Optimizing CT Image Quality and Dose Management Using Collaborative Clinically Focused Physics Education

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www.sprawls.org/ipad
Effective and Safe Clinical Procedures

Imaging

Radiation Therapy

Require an extensive knowledge of Applied Physics and The Associated Technology
Who needs a knowledge of Physics applied to clinical imaging?

Radiologists, Residents and Fellows

Technologists

Medical Physicists

Each provides unique challenges and opportunities.
Computed Tomography

Image Characteristics and Quality

Radiation Dose

Imaging Protocols

Technology

Physics

Number of Pixels

CT Number Values
Clinically Focused Physics Education

Classroom | Clinical Conference | Small Group | “Flying Solo”

Learning Facilitator “Teacher” | Individual and Peer Interactive Learning

Each type of learning activity has a unique value.
Clinically Focused Physics Education

Classroom
Clinical Conference
Small Group
“Flying Solo”

Learning Facilitator “Teacher”

The Goal...

Increase the EFFECTIVENESS of each type of learning activity with the necessary resources and understanding of the process by the Learning Facilitators.

Sprauls
Five Dynamics

“It’s a new ball game!”

Capability & Complexity
Geographic Dispersion
Learning & Teaching Knowledge
Expanding Educational Resources
Increased Connectivity

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Capability & Complexity
(Computed Tomography)

The Three Phases of CT Image Formation

Major Protocol Factors

CT Dose Quantities

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Digital Resources to Enrich Learning Activities

The Web
Connecting and Sharing

Textbooks
Modules
Visuals
Clinical Images
Modules
References
Teaching Files

Classroom
Clinical Conference
Small Group
“Flying Solo”
Sprawls
Physics Education to Enhance CT Image Quality Optimization and Dose Management

Physicists With Experience in Clinical CT

Open Access Educational Resources
- Visuals
- Modules

Global Impact

Teach, Collaborate, Consult
Physicists in Local Institutions
(with Limited Clinical CT Experience)

A resource to enhance the performance of medical physicists in every country of the world.
Learning is a Natural Human Process

We Learn by Experience

Learner -> Observe -> Physical Universe

Interact

Our Early Physics Learning Activities
Teaching is helping someone
Building a Knowledge Structure in the Brain

Physical Universe

Learner

A mental representation of physical reality

Connect  Organize  Guide
The Role of Formal Education

Connect

Physical Universe

Learner

Observe

Interact

Organize and Guide
The Barrier

Physics Education

Clinical Imaging

Efficiency

Location, Resources, Human Effort, Cost

Limited Experience
Technology Enhanced Learning

Learning Guide

Learner

Visuals for Classroom

Online Resources

Notes and Text

Compton Scatter Interactions

X-Ray Photon

Energy

Weak

Nucleus
**Visuals**

to be used by

Physicists in Classroom and Conference Discussions

**Computed Tomography Image Quality Optimization**

and Dose Management

Companion Module


RIGHT CLICK on each visual to download and use in PowerPoint or other display programs.
Visuals for Learning and Teaching

The Imaging Process

The Three Phases of CT Image Formation

Scan and Data Acquisition
- KV
- MA
- Pitch
- Beam Width
- Time

Image Reconstruction
- Slice Thickness (Slice Th.)
- Field of View (FOV)
- Matrix
- Filter

Digital/Analog Conversion and Display Control
- Window Width
- Window Level
- Zoom

Clinical Images
The Three Phases of CT Image Formation

Scan and Data Acquisition

Image Reconstruction

Digital/Analog Conversion and Display Control

Major Protocol Factors

KV
Pitch
Slice Th.
FOV
Matrix
Filter

MA
Beam Wid.

Time
Window Width
Window Level
Zoom

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Spiral Scan

Continuous

Distance per Revolution

Pitch $= \frac{D}{W}$

Beam Width
CT Slice Divided into Matrix of Voxels

Field Of View (mm)

Matrix Size (voxels/pixels)

Slice Thickness (mm)

Voxel Size Controlled By

FOV ÷ Matrix = Slice Th.
Reconstruction Filter Kernels

Filtered Back Projection

Noise Reduction

Filter

Standard

Enhance Detail

Increased Blurring

Reference Image

Increased Noise

(Effects exaggerated for illustration here)
Factors That Determine Image Detail (Sources of Blurring)

Scan Data → Filtered Back Projection → Digital Image

Focal Spot

Pitch

Beam Wid.

Detector

Filter

Slice Th.

FOV

Matrix

Voxel Size

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Relationship of Radiation Dose to Image Detail

Lower Dose

When detail is increased by

- Decreasing Slice Th.
- Increasing Matrix
- Decreasing FOV

Noise Increases

Because of decreased voxel size

Higher Dose

Dose must be increased to reduce noise.

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Two Major Image Quality Goals

High Detail  
Low Noise

Voxel Size

Small  |  Large

Protocol Factors

FOV  |  Matrix  |  Slice Th.
Factors That Determine Image Noise

Scan Data → Filtered Back Projection → Digital Image

Concentration of Absorbed Photons and Energy at Each Location In the Body Tissue

KV
MA
Time
Pitch

Slice Th.
FOV
Matrix

Voxel Size Determines Number of Photons

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Effect of Matrix Size on Image Noise

Small Matrix

Large Voxels

Low Noise

Large

Small Voxels

High Noise

The same radiation dose for both images.
Decreasing Noise

Requires Increased Photons Absorbed Per Voxel

Produces Increasing Dose

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Computation Tomography Image Quality Optimization
and Dose Management
Perry Sprawls, Ph.D.

To step through module, CLICK HERE.
To go to a specific topic click on it below.

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During the reconstruction process, mathematical filters are used to change some of the image characteristics. These might be referred to by different names such as algorithms or kernels but their effects are the same.

Each CT system has many different filters that the operator can select from for a specific clinical procedure. The filters that are appropriate for the various clinical procedures have been determined from experience and are typically included in the established protocols for a facility.

We are not going into the characteristics of all of the filters here but focusing our attention on their effects of the two image characteristics, noise and detail as illustrated here.

Some filters can be selected to reduce noise in an image. However, the reduction of noise by digital image processing usually increases the blurring in the image and reduces the visibility of detail.

Filters that are selected to increase or enhance detail typically increase the visibility of image noise.

This is all part of the compromise between image detail and image noise.

In general, noise is reduced by increased blurring (voxel size, filter, etc.) but that reduces image detail.

That is all part of the process of developing an optimized imaging protocol.
Clinically Focused Physics Education

Classroom
Clinical Conference
Small Group
“Flying Solo”

Highly Efficient
For General Physics and Related Topics

Highly Effective
Clinically Rich Learning Activities

Visuals Images Online Modules Resources and References

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Effective Medical Imaging Physics Learning...In The Clinic

The Real World Motivating Interactive Collaborative

Radiologist

Resident

The Physicist Provides:
Learning Modules & Collaboration

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References and Resources

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EFFECTIVE PHYSICS EDUCATION FOR OPTIMIZING CT IMAGE QUALITY AND DOSE MANAGEMENT WITH OPEN ACCESS RESOURCES

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Visuals and Module

www.sprawls.org/resources

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