is as uncorrelated to the high frequency defect signal **548** as possible. If given the task, a human operator would subtract more or less of the defect signal **548** as controlled by turning the "knob" of gain block **530**. The human operator would stop when the defect "disappears" from corrected image signal **546** as seen by viewing the corrected image **514**. This point is noted by the human operator as "disappearance" of the defect and is mathematically defined as the point at which the defect signal **544** or **548** and the corrected signal **546** are uncorrelated. This process could be repeated for each segment of the image with slightly different values of gain resulting as the optimum gain for each segment.

Despite the flexibility introduced by the gain block **530** of FIG. **5**, it has been found that often a defect is incompletely nulled because deficiencies in the scanner cause the defect to look different in the infrared and the visible, such that no setting of gain can eliminate all aspects of the defect.

A need has thus arisen for an improved method for image defect correction.

SUMMARY OF THE INVENTION

In accordance with the present invention, surface defects in a reflection scan of an image consisting of pixels made with visible light are corrected by using a scan of the image consisting of pixels made with infrared light. This correction of surface defects is performed by first establishing for each pixel an upper and lower bound for defect intensity based on the infrared record. The corresponding visible pixel is then corrected by substracting the combination of upper and lower bound resulting in a corrected pixel.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and for further advantages thereof, reference is now made to the following Description of the Preferred Embodiments taken in conjunction with the accompanying Drawings in which:

FIG. **1** compares light transmission of dyes with light transmission of a surface defect;

FIGS. **2***a–d* compare visible and infrared transmissions of a film with and without a defect;

FIG. **3** illustrates an overview of a prior art process for infrared surface defect correction;

FIG. **4** illustrates a method of surface defect correction applied in logarithmic space;

FIG. **5** illustrates a method of surface defect correction applied in split frequency space;

FIG. **6** teaches the present method of bounded subtraction used in surface defect correction;

FIGS. **7***a*–**7***f* graphically detail the effect of the bounded subtraction shown in FIG. **6**;

FIG. **8** is a flow chart illustrating details of the present method for accomplishing bounded subtraction;

FIG. **9***a*–**9***e* graphically show bounded subtraction applied in split frequency space;

FIG. **10** shows an effect of bounded subtraction in two dimensions;

FIG. **11** teaches defect correction applied in transform space;

FIG. **12** further details correction in transform space with displacement;

FIG. **13** is a flow chart illustrating the method for obtaining a correlation value;

FIGS. **14***a*–**14***e* show graphically the calculation of upper and lower bounds; and

FIG. **15** is a flow chart illustrating the method for obtaining the upper and lower bounds.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The topology of FIG. **6** of the present invention seeks to overcome the problem of incompletely nulling a defect by utilizing a bounded subtraction function block **602** capable of totally zeroing a defect within a bounded range.

FIG. **6** assumes operation within the logarithmic domain as demarcated by the dotted box **402** of FIG. **4**, and further assumes operation on images that have been band passed or high passed as shown previously in FIG. **5** such that the values of the pixels comprising the images average to zero within a region. Because the values of the pixels average to zero, zero is a "base" to which the image can be driven that will always give a reasonable erasure of detail. If the image were not band passed or high passed, setting pixels to zero would produce black dots that would not represent a reasonable erasure of detail.

Further, it should be understood that "zero" is a relative term, and that a fixed bias, or a bias varying with the low frequency of the image, could be introduced, and that setting pixels to "zero" would represent setting them to this bias value. In AC coupled analog electronics, "zero" may or may not represent zero absolute volts, and "zero" is used here in that sense.

Continuing with the description of the preferred embodiment shown in FIG. **6**, a pixel **604** from infrared image **606** is processed in conjunction with adjacent pixels by an upper bound function block **608** to estimate, all things considered, what the maximum value for that pixel might be if scanned with an ideal scanner. That maximum value must account for errors in registration, sharpness, and so forth. That maximum value is placed in the upper bound infrared image **610** at pixel **612**. Similarly, the same original pixel **604** is processed with adjacent pixels by the lower bound function block **614** to produce a lower bound estimate placed in pixel **616** of the lower bound infrared image **618**.

The bounded subtractor function block **602** receives the value of the visible pixel **620** from visible image **622**. The upper bound estimate **612** is subtracted from this visible pixel to reduce an upper bound corrected estimate, and the lower bound estimate **616** is subtracted to reduce a lower bound corrected estimate. To the extent the estimators **608** and **614** are operating correctly, the ideal corrected value will lie between the upper and lower bound corrected estimates. An assumption used to select one of the corrected estimates is that if a mistake is made in choosing one estimate, the mistake will be less noticeable if it results in an estimated value closer to zero than if it results in an estimated value farther from zero. Therefore the one of the two upper and lower corrected estimates that is closest to zero is selected as the final estimate. If one estimate is positive and the other negative, and therefore zero is between the two estimates, then zero is output as the final estimate from the bounded subtraction block **602** to place in pixel **626** of the corrected image **628**.

Turning now to FIG. **7**, the operation and effect of the bounded subtractor are further explained. In FIG. **7**, a one-dimensional image is portrayed, which may be a single scan line through a two-dimensional image. It should be understood that the same concepts apply in one or two dimensions.