The Medicine Behind the Image

DICOM Display Update: Color Presentation States Hanging Protocols

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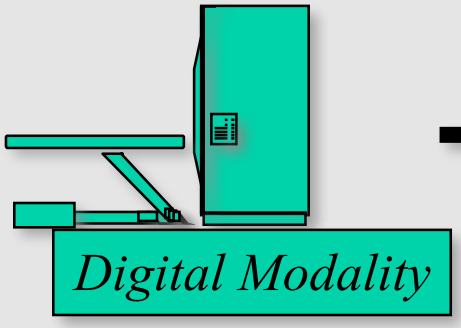
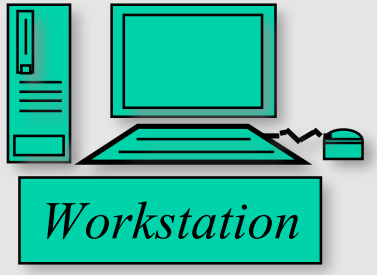
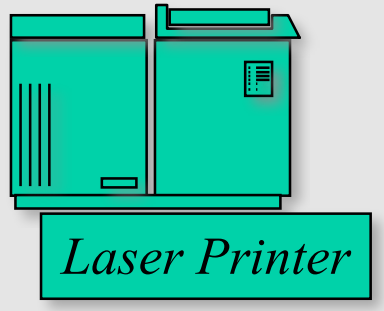
Overview

- Review of Grayscale Presentation State
- Color Presentation States
  - Color Consistency
  - Presentation States applied to Color Images
  - Color Blending - CT-PET fusion
- Hanging Protocols

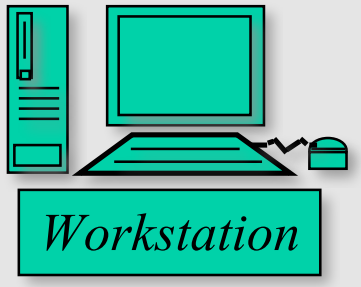
Distributed Image Consistency



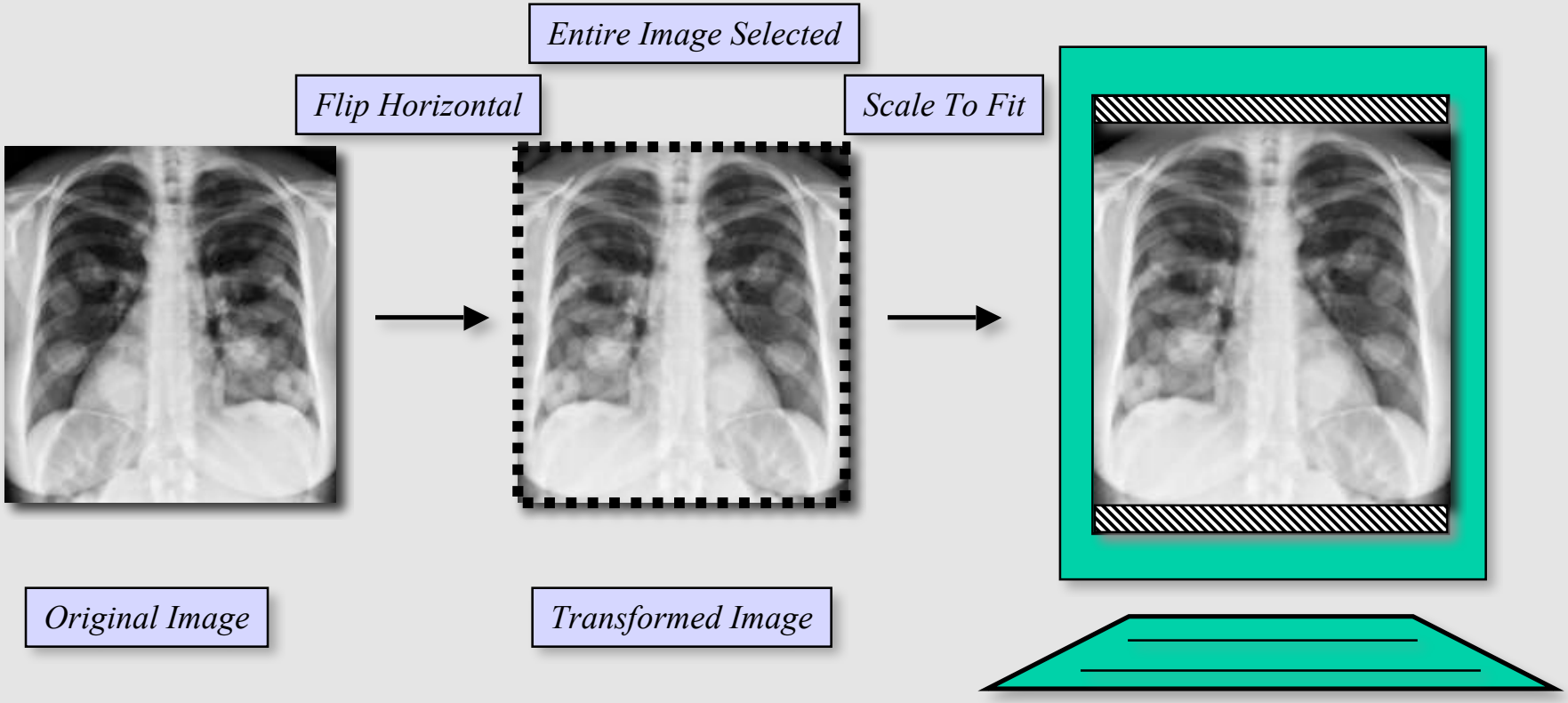




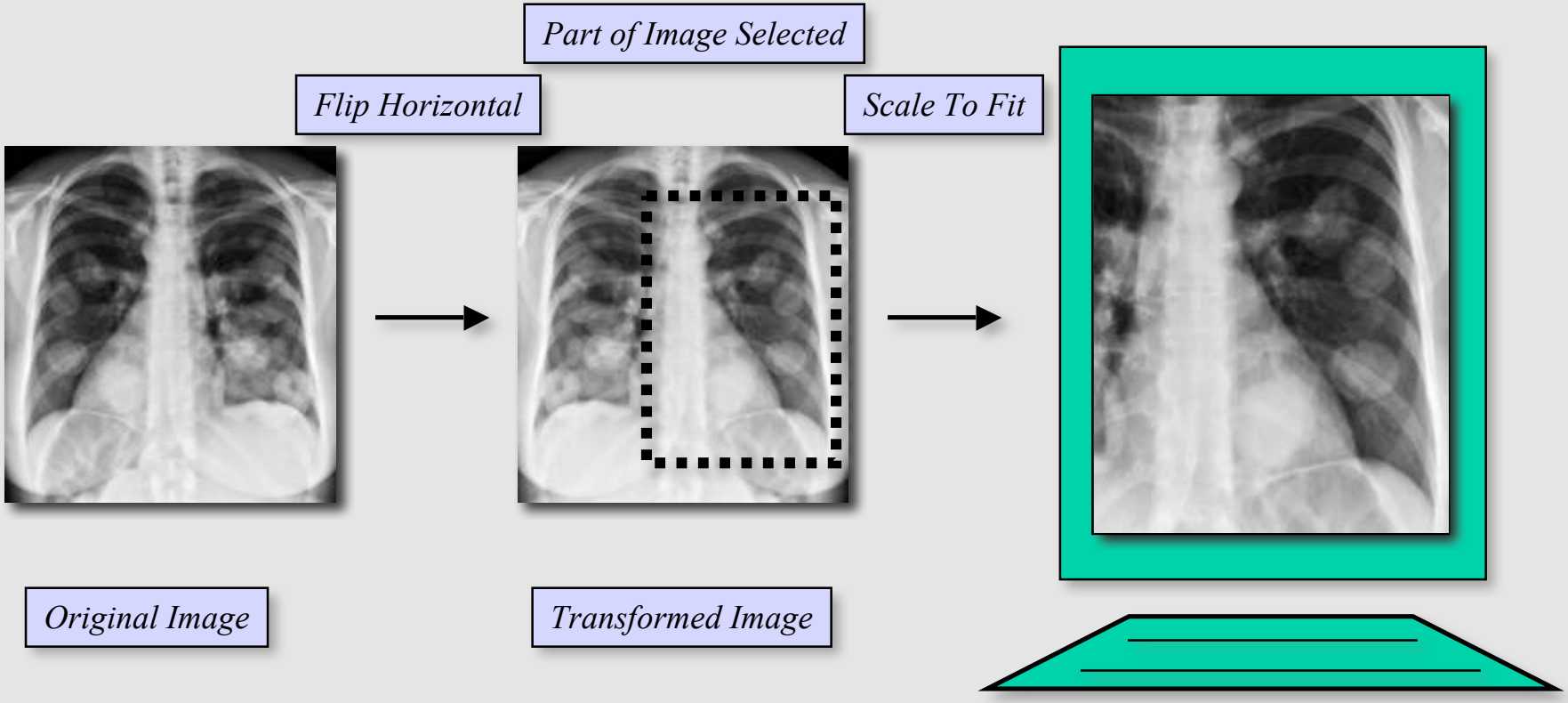
Identical perceived contrast



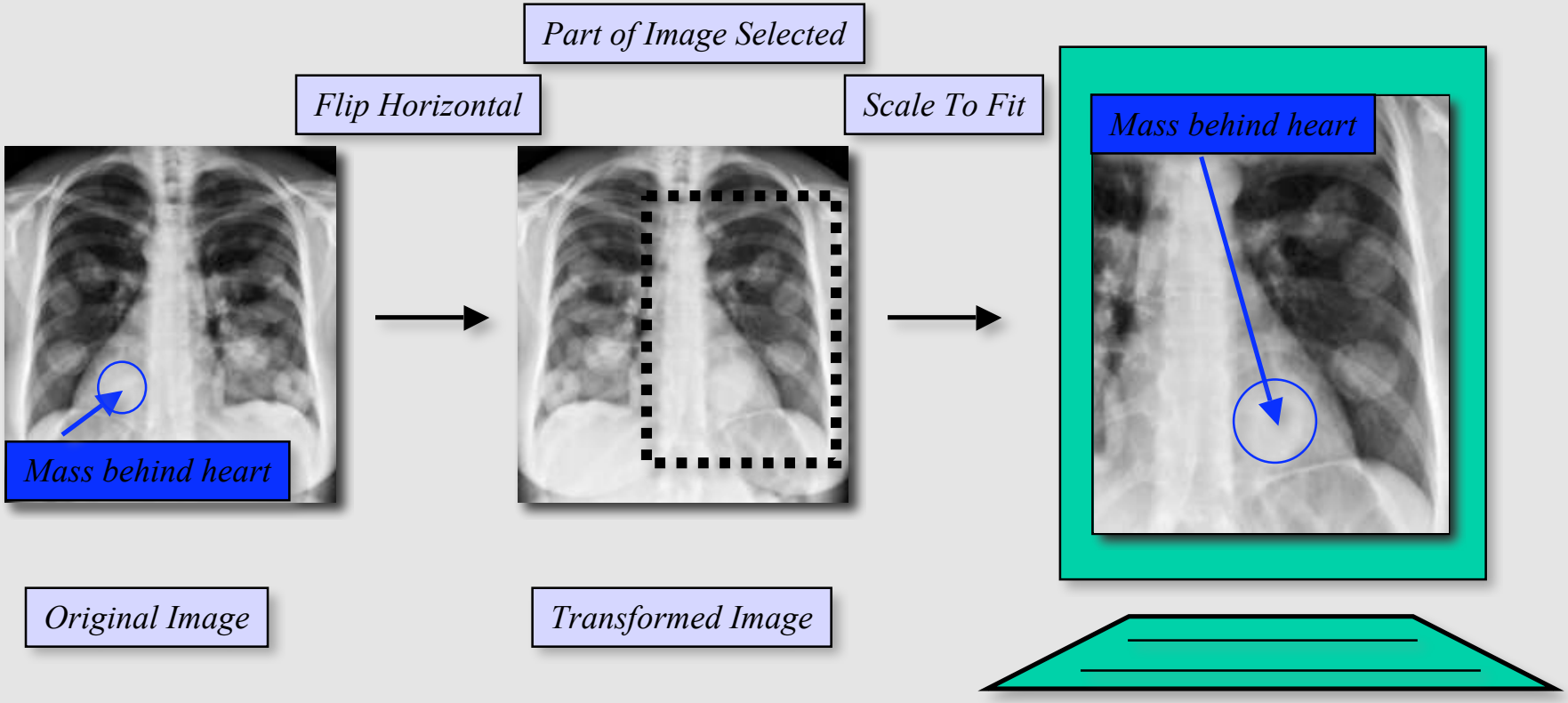
Spatial Transformations



Spatial Transformations



Transformation & Annotation

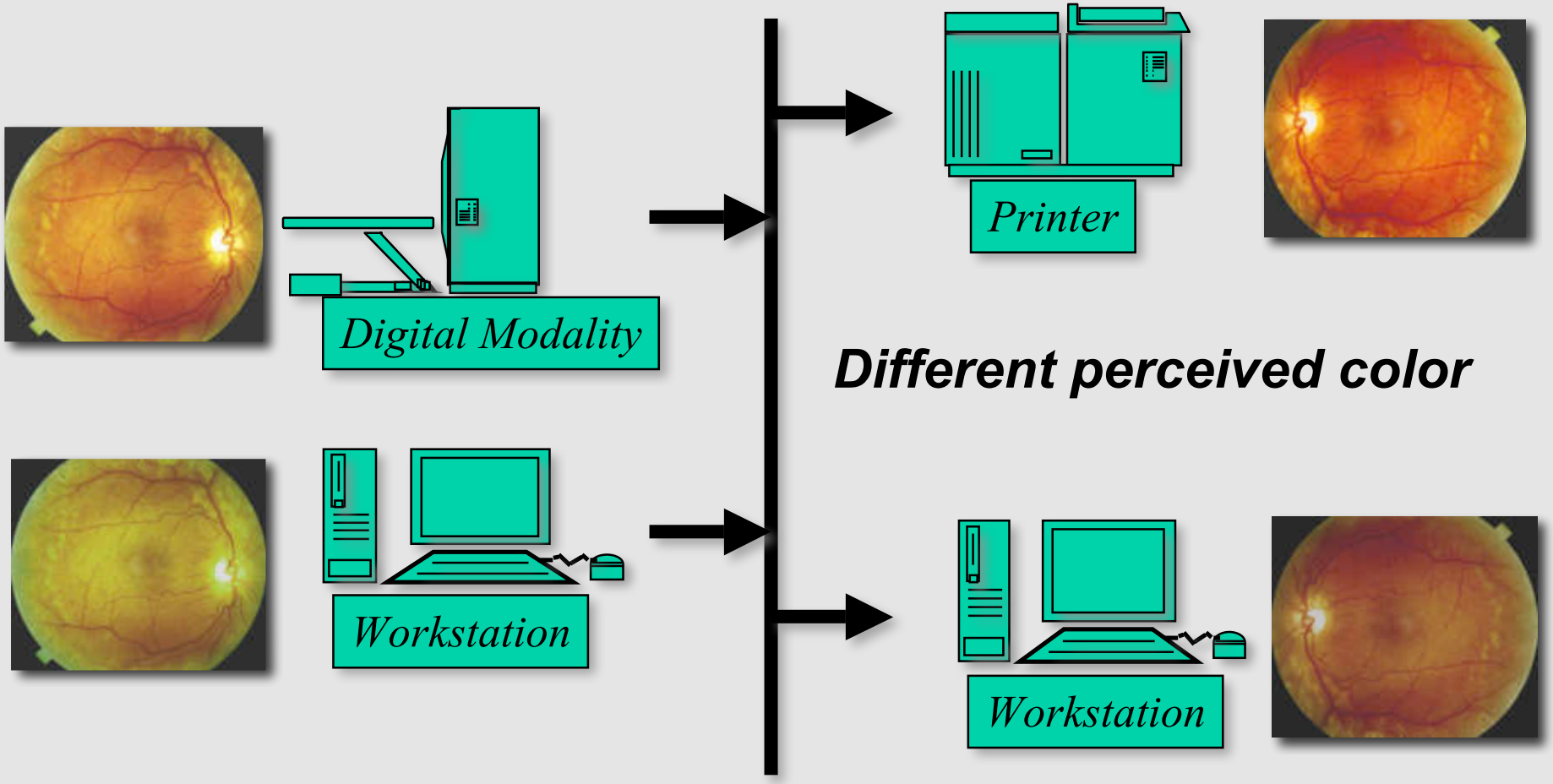


In this example,
- text annotation is specified by image relative visible anchor point
- the circle is a separate image relative graphic annotation

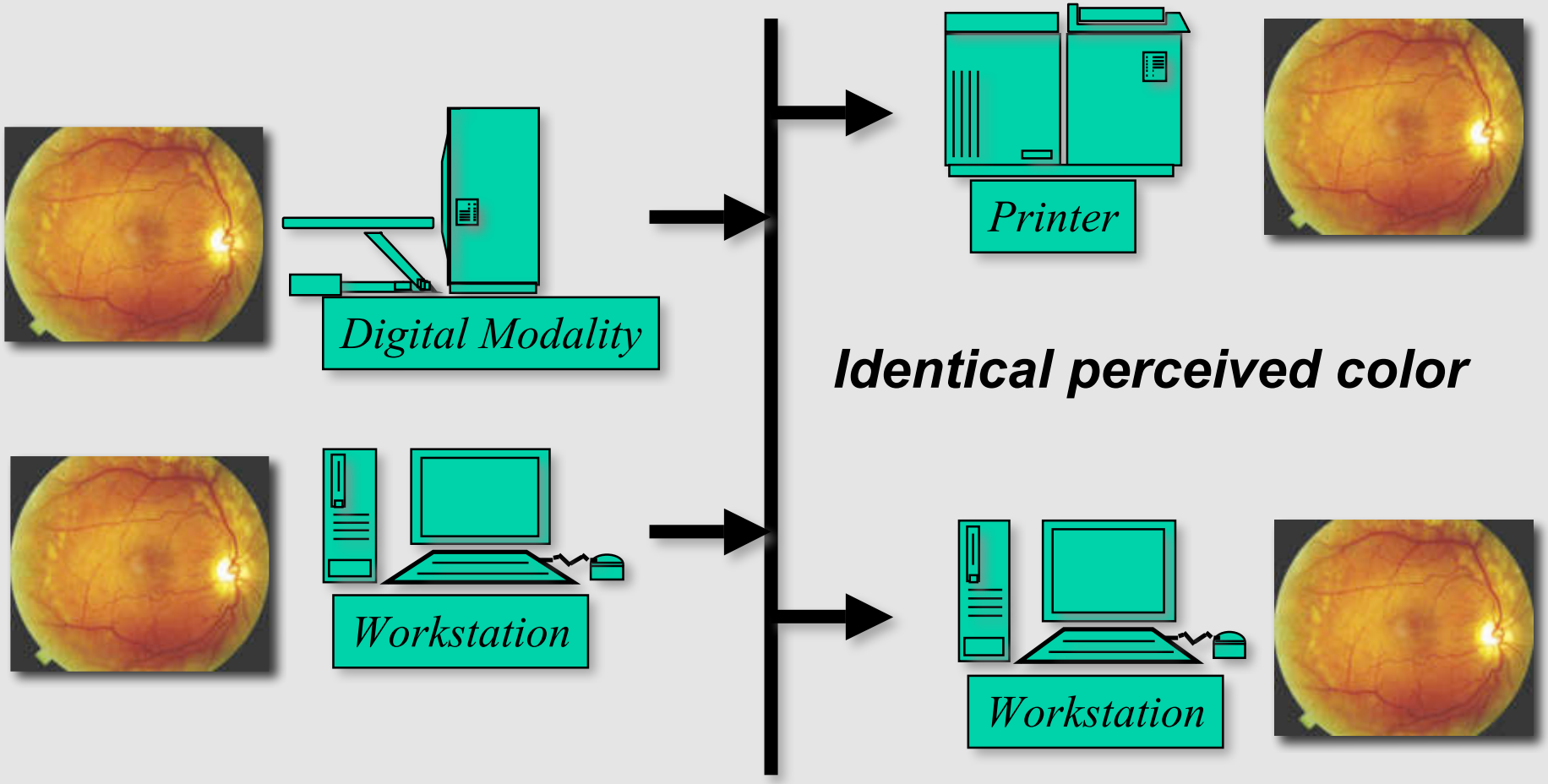
Limitations of Grayscale Presentation States

- Apply to grayscale images
  - no means to specify spatial transformations or graphic annotations for color images
- Only grayscale consistency
  - standard display function defined only for luminance
- No pseudo-color capability
- No blending or fusion capability

Distributed Image Consistency

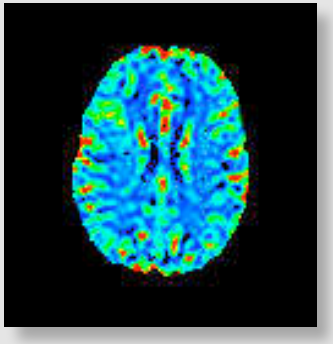
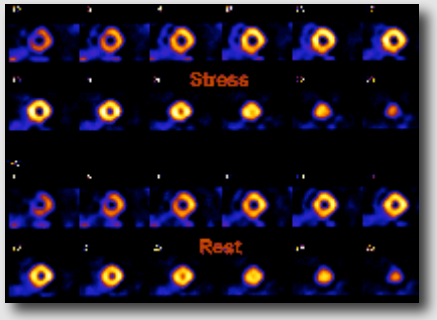


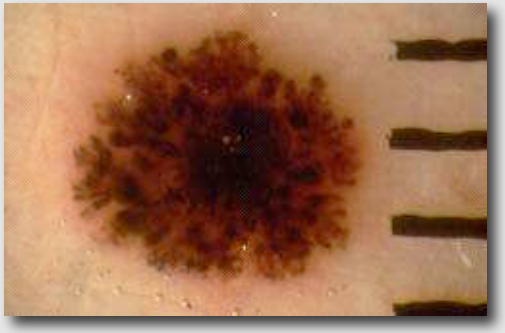
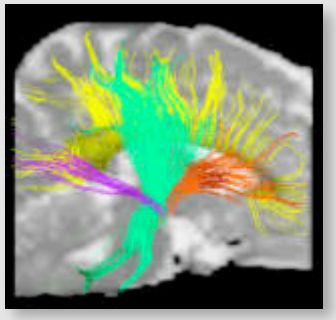
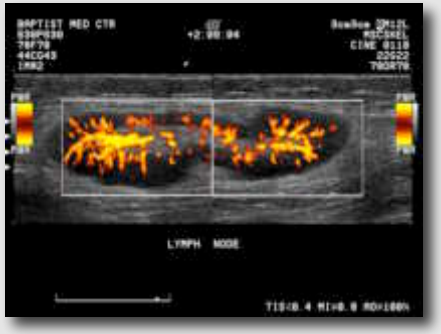
Distributed Image Consistency

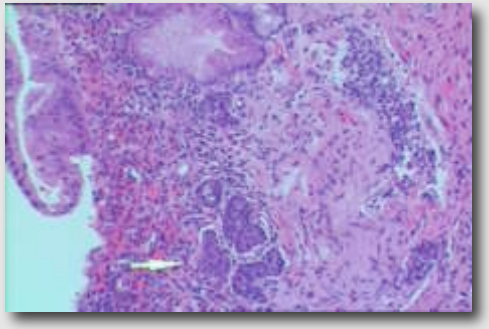
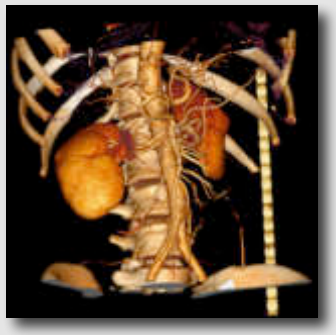


True and Pseudo-Color




Goals for Color

- Color consistency
  - standard function
  - defined for image output space of existing color images
- Transformation and annotation pipeline
- Pseudo-color for grayscale images
- Blending of grayscale images
  - alpha blending function
  - colorizing superimposed image

Standard Color Space

- GSDF filled a void
- Color consistency already standardized
- ICC - International Color Consortium
- Graphics and pre-press industry
- CIE Colorimetry
- Profiles of input and output devices
- COTS color management software handles conversion
- Perceptual rendering intent

Three New SOP Classes

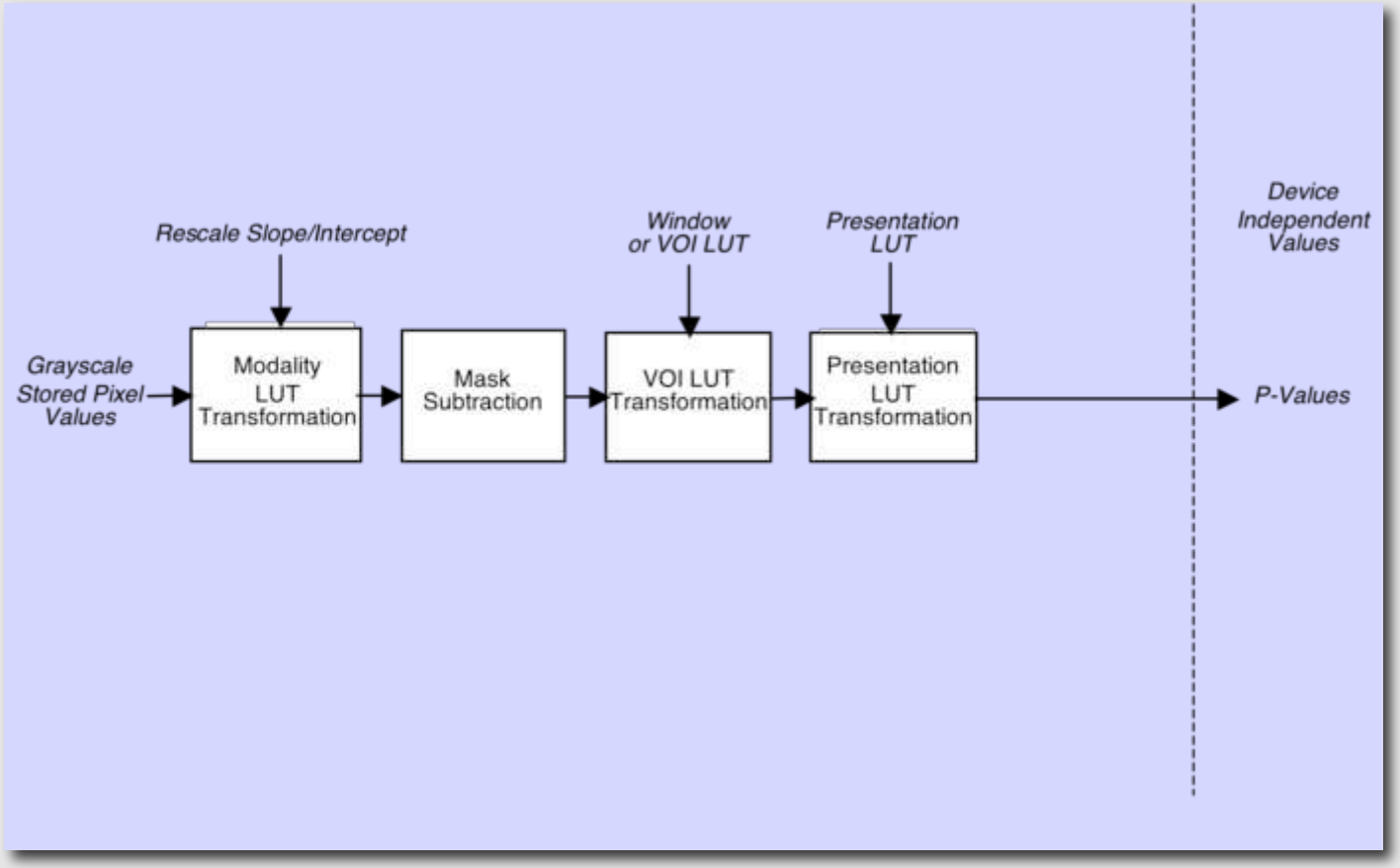
- Color Presentation State
- Pseudo-Color Presentation State
- Blending Presentation State

- ICC Profile
  - Defines output of all color presentation states
  - Optionally present in all color images
- PCS-Values (analogous to grayscale P-Values)
  - Profile Connection Space (CIELAB or CIEXYZ)

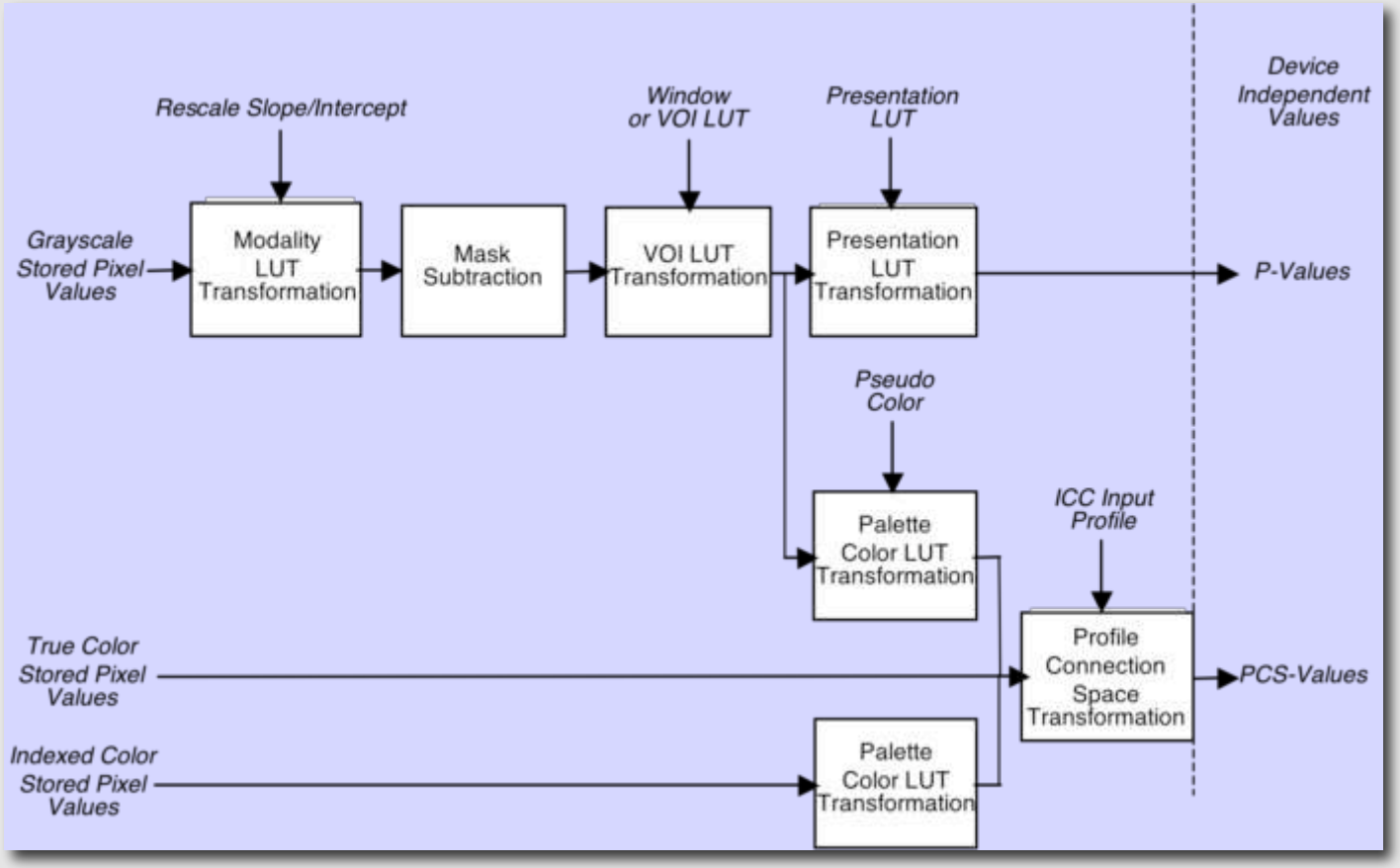
Commonality

- All presentation states share identical
  - Spatial transformation pipeline
  - Graphic and text annotation pipeline
- Choice of output space
  - P-Values for grayscale
  - PCS-Values for color and pseudo-color and blending

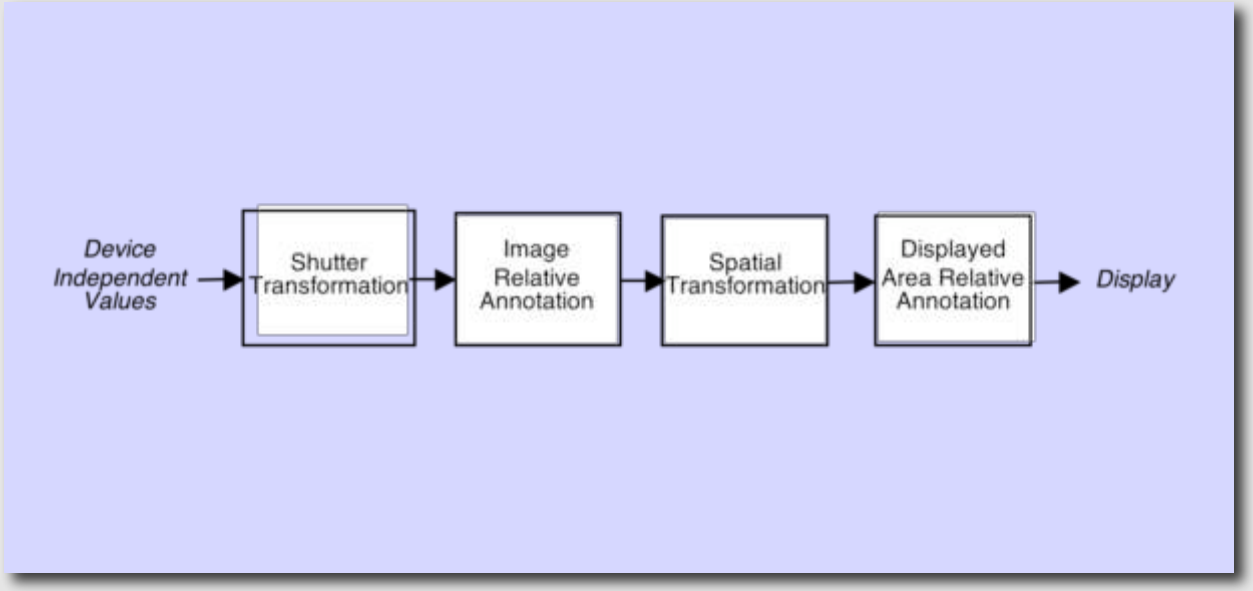
Old Grayscale Pipeline



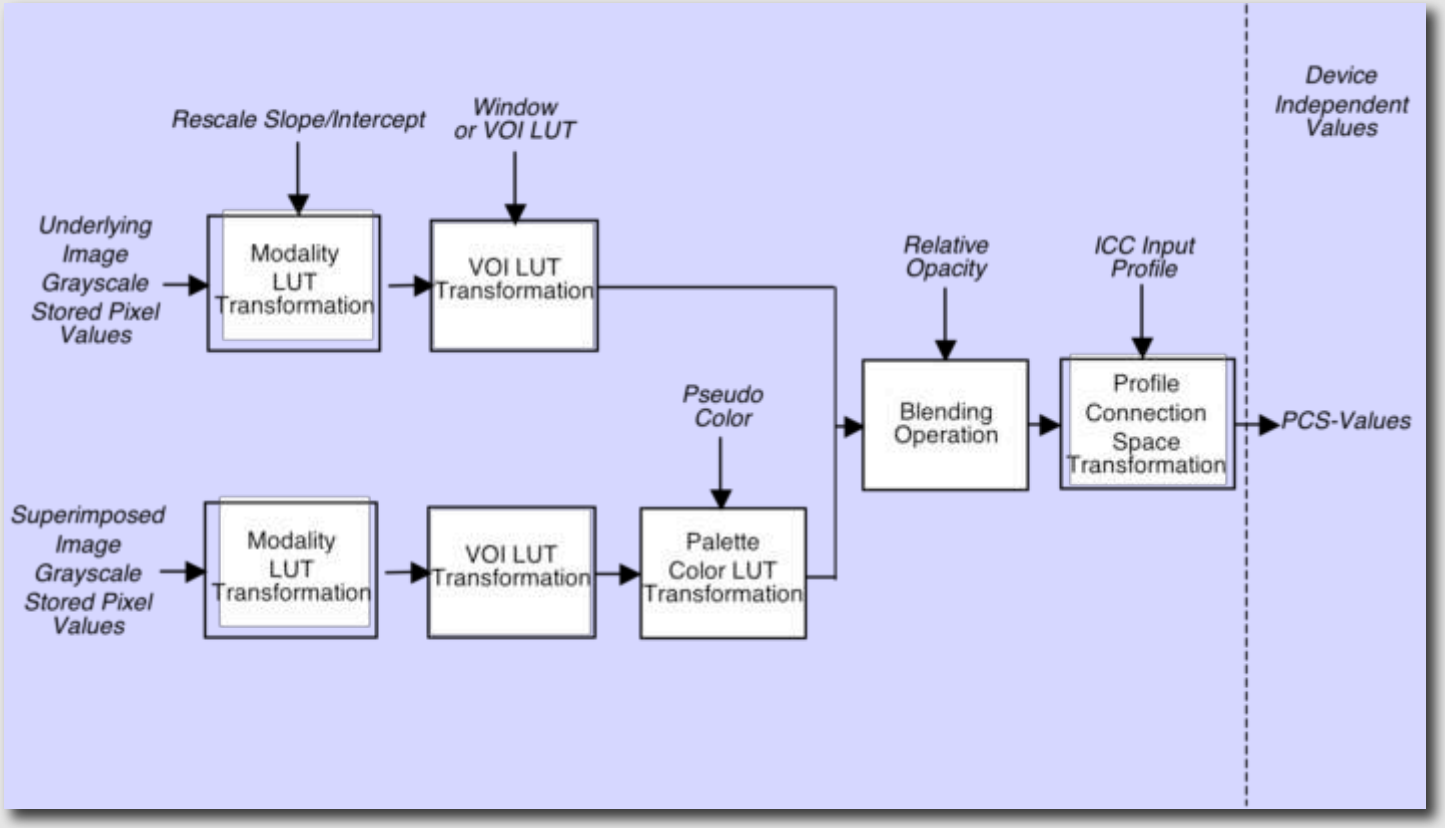
Grayscale & Color Pipeline



Common Spatial & Annotation Pipeline

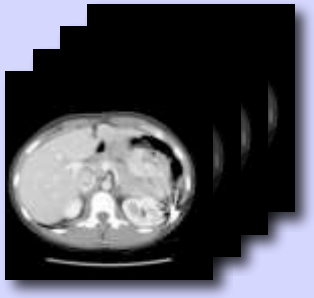


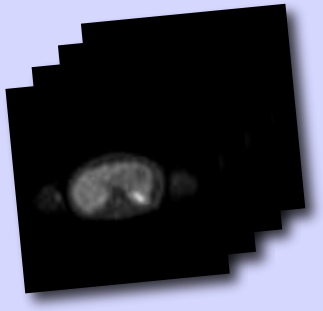
Blending Pipeline



Blending for CT-PET

select underlying



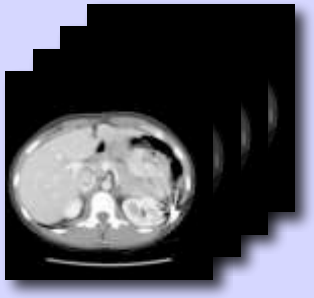


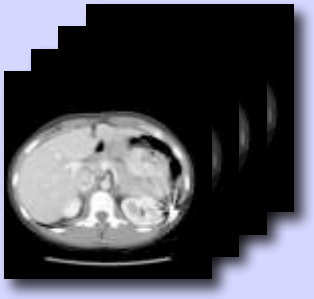
select superimposed

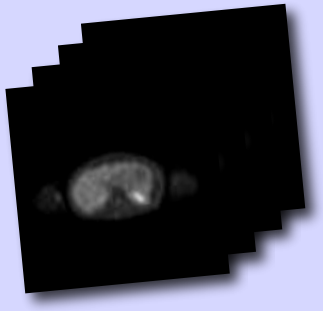
Blending for CT-PET

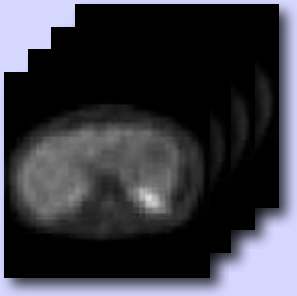
select underlying

[register]







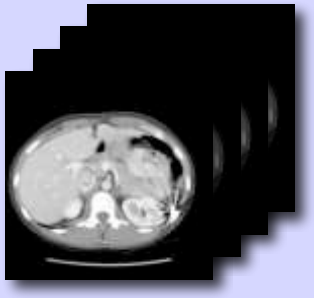


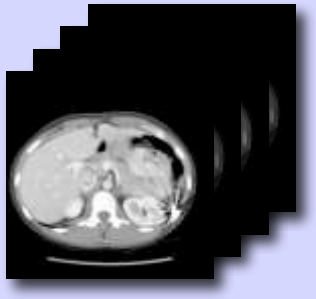
select superimposed

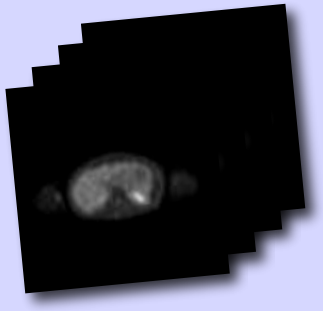
Blending for CT-PET

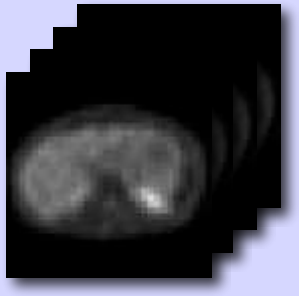
select underlying

[register]







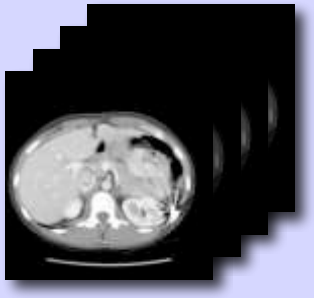


select superimposed

resample

Blending for CT-PET

select underlying



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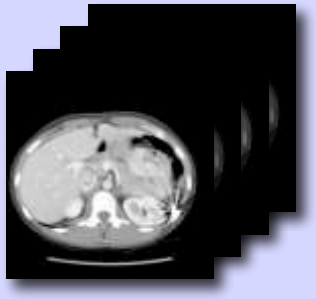
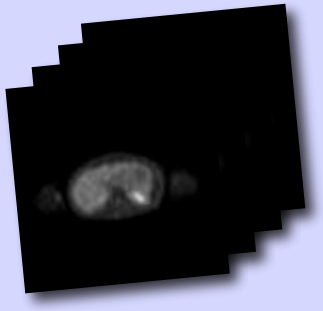
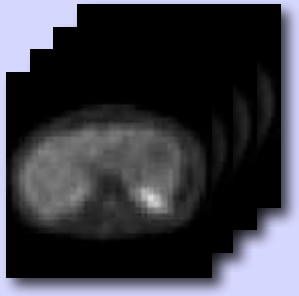
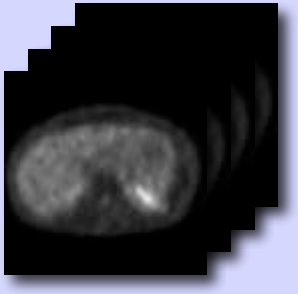




select superimposed



resample

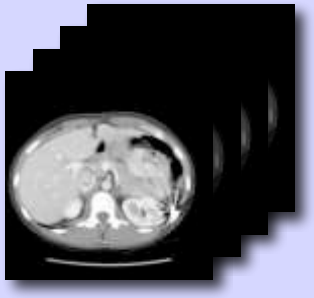


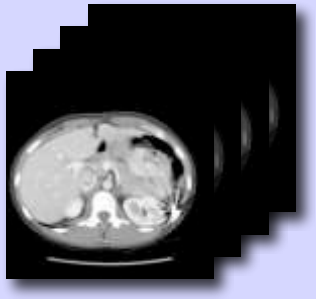
within slices

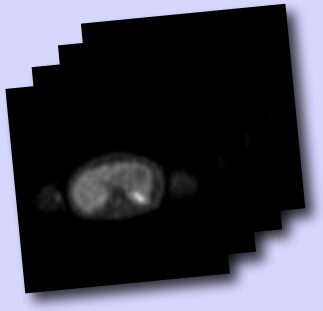
Blending for CT-PET

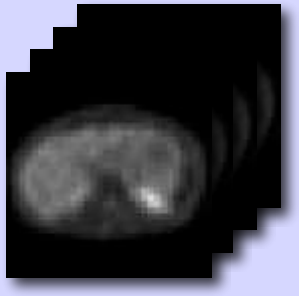
select underlying

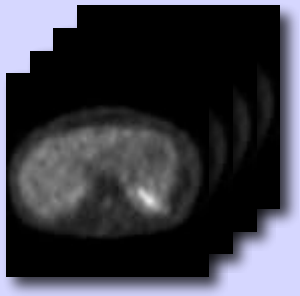
[register]











select superimposed

resample

within slices

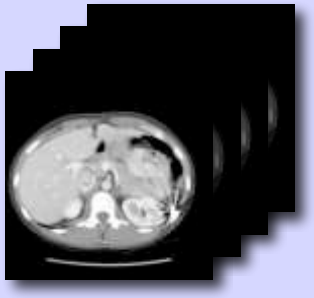
[between slices]

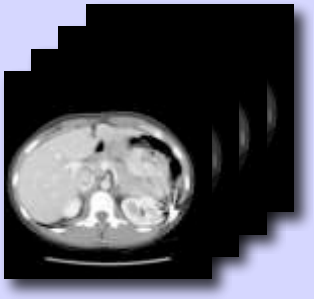
Blending for CT-PET

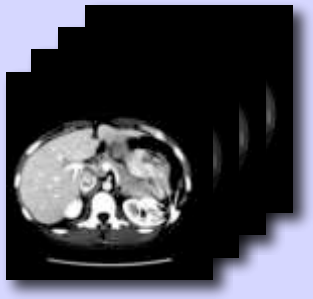
select underlying

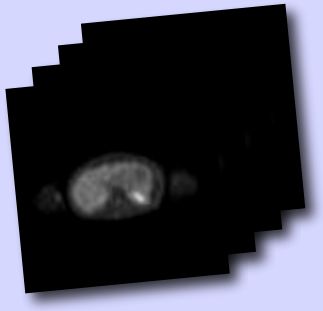
[register]

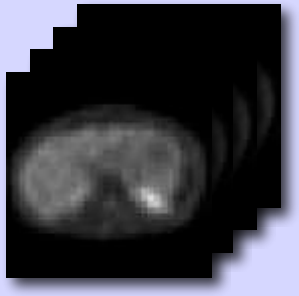
rescale and window

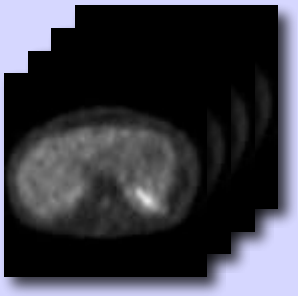


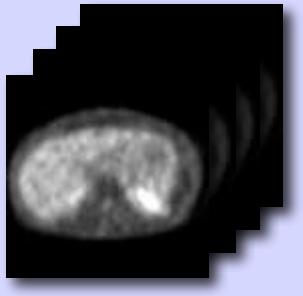












select superimposed

resample

within slices

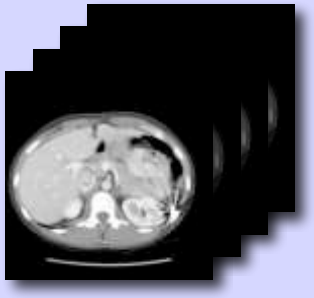
[between slices]

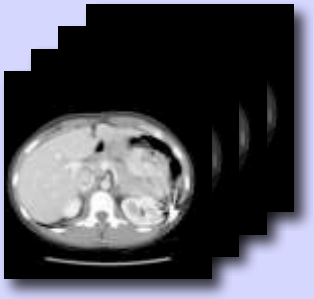
Blending for CT-PET

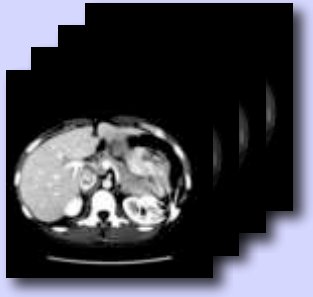
select underlying

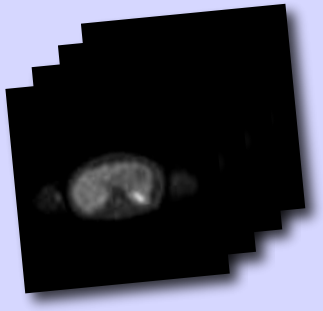
[register]

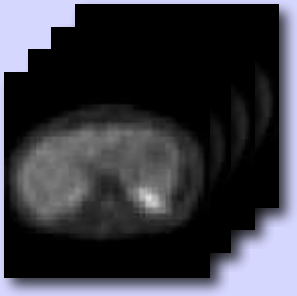
rescale and window

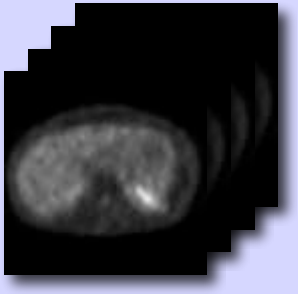


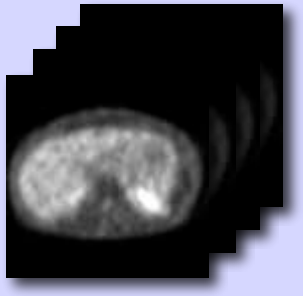


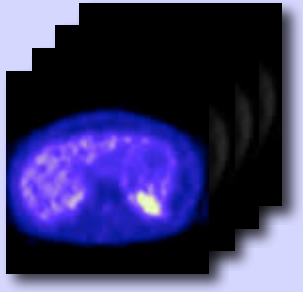












select superimposed

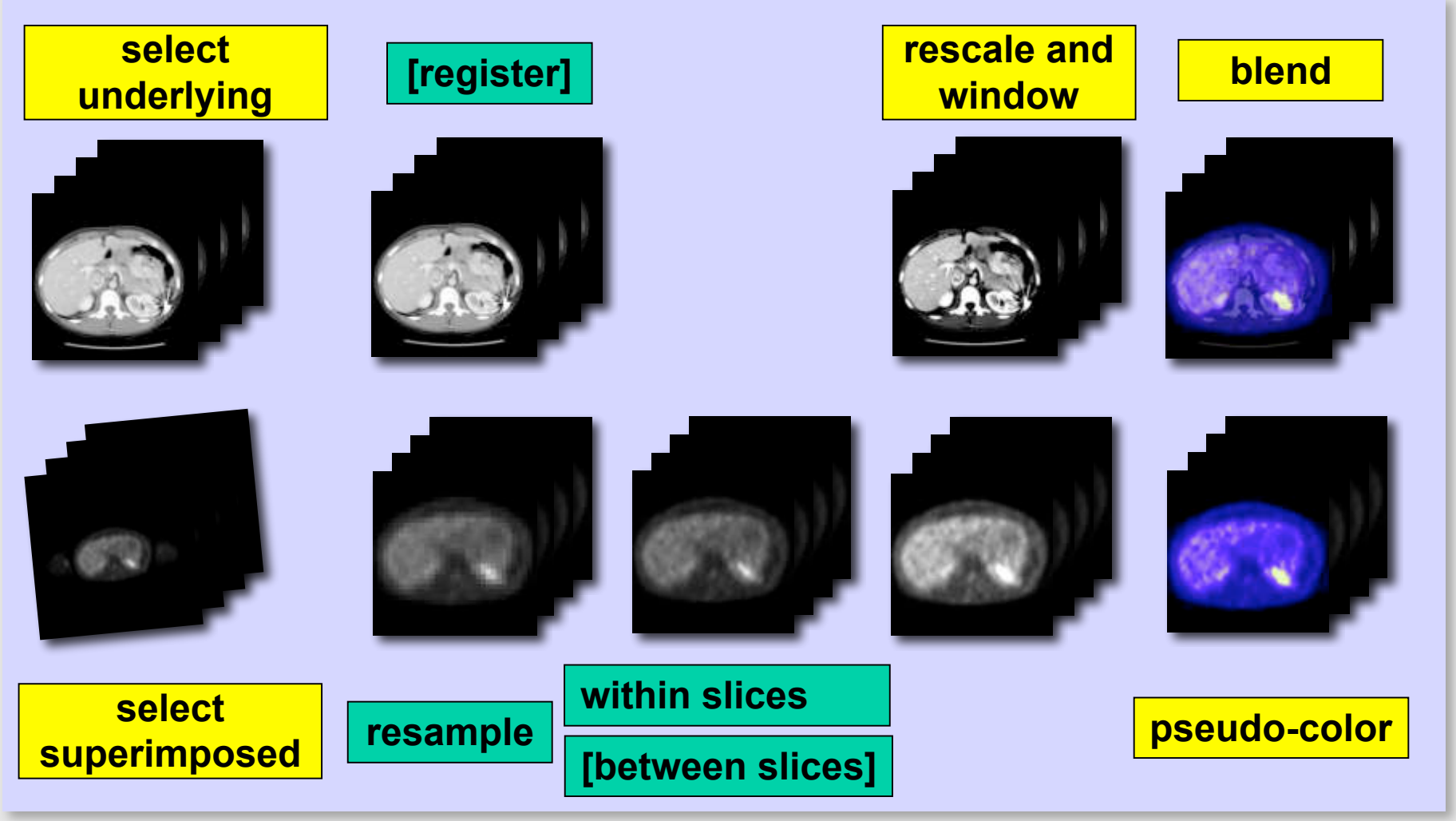
resample

within slices

[between slices]

pseudo-color

Blending for CT-PET



Color - Conclusion

- Color consistency using industry standard
- Transformation/annotation for color images
- Exchange of pseudo-color information
- Support for specifying sets of images to be blended, and how to blend (but not register or resample) them

Overview

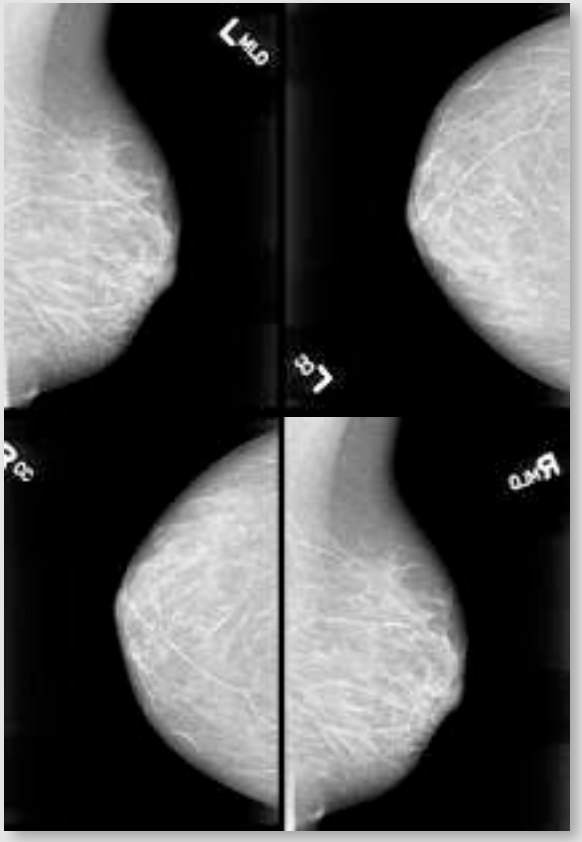
- Review of Grayscale Presentation State
- Color Presentation States
  - Color Consistency
  - Presentation States applied to Color Images
  - Color Blending - CT-PET fusion
- Hanging Protocols

Hanging Protocols

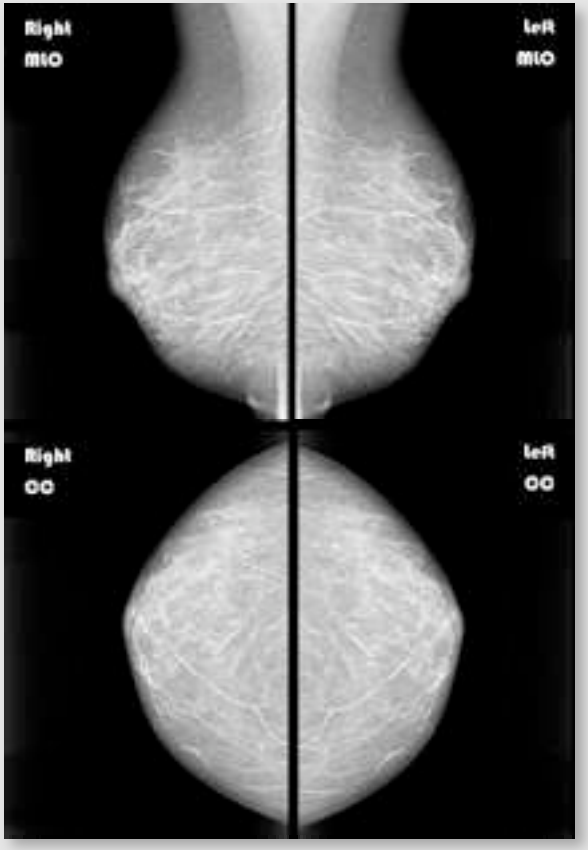
- “Default display protocols”
- A set of instructions
- How to layout a class of images for display
- Order, orientation, windowing, processing

- Not specific to a particular patient’s images
- Hence a protocol, not a presentation state

Hanging Protocols

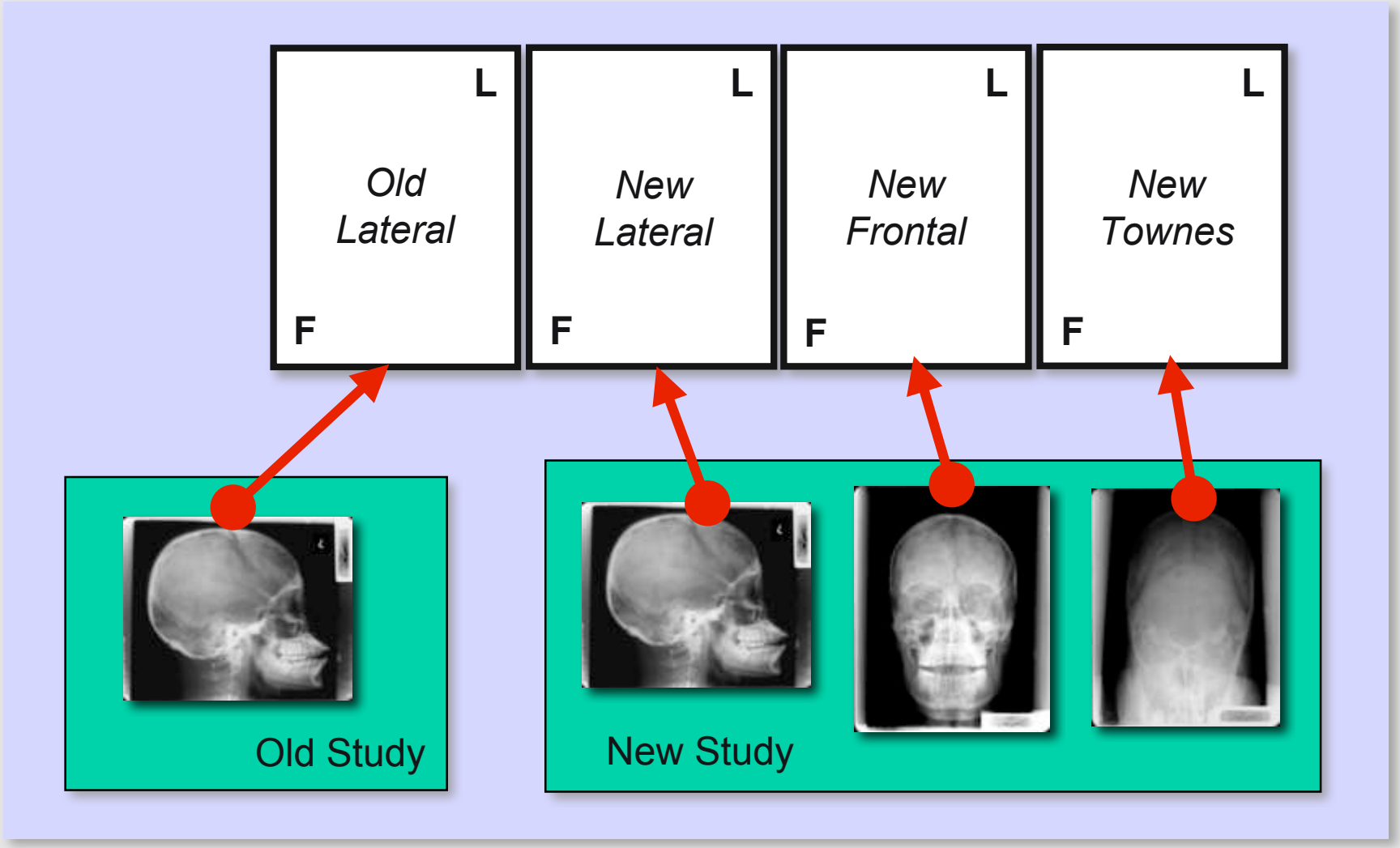


✗



✓

Hanging Protocols



Hanging Protocol Goals

- Encode
  - Applicability of protocol (type of display & images)
  - Selection of images
  - Display of selected images
- Store centrally, retrieve and exchange
  - Persistent composite objects
  - Query, retrieval and media encoding
- Vendor neutrality
  - Interchange between sites, PACS and workstations
  - Survive upgrades and replacements
  - “Public” library of “good” hanging protocols ?

New Information Model

- Required for storage and query/retrieval
- No Patient/Study/Series hierarchy

- New Storage Service Class
- New Query Model
- Still C-STORE, C-FIND, C-MOVE

Using a Hanging Protocol

- Given a current exam (e.g. reading worklist)
- Find potentially applicable protocols
- Retrieve them from archive
- Select one from those available
- Select image +/- other studies to which it applies
- Display selected images as instructed

Finding a Protocol

- Definition Module
  - Name, description, level, creator, creation datetime
  - Modality, anatomy, laterality
  - Procedure, reason for procedure
  - Number of priors
- Environment Module
  - Number of screens
  - Size(s) of screens
  - Color or grayscale bit depth

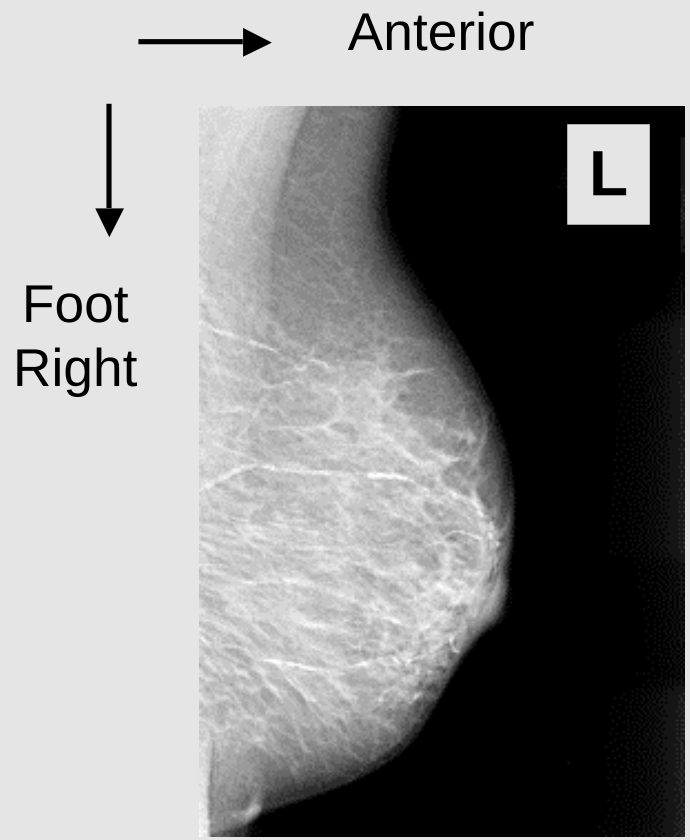
Selecting Images

- Definition of “image sets”
- By attribute values
  - Specific attributes, e.g. Modality, Anatomy
  - Specific values, e.g, CT, Chest
  - Supports all VRs, coded sequences, private elements and multi-frame functional groups
- By time
  - Relative time (today, yesterday, within last week)
  - Abstract priors (last, oldest, pre-operative, etc.)

Successful Selection

- All hanging protocols depend on consistent and reliable (and standard) information being present in the images
- DICOM Hanging Protocols don’t solve this integration problem
- Ideally - modality inserts correct anatomy and procedure and reason and orientation codes, and uses standard technique descriptions
- Worst case (typically?) - modality protocol (or operator) inserts recognizable Series Description

Information for Hanging



Modality: Mammography
Anatomic Region: Breast
Image Laterality: L
View Code: Medio-Lateral Oblique
Patient Orientation: A\FR

Priors

- Concept of the “current” study required
- Protocol chooses priors based on
  - Relative time
  - Abstract temporal ranges (previous, last, etc.)
  - Abstract coded descriptions (“pre-operative”)
- Does NOT specify how to find them or get them
- May have been pushed, may need a query
- May be hard to find by abstract descriptions
- Creative use of queries or out-of-band information

Mapping to Image Boxes

- Image Sets are mapped to Image Boxes
- Image Box types
  - Tiled (e.g. 3x4)
  - Stack (single image paged manually)
  - Cine (time-based play back)
  - Processed (e.g. MPR, 3D)
  - Single (e.g. a place for a report or waveform)
- Specify
  - Scrolling mode
  - Playback rate

Mapping to Image Boxes

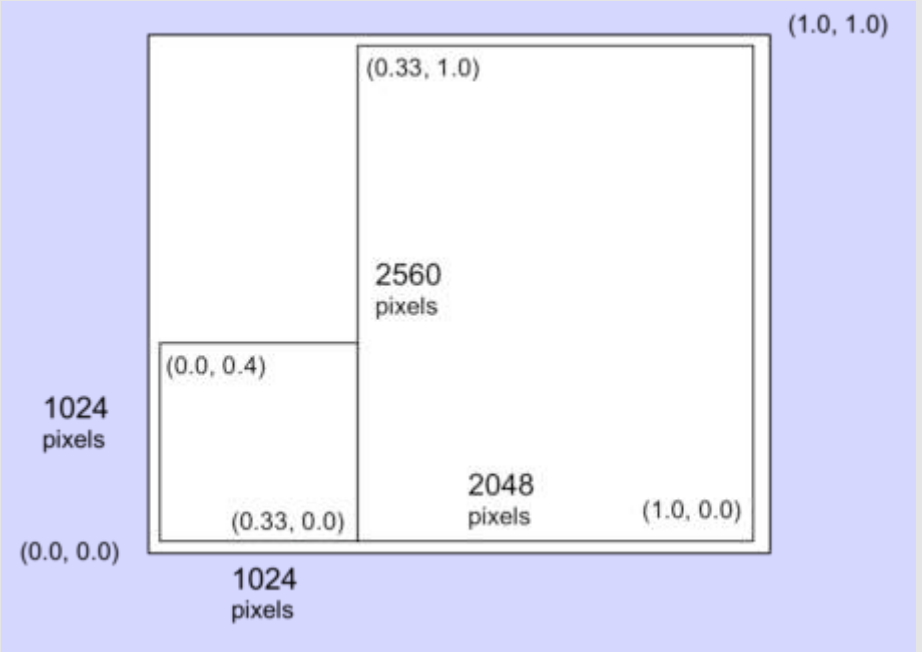
- Filtering
  - By attribute, or abstract, e.g. “category” of “image plane” “axial”
- Sorting
  - By attribute, or abstract, e.g. “along axis” “increasing”
- Orientation
  - E.g. rotate/flip until row left column posterior (L\P)
- Annotation
  - Patient demographics, technique and graphics on or off

Processing & Presentation

- Reformatting, e.g., MPR, 3D, slab
- Thickness, interval
- View direction, e.g., axial, sagittal, coronal
- Type, e.g., MIP, surface, volume
- VOI Type (windowing), e.g., brain, bone
- Pseudo-color type, e.g., hot iron
- Invert grayscale
- True size
- Synchronized scrolling (by Display Set number)
- Navigation and localization

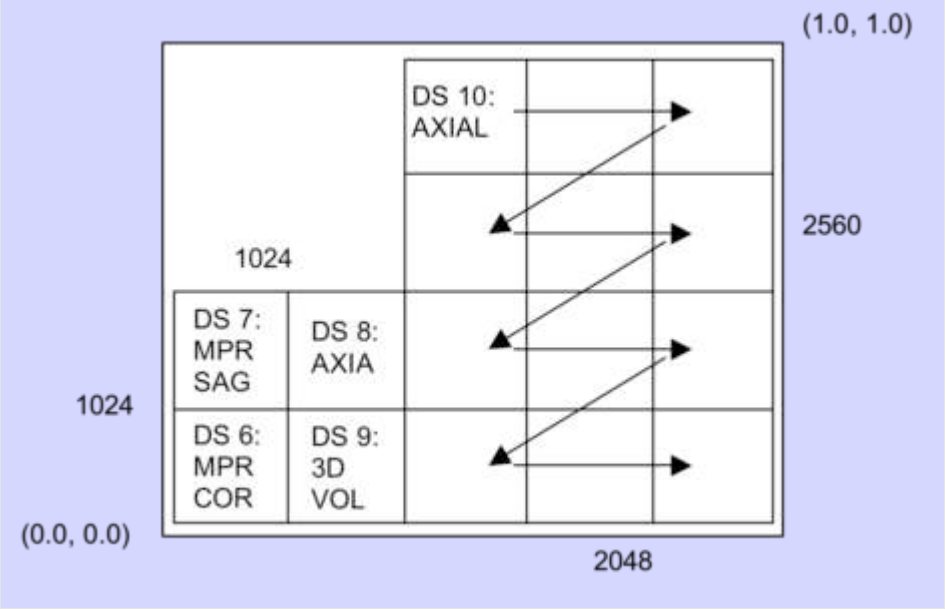
Display of Image Boxes

- Entire display environment from 0,0 to 1,1
- Individual screens are not distinguished



Display of Image Boxes

- Image Sets displayed in Image Boxes
- Image Boxes rendered at relative location



Hanging Protocols - Conclusion

- Interchangeable
- Vendor neutral
- Multi-modality
- Support selection of priors
- Full richness of current display modes
- Flexible
- Extensible

- Non-trivial to implement and retrofit
- Dependent on reliable image attributes