Fuji Image processing

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Outline

- Fuji CR
- Fuji CR image formation
- Fuji General description of image processing
  - Automatic sensitivity correction (EDR)
  - Image Processing
    - Gradation
    - Spatial Filtering
    - Multi-objective frequency filtering (MFP)

CR Basics

Computed Radiography refers to the use of Photostimulable Storage Phosphors (PSPs) in image capture and subsequent image digitization for Projection Radiography applications.

PSP – The Imaging Plate

- Imaging Plate Cross Section
  - Fuji ST-VN
  - Protective Laminate
  - Phosphor Layer
  - BaF(BrI):Eu²⁺
  - Conductive Layer
  - Flexible support
  - Light Shielding Layer
  - Backing Layer
  - ID Barcode Label

- Linear response to Radiation
- Wide exposure latitude
- 4 decades of exposure recording

PSP – The Imaging Plate
**PSP – The Imaging Plate**

*Sizes:* (FCR)
- 17 x 17 (5501/5502)
- 14 x 17
- 14 x 14
- 10 x 12 (24 x 30)
- 8 x 10 (18 x 24)

*Types Available:*
- ST – Standard
- HR – High Resolution

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**CR Basics**

- **STORAGE PHOSPHOR**
  - Photostimulable phosphor plates emit retained X-Ray energy when stimulated by laser beam

**CR Reading Unit**

- As the laser scans the Moving IP, light is emitted and collected up the Light Guide to a PMT. It is amplified and then goes to the A/D converter for Signal output to EDR software.

**Automatic Sensitivity Control Function**

- Images need suitable density and contrast
- Exposure Data Recognizer (EDR) is used by Fuji for adjusting images automatically
- Refer to “Auto” Mode

**Image Formation: Three Steps Process**

- **EDR-** Exposure Data Recognizer
- **PRIEF** (Pattern Recognizer for Irradiated Exposure Fields)
  - Recognition of divided exposure patterns
  - Histogram Analysis

**EDR - PRIEF (FCR)**

- Pattern Recognition:
  - Various shapes and patterns are recognized.

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Irradiated Field Recognition Process (PRIEF)

Figure 3.5 Difference in histograms derived from the entire IP surface and irradiation field internal area

PRIEF

Figure 3.6 Central point determination

“Exposure Data Recognition (EDR)”

Histogram Analysis (FCR)

What is EDR?

- Digital imaging is contrast limited = wide dynamic range
- FCR digitizes ONLY the necessary range of “Exposure” and convert to 10 bits digital numbers
- The process is based on the acquired “histogram”
(S1 and S2) are established to define the Lowest and Highest areas of useful exposure as determined by the menu selection.

Histogram Analysis (FCR)

Histogram analysis

Density will be adjusted to be close to film OD

L value = width of the range

S value = 4 x 10^4 (4-SK)

Smax-Smin = max and min S (Plate exposure values)

Qmax-Qmin = max and min quantized digital values

“L” Value - Latitude

“L” represents the number of decades covered by exposure

Each exposure menu has a range that sets the minimum and maximum “L” value

Typical L values range from 1.6 to 2.3

“S” Number - Sensitivity

It reflects the center of the usable portion of the histogram

Calibration is based on a 1 mR exposure at 80 kVp to the IP. Using a 72” distance through air to achieve an “S” number of 200 with a fixed latitude of 1.

“S” Numbers

3 different mAs exposures (80kV)

The histogram shape is the same

The position on the exposure axis changes.
Histogram Analysis

- Low energy (kVp) gives a wider histogram
- High energy (kVp) gives a narrow histogram

Histogram Analysis

- Histogram width is controlled by the kVp and subject contrast
- The lowest amount of exposure (Smin/S1) and highest (Smax/S2) are recorded

EDR- Exposure Data Recognizer

- Four Reading Modes
  - AUTO
  - SEMI
  - SEMI-X
  - FIXED
  - Selected on the options page of specific menu.

EDR- Auto

- AUTO
  - Collimation recognition
  - Complete Histogram analysis

EDR- Auto

Good collimation practices should be used
Your lead marker Must be in the exposure area
Avoid Overlapping Exposures

Auto Mode in Practical Use
Auto Mode in Practical Use

EDR- Semi

- Fixed "L" value
- Small reading area
- No collimation.
- Detection done.
- Proper kVp must be used to maintain subject contrast.

Exams:
- Odontoid
- L5/ S1 spot
- Sinuses
- Other tightly collimated exams

Precautions:
- Exam must be properly centered
- Not Recommended for high absorption objects (prosthesis)

EDR- Semi-X

- Area of interest is Selected by tech
- Same precautions as Semi-Mode
- Must know where the Green stripe is in relation to AOI.
- Helpful in cross-table exams

EDR- Fixed

- No Histogram analysis
- No PRIEF
- "S" number and "L" values are fixed
  - "S" number set by the user
  - "L" value set by the menu selected

Semi Mode in Practical Use

L-Value fixed at 2.2
7cm x 7cm center Reading area.
Contrast is affected by kVp.
When to Use
- X-Table Hips
- C7-T1 Laterals
- Any body part with a lot of metal
- Images that cannot be centered

Fixed Mode in Practical Use

Factors that affect \( S \) number
- Scatter – Use of Grids
- Distance- SID and OFD
- Collimation
- Menu selection
- Delay in processing from time of exposure

“S” Number
An “S” number under 75 is typically considered overexposure
Under exposure is generally represented by an “S” number greater than 500

Typical \( S \) # Range

<table>
<thead>
<tr>
<th>Body Part</th>
<th>( S ) # Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest, General</td>
<td>200-600</td>
</tr>
<tr>
<td>Skull</td>
<td>100-400</td>
</tr>
<tr>
<td>Spine</td>
<td>100-400</td>
</tr>
<tr>
<td>Extremities</td>
<td>75-200</td>
</tr>
<tr>
<td>Chest, Pedi.</td>
<td>200-700</td>
</tr>
<tr>
<td>Abdomen</td>
<td>100-400</td>
</tr>
<tr>
<td>GI</td>
<td>100-300</td>
</tr>
<tr>
<td>Abdomen, Pedi.</td>
<td>200-700</td>
</tr>
</tbody>
</table>
“S” and “L” Range

- Exposures falling outside recommended range can compromise image quality
- “S” number below 25 or above 2000 with an “L” value greater than 2.0
- Grossly over exposed images could appear light due to EDR over correction of saturated IP

Fuji Computed Radiography Image Processing Parameters

Standard Image Processing for FCR Images

- The seven standard processing parameters can be divided into two groups.
  - Gradation Processing: dealing with image contrast and density.
  - Spatial Frequency Processing: dealing with image enhancement and blurring.
- These parameters can be adjusted to optimize diagnostic accuracy, expanding the diagnostic scope of the image.

Fuji Image Processing

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>GA</td>
<td>Controls the global contrast of the image.</td>
</tr>
<tr>
<td>GT</td>
<td>Determines the shape of the Look Up Table to be used.</td>
</tr>
<tr>
<td>GC</td>
<td>Sets a fixed point of optical density around which GA is rotated to change contrast.</td>
</tr>
<tr>
<td>GS</td>
<td>Adjusts the global optical density of the image.</td>
</tr>
<tr>
<td>RN</td>
<td>Determines the size of the structures to be enhanced.</td>
</tr>
<tr>
<td>RT</td>
<td>Controls the degree of enhancement for each density using a Look Up Table.</td>
</tr>
<tr>
<td>RE</td>
<td>Determines the degree of image enhancement.</td>
</tr>
<tr>
<td>DRN</td>
<td>Defines the unsharp mask.</td>
</tr>
<tr>
<td>DRT</td>
<td>Determines the type of unsharp mask.</td>
</tr>
<tr>
<td>DRE</td>
<td>Defines the weight (affect) with which the unsharp mask is applied.</td>
</tr>
</tbody>
</table>
A good image means the region which is important to the diagnosis of the diseases should be in the range of OK exposure for the film.

**Film Speed**

- Speed is the inverse of the exposure (E) needed to produce 1 OD above base plus fog.
- If 10 mR (0.34) is needed, then the speed of the screen/film is 100.

Unfortunately, manufacturers do not use this system. Kodak 400 speed requires about 0.3 mR to make B+F+1 OD.

**Gradation Processing**

- Gradation Processing is done by selecting the basic contrast curve and then adjusting the contrast and density to meet clinical purposes.
Digital: Gradation Processing

Contrast vs Density

Gradation Adjustment
- First, adjust GS to obtain proper density
- Next, vary GA parameter to obtain proper contrast

GT Varieties
- A – No conversion
- M – Reversed gradation
- B-J Non-linear gradation by systematically vary the shoulder and foot
- K and L Non-linear gradation with contrast raised for subtraction images
- GT – Frequently used
- E – Chest
- G – Latitude type
- O – Orthopedics
- P – General HR-S gradation
- R – Mammo (high contrast gradation)

Spatial Frequency Filtering
- Mainly for sharpness control
- Refer as spatial frequency filtering
- Start with “unsharp” masking images
- Process based on Fourier Transformation
**Spatial Frequency Filtering**

![Spatial Frequency Filtering Diagram]

**Meaning of frequency enhancement process parameters**

- **Frequency rank (RN)**
  - Low (0-3) = enhance large structure (soft tissue)
  - Intermediate (4 and 5) = general structure such as lung field blood vessels
  - High (6-9) = small structures

- **Degree of frequency enhancement (RE)**
- **Enhancement type (RT)**

**Dynamic Range Control (DRC)**

![Dynamic Range Control Diagram]
Multi-Objective Frequency Processing (MFP)

- Develop to improve image quality provided by image processing
- MFP enhances various structures at the same time
  - Grey-scale shadow and shape shadows can be enhanced in a well balance manner without sacrificing the graininess
  - Invisible areas can be depicted with an increase degree of naturalness (improve DR control process)
  - The degree of enhancement is suppressed for metals and other extraneous to the human body

MFP Process Overview

MFP consists frequency enhancement for dot and line shadows and DR control for the image dynamic range.

MFP - contrast-dependent-nonlinear function conversion

MFP enhancement characteristics