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(54) **AUTOMATIC UPDATE OF CAMERA FIRMWARE**

(75) Inventors: **Mark R. Fichtner**; **Mannan A. Mohammed**, both of Chandler; **Dennis R. Kush**, Tempe; **Edward P. Tomaszewski**, Phoenix, all of AZ (US)

(73) Assignee: **Intel Corporation**, Santa Clara, CA (US)

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(58) **Field of Search** 395/712; 348/231; 711/202; 717/11; 375/222; 713/1, 2, 100; 703/20; 709/228; 455/419; 710/8–14, 62–74

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,924,513 A * 5/1990 Herbison et al. 380/21
5,138,459 A * 8/1992 Roberts et al. 348/232
5,226,145 A * 7/1993 Moronaga et al. 711/202
5,262,868 A * 11/1993 Kaneko et al. 348/233
5,268,928 A * 12/1993 Herh et al. 375/222
5,477,264 A * 12/1995 Sarbadhikari et al. 348/231
5,566,335 A * 10/1996 Nash et al. 713/1
5,623,604 A * 4/1997 Russell et al. 717/11
5,696,899 A * 12/1997 Kalwitz 709/228
5,701,492 A * 12/1997 Wadsworth et al. 717/11
5,737,585 A * 4/1998 Kaneshima 703/20
5,790,260 A * 8/1998 Myers 358/296
5,822,692 A * 10/1998 Krishan et al. 455/419
5,878,256 A * 3/1999 Bealkowski et al. 713/2
6,115,799 A * 9/2000 Ogawa 711/171

OTHER PUBLICATIONS

PCT Search Report, International Application No. PCT/US99/01398, Jan. 22, 1999, 4 pgs.

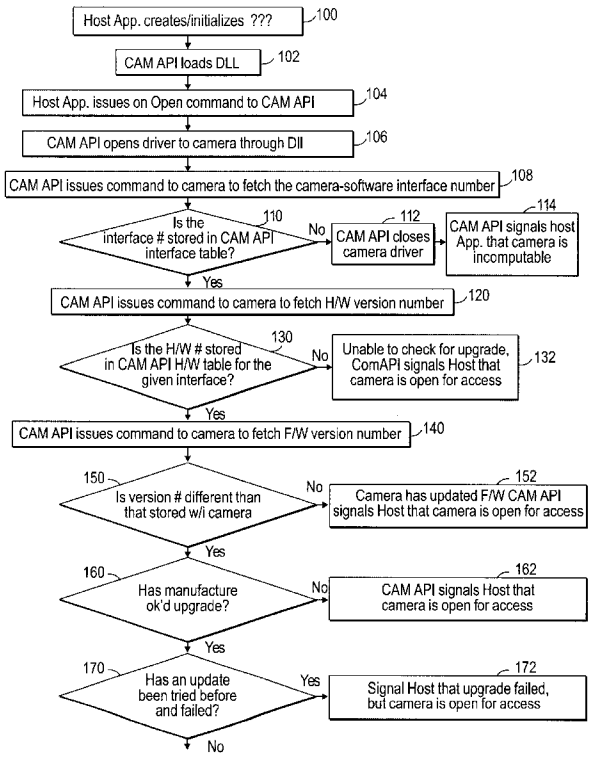
* cited by examiner

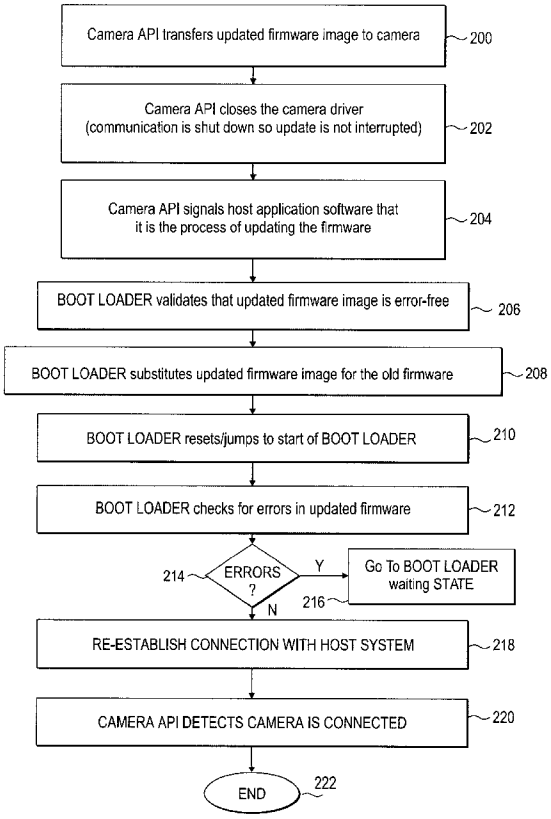
Primary Examiner—Mark R. Powell
Assistant Examiner—Hoang-Vu Antony Nguyen-Ba
(74) *Attorney, Agent, or Firm*—Benjamin Burge

(57) **ABSTRACT**

A method of updating firmware between an imaging device and a host system is disclosed. The host system detects that the firmware on the imaging device is incompatible with a configuration of the host system. In response to detecting the incompatibility, an updated firmware image is transferred from the host system to the imaging device.

32 Claims, 10 Drawing Sheets





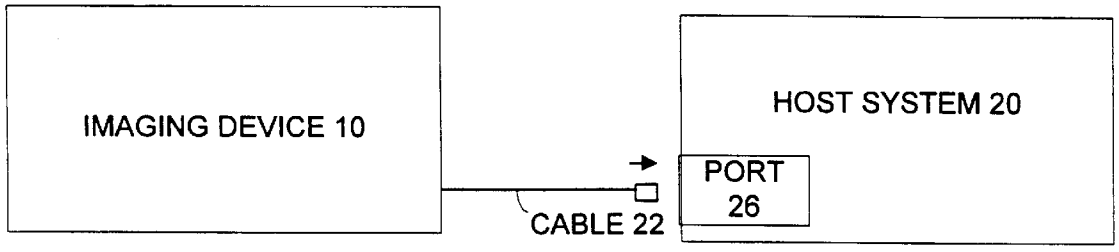


FIG. 1

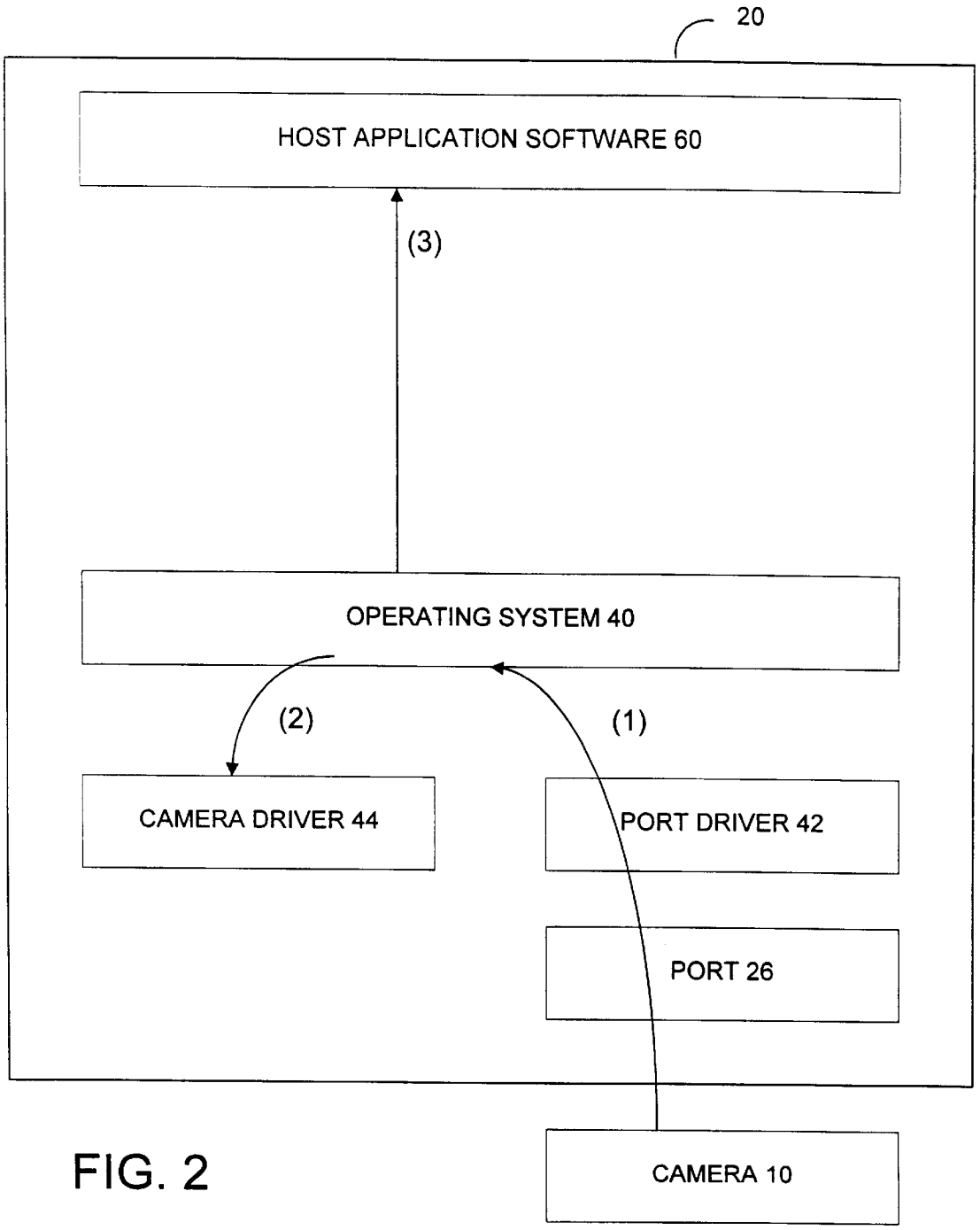

20
HOST APPLICATION SOFTWARE 60
(3)
OPERATING SYSTEM 40
(2)
(1)
CAMERA DRIVER 44
PORT DRIVER 42
PORT 26
CAMERA 10

FIG. 2

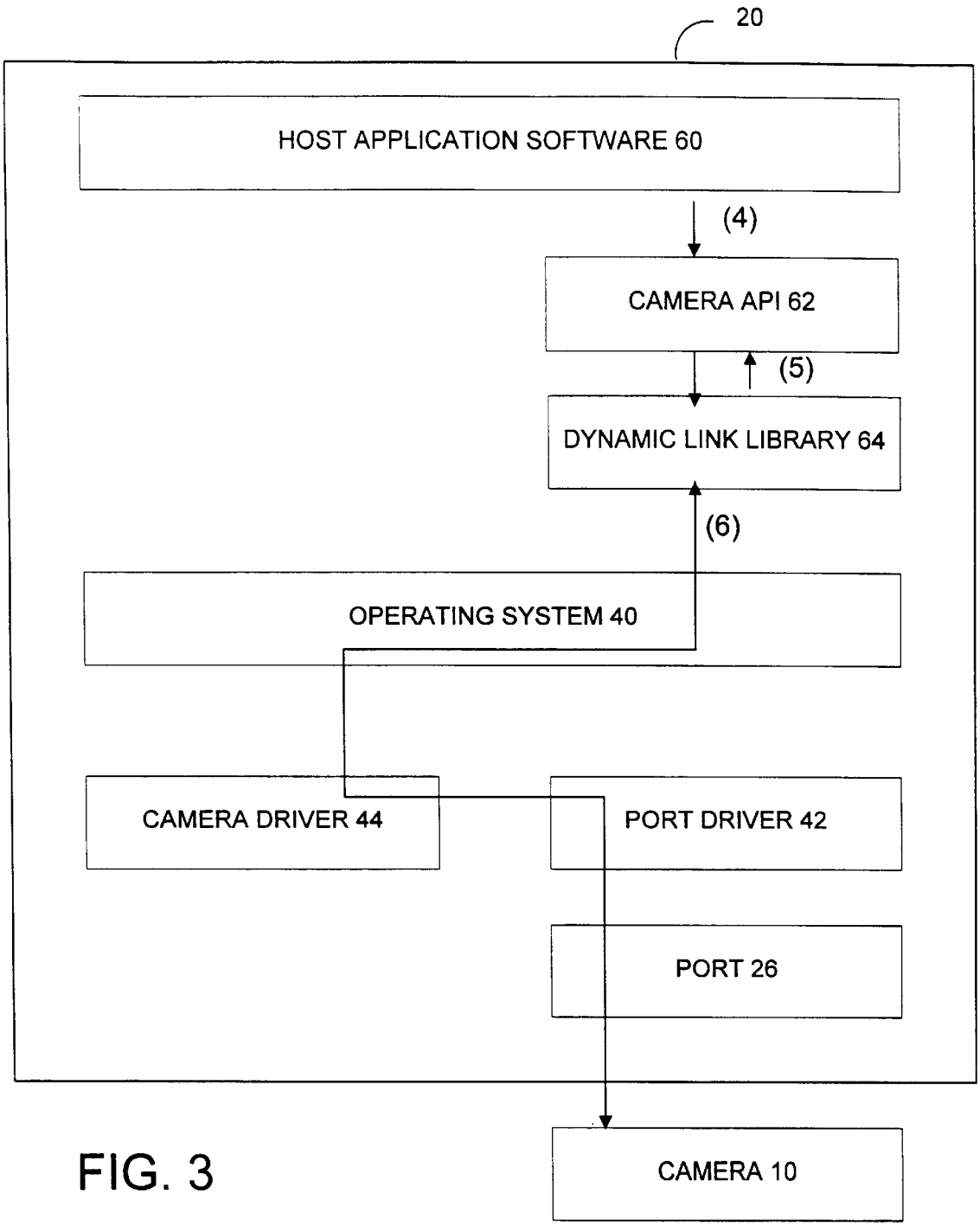

20
HOST APPLICATION SOFTWARE 60
(4)
CAMERA API 62
(5)
DYNAMIC LINK LIBRARY 64
(6)
OPERATING SYSTEM 40
CAMERA DRIVER 44
PORT DRIVER 42
PORT 26
CAMERA 10

FIG. 3

OPERATING SYSTEM	HOST APPLICATION S/W	CAMERA API
Open Host Application S/W →	Create and Initialize CameraAPI →	Reset internal variables
	→	Load DLLs
	→	Create & start backgrd thread
	→	Insert a CM_SIGNAL_STATUS message into backgrd-threaded queue
	Add main window to CameraAPI's callback list	

FIG. 4

CAMERA API		HOST APPLICATION SOFTWARE
CM_SIGNAL_STATUS If Camera is not Open If OpenDriver() succeeds Close Driver() If message has not been sent before Signal all callback windows	→	**WM_CAMERAAPI_STATUS** If Message is CM_IS_CONNECTED
CM_OPEN_DRIVER Open camera driver Check for compatible camera	←	OpenDriver()
CM_GET_NO_OF_IMAGES Returns number o f images on camera	←	Get number of images
CM_GET_IMAGE_LIST Returns list of image names and sizes	←	If number of images > 0 Get Image List
CM_GET_IMAGE_BY_NAME Returns image with given name	←	Download images, one-by-one

FIG. 5

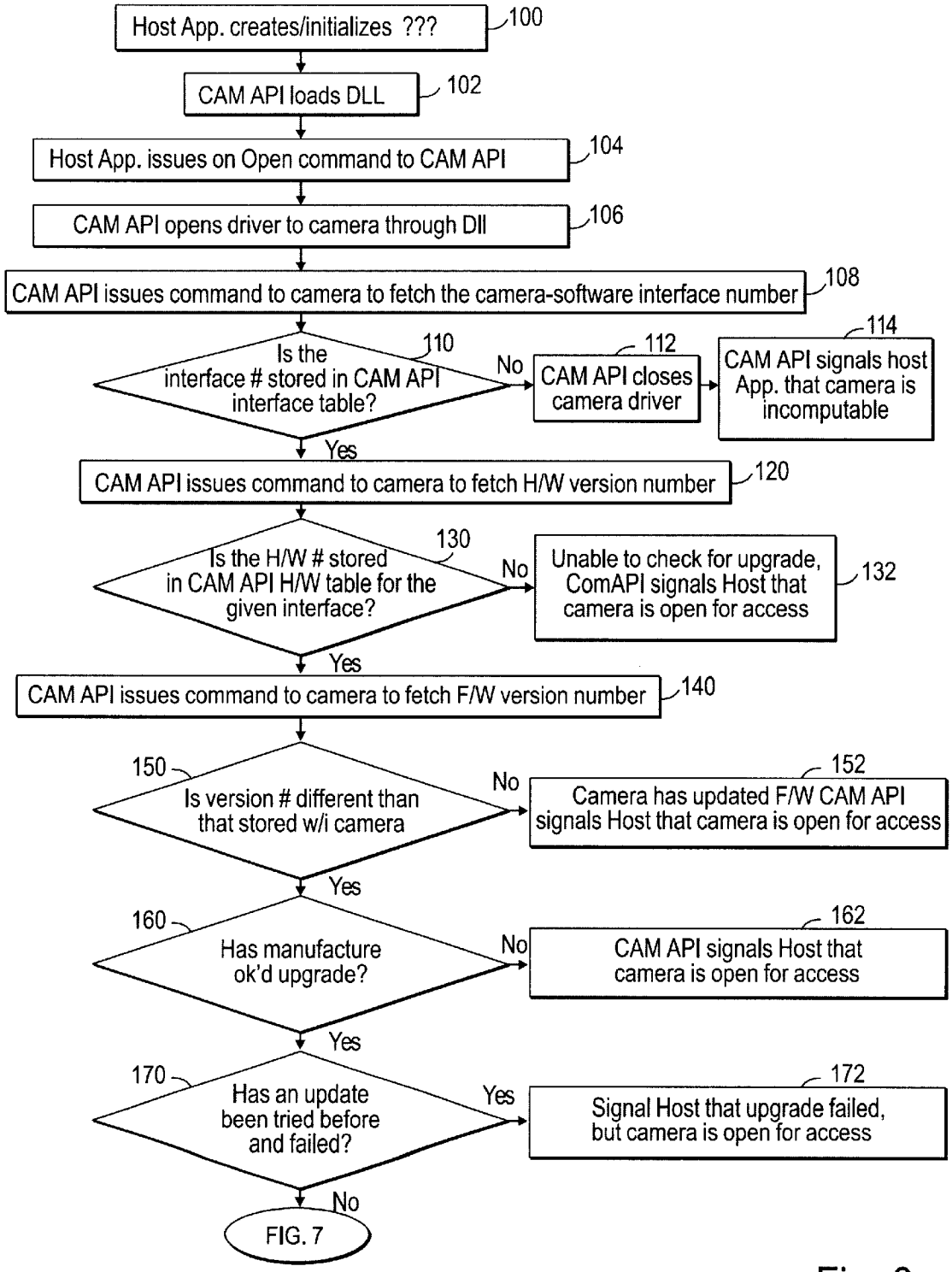

Host App. creates/initializes ???
100
CAM API loads DLL
102
Host App. issues on Open command to CAM API
104
CAM API opens driver to camera through Dll
106
CAM API issues command to camera to fetch the camera-software interface number
108
Is the interface # stored in CAM API interface table?
110
No
CAM API closes camera driver
112
CAM API signals host App. that camera is incomputable
114
Yes
CAM API issues command to camera to fetch H/W version number
120
Is the H/W # stored in CAM API H/W table for the given interface?
130
No
Unable to check for upgrade, ComAPI signals Host that camera is open for access
132
Yes
CAM API issues command to camera to fetch F/W version number
140
Is version # different than that stored w/i camera
150
No
Camera has updated F/W CAM API signals Host that camera is open for access
152
Yes
Has manufacture ok'd upgrade?
160
No
CAM API signals Host that camera is open for access
162
Yes
Has an update been tried before and failed?
170
Yes
Signal Host that upgrade failed, but camera is open for access
172
No
FIG. 7

Fig. 6

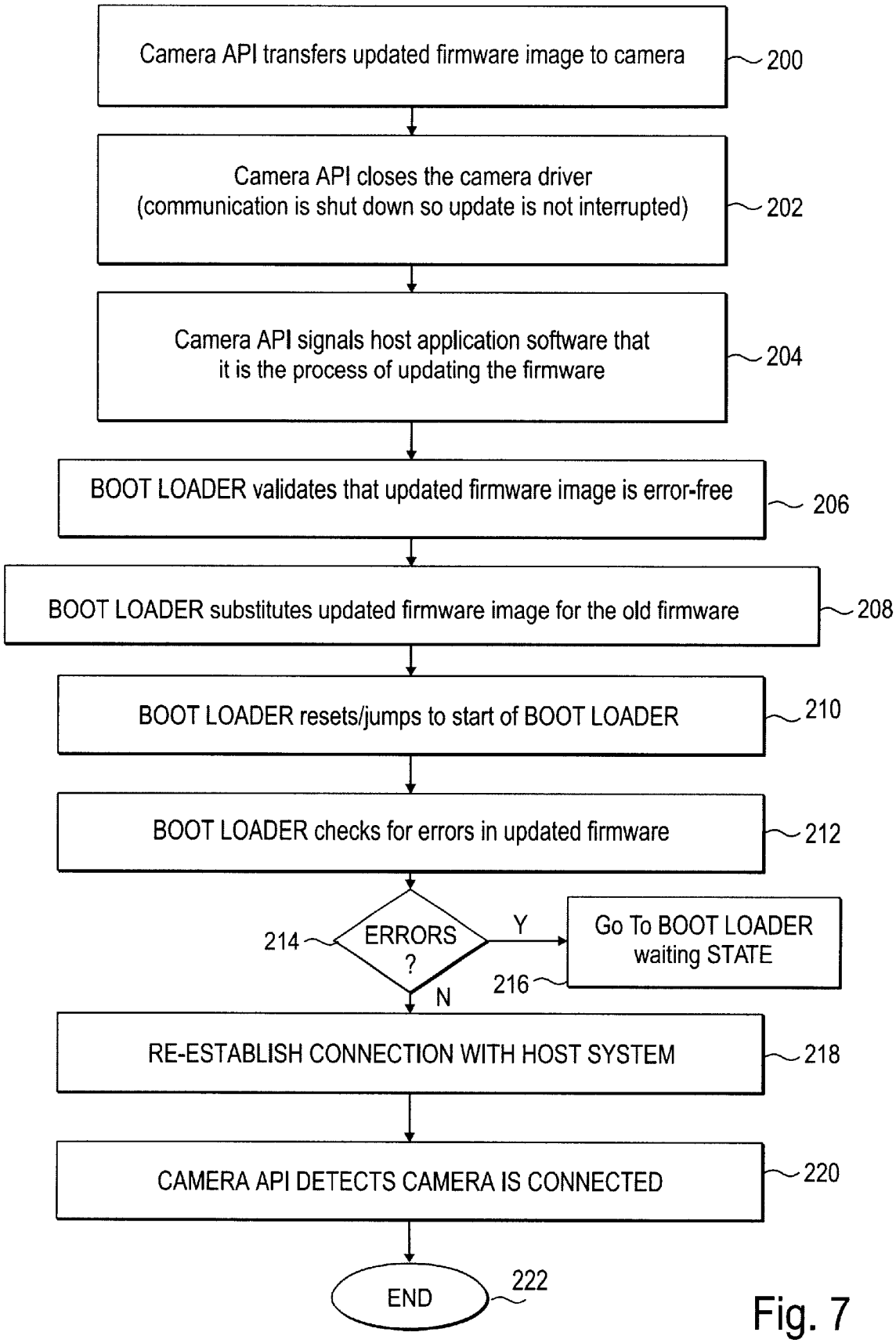

Camera API transfers updated firmware image to camera
200
Camera API closes the camera driver
(communication is shut down so update is not interrupted)
202
Camera API signals host application software that
it is the process of updating the firmware
204
BOOT LOADER validates that updated firmware image is error-free
206
BOOT LOADER substitutes updated firmware image for the old firmware
208
BOOT LOADER resets/jumps to start of BOOT LOADER
210
BOOT LOADER checks for errors in updated firmware
212
214
ERRORS
?
Y
Go To BOOT LOADER
waiting STATE
216
N
RE-ESTABLISH CONNECTION WITH HOST SYSTEM
218
CAMERA API DETECTS CAMERA IS CONNECTED
220
END
222

Fig. 7

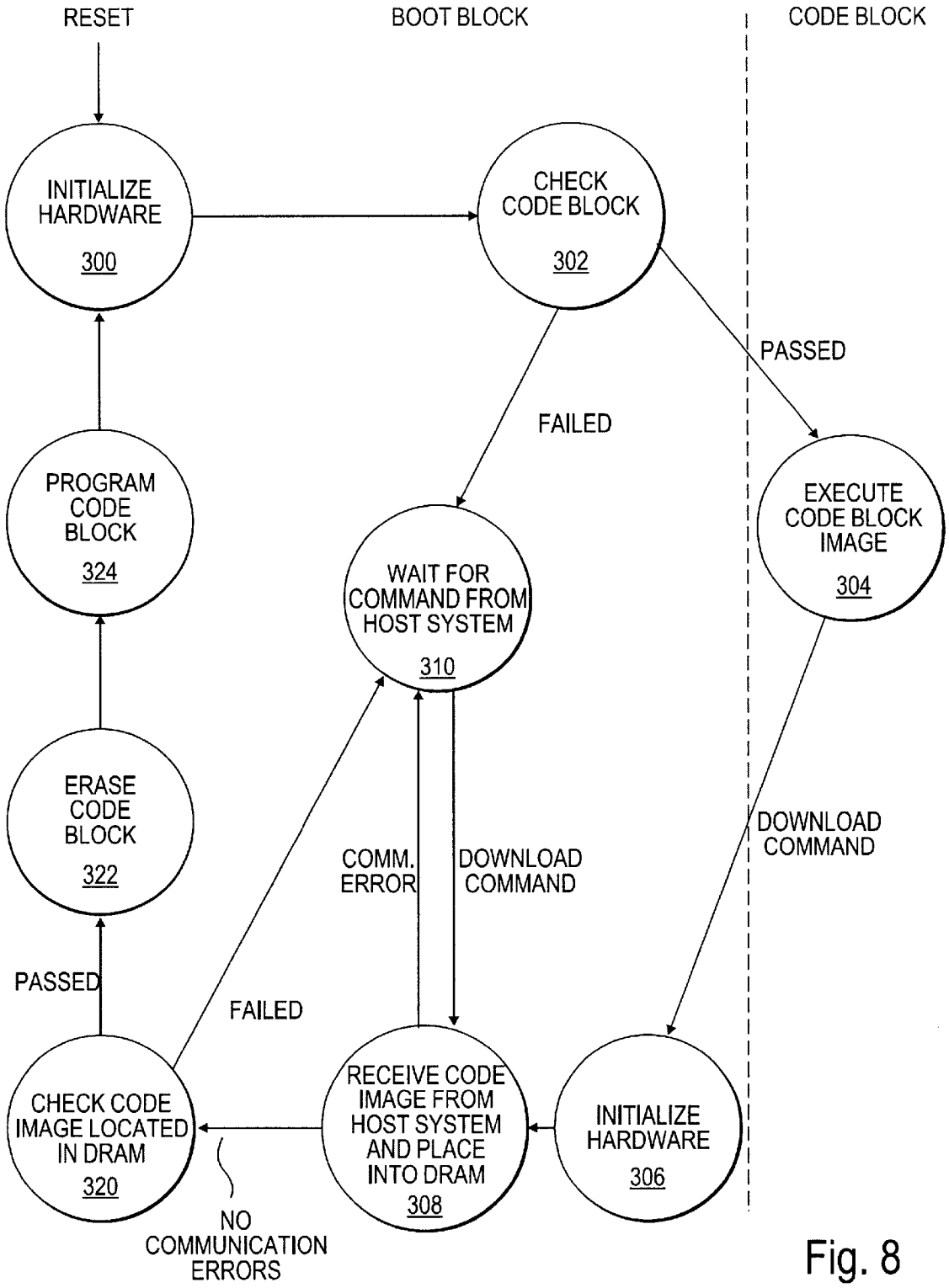

RESET
BOOT BLOCK
CODE BLOCK
INITIALIZE HARDWARE 300
CHECK CODE BLOCK 302
PASSED
FAILED
PROGRAM CODE BLOCK 324
EXECUTE CODE BLOCK IMAGE 304
WAIT FOR COMMAND FROM HOST SYSTEM 310
ERASE CODE BLOCK 322
DOWNLOAD COMMAND
COMM. ERROR
DOWNLOAD COMMAND
PASSED
FAILED
CHECK CODE IMAGE LOCATED IN DRAM 320
RECEIVE CODE IMAGE FROM HOST SYSTEM AND PLACE INTO DRAM 308
INITIALIZE HARDWARE 306
NO COMMUNICATION ERRORS

Fig. 8

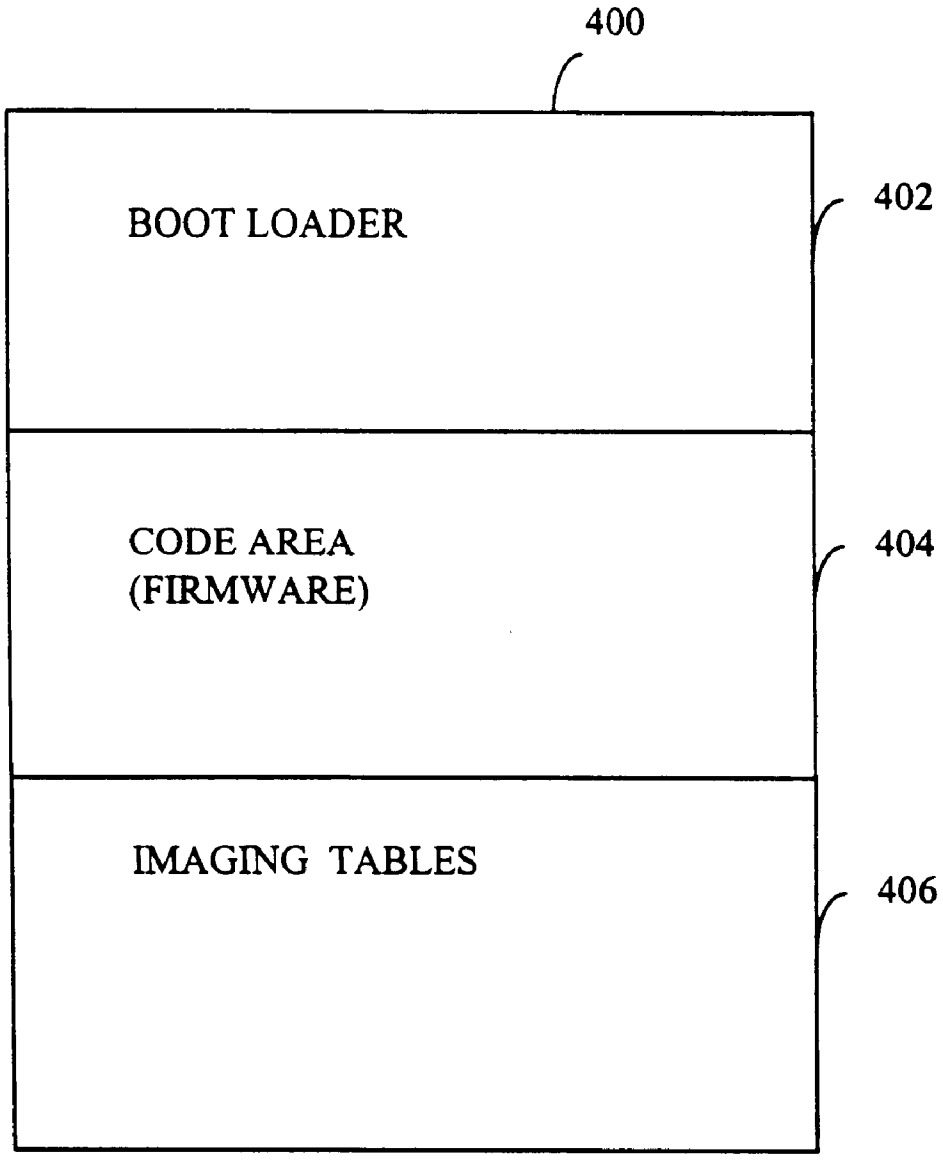

400
BOOT LOADER
402
CODE AREA
(FIRMWARE)
404
IMAGING TABLES
406

FIG. 9

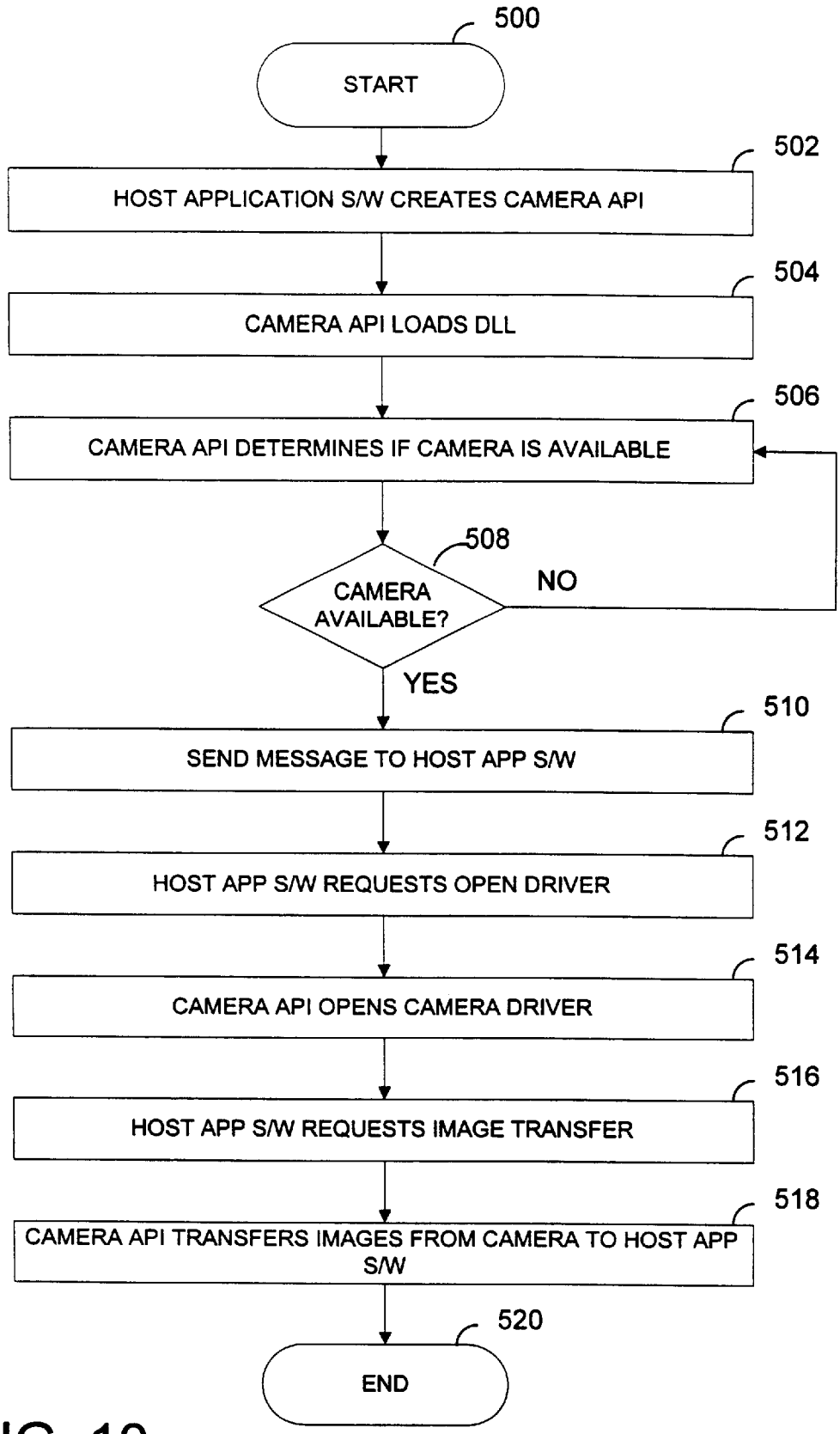

500
START
502
HOST APPLICATION S/W CREATES CAMERA API
504
CAMERA API LOADS DLL
506
CAMERA API DETERMINES IF CAMERA IS AVAILABLE
508
CAMERA AVAILABLE?
NO
YES
510
SEND MESSAGE TO HOST APP S/W
512
HOST APP S/W REQUESTS OPEN DRIVER
514
CAMERA API OPENS CAMERA DRIVER
516
HOST APP S/W REQUESTS IMAGE TRANSFER
518
CAMERA API TRANSFERS IMAGES FROM CAMERA TO HOST APP S/W
520
END

FIG. 10

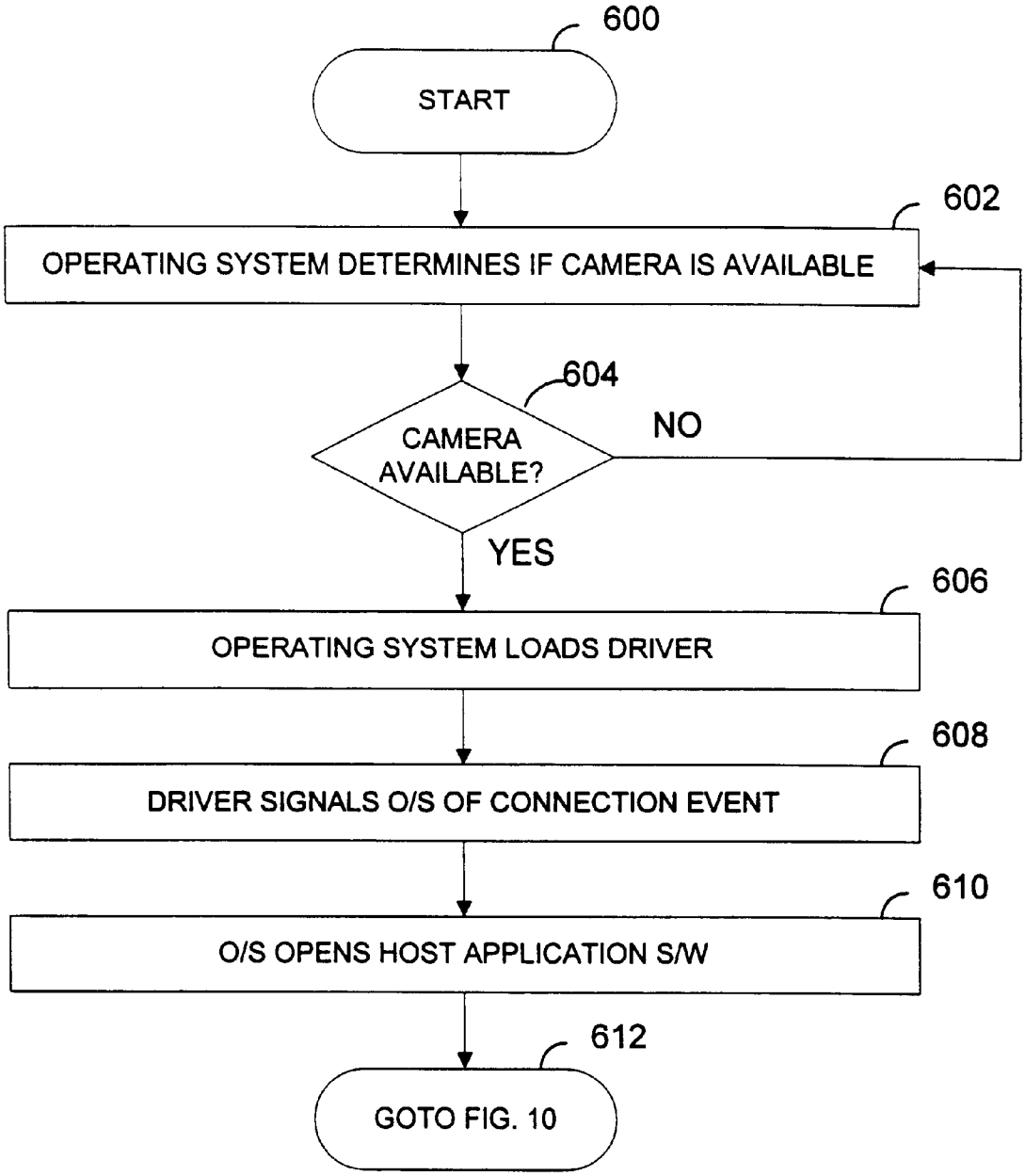

600
START
602
OPERATING SYSTEM DETERMINES IF CAMERA IS AVAILABLE
604
CAMERA AVAILABLE?
NO
YES
606
OPERATING SYSTEM LOADS DRIVER
608
DRIVER SIGNALS O/S OF CONNECTION EVENT
610
O/S OPENS HOST APPLICATION S/W
612
GOTO FIG. 10

FIG. 11

AUTOMATIC UPDATE OF CAMERA FIRMWARE

FIELD OF THE INVENTION

The present invention relates to the field of imaging. More particularly, this invention relates to updating firmware between an imaging device and a host system.

BACKGROUND OF THE INVENTION

Imaging devices, such as cameras, typically store still or moving (video) image information on film, video tape, or other media. Digital cameras capture image information in digital format and store the image information in memory, such as a flash memory, or on other digital storage media. The digital image information can be downloaded to a host system, such as a personal computer. The image information can then be manipulated by rotating the image, cropping the image, or otherwise altering the image with software applications residing on the host system.

The imaging device includes firmware that allows the imaging device to communicate with software on the host system. The firmware includes instructions for performing various functions. For example, the firmware may be used to determine the exposure of an image, sense color in a particular manner, compress image data, conserve power, perform self tests, and/or specify accessing and formatting protocols to the storage medium on the camera.

Oftentimes, it is desirable to upgrade either the host software and/or the camera firmware with a new release of software or firmware. A common method for upgrading software is through the use of a patch, or service pack upgrade. This method consists of distributing a set of programs via floppy disk, CD-ROM, or World Wide Web to the host machine. The service pack, when run, modifies the components of the host software that need updating.

Updating the firmware is more problematic. This process is typically performed manually by a user. It may involve running an executable program, then resetting the imaging device. Manual updating of the firmware is inconvenient, and may lead to errors caused by incompatible versions of firmware and host system software.

SUMMARY OF THE PRESENT INVENTION

A method of updating firmware on an imaging device coupled to a host system is disclosed. The host system detects that the firmware on the imaging device is incompatible with a configuration of the host system. In response to detecting the incompatibility, an updated firmware image is transferred from the host system to the imaging device. In one embodiment, the updated firmware image is an older version of firmware than the one that is replaced.

Other features, and advantages of the present invention will be apparent from the accompanying drawings and from the detailed description that follows below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a representation of an imaging device that is attachable to a host system.

FIG. **2** shows one embodiment of the flow of information among the components of the host system when the imaging device **10** is first connected to the host system **20**.

FIG. **3** shows one embodiment of the flow of information among the components of the host system after the host application software **60** has been initiated.

FIG. **4** shows one embodiment of the polling initialization process.

FIG. **5** shows an embodiment of the polling process between the camera API **62** and the host applications software **60**.

FIG. **6** shows a flowchart of one embodiment of the process of checking whether a compatible imaging device is connected to the host system.

FIG. **7** shows a flowchart of one embodiment of updating the firmware.

FIG. **8** shows one embodiment of a state transition diagram of the firmware boot process.

FIG. **9** shows a diagram of an exemplary nonvolatile memory **400** which stores the firmware.

FIG. **10** shows a flowchart of one embodiment of the process of initializing the host application software to establish a communication with a camera.

FIG. **11** shows a flowchart of one embodiment of the process of detecting that an imaging device such as a camera is attached to a host system.

DETAILED DESCRIPTION

A method of updating firmware between an imaging device and a host system is disclosed. The firmware includes instructions which are used to control an embedded system, such as an imaging device. In one embodiment, the firmware update is performed automatically upon connecting the imaging device to the host system. This simplifies operation for the user while ensuring compatibility between the imaging device and the host software. The firmware update may provide "bug" fixes, enhancements to algorithms, updated color sensing, updated compression, new protocols for accessing and formatting the storage medium, and so forth. As will become clear, the automatic firmware update is particularly useful when multiple a imaging devices with different versions of firmware are used with host systems that have different versions of software.

The following description describes the firmware update in the context of a system that transfers image information between the image device and the host system automatically upon coupling the image device to the host system. However, the firmware update is not limited to such a system.

The imaging device may be an image capture device, such as a camera. Alternatively, the techniques disclosed can be used with any device that is capable of storing image information. The host system may be any system which is capable of manipulating image information. For example, the host system may be a personal computer such as an IBM-compatible personal computer running on an Intel Pentium® or Pentium® II processor. However, the host system could alternatively be a printer, plotter, fax machine, display device, or storage device.

For purposes of clarity, the following description is written in terms of the imaging capture device being a camera and the host system being a computer. It should be understood that other imaging devices and host systems may be employed.

FIG. **1** shows a representation of an imaging device **10** that is attachable to a host system **20**. In one embodiment, the imaging device **10** is attached via a cable **22** to a port **26** of the host system **20**. The imaging device **10** is preferably coupled to the host system **20** using a data transfer protocol that supports a high data transfer rate. In one embodiment, the imaging device **10** is coupled to the host system **20** via

a Universal Serial Bus (USB) connection. The USB connection provides for a data transfer rate of up to 12 Mb/s. Other connections and data transfer protocols may alternatively be used, such as the 1394 protocol. (More information on USB can be obtained from the World Wide Web at the URL http://www.usb.org/. The 1394 standard is maintained and distributed by the Institute of Electrical and Electronic Engineers. Firewire, one implementation of 1394, is defined by IEEE Standard 1394–1995.)

FIGS. **2** and **3** are embodiments showing the relationship and messaging between components of the host system **20** and imaging device (camera) **10**. FIG. **2** shows one embodiment of the flow of information among the components of the host system when the imaging device **10** is first connected to the host system **20**. The host system **20** includes an operating system (O/S) **40** and host application software **60**. The host system **20** detects when an imaging device such as a camera **10** is attached to the host system **20**. In one embodiment, the operating system **40** detects whether a camera **10** is attached to the system by polling the port **26**. A port driver **42** may be used to provide an interface between the operating system **40** and the port **26**. In one embodiment, the port **26** is a USB port and the port driver is a USB driver.

The operating system may be one of a variety of different operating systems. In one embodiment, the operating system is a Windows* operating system, such as Windows* 95, or Windows* 98 made by Microsoft Corporation. Windows 98 includes hooks which allow the polling of ports. Other operating systems may be modified to provide for such polling. The polling is preferably performed in the background so that the user need not be aware that it is being performed. Alternatively, host application software **60** can perform the polling of the port **26**. However, polling by the operating system **40** (instead of by host application software **60**) has a performance advantage, since the operating system is already set up for polling various activities, such as keyboard pushes, mouse movements, and so forth. For the purposes of illustration, the following description assumes that the operating system does the polling. A person skilled in the art can make the modifications to allow an application to do the polling.

* Third-party marks and brands are the property of their respective owners.

When a camera **10** is connected to the port **26** of the host system **20**, the port driver **42** signals the operating system **40** that the camera has been attached to the host system **20**. This is illustrated by the arrow marked **(1)** shown in FIG. **1**. The operating system **40** identifies the device as a camera and loads the corresponding software driver **44** into memory as illustrated by the arrow **(2)**. In one embodiment, the operating system **40** interrogates the camera **10** to get an identifier. The operating system **40** loads the software driver **44** corresponding to the identifier. In this example, a camera driver **44** is loaded by the operating system **40**.

The operating system **40** then loads one or more software applications corresponding to the camera. In one embodiment, the operating system allows software applications to be registered. Upon meeting a predetermined condition (such as a camera with a particular identifier being detected), the registered host application software is loaded. In this case, the host application software **60** (for the camera) is loaded as shown by the arrow **(3)**. In one embodiment, the camera driver **44** signals the operating system **40** to initiate the host application software **60**. The host application software **60** initiates the transfer of image information between the image device (camera) **10** and the host system **20**. The host application software **60** may also process images. For example, the host application software **60** can perform decompression and/or color correction on the images. Furthermore, the host application software **60** may perform rotation, cropping, and other image manipulation functions.

Some operating systems, such as Windows 98 allow specific events to cause software applications to be launched. For example, the camera driver **44** can be set up with registered events such as "connection detected with camera" or "shutter button on camera is pushed." Thus, an operating system can be set up to automatically launch an application such as the host application software **60** when the camera **10** is attached.

In one embodiment, if the camera driver **44** or the host application software **60** is not installed on the host system **20** when the camera **10** is attached to the host system **20**, then the user is requested to provide the camera driver **44** and/or host application software **60** for the device that has been attached to the port **26**. Once the installation has been completed, the process proceeds as previously described.

FIG. **3** shows one embodiment of the flow of information among the components of the host system after the host application software **60** has been initiated. In this embodiment, after being loaded, the host application software **60** creates and initializes a camera Applications Programming Interface (API) **62** as indicated by arrow **(4)**. The camera API **62** may perform its task in a background thread. In this manner, the host application software **60** need not wait for the camera API **62** to complete before performing other tasks. In one embodiment, the camera API **62** is a COM object which loads a dynamic link library (DLL) **64** as shown by arrows **(5)**. The DLL may be O/W dependent. The camera API **62** communicates to the operating system **40** via the DLL **64**. (In another embodiment, the camera API **62** incorporates the DLL **64**.) The operating system **40** in turn communicates with the camera **10** via the camera driver **44** and the port driver **42** as shown by arrows **(6)**.

FIG. **4** shows one embodiment of the polling initialization process. The polling initialization process begins with the operating system opening the host application software. The host application software **60** then creates and initializes a camera API **62**. In one embodiment, the host application software **60** adds itself to the camera API's callback list, so that the host application software **60** will be notified when the camera API is successful in the polling process.

In one embodiment, the camera API upon initialization resets its internal variables, loads a DLL, and creates and starts a background thread. The camera API then inserts a message into the background threaded queue that tries to open the camera driver. (A driver is "opened" by establishing a connection between the camera API and the driver.) In one embodiment, the camera driver is only opened when a camera is attached: If the camera driver cannot be opened, then a camera is not attached to the host system. If a camera driver can be opened, then a camera is attached. In one embodiment, the camera API **44** attempts to open the camera driver every half a second.

FIG. **5** shows an embodiment of the polling process between the camera API **62** and the host application software **60**. In this embodiment, the camera API **62** attempts to open the camera driver (CM_SIGNAL_STATUS). When it is successful at opening the camera driver, the camera API closes the camera driver, and notifies the applications in its callback queue. Since the host application software **60** is in the callback queue of the camera API, it is notified that a camera has been detected.

In this embodiment, the host application software **60** re-opens the camera driver **44** by signaling the camera API **62** to open the camera driver **44** and check for a compatible

camera (CM_OPEN_DRIVER). The host application software **60** can then send various commands to the camera **10** via the camera API **62** (and the operating system **40** and drivers **44** and **42**). For example, the host application software **60** can request the number of images stored in the camera (CM_GET_NO_OF_IMAGES). The host application software **60** can request a list of the names of the images and the image sizes (CM_GET_IMAGE_LIST), or it can request a particular image (CM_GET_IMAGE_BY_NAME).

In one embodiment, the camera API **62** checks whether a compatible imaging device is connected to the host system, and automatically updates the firmware on the imaging device, if necessary. The automatic firmware update may be disabled or enabled as a factory setting by the manufacturer, or it may be alterable by the user.

FIG. **6** shows a flowchart of one embodiment of the process of checking whether a compatible imaging device is connected to the host system. In one embodiment, this process is performed by the camera API **62**. As previously mentioned, the camera API **62** is created and initialized by the host application software **60** as shown at block **100**. The camera API **62** loads a DLL that may be operating system dependent at block **102**, and the host application software **60** issues an open command to the camera API **62** at block **104**. The camera API in response, opens the camera driver **62** via the DLL **64**, as shown in block **106**.

At block **108**, the camera API **62** issues a command to the camera to fetch the camera interface number. In one embodiment, a unique camera interface number is assigned to a set of commands that the camera supports.

Operation continues at decision block **110**. The interface number from the camera is compared with an interface table in the camera API **62**. If the interface number is not stored in the camera API **62** interface table, then the camera API **62** closes the camera driver and signals to the host application software that the camera is incompatible, as shown at blocks **112** and **114**. The camera API is not able to communicate with the camera because the commands that the camera supports is not known.

At block **110**, if the interface number from the camera is stored in the interface table of the camera API **62**, then the camera API **62** issues a command to the camera to fetch a hardware version number, as shown at block **120**.

At block **130**, the hardware version number from the camera is compared with a hardware table stored in the camera API **62**. If the hardware version number from the camera is not stored in the hardware table of the camera API **62**, then the camera API **62** is unable to check for an update. The camera API **62** signals the host application software that the camera is open for access, as shown at block **132**. The camera API **62** is able to communicate with the camera because its interface is compatible, but it does not update the firmware because it does not recognize the hardware configuration.

At block **130**, if the hardware version number from the camera is stored in the hardware table of the camera API **62**, then operation proceeds to block **140**. At block **140**, the camera API issues a command to the camera to return the firmware version number.

Operation proceeds to block **150**. If the firmware version number is not different than that stored within the camera API **62**, then the camera has updated firmware already. The camera API **62** signals the host application software that the camera is open for access.

If the firmware version number is different than that stored in the camera API **62**, then operation continues at block **160**. If the manufacturer has disabled the firmware updates, then the camera API **62** does not perform a firmware update and signals the host application software that the camera is open for access. For example, the manufacturer may set a bit in a register of the camera disabling firmware updates. Although the installed firmware may not be the latest version, the installed firmware is still able to perform with the host software as long as the interface and hardware are compatible.

At block **170**, a check is made whether the update has been tried before and failed. In one embodiment, a predetermined number of update tries is performed. If the update has been tried before and failed, then the camera API **62** signals to the host application software that the upgrade failed, and that the camera is open for access, as shown at block **172**.

At block **170**, if the update has not been tried before, then the flowchart proceeds with the firmware update process, as shown in FIG. **7**.

FIG. **7** shows a flowchart of one embodiment of updating the firmware. At block **200**, the camera API transfers an updated firmware image to the camera. In one embodiment, the camera API sends a download firmware command to the camera, so that the firmware will be ready to receive a new firmware image. The updated firmware image is then transferred from the host system to the camera. In one embodiment, the updated firmware image is stored on the camera in a temporary buffer, such as volatile memory.

At block **202**, the camera API **62** closes the camera driver. This shuts down communication between the camera and the host system so that the firmware update is not interrupted. The camera API then signals the host application software that it is in the process of updating the firmware, as shown at block **204**. The camera API begins to poll for the firmware to re-establish a connection with it.

The firmware is made up of a boot block and a code block. The boot block, also called the bootloader, is not replaced when the firmware is replaced. Only the code block is replaced. The bootloader maintains the routine for updating the firmware. At block **206**, the bootloader validates that the updated firmware image is error free. This can be performed by generating a checksum, for example. The bootloader then substitutes the updated firmware image for the old (installed) firmware, as shown at block **208**. In one embodiment, this is performed by transferring the firmware image from volatile memory into nonvolatile memory. The bootloader then either causes a reset, or it jumps to the start of the bootloader to initiate the newly updated firmware, as shown at block **210**. This causes the bootloader to restart, at which point the bootloader checks for errors in the updated firmware, as shown at block **212**. If the checksum is correct, then the firmware in the code block is executed, as shown at block **214** and **218**.

If the checksum is incorrect, the bootloader re-establishes a connection with the host system and moves to a waiting state, as shown at block **216**. In this waiting state, the camera API may get status from the bootloader to determine whether the new firmware image was loaded properly into the code block, or whether there was a problem, and the bootloader is in the waiting state. The camera API may attempt another update of the firmware.

Proceeding from block **218**, once the firmware is able to restart with a correct checksum on its code block, then the firmware can establish a connection with the host system. The camera API will detect from its polling that the camera is connected at block **220**. The camera API can then re-open the camera driver and perform accesses to the camera.

FIG. **8** shows one embodiment of a state transition diagram of the firmware boot process. The state transition diagram is divided into boot block states on the left hand side of the FIG. **8** and a code block state on the right hand side of FIG. **8**. At state **300**, a reset initializes the camera hardware. This may include resetting registers and/or turning off certain units of the camera, so that the camera is in a known state. From state **300**, there is a transition to state **302**, at which the code block is checked. In one embodiment, a checksum is performed on the code block. If the checksum passes, then the instructions in the code block are executed, as shown at state **304**. The firmware in the code block is able to establish a connection with the host system and handles various commands received from the host system. If the firmware in the code block detects that the host system has issued a download command, then the state transitions to state **306**, at which the camera hardware is initialized into a known state. For example, the sensor and strobe may be turned off, and the DRAM may be turned on. In one embodiment, the camera hardware is turned off when not in use in order to save power. The state transitions to block **308**, at which the updated firmware code is received from the host system. The updated firmware code is temporarily stored in DRAM in one embodiment If there is a communication problem at state **308**, then there is a transition to waiting state **310**. At waiting state **310**, the boot block waits for a command from the host system.

From state **302**, if the checksum fails, then there is also a transition to waiting state **310**. At waiting state **310**, the boot block waits for a command from the host system. The host system, for example, may request status information from the boot block. When the host system realizes that the boot block is in waiting state **310**, the host system can issue another download command, which results in a transition back to state **308**.

From state **308**, if the firmware image is downloaded without errors, then there is a transition to state **320**, at which the code that was downloaded is checked for errors. In one embodiment a checksum is performed. If the checksum fails, then the boot block returns to waiting state **310**. If the checksum passes, then the state transitions to block **322**, at which the code block is erased. Subsequently, the code block is re-programmed in state **324**. From state **324**, there is a transition back to state **300** at which the camera hardware is re-initialized and the state transition diagram restarts as previously described.

FIG. **9** shows a diagram of an exemplary nonvolatile memory **400**. In one embodiment, the nonvolatile memory is a flash memory. In one embodiment, the boot block **402** and code block **404** are stored in the flash memory, and the boot block is locked so that it is not overwritten. The code block is re-programmable.

In one embodiment, the nonvolatile memory also stores one or more imaging tables **406**. The imaging tables may include information associated with the configuration of the camera.

In one embodiment, the following imaging tables are stored in the flash memory.

1) dead pixel table
2) encoder table
3) exposure table
4) compander table
5) color correction tables

The imaging tables allow for processing of an image in the camera. For example, the dead pixel table may include information on particular pixels of the camera which do not work properly. The dead pixel table may be determined during manufacturing testing, for example. Alternatively, a camera may be able to determine dead pixels dynamically. The dead pixel table allows for interpolation using neighboring pixels to compensate for the defective pixels.

Similarly, the other imaging tables allow manipulation of imaging data. For example, the encoder table may specify particular values used for encoding or compressing an image. Exposure tables may include information on exposure time, gain, strobe use and intensity. The companding table may include information used to map data from a bit representation using a first number of bits to a bit representation using a smaller number of bits. The color correction tables may be used to correct colors.

In one embodiment, the imaging tables include values that are associated with a particular illuminant. For example, the imaging tables may include different values corresponding to the capture of an image in either sunlight, fluorescent lighting, or tungsten bulb lighting.

The imaging tables may be stored into the nonvolatile memory **400** during manufacturing, but may be updated later by the firmware. In one embodiment, the firmware is able to delete imaging tables in the nonvolatile memory and transfer new imaging tables from the host system to the nonvolatile memory of the camera. The firmware receives commands from the host system which indicates whether a table is to be transferred to the camera, or whether an imaging table is to be deleted.

In one embodiment, because some nonvolatile memories (e.g., some flash memories) are not able to both read from the nonvolatile memory and write to the nonvolatile memory at the same time, a DRAM is used to temporarily store code from the nonvolatile memory. The firmware copies a portion of its code to the DRAM, then transfers execution to the DRAM. A microcontrolller executing instructions out of the DRAM is able to then write the new imaging tables to the nonvolatile memory. Execution is subsequently transferred back to the code section of the nonvolatile memory.

Tables 1 and 2 are used to show examples of how various versions of interfaces, firmware, and camera APIs on different cameras and personal computers (PCs) may interrelate. Table 1 indicates a configuration table stored in a first camera API (CAMAPI **#400**). Table 2 indicates a configuration table stored in a second camera API (CAMAPI **#420**). Some examples of various embodiments using the configuration information stored in these tables will help to illustrate.

TABLE 1

Interface Identifier	Hardware Version	Firmware Version/ Firmware Image
0x0101	1.00	1.00/Filename 3
	1.01	1.02/Filename 4
	1.02	1.07/Filename 5
0x0202	2.00	1.08/Filename 6

TABLE 2

Interface Identifier	Hardware Version	Firmware Version
0x0303	3.00	1.09/Filename 8
3.01	1.09	Filename 8
3.02	2.18	Filename 12
0x0404	4.00	3.08 Filename 13

Example 1: Assume that two users, A and B, have the same version of host application software and firmware

versions. Let the software version be 1.0 which creates CAMAPI #**400** having the table of identifiers shown in Table 1. The interface identifier is 0x0101, and the firmware version is 1.00. Next, user A receives an upgrade and updates his host application software to version 1.02, which has the same interface (0x0101).

After the host application software is upgraded, the first time that user A tries to access the camera, the camera API **62** will detect an incompatible version of firmware. It will trigger the firmware to be updated automatically, as was previously described.

Subsequently, assume that user B (who still has firmware version 1.00 on his camera) brings his camera to A's PC and plugs it in. The camera API on A's PC will again detect the firmware and software versions. The camera API will update the firmware on B's camera to 1.02. B's camera will now have a different firmware (1.02) than the host software on B's PC. When B takes his camera back to B's PC, the camera API **62** will have no knowledge of the firmware version 1.02. The camera API **62** will transfer the firmware image version 1.00 to B's camera. Thus, B's camera is restored to its original firmware so that it can communicate with the software on B's PC.

The firmware update is transparent to B. B is able to use his camera on either A's updated system or B's system with older host application software.

Example 2: Assume that A has firmware version 1.00, interface 0x0101, and B has firmware version 1.08, interface 0x0202. B cannot use A's PC unless A upgrades her software to recognize the new interface 0x0202. If B's PC uses the camera API including all revisions shown in Table 1, then B's PC can be used with either A's camera or B's camera.

Example 3: If user A has firmware version 1.0 and uses CAMAPI #**400** as shown in Table 1, and user B has firmware version 3.0 and uses CAMAPI #**420**, as shown in Table 2, then a PC must have both versions of software that interface with the separate interfaces to the cameras in order to access both cameras.

In one embodiment, the interfaces have unique interface identifiers. One example of an interface is the TWAIN interface, which describes to an imaging application how to go about acquiring images from a scanner or other digital imaging devices. The current version of TWAIN is 1.7. TWAIN is maintained by a standards group made up of several industry participants. More information on TWAIN is available through http://www.twain.org. Proprietary interfaces may also be used. For example, DLLs supporting a particular application program so that the application program has the ability to transfer and delete images from the imaging device may be supported.

The hardware identifier specifies hardware changes, for example, a stepper motor may be added to the imaging device. Firmware releases may be set up to track minor and major changes. For example, a minor change may be a bug fix or enhancement. A major change may be the addition of new hardware.

FIG. **10** shows a flowchart of one embodiment of the process of initializing the host application software to establish a communication with an imaging device. In this disclosed embodiment, the imaging device is a camera, and the host system is a personal computer. The flowchart begins at block **500**. The process continues at block **502**, at which the host application software creates a camera API. The camera API loads a DLL that may be operating system dependent at block **504**. At block **506**, the camera API determines if a camera is available.

At block **508**, if a camera is not available, then the flowchart returns to block **506**. However, if a camera is available, the process continues at block **510**. At block **510**, the camera API sends a message to the host application software indicating that a camera is available. The host application software requests that the camera driver be open at block **512**. The camera API responds by opening the camera driver, as shown at block **514**. The process of opening a driver means establishing a connection between the camera API and the camera driver. The firmware update process, as previously described, occurs at this point.

At block **516**, the host application software requests that images are transferred from the camera to the host system. The camera API responds by transferring image information from the camera to the host application software at block **518**. Image information may include image pixel data as well as other information, such as color palette information, compression information, orientation of the image, and so forth. The flowchart terminates at block **520**.

FIG. **11** shows a flowchart of one embodiment of the process of detecting that an imaging device such as a camera is attached to a host system. The flowchart starts at block **600**. It continues at block **602**, in which the operating system determines if a camera is available. This may be done with the aid of a port driver such as a USB driver. If the camera is not available, the process returns to block **602**. If a camera is available at block **604**, the process continues at block **606** at which the operating system loads the camera driver.

In one embodiment, an operating system such as Windows 98 is used by the host system. Windows 98 allows the driver to signal the operating system of the camera being connected to the host system (the connection event), as shown by block **608**. The operating system then opens the applications that are registered with the connection event. In this case, the host application software for the camera is initiated, as shown at block **610**. The flowchart then continues with the flowchart of FIG. **10**.

If the operating system does not provide a way of opening an application based on the connection event, an alternate embodiment may use a "service" instead of the steps shown by blocks **608** and **610**. The service is installed by the user and is initiated on the host system automatically when the host system boots up. The service opens the host application software when a camera is detected. In one embodiment, the service uses the camera API to determine if the camera is available. Thus, the service acts as a mini-host application in a manner similar to that shown in FIG. **10**. However, the service initiates the host application software when a connection to the camera driver is established. The host application then establishes its own connection to the camera driver to transfer images from the camera.

In one embodiment, the host application software **60** and the camera driver **44** are shipped with the camera **10**. The host application software **60** and camera driver **44** may be shipped via floppy disk or CD-ROM. Alternatively, the host application software **60** and camera driver **44** can be downloaded via the World Wide Web. The host application software **60** and camera driver **44** are installed to a storage medium on the host system, such as a hard disk, dynamic random access memory (DRAM), static random access memory (SRAM), or flash memory.

In the foregoing specification, the invention has been described with reference to specific exemplary embodiments thereof It will, however be evident to someone having the benefit of this disclosure, that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention as set forth in the appended claims. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.

What is claimed is:

1. A method of updating firmware on an imaging device, the method comprising:

upon establishing a connection between the imaging device and a host system, automatically detecting if a firmware version on the imaging device matches a firmware version on the host system;

if the firmware version on the imaging device does not match,

updating the firmware on the imaging device automatically with firmware located on the host system, and executing the updated firmware; and

if the firmware version on the imaging device matches, executing the firmware on the imaging device.

2. The method of claim 1, wherein the step of detecting further comprises:

receiving device interface information from the imaging device; and

comparing the device interface information with interface information stored on the host system.

3. The method of claim 1, wherein the step of updating further comprises:

loading the firmware from the host system to a buffer memory on the imaging device;

checking for errors in the loaded firmware; and

refreshing the firmware on the imaging device with the loaded firmware if the loaded firmware is error free.

4. The method of claim 3, wherein the step of updating is repeated if the loaded firmware is not error free.

5. The method of claim 1, wherein the step of updating is performed if the firmware version on the imaging device is an earlier version of the firmware than the firmware version on the host system.

6. The method of claim 1 further comprising:

loading at least one configuration table into the imaging device from the host system.

7. The method of claim 6, wherein the at least one configuration table are used to manipulate imaging data on the imaging device.

8. The method of claim 1 wherein the step of executing the updated firmware is performed by initiating a reset to the beginning of a bootloader.

9. A system comprising:

a processor;

a storage medium storing instructions which when executed by the processor cause the processor to:

detect if a connection is established between an imaging device and a configuration system;

if a connection is established, detect if a firmware version on the imaging device matches a firmware version on the configuration system;

if the firmware version on the imaging device does not match, update the firmware on the imaging device automatically with firmware from the configuration system, and execute the updated firmware; and

if the firmware version on the imaging device matches, execute the firmware on the imaging device.

10. The system of claim 9, wherein the step of detecting comprises:

receiving device interface information from the imaging device; and

comparing the device interface information with interface information stored on the configuration system.

11. The system of claim 9, wherein the step of updating further comprises:

loading at least one configuration table into the imaging device from the configuration system.

12. The system of claim 11, wherein the at lest one configuration table are used to manipulate imaging data on the imaging device.

13. A computer-readable medium containing executable instructions which, when executed in a processing system, causes the processing system to update the firmware on an imaging device by:

detecting if a connection is established between an imaging device and a host system;

if a connection is established, detecting if a firmware version on the imaging device matches a firmware version on the host system;

if the firmware version on the imaging device does not match, updating the firmware on the imaging device automatically with firmware from the host system, and executing the updated firmware; and

if the firmware version on the imaging device matches, executing the firmware on the imaging device.

14. The medium of claim 13, wherein detecting if a firmware version on an imaging device matches a firmware version on a host system further comprises:

receiving device interface information from the imaging device; and

compating the devine interface information with interface information stored on the host system.

15. The medium of claim 13 further comprising:

loading at least one configuration table into the imaging device from the host system.

16. The medium of claim 15, wherein the at least one configuration table are used to manipulate imaging data on the imaging device.

17. The medium of claim 13, wherein the step of updating further comprises:

loading the firmware from the host system to a buffer memory on the imaging device;

checking for errors in the loaded firmware in the buffer memory; and

refreshing the firmware on the imaging device with the loaded firmware in the buffer memory if the loaded firmware is error free.

18. The medium of claim 17, wherein the step of updating is performed if the firmware version on the imaging device is an earlier version of the firmware than the firmware version on the host system.

19. A method of updating firmware on a camera, the method comprising:

connecting the camera to a host system;

detecting if a firmware version on the camera matches a firmware version on the host system;

if the firmware version on the camera does not match,

updating the firmware on the camera automatically with firmware from the host system, and

executing the updated firmware; and if the firmware version on the camera matches,

executing the firmware on the camera.

20. The method of claim 19, wherein the step of detecting further comprises:

receiving device interface information from the camera; and

comparing the device interface information with interface information stored on the host system.

21. The method of claim **19** further comprising:

loading at least one configuration table into the camera from the host system.

22. The method of claim **21**, wherein the at least one configuration table are used to manipulate imaging data on the imaging device.

23. A system for updating firmware on an imaging device comprising:

means for detecting if a firmware version on the imaging device matches a firmware version on a host system;

if the firmware version on the imaging device does not match,

means for updating the firmware on the imaging device automatically with firmware from the host system, and

means for executing the updated firmware; and if the firmware version on the imaging device matches,

means for executing the firmware on the imaging device.

24. A method of updating firmware on an imaging device, the method comprising:

sending a firmware version on the imaging device to a host system in response to a request from the host system;

if the host system transfers firmware to the imaging device,

updating the firmware on the imaging device automatically with the firmware from the host system, and

executing the updated firmware; and

if the host system does not transfer firmware,

executing the firmware on the imaging device.

25. The method of claim **24**, wherein the step of updating further comprises:

loading the firmware from the host system to a buffer memory; checking for errors in the loaded firmware; and

refreshing the firmware with the loaded firmware if the loaded firmware is error free.

26. The method of claim **25**, wherein the step of updating is repeated if the loaded firmware is not error free.

27. The method of claim **24** further comprising:

loading at least one configuration table into the imaging device from the host system.

28. The method of claim **27** wherein the at lest one configuration table are used to manipulate imaging data on the imaging device.

29. A system for updating firmware on an imaging device comprising:

means for sending a firmware version on the imaging device to a host system in response to a request from the host system;

if the host system transfers firmware to the imaging device,

means for updating the firmware on the imaging device automatically with the firmware from the host system, and

means for executing the updated firmware; and

if the host system does not transfer firmware, means for executing the firmware on the imaging device.

30. A system for updating firmware on an imaging device comprising:

a firmware version on the imaging device; and

updating logic within a host system configured to update the firmware on the imaging device automatically with firmware from a host system if the firmware version on the imaging device does not match a firmware version on the host system.

31. The system of claim **30** further comprising:

a buffer memory on the imaging device for receiving firmware from the host system; and

a bootloader on the imaging device configured to check for errors in the firmware received by the buffer memory from the host system.

32. The system of claim **31** wherein the updating logic automatically updates the firmware on the imaging device upon establishing a connection between the imaging device and the host system.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,360,362 B1
DATED : March 19, 2002
INVENTOR(S) : Fichtner et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 2,
Line 36, after “multiple”, delete “a”.

Signed and Sealed this

Seventeenth Day of September, 2002

Attest:

Attesting Officer

JAMES E. ROGAN
Director of the United States Patent and Trademark Office