



---

Kaleidoscope: A Series Projection Visualization Tool for Review of  
DICOM Images for Protected Health Information



William Bennett

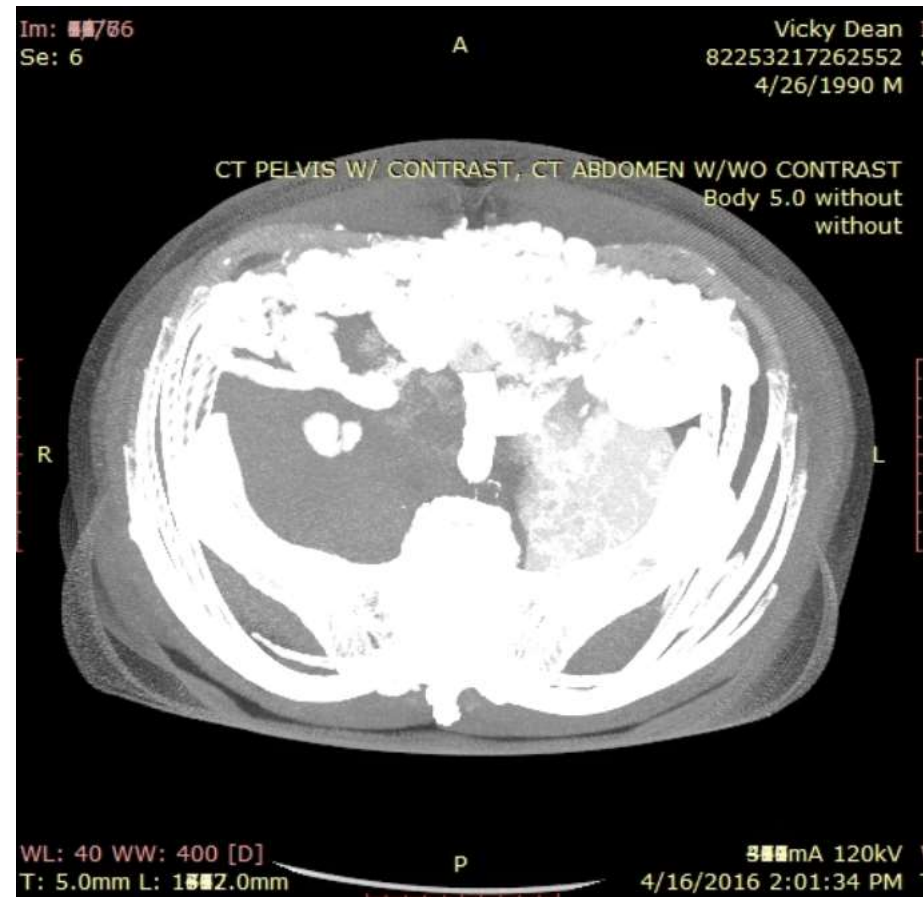
Department of Biomedical Informatics

# What's the Problem

- TClA standard way of scanning for burned in PHI is:
  - Time consuming
  - Error prone
  - Therefore unreliable
- Not readily fully automated
- Running into scale issues
- Collection sizes are growing

# What is “Burned in PHI” ?

- You know it when you see it
- (By the way. This is a pseudonym, not PHI)



# Larger Collections:

collection	site	num_subjects	num_series	num_images
ACRIN-FLT-Breast	ACRIN	83	1498	678406
ACRIN-FMISO-Brain	ACRIN	45	4633	669638
HNSCC	MDA	887	3633	624957
MyelomaTT3aPET	UAMS	32	2185	610995
Phantom FDA	FDA	3	1800	596230
ACRIN-NSCLC-FDG-PET	ACRIN	193	3255	445397
LDCT	Lahey	267	1485	347432
NSCLC Radiogenomics	Stanford	211	1203	285260
Exceptional-Responders	NCI	79	1851	256161
Anti-PD-1_MELANOMA	MDA	47	1814	234113

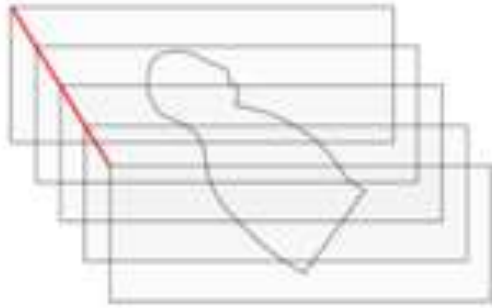
# We Rejected Auto Text Detection

- Auto Text Detection
  - What's the source of truth?
  - Its what you don't see that hurts you
  - Didn't have time to validate
- Detection by DICOM tag
  - Not reliably populated
  - Secondary Captures you want to keep

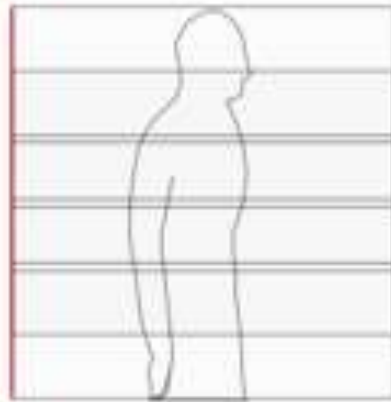
# What We Decided to Build

- Way to view series holistically
- Using Projections of the Series
  - Max Intensity
  - Min Intensity
  - Average Intensity
- Takes care of black on white vs white on black problem

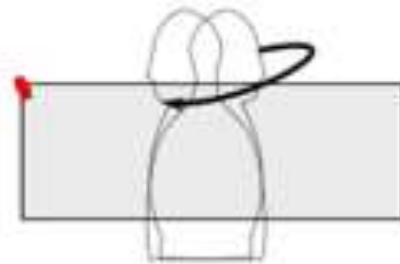
# A Little Picture



A



B



C

# Posda/Kaleidoscope/Quince

- Web-based Curation Tools
- Interface is Browser
- Linked together for DICOM curation




# CT Coronal Reconstruction Series

Kaleidoscope

Go Back Skip Forward

Good Bad Blank Scout Other



IEC 65169 [Open in Quince](#)

Images in IEC 134

Patient ID RSNA-2018-028

Body part examined KIDNEY

Current review status Good

Series Instance UID 1.3.6.1.4.1.14519.5.2.1.179756513298371936943186781847280296  
[Open in Quince](#)


Path /nas/public/posda/storage/a2/cf/e9/a2cfe9110a3757a4ca4abf16a050cf3f

# CT Axial Projection

Kaleidoscope

Go Back Skip Forward

Good Bad Blank Scout Other

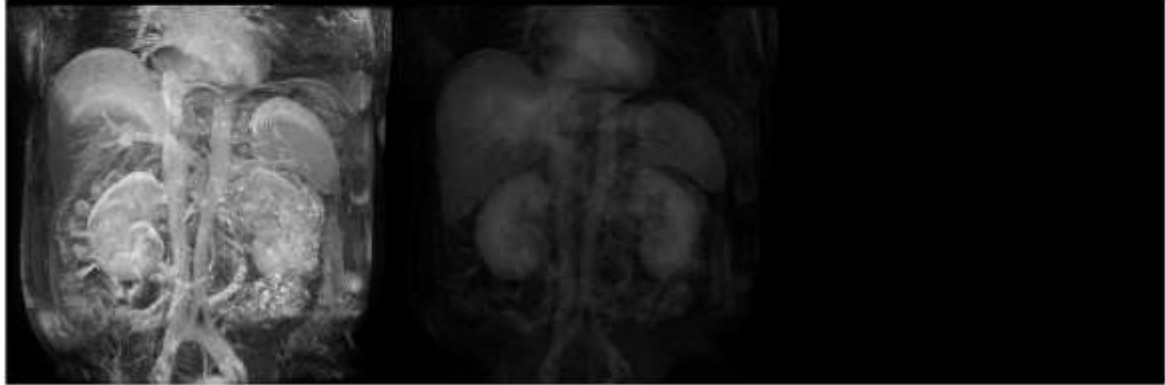


IEC	65197	<a href="#">Open in Quince</a>
Images in IEC	96	
Patient ID	RSNA-2018-022	
Body part examined	KIDNEY	
Current review status	Good	
Series Instance UID	1.3.6.1.4.1.14519.5.2.1.72546412894915858402342148823513956171	<a href="#">Open in Quince</a>
Path	/nas/public/posda/storage/b3/53/44/b35344ceb9bb436f7dd101c2da1f6400	

Kaleidoscope

Go Back Skip Forward

Good Bad Blank Scout Other



IEC	64977	<a href="#">Open in Quince</a>
Images in IEC	304	
Patient ID	RSNA-2018-002	
Body part examined	KIDNEY	
Current review status	Good	
Series Instance UID	1.3.6.1.4.1.14519.5.2.1.125504612260331559391164278962683925144	<a href="#">Open in Quince</a>
Path	/nas/public/posda/storage/89/a4/09/89a409cf0edb28ed50107ed37ca5d47f	

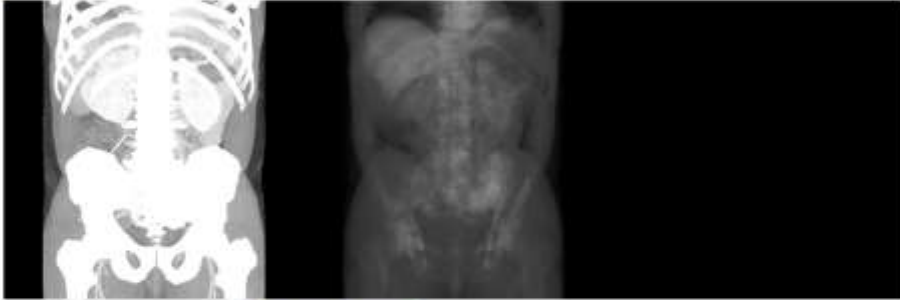
# MR Coronal Projection

# Equivalence Classes:

Kaleidoscope

Go Back Skip Forward

Good Bad Blank Scout Other



IEC 65169 [Open in Quince](#)

Images in IEC 134

Patient ID RSNA-2018-028

Body part examined KIDNEY

Current review status Good

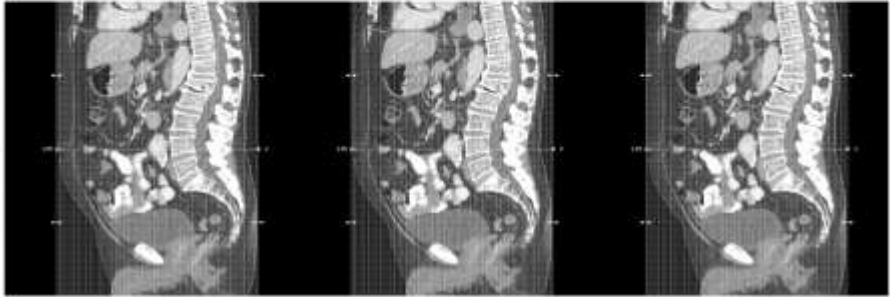
Series Instance UID 1.3.6.1.4.1.14519.5.2.1.179756513298371936943186781847280296 [Open in Quince](#)

Path /nas/public/posda/storage/a2/cf/e9/a2cfe9110a3757a4ca4abf16a050cf3f

Kaleidoscope

Go Back Skip Forward

Good Bad Blank Scout Other



IEC 65168 [Open in Quince](#)

Images in IEC 1

Patient ID RSNA-2018-028

Body part examined KIDNEY

Current review status Good

Series Instance UID 1.3.6.1.4.1.14519.5.2.1.179756513298371936943186781847280296 [Open in Quince](#)

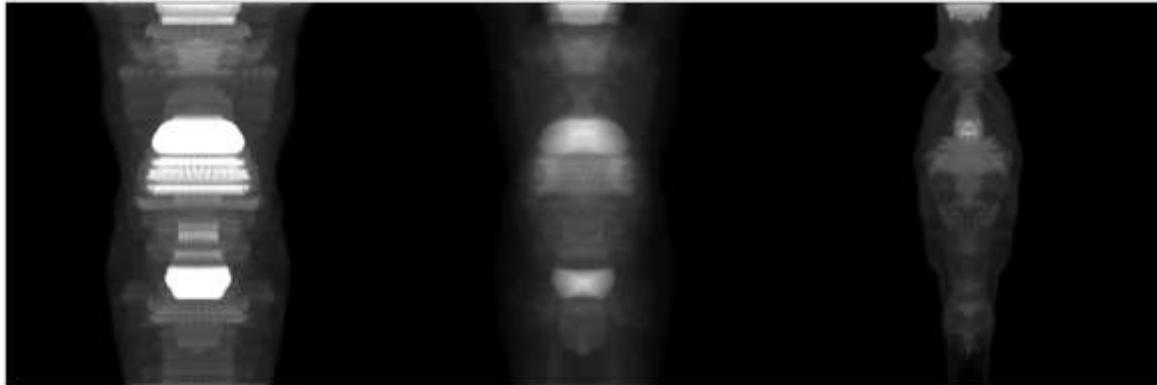
Path /nas/public/posda/storage/ab/b0/9a/abb09a3310af8832510e9fcd679fd41

# Pet Radial Projection

Kaleidoscope

Go Back Skip Forward

Good Bad Blank Scout Other



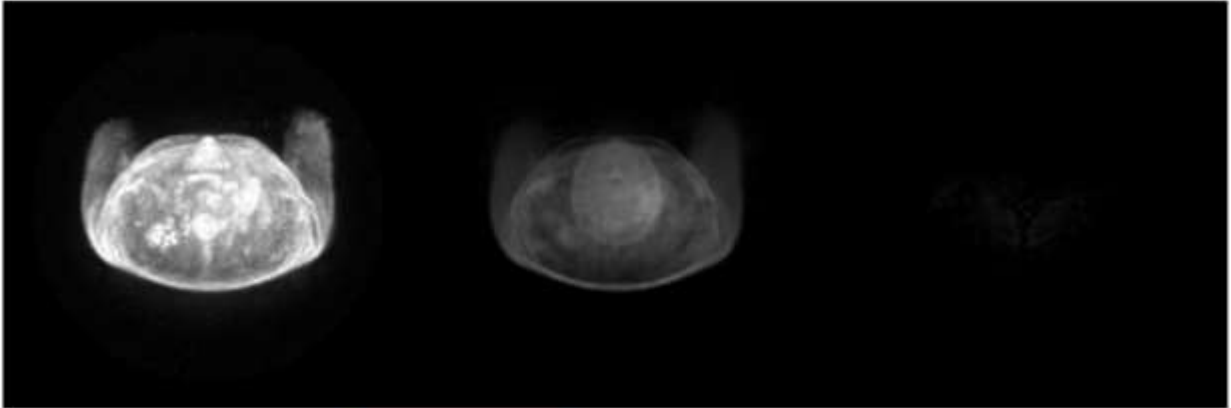
IEC	65046	<a href="#">Open in Quince</a>
Images in IEC	32	
Patient ID	RSNA-2018-010	
Body part examined		
Current review status	Good	
Series Instance UID	1.3.6.1.4.1.14519.5.2.1.63093600202719867479131805389361404718	<a href="#">Open in Quince</a>
Path	/nas/public/posda/storage/03/38/2b/03382bd7b86cfab7c696af7e3f329b70	

# Another PET Projection

Kaleidoscope

Go Back Skip Forward

Good Bad Blank Scout Other



IEC 64976 [Open in Quince](#)

Images in IEC 326

Patient ID RSNA-2018-010

Body part examined

Current review status Good

Series Instance UID 1.3.6.1.4.1.14519.5.2.1.162262476542276114508645991768498097907 [Open in Quince](#)


Path /nas/public/posda/storage/b2/5d/ea/b25dead0b144ccf9a081a6aa830f8b56

# Secondary Capture with (Pseudo) PHI

Kaleidoscope

Go Back Skip Forward

Good Bad Blank Scout Other



IEC 64957 [Open in Quince](#)

Images in IEC 76

Patient ID RSNA-2018-023

Body part examined

Current review status Bad

Series Instance UID 2.25.325727417459033762273638179184237194228.76.500 [Open in Quince](#)

Path /nas/public/posda/storage/c7/d9/76/c7d9762bc018343a07089e1a5f1fe4bd

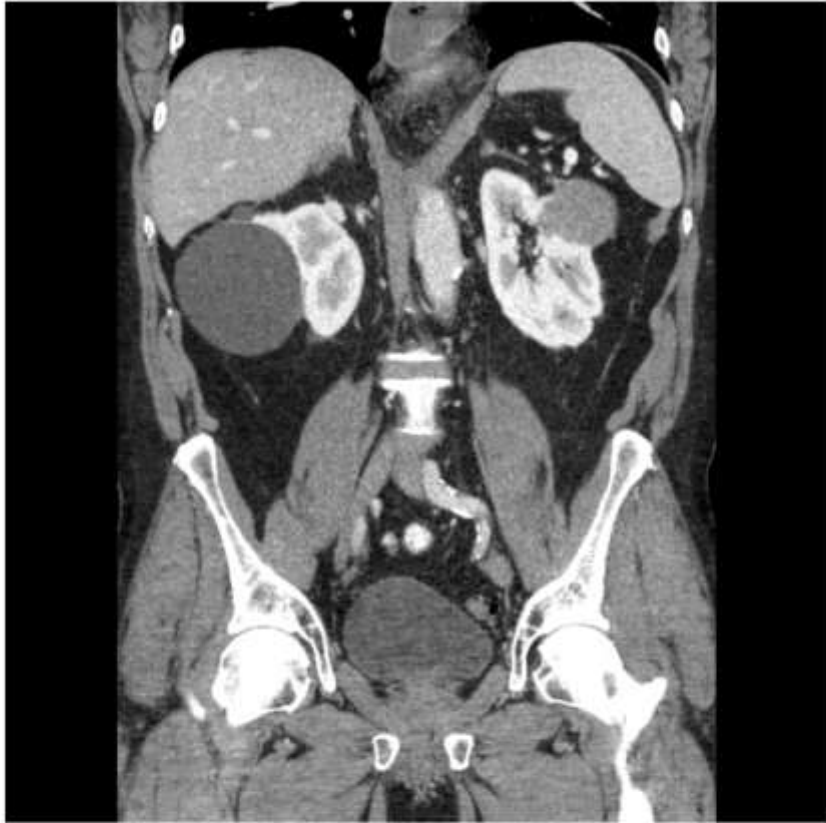
# Kaleidoscope Operations

- Mark Equivalence Class as Good
- Mark Equivalence Class as Bad
- Mark Equivalence Class as Blank (Indeterminate)
- Mark as “Scout” or “Other” (deprecated)
- View Equivalence Class in Quince
- View Series in Quince





# Quince is a Simple Image Viewer



# Quince Operations

- Window/Level
- Pan/Zoom
- Cine Images
- Series Information
- DICOM Dump
- Download Series as tgz
- Provides two levels of “Phone a friend”

# Results

collection	site	num_subjects	num_series	num_images	Image (Days)	Projection (Hours)	Improvement
ACRIN-FLT-Breast	ACRIN	83	1498	678406	5.50	0.62	211.34
ACRIN-FMISO-Brain	ACRIN	45	4633	669638	5.43	1.93	67.45
HNSCC	MDA	887	3633	624957	5.06	1.51	80.28
MyelomaTT3aPET	UAMS	32	2185	610995	4.95	0.91	130.49
Phantom FDA	FDA	3	1800	596230	4.83	0.75	154.58
ACRIN-NSCLC-FDG-PET	ACRIN	193	3255	445397	3.61	1.36	63.86
LDCT	Lahey	267	1485	347432	2.81	0.62	109.18
NSCLC Radiogenomics	Stanford	211	1203	285260	2.31	0.50	110.66
Exceptional-Responders	NCI	79	1851	256161	2.08	0.77	64.58
Anti-PD-1_MELANOMA	MDA	47	1814	234113	1.90	0.76	60.23
Average							105.26

Two orders of magnitude faster on average!

# Conclusion

- Visual Review of Image for PHI is no longer a bottleneck.
- More improvements in progress:
  - Support additional modalities (viz. “Enhanced” CT, MR; Segmentations, ...)
  - Better Window/Level algorithm
- General rule of thumb: a quantitative order of magnitude indicates a qualitative improvement
  - Since we have around two order of magnitude, we potentially have an order of magnitude of qualitative improvement
  - We are still figuring out what to do with that

# Acknowledging Our Implementation Team



Quasar Jarosz



Joseph Utecht



Sonya Utecht

# Our Team

## University of Arkansas

Fred Prior  
Lawrence Tarbox  
Mathias Brochhausen  
Yasir Rahmatallah  
Xiuzhen Huang  
Jonathan Bona  
Kirk Smith  
Bill Bennett  
Tracy Nolan  
Jason Causey  
Dwayne Dobbins  
Jeremy Jarosz  
Jeff Tobler  
Joseph Utecht  
Julie Frund  
Sonya Utecht  
Diana Stockton  
Betty Levine  
Pamela Angelus  
Erica Bilello  
Geri Blake  
Robert Brown

## Frederick National Laboratory for Cancer Research (FNLCR)

John Freymann  
Justin Kirby  
Brenda Fevrier-Sullivan  
Carl Jaffe  
Luis Cordeiro  
Craig Hill

## Emory University

Ashish Sharma  
Andrew Post  
Ryan Birmingham  
Ping Gu  
Pradeeban Kathiravelu

## Our Funders

1. **NCI 1U01CA187013-01** *Resources for development and validation of Radiomic analyses & Adaptive Therapy* (Prior, Sharma)
2. **Leidos Biomedical Research, Contract 16X011** for NCI, *Maintenance and Extension of The Cancer Imaging Archive (TCIA )* (Prior)
3. **NCI 1U24CA215109**, *TCIA Sustainment and Scalability - Platforms for Quantitative Imaging Informatics in Precision Medicine* (Prior, Sharma, Saltz)

The content of this presentation does not necessarily reflect the views or policies of the Department of Health and Human Services, nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. Government

## Washington University St. Louis

Malcolm Tobias  
Walter Bosch

## Stony Brook University

Joel Saltz  
Tahsin Kurc  
Jonas Almeida  
Erich Bremer  
Feiqiao Wang  
Joseph Balsamo

## QARC/University of Massachusetts

TJ Fitzgerald  
Richard Hanusik

## NBIA Team (NCI/FNLCR/Ellumen)

Ed Helton  
Ulli Wagner  
Scott Gustafson  
Qinyan Pan  
Russ Rieling  
Carolyn Klinger  
Martin Lerner  
Tin Tran