Image DePHI and the DSA: Open Source tools for Histology Image De-Identification

David A Gutman MD PhD
Associate Professor of Pathology Emory University

EMORY
UNIVERSITY
SCHOOL OF
MEDICINE

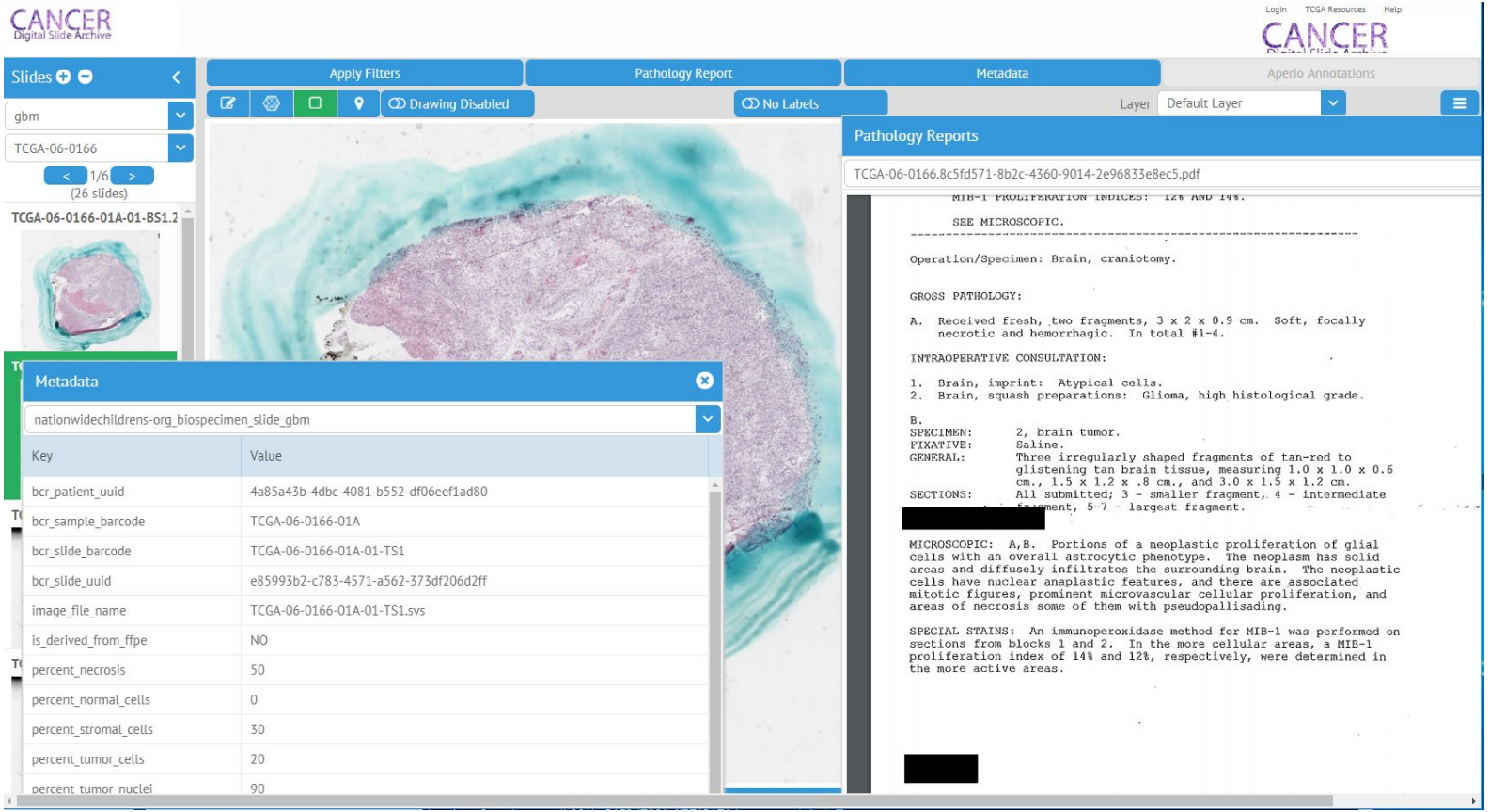
NATIONAL CANCER INSTITUTE
Informatics Technology for
Cancer Research

EMORY
UNIVERSITY

Disclosures

I own stock in Histowiz Inc, LLC and am a co-founder of SwitchboardMD

The Cancer Digital Slide Archive



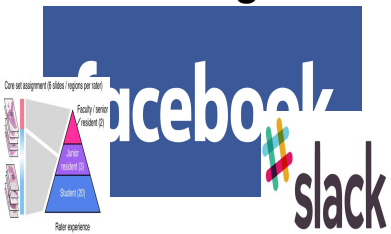
NCI ITCR U24CA194362

http://cancer.digitalisdearchive.net

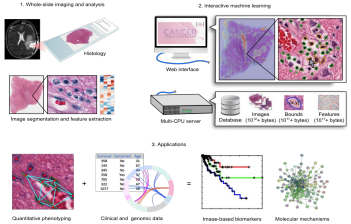
Open-source digital pathology: Digital Slide Archive (DSA)

EMORY UNIVERSITY SCHOOL OF MEDICINE

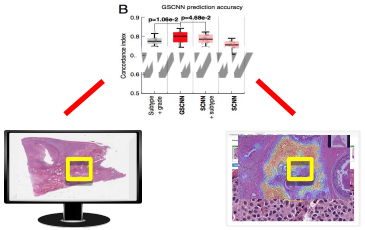
Manage



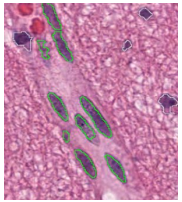
Annotate



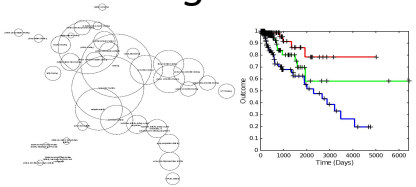
Share

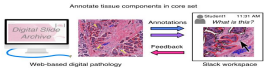


Analyze



Integrate





NIH NATIONAL CANCER INSTITUTE Informatics Technology for Cancer Research http://itcr.nci.nih.gov/

1U24CA194362-01

docker

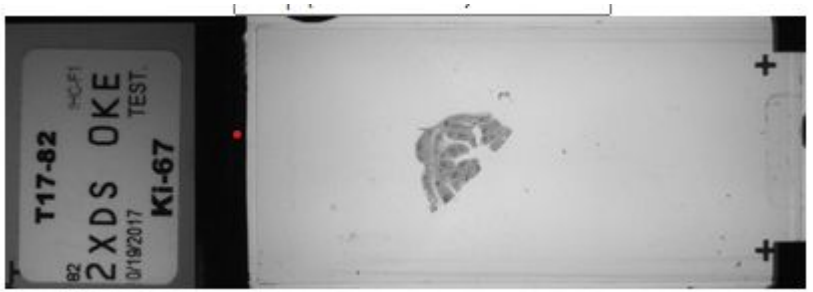
DA Gutman *et al*, The Digital Slide Archive: A Software Platform for Management, Integration and Analysis of Histology for Cancer Research, *Cancer Research*, 77(21), pp. 75-78, November 2017

https://digitalslidearchive.github.io/digital_slide_archive/

Protected Health Information in WSI
What & Where?

- For WSI images, if present, there are three places PHI are likely to reside
  - Filename
  - Embedded Image Metadata
  - Embedded Label / Macro Images

Property	Value
aperio.AppMag	20 **REDACT** Keep (do not redact)
aperio.Date	~~12/14/18~~ 01/01/18
aperio.DisplayColor	0 **REDACT** Keep (do not redact)
aperio.Exposure Scale	0.000001 **REDACT** Keep (do not redact)
aperio.Exposure Time	109 **REDACT** Keep (do not redact)
aperio.Filename	~~28-A~~ 0579XY112001_03_10
aperio.Focus Offset	-0.000500 **REDACT** Keep (do not redact)



Example Label and Macro WSI Images

Embedded Image Metadata

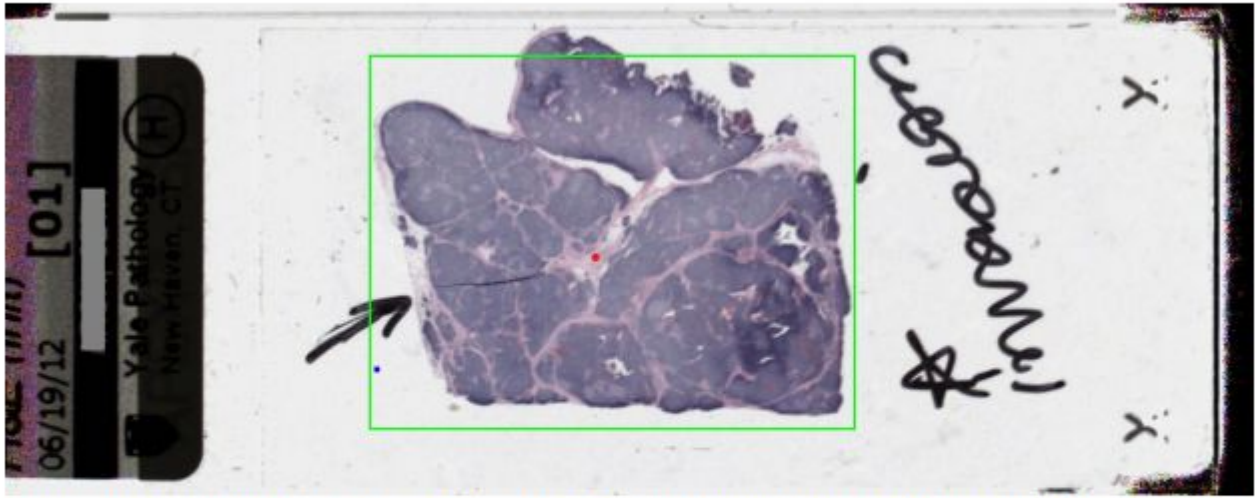
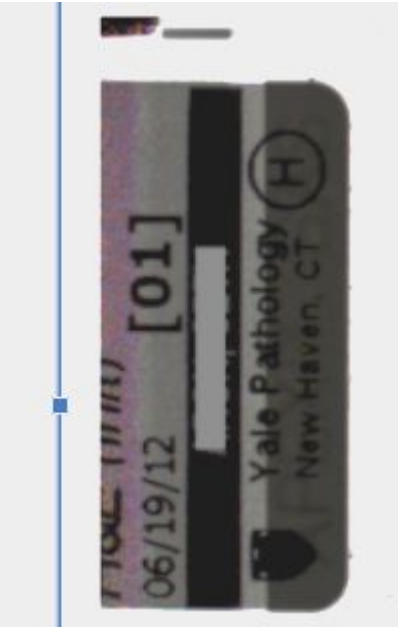


Figure 4: The macro image from TCGA file TCGA-4X-A9FB-01Z-00-DX1.211CC9AA-F721-4D16-8663-68A393223F80.svs. The left side shows part of the label which included the patient name. This has been manually redacted with a grey bar in this figure. This file was released to the public in 2016.



4X	Yale University	Thymoma	NCH

Embedded Image Metadata

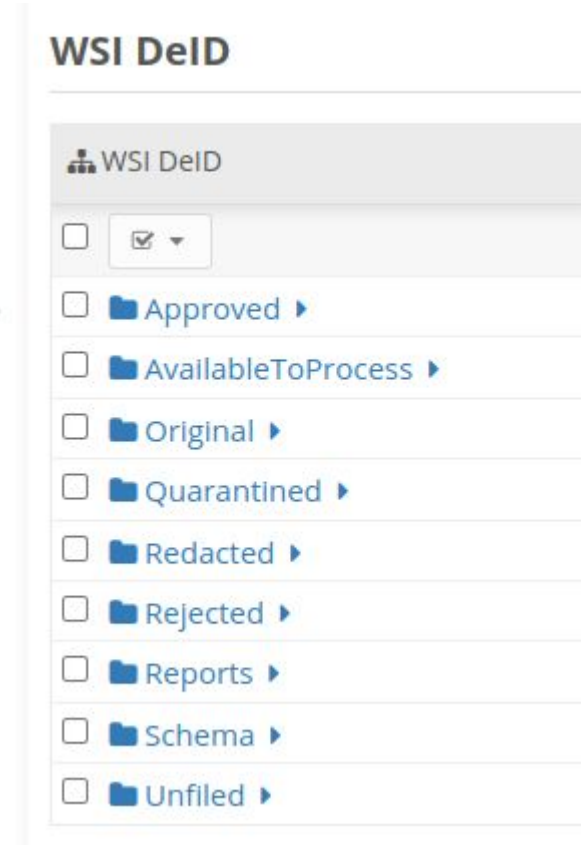
```
TIFF Directory at offset 0xbbc777fe (3150411774)
  Subfile Type: (0 = 0x0)
  Image Width: 109559 Image Length: 84381 Image Depth: 1
  Tile Width: 240 Tile Length: 240
  Bits/Sample: 8
  Compression Scheme: JPEG
  Photometric Interpretation: RGB color
  YCbCr Subsampling: 2, 2
  Samples/Pixel: 3
  Planar Configuration: single image plane
  ImageDescription: Aperio Image Library v12.0.15
111760x84481 [0,100 109559x84381] (240x240) JPEG/RGB Q=70|AppMag = 40|StripeWidth = 2032|ScanScope ID = APERIONP|Filename = E20-72_8 TAU|Date = 08/24/20|Time = 22:27:25|Time Zone = GMT-04:00|User = 81e564c9-09
ad-4e80-95ce-ec8daa7330cd|MPP = 0.2519|Left = 17.393621|Top = 22.502415|LineCameraSkew = 0.000365|LineAreaXOffset = -0.014056|LineAreaYOffset = 0.007910|Focus Offset = 0.000000|ImageID = 1030008|Exposure Time
= 45|Exposure Scale = 0.000001|DisplayColor = 0|SessonMode = NR|OriginalWidth = 111760|OriginalHeight = 84481|ICC Profile = AT2
  ICC Profile: <present>, 1687824 bytes
  JPEG Tables: (574 bytes)
TIFF Directory at offset 0xbbf713d0 (3153531856)
  Subfile Type: (0 = 0x0)
  Image Width: 997 Image Length: 768 Image Depth: 1
  Bits/Sample: 8
  Compression Scheme: JPEG
  Photometric Interpretation: RGB color
  YCbCr Subsampling: 2, 2
  Samples/Pixel: 3
  Rows/Strip: 16
  Planar Configuration: single image plane
  ImageDescription: Aperio Image Library v12.0.15
109559x84381 -> 997x768 - |AppMag = 40|StripeWidth = 2032|ScanScope ID = APERIONP|Filename = E20-72_8 TAU|Date = 08/24/20|Time = 22:27:25|Time Zone = GMT-04:00|User = 81e564c9-09ad-4e80-95ce-ec8daa7330cd|MPP =
 0.2519|Left = 17.393621|Top = 22.502415|LineCameraSkew = 0.000365|LineAreaXOffset = -0.014056|LineAreaYOffset = 0.007910|Focus Offset = 0.000000|ImageID = 1030008|Exposure Time = 45|Exposure Scale = 0.000001|
DisplayColor = 0|SessonMode = NR|OriginalWidth = 111760|OriginalHeight = 84481|ICC Profile = AT2
  JPEG Tables: (289 bytes)
```

Results of tiffinfo on an Aperio Image provides access to some of the internal TIFF metadata.

```
  ImageDescription: Aperio Image Library v12.0.15
109559x84381 -> 997x768 - |AppMag = 40|StripeWidth = 2032|ScanScope ID = APERIONP|Filename = E20-72_8 TAU|Date = 08/24/20
 0.2519|Left = 17.393621|Top = 22.502415|LineCameraSkew = 0.000365|LineAreaXOffset = -0.014056|LineAreaYOffset = 0.007910
DisplayColor = 0|SessonMode = NR|OriginalWidth = 111760|OriginalHeight = 84481|ICC Profile = AT2
```

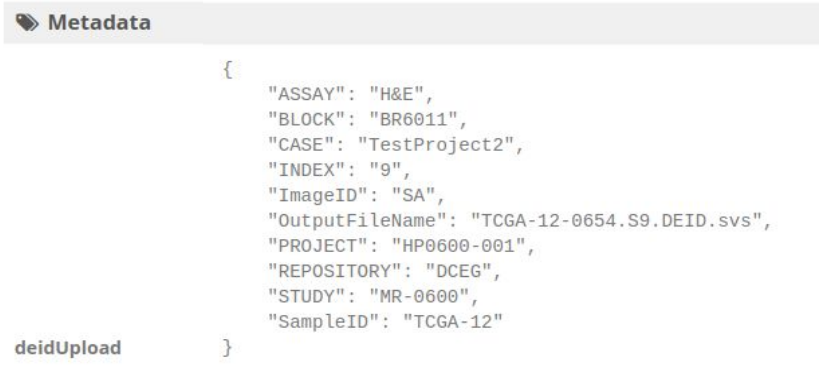
As an example, the ImageDescription tag may contain the original filename, ir may contain specific dates or other PHI.

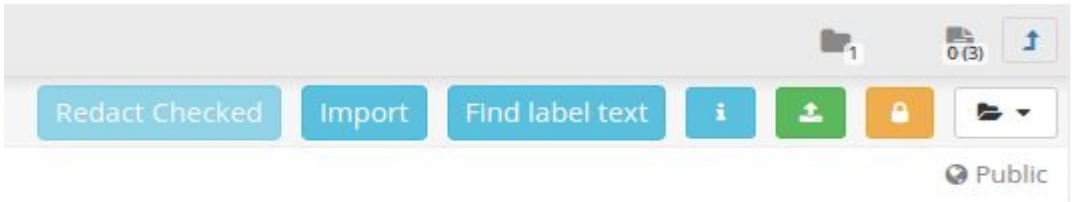
DSA Plugin for DeID*



Step 1: Load / Copy over image set for De-ID

- User supplies CSV file or uploads metadata to the DSA via API





*Under Active Development

https://github.com/dgutman/nci-dsa-deid

AVOID CLICKS AT ALL COSTS!

Metadata Mapping… The Hard Part

- Slide label and image name contain primary mechanism to map slide → patient
- Metadata is validated against a custom JSON Schema
  - System won't allow redaction if validation fails
- Metadata can also be encoded into bar code

https://hollowlands.com/wp-content/uploads/2016/11/JustMetaData.jpg

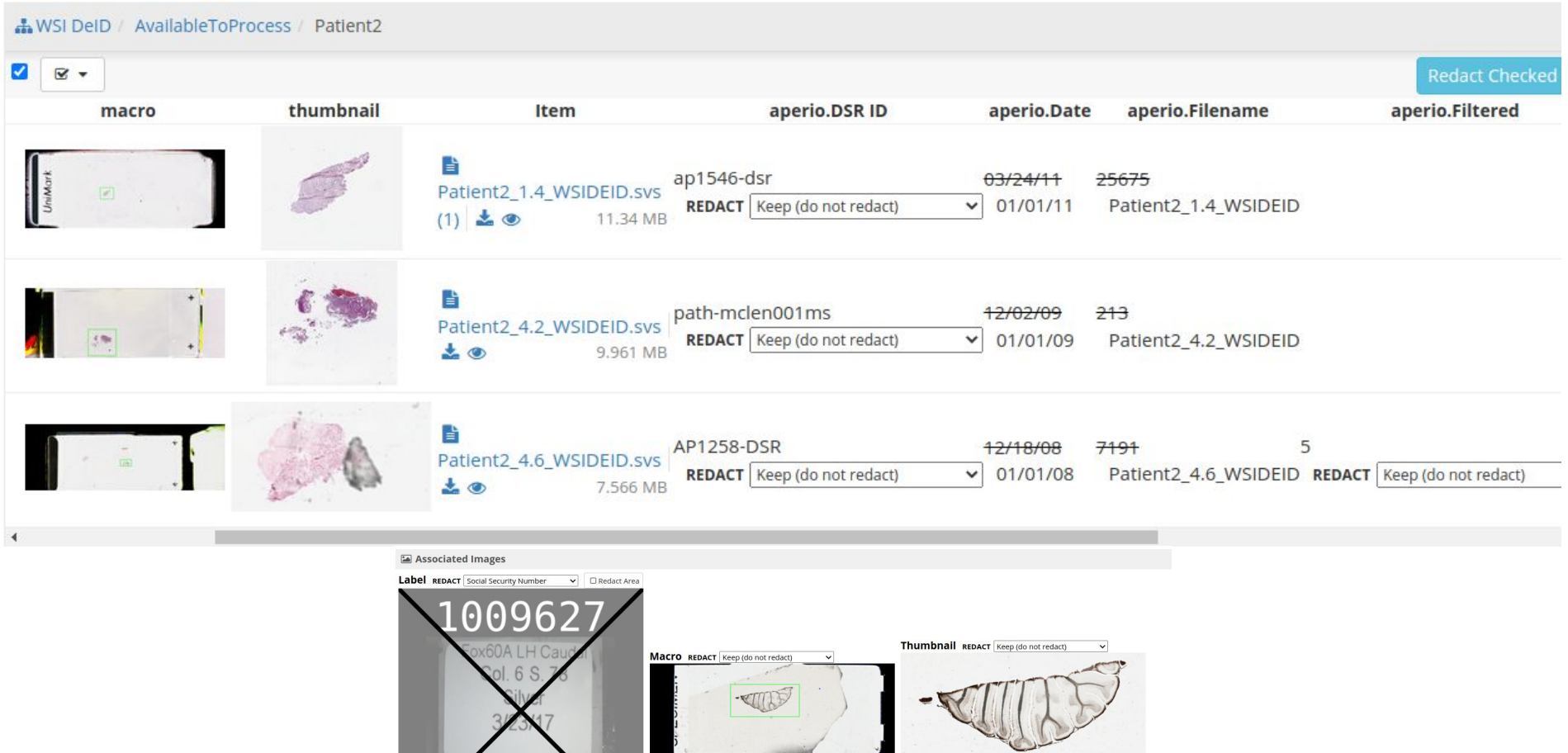
More Text To Stare At

Schema 1.0 →

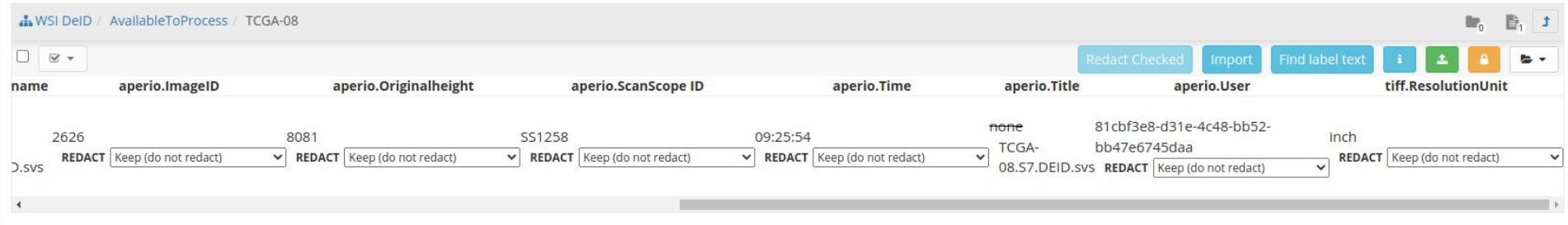
```
{
"$schema": "http://json-schema.org/draft-07/schema",
"$id": "http://example.com/example.json",
"type": "object",
"title": "Working schema for NCI CBIIT deidentification workflow validation",
"description": "The schema to validate the DeID Upload CSV file for the NCI CBIIT DeID Project.",
"default": {},
"required": ["InputFileName","SampleID","OutputFileName"],
"properties": {
  "PatientID": {
    "type": "string",
    "pattern": "^[a-zA-Z0-9]",
    "description": "The patient ID has to start with a letter or number."
  },
  "SampleID": {
    "type": "string"
  },
  "REPOSITORY": {
    "type": "string"
  },
  "STUDY": {
    "type": "string"
  },
  "PROJECT": {
    "type": "string"
  },
  "CASE": {
    "type": "string"
  },
  "BLOCK": {
    "type": "string"
  },
  "ASSAY": {
    "type": "string"
  },
  "INDEX": {
```

```
InputFileName,SampleID,REPOSITORY,STUDY,PROJECT,CASE,BLOCK,ASSAY,INDEX,ImageID,OutputFileName
TCGA-06-5408-01A-01-TS1.68665795-aac7-4a6d-9a14-c306bc941b26.svs,TCGA-06,DCEG,MR-0600,HP0600-001,TestProject,BR6011,H&E,1,SA,TCGA-06.S1.DEID.svs
TCGA-06-5412-01A-01-TS1.4e47da5e-588a-4cc1-8c10-a701764b1f7c.svs,TCGA-06,DCEG,MR-0600,HP0600-001,TestProject,BR6011,H&E,2,SA,TCGA-06.S2.DEID.svs
TCGA-06-5414-01A-01-TS1.660d19f8-1237-47f0-8d5d-71037df4ed67.svs,TCGA-06,DCEG,MR-0600,HP0600-001,TestProject,BR6011,H&E,3,SA,TCGA-06.S3.DEID.svs
TCGA-06-5416-01A-01-TS1.1749a247-c33d-4a06-88f2-4deef3c5d982.svs,TCGA-06,DCEG,MR-0600,HP0600-001,TestProject2,BR6011,H&E,4,SA,TCGA-06.S4.DEID.svs
TCGA-06-5417-01A-01-TS1.a84b8f46-a57d-469d-a65e-4aa5f45da5f3.svs,TCGA-06,DCEG,MR-0600,HP0600-001,TestProject2,BR6011,H&E,5,SA,TCGA-06.S5.DEID.svs
TCGA-06-5418-01A-01-TS1.6600b787-bac7-4ad1-8711-f27bae721e7a.svs,TCGA-06,DCEG,MR-0600,HP0600-001,TestProject2,BR6011,H&E,6,SA,TCGA-06.S6.DEID.svs
TCGA-08-0509-01A-01-TS1.27f6ae4c-e445-4e2e-a94b-31d449ba69c9.svs,TCGA-08,DCEG,MR-0600,HP0600-001,TestProject2,BR6011,H&E,7,SA,TCGA-08.S7.DEID.svs
TCGA-12-0620-01Z-00-DX1.5d4cc50f-9b78-4b8b-8e8e-1c20ae415d71.svs,TCGA-12,DCEG,MR-0600,HP0600-001,TestProject2,BR6011,H&E,8,SA,TCGA-12.S8.DEID.svs
TCGA-12-0654-01C-01-BS1.52cba7d5-7130-48c1-a31e-349f8b12822b.svs,TCGA-12,DCEG,MR-0600,HP0600-001,TestProject2,BR6011,H&E,9,SA,TCGA-12-0654.S9.DEID
TCGA-12-0820-01Z-00-DX1.43DEB9E2-D419-4263-8188-20FEBB070AAF.svs,TCGA-12,DCEG,MR-0600,HP0600-001,TestProject2,BR6011,H&E,10,SA,TCGA-12.S10.DEID.sv
```

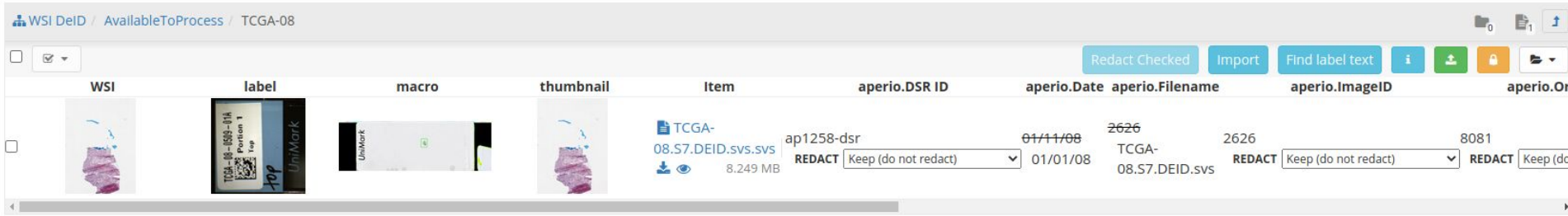
Select Cases for Redaction



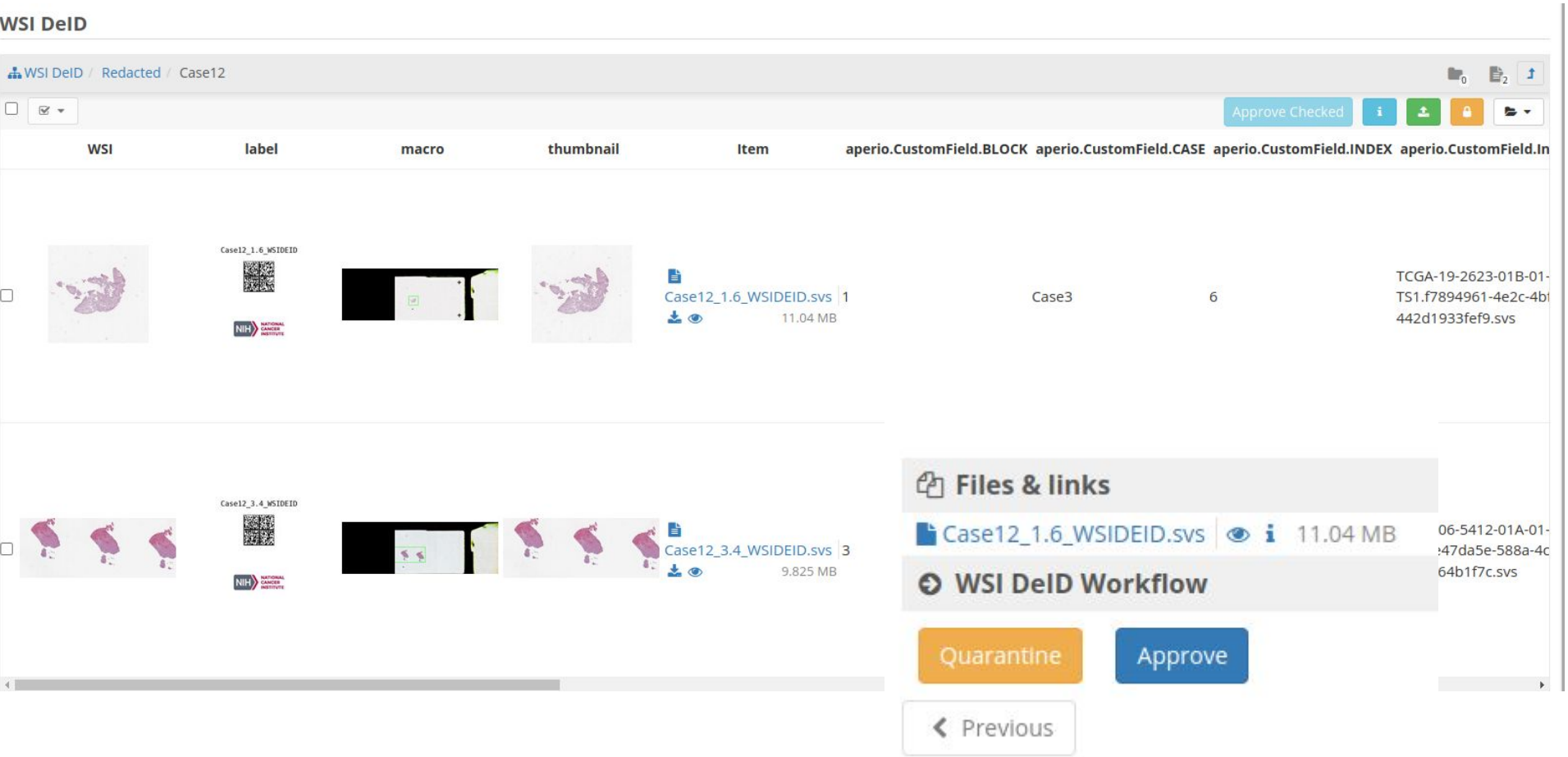
Redact: With Default Profile



Step 2: Images Are Staged for De-ID & Renamed



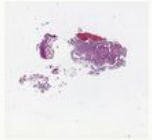
Review Redacted Results



Export Results To Target

WSI DeID / Approved / Patient2

Export Recent | Export All

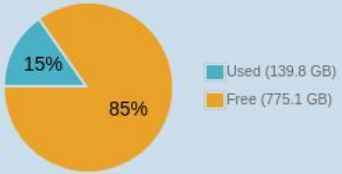
WSI	label	macro	thumbnail	Item	aperio.CustomField.BLOCK	aperio.CustomField.CASE	aperio.CustomField.
							
							

Assetstores

View all past Imports

Below is a list of all of the assetstores available to the server. The one set as "current" is the one that uploaded files will be written to.

Name: Assetstore **(Current assetstore)**
Unique ID: 63bda50af50b104ce17506de
Type: Filesystem
Root path: /assetstore
File creation permissions (octal): 600
Capacity: 775.1 GB free of 914.8 GB total



Edit | Delete | Import data | View past imports

Image Format Whack-a-Mole

Running on a recent .svs fails with default rules due to unexpected keys:

- CalibrationAverageBlue
- CalibrationAverageGreen
- CalibrationAverageRed
- ScannerType
- SessionMode
- Scan Warning

This slide was generated using a Leica GT450. If necessary, we can find a shareable instance.

```
$ ./imagedephi-macOS gui
[2023-05-17 14:34:26 -0500] [44941] [INFO] Running on http://127.0.0.1:65305 (CTRL + C to quit)
Server is running at http://127.0.0.1:65305/ .
Redacting 017a8f83-6be0-63e4-5fe6-125901b4e243_4_5_173735.svs...
Redaction could not be performed for 017a8f83-6be0-63e4-5fe6-125901b4e243_4_5_173735.svs.
The following keys were found in Aperio ImageDescription strings and could not be redacted given the current se
Missing key (Aperio ImageDescription): CalibrationAverageGreen
Missing key (Aperio ImageDescription): ScannerType
Missing key (Aperio ImageDescription): SessionMode
Missing key (Aperio ImageDescription): Scan Warning
Missing key (Aperio ImageDescription): CalibrationAverageRed
Missing key (Aperio ImageDescription): CalibrationAverageBlue
```

Stand Alone App

ImageDePHI

ImageDePHI is an application to redact personal data (PHI) from whole slide images (WSIs).

> This project has been funded in whole or in part with Federal funds from the National Cancer Institute, National Institutes of Health, Department of Health and Human Services, under Contract No. 75N91022C00033

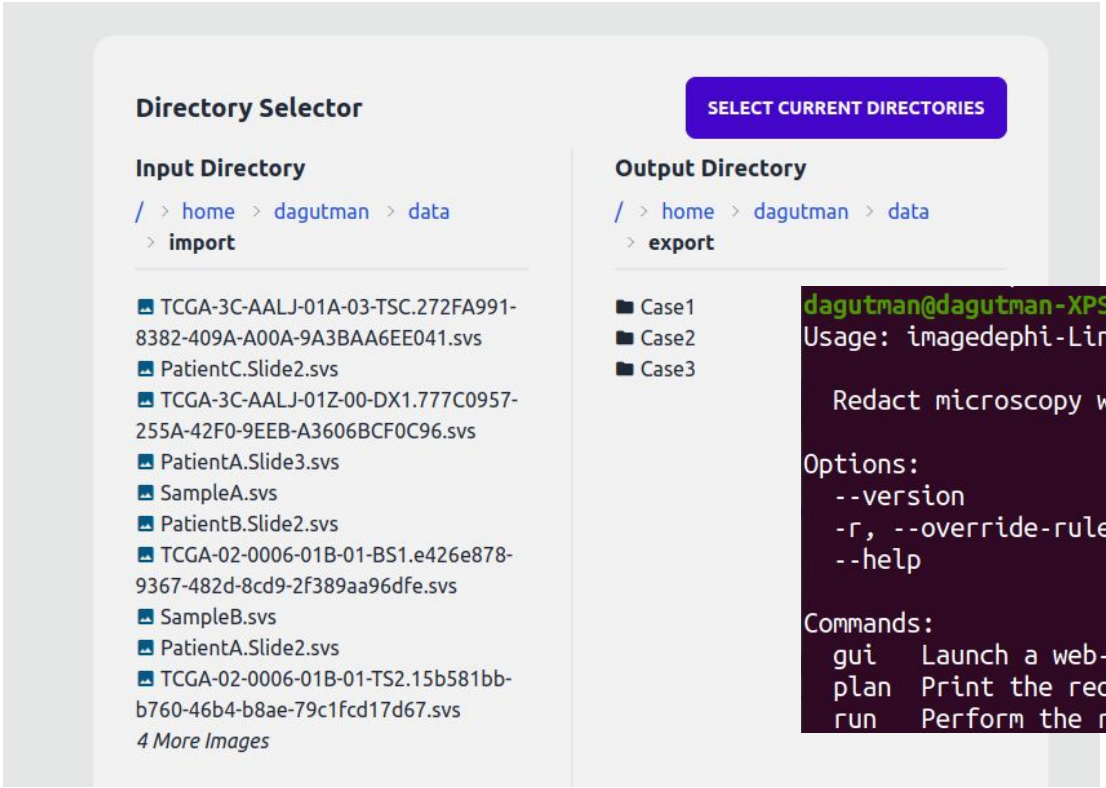
Goal: Standalone application that works on Linux, Windows & MacIntosh

Format Support: SVS, NDPI, Philips TIFF, iSyntax**

https://github.com/DigitalSlideArchive/ImageDePHI

**With appropriately licensed SDK.

ImageDePHI: Basic GUI or command line




```
dagutman@dagutman-XPS-9315:~/Downloads$ ./imagedephi-Linux --help
Usage: imagedephi-Linux [OPTIONS] COMMAND [ARGS]...

  Redact microscopy whole slide images.

Options:
  --version                       Show the version and exit.
  -r, --override-rules FILENAME   User-defined rules to override defaults.
  --help                          Show this message and exit.

Commands:
  gui   Launch a web-based GUI.
  plan  Print the redaction plan for images.
  run   Perform the redaction of images.
```

{"message":"You chose this input directory: /home/dagutman/data/import and this output directory: /home/dagutman/data/export"}

Set it and forget it….

Case1

REDACTED_PatientA.Slide2.svs

REDACTED_PatientC.Slide2.svs

Case2

REDACTED_PatientA.Slide3.svs

REDACTED_SampleA.svs

Case3

REDACTED_PatientA.Slide4.svs

REDACTED_SampleB.svs

DeID Export Job 20221222 181324.xlsx

REDACTED_PatientB.Slide1.svs

REDACTED_TCGA-02-0006-01B-01-BS1.e426e878-9367-482d-8cd9-2f389aa96dfe.svs

REDACTED_PatientA.Slide1.svs

REDACTED_PatientB.Slide2.svs

REDACTED_TCGA-02-0006-01B-01-TS2.15b581bb-b760-46b4-b8ae-79c1fcd17d67….

What did it do?

```
TRL + C to quit)
Server is running at http://127.0.0.1:41011/ .
Redacting TCGA-3C-AALJ-01A-03-TSC.272FA991-8382-409A-A00A-9A3BAA6EE041.svs...
Redacting PatientC.Slide2.svs...
Redacting TCGA-3C-AALJ-01Z-00-DX1.777C0957-255A-42F0-9EEB-A3606BCF0C96.svs...
Redacting PatientA.Slide3.svs...
Redacting SampleA.svs...
Redacting PatientB.Slide2.svs...
Redacting TCGA-02-0006-01B-01-BS1.e426e878-9367-482d-8cd9-2f389aa96dfe.svs...
Redacting SampleB.svs...
Redacting PatientA.Slide2.svs...
Redacting TCGA-02-0006-01B-01-TS2.15b581bb-b760-46b4-b8ae-79c1fcd17d67.svs...
```

```
Tiff Tag 32997 - ImageDepth: keep (base)
Tiff Tag 273 - StripOffsets: keep (base)
Tiff Tag 278 - RowsPerStrip: keep (base)
Tiff Tag 279 - StripByteCounts: keep (base)
Tiff Tag 317 - Predictor: keep (base)
SVS Image Description - AppMag: keep (base)
SVS Image Description - StripeWidth: keep (base)
SVS Image Description - ScanScope ID: delete (base)
SVS Image Description - Filename: delete (base)
SVS Image Description - Title: delete (base)
SVS Image Description - Date: delete (base)
SVS Image Description - Time: delete (base)
SVS Image Description - User: delete (base)
SVS Image Description - MPP: keep (base)
SVS Image Description - Left: keep (base)
SVS Image Description - Top: keep (base)
SVS Image Description - LineCameraSkew: keep (base)
SVS Image Description - LineAreaXOffset: keep (base)
SVS Image Description - LineAreaYOffset: keep (base)
SVS Image Description - DSR ID: delete (base)
SVS Image Description - ImageID: delete (base)
SVS Image Description - OriginalWidth: keep (base)
SVS Image Description - Originalheight: keep (base)
The redaction plan is comprehensive.
```

Thanks

Lee AD Cooper (Northwestern)
David Manthey (Kitware)
Juan Carlos Vizcarra (Emory)
Alison Van Dyke (NCI)
Scott Lawrence (NCI)

Questions: Email me at dgutman@emory.edu or dagutman@gmail.com

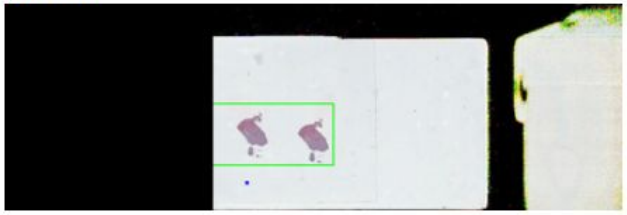
Supported by NCI ITCR U24CA194362, U01-AG061357-04

and NCI SBIR Contract No. 75N91022C00033

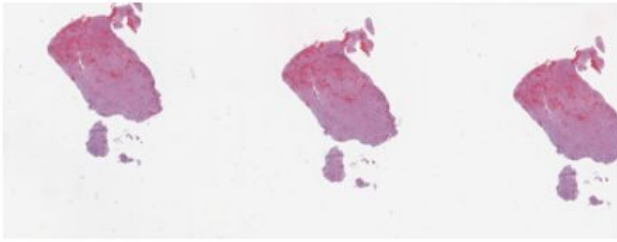
Label

Patient3_3.5_WSIDEID

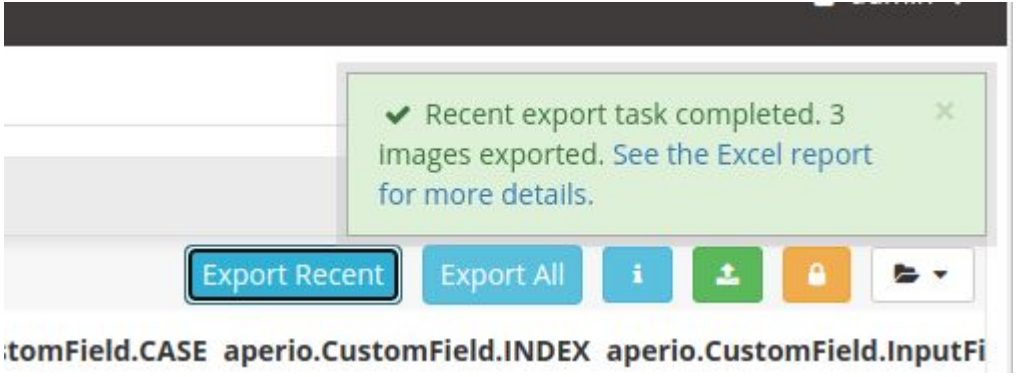
Macro



Thumbnail



NIH NATIONAL CANCER INSTITUTE



Info

335.6 MB (351938845 bytes)

Created on May 23, 2023 at 9:56:39

Updated on May 23, 2023 at 9:56:39

Unique ID: 646cc6170ebbcb64be7b1a48

Image Viewer

Clear Area | Other PHI/PII | Reject | Keep (do not reject)