Abstract: The object of the present invention refers to a versatile CCD camera which is realised through a modular architecture in order to achieve maximum flexibility of operation. The CCD camera according to the present invention can be operated via a personal or embedded computer and via remote connection and allows the operator to configure and program every functional parameter in order to adapt the CCD camera according to the present invention to different kind of image acquisition and processing.
Versatile CCD Camera

Field of the invention
This invention refers to the field of CCD Cameras.

State of the art
Charged Coupled Devices (CCD) have recently gained a primary importance role in the field of image sensors and they are installed in most of videocameras and photocameras available today.

CCD cameras have been initially employed for astronomical investigations and then they have progressively broaden their range of application to many other scientific and industrial fields like digitalisation of radiographic films, Transmission Electron Microscopy, wind tunnel test in connection with pressure sensitive fluorescent paints, brain cortex images acquisition, digital processing of images from microscopes, analysis of electronic diffraction, analysis of biologic fluorescence, debugging of printed circuit boards, astronomical spectroscopy etc.

On one side all these new application have proved the great flexibility of use of CCD sensors, on the other side they have highlighted the lack of versatility of actual cameras installing CCD sensors. In fact, it is not possible, at present, to optimise simultaneously all the different features required to a CCD camera in order to perform all the tasks it is potentially able to carry on.

For example, CCD cameras with high acquisition rate are characterised by high level of read-out noise, and therefore high speed, especially required for large size of CCD arrays, is not compatible with wide dynamic ranges. This is the reason why actual CCD cameras are designed to work in selected fields and to perform only selected tasks and they employ CCD sensors optimised for those particular tasks.

Current commercial CCD cameras have the following drawbacks:
- they are designed and built around one specific CCD sensor that can not be replaced by a different one in order to adapt the camera's performances to a different task
- users are allowed to modify the basic working parameters (such as pixel-rate, gain, exposure time etc.) but usually just in a few discrete steps
- users are not allowed to access or to modify time settings and bias voltages
they do not generate output signals that can be used to synchronise and drive external electrical or mechanical equipment.

- they are generally equipped with a not-intuitive and not-user friendly software interface, especially in a scientific application that requires the highest performance and therefore the finest optimisation: non-standard utilizations usually require expert operators to manage the CCD camera.

- they are neither modifiable nor upgradeable: users are not allowed to substitute the CCD sensor, to change or add functionalities, to upgrade parts or components.

- they are not fully remote-controllable.

- they do not include diagnostic or upgrading procedures from a remote location.

The CCD camera according to the present invention overcomes the drawbacks of existing cameras offering a total versatility in terms of editing functional parameters, in order to match the specific phenomenon to be examined. The CCD camera according to the present invention allows the user to adopt only one device for different tasks, setting parameters and both hardware and software configurations in a straight and simple way.

A further aim of the present invention is a complete apparatus for acquisition and analysis of images based on the CCD camera introduced above. Such apparatus includes the following features:

- advanced concept of modularity, that will introduce the concept of the hardware easy strengthening, expansion and upgrade. The user will take advantage from this innovation thanks to the possibility to maintain its CCD camera always at the top of the performances and to cope with changing experimental requirements. For instance, the user can choose to substitute the air-cooler module with a fluid-cooler module, or to add (or remove) the vacuum interface module. Moreover, the CCD camera according to the present invention offers the possibility to replace the sensor, bringing minimal hardware changes and modifying the electronic parameters directly by the software interface.

- full remote control and parameter setting in order to operate the camera according to the present invention via a cabled or wireless local area network or via Internet.
the possibility to carry out a complete post-sale assistance that includes: on-site assistance, remote debug/diagnosis by means of an Internet connection, free upgrade of both firmware and software.

- every control signal and bias can be finely tuned both in the time and amplitude domains.

- resources are available to control auxiliary external peripherals related to the image to be acquired, such as temperature monitoring or to operate external mechanical components as shutters, telescope motors, filter wheels, gratings etc.

- the CCD camera according to the present invention is fully high vacuum compatible and two configurations are available: a sealed camera or a camera with a vacuum interface module that allows the user to perform custom air-vacuum cycles.

- the CCD camera according to the present invention is available in a stand-alone version, with all features attainable.

- automatic acquisition procedures are available, with customizable pixel rates and exposure times.

- user interface based on multiplatform software compatible with the most diffused operating systems (Windows, Linux, Unix, MacOS).

- a graphical interface shows a real-time representation of all signals the user is setting, thus permitting a scientific use also to novice users.

- an integrated software interface to configure the camera, acquire images and perform the tasks of a first analysis, both visual and statistical, with advanced tools for digital processing.

Summary

The present invention concerns a CCD camera apparatus and the related method for the acquisition of digital images; said CCD camera apparatus comprising at least one camera head module allocating the CCD sensors and its proximity electronic control circuitry, and realised with multiple modules that can be individually extracted and substituted.

Brief description of the drawings:
**Detailed description of the invention**

With reference to Fig. 1, the generic block diagram of the architecture of the multi-purpose CCD camera according to the present invention comprises the following components:

- A control device, for example an external or an embedded personal computer

10 to manage and drive CCD camera operation
The camera head 11 comprising the CCD sensor and the proximity electronic control circuitry

- The camera controller 12 comprising electronic boards to drive the CCD sensor and acquire and digitize images

- The cooling system 13 provided with a CCD temperature automatic management

These components provide full flexibility to the CCD camera according to the present invention in order to make such CCD camera compatible with different tasks allowing for full versatility of use.

A fundamental feature of the head 11 of the CCD camera according to the present invention is its modularity, as depicted in Fig. 2. Every single section of said camera head is realised with a module that can be individually extracted from the camera chassis thus allowing for the maximum flexibility of use and the maximum adaptability of the camera according to the present invention to different applications.

In order to achieve this modularity, the following sections have been separated from each other, placed in separate housings and interconnected with cables:

- the CCD sensor,
- the pre-amplifier,
- the filters and wave shapers,
- the thermal cooler
- the connectors module.

As depicted in Fig. 2, the camera head 11 is composed of three fundamental modules: the CCD module 21, the proximity electronic module 22 and the connectors module 23.

More optional modules can be included in said camera head to add more functionalities: an internal cooler module 26, an optics module 20 including shutter and lenses, a CDS-ADC module, a fiber-optic module to transmit the digital images to a remote instrument. The camera head is further customisable by realising it sealed or fully vacuum compatible by means, for example, of an external vacuum system. In addition, said cooling system 13, 26 can be chosen of the air-chilled type or of the liquid-chilled type and they can be either active
(Thermo-Electric Cooler, TEC) or passive (liquid nitrogen). User can substitute them according to his experimental requirements.

The proximity electronic circuitry 22 includes two functional blocks, a pre-amplifier circuit 24 for the processing of the CCD output-signal, that is required due to the very low voltage level of CCD output signal (tipically ranging from a few µV to 0.1V), and filters means 25 to delimit the frequency band of the video signal and to wave-shape the CCD clock signals.

The connectors module 23 realises the hardware connectivity between the different parts of the camera according to the present invention thus allowing for the required modularity,

With reference to Fig. 3 the camera controller 12 comprises the following components:
- A bias generator 30 that supplies bias voltages to the output stages of the CCD sensor
- A Clock Driver 31 required to adapt the voltage levels of the clock signals to the voltage levels required by the CCD sensor and to supply the required current to the CCD sensor via an appropriate output buffer stage
- At least one Analog to Digital Converter module 33 that samples CCD output signal and converts it in digital format. If the user prefers a faster and parallel readout from more than one CCD output gate, more modules are necessary
- At least one Correlated Double Sampling Circuitry 32 that provides additional filtering and includes a post-amplifier stage for the output signal of the CCD sensor
- A Sequencer module 34 that generates the timing sequence required to perform all the tasks carried on by the CCD camera according to the present invention such as image acquisition and digitizing, integration of multiple images and management of parameters like exposure time, number of pixels to be acquired etc. Said Sequencer can be also responsible for the connection of the CCD camera controller to one or more external personal computer by which a user can operate the CCD camera.
- A power supply unit 35 designed to provide the required supply voltages for all the electronic circuits of the CCD camera according to the present invention
- A temperature management circuit 36 that controls the CCD temperature and
the operation of the CCD camera cooling system
- An interface module 40 comprising the following sub-modules:
- A Program interface module 37 used to program the programmable logics and
  the microcontroller from the external or embedded personal computer.
- A communication interface 38
- An output module 39 to send to the external personal computer the acquired
  images

All of these modules can be extracted, substituted or added to modify, update and
expand the functionalities of the CCD camera. The Sequencer is based on a
microcontroller and programmable logics (PLs, sometimes referred to as Complex
Programmable Logic Devices - CPLD - or Field Programmable Gate Array - FPGA) in order to achieve the required level of versatility and flexibility of the CCD
camera according to the present invention.

The PLs can be programmed by a JTAG interface or through the microcontroller;
the microcontroller can be programmed by a serial interface or by a custom circuit.
Said communication interface can be a serial RS232 interface or can be included
into the Image Output Interface. This one is usually accomplished with a more
complex protocol, for instance: fast serial protocols such as IEEE-1394 or USB,
parallel protocols such as a SCSI interface, the recent Camera Link or the
astronomical SpaceWire protocol.

If necessary, these protocols can also be coupled to a fiber optic interface to
increase the maximum distance of the cable or to implement a wireless network.
The microcontroller preferably comprises at least one serial communication
interface, at least one power output for driving external devices, an input A/D
converter and an output D/A converter.

The Sequencer 34 includes also flash memory, embedded into the microcontroller
and into the PLs, in order to allow on-board programming, a feature that is
important to provide the required versatility and the possibility to reprogram the
CCD camera firmware according to the present invention, even through a remote
connection.

A block diagram of the Sequencer 34 is shown on Fig. 4, its architecture consists
of two main logic modules:
- Programmable logics module 4.1
- Microcontroller module 4.7

The Programmable logic block 4.1 includes all logic functions performed by PLs. The microcontroller 4.7 of the Sequencer 3.4 according to the present invention is programmed with firmware that allows the Sequencer to manage the operation of the CCD camera and its interface to one or more external personal computers, with other microcontrollers, with PLs and with external peripherals.

With reference to Fig. 4, the PLs 4.1 implement the following blocks: an addressing-demultiplexing module 42, a self-check management module 43, a parameter setting management module 44, an image acquisition management module 45 and an auxiliary logic module 46.

In a preferred embodiment of the present invention, three logic architecture configurations are available for the Sequencer:

i) PLs and Interfaces

ii) Microcontroller and Interfaces

iii) PLs, Microcontroller and Interfaces

The Sequencer can satisfy the application requirements, selecting the proper configuration: the configuration i) is useful for applications where only a few logic functions are required, and no PC communication is needed; the configuration ii) can be selected if complex software functions are required; the configuration iii) is ideal for highest performances and versatility.

The main flowchart of the method performed by the above mentioned firmware and according to a preferred embodiment of the present invention is depicted in Fig. 5 and can be represented by the following steps:

a) System power-up 5.0
b) Start-up check 5.1
c) Control and diagnostic selection 5.2
d) Temperature control 5.3
e) Parameters initialisation 5.4
f) Clearing Loop 5.5
g) Video mode / Image acquisition 5.6

During the system power-up 5.0 all the necessary voltages are converted by the
input supply with a controlled rising slope; then they are checked by means of DACs to verify that they lay in the expected voltage range.

With reference to Fig. 7, in the start-up check mode 51 the following actions are performed:

h) the microcontroller generates 70 the appropriate signals to check hardware functionality and get hardware ready for start-up and

i) the microcontroller delivers 71 the signals generated at the previous step to the PLs

j) the PLs send out 72 a feedback to the microcontroller

k) the microcontroller reads 73 and checks 74 the feedback from the PLs

l) If previous check is successful the initialization step is enabled 75, otherwise,

m) an error message is generated 76 and sent out to the user interface and the initialization is disabled 77

In the Control and diagnostic selection mode 52 the following actions are performed, as depicted in the flowchart of Fig. 12:

n) a check 120 is made about the control to apply to the CCD camera according to the present invention, if the local user choose to keep the control, then

o) we step to the temperature control phase 53, otherwise

p) a further check 121 is made regarding the next action to be performed, remote diagnostic or full remote control. If only a remote diagnostic is required

q) then remote diagnostic phase 122 is performed, at the end of which step 120 is repeated

r) otherwise remote control model 23 starts and the operator is allowed to operate the CCD camera according to the present invention through the established remote connection and a dedicated software

The remote diagnostic phase 122 is performed, according to the block diagram depicted in Fig. 6, through the following steps:

s) First, a remote connection, for example a TCP/IP connection, is established 60,

t) then a full hardware check 61 is performed, regarding power supplies, CCD sensors, PLs and microcontroller

u) a local software check 62 is performed.

v) A message is displayed 63 to the operator with the result of the check
performed
After Control and diagnostic selection mode 52, Temperature control mode 53
starts and the following steps are performed, as depicted in Fig. 11:
w) a first check 111 is performed regarding the presence of a request by the user
to check the CCD sensor temperature
x) in case no check has been requested, the parameter initialisation phase 54
starts
y) in case a CCD sensor temperature check has been requested, the setting of
the temperature parameters is first requested to the user 113
z) then the microcontroller reads the CCD sensor temperature 114
aa) finally the microcontroller attempts to get the target temperature range by
enabling 116 or disabling 117 its cooling section and by continuously reading
back the CCD temperature
bb) If CCD has reached the target temperature, the microcontroller initialises the
configuration parameters 54 only the first time since the camera was powered
on (n=1). If n≠1, the microcontroller continues to read the CCD temperature
114
In the Parameter Initialisation mode 54 the following actions are performed, as
depicted in the flowchart of Fig. 8:
cc) the external personal computer receives 80 inputs from the user through the
user interface. These inputs referring to the setting of functional parameters of
the CCD camera according to the present invention
dd) the external personal computer generates 81 an array of data corresponding to
the parameters setting selected by the user at the previous step
ee) the external personal computer delivers 82 to the microcontroller of the
Sequencer the array of data generated at the previous step
ff) the microcontroller loads 83 the data received at the previous step into the
latches of the Sequencer PLs; each datum is then available at the input of the
proper programmable counter, but not yet loaded
gg) the microcontroller loads the data 84 into the programmable counters of the
Sequencer PLs
hh) the microcontroller sends back 85 to the personal computer an acknowledge
signal to confirm that all the above operations have been performed successfully.

At the end of the Initialisation mode described above, the Clearing Loop mode automatically starts and performs the following step depicted in Fig. 9:

i) the Sequencer PLs generate the timing pattern in order to clear any spurious charges generated by thermal effects inside the CCD sensor.

jj) The above described Clearing Loop mode is continuously carried on until a new image acquisition is requested.

When the personal computer, via user interface, receives the request for performing a new image, the Image Acquisition / Video Mode (Video Mode is a useful setting-up procedure in which the camera continuously acquire and display images) starts and proceeds as follows and depicted in Fig. 13:

kk) a first check is performed regarding the presence of a request by the user to enter the video mode.

ll) in case the request is not present, image acquisition mode starts otherwise a new image is loaded.

mm) the loaded image is displayed on the user interface.

oo) the previous two steps are performed until the video mode is stopped by the user.

pp) if acquisition is requested by the user, the image acquisition starts, otherwise the clearing loop starts again.

With reference to Fig. 10, said acquisition mode is performed as follows:

qq) the control device, for example the external or embedded personal computer, receives 100 inputs from the user through its user interface. These inputs referring to the request of a new image acquisition.

rr) the control device, for example the external or embedded personal computer, delivers 101 to the microcontroller of the Sequencer the "acquire image" command.

ss) the microcontroller requires 102 the PLs to stop the Clearing Loop mode and to start the Acquisition (which is made of two modes: Exposure mode and Readout mode, see below).

tt) the PLs end the current clearing loop.
uu) the PLs generate the signals for image acquisition (including the shutter control signals and timing pattern signals)

w) the Exposure mode starts and the "exposure signal" is generated by the PLs to manage the shutter

ww) When the Exposure time ends, the shutter is closed and the Readout mode starts

xx) In the Readout mode, a certain number of Image clocks (determined by CCD sensor requirements) is generated in order to shift the image to the readout register, one row at a time

yy) then the image clocks are temporarily locked and the PLs generate a certain number of Serial clocks in order to transfer all pixels of the row to the sensing node(s) to read them out, and three or more signals to manage the CDS and ADC conversion.

zz) Acquisition is performed until the image has been completely acquired.

aaa) The acquired image is saved and/or displayed on the user interface
Claims

1. CCD camera apparatus comprising at least one camera head module allocating the CCD sensors and the related proximity electronic control circuitry, characterised in that said camera head is realised with multiple modules that can be individually extracted and substituted.

2. CCD camera apparatus according to claim 1 characterised in that said multiple modules of said camera head that can be individually extracted and substituted comprise: at least one optical module (20), at least one CCD module (21), at least one CCD sensor electronic control circuitry module (22), at least one connectors module (23), at least one internal cooler module (26), at least one fiber-optic module.

3. CCD camera apparatus according to claims 1-2 characterised in that it further comprises: at least one camera controller module (12), at least one thermal management module (13), at least one external control device.

4. CCD camera apparatus according to claim 3 characterised in that said external control device consist of an external personal computer (10).

5. CCD camera apparatus according to claim 3 characterised in that said external control device consist of an embedded personal computer.

6. CCD camera apparatus according to claim 4-5 characterised in that said camera controller module (12) comprises one bias generator (30), one clock driver (31), one correlated double sampling circuitry (32), one analog to digital converter module (33), one sequencer module (34), one power supply unit (35), one temperature management circuit (36), one interface module (40).

7. CCD camera apparatus according to claim 6 characterised in that said interface module (40) further comprises one program interface module (37), one communication interface (38), one output module (39).

8. CCD camera apparatus according to claim 7 characterised in that said communication interface is selected from the group consisting of RS232, IEEE-1394, USB, SCSI, Camera Link, Spacewire and wireless communication interfaces.

9. CCD camera apparatus according to claims 7-8 characterised in that said communication interfaces are coupled to a fiber optic interface.
10. CCD camera apparatus according to claims 6 - 9 characterised in that said sequencer module (34) comprises one programmable logics module (41) and one microcontroller module (47).

11. CCD camera apparatus according to claim 10 characterised in that said programmable logics module (41) comprises one addressing-demultiplexing module (42), one self-check management module (43), one parameter setting management module (44), one image acquisition management module (45) and one auxiliary logic module (46).

12. CCD camera apparatus according to claims 10 - 11 characterised in that said sequencer module (34) can be configured according to three different architecture: programmable logics module (41) plus Interfaces; microcontroller module (47) plus Interfaces; programmable logics module (41) plus microcontroller module (47) plus Interfaces.

13. Method for the acquisition of digital images comprising the steps of checking the employed hardware, acquiring, storing and processing a digital image, characterised in that it further comprises the following steps:
   a) System power-up (50)
   b) Start-up check (51)
   c) Control and diagnostic selection (52)
   d) Sensor Temperature control (53)
   e) Parameters initialisation (54)
   f) Clearing Loop (55)
   g) Video mode / Image acquisition (56)

14. Method for the acquisition of digital images according to claim 13 characterised in that said step b) is performed through the following steps:
   h) the microcontroller generates (70) the appropriate signals to check hardware functionality and get hardware ready for start-up and
   i) the microcontroller delivers (71) the signals generated at the previous step to the PLs
   j) the PLs send out (72) a feedback to the microcontroller
   k) the microcontroller reads (73) and checks (74) the feedback from the PLs
   I) If previous check is successful the initialization step is enabled (75),
otherwise, m) an error message is generated (76) and sent out to the user interface and the initialisation is disabled (77)

15. Method for the acquisition of digital images according to claim 13 characterised in that said step c) is performed through the following steps:

n) a check (120) is made about the control to apply to the CCD camera according to the present invention, if it's going to be local, then

o) temperature control phase (53) is performed, otherwise

p) a further check (121) is made regarding the next action to be performed, remote diagnostic or full remote control. If only a remote diagnostic is required

q) then remote diagnostic phase (122) is performed, at the end of which step (120) is repeated

r) otherwise remote control mode (123) starts and the operator is allowed to operate the CCD camera according to the present invention through the established remote connection and an appropriate software

16. Method for the acquisition of digital images according to claim 15 characterised in that said diagnostic phase (122) of step q) is performed through the following steps:

s) a remote connection, for example a TCP/IP connection, is established (60),

t) then a full hardware check (61) is performed, regarding power supplies, CCD sensors, PLs and microcontroller

u) a local software check (62) is performed

v) a message is displayed (63) to the operator with the result of the performed check

17. Method for the acquisition of digital images according to claim 13 characterised in that said step d) is performed through the following steps:

w) a first check (111) is performed regarding the presence of a request by the user to check the CCD sensor temperature

x) in case no check has been requested, the parameter initialisation phase (54) starts

y) in case a CCD sensor temperature check has been requested, the setting
of the temperature parameters is first requested to the user (113)
z) the microcontroller reads the CCD sensor temperature (114)
aa) the microcontroller attempts to get the target temperature range by
   enabling (116) or disabling (117) its cooling section and by continuously
   reading back the CCD temperature

18. Method for the acquisition of digital images according to claim 13 characterised
   in that said step e) is performed through the following steps:
   bb) the external personal computer receives (80) inputs from the user through
      its interface,
   cc) the external control device generates (81) an array of data corresponding
      to the parameters setting selected by the user at the previous step
   dd) the external personal computer delivers (82) to the microcontroller of the
      Sequencer the array of data generated at the previous step
   ee) the microcontroller loads (83) the data received at the previous step into
      the latches of the Sequencer PLs
   ff) the microcontroller loads the data (84) into the programmable counters of
      the Sequencer PLs
   gg) the microcontroller sends back (85) to the personal computer an
      acknowledge signal to confirm that all the above operations have been
      performed successfully

19. Method for the acquisition of digital images according to claim 13 characterised
   in that said step f) is performed through the following action:
   hh) the Sequencer PLs generate 90 the timing pattern in order to clear any
      spurious charges generated by thermal effects inside the CCD sensor
   ii) the above described Clearing Loop mode is continuously carried on until a
      new image acquisition is requested (91)

20. Method for the acquisition of digital images according to claim 13 characterised
    in that said step g) is performed through the following steps:
    jj) a first check (130) is performed regarding the presence of a request by the
        user to enter the video mode
    kk) in case the request is not present, image acquisition mode starts (134)
    ll) otherwise a new image is loaded (131)
the loaded image is displayed (132) on the user interface.

nn) the previous two steps are performed until the video mode is stopped by

the user and acquisition mode starts.

21. Method for the acquisition of digital images according to claim 20 characterised

in that said acquisition mode (134) is performed through the following steps:

oo) the external personal computer receives (100) inputs from the user through

its user interface. These inputs referring to the request of a new image

acquisition

pp) the external personal computer delivers (101) to the microcontroller of the

Sequencer the "acquire image" command

qq) the microcontroller requires (102) the PLs to stop the Clearing Loop mode

and to start the Acquisition

rr) the PLs end (103) the current clearing loop

ss) the PLs generate (104) the signals for image acquisition

tt) the Exposure mode starts and the "exposure signal" is generated (105) by

the PLs to manage the shutter

uu) when the Exposure time ends, the shutter is closed and the Readout mode

starts (106)

w) a plurality of Image clock signals is generated (107) in order to shift the

image to the readout register

ww) the PLs generate (108) a plurality of Serial clock signals in order to

transfer all pixels of the row to the sensing node(s) to read them out, and

three or more signals to manage the CDS and ADC conversion

xx) acquisition is performed (109) until the image has been completely acquired

yy) the acquired image is saved and/or displayed (110) on the user interface

22. Method for the acquisition of digital images according to claim 13

characterised in that said steps a) to g) are performed according to claims 13

to 20

23. Method for the acquisition of digital images according to claims 13 to 22

characterised in that it is performed by a CCD camera apparatus according to

claims 1 to 12.
Acquisition

System Power-UP

Start-UP Check

Control and Diagnostic Selection

Temperature Control

Parameters Initialisation

Clearing Loop

Image Acquisition

Video Mode

Fig. 5
Remote Diagnostic

Remote Connection is established

Full Hardware Check

Local Software Check

Check Result message is displayed

Fig. 6

Clearing Loop

Sequencer CPLDs generate timing pattern to clean up CCDs

Is a new acquisition requested?

Image Acquisition / video mode starts

Fig. 9
5/10
Start-UP Check

70. Microcontroller generates signals for HW check

71. Microcontroller delivers signals to CPLDs

72. CPLDs deliver feedback to Microcontroller

73. Microcontroller reads feedback from CPLDs

74. Check successful?

75. YES
   - Initialisation enabled
   
76. NO
   - Error message sent to user interface
   - Initialisation disabled

Fig. 7
Parameters Initialisation

External PC receives input from user

External PC generates an array of data

External PC delivers data to Sequencer Microcontroller

Microcontroller loads data into latches of Sequencer CPLDs

Microcontroller loads data into programmable counters of Sequencer CPLDs

Microcontroller sends acknowledge signal to PC

Fig. 8
Image Acquisition

100. Control Device receives input from user

101. Control Device generates the "acquire" command and delivers it to the Microcontroller

102. Microcontroller requests CPLDs to start acquisition

103. CPLDs end the Clearing Loop

104. CPLDs generate the signals to start acquisition

105. Exposure mode starts

106. Exposure mode stops and Readout mode starts

107. CPLDs generate Image Clock signals

108. CPLDs generate Serial Clock and Control signals

109. Image completely acquired?

110. View/store image

Fig. 10
8/10
Temperature Control

52

YES
Check sensor temp?

NO

113
Temperature parameters setting

54
Parameters initialisation

114

Microcontroller reads CCD temp

115

YES
CCD temp has reached the target?

NO

116
Microcontroller enables Peltier Cells

117
Microcontroller disables Peltier Cells

54

n=1

YES
Parameters initialisation

Fig. 11
Control and Diagnostic Selection

Temperature Control

Local Control?

Remote Diagnostic?

Remote Diagnostic Mode

Remote Ctrl Mode

Fig. 12
# INTERNATIONAL SEARCH REPORT

**A. CLASSIFICATION OF SUBJECT MATTER**

H04N5/225  H04N5/232

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)

H04N

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 practical, search terms used)

EPO-Internal, PAJ, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No</th>
</tr>
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<tbody>
<tr>
<td>X</td>
<td>US 5 221 964 A (CHAMBERLAIN ET AL) 22 June 1993 (1993-06-22)</td>
<td>1</td>
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<tr>
<td>Y</td>
<td>column 1, line 13 - column 8, line 16 claims 14-23 figure 2</td>
<td>3-12</td>
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<td>Y</td>
<td>US 2002/180866 A1 (MONROE DAVID A) 5 December 2002 (2002-12-05) paragraph '0138! - paragraph '0143! paragraph '0228! - paragraph '0322! figures 3,4,11a,12a</td>
<td>3-12</td>
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</tbody>
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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 document but published on or after the international filing date

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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

A* document member of the same patent family

Date of the actual completion of the international search 7 October 2005

Date of mailing of the international search report 17.02.2006

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 epi nl Fax (+31-70) 340-3016

Authorized officer Didierl aurent, P
<table>
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<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>US 5 040 068 A (PARULSKI ET AL) 13 August 1991 (1991-08-13) column 3, line 18 - line 22 column 5, line 9 - line 54 column 6, line 25 - line 50 figure 2</td>
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<td>A</td>
<td>US 5 493 332 A (DALTON ET AL) 20 February 1996 (1996-02-20) column 1, line 15 - column 2, line 46 column 3, line 53 - line 67 column 5, line 44 - line 50 figure 1</td>
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**INTERNATIONAL SEARCH REPORT**

**PCT/EP2005/053286**

### Box II Observations where certain claims were found unsearchable

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

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

2. [ ] 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. [ ] Claims Nos: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

### Box III Observations where unity of invention is lacking

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

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see additional sheet
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1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

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.: 1 and 3-12 as far as dependent on 1

**Remark on Protest**

[ ] The additional search fees were accompanied by the applicant's protest

[ ] No protest accompanied the payment of additional search fees

Form PCT/ISA/21 0 (continuation of first sheet (2)) (January 2004)
This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1 and 3-12 as far as dependent on 1
   CCD camera apparatus with an external control device

2. claims: 2 and 3-12 as far as dependent on 2
   CCD camera apparatus with a fiber optic module

3. claims: 13-23
   Method for the acquisition of digital images including a step of checking the employed hardware
<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
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