A TECHNICAL NOTE

Computed Radiography: User-Programmable Features and Capabilities

Eric L. Gingold, Douglas M. Tucker, and Gary T. Barnes

Digital or computed radiography (CR) using photo-stimulable storage phosphor plate technology is becoming increasingly popular in certain clinical applications, such as bedside radiography, where it possesses clear advantages over conventional screen-film imaging. The majority of CR systems in clinical use have been manufactured by Fuji Medical Systems USA, Inc (Stamford, CT) and provide a surprising degree of flexibility. Fuji CR units are delivered with preset menus, hardcopy format, and image-processing parameters for each examination. Of practical importance is that users may change the exam menu and printed film format as well as the image-processing parameters for each examination. There is, however, a lack of documentation describing these features and how they are programmed. This paper addresses these issues. Examples are given on how to change: 1) the printed film format, 2) the contrast and gray-scale processing, 3) spatial frequency enhancement, and 4) the appearance of the operator interface menus.
Copyright © 1994 by W.B. Saunders Company

KEY WORDS: digital radiography, computed radiography, image processing.

COMPUTED RADIOGRAPHY (CR) is based on the use of photostimulable storage phosphor plate technology and is replacing conventional screen-film systems in a number of areas. An example is bedside radiography, where CR systems can produce useful images with techniques that would overexpose or underexpose screen-film combinations. CR is an inherently digital technology, and thus, is a convenient choice for digital image postprocessing or picture archiving and communication system (PACS) integration.

In screen-film radiography, the receptor sensitivity (speed), contrast, latitude, and sharpness depend on the choice of the image intensifying screen and film. Speed and image contrast are also influenced by film processing, ie, temperature, cycle time, and chemistry. In CR, the sensitivity, contrast, degree of high-frequency enhancement and format of the film image are controlled by manipulating parameters stored in the CR system's computer memory. CR systems provide a great deal of flexibility, and a thorough understanding of the features and capabilities of the system is necessary to achieve optimal performance.

Until recently, all of the commercially available CR systems used image plates and plate reader-printer systems manufactured by Fuji Medical Systems USA, Inc (Stamford, CT). The Fuji FCR AC-1, AC-1 Plus, and AC-2 models use a common host computer and software instruction set. This instruction set is similar in many respects to the Fuji CR 7000 and 9000 models.

Several papers have described the image processing used by the Fuji CR systems in general terms.[1,2] However, specific implementation steps are not discussed. To date, Fuji and other CR system vendors have not provided sufficient documentation on the details of their implementation, and it is difficult if not impossible for the end user to program the Fuji AC family of systems. This paper addresses these issues. Presented is the overall organization of the Fuji AC system software, the image-processing algorithm options available, and the relationship between the options and user-selectable parameters. Also reviewed are the general system configuration setup options that determine the appearance of the operator interface menus and the formatting of hard-copy films. Included are detailed descriptions of how one programs gray-scale processing, spatial frequency enhancement, operational menu and printed film format. Routine operational procedures such an loading and unloading cassettes and identifying the type of radiographic proce-

dure are described in the operation manual[3] supplied with each unit, and are not covered here.

IMAGE PROCESSING

In normal CR operation spatial frequency processing precedes contrast processing. Spatial frequency processing is accomplished by using a blurred-mask subtraction algorithm. The algorithm is given by the expression

$$I_p[x, y] = I_o[x, y] + g(I_o[x, y])$$
$$\times (I_o[x, y] - I_b[x, y]) \qquad (1)$$

where I_p, I_o and I_b are the processed, original, and blurred-image pixel values, respectively, and $g(I_o [x,y])$ is an enhancement factor that varies with the original image gray-scale value. The blurred image (I_b) is produced by the convolution of the original image (I_o) with a uniform (square) kernel. The size of the kernel (number of pixels) is set by the user-programmable parameter, RN. RN can take on integral values between 0 and 9, with 0 corresponding to a large kernel (enhancement occurs at mid as well as higher spatial frequencies) and 9 being the smallest kernel (enhancement occurs only at higher spatial frequencies). The number of pixels associated with the value of RN is given in reference 2. The enhancement factor, $g(I_o[x,y])$ is defined as

$$g(I_o[x, y]) = RE \times RT (I_o[x, y]) \qquad (2)$$

where $RT(I_o[x,y])$ is a function that returns a value between 0 and 1, and RE is a weighting constant. The different $RT(I_o[x,y])$ functions are implemented as a set of eight lookup tables that map input pixel values to an enhancement factor. Figure 1 graphically represents the set of available lookup tables. RE is a two-digit number ranging between 0.0 and 16 (ie, 0.0, 0.1, 0.2, . . . , 9.9, 10, 11, . . . , 16). RE and the function $RT(I_o[x,y])$ are user selectable.

Contrast processing is implemented by mapping the input pixel values to output pixel values using user-generated lookup tables. There are four parameters (GA, GC, GS, and GT) that determine the final form of the lookup table. All four are user selectable. GT determines which one of 15 preset mappings will be used to
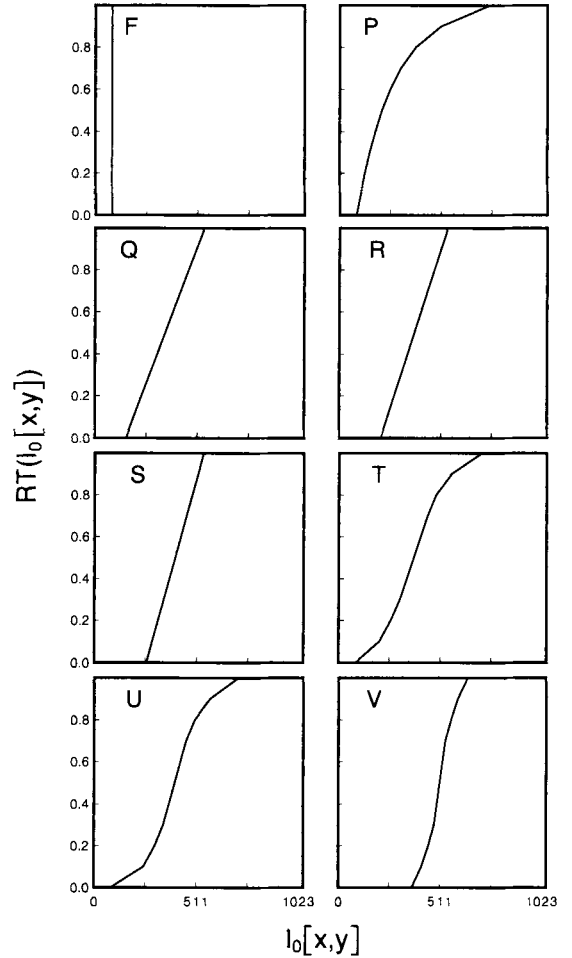

Fig 1.   Mapping functions RT (I_o[x,y]), used by the blurred-mask subtraction algorithm.

generate the final lookup table. The selection of a GT parameter is analogous to selecting a particular characteristic curve for a screen-film system (see Fig 2). The parameters GA and GC jointly determine the amount of contrast provided by the lookup table. GC specifies a film optical-density value about which the lookup table is "stretched" to increase or decrease contrast. Values of GC range from 0.3 to 2.6 in increments of 0.1, corresponding to the base + fog and maximum optical density (D_{max}) of the output film. To convert GC to a pixel value, the contrast algorithm uses the relation

$$C_o = 355.6 \times GC + 84.3 \qquad (3)$$

where C_o is the output pixel value (on the original GT curve) that is held fixed while the
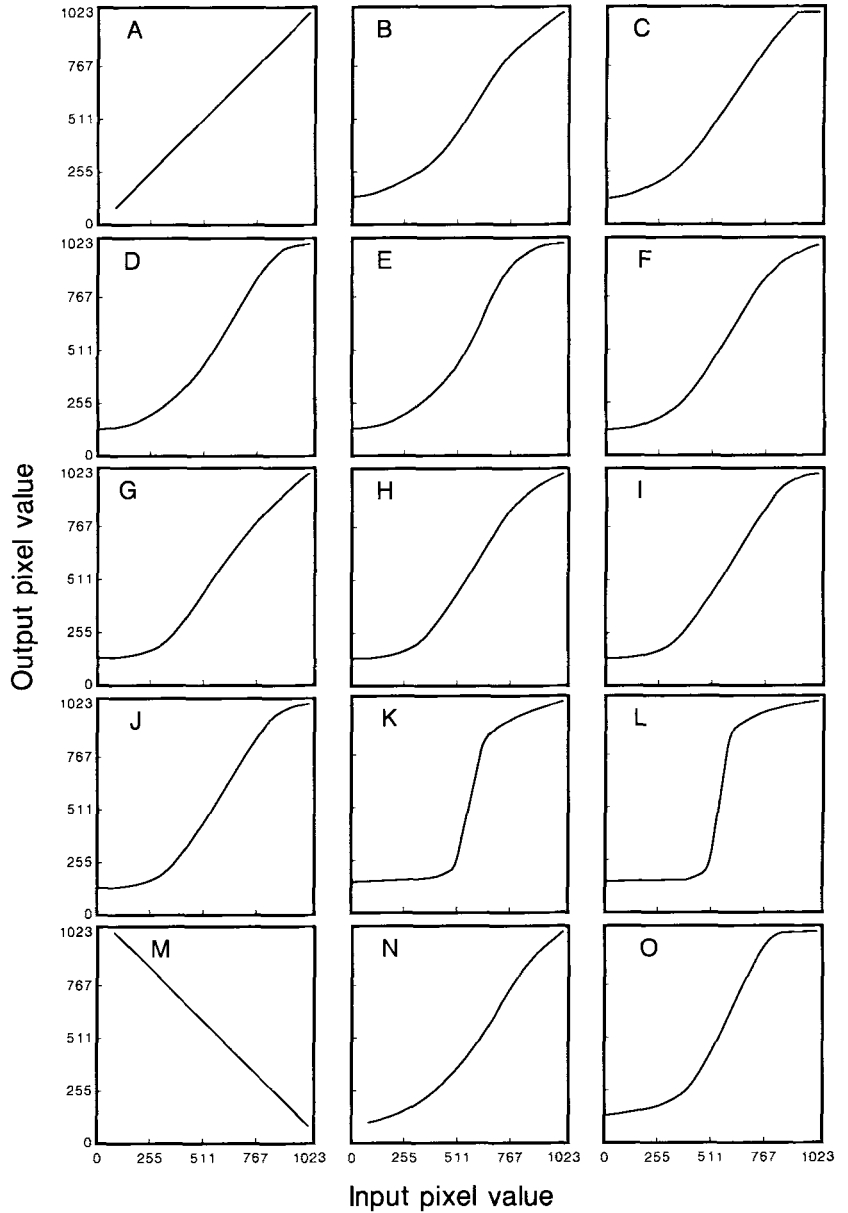
Fig 2. Characteristic curves denoted by the parameter GT, used by the contrast-processing algorithm.

rest of the curve is "stretched" by an amount equal to 1/GA. GA values less than 1.0 will result in a horizontal expansion (or "stretch") of the contrast processing curve, thus decreasing the contrast of the resulting image. GA values greater than 1.0 will result in a horizontal compression of the contrast curve that increases the contrast in the resulting film. GA may take on values of 0.1 to 4.0 or −0.1 to −4.0, in increments of 0.1. Note that negative values of GA correspond to a left/right reflection of the

contrast curve about the fixed point C_o. GS is referred to as a gradation shift parameter, and is analogous to changing the film speed of a conventional screen-film system. GS may assume values in the range −1.44 to +1.44, in increments of 0.01. A negative GS value produces a right shift of the contrast curve, reducing the sensitivity (speed) of the system. Conversely, positive GS yields a left shift, and a corresponding increase in system sensitivity. The amount of the shift (in pixel value units) is

equal to the constant 355.6 times the value of GS. The effect of the four contrast-processing parameters are depicted graphically in Fig 3.

CUSTOMIZING THE OPERATION OF THE PLATE READER

To interact with the CR system for the purposes of configuration and setup, Fuji has provided a Built-In Terminal (BIT), which allows the user to interact with the host computer via a command-line interface, similar to the operating system of a personal computer or the shell of a UNIX workstation. A modified keyboard (Fig 4) is used to issue a limited set of commands, to access functions that are hidden during routine operation. A description of the functionality and usage of the BIT is given in the Appendix.

Software provided with the CR plate reader allows the user to custiomize its operation. The configuration software consists of two programs, the Configuration Editor (CE) and the Menu Editor (ME). The CE controls the overall operation of the system, including how images are formatted when printed to film. The ME allows the customization of choices that, during routine operation of the CR unit, are presented to the user (typically a radiologic technologist) as a set of hierarchical menus. In addition, the
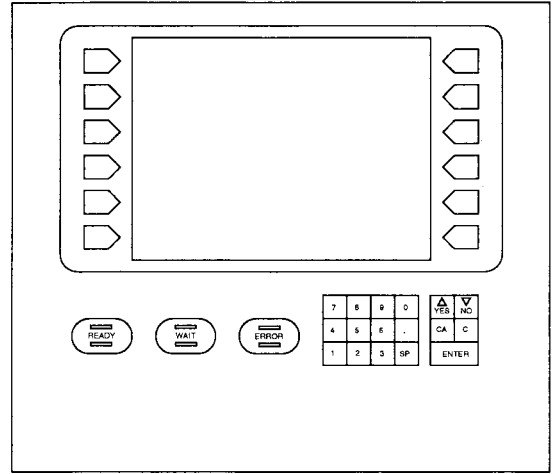

Fig 4. Fuji AC family operator's console, featuring a modified alphanumeric keyboard.

ME is the tool with which one modifies the image-processing parameters. A detailed description of the CE and ME is in the Appendix.

CASE EXAMPLES

Below are four practical examples of using the built-in software to customize the operation of the CR plate reader. These examples are meant to show how these software tools can be used to meet the particular needs or preferences of a site.

Case 1: Changing the Format of the Printed Film

Fuji CR software calculates a number referred to as the "S-value," which is related to the energy deposited in the phosphor plate. Because most CR imaging is performed without the benefit of phototiming, the exposure incident on the plate can vary quite widely. In fact, one of the chief benefits of storage phosphor technology is its wide exposure latitude. The S-value is inversely proportional to the energy absorbed in the plate, and represents the sensitivity (or "gain") of the amplifiers that boost the stimulated luminescence signal to a nominal level appropriate for digitization. On Fuji CR units that are docked to a Fuji film processor, software can be configured so that the S-number is printed on each film. This is accomplished by starting the CE program described in the Appendix, choosing item 04 (code name "SVL"), and then setting its value to 1. To disable S-value printing, set SVL to 0.

Films printed by Fuji CR systems contain a border on the edge of the film. CE item 09 (code name FED) controls the appearance of the border. FED is set to B for a black border, and W for a white border.

Fuji CR systems can be programmed to have the hospital or institution name appear in the upper left corner (in the border area) of all films. The text (20 ASCII characters maximum) is entered into the HNM field (item 31) of the CE.
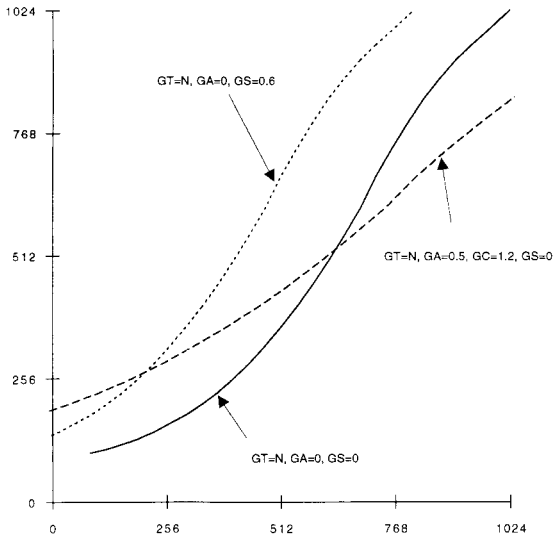

Fig 3. A representative contrast curve (GT), and the three parameters that modify the shape of the GT curve: shift amount (GS), stretch amount (GA), and film density of point held fixed during the stretch (GC).

Case 2: Modifying the Contrast Processing Parameters

Fuji CR systems are shipped with default image-processing parameter sets corresponding to various types of radiographic examinations. Users may wish to add new classes of examinations to the menu list, or modify the default image-processing parameters to achieve a different contrast or degree of frequency enhancement. This is accomplished using the ME, described in the Appendix. From the top level of the ME, the user selects choice 3 (EDIT). A list of anatomical regions is presented (eg, 0: HEAD; 1: NECK; 2: CHEST; etc), followed by the prompt, "TYPE POSITION NUMBER." The user then chooses a number from the list, and the system responds with a list of types of exams that fall into the selected class (eg, for the class "CHEST," the exams might include "00: CHEST, GENERAL" and "01: CHEST, PORTABLE"). The user selects the desired exam by using its two-digit code. The response is a listing of 34 setup parameters that determine the image processing and (default) film formatting for that exam. To increase the amount of contrast in the image, for example, one might increase the value of GA, the characteristic curve-rotation parameter. Alternatively, the overall density of the image can be increased (without changing the inherent contrast in the digital image data) by increasing the value of the GS parameter.

Case 3: Modifying the Spatial Frequency Processing Parameters

As discussed above, spatial frequency processing is under the control of three parameters. At our institution, we have changed the frequency parameters RN, RT, and RE) for the "CHEST, PORTABLE" examination from 4, R, and 0.6 to 5, F, and 0.6. Changing RN from 4 to 5 shifted the central enhancement frequency up from 0.35 to 0.5 line pairs/mm. Computationally, the effect of increasing RN is to decrease the size of the blurring kernel used in the blurred-mask subtraction algorithm [see discussion after equation (1)]. The motivation for changing RN was to reduce the amount of enhancement applied to mid-frequency structures in the lung. It was found that overemphasis of these structures could add difficulty to the problem of the diagnosis of interstitial disease. In addition, nonuniform application of frequency enhancement across the image was found to be objectionable by our radiologists. The RT functions designated by the letters P to V (see Fig 1) produce more enhancement at higher optical densities (eg, in the lung field), and less enhancement in the less-dense regions. The F function applies uniform frequency enhancement to all densities in the image. With the current set of frequency-processing parameters, underpenetrated regions such as the mediastinum receive some spatial frequency enhancement, resulting in improved visualization of fine structure in those areas.

Case 4: Changing the Appearance of the Operator Interface Menus

The ME can be used to alter the order in which the examination menus are presented to the operator. For ease of use, exam types can be arranged so that frequently performed examinations appear first in the list. When exam types are moved, the parameters that are associated with that examination are retained, and need not be reentered. Menu organization is controlled using the (MOVE) function, which is item 1 on the first screen of the ME. The software prompts the operator to identify the source and destination locations of the examination being moved.

DISCUSSION

Effective use of storage phosphor plate imaging requires training of technologists, radiologists, and other clinicians who will be reading CR images, and a familiarity of the formatting and image-processing features of the system on the part of the radiologic physicist. For radiologists and clinicians trained on screen-film radiography, the transition to reduced-size frequency-enhanced CR images may be difficult. The enhancement algorithms can exaggerate areas of high-frequency texture such as in interstitial lung disease. Customizing the degree and nature of the enhancement to the particular tastes of the department staff can make the transition to CR go more smoothly.

The manufacturers of CR equipment have anticipated the need for customization, and have provided the software tools necessary to edit the system configuration on-site. In our experience, these tools were delivered with inadequate documentation, and although they may not be optimal, many users continue to use the factory-set parameters. We have provided an overview and explanation of the software tools included in the Fuji CR reader-printer systems that are used in almost all commercial CR products. This description and the examples provided should enable users to modify the image-processing parameters for different exams, as well as the overall configuration of the system and the formatting of laser-printed films.

APPENDIX: BUILT-IN TERMINAL USAGE

I. Entering Built-In Terminal Mode

The Built-In Terminal (BIT) can be activated in one of two ways: either during the system start-up, or from the UTILITY menu during routine operation of the CR system. To enter BIT mode during system start-up, the user

presses the ⟨NO⟩ button* (on CR system keypad) after the "SOFTWARE ID#" appears on the screen, but before the "Subsystem MAIN ready to start initial sequence" message appears. If successful, the following message will appear on the screen: "Hit YES-key to continue, or ENTER-key to get service utility." A ⟨YES⟩ response will resume normal system initialization. Pressing ⟨ENTER⟩ results in a password prompt, "passwd = ." All Fuji CR units are shipped with a factory-set password of "0987." This may be changed at any time using the CE, described below. (The current password appears on the console display during the normal boot procedure, as "KEY: XXXX," where *XXXX* is the password code.) Keying in the correct password followed by ⟨ENTER⟩ activates the BIT, identified by the "%" prompt.

Alternatively, the BIT can be started after a normal boot of the CR system. To start BIT, the user first enters the Utility mode by selecting the button labeled ⟨UTILITY⟩ from the main menu. From the Utility menu, the user presses the ⟨MENU EDIT⟩ button, then presses the ⟨ENTER⟩ button within 2 seconds. The user then receives a password prompt, and continues as described above. If the user fails to hit ⟨ENTER⟩ within the prescribed 2 seconds, a restricted version of the ME ("ME user mode") is loaded. The ME program is discussed below.

II. The BIT User Interface

The BIT software uses the display screen and the 12 adjacent buttons (6 each on the left and right sides of the display) to allow alphabetic and special character input (see Fig 4). The buttons on the left-hand side select a range of characters in the alphabet, and 6 characters within the selected range are displayed next to the corresponding buttons on the right-hand side. For example, if the topmost button on the left-hand side is selected, the characters a through f will be mapped to the buttons on the right-hand side of the display. Special characters, such as ', *, and # follow a through z.

---

*The notation "⟨⟩" is used to identify actions performed by either pressing buttons on the control panel, or via alphanumeric keystroke entry using the BIT pseudokeyboard.

Upper-case characters are available by pressing the ⟨YES⟩ button, which functions like Caps Lock on a standard keyboard. ⟨NO⟩ resets the Caps Lock mode. The characters 0 through 9, space (⟨SP⟩), control-C (⟨CA⟩), backspace (⟨C⟩), and ⟨ENTER⟩ are located on a separate keypad.

III. The BIT Instruction Set

Table 1 is a listing of the commands that are available from the BIT. To terminate a BIT session, the user enters the character ⟨q⟩ followed by pressing the ⟨ENTER⟩ key. If BIT was activated during start-up or if the user mode of the ME was active, then the system must be terminated (powered down) and restarted. If BIT was activated by choosing ⟨MENU EDIT⟩ from the Utility menu, and any of the extended (ie, service mode) ME functions were used, then the program returns to the Utility menu. However, it has been our experience that the CR system should be rebooted and restarted after any BIT session.

The following sections describe two of the programs available via the BIT. The Board Test (BT) and Error Log Program (ELGP) are not described, and the reader is referred to the manufacturer's service manual for more information about these programs.

A. Configuration Editor

The CE allows the user to review and change system parameters controlling general functions of the CR system. Included in this category are parameters that control the user's interaction with the CR system and the layout and appearance of films. There are 46 different parameters that can be changed by the user during a CE session. Each parameter controls a certain aspect of the CR system's operation, such as the printing of clear or black film border, or the formatting of dates and patient ages. Each

---

Table 1. BIT Instruction Set

BIT Command	Program
ce	Configuration editor
bt	Board test (circuit board functional test)
elgp	Error log program
me	Menu editor, user mode
me s	Menu editor, service mode

parameter is identified to the system as a unique number in the range 0 to 45, and a three-character code name. Table 2 is a listing of the CE parameter names, reference numbers, types, and default values.

To load the CE software, the user enters the command ⟨ce⟩ ⟨ENTER⟩ from the BIT prompt ("%"). The user is presented with a screen that displays parameters 0 through 16 along with their current values, and instructions for displaying the next (or previous) page of parameters, reprinting the current page of parameters, or exiting the CE. Scrolling to the next page will display parameters 17 through 32. When quitting, CE will ask the user to save any changes to parameter values made during the CE session. The user responds by entering either the character ⟨y⟩ or ⟨Y⟩ to save any changes, or ⟨n⟩ or ⟨N⟩ to discard any changes. Upon exiting of the CE session, the user will return to a BIT prompt.

To change the current value of any parameter, the user enters the number identifying that parameter, followed by ⟨ENTER⟩. The CE will respond by displaying the parameter's three-character code, a list or range of possible values (in parentheses) and the current value of the variable. The user inputs a value and presses ⟨ENTER⟩. If no value is entered and the user presses ⟨ENTER⟩, the parameter's current value will be retained. If the entered value is invalid, the CE will reject it and prompt the user for a valid value.

B. Menu Editor

When a technologist loads a storage phosphor image plate into the CR system, he or she must select an exam type that determines how the image will be processed. This is accomplished by navigating through a series of menu selections to arrive at the desired exam type. The top-level menu lists several anatomic regions (eg, HEAD, CHEST, ABDOMEN, etc.). Selecting an anatomic region causes the computer to display a screen with a list of examination types; eg, under the menu for "CHEST" one would find "CHEST, GENERAL," "THORACIC SPINE," "CHEST, PORTABLE," "CHEST, PEDIATRIC," etc. The list of examination types can extend to several screens, and the user can scroll to the next set of choices by pressing the ⟨PAGE⟩ button. Each exam type consists of 34 individual parameters, identified by a unique number ranging from 0 through 33, which control the details of the image reading, processing, and formatting performed by the CR system. Table 3 is a listing of the parameters, along with a brief description. When the CR system is installed, preset parameter files are loaded that set up initial values for the parameters for all of the exam types. The ME allows the users to review and change parameters associated with each type of examination.

The ME has two modes: service and user. The user mode is identical to the service mode except that two features (⟨COPY⟩ and ⟨DELETE⟩) are disabled. The user mode of ME can be started in one of two ways, either by pressing the ⟨MENU EDIT⟩ button of the Utility menu or by entering ⟨me⟩ from the BIT. To load ME in user mode, the user must not press ⟨ENTER⟩ after pressing the ⟨MENU EDIT⟩ button. Doing so will initiate the BIT, as described above. To enter the service mode of ME, the user enters the command ⟨me s⟩ from the BIT.

There are seven different functions that the user can perform with the ME software. These are listed in Table 4, along with a brief description of the functionality provided. Most of the ME functions are concerned with the screen presentation of the exam types to the operator. The ⟨LIST⟩ command will show the available exam types for the selected anatomic region menu. The ⟨MOVE⟩ command allows the user to control the position of an exam type in its menu. Likewise, the ⟨SELECT⟩ command allows the user to move exams from one menu (ie, anatomic region) to another. The ⟨DELETE⟩ command will remove an exam from a menu; ⟨COPY⟩ will duplicate an exam type, and the user may assign a new exam name to the copy. ⟨FILE⟩ allows the user to perform backups of the edited exam types.

To terminate the ME, the user selects the ⟨QUIT⟩ option from the available options in ME. Like the CE program, ME will prompt the user to save or to discard the changes made to the exam types. Once the ME has been terminated, the user will either be at the BIT prompt (if ME was loaded from the BIT) or in the UTILITY menu. As discussed above, after a

Table 2. Configuration Editor Parameter Names, Types, and Default Values. (software version A02)

Item	Key Word	Meaning	Contents	Default
1	STC	Stacker (STC) configuration	Decimal: 10 digits, values 1-4	4444444222
2	MAG	Magazine present	Binary: 0 = absent/1 = present	0
3	DEV	Automatic developer information	Hexadecimal: 12-digit	20000036017C
4	SVL	S-value display	Binary: 0 = do not display/1 = display	0
5	CDF	Flag before/after CD	Binary: 0 = before CD/1 = after CD	1
6	DMC	DMC board present	Binary: 0 = absent/1 = present	0
7	DMN	Default menu for power recovery	Text: 4 characters (MPM code)	0200
8	LNG	Display language	Text: J = Japanese/E = English	J
9	FED	Film edge (border) type	Text: B = Black/W = White	W
10	DTP	Data type	Text: A = American/E = European/S = ANSI	A
11	DLG	Date length	Text: S = short/L = long	S
12	BDY	Age in years/Year of birth	Text: A = age/Y = year of birth	Y
13	CCD	CCD control parameter	Hex: 6 digits (01-FF, 3 groups)	505E50
14	DUP	Time during which ID duplication is possible	Hex: 2 digits	40
15	TRY	IP tray control parameter	Hex: 4 digit (01-FF, 2 groups)	8080
16	FLM	No. sheets of film remaining when warning is to be issued	Hex: 2 digit (01-95)	14
17	KEY	Password	Decimal: 4 digit	0987
18	I/M	Inches/metric	Text: I = inches/M = metric	I
19	ODF	ODF present	Binary: 0 = absent/1 = present	0
20	HIC	HIC directly connected	Binary: 0 = not directly connected/1 = directly connected	0
21	IDD	ID input device	Decimal: 0 = without/1 = CCD/2 = card reader/3 = IDT/4 = PC	3
22	MCT	Magnetic card type	Binary: 0 = domestic (JIS-II)/1 = overseas (ISO-7011)	0
23	SC0	CH#0/CPU setting	Hex: 2 digits	12
24	SC1	CH#1/CPU setting	Hex: 2 digits	96
25	SC4	CH#4/CPU setting	Hex: 12 digits	211212225511
26	SC5	CH#5/CPU setting	Hex: 12 digits	211212225511
27	WMG	Image storage warning message	Binary: 0 = first time/1 = every time	1
28	MTP	Menu ID display	Binary: 0 = standard menu/1 = menu with ID No.	0
29	LDV	Logical reading margin data	Binary: 0 = transparent image(0)/1 = black (1023)	0
30	FRD	Film recording system	Decimal: 0 = no record/1 = internal record/2 = LP I/F record	1
31	HNM	Hospital name in ASCII	Text: 20 characters	STANDARD
32	KHN	Hospital name in Kanji	S-JIS 10 characters hexadecimally shown in ASCII 40 characters	AC-1
33	MID	Device type code	Text: 2 characters	AC
34	MNM	FCR recognition code	Text: 1 character	A
35	MST	Device type character row	Text: 10 characters	AC-1
36	EDR	EDR backup	Decimal: 0 = without backup/1 = FD/2 = GPIB	0
37	SAN	Available (or not) for industrial use	Binary: 0 = standard/1 = available for industrial use	0
38	AX0	Reserved	Text: 1 character	0
39	AX1	Reserved	Text: 1 character	0
40	AX2	Reserved	Text: 1 character	0
41	AX3	Reserved	Text: 1 character	0
42	AX4	Reserved	Text: 1 character	0
43	AX5	Reserved	Text: 1 character	0
44	AX6	Reserved	Text: 1 character	0
45	AX7	Reserved	Text: 1 character	0

Table 3. Menu Editor Parameters

Item No.	Key Word	Meaning	Contents
0	MENU	Name of exam	Text: 20 characters maximum
1	EDR	Exposure data recognizer mode	Decimal: 0 = auto/1 = semi/2 = fix
2	S	System speed	Decimal (0-20000)
3	HI-SP	Hi-speed (ie, sensitivity)	Binary: 0 = no/1 = yes
4	EXP	Express (high-speed reading of IP)	Binary: 0 = no/1 = yes
5	PRTIAL	Logical reading flag	Decimal: 0 = none/1 = center reference/2 = edge reference
6	T/S	Twin/single film format	Binary: 0 = twin/1 = single
7	L/R	Left/right reversal	Binary: 0 = no/1 = yes
8	U/D	Up/down reversal	Binary: 0 = no/1 = yes
9	D-Shift	Image density shift	Scaling operation: /2.0-/1.0, *1.0-*2.0
10	G-Shift	Image gradation shift	Scaling operation: *0.5-*2.0
11	COPY	Number of film copies	Decimal: (01-09)
12	FILE	· Image file flag (for left image)	Binary: 0 = no/1 = yes
13, 20, 27	GA	Contrast rotation amount	Decimal: −4.0-−0.1, 0.1-4.0
14, 21, 28	GT	Contrast type (curve)	Text, 1 character: A-O
15, 22, 29	GC	Contrast rotation center	Decimal: 0.3-2.6
16, 23, 30	GS	Density shift	Decimal: −1.44-1.44
17, 24, 31	RN	Frequency rank (enhancement frequency)	Decimal: 0-9
18, 25, 32	RT	Frequency type (curve for nonlinear unsharp mask)	Text, 1 character: F, P-V
19, 26, 33	RE	Frequency enhancement amount	Decimal: 0.0-9.9, 10-16

BIT session, it is recommended that a complete system reboot be performed.

By far the most important use of the ME is to review and modify parameters for examination types. To do this, the user selects the ⟨EDIT⟩ option from ME's list of functions. The user will be prompted to select the menu where the desired exam type is located. The system will then display on the screen all of the types of exams for the selected menu. For menus with more than one page of exams, the ⟨ENTER⟩ button will scroll subsequent pages to the display. Associated with each exam type is a number that uniquely identifies the exam to the

Table 4. Menu Editor Top Menu

Item No.	Name	Function
0	LIST	List the exam headings (eg, HEAD, NECK, CHEST, etc)
1	MOVE	Move a parameter set to a different menu location within the same general heading
2	SELECT	Move a parameter set to another general heading
3	EDIT	Change individual parameters for a specific exam
4	COPY	Create a duplicate copy of an existing parameter set
5	DELETE	Remove a parameter set from the menu
6	FILE	Save or restore a backup of the parameter sets
7	QUIT	Exit Menu Editor

system. Once all of the exam types have been displayed, the user is prompted to identify the exam type that they wish to edit, which they do by entering the corresponding exam number.

Once an exam type has been selected for editing, the session is structured very similar to a CE session. To select a parameter for editing, the user enters the number identifying that parameter. The ME will then display the parameter, a list or range of possible values, and the current value. The user enters a new value, followed by ⟨ENTER⟩ to change the current value, or presses ⟨ENTER⟩ alone to retain the current value. If the user enters a value that is out of range, the system will disregard the user entry and redisplay the prompt line. The user can redisplay all current values by entering ⟨*⟩ followed by ⟨ENTER⟩. To terminate the editing function the user enters either ⟨q⟩ or ⟨e⟩ followed by ⟨ENTER⟩.

As mentioned above, there are 34 parameters in each exam type. Each parameter is identified to the system by a number ranging from 0 to 33. The parameters can broadly be categorized into 4 groups: the parameters identifying the type of exam to the system (#00), parameters controlling the image plate reading characteristics (#01 through 05), parameters controlling film format (#06 through 11), and parameters con-

trolling image processing (#13 through 33). The functions of the parameters controlling image processing were discussed in the text. However, it should be noted that separate image processing parameters are specified for each image of the two-on-one format, and for the single image of a one-on-one format. The default processing, whether one-on-one or two-on-one, is controlled by parameter #06.

REFERENCES

1. Ishida M: Image processing, in Tateno Y, Iinuma T, Takano M (eds): Computed Radiography. Tokyo, Japan, Springer-Verlag, 1987, pp 24-30

2. Templeton AW, Wetzel LH, Cook LT, et al: Enhancement of storage phosphor plate images: A C-language program. J Digit Imaging 5:59-63, 1992

3. Fuji Photo Film Co Ltd: Fuji Computed Radiography System FCR AC-1 Operation Manual, 1990