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Navy Case No. 73,922 PATENTS

VARIABLE RATE OPTICAL ITERATIVE PROCESSING OF OPTICAL INFORMATION

BACKGROUND OF THE INVENTION

This invention relates in general to optical signal processing, including the use of two-dimensional optical delay lines through which real-time transfer rate control of optical data is exercised.

Pattern recognition systems involving identification and classification of input data are presently utilized for a wide variety of purposes including but not limited to product line inspection, computer text scanning, robotics, medical diagnostics, fingerprint identification, product code scanners in supermarkets, airport security and character recognition. There is also significant military interest in pattern recognition for autonomous identification of enemy targets through a smart weapon system where speed and accuracy requirements are high. Such requirements can be met by the high throughput realized from the parallelism inherent in optical signal processing systems.

As referred to in U.S. Patent No. 5,289,304 (the disclosure of which is incorporated herein by reference), various techniques are presently known in the art for use in pattern recognition systems having certain problems associated therewith. As to an optical ring system as a solution to such problems, prior multiple image rotation or scaling by such a system have heretofore been performed at rates too rapid for subsequent processing, while use of mechanical stages has been too slow and cumbersome.

It is therefore an important object of the present invention to introduce a two-dimension optical ring system with variable transfer rate control, thus resolving major problems of the optical ring and allow practical implementations of optical iterative processing in any optical data processing system requiring iterative processing, such as scale and/or rotation invariant pattern classification which include optical associative memories, optical artificial neural network and optical wavelet processing.

SUMMARY OF THE INVENTION

In accordance with the present invention, an optical data transfer module is introduced within an optical ring system to provide control of the data transfer rate on a real-time basis. The data is stored during data transfer between spatial light modulators. An image input impinges on one spatial light modulator producing a charge distribution which matches the local intensity of the image input. This charge distribution can be held or stored by the data transfer module for selected time periods, thus providing an optical delay within the optical ring system to match cyclic processing within a data processor to which the output of the optical ring system is fed.

For scale invariant pattern recognition purposes, according to one embodiment, a set of zoom lens is placed within the optical ring system so that each data iteration produces either a magnification or reduction of the image. Such image is then transferred out of the ring for matching with a reference image. Each transfer is a scaled image of the previous image. For rotation of invariant classification according to another embodiment, a Dove prism arrangement is utilized, thus producing image rotation.

BRIEF DESCRIPTION OF DRAWING FIGURES

Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawing wherein:

FIG. 1 is a block diagram of an optical data transfer system in accordance with the present invention;

FIG. 2 is a block diagram corresponding to that of FIG. 1, depicting the variable delay module component in greater detail; and

FIG. 3 is a block diagram corresponding to those of FIGS. 1 and 2 depicting the optical ring system in greater detail .

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing in detail, FIG. 1 diagrammatically depicts an optical variable delay module 10 interrelated with an optical ring system 60 in order to control performance of iterative operations with respect to two-dimensional image data received from an input source 12. pursuant to the present invention, performance of such iterative operations involves cyclic processing of the input image data by rotation or scaling for rate control matching a subsequent optical data processor 14 to which the data processed output from the optical ring 60 system is fed.

As diagrammed in FIG. 2, the image data from source 12 is initially applied to and temporarily stored within an optically addressed spatial light modulator 16 of the optical delay module 10. Such input data after a predetermined time period is transferred from modulator 16 through a beam splitter 18 to a second optically addressed spatial light modulator 20 from which it is then sequentially transferred to the subsequent processor 14 through the optical ring system 60. Each of the modulators 16 and 20 has a write operating state and a read or storage operating state. Such operating states for each of the modulators 16 and 20 is electrically determined through electrical control lines 24 and 26 to limit operation thereof to different states. Thus, when one modulator is in the read or storage state the other modulator is in the write state. The modulators 16 and 20 are constructed, operated and controlled as disclosed and described in U.S. Patent No. 5,289,304 hereinbefore referred to.

The variable delay module 10 as hereinbefore described is utilized to control the rate of cyclic image data processing within the optical ring system 60, thereby matching processing of the image data by the subsequent processor 14. Toward that end, the delay module 10 according to one embodiment of the present invention also includes a spatial light modulator 74 optically addressed by an input write beam 32 from the input image data source 12 to control the passage of radiation from a laser source 30. An optical data output beam 15 from the modulator 74 is thereby produced as diagrammed in FIG. 2. The other spatial modulators 16 and 20 modulate polarization of read beam 28 within the optical ring system 60 reflected by and passing through a beam splitter 18. The spatial modulator 16 also receives a reflected output beam 29 within the optical ring system 60 for polarization thereof within the variable delay module 10 as a function of the intensity varying input write beam 32 from source 12.

Referring now to FIG. 3, the output beam 15 from the module 10 is fed to an optical data processor 62 through a beam splitter 64 and a reflecting mirror 66 of the optical ring system 60. The output beam so transferred to processor 62 is processed into optical image data transmitted by mirror 68 and beam splitter 70 into an output beam 72 transferring image data to the data processor 14. The other portion of the image data beam transmitted from mirror 68 to the beam splitter 70 forms the beam 29 fed back to the spatial light modulator 16 of the delay module 10 as aforementioned. The beam splitter 64 in addition to receiving the output beam 15 from module 10, also initially receives an input modulated beam from spatial light modulator 74 to which laser radiation is fed from laser source 30. The beam splitter 64 accordingly directs a laser control beam during an initial input phase from laser source 30, modified by modulator 74, to mirror 76 establishing a coupling portion of the optical ring system 60 that is subsequently inactivated. The reflected beam from mirror 76 passes along the circuit path of such coupling portion through a shutter 78 to mirror 80 from which the beam 28 is derived as the radiation input to the beam splitter 18 of module 10. The module 10 thereby acts to delay and control the rate of passage of optical image data through the optical ring system 60.

With continued reference to FIG. 3, the optical processor 62 is utilized to effect cyclic processing of the optical image being transferred at a rate determined by the delay module 10 for providing the optical ring system 60 with the capability of matching a variable cyclic rate of the data processor 14 to which the output image beam 72 is fed. To enter an image into the optical ring system 60, the laser 30 of a randomly-polarized He-Ne type fires to read data stored in modulator 74 and produce input beams reflected by beam splitter 64 to mirrors 66 and 76. Shutter 78 controls one of the reflected beams further reflected off mirror 80 into the module 10 to vary the image transfer rate by means of its output beam 15 impinging on the input beam splitter 64. The other of the reflected input beams from beam splitter 64 is further reflected by mirror 66 for cyclic image processing before reflection by mirror 68 into the output beam 72 through the beam splitter 70. The beam splitter 70 reflects such output beam into the module 10 through which the variable image transfer rate is controlled.

According one embodiment of the invention, the optical processor 62 is a Dove prism by means of which optical image data undergoes cyclic rotational reorientation at a rate varied under control of the module 10 so as to operationally match the data processor 14. Such a Dove prism is disclosed and described in greater detail in U.S. Patent No. 5,289,304 aforementioned. As an alternate embodiment, the optical processor 62 may be a zoom lens set-up for scaling the optical image by magnification or demagnification at a cyclic rate varied under control of module 10, as hereinbefore described, for operationally matching the data processor 14.

Obviously, other modifications and variations of the present invention may be possible in light of the foregoing teachings. It is therefore to be understood that

the invention may be practiced otherwise than as specifically described.

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ABSTRACT OF THE DISCLOSURE

Two-dimensional image data is transferred by a delay module through an optical ring to a subsequent optical data processor at a controlled cyclic processing rate varied to operationally match such data processor. Cyclic processing of the input image data is performed within the optical ring by rotational reorientation or scaling of the image data.

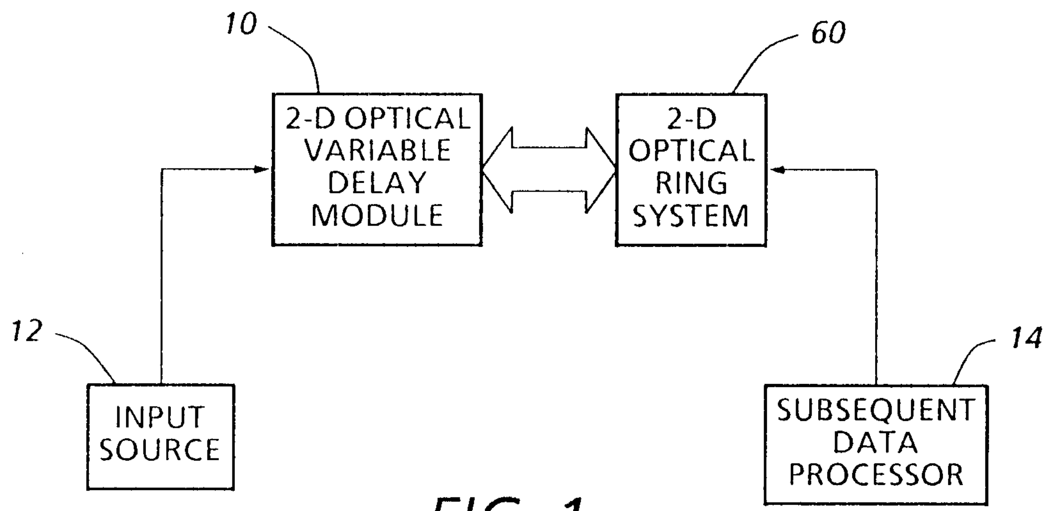
10
60
2-D OPTICAL VARIABLE DELAY MODULE
2-D OPTICAL RING SYSTEM
12
14
INPUT SOURCE
SUBSEQUENT DATA PROCESSOR

FIG. 1

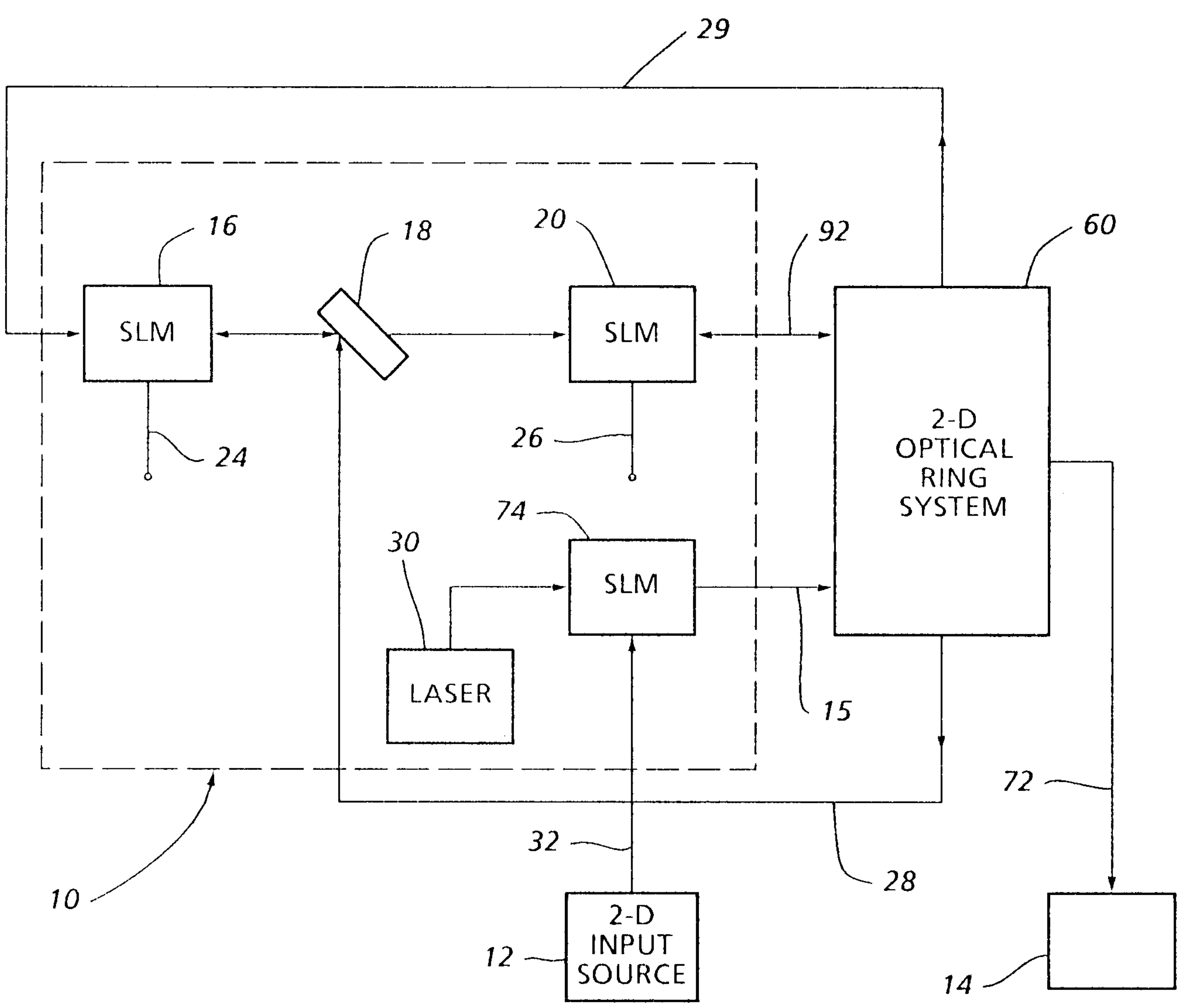
29
16
18
20
92
60
SLM
SLM
24
26
2-D OPTICAL RING SYSTEM
74
30
SLM
LASER
15
72
10
32
28
2-D INPUT SOURCE
12
14

FIG. 2

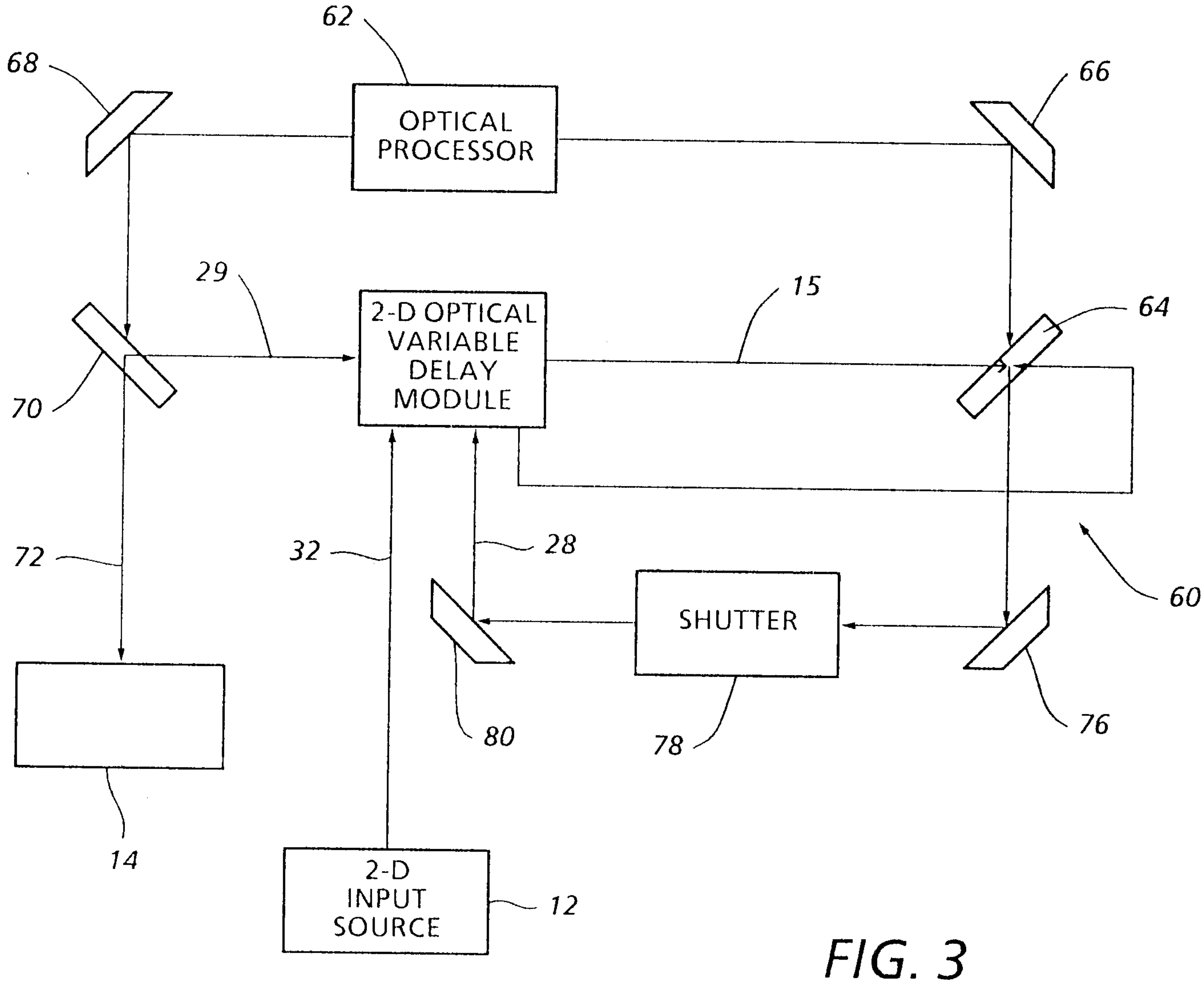
62
68
66
OPTICAL
PROCESSOR
29
15
64
2-D OPTICAL
VARIABLE
DELAY
MODULE
70
72
32
28
60
SHUTTER
80
78
76
14
2-D
INPUT
SOURCE
12

FIG. 3