A novel system and method is disclosed for enhancing the quality of an image displayed by a display system of a digital electronics projector of motion picture images, or other images, on a display unit. The display system may include a display panel driver subsystem, an optical system that may include display panels with display pixels, with each panel configured to enhance outputted image resolution on the display unit by compensating for a defective display panel; and a low power light source electronics subsystem so that the display panel driver subsystem instructs the light source electronics subsystems to utilize the electronic display driver to energize the pixels in the display panels of the optical system. The result is to minimize the negative effects of a defective pixel in one of the display panels, hence enhancing the overall quality of the image on the display unit.
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A SYSTEM AND METHOD FOR DEFECT ELIMINATION IN
LARGE ARRAY PIXEL PROJECTORS

Field of the Invention

This invention relates to a method and apparatus for delivery of electronic images such
as digitized motion pictures to an image projection system utilizing digital electronics
technology. More particularly, this invention relates to minimizing the negative effects of a
defective or malfunctioning display pixel associated with a pixel of a Liquid Crystal Display
panel or any similar multi-pixel device.

Description of the Related Art

Presently, the method of delivering digital images to an image projection system is to
utilize either a cathode ray tube display system, which writes images onto the input of an image
light amplifier in the writing system of the device, or a liquid crystal display (LCD) system.
LCDs are considered to be a preferred candidate as the display system for the successful
realization of large arrayed display screens largely due to their inherently desirable
characteristics of relatively low power consumption, thinner design and often substantially
lighter weight. However, the LCD display systems currently provide resolutions of less than
2,000,000 pixels per frame which are unsuitable for the resolution required for large screen
picture display. To achieve resolutions above 2,000,000 pixels per frame requires a device
with a resolution of 1080 x 1920 pixels, or more.

An LCD device also suffers from several disadvantages however, particularly when its
size is increased to that required by a large array display screen. In theory, a display system
utilizing LCD (or even electroluminescence technology) in a large array of pixel format can
provide the required resolution, but as practical matter the problems of pixel defects in the
manufacturing of such devices severely hamper an effective realization of the technology.
Moreover, the larger the display area, the greater potential for pixel defects. The increased
number of defects negatively impact the image quality by causing noticeable degradation in
picture resolution of the viewed image. The greater the number of defects, the more noticeable
the degradation in picture quality. For example, the aforesaid disadvantage is particularly acute
with displays having dimensions greater than 480 by 640 pixels and becomes quite dramatic in
screens such as those needed for digital motion picture projection systems where the number of
pixels will likely exceed 2,000,000.
One current method of compensating for a pixel defects is used in a Charged Coupled Device (CCD) Camera by determining the location of the defective pixel element; determining the location of the defective pixel’s surrounding pixels; mathematically calculating the average color value for the surrounding pixels; and to use the average as the output value of the defective pixel. This method, however, is not applicable to the LCD displays because of a fundamental difference in the way a CCD camera operates compared to an LCD. In the current art, there is no method to compensate for a defect in the LCD because a pixel failure creates a lack of ability to modulate the flow of the outputted photons. The foregoing method also suffers from several shortcomings as it only partially masks the defect. The defect itself remains. Moreover, the average calculated output will not accurately reflect the intended value for the defective pixel if the surrounding pixels are not all of the same color. Thus, the problem with degradation of picture resolution persists. Furthermore, this method is effective only when the number of pixel defects remains generally low. In an instance where a large number of pixels are defective and particularly when concentrated in one area, calculation of pixel value based on the value of surrounding pixels which are themselves defective, leads to conjectured output values that are likely to be drastically different than the intended value for the defective pixel. This anomalous result is particularly undesirable in the context of large screens used in projection systems since the defect is amplified many times and becomes noticeable and distracting to the viewer.

Summary Of The Invention

It is an object of the present invention to overcome the shortcomings of the prior art at least as described above.

Another object is to provide an improved LCD array that addresses problems associated with pixel defects.

The present invention seeks to achieve the foregoing objects and other objects not specifically enumerated here by providing a system and method where a number of display panels, such as LCD panels, can be used together so that only the properly functioning pixels in each are used in the display unit of the image projection system.

In one embodiment, the present invention is a system for enhancing outputted image resolution on a display unit of a system that displays electronic images. The system may include display panel driver subsystem, an integrated electronic display driver, an optical system having display panels with each display panel having display pixels and configured to enhance outputted image resolution on the display unit by compensating for a defective display.
panel, and a light source electronics subsystem where the display panel driver subsystem instructs the light source electronics subsystems to utilize the electronic display driver to energize the pixels in the display panels of the optical system.

The display panel driver subsystem may further include a signal processing module which receives an input signal having an incoming image file signal and a clock information, the signal processing module parses the clock information from the input signal and processes the incoming image file signal into digital image data bit-streams, then to duplicate each digital image data bit-stream so that one duplicate is generated for each display panel in the display panels. The display panel driver subsystem also may include a timing module which receives the clock information from the signal processing module, and a controller module which receives timing information from the timing module and instructs the signal processing module of the correct time to deliver image data to the electronic drive system of the optical system based on the received timing information. The controller module also selects the image data to energize the corresponding display pixels of the display panels, and sends instructions containing signal levels and timing parameters to the light source electronics subsystem to energize the light source to illuminate the display panel.

The optical system may further include at least one integrated electronic display driver to provide the display signals to the display panels, at least one beam splitter, and an output lens subsystem, such that the output lens subsystem focuses the combined outputs of the display panels outputted through the beam splitter onto an image light amplifier.

The display panels may be arranged in two configurations. In the first configuration, each display panel energizes its each properly functioning pixel at the same fraction of full intensity as the corresponding properly functioning pixels in the other display panels. For example, a display panel energizes its properly functioning pixels at full intensity where the corresponding pixels in all other display panels have become defective. Under the second configuration the display panels are used in a master/slave relationship, so that one display panel is selected as a master and the other panels selected as slaves so that each properly functioning pixel in the master is energized at full intensity by the master and each defective pixel in the master is compensated for by selection of a backup slave from the slaves, with the backup slave to have a properly functioning corresponding pixel and to energize the corresponding pixel at full intensity to compensate for the corresponding defective pixel in the master. In both configurations, a sensing mechanism can determine whether each display panel and its associated hardware have become defective and to adjust the other display panels to compensate for the defective display under one of the two foregoing approaches.
In another embodiment, the present invention may be a system for automatic alignment of display panels of a system that displays electronic images on a display unit. The system may include a display panel driver subsystem, an integrated electronic display driver, a feedback mechanism to relay feedback data, an optical system having adjustable display panels with display pixels so that an automatic alignment mechanism aligns the adjustable display panels based on the relayed feedback data by the feedback mechanism, and at least one light source electronics subsystem where the display panel driver subsystem instructs at least one light source electronics subsystems to utilize the electronic display driver to energize the pixels in the display panels of the optical system.

The feedback mechanism may further include of an image receiving device to record the images outputted by the display panels, an image analysis subsystem to analyze the images received by the image receiving device and to determine whether each outputted image of the display panel is precisely superimposed on top of the outputted image of the other display panels in the plurality of display panels and to generate analysis data, and a relay substation to relay the analysis data to the feedback mechanism. The image receiving device is placed in one of two ways: at a distance farther than the distance of the display unit from the optical system, or in the alternate, at a distance substantially close to an image outputting outlet in the optical system.

The automatic alignment mechanism may further include a display adjuster subsystem coupled to the adjustable display panels to progressively move the display panels based on the analysis data of the feedback mechanism relayed by the relay substation until the analysis data match a pre-determined set of alignment data to indicate precise alignment of the adjustable display panels.

In a third embodiment, the present invention may be a method for automatic aligning of a set of display panels of a system that displays electronic images on a display unit. The method may include operating a display panel driver subsystem, operating an integrated electronic display driver, operating a feedback mechanism for relaying feedback data, operating an optical system having a set of adjustable display panels with a set of display pixels, so that operating an automatic alignment mechanism aligns the adjustable display panels based on the relayed feedback data by the feedback mechanism, and operating at least one light source electronics subsystem such that the display panel driver subsystem instructs the at least one light source electronics subsystems to utilize the electronic display driver to energize the pixels in the display panels of the optical system.
The operating of the feed-back mechanism may further include operating an image receiving device to record the images outputted by the set of display panels, operating an image analysis subsystem to analyze the images received by the image receiving device, determining whether each outputted image of a display panel is precisely superimposed on top of the outputted image of the other display panels in the set of display panels, and generating analysis data, and operating a relay substation to relay said analysis data to the feed-back mechanism. The operating of the image receiving device is done in one of two ways: by placing the image receiving device at a distance farther than the distance of the display unit from the optical system, or in the alternate, by placing the image receiving device at a distance substantially close to an image outputting outlet in the optical system.

The operating of the automatic alignment mechanism may further include coupling a display adjuster subsystem to the set of adjustable display panels, moving the display panels progressively based on the analysis data of the feed-back mechanism relayed by the relay substation, and repeating the moving of display panels until the analysis data match a predetermined set of alignment data to indicate precise alignment of the adjustable display panels.

In a preferred embodiment, the present invention may be used for projection of digitized motion pictures onto a movie screen and would use two to three LCD panels with one to two LCDs mounted on a fixed stand and with one other mounted on a two axis piezoelectric positioner, so that the output of all LCDs pass through a beam splitter which would then guide the combined beams onto an image light amplifier prior to a further projection onto a display unit such as a movie screen. A feed-back mechanism is also used in conjunction with an automatic alignment mechanism to align and continually keep the one to two LCD panels in alignment by adjusting the position of the one LCD panel that is mounted on the two axis piezoelectric positioner.

This brief summary has been provided so that the nature of the invention may be understood quickly. A more complete understanding of the invention can be obtained by reference to the following detailed description of the preferred embodiment thereof and to the drawings.

**Brief Description Of The Drawings**

Without limiting the invention in anyway, a number of preferred embodiments of the invention have been described in association with the accompanying drawings herein:

Figure 1 is a diagram of a preferred version of the overall system embodying the present invention;
Figure 2 is a diagram of a preferred version of an LCD version of an optical system embodying the present invention;

Figure 3a is a diagram of a preferred version of the electronic drive system utilized to send the image data into the LCD Display Panels of the optical system in the Equal Use Embodiment of the present invention;

Figure 3b is a diagram of a preferred version of the electronic drive system utilized to send the image data into the Display Panels of the optical system in the Master/Slave Embodiment of the present invention;

Figure 4a is a diagram of a preferred version of the feedback mechanism used in conjunction with the Optical System for providing alignment analysis data;

Figures 4a1 and 4a2 illustrate two different placing of the feedback mechanism;

Figure 4b is a diagram of a preferred version of the automatic alignment mechanism for aligning the Display Panels in the Optical System;

Figure 5a is a diagram of a preferred version of the image analysis subsystem to determine imperfect image superimposition;

Figure 5b is a diagram of a preferred version of the image analysis subsystem to determine a perfect image superimposition; and

Figure 6 is a diagram of a preferred version of a display system which provides redundancy for further minimizing defects in the outputted image if one LCD panel fails.

Detailed Description Of The Invention

Referring to FIG. 1, the overall system architecture of one embodiment of the present invention comprises three main subsystems, which include:

1. Display Panel Driver Subsystem 10 which comprises, a Signal Processing Module 11 which processes the incoming source digitized image file into a digital image data bitstream, a Timing module 12, and a Controller 13.

2. Display System 20, which comprises, an Optical System 21 which receives as input the digital image data bitstream provided by the Display Panel Driver Subsystem 10 and low power light from the Low Power Light Source Electronics Subsystem 30, an Image Light Amplifier 22 which receives outputted images from the Optical System 21 the outputs images onto a Display Unit 23.

3. Low Power Light Source Electronics Subsystem 30, which receives timing data from the Controller 13 of the Display Panel Driver Subsystem 10 and delivers
an appropriate voltage to the Light Source 26 synchronized with the displaying of image data into the LCD Display Panels 24.

Referring to **FIG. 2**, the subsystems of the Optical System 21 are:

1. LCD Display Panels 24,
2. Electronic Drive System 25,
3. Light Sources 26,
4. Collimating Lenses 27,
5. Beam Splitter 28,
6. Output Lens Subsystem 29,

Referring to **FIG. 3a**, the subsystems of the Electronic Drive System 25 for the Equal Use Embodiment (discussed below) are:

1. Ganged Switch 31,
2. Holding Register 32a,
3. Digital to Analog Converter 33,
4. Drive Amplifier 34,

Referring to **FIG. 3b**, the subsystems of the Electronic Drive System 25 for the Master/Slave Embodiment (discussed below) are:

1. Holding Register 32b,
2. Digital to Analog Converter 33,
3. Drive Amplifier 34,

Referring to **FIG. 4a**, the subsystems of the Feedback Subsystem 41 are:

1. Image Receiving Device 42,
2. Image Analysis Subsystem 43,
3. Relay Substation 44,

Referring to **FIG. 4a1**, the Image Receiving Device 42, is placed at a distance farther than the distance of the Display Unit 23 from the Optical System 21.

Referring to **FIG. 4a2**, the Image Receiving Device 42, is placed at a distance close to the image outputting outlet in the Optical System 21.

Referring to **FIG. 4b**, the subsystems of the Automatic Alignment Subsystem 45 are:

1. Display Adjuster Subsystem 46,
2. Adjustable Display Panel Subsystem 47,

Referring to **FIG. 5a** and **5b**, a randomly selected test pattern is chosen to better illustrate the superimposition workings of the Image Analysis Subsystem 42 in the Feedback Subsystem 41.
Referring to FIG. 6, the subsystems of the embodiment which provides redundancy are:

1. Display Panel Driver Subsystem 10,
2. Display System 20
3. Low Power Light Source Electronics Subsystem 30

A more detailed description of the operation of the present invention is provided below while referencing the foregoing Figures to better illustrate the different embodiments of the present invention and their enumerated subsystems.

A  Display Panel Driver Subsystem

The Display Panel Driver Subsystem 10 receives a digitized image file from an external source and then provides the necessary processing required to convert the image file into a format which can be used to convey the image data into a set of display panels. It also provides the timing information and other parameters required to turn on and off external light sources on a timed basis. These functions are provided by the structures discussed below.

1. Signal Processing Module

The incoming bitstream from an external source of digitized image files is a series of digital representations of the images, one for each frame of the image. A frame is delivered to the Signal Processing Module 11, together with timing data, and other associated data, in the serial bitstream. The image data bitstream is processed by the Signal Processing Module 11, which reformats the incoming data for delivery to an Electronic Drive System 25 of an Optical System 21, and extracts the timing data and other data. The timing data is forwarded to the Timing Module 12.

The Signal Processing Module 11 may also contain a table which defines the specific locations of defective pixels for each of the Display Panels 24.

2. Timing Module

The Timing Module 12 receives the timing data from the Signal Processing Module 11 and formats the timing data into timing signals. The timing signals are delivered to all the modules, systems, and subsystems so that they are synchronized with the image data bitstream such as the Signal Processing Module 11, Controller 13 and the Low Power Light Source Electronic Subsystem 30.
3. Controller

The Controller 13 in the Display Panel Driver Subsystem 10 defines the parameters which are used to actuate the light sources, as well as the parameters and timing data to be used by the Signal Processing Module 11. This control data is then sent to the Low Power Light Source Subsystem 30, the Signal Processing Module 11, and the Timing Module 12. The timing of the delivery of data to the Optical System 21, and the delivery of voltage waveforms to the light sources by the Low Power Light Source Electronics Subsystem 30, are under the direction of the Controller 13.

B. Optical System

FIG. 2 is a block diagram of the Optical System 21. The components of the Optical System 21 are discussed in greater detail below.

1. LCD Display Panel

The specifications for each of the Display Panels 24 depend upon the picture image resolution chosen for display system. A preferred version of the present invention uses a single crystal, active matrix liquid crystal display (AMLCD) Display Panel with a 3840 x 2160 pixel output format. The following discussion is based upon this selection. However, alternative output formats such as 1920 x 1080 can be used for the Display Panel pixel format. An example of an off-the-shelf LC Display Panel is the Kopin Corporation part number KCM-SK01 AA Display PC Kit.

In a preferred version of the present invention, the Display Panels 24 include an Electronic Driver Subsystem 25 as illustrated in FIG 2, which is used to convert the input signal into the format required by each of the Display Panels' matrix elements, for example, transistors. The Electronic Driver Subsystem 25 provides the ability to convert the input signal into parallel signals which energize each individual Display Panel 24 matrix elements.

Other image display panels, well known to those skilled in the art, can be used in the present invention. For example, electroluminescence, digital mirror device (DMD) or ferroelectric liquid crystal display writing panels can be utilized, with the appropriate optical and illumination source subsystems.

Described herein are two preferred embodiments of the present invention for minimizing the negative effects associated with a defective pixel in one of the Display Panels 24, hence enhancing the overall quality of the image on the display unit.
a. Equal Use of Display Panels

FIG. 2 illustrates the basic concept of what is described herein as "Equal Use" embodiment of the present invention. For simplicity, the illustration in FIG. 2 has been limited to two LCD Display Panels 24 but any number of display panels can be used in the system. In FIG. 2 the output of the two Display Panels 24 are imaged onto the photo-conductive layer of the Image Light Amplifier 22 (ILA) by the Output Lens Subsystem 29 and Beam Splitter 28.

The Display Panels 24 are fed by display signals supplied by the Electronic Drive System 25 of the Optical System 21. These display signals are identical in display data content so that the Display Panels' outputted images are identical as well. The Display Panels 24 are aligned so that their outputted images are precisely superimposed on one another. When the corresponding pixels in the Display Panels are properly functioning, each panel contributes an equal share of the full intensity of a properly functioning pixel. In the case of two Display Panels as in FIG. 2, each panel is operating at half of the full intensity.

For example, in as shown FIG. 2, the pixel in the Display Panel 24 from which Pixel Image Beam 1 emanates corresponds to the pixel in the Display Panel 24 from which Pixel Image Beam 2 emanates. Beam 1 and Beam 2 have identical data outputs and connect at precisely the same point on the Beam Splitter 28. The Beam Splitter 28 reflects the light from one panel, for example Beam 1, while passing the light from the other, for example Beam 2. When the two beams are connected in this fashion on the Beam Splitter as shown in FIG. 2, the light intensities (here at one half) add, pixel by pixel to a full intensity, then imaged onto the photo-conductive layer of the ILA.

When a pixel in one of the panels becomes defective, the alternate panels' pixels would each readjust their intensity levels to continue to contribute equally to provide full intensity. In case of FIG. 2, if the pixel outputting Beam 1 becomes defective and thus falls to zero output intensity, the other Display Panel would increase the intensity of Beam 2 to full intensity to fully compensate for the defective pixel's zero output.

In the preferred embodiment, each Display Panel is illuminated by a separate Light Source 26 and Collimating Lens 27, although any of the light sources can be derived from another by use of, for example, one light source and a beam splitter. Each set of the combination Light Source 26, Collimating Lens 27, Display Panel 24 and Output Lens Subsystem 29 could provide the display images for the output stage in the ILA 22. The ILA, also known as a Liquid Crystal Light Valve, is typically an off-the-shelf product available from a number of suppliers, and is described, for example, in U.S. Patent No. 5,083,854.
Each of the Display Panels 24 is typically assumed to have a large number of pixels, although the technique will work for any size image. Each panel is also typically assumed to have a small number of defective pixels (50-100) although the technique will work for any number of defective pixels.

The Display Panels 24 are designed so that when a pixel becomes defective it becomes black; i.e., transmits zero light. In a preferred version utilizing matrix transistors, the normal failure mode of a matrix transistor is to fail to a short circuit, which results in alignment of the LCD crystals at the matrix location, thus passing light. To prevent passage of light at the matrix location, the matrix transistor must fail to an open circuit. To accomplish this requirement, the Display Panels matrix transistors are tested. Matrix transistors which are found to be defective are then modified to create an open circuit condition. For example, the defective matrix transistor may be removed using a laser, thus leaving the LCD crystals unaligned and preventing light from passing through the specific matrix location. Thus, the pixels, have only one-half the intensity when both Display Panels have properly functioning pixels. In a location where either of the panels has a defective pixel, the other panel uses a full intensity pixel. A testing and selection of display panels can be performed before assembly to ensure that no single location has defective pixels from both panels.

b. Alternate Use Display

In another embodiment which shall be referred to as the “Alternate Use” embodiment, as also illustrated in FIG 2, a number of Display Panels are used in a Master/Slave relationship with one Display Panel selected as Master and the others as Slave. For simplicity, the illustration in FIG. 2 has been limited to two Display Panels, with one operating as a Master and the other as a Slave but any number of Display Panels can be used in the system.

In this embodiment, wherever the Master Display Panel has properly functioning pixels, it is displayed at full intensity, while the Slave Display Panel is displayed at zero intensity, as black. In the event of defective pixels in the Slave Display Panel, the output remains black whether displayed or not. In the event of defective pixels in the Master Display Panel, a corresponding properly functioning pixel in a selected Slave Display Panel is displayed at full intensity. If the pixel in the selected slave also becomes defective, another slave is selected from the remaining slaves with properly functioning pixel, to function as the Slave Display Panel. In this manner more than one slave may be operational along side a Master Panel at a given time. Testing is typically performed before assembly to ensure that the two Display
Panels 24 selected for the Optical System 21 do not have defective pixels in the same matrix locations.

2. Electronic Drive System

**FIG. 3a** shows the Electronic Drive System 25 for the Equal Use Writing System. The display signal for the Display Panels 24 is the output of a Drive Amplifier 34 fed from a Digital-to-Analog Converter (DAC) 33. The DAC 33 is fed from a Holding Register 32a. The Holding Register 32a stores the output of the digital source material as fed from a Ganged Switch 31.

In normal operation, where all Display Panels 24 have properly functioning pixels, the source data is shifted to the right one bit position, so that the output intensity for that panel will then only be a fraction of the full scale. The intensity fraction is inversely proportional to the number of Display Panels 24 used. For example, in a system where three Display Panels are employed, the intensity fraction for each panel is originally at one third of full intensity. However, since there are a number of such panels, the display intensity on the photo-conductive layer of the ILA adds to full scale.

If one of the pixels of a LC Display Panel 24 is defective, the source data value is loaded into the holding register without a right shift. Thus, in the illustration of FIG 2., the Display Panel 24 without this defect provides the full scale intensity. The defective pixel is not visible, since it is black.

For the Alternate Use embodiment, as illustrated in **FIG. 3b**, the Electronic Drive System 25 resembles largely that of FIG. 3a, except that the Ganged Switch 31 is not required and a different Holding Register 32b is used. The Holding Register 32b in this embodiment is different in that there exist an input to the Holding Register 32b which allows it to be reset, thus creating a black pixel.

3. Light Source and Collimating Lens

The Light Source 26 as shown in FIG 2 consists of a low power white light source with a high content of longer wavelengths. In the preferred embodiment, this source should be capable of being strobed. The Collimating Lens 27 accepts the diverging light rays from the source and forms a collimated output beam.
4. **Beam Splitter**

The Beam Splitter 28 reflects the light from one panel while passing the light from the other, thus allowing both to be imaged onto the photo-conductive layer of the ILA 22.

5. **Output Lens Subsystem**

The Output Lens Subsystem 29 includes the lens which images the LC Display Panels 24 onto the ILA 22. It may also include an optical band pass filter which passes only the wavelengths utilized by the photo-conductive layer of the ILA 22.

C. **Low Power Light Source Electronics Subsystem**

The Low Power Light Source Electronics Subsystem 30 contains the electronics which energize the Light Source 26. These include the ability to pulse the Light Source 26 at different rates and with different pulse widths and waveforms. The Low Power Light Source Electronics Subsystem 30 receives instructions from the Controller 13 defining the voltage waveform to be delivered to the light source. It receives timing data from the Timing Module 12 which is used to synchronize the timing of the energizing of the light sources with the display of the image data written into the LC Display Panels 24.

D. **Display System Which Provides Redundancy**

**FIG 6.** illustrates an embodiment of the present invention in which three or more Display Panels are used. For simplicity, the illustration in FIG. 6 has been limited to three Display Panels and can be used in both the Equal Use and Alternate Use Display embodiments as illustrated in FIG 2 but with the following differences:

1. The Signal Processing Module 11 stores in memory the matrix position of each defective pixel of each of the Display Panels 24, here three;

2. The Signal Processing Module 11 receives status information from each of the Display Panels 24 indicating whether the Display Panel 24 is properly functioning or not properly functioning;

3. The Signal Processing Module 11 generates image data file bitstreams for each of the Display Panels 24, dependent on the status of the Display Panels 24;

4. The Controller 13 receives control data from the Signal Processing Module 11, including status data if a Display Panel 24 is not functioning;

5. The Controller 13 instructs the Signal Processing Module 11 to deliver the digital image data bitstream generated by the Signal Processing Module 11 to the
Electronic Drive Systems 25 of the Optical System 21, depending on the status data provided to it by the Signal Processing Module 11;

6. The digital image data bitstream delivered to the Electronic Drive Systems 25 is specific to the intended destination Display Panel 24;

7. The Electronic Drive System 25 reformats the received digital image data bitstream into the format required by the internal, integrated electronics driver subsystem of the Display Panel 24;

8. The Optical System 21 includes additional Display Panel 24 (here a third one) which is used to provide redundancy in Display Panels under the foregoing Equal Use or Alternate Use embodiments. For the Equal Use embodiment, as illustrated in FIG. 5, the redundancy is provided by having all three Display Panels operate at one third the intensity and if one of the Display Panels 24 fails, the remaining Display Panels 24 are energized to a half intensity each panel. For the Alternate Use embodiment, as illustrated in FIG. 5, a 1:2 redundancy in the Master/Slave configuration is provided. That is, if one of the Slave Display Panels 24 fails, a second Slave Display Panel 24 is energized in place of the failed panel. For example, if the failed Display Panel 24 had been energized in matrix locations to eliminate the defects of a first Display Panel 24, then the redundant panel would be used to energize the same matrix locations as the failed panel;

9. The Optical System 21 includes additional Beam Splitters 28, Collimating Lenses 27, and Light Sources 26;

10. The output of the Display Panels 24 are combined at the photo-conductive layer of the ILA 22;

11. The Low Power Light Source Electronics Subsystem 30 includes additional electronic circuitry to deliver the appropriate voltage waveform to the additional Light Sources 26.

E. Automatic Alignment Subsystem

Another embodiment of the present invention is a system for automatic alignment of display panels of a system that displays electronic images on a display unit, as illustrated in FIG 4a and 4b. The Automatic Alignment Device 40 comprise of a Feedback Subsystem 41 and an Automatic Alignment Subsystem 45.

Referring to FIG. 4a, the subsystems of the Feedback Subsystem 41 include an Image Receiving Device 42, Image Analysis Subsystem 43, and Relay Substation 44. The Image
Receiving Device 42 is typically a camera unit that is not only capable of recording images but one which can also receive as input a number of images superimposed on one another, such as the images outputted by the Optical System described in FIG. 2. The images recorded by the Image Receiving Device 42 are then transmitted in a real-time or time-delayed fashion to the Image Analysis Subsystem 43. The Image Analysis Subsystem 43 then matches the corresponding pixel position in each superimposed image against the others to determine whether a perfect superimposition has taken place.

In the preferred embodiment, a computer running an image recognition application matches a set of corresponding, predetermined test pixel positions for each image against the other images. For example, as illustrated in FIG. 5a, when two superimposed images are received, the Image Analysis Subsystem 43 uses the corresponding predetermined pixel positions marked by line 50 to determine that a perfect superimposition has not taken place since both lines 50 have not perfectly transposed into one line. FIG. 5b illustrates a perfect superimposition as only one line can be seen. If the superimposition is determined to be perfect, no further action is taken. If the superimposition is determined to be not perfect, then the Image Analysis Subsystem 43 determines the adjustment data for obtaining a perfect superimposition of the images and the result is relayed by the Relay Substation 44 to the Automatic Alignment Subsystem 45, illustrated in FIG. 4b.

In one embodiment, as illustrated in FIG 4a1, the Image Receiving Device 42 is placed behind the Display Unit 23 for optimal determination of perfect superimposition by the Image Analysis Subsystem 43.

In another embodiment, as illustrated in FIG 4a2, the Image Receiving Device 42 is placed near the output point of the images outputted from the Optical System 21 resulting in a more coarse determination of perfect superimposition by the Image Analysis Subsystem 43. In the preferred embodiment, the Image Receiving Device 42 can record the images by use of a second Beam Splitter 48 as illustrated in FIG. 4a2.

FIG. 4b, illustrates the subsystems of the Automatic Alignment Subsystem 45 which include a Display Adjuster Subsystem 46, and Adjustable Display Panels Subsystem 47 with the Adjustable Display Panel Subsystem 47 further comprising of Adjustable Display Panels 48 and Actuators 49. The Display Adjuster Subsystem 46 receives the adjustment data relayed to from the Relay Substation 44 and converts the adjustment data into corresponding instruction for the Actuators 49 to move the Adjustable Display Panels 48 to move the adjustable display panels toward a precise alignment resulting in a perfect superimposition of the images as determined the Image Analysis Subsystem 43.
In the preferred embodiment, two Display Panels are used with one Display Panel being an Adjustable Display Panel and the other aligned manually and fixed. The Adjustable Display Panel is mounted on a two-axis piezoelectric positioner which act as an Actuator and receives converted instructions from the Display Adjuster Subsystem 46 to adjust the Adjustable Display Panel toward a precise alignment with the fixed Display Panel resulting in a perfect superimposition of the images as determined by the Image Analysis Subsystem 43. In the preferred embodiment, the Feedback Subsystem 41 continually provides adjustment data to the Automatic Alignment Subsystem 45 for the Actuators to progressively move the Adjustable Display Panel until a precise alignment with the fixed Display Panel results.

Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

In the following claims, those claims which do not contain the words “means for” are not intended to be interpreted in accordance with 35 U.S.C. section 112, paragraph 6.
What is claimed is:

1. A system for enhancing outputted image resolution on a display unit of a system that displays electronic images comprising:
   a display panel driver subsystem;
   an integrated electronic display driver;
   an optical system comprising a plurality of display panels, each said display panel having a plurality of display pixels, wherein each panel is configured to enhance outputted image resolution on the display unit by compensating for a defective display panel; and
   a light source electronics subsystem, said display panel driver subsystem to instruct the light source electronics subsystems to utilize the electronic display driver to energize the pixels in the display panels of the optical system.

2. The system of Claim 1, wherein the display panel driver subsystem further comprising:
   a signal processing module which receives an input signal, said input signal comprising an incoming image file signal, and a clock information, said signal processing module to parse clock information from the input signal, to process said incoming image file signal into a plurality of digital image data bit-streams, and to duplicate each digital image data bit-stream wherein one duplicate is generated for each display panel in the plurality of display panels;
   a timing module which receives the clock information from signal processing module; and
   a controller module, said controller module to receive timing information from the timing module and to instruct the signal processing module of the correct time to deliver image data to the electronic drive system of the optical system based on the received timing information, said controller module to select the image data to energize corresponding display pixels of the display panels, said controller module to send instructions containing signal levels and timing parameters to the light source electronics subsystem to energize the light source to illuminate the display panel.

3. The system of Claim 1, wherein the optical system further comprising:
   at least one integrated electronic display driver to provide the display signals to the display panels;
at least one beam splitter; and
an output lens subsystem, wherein the output lens subsystem to focus the
combined outputs of the display panels outputted through the beam splitter onto an image
light amplifier.

4. The system of Claim 1, wherein the light source electronics subsystem is a low
power light source electronics subsystem.

5. The system of Claim 1, wherein the light source electronics subsystem
generates timed voltage waveforms to utilize the electronic display driver.

6. The system of Claim 1, wherein the light source electronics subsystem further
comprising at least one light source with each said light source comprising one collimating
lens.

7. The system of Claim 2, wherein each said digital image data bit-stream
generated by the signal processing module is multiplexed together with said timing information
to form a serial bit stream appropriate to sequentially deliver the said data bitstream to the
integrated electronic display driver.

8. The system of Claim 7, wherein the digital image data bit stream is delivered to
the electronic drive system.

9. The system of Claim 1, wherein the integrated electronic display driver
processes the input image data bit stream into the signal format required by the display panel at
data rates consistent with the display of high resolution images at frame rates ranging from 15
to over 78 frames per second.

10. The system of Claim 1, wherein the display panel can be selected from a group
of image displaying devices consisting of electroluminescent panels, ferroelectric liquid crystal
displays, and digital mirror devices.

11. The system of Claim 1, wherein the optical system is comprised of a plurality of
independent single crystal AMLCD display panels.

12. The system of Claim 1, wherein each display panel in the plurality of display
panels energizes its each properly functioning pixel at the same fraction of full intensity as the
Corresponding properly functioning pixels in the other display panels so that a display panel
energizes its properly functioning pixels at full intensity where the corresponding pixels in all other display panels have become defective.

13. The system of Claim 12, wherein a sensing mechanism determines whether any display panel and its associated hardware in the plurality of display panels have become defective and to adjust the other display panels to compensate for the defective display.

14. The system of Claim 1, wherein the plurality of display panels are used in a master/slave relationship, said master/slave relationship to operate with one display panel selected as a master and the other panels selected as a plurality of slaves wherein each properly functioning pixel in the master is energized at full intensity by the master and each defective pixel in the master is compensated for by selection of a backup slave from the plurality of slaves, said backup slave to have a properly functioning corresponding pixel and to energize the corresponding pixel at full intensity to compensate for the corresponding defective pixel in the master.

15. The system of Claim 14, wherein the plurality of slaves are configured so that in the event of a defect in the corresponding pixel of the backup slave an alternate backup slave is selected from the plurality of slaves to compensate for the corresponding defective pixel in the master.

16. The system of Claim 14, wherein a sensing mechanism determines whether any display panel and its associated hardware in the plurality of display panels have become defective and to adjust the other display panels to compensate for the defective display.

17. The system of Claim 14, wherein the plurality of display panels comprise of three display panels configured to a two-to-one redundancy configuration wherein a first display panel is selected to be in an inactive mode while a second and a third display panels are placed in a master/slave relationship wherein each properly functioning pixel in the master is energized at full intensity by the master and each defective pixel in the master is compensated for by a properly functioning corresponding pixel in the slave, said corresponding pixel in the slave energized to full intensity, and wherein the plurality of panels are configured so that in the event of a defect in the corresponding pixel of the slave, a corresponding pixel in the first display panel is energized to full intensity to compensate for the corresponding defective pixel in the master.
18. The system of Claim 14, wherein the master in the plurality of display panels is selected in an alternate fashion so as to maximize its operational lifetime.

19. The system of Claim 1, wherein a test pattern is inputted into the plurality of display panels and the combined outputs of the plurality of display panels projected onto the display unit so that to align the display panels.

20. The system of Claim 18, wherein a test pattern is inputted into all three display panels and the combined outputs of the three display panels projected onto the display unit so that to align the three display panels.

21. The system of Claim 1, wherein the display unit is a screen.

22. The system of Claim 21, wherein the screen is a movie screen.

23. A system for automatic alignment of a plurality of display panels of a system that displays electronic images on a display unit comprising:
   a display panel driver subsystem;
   an integrated electronic display driver;
   a feed-back subsystem to relay feed-back data;
   an optical system comprising a plurality of adjustable display panels, each said display panel having a plurality of display pixels, wherein an automatic alignment subsystem aligns said adjustable display panels based on the relayed feed-back data by the feed-back subsystem; and
   at least one light source electronics subsystem, said display panel driver subsystem to instruct the at least one light source electronics subsystems to utilize the electronic display driver to energize the pixels in the display panels of the optical system.

24. The system of Claim 23, wherein the display panel driver subsystem further comprising:
   a signal processing module which receives an input signal, said input signal comprising an incoming image file signal, and a clock information, said signal processing module to parse clock information from the input signal, to process said incoming image file signal into a plurality of digital image data bit-streams, and to duplicate each digital image data bit-stream wherein one duplicate is generated for each display panel in the plurality of display panels;
a timing module which receives the clock information from signal processing module; and

a controller module, said controller module to receive timing information from the timing module and to instruct the signal processing module of the correct time to deliver image data to the electronic drive system of the optical system based on the received timing information, said controller module to select the image data to energize corresponding display pixels of the display panels, said controller module to send instructions containing signal levels and timing parameters to the light source electronics subsystem to energize the light source to illuminate the display panel.

25. The system of Claim 23, wherein the optical system further comprising:
   at least one integrated electronic display driver to provide the display signals to the display panels;
   at least one beam splitter; and,
   an output lens subsystem, wherein the output lens subsystem to focus the combined outputs of the display panels outputted through the beam splitter onto an image light amplifier.

26. The system of Claim 23, wherein the light source electronics subsystem is a low power light source electronics subsystem.

27. The system of Claim 23, wherein the light source electronics subsystem generates timed voltage waveforms to utilize the electronic display driver.

28. The system of Claim 23, wherein the light source electronics subsystem further comprising at least one light source with each said light source comprising one collimating lens.

29. The system of Claim 23, wherein the feed-back subsystem further comprising:
   an image receiving device to record the images outputted by the plurality of the display panels;
   an image analysis subsystem to analyze the images received by the image receiving device, to determine whether each outputted image of a display panel is precisely superimposed on top of the outputted image of the other display panels in the plurality of display panels, and to generate analysis data; and
a relay substation to relay said analysis data to the automatic alignment subsystem.

30. The system of Claim 29, wherein the image analysis subsystem is a computer running an image recognition application.

31. The system of Claim 29, wherein the image receiving device is a camera capable of recording images.

32. The system of Claim 23, wherein the automatic alignment subsystem further comprising:
   a display adjuster subsystem coupled to said plurality of adjustable display panels to progressively move said display panels based on the analysis data of the feed-back subsystem relayed by the relay substation until said analysis data match a pre-determined set of alignment data to indicate precise alignment of the adjustable display panels.

33. The system of Claim 29, wherein the image receiving device is placed at a distance farther than the distance of the display unit from the optical system.

34. The system of Claim 29, wherein the image receiving device is placed at a distance substantially close to an image outputting outlet in the optical system.

35. The system of Claim 34, wherein a second beam-splitter directs the images to the image receiving device.

36. The system of Claim 23, wherein the display unit is a screen.

37. The system of Claim 35, wherein the screen is a movie screen.

38. A method for automatic aligning of a set of display panels of a system that displays electronic images on a display unit comprising:
   operating a display panel driver subsystem;
   utilizing a feed-back subsystem for relaying feed-back data;
   operating an integrated electronic display driver;
   operating an optical system wherein said optical system comprising a set of adjustable display panels, each said display panel having a set of display pixels, wherein operating an automatic alignment subsystem aligns said adjustable display panels based on the relayed feed-back data by the feed-back subsystem; and,
operating at least one light source electronics subsystem, said display panel
driver subsystem to instruct the at least one light source electronics subsystems to utilize the
electronic display driver to energize the pixels in the display panels of the optical system.

39. The method of Claim 38, wherein the display panel driver subsystem further
comprising:

a signal processing module which receives an input signal, said input signal
comprising an incoming image file signal, and a clock information, said signal processing
module to parse clock information from the input signal, to process said incoming image file
signal into a set of digital image data bit-streams, and to duplicate each digital image data bit-
stream wherein one duplicate is generated for each display panel in the set of display panels,

a timing module which receives the clock information from signal processing
module; and

a controller module, said controller module to receive timing information from
the timing module and to instruct the signal processing module of the correct time to deliver
image data to the electronic drive system of the optical system based on the received timing
information, said controller module to select the image data to energize corresponding display
pixels of the display panels, said controller module to send instructions containing signal levels
and timing parameters to the light source electronics subsystem to energize the light source to
illuminate the display panel.

40. The method of Claim 38, wherein the optical system further comprising:
at least one integrated electronic display driver to provide the display signals to
the display panels,

at least one beam splitter; and

an output lens subsystem, wherein the output lens subsystem to focus the
combined outputs of the display panels outputted through the beam splitter onto an image
light amplifier.

41. The method of Claim 38, wherein the light source electronics subsystem is a
low power light source electronics subsystem.

42. The method of Claim 38, wherein the light source electronics subsystem
generates timed voltage waveforms to utilize the electronic display driver.
43. The method of Claim 38, wherein the light source electronics subsystem further comprising at least one light source with each said light source comprising one collimating lens.

44. The method of Claim 38, wherein operating the feed-back subsystem further comprising:
   operating an image receiving device to record the images outputted by the set of display panels;
   operating an image analysis subsystem to analyze the images received by the image receiving device, determining whether each outputted image of a display panel is precisely superimposed on top of the outputted image of the other display panels in the set of display panels, and generating analysis data; and
   operating a relay substation to relay said analysis data to the automatic alignment subsystem.

45. The system of Claim 44, wherein the image analysis subsystem is a computer running an image recognition application.

46. The method of Claim 44, wherein the image receiving device is a camera capable of recording images.

47. The method of Claim 38, wherein operating the automatic alignment subsystem further comprising:
   coupling a display adjuster subsystem to said set of adjustable display panels,
   moving said display panels progressively based on the analysis data of the feed-back subsystem relayed by the relay substation; and
   repeating said moving of display panels until the analysis data match a predetermined set of alignment data to indicate precise alignment of the adjustable display panels.

48. The method of Claim 44, wherein operating the image receiving device further comprise of:
   placing the image receiving device at a distance farther than the distance of the display unit from the optical system.
49. The method of Claim 44, wherein operating the image receiving device further comprise of:
   placing the image receiving device at a distance substantially close to an image outputting outlet in the optical system.

50. The method of Claim 49, wherein operating the image receiving device further comprise of:
   operating a second beam-splitter that directs the images to the image receiving device.

51. The method of Claim 38, wherein the display unit is a screen.

52. The method of Claim 51, wherein the screen is a movie screen.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04N5/74 H04N9/31

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04N

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

Electronic database consulted during the international search (name of database and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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Further documents are listed in the continuation of box C. Patent family members are listed in annex.

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Date of mailing of the international search report: 14/06/2000

Name and mailing address of the ISA
European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer
Pigniez, T
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