipulation algorithm executable to manipulate the input image data to
generate an output image that is a negative of the input image. The content
engine may thus execute such an "image inversion" image data manipulation
algorithm where the display system produces a negative/positive output image of
a positive/negative input image.

It should be appreciated that any of the visual effects described herein can
be considered a display content type for the purpose of this specification.
Accordingly, the terms "multi-layered," "multi-layered display content" or the like
may include one or more of the visual effects described herein.
The stereoscopic display content type creates an illusion of depth by using a pair of two-dimensional (2D) images that are slightly different to each other to correspond to the different perspectives as would normally be seen of the left and right eye of the viewer of an equivalent 3-Dimensional (3D) object. Different parts of the image thus appear to be at different depths depending on the difference in each part of the components of the left and right eye images.

The differences in the pair of images may be created in a number of ways. For example, color anaglyph may be used to color the image in different colors depending on whether that part of the image is to be viewed by the left or right eye. This method requires the viewer to wear glasses with complementary colored filters for left and right eyes. Alternatively, polarizing filters may be used to polarize light corresponding to left and right eye images. A viewer may thus wear glasses with left and right eye polarized lenses corresponding to the left and right eye images. Another method may include using temporal shutter glasses. The display successively displays the left and right eye images at a high frequency and the shutter glasses are synchronized with the display so that each frame displaced is only seen by one eye.

In one embodiment, the stereoscopic display content type may be an auto-stereoscopic display content type. Auto-stereoscopic displays do not require the viewer wear glasses as they use a lenticular lens or parallax barrier to split the left and right eye components in slightly different directions. A parallax barrier or mask may be placed over an interlaced image to block light from the left image to the right eye and vice versa.

It should be appreciated that reference hereinafter to "stereoscopic" also includes "auto-stereoscopic" and vice versa.
In an MLD display system, an image may be displayed as a stereoscopic display content type by using the front or rear display layer as a parallax barrier and respectively displaying an interlaced image on the rear or front display layer. The parallax barrier may be formed by the pixels of the front/rear display layer selectively blocking light at different viewing angles to the left and right parts of the image on the rear/front layer. A "light barrier" can be formed using the rear display layer to achieve the same effect as a front parallax barrier. In one embodiment, a light barrier formed using the rear display layer may be used to provide improved clarity since the diffusion layer between the front and rear display layers may produce less diffusion of the resultant image.

The degree of separation between the front and rear display layers can affect the angle between the left and right image components for a given angle of light divergence from the rear display layer. The angle of divergence can also affect the "optimum" viewing position of the stereoscopic display system, e.g., where the viewer is positioned such that left and right eye image components intersect the left and right eyes of the viewer. This "optimum" viewing position can be determined by the thickness and phase difference of the parallax/light barrier, the spacing between the display layers and/or the spacing between left and right eye components of the interlaced image.

In one embodiment, a content engine includes a "stereo-spacing" image data manipulation algorithm executable to process MLD data and determine the spatial separation between front and rear display layers. Spacing data may be output which specifies the spacing between left and right eye components of the output image. Such a stereo-spacing image data manipulation algorithm thus provides a means for determining the separation between left and right eye image components for a given separation between display layers of an MLD system.
In one embodiment, a computer system is operable to manipulate input image data relating to a first display content type to generate an output image of a second display content type for display on a display system. The computer system may include a system memory coupled by a bus to a processor, wherein the system memory stores instructions providing a content engine capable of manipulating the input image data. The content engine can be configured to receive metadata and the input image data, the metadata specifying the second display content type. The content engine can process the metadata and manipulate the input image data accordingly to generate a data signal for generating the output image for display on the display system.

In one embodiment, a display system includes a display layer capable of displaying an image. The display system also includes a computer system as aforementioned, wherein the computer system is operable to process the input image data and the metadata to generate a data signal for generating the output image for display on the display layer. Additionally, the display system is capable of displaying the output image as one or more of the following display content types: 2D; 2D with depth map; 3D Object Data; stereoscopic; Multi Layered; and enhanced color and/or contrast.

The display system can therefore be used to display images of various different display content types without requiring the image data of each image to be specifically designed for the display system. Thus, the display system can be used to display images designed for different display content types. And in one embodiment, the display system is capable of simultaneously displaying at least two images of differing display content types.

The display system may be any type of display system, e.g., a single layered display (SLD), stereoscopic display, volumetric display, another type of 3D display, etc. In one embodiment, the display system is a multi-layer display (MLD) including at least a first and second display layer, where the first and
second display layers overlap and at least one of which has at least a portion capable of being made substantially transparent such that a viewer can look through the transparent portion to view the other display layer.

The first and second display layers may respectively include a first and second plurality of pixels operable to display images using at least some of the first and/or second plurality of pixels. And in one embodiment, the display system may include further display layer(s), where the first display layer and/or the second display layer overlap the further display layers.

The MLD system can therefore be used to display images of each of the various different display content types without requiring the image data of each image to be specially designed for the MLD system. In one embodiment, the MLD system is capable of simultaneously displaying images of at least two display content types. Thus, the MLD system can be used to display images designed for different and/or conventional display content types, e.g., stereoscopic, 2D or simulated 3D images. Furthermore, as the MLD system can be capable of simultaneously displaying the images in all of the aforementioned display content types, the MLD system thus offers enhanced visual effects over conventional single layer displays which are generally only capable of displaying 2D or stereoscopic images.

In one embodiment, a multi-layer display (MLD) system may include at least a first and second display layer, each capable of displaying an image using a first and second plurality of pixels respectively, the first display layer overlapping the second display and having at least a portion capable of being made substantially transparent such that a viewer can look through the overlapping first display layer to view the second display layer. The MLD system may also include a computer system for manipulating input image data relating to a first display content type to generate an output image of a second display content type for display on the MLD system. The computer system may include
a memory coupled to a processor, wherein the memory stores instructions providing a content engine capable of manipulating the input image data. The content engine can be configured to receive metadata and the input image data, the metadata specifying the second display content type. The content engine can also be configured to process the metadata and manipulate the input image data accordingly to generate a data signal for generating the output image for display on the MLD system.

The MLD system may be capable of displaying the output image as one or more of the following display content types: 2D; 2D with depth map; 3D Object Data; stereoscopic; Multi Layered; and enhanced color and/or contrast. In one embodiment, the MLD system may be capable of simultaneously displaying at least two images of differing display content types in contrast to conventional display systems capable of displaying only a single display content type. Therefore, since the MLD system is capable of simultaneously displaying images of one or more display content types, the MLD system is more adaptable and offers viewers an enhanced visual experience comparable to conventional display systems.

In one embodiment, the content engine may include or may be embodied in a Hardware Abstraction Layer (HAL) capable of processing the metadata and outputting a data signal in a form readable by the display system to display the output image. As the metadata specifies the second display content type and the manipulation required, the HAL can act as an interface between the particular display type used and the input image data, regardless of the form of the input image data or the display type.

The HAL may generate an output image including front and rear images for display on front and rear display layers respectively of an MLD system. Additionally, the HAL can be configured to process the metadata to split components of the input image data into the front and rear images as specified.
by the metadata. As the metadata can specify which images or image parts are displayed on each of the first and second display layer, the HAL can be used to display images correctly on differing types of MLD systems, e.g., with a different display layer separation, depth, polarizer, diffuser configuration or display layer relationship.

In one embodiment, the HAL may include one or more image data manipulation algorithms executable to receive image data relating to an image configured for display on a first MLD system with a first hardware parameter, and also receive hardware parameter information of a second MLD system with a second hardware parameter, where the second hardware parameter is different than the first hardware parameter. The image data manipulation algorithms may also be executable to process the image data to display the image on the second MLD system. The hardware parameter (e.g., of the first MLD system and/or the second MLD system) may include one or more of: spacing between display layers; level of light diffusion through display layers; polarization through a display layer(s); color profiles of a display layer(s); whether the display layers are being treated as end-on-end or side-by-side; and whether the display layers are treated as two separate displays or one combined display.

The collective parameter set (e.g., including at least two hardware parameters) of a given MLD system may be referred to as a hardware "profile." Thus, in one embodiment, the one or more image data manipulation algorithms may be executable to receive image data relating to an image configured for display on a first MLD system with a first hardware profile, and also receive hardware profile information of a second MLD system with a second hardware profile, the second hardware profile different to the first hardware profile. The one or more image data manipulation algorithms may also be executable to process the image data to display the image on the second MLD system. Accordingly, the HAL may effectively "de-couple" the input image data from the particular hardware that the input image data was designed for.
In one embodiment, the HAL may include a Hardware Identification Algorithm that automatically detects the type of display system and runs appropriate image data manipulation algorithms accordingly.

Examples of first display content types and, for each, an exemplary input image data manipulation performed by the content engine to generate the output image of the second display content type, are set out in Table 1.

<table>
<thead>
<tr>
<th>First Display Content Type</th>
<th>Second Display Content Type</th>
<th>Metadata</th>
<th>Input Image Data Manipulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D content</td>
<td>Multi Layered</td>
<td>Metadata specifies: Which parts of the input image are to be displayed on first and second (e.g. front and rear) display layers.</td>
<td>Content Engine includes image data manipulation algorithm executable to process the metadata and input image data to: Separate the input image data into two portions corresponding to the front and rear parts of the input image.</td>
</tr>
<tr>
<td>2D content</td>
<td>Stereoscopic</td>
<td>Metadata specifies: The apparent depth of each part of the input image and therefore the left and right eye images.</td>
<td>Content Engine includes image data manipulation algorithm executable to process the metadata and input image data to: Generate left and right eye stereo pairs of images based on the depth of each part of the input image.</td>
</tr>
<tr>
<td>Multi Layered</td>
<td>2D Content</td>
<td>Metadata specifies:</td>
<td>Content Engine includes image data manipulation algorithm executable to process the metadata and input image data to:</td>
</tr>
<tr>
<td>--------------</td>
<td>------------</td>
<td>---------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Multi Layered</td>
<td>Stereoscopic</td>
<td>The front and rear input images and may also include depth information.</td>
<td>Merge the front/rear input image pairs to form a single output image. Multi-Layered depth effects may be emulated using 2D depth cues.</td>
</tr>
<tr>
<td>Stereoscopic</td>
<td>Multi Layered</td>
<td>Metadata specifies:</td>
<td>Content Engine includes image data manipulation algorithm executable to process the metadata and input image data to:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The front and rear input image pairs.</td>
<td>Create left/right stereo output image pairs from front/rear input image pairs to emulate discreet layers for stereoscopic display system.</td>
</tr>
<tr>
<td>2D, 3D or MLD content</td>
<td>Multi-Layered using only one polariser between display layers</td>
<td>Metadata specifies:</td>
<td>Content Engine includes &quot;image inversion&quot; image data manipulation algorithm executable to process the metadata and input image data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Which parts of the input image are to be displayed on first and</td>
<td></td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>2D Content</th>
<th>Multi-Layered with enhanced colour</th>
<th>Metadata specifies:</th>
<th>The display should show the input image with enhanced color.</th>
</tr>
</thead>
<tbody>
<tr>
<td>to:</td>
<td>Generate front and rear image pairs for display on the front and rear display layers.</td>
<td>Invert the front image so that it is a negative of the input front image.</td>
<td></td>
</tr>
<tr>
<td>Content Engine includes image data manipulation algorithm executable to process the metadata and input image data to:</td>
<td>Generate a front and rear image pair where the front image is a copy of the input image and the rear image is a copy of the front image but optionally with no black pixels or with a blurring algorithm applied.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2D Content</th>
<th>Multi-Layered with enhanced contrast</th>
<th>Metadata specifies:</th>
<th>The display should show the input image with enhanced contrast.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Engine includes image data manipulation algorithm executable to process the metadata and input image data to:</td>
<td>Generate a front and rear image pair where the front image is a copy of the input image and the rear image is a grayscale copy of the front image but optionally with no black pixels or with a blurring algorithm applied.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2D Content</td>
<td>Metadata specifies: The display should show the input image with both enhanced color and contrast.</td>
<td>Content Engine includes image data manipulation algorithm executable to process the metadata and input image data to: Generate a front and rear image pair where the front image is a copy of the input image and the rear image is a combination of a grayscale and color copies of the front image but optionally with no black pixels or with a blurring algorithm applied.</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>2D, 3D or MLD content</td>
<td>Metadata specifies: The depth information of each part of the input image.</td>
<td>Content Engine includes image data manipulation algorithm executable to process the metadata and input image data to: Split and distribute the input image into front and rear images based on the depth information.</td>
<td></td>
</tr>
<tr>
<td>2D content</td>
<td>Metadata specifies: The depth or overlap information of each part of the input image.</td>
<td>Content Engine includes image data manipulation algorithm executable to process the metadata and input image data to: Generate front and rear images based on the depth or overlap information, e.g. deeper or overlapped parts of the input image may be displayed on rear screen while shallower or overlapping objects may be displayed on the front screen.</td>
<td></td>
</tr>
</tbody>
</table>
It should be appreciated that various combinations and permutations of the conversions in this table may also take place. Such combinations or permutations may take place in parallel or sequentially.

In one embodiment, a method may be used to manipulate input image data relating to an input image of a first display content type to generate an output image of a second display content type for display on a display system. The method may be performed using a computer system which has a memory coupled to a processor, and wherein the memory stores computer-readable instructions providing a development environment capable of creating metadata. The method may include creating metadata relating to the input image data, where the metadata may specify the second display content type.

In one embodiment, a method may be used to manipulate input image data relating to an input image of a first display content type to generate an output image of a second display content type for display on a display system. The method may be performed using a computer system which has a memory coupled to a processor, and wherein the memory stores computer-readable instructions providing a development environment capable of creating metadata relating to the input image data and a content engine capable of manipulating the input image data. The method may include creating metadata relating to the input image data, where the metadata may specify the second display content type. The method may also include retrieving the metadata and the input image data. The method may further include using the content engine to process the metadata and manipulate the input image data to generate the output image, wherein the content engine is capable of outputting a data signal for generating the output image on the display system.

In yet another embodiment, computer software may include a development environment for creating metadata relating to input image data of
an input image of a first display content type, where the metadata may specify a
second display content type for an output image to be displayed on a display
system. The development environment may be embodied in computer-readable
instructions and may include a user interface capable of receiving user input
specifying the second display content type for a the input image or part thereof.
The development environment may also include a metadata encoding algorithm
which may be executable to create the metadata based on the user specification
of the second display content type.

The metadata encoding algorithm may be capable of creating metadata
for each display content type specifying how the input image data is to be
manipulated to generate the output image. The development environment may
thus provide a means for the user to create the metadata by indicating the
second display content type they require and therefore the visual effect applied to
the output image presented to the viewer of the display system.

In one embodiment, the development environment may include a display
content type identification algorithm for automatically identifying the first display
content type. As such, responsive to the user specifying the second display
content type, the metadata encoding algorithm(s) will create the correct metadata
for the display content type. Alternatively, responsive to the user may manually
specifying the first display content type via the user interface, the metadata
encoding algorithm(s) may create the correct metadata for the display content
type.

In one embodiment, the content engine and/or development environment
may be stored on a computer-readable medium. And in one embodiment, a data
signal may be generated by a computer system as aforementioned.

In one embodiment, a method of displaying an image on a display system
includes receiving the data signal generated by the content engine. The method
may also include operating the display system to display the output image of the second display content type.
BRIEF DESCRIPTION OF THE DRAWINGS

Further aspects of the present invention will become apparent from the following description which is given by way of example only and with reference to the accompanying drawings.

Figure 1 shows a schematic process diagram of a method of manipulating image data.

Figures 2a and 2b show pictorial diagrams of two multilayered displays (MLD).

Figures 3a-d respectively show pictorial diagrams of some of the different display content types capable of being displayed on an MLD.

Figures 4a-d respectively show pictorial diagrams of some of the different display content types capable of being displayed on a SLD.

Figures 5a-d respectively show pictorial diagrams of some of the different display content types capable of being displayed on a 3D (stereoscopic) display system.

Figure 6b shows a MLD system according to one embodiment of the present invention with two overlapping display layers.

Figure 6a shows the MLD system of Figure 5a with the display layers non-overlapping to show the Constituent images.

Figure 7 shows a pictorial representation of a depth fusion effect.

Figure 8 shows a table of different combinations of input-output images being displayed by the MLD system of Figures 5a and 5b.
Figure 9a shows pictorial diagrams of the front and rear images of an MLD using Occlusion;

Figure 9b shows pictorial diagrams of the front and rear images of an MLD using Occlusion;

Figure 9a shows pictorial diagrams of the front and rear images of a monochrome and color MLD;
DETAILED DESCRIPTION OF THE INVENTION

Figure 1 shows a schematic process diagram of a method of manipulating image data in accordance with one embodiment of the present invention. The method may be performed by computer software that runs on a computer system which has a memory coupled to a processor, where the computer software may be stored in the memory.

As shown in Figure 1, a content engine (1) is operable to execute image data manipulation of input image data (2a and/or 2b) relating to an input image (3a and/or 3b) of a first display content type (4) to generate an output image (5) of a second display content type (6) for display on a display system (7a, 7b or 7c). The content engine (1) can be embodied in computer-readable instructions including an image data manipulation algorithm (8), executable to process the input image data (2a and/or 2b) and metadata (10) associated with the input image data (2a and/or 2b), the metadata (10) specifying the second display content type (6). The content engine (1) may also generate a data signal (11) for generating the output image (5) for display on the display system (7a, 7b or 7c). A display controller (12a, 12b, 12c) of the display system (7a, 7b, 7c) can receive the data signal (11) and render the output image (5) on the display system (7a, 7b, 7c). Alternatively, the content engine (1) may also include or operate as a display controller (12a, 12b, 12c) for the display system (7a, 7b, 7c).

In one embodiment, metadata (10) for the input image data (2a) may be generated by a development environment (13). The development environment (13) may be provided as an independent software module to the content engine (1) and may include a user interface (14) capable of receiving user input specifying the second display content type (6) which the input image (3a) is to be displayed as. The user of the development environment (13) may use an existing input image (3a) or create the image (3a) and input image data (2a) in the development environment (13) via the user interface (14). The input image (3a)...
will have a first display content type (4) as determined from the input image data (2a) or specified by the user. The development environment (13) may also have a metadata encoding algorithm (15) which is executable to create the metadata (10) based on the first display content type (4) and the user specification of the second display content type (6).

The development environment (13) may output an "image file" (16) which may contain the input image data (2a) and encoded metadata (10). The image file (16) may also contain executable scripts or be sent to the content engine (1) in parallel with such executable scripts which the content engine may run to manipulate the input image data (2a) and/or metadata (10) or perform another function. Metadata (10) may vary with the different types of input image data (2a) that correspond to the first (4) and second (6) display content types and any other effects or processes that need to be applied.

The development environment (13) optionally has a display content type identification algorithm (not shown) which automatically identifies the first display content type (4) by processing the input image data (2a). The metadata encoding algorithm (15) can thus use the information created by the display content type identification algorithm to apply the correct metadata (10) to achieve the desired conversion of one display content type to another. In one embodiment, the user may specify the second display content type (6) and the metadata encoding algorithm (15) will automatically create the correct metadata (10) for the particular conversion between the first (4) and second (6) display content types. Alternatively, the user may manually specify the first display content type (4) via the user interface (15).

The first display content type (4) and second display content type (6) may be the same or different. Additionally, the first content type (4) and/or the second display content type (6) may be specified by the metadata (10) in one
embodiment. Alternatively, the content engine (1) is also capable of receiving
input image data (2) without metadata (10).

In one embodiment, the input (2) and output (5) images may have the
same display content type. As such, the input image (2) may be displayed as the
"output image" (5) in an unaltered state.

Three examples of possible display systems are shown in Figure 1 and
include a Multi Layered Display (MLD) system (7a), a Single Layered Display
(SLD) system (7b) and a 3D Display system (7c). The 3D Display system (7c)
may be a stereoscopic display in one embodiment. The particular display system
(7a, 7b, 7c, etc.) used may be determined by a user's requirements, by a display
content type (4) of the input image (2), by a display content type (6) of the output
image (5), some combination thereof, etc.

Each display system (7a, 7b, 7c) includes at least one display layer
capable of displaying an image and is connected to the computer system via a
wired, wireless or any communication channel capable of carrying a data signal.
The display layer(s) may be LCD panels or some other type of display
technology. The SLD system may include a single display layer capable of
displaying images, e.g., an LCD, OLED or Plasma Display panel. The '3D'
Stereoscopic display system (7c) may include a display layer (LCD, OLED,
Plasma display panel, etc.) with a parallax barrier, lenticular lens or the like,
overlaying the display layer and may be capable of displaying a stereoscopic
image and/or an auto-stereoscopic image.

Example of a Multi-Layered Display (7a) or "MLD" are shown in figures 2a)
and 2b). The MLD system (7a) may include a plurality of overlapping display
layers and in this embodiment shown in figure 2, includes two display layers
(101, 102) a front display layer (101 ) overlapping a rear display layer (102).
Each of the display layers (101 , 102) includes a respective array of pixels
operable to display a respective image (103, 104). The pixels of the front display layer (101) can be made substantially transparent so that a viewer can look through the first display layer (101) to view the second display layer (102) and any images (104) displayed thereon. In one embodiment, one or more of the display layers (101, 102) may be formed from LCD panels.

The SLD system (7b) may include a single display layer. Accordingly, the SLD system (7b) may display 2D images and/or 2D images with depth cues (e.g., shading, perspective, etc.).

In one embodiment, the MLD system (7a) may display any of the display content types described herein, e.g., 2D, 2D with depth map, stereoscopic, auto-stereoscopic, multi-layered, enhanced color, enhanced contrast, etc. The MLD system (7a) can therefore be used to display images of various different display content types without requiring the image data of each image to be specifically designed for the MLD system (7a).

The MLD system (7a) is also capable of simultaneously displaying images of different display content types. For example, a first auto-stereoscopic image, a second multi-layered image and a third image with enhanced color and/or contrast may be simultaneously displayed using the MLD system (7a).

As shown in Figure 1, the first display content type (4) may include any of the following display content types: 2D (4a); 2D with depth map (4b); stereoscopic (4c); Multi-Layered (4d); 3D Object Data (4e); and enhanced color and/or contrast (4f). In one embodiment, the input image data (2) may relate to an input image (3) of a first display content type (4). Additionally, the second display content type (6) may include any of the following display content types: 2D; 2D with depth map; stereoscopic; Multi-Layered; 3D Object Data; and enhanced color and/or contrast.
It should be appreciated that the display content types listed here are not
exhaustive and any combination of any display content types described herein may be converted. It should also be appreciated that conversions may involve more than one step, e.g. the input image may be converted from a first display content type to a second and then to a third display content type.

For example, as referred to herein the "MLD" first (4) and second (6) display content types should be interpreted to include any of the MLD methods and techniques described or referred to herein and byway of example include: multi-layered Graphical User Interface (GUI); Advanced White Silhouetting (AWS); overall opacity control with alpha blending of back or front colored silhouette; 2D Gradient Blending; Depth Fusion; jumping; perspective jumping; separate image overlays where an annotation or other descriptor overlaps an image on another display layer; masking visible MLD Area; layered distortion effects including lens effects, fish eye lens, magnifying effects, reflections and shadowing, etc.; layered particle effects; suggestive volume techniques; Enhanced Color and/or Contrast (ECC); Colorimetric ECC; Color Gamut Enhancing (CGE); multi view; Occlusion; Occlusion; Monochrome and Color MLD; Parallax Barrier Stereoscopic Effect; Double Frame Rate.

In another embodiment, the first (4) and second (6) display content types may include any one or more of the following display content types: 2D, 2D with depth map, stereoscopic, MLD, 3D Object Data, enhanced color and/or contrast (4f), depth fusion, AWS.

Where an MLD system (7a) is used as the display system, the content engine (1) may be also embodied in a Hardware Abstraction Layer (HAL) (17) and may be capable of outputting an output image (5) including first and second images for display on first and second display layers respectively of the MLD system (7c). The HAL (17) can be configured to read the metadata (10) and process the input image data (2) to split appropriate components of the input
image data (2) into the first and second display layer images as specified by the metadata (10). As the metadata (10) specifies the second display content type (6) and the manipulation required, the HAL (17) can thus act as an interface between the particular MLD system used and the input image data (2), regardless of the form of the input image data (2) or hardware profile. Further, where the metadata (10) specifies which images or image parts are displayed on each of the first (101) and second (102) display layers, the HAL (17) can also be used to display images correctly on MLD systems with different hardware profiles.

Examples of the various display content types described above are shown in Figures 3 through 7. The metadata (10) specifies the second display content type (6) and also how the input image data (2) is to be manipulated to generate the output image (5). As an example, some of the manipulation methods to achieve the conversions between display content types are set out in Table 1 (described above).

Figures 3a through 3d show various display content types displayed on an MLD system (7a). As described in Table 1, the metadata (10) for an MLD system (7a) can specify which part of the input image(s) is to be displayed on each of the front (101) and rear (102) display layers. Figures 3a through 3d thus show the front (5a) and rear (5b) pairs of images for each display content type.

Figure 3a shows a multi-layered output image formed from a front image (5a) and a rear image (5b) displayed on a front display layer (101) and a rear display layer (102), respectively, of an MLD system (7a). In one embodiment, the front image (5a) and/or the rear image (5b) may be manipulated to provide an Advanced White Silhouetting (AWS) effect where a white/transparent shadow or silhouette of the front image (5a) is projected onto the rear image (5b) and the edges of the shadow are blended with the background image (5b). The front image (5a) has a boundary region that is a blurred or otherwise de-emphasized
copy of the overlapped portion of the rear image (5b). As such, simultaneous display of the front image (5a) and the rear image (5b) may create an Advanced White Silhouetting (AWS) effect.

Figure 3b shows an enhanced color and/or contrast image formed from a front image (5a) and a rear image (5b) displayed on a front display layer (101) and a rear display layer (102), respectively, of an MLD system (7a). In one embodiment, the rear image (5b) may be a blurred copy of the front image (5a) (or vice versa) in color and/or grayscale. The front (5a) and rear (5b) images overlap and thus the viewer will see a resultant image that is formed from the overlapping pixel pairs of the two images (5a) and (5b). As the front (5a) and rear (5b) images are the same (or same but one in grayscale) the resultant image is seen as having a higher level of color and/or contrast.

Figure 3c shows a stereoscopic output image formed by generating a parallax light barrier pattern (5b) of black and white pixels in alternating vertical lines on the rear display layer (102) and generating an image (5a) on the front display layer (101) composed of interlaced left eye components (5L) and right eye components (5R). The parallax barrier (102) prevents light from passing to either the left or right eye components depending on the viewing angle and thus defines angle of visibility of the pixels on the front screen (101). A viewer in the correct position will therefore see only the Left eye components (5L) with their left eye and right eye components (5R) with their right eye thereby creating a stereoscopic effect. In an alternative embodiment the parallax barrier (5b) may be displayed on the front display layer (101) and the interlaced pair of left and right eye images displayed on the rear display layer (102).

Figure 3d shows an output image with a depth fusion visual effect formed by displaying a front image (5a) and a rear image (5b) merged together over a smooth brightness and/or color gradient. The depth fusion effect is more clearly shown in figure 7.
Figures 4a through 4d show various display content types (200) on a SLD system (7b). As described in Table 1, the metadata (10) for an SLD system (7b) may specify the depth information which is to be emulated in the 2D image displayed on the SLD system (7b).

Figure 4a shows a 2D output image (5) generated based on a multi-layered input image. In one embodiment, the multi-layered input image may be manipulated to generate the 2D output image (5), where the manipulation of the multi-layered input image may involve applying or using at least one depth cue to emulate the layering of the multi-layered image.

Figure 4b shows a 2D output image (5) generated based on an enhanced color and/or contrast input image. In one embodiment, the 2D output image (5) may be left unaltered. And in one embodiment, the color and/or contrast of the 2D output image (5) may be improved using conventional image processing techniques.

Figure 4c shows a 2D output image (5) generated based on a stereoscopic input image. In one embodiment, the stereoscopic input image may be manipulated to generate the 2D output image (5), where the manipulation of the stereoscopic input image may involve emulation of the stereoscopic effect using conventional pseudo-3D techniques.

Figure 4d shows a 2D output image (5) generated based on an input image with the depth fusion visual effect. In one embodiment, the input image may be manipulated to generate the 2D output image (5), where the manipulation of the input image may involve emulation of the depth fusion visual effect using conventional pseudo-3D techniques.
Figures 5a through 5d show various display content types on a stereoscopic display system (7c). As described in Table 1, the metadata (10) for a stereoscopic display system (7c) may specify the left and right eye image information as an image pair (e.g., a left image (5L) and a right image (5R)). In one embodiment, the image pair (e.g., left image (5L) and right image (5R)) may be displayed as an interlaced image on the same display layer of the stereoscopic display system (7c).

Figure 5a shows a right image (5R) and a left image (5L) generated based on a multi-layered input image. The right image (5R) and the left image (5L) may be generated such that the layered depth information of the multi-layered input image is emulated as discrete image planes formed in the stereoscopic output image (5).

Figure 5b shows a right image (5R) and a left image (5L) generated based on an enhanced color and/or contrast input image. In one embodiment, the color and/or contrast of the stereoscopic output image (5) may be improved using conventional image processing techniques.

Figure 5c shows a right image (5R) and a left image (5L) generated based on a stereoscopic input image. In one embodiment, the right image (5R) and the left image (5L) may be generated from the stereoscopic input image without any manipulation.

Figure 5d shows a right image (5R) and a left image (5L) generated based on an input image with a depth fusion visual effect. In one embodiment, the input image may be manipulated to generate the right image (5R) and the left image (5L), where the manipulation of the input image may involve emulation of the depth fusion visual effect using conventional image processing techniques.
As shown in Figure 2, the MLD system (7a) includes a front display layer (101) and a rear display layer (102). As shown in Figure 6, the front display layer (101) can display a front image (e.g., 21a, 22a, 23a, 24a, etc.), whereas the rear display layer (102) can display a rear image (e.g., 22b, 23b, 24b, etc.). The front and rear images can be displayed simultaneously to form a multi-layered output image (5), which is depicted in Figure 6b as a 2D image (21), an enhanced color and/or contrast image (22), a Multi-Layered image (23), a stereoscopic image (24).

The 2D output image (21) may be formed by displaying a front image (21a) on front display layer (101). The front image (21a) may use shading as a depth cue.

The enhanced color and/or contrast image (22) may be formed by displaying a front image (22a) on the front display layer (101) and a rear image (22b) on the rear display layer (102). In one embodiment, the front image (22a) may overlap the rear image (22b). And in one embodiment, the rear image (22b) may be a blurred color or grayscale copy of the front image (22a).

The multi-layered image (23) may be formed by displaying a front image (23a) on the front display layer (101) and a rear image (23b) on the rear display layer (102). In one embodiment, the front image (23a) may overlap the rear image (23b).

The stereoscopic image (24) may be formed by displaying a front image (24a) on the front display layer (101) and a rear image (24b) on the rear display layer (102). The front image (24a) may be an interlaced image including a right image (24R) and a left image (24L), where right image (24R) includes right eye components and left image (24L) includes left eye components. The rear image (24b) may form a localized light barrier or parallax barrier. In one embodiment, rear image (24b) may be displayed on the front display layer (101) and front image (24a) may be displayed on the rear display layer (102).
As shown in Figure 6b, the MLD system (7a) is capable of displaying images of different display content types (200). For example, MLD system (7a) can display a 2D image (21), an enhanced color and/or contrast image (22), a Multi-Layered image (23), a stereoscopic image (24), some combination thereof, etc. In one embodiment, the MLD system (7a) may simultaneously display images of different display content types. Accordingly, the MLD system (7a) is more adaptable and offers viewers an enhanced visual experience compared to conventional display systems.

Figure 7 shows a depth fusion effect on an MLD (7a) where the output image (5) is formed from front (5a) and rear (5b) images displayed on front (101) and rear (102) screens respectively. Figure 7a shows the resultant image (5) and figure 7b show the constituent images (5a, 5b). The input image (2) is split into the two images (5a and 5b) according to the depth of each part of the object e.g. parts of the drinks-can that are to be perceived farthest away are displayed only on the rear screen (102) while the closest parts are displayed only on the front screen (101). Intermediate parts are displayed on both front (101) and rear (102) screens with different proportions depending on the depth information. The resultant image (5) thus appears to continuously extend between the screens (101, 102). The Depth Fusion algorithm takes pixels and blends them between the front and back layers depending on the depth values assigned to that pixel. This allows a smooth transition from front to back layer and a 3D volumetric effect is achieved when the viewer’s eye sees part of an object on the front layer and part on the back, with a smooth transition between.

Figure 8 shows a table with examples of how an input image (3) of a first display content type (4) can be displayed on an MLD system (7a) as a second display content type (6). For example, the first row in Figure 8 shows a 2D input image (3) specified by the metadata (10) to be displayed as a Multi-Layered image (23) formed from a front image (23a) and a rear image (23b). In one
embodiment, the front image (23a) and the rear image (23b) may be manipulated so as to provide an Advanced White Silhouetting (AWS) effect.

The second row of Figure 8 shows a 2D input image (3) that can be specified by the metadata (10) to be displayed as a stereoscopic output image (24). The 2D image (3) can be split into left and right eye components (e.g., a right image (24R) and a left image (24L)) of an interlaced image (24b) for display on an MLD system (7a). In one embodiment, the stereoscopic effect may be provided by displaying the interlaced image (24b) which includes the left and right eye components on the rear display layer (102) and a localized light barrier or parallax barrier (24a) displayed or formed on the front display layer (101). The reverse configuration is also possible, e.g., displaying or forming the localized light barrier or parallax barrier (24a) on the rear display layer (102) and displaying the interlaced image (24b) on the front display layer (101).

The third row of Figure 8 shows a multi-layered input image (3) including a front input image (3a) and rear input image (3b) that can be specified by the metadata (10) to be displayed as a 2D output image (21). In one embodiment, the front image (3a) and the rear image (3b) can be combined and displayed on the rear display layer (102) while the front display layer (101) is made transparent.

The fourth row of Figure 8 shows a multi-layered input image (3) including a front input image (3a) and rear input image (3b) that can be specified by the metadata (10) to be displayed as a stereoscopic output image (24). The front input image (3a) and the rear input image (3b) may be analyzed or processed (e.g., to determine depth information, etc.). A right image (24R) and a left image (24L) may then be generated based on the front input image (3a) and the rear input image (3b), where the right image (24R) and the left image (24L) may be interlaced to form an interlaced image (24a). In one embodiment, the interlaced image (24a) may be displayed on the front display layer (101) and a localized
light barrier or parallax barrier (24b) may be displayed or formed on the rear display layer (102) to produce a stereoscopic image (24) which emulates the layering of the front and rear input images (3a and 3b) displayed using an MLD system (7a). In another embodiment, the interlaced image (24a) may be displayed on the rear display layer (102) and a localized light barrier or parallax barrier (24b) may be displayed or formed on the front display layer (101) to produce a stereoscopic image (24) which emulates the spacing or layering of the front and rear input images (3a and 3b) displayed using an MLD system (7a).

The fifth row of Figure 8 shows a stereoscopic input image (3) including a left eye component (e.g., a left image (3L)) and a right eye component (e.g., a right image (3R)) that can be specified by the metadata (10) to be displayed as a multi-layered output image (23) including a front image (23a) and rear image (23b). The right image (3R) and the left image (3L) may be analyzed or processed to determine spacing and/or depth information. The spacing and/or depth information may then be used to generate the front image (23a) and the rear image (23b) for display on the MLD system (7a).

Figure 9a shows an Occlusion effect on an MLD (7a) where the output image (5) is formed from front (5a) and rear (5b) images displayed on front (101) and rear (102) screens respectively. The input image (2) is an MLD image comprising front and rear images. The rear input image is sharpened and displayed on the rear screen (102) as rear output image (5c) and a blurred copy (5d) of the rear input image is displayed on the front screen (101). Similarly, the front input image is sharpened and displayed on the front screen (101) as front output image (5e) and a blurred copy (5f) of the front input image is displayed on the rear screen (102). The resultant image (5) thus appears to have more opaque components than the input image as each pixel of the image (5) is formed from a sharpened and blurred pixel (5c and 5d or 5e and 5f) that multiply together.
Figure 9b shows an Occlusion effect on an MLD (7a) which is a combination of the Occlusion effect of Figure 9a and the Depth Fusion effect of Figure 7. In Figure 9b a front object (5e) is to appear opaque and fused with the background (5c). Reference components are the same as per figure 9a.

Figure 9c shows an MLD (7a) comprising a monochrome screen (101) which overlaps a color screen (102). The front (5a) and rear (5b) images also show an Occlusion effect similar to Figure 9b. While not shown in this drawing, the rear screen (102) displays in color while front screen (101) is monochrome. The input image may be an MLD color image comprising front and rear input images which may be converted to display on the MLD (7a). The image (5a) displayed on the front screen (101) may be a grayscale duplicate of the front input image. To generate the rear image (5b) the input image data may be converted to Hue, Saturation Value (HSV) color-space and the saturation values of each portion of the input image may then be calculated by adding saturation values of corresponding portions the front and rear input images. The calculated saturation values may be then converted back into RGB color-space. The rear image (5b) is thus displayed with the calculated saturated RGB color values

In another embodiment, the image (5b) on the rear color screen (102) may be generated by multiplying color values of each portion of the front and rear input images and dividing by the grayscale values of the rear image (5b). However, in this embodiment, the output image (5) will be of better quality if the monochrome screen is the rear display layer.

The aforementioned method, software and system thus provide means for converting an input image of one display content type into an output image of another display content type by using metadata that specifies the first and/or second display content types and operating a content engine including image data manipulation algorithms which manipulate the data for conversion between
the first and second display content types. The second display content type may be a visual effect applied to the input image (then displayed as the output image) to alter the visual appearance for entertainment, quality enhancement, information-conveyance or other purpose. A viewer can thus use the aforementioned method with one type of display system for viewing content designed for another type of display system and vice versa.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof.
CLAIMS

What is claimed is:

1. A method of manipulating image data, said method comprising:
   accessing first image data configured for display using a first display device;
   accessing information associated with a manipulation of said first image data; and
   generating second image data from said first image data using said information, wherein said second image data is configured for display using a second display device.

2. The method of Claim 1, wherein said generating is performed using a hardware abstraction layer.

3. The method of Claim 1 further comprising:
   automatically detecting a type of said second display device; and
   wherein said generating further comprises generating said second image data responsive to said automatically detecting.

4. The method of Claim 1, wherein said first display device is a two-dimensional display, wherein said second display device is a multi-layered display, wherein said generating further comprises separating said first image data into a plurality of portions, and wherein each portion of said plurality of portions is operable for display using a respective display screen of said multi-layered display.

5. The method of Claim 1, wherein said first display device is a two-dimensional display, wherein said second display device is a multi-layered display, wherein said generating further comprises generating a plurality of images, wherein each image of said plurality of images is operable for display using a respective display screen of said multi-layered display, and wherein said
plurality of images are operable to create an effect selected from a group consisting of advanced white silhouetting, enhanced color, enhanced contrast, and depth fusion.

6. The method of Claim 1, wherein said first display device is a two-dimensional display, wherein said second display device is a multi-layered display, wherein said generating further comprises generating an interlaced image for display on a first display screen of said multi-layer display, wherein said generating further comprises generating a parallax barrier for display on a second display screen of said multi-layer display, and wherein said interlaced image and said parallax barrier are operable to create a stereoscopic image.

7. The method of Claim 1, wherein said first display device is a two-dimensional display, wherein said second display device is a stereoscopic display, wherein said generating further comprises generating an interlaced image including a first image and a second image, wherein said first image is configured for viewing by a right eye of an observer, and wherein said second image is configured for viewing by a left eye of said observer.

8. The method of Claim 1, wherein said first display device is a multi-layered display, wherein said second display device is a two-dimensional display, wherein said generating further comprises merging a plurality of images to create said second image data, and wherein said plurality of images are configured for display using a plurality of display screens of said multi-layered display.

9. The method of Claim 7, wherein said second image data comprises at least one depth cue.

10. The method of Claim 1, wherein said first display device is a multi-layered display, wherein said second display device is a stereoscopic display, wherein said multi-layered display is operable to display a first image using a first display
screen, wherein said multi-layered display is further operable to display a second image using a second display screen, wherein said generating further comprises generating an interlaced image based on said first and second images, wherein said interlaced image includes a first image configured for viewing by a right eye of an observer, and wherein said interlaced image further includes a second image configured for viewing by a left eye of an observer.

11.  The method of Claim 1, wherein said first display device is a stereoscopic display, wherein said second display device is a multi-layered display, wherein said generating further comprises determining depth information from said first image data, wherein said generating further comprises generating a plurality of images from said first image data based on said depth information, and wherein each image of said plurality of images is configured for display on a respective display screen of said multi-layered display.

12.  The method of Claim 1, wherein said first display device is a first multi-layer display associated with a first hardware parameter, wherein said second display device is a second multi-layered display associated with a second hardware parameter, and wherein said information is associated with said first and second hardware parameters.

13.  The method of Claim 1, wherein said first and second hardware parameters are each selected from a group consisting of a spacing between display screens, a level of light diffusion through at least one display screen, a level of polarization through at least one display screen, and a color profile of at least one display screen.

14.  The method of Claim 1, wherein said first hardware parameter is associated with a relationship of display screens of said first multi-layer display, and wherein said relationship is selected from a group consisting of end-on-end, side-by-side, separate displays, and a combined display.
15. The method of Claim 1, wherein said second hardware parameter is associated with a relationship of display screens of said second multi-layer display, and wherein said relationship is selected from a group consisting of end-on-end, side-by-side, separate displays, and a combined display.

16. A computer-readable medium having computer-readable program code embodied therein for causing a computer system to perform a method of manipulating image data, said method comprising:

   accessing first image data configured for display using a first display device;

   accessing information associated with a manipulation of said first image data; and

   generating second image data from said first image data using said information, wherein said second image data is configured for display using a second display device.

17. The computer-readable medium of Claim 16, wherein said generating is performed using a hardware abstraction layer.

18. The computer-readable medium of Claim 16, wherein said method further comprises:

   automatically detecting a type of said second display device; and

   wherein said generating further comprises generating said second image data responsive to said automatically detecting.

19. The computer-readable medium of Claim 16, wherein said first display device is a two-dimensional display, wherein said second display device is a multi-layered display, wherein said generating further comprises separating said first image data into a plurality of portions, and wherein each portion of said
plurality of portions is operable for display using a respective display screen of said multi-layered display.

20. The computer-readable medium of Claim 16, wherein said first display device is a two-dimensional display, wherein said second display device is a multi-layered display, wherein said generating further comprises generating a plurality of images, wherein each image of said plurality of images is operable for display using a respective display screen of said multi-layered display, and wherein said plurality of images are operable to create an effect selected from a group consisting of advanced white silhouetting, enhanced color, enhanced contrast, and depth fusion.

21. The computer-readable medium of Claim 16, wherein said first display device is a two-dimensional display, wherein said second display device is a multi-layered display, wherein said generating further comprises generating an interlaced image for display on a first display screen of said multi-layer display, wherein said generating further comprises generating a parallax barrier for display on a second display screen of said multi-layer display, and wherein said interlaced image and said parallax barrier are operable to create a stereoscopic image.

22. The computer-readable medium of Claim 16, wherein said first display device is a two-dimensional display, wherein said second display device is a stereoscopic display, wherein said generating further comprises generating an interlaced image including a first image and a second image, wherein said first image is configured for viewing by a right eye of an observer, and wherein said second image is configured for viewing by a left eye of said observer.

23. The computer-readable medium of Claim 16, wherein said first display device is a multi-layered display, wherein said second display device is a two-dimensional display, wherein said generating further comprises merging a
plurality of images to create said second image data, and wherein said plurality of images are configured for display using a plurality of display screens of said multi-layered display.

24. The computer-readable medium of Claim 23, wherein said second image data comprises at least one depth cue.

25. The computer-readable medium of Claim 16, wherein said first display device is a multi-layered display, wherein said second display device is a stereoscopic display, wherein said multi-layered display is operable to display a first image using a first display screen, wherein said multi-layered display is further operable to display a second image using a second display screen, wherein said generating further comprises generating an interlaced image based on said first and second images, wherein said interlaced image includes a first image configured for viewing by a right eye of an observer, and wherein said interlaced image further includes a second image configured for viewing by a left eye of an observer.

26. The computer-readable medium of Claim 16, wherein said first display device is a stereoscopic display, wherein said second display device is a multi-layered display, wherein said generating further comprises determining depth information from said first image data, wherein said generating further comprises generating a plurality of images from said first image data based on said depth information, and wherein each image of said plurality of images is configured for display on a respective display screen of said multi-layered display.

27. The computer-readable medium of Claim 16, wherein said first display device is a first multi-layer display associated with a first hardware parameter, wherein said second display device is a second multi-layered display associated with a second hardware parameter, and wherein said information is associated with said first and second hardware parameters.
28. The computer-readable medium of Claim 16, wherein said first and second hardware parameters are each selected from a group consisting of a spacing between display screens, a level of light diffusion through at least one display screen, a level of polarization through at least one display screen, and a color profile of at least one display screen.

29. The computer-readable medium of Claim 16, wherein said first hardware parameter is associated with a relationship of display screens of said first multi-layer display, and wherein said relationship is selected from a group consisting of end-on-end, side-by-side, separate displays, and a combined display.

30. The computer-readable medium of Claim 16, wherein said second hardware parameter is associated with a relationship of display screens of said second multi-layer display, and wherein said relationship is selected from a group consisting of end-on-end, side-by-side, separate displays, and a combined display.

31. A system comprising a processor and a memory, wherein said memory comprises instructions that when executed by said system implement a method of manipulating image data, said method comprising:

   accessing first image data configured for display using a first display device;

   accessing information associated with a manipulation of said first image data; and

   generating second image data from said first image data using said information, wherein said second image data is configured for display using a second display device.

32. The system of Claim 31, wherein said generating is performed using a hardware abstraction layer.
33. The system of Claim 31, wherein said method further comprises: 
automatically detecting a type of said second display device; and 
wherein said generating further comprises generating said second image 
data responsive to said automatically detecting.

34. The system of Claim 31, wherein said first display device is a two- 
dimensional display, wherein said second display device is a multi-layered 
display, wherein said generating further comprises separating said first image 
data into a plurality of portions, and wherein each portion of said plurality of 
portions is operable for display using a respective display screen of said multi-
layered display.

35. The system of Claim 31, wherein said first display device is a two- 
dimensional display, wherein said second display device is a multi-layered 
display, wherein said generating further comprises generating a plurality of 
images, wherein each image of said plurality of images is operable for display 
using a respective display screen of said multi-layered display, and wherein said 
plurality of images are operable to create an effect selected from a group 
consisting of advanced white silhouetting, enhanced color, enhanced contrast, 
and depth fusion.

36. The system of Claim 31, wherein said first display device is a two- 
dimensional display, wherein said second display device is a multi-layered 
display, wherein said generating further comprises generating an interlaced 
image for display on a first display screen of said multi-layer display, wherein said 
generating further comprises generating a parallax barrier for display on a 
second display screen of said multi-layer display, and wherein said interlaced 
image and said parallax barrier are operable to create a stereoscopic image.
37. The system of Claim 31, wherein said first display device is a two-dimensional display, wherein said second display device is a stereoscopic display, wherein said generating further comprises generating an interlaced image including a first image and a second image, wherein said first image is configured for viewing by a right eye of an observer, and wherein said second image is configured for viewing by a left eye of said observer.

38. The system of Claim 31, wherein said first display device is a multi-layered display, wherein said second display device is a two-dimensional display, wherein said generating further comprises merging a plurality of images to create said second image data, and wherein said plurality of images are configured for display using a plurality of display screens of said multi-layered display.

39. The system of Claim 38, wherein said second image data comprises at least one depth cue.

40. The system of Claim 31, wherein said first display device is a stereoscopic display, wherein said second display device is a multi-layered display, wherein said generating further comprises determining depth information from said first image data, wherein said generating further comprises generating a plurality of images from said first image data based on said depth information, and wherein
each image of said plurality of images is configured for display on a respective display screen of said multi-layered display.

42. The system of Claim 31, wherein said first display device is a first multi-layer display associated with a first hardware parameter, wherein said second display device is a second multi-layered display associated with a second hardware parameter, and wherein said information is associated with said first and second hardware parameters.

43. The system of Claim 31, wherein said first and second hardware parameters are each selected from a group consisting of a spacing between display screens, a level of light diffusion through at least one display screen, a level of polarization through at least one display screen, and a color profile of at least one display screen.

44. The system of Claim 31, wherein said first hardware parameter is associated with a relationship of display screens of said first multi-layer display, and wherein said relationship is selected from a group consisting of end-on-end, side-by-side, separate displays, and a combined display.

45. The system of Claim 31, wherein said second hardware parameter is associated with a relationship of display screens of said second multi-layer display, and wherein said relationship is selected from a group consisting of end-on-end, side-by-side, separate displays, and a combined display.
### Figure 8

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<th>First Display Content Type</th>
<th>Second Display Content Type</th>
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<td><img src="image4.png" alt="Image 4" /> 101</td>
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INTERNATIONAL SEARCH REPORT

International application No
PCT/NZ20/000091

A CLASSIFICATION OF SUBJECT MATTER

Int C1

G09G 5/397 (2006 01)  G02F 1/1347 (2006 01)  INW/5/46 (2006 01)
G02B 27/22 (2006 01)  G09G 5/14 (2006 01)  WW/3/00 (2006 01)

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

B FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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

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

EPDOC, WPI, Google Scholar IPC G02B, G02F, G06T, G09G, H04N with keywords imag, visual, graphic, video, television, convert, conversion, map, generat, transform, 3d, three dim, depth, stereoscop, multilayer parallax data, format, and similar terms

C DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No</th>
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<td>X</td>
<td>WO 1999/042889 A1 (POWER BEAT INTERNATIONAL LIMITED) 26 August 1999 Pages 6, 9, 11</td>
<td>1-5, 7-20, 22-35, 37-45</td>
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</table>

Further documents are listed in the continuation of Box C

See patent family annex

* Special categories of cited documents
  "A" document defining the general state of the art which is not considered to be of particular relevance
  "E" earlier application or patent but published on or after the international filing date
  "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  "O" document referring to an oral disclosure, use, exhibition or other means
  "P" document published prior to the international filing date but later than the priority date claimed
  "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
  "X" document of particular relevance the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
  "Y" document of particular relevance the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents such combination being obvious to a person skilled in the art
  "&" document member of the same patent family

Date of the actual completion of the international search 16 August 2010

Date of mailing of the international search report 19 AUG 2010

Name and mailing address of the ISA/AU

AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
E-mail address pct@ipaustralia.gov.au
Facsimile No +61 2 6283 7999

Authorized officer

MICHAEL HALL

AUSTRALIAN PATENT OFFICE
(ISO 9001 Quality Certified Service)
Telephone No +61 2 6283 2474

Form PCT/ISA/2 10 (second sheet) (July 2009)
This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Box No. I Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

   Claims Nos:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

   Claims Nos:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

   This International Searching Authority found multiple inventions in this international application, as follows

   See Supplemental Box.

   1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
   2. As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees
   3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos:
   4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos:

Remark on Protest

   The additional search fees were accompanied by the applicant’s protest and, where applicable, the payment of a protest fee.
   The additional search fees were accompanied by the applicant’s protest but the applicable protest fee was not paid within the time limit specified in the invitation.
   No protest accompanied the payment of additional search fees.

Form PCT/ISA7210 (continuation of first sheet (2)) (July 2009)
Continuation of Box No: III

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

In assessing whether there is more than one invention claimed, I have given consideration to those features which can be considered to potentially distinguish the claimed combination of features from the prior art. Where different claims have different distinguishing features they define different inventions.

This International Searching Authority has found that there are four different inventions as follows:

- Claims 2-3, 11-15, 17-18, 26-30, 32-33 and 41-45 are directed to hardware aspects of independent claims 1, 16 and 31. It is considered that these hardware aspects comprise a first distinguishing feature.

- Claims 4-6, 8, 19-21, 23, 34-36 and 38 are directed to conversion between images configured for two-dimensional and multi-layer displays. It is considered that conversion between images configured for two-dimensional and multi-layer displays comprises a second distinguishing feature.

- Claims 7, 9, 22, 24, 37 and 39 are directed to conversion between images configured for two-dimensional and stereoscopic displays. It is considered that conversion between images configured for two-dimensional and stereoscopic displays comprises a third distinguishing feature.

- Claims 10-1, 25-26 and 40-41 are directed to conversion between images configured for stereoscopic and multi-layer displays. It is considered that conversion between images configured for stereoscopic and multi-layer displays comprises a fourth distinguishing feature.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

The only feature common to all of the claims is a method as per claim 1, where first image data configured for a first display device and information associated with a manipulation of first image data are used to generate second image data configured for a second display device. However this concept is not novel in the light of, for example:


This document discloses many such manipulations, including conversion between SD and HD data, and between SD and stereoscopic data (see, eg, abstract). Further, while the 3rd and 4th groups of claims share the common feature that one of the displays is a stereoscopic display, this is similarly not novel in the light of, for example, the document identified above (eg, abstract and paragraphs 160-190).

This means that the common features cannot constitute a special technical feature within the meaning of PCT Rule 13.2, second sentence, since they make no contribution over the prior art. Note that claims 1, 16 and 31 are not grouped with any of the above inventions since they have no special technical features in light of the above document.

Because the common features do not satisfy the requirement for being a special technical feature it follows that they cannot provide the necessary technical relationship between the identified inventions. Therefore the claims do not satisfy the requirement of unity of invention aposteriori.

It was considered that all inventions could be searched without significant additional effort.
This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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| Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX