BUILDING YOUR WITTY LAB:
TOOLS FOR ANALYZING MICROSCOPY DATA

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https://github.com/dani-lbnl/2017_ucberkeley_course

CLEVER IN PERCEPTION & EXPRESSION

[wit-ee]

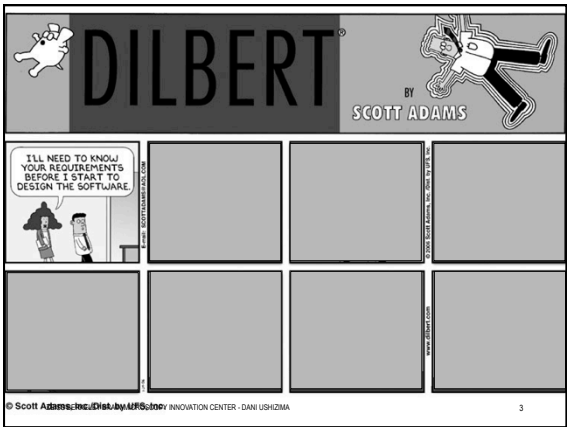
Spell Syllables

Synonyms Examples Word Origin

See more synonyms on Thesaurus.com

adjective, wittier, wittiest.

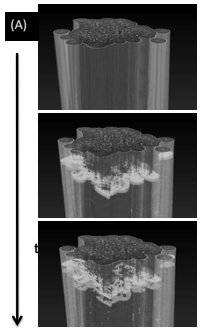
1. possessing wit in speech or writing; amusingly clever in perception and expression:
   a witty writer.
2. characterized by wit :



Collaborations among national labs, academia and industry

USE-CASES

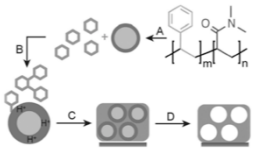
Quantification of micro-structural damage



(A) Rendering of samples under deformation after image processing and analysis to detect the matrix (gray) and fibers (red) of a single tow at different applied loads, leading to microfractures (blue); (B) Deployed tool: F3D.

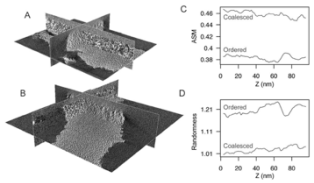
Ushizima, Perciano, Krishnan, Parkinson. "Fast Detection of Material Deformation through Structural Dissimilarity", IEEE Int. Conf on Big Data, 2015.
Donatelli, Hesse, Ringler, Trebotich, Colella, Ushizima, Yang, Sethian. "CAMERA: The Center for Advanced Mathematics for Energy Research Applications". Synchrotron Radiation News, 28:2. 2015.

Quality control during assembly of films



- Porosimetry for finding the lowest ever dielectric constants for PMO matrix material, used in microelectronics;
- Delivered analysis method, second-order statistics of

Metrology of material architecture and porosimetry

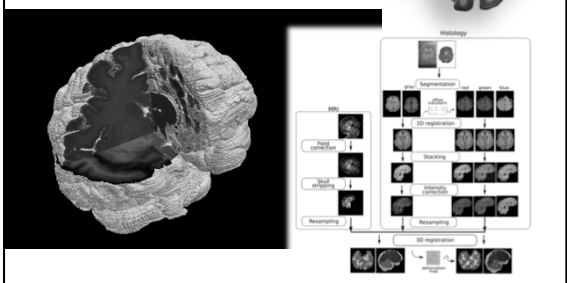


. Wills, Michalak, Ercius, Rosenberg, Perciano, Ushizima, Runser and Helms. "Block Copolymer Packing Limits and Interfacial Recongurability in the Assembly of Periodic Mesoporous Organosilicas". Advanced Functional Materials, 4120-4128, 2015.

PATHWAY TOWARD DIAGNOSING AND MONITORING PRODROMAL ALZHEIMER'S DISEASE USING NOVEL IMAGING BIOMARKERS

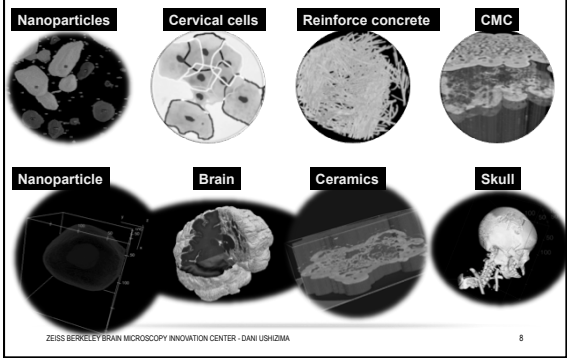
Lea T. Grinberg, M.D, Ph.D (UCSF), Maryana Alegro, Ph.D (UCSF/LBNL) and Dani Ushizima, Ph.D (LBNL/BIDS)

Tissue



Alegro, Amaro, Heisen, Loring, Alho, Zollei, Ushizima, Grinberg, "Multimodal whole brain registrations: MRI and high resolution histology", IEEE CVPR 2016.

IMAGE ACROSS DOMAINS WITH FREE TOOLS



OUTLINE

1. Image format and metadata
2. Image enhancement and filtering
3. Image statistics
4. Image segmentation: super-pixel to object
5. Object description
6. Object classification
7. Object visualization

SOFTWARE TOOLS

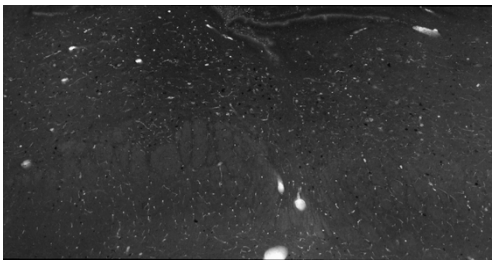
A. ImageJ, Fiji
B. Python, ipython, jupyter notebooks
C. R, Rstudio
D. Paraview, Tomviz

CONNECTING THE DOTS

1. Image format and metadata
2. Image enhancement and filtering
3. Image statistics
4. Image segmentation
5. Object description
6. Object classification
7. Object visualization

A. Fiji
B. Python
C. R
D. Tomviz

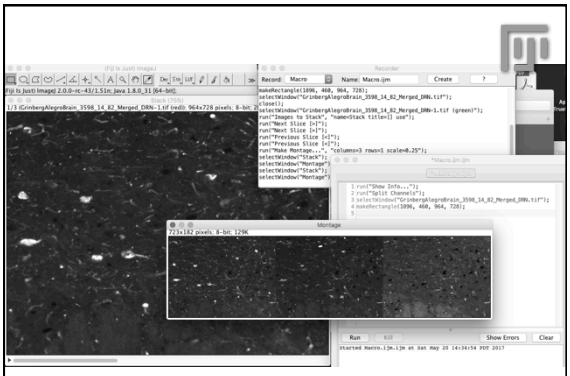
DATA: NEURONS UNDER IMMUNOFLUORESCENCE



Courtesy: Grinberg's lab - http://memory.ucsf.edu/ourcenter/staff/lgrinberg

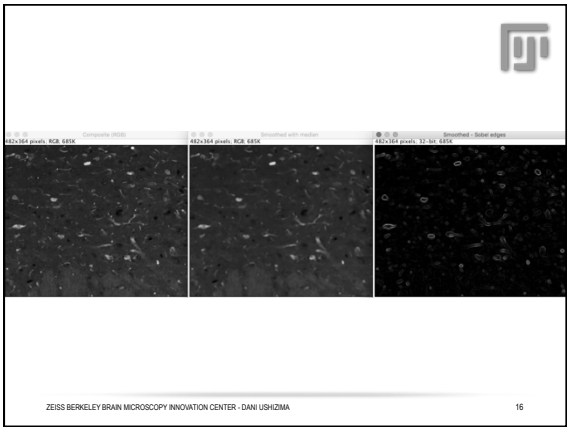
1. IMAGE FORMAT AND METADATA

a) Other info & metadata – Cmd + I
b) Macro
c) Image size
d) Best sample for prototyping
e) Color channels and stacks
f) Montage



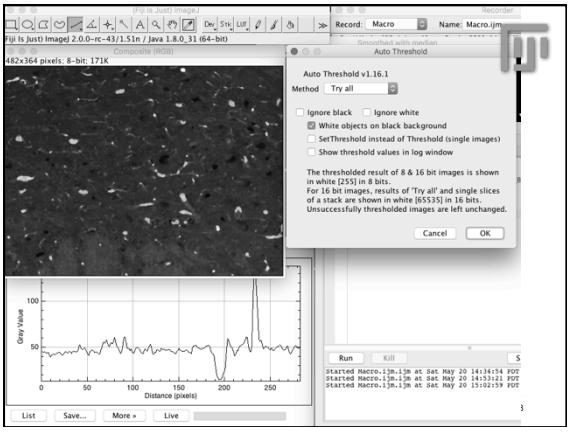
2. IMAGE ENHANCEMENT AND FILTERING

a) Crop and resize
b) Color, grayscale and LUT
c) Enhancement for what? Smooth vs. crispy
d) Border detection
e) Create an animated gif



3. IMAGE STATISTICS

a) Profile – Cmd+K
b) Image histogram
c) Enhance with histogram
d) Segment with thresholding - Cmd+Shift+t
e) Algorithms to automate thresholding
f) Overlay your results

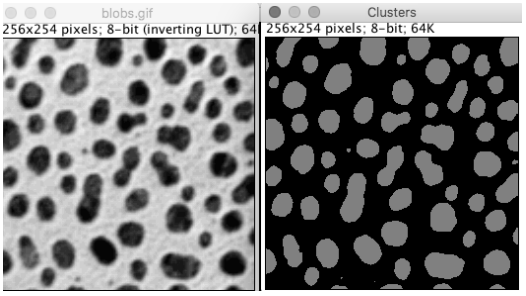


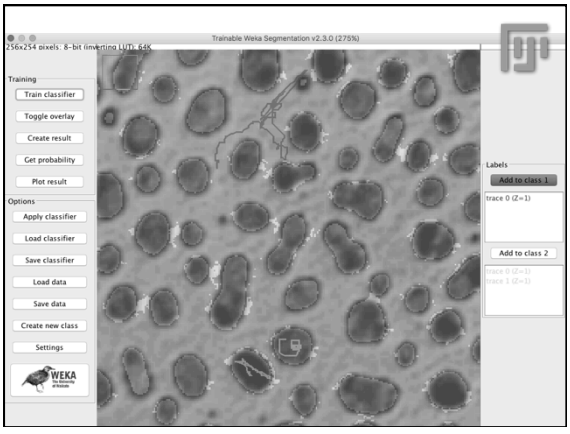
4. IMAGE SEGMENTATION

a) Thresholding
b) K-means
c) Statistical region merging
d) Clustering and super-pixel
e) Machine learning and images
f) Weka

Statistical Region Merging

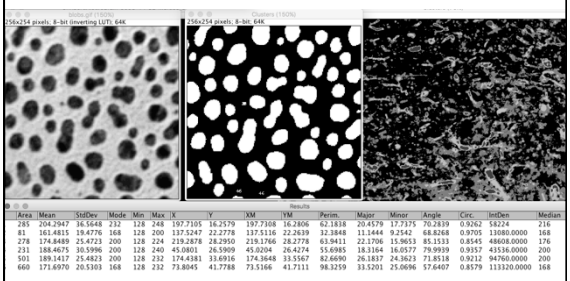
K-means





5. OBJECT DESCRIPTION

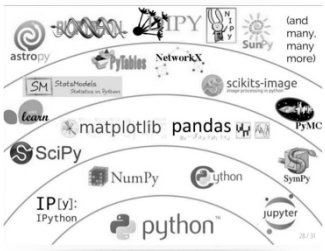
- Feature extraction for compact image representation - calculate characteristics;
- Type of dimensionality reduction that translates interesting parts of an image (regions of interest or ROIs) as a compact feature vector;
- Examples of features:
  - Shape
  - Color
  - Texture
  - Motion



Area	Mean	StdDev	Mode	Min	Max	X	Y	XM	YM	Perim.	Major	Minor	Angle	Circ.	IntDen	Median
285	204.2947	36.5648	232	128	248	197.7105	16.2579	197.7108	16.2806	62.1838	20.4579	17.7375	70.2839	0.9262	58224	216
81	161.4815	19.4776	168	128	200	137.5247	22.2778	137.5116	22.2639	32.3848	11.1444	9.2542	68.8268	0.9705	13080.0000	168
278	174.8489	25.4723	200	128	224	219.2878	28.2950	219.1766	28.2778	63.9411	22.1706	15.9653	85.1533	0.8545	48608.0000	176
231	188.4675	30.5996	200	128	240	45.0801	26.5909	45.0204	26.4274	55.6985	18.3164	16.0577	79.9939	0.9357	43536.0000	200
501	189.1417	25.4823	200	128	232	174.4381	33.6916	174.3648	33.5567	82.6690	26.1837	24.3623	71.8518	0.9212	94760.0000	200
660	171.6970	20.5303	168	128	232	73.8045	41.7788	73.5166	41.7111	98.3259	33.5201	25.0696	57.6407	0.8579	113320.0000	168

Python

How to navigate and choose among the several scientific computing packages freely available for Python?



@jakevdp

USING PYTHON FOR IMAGES

Software

Python for Science

- Python

If you are new to Python, please install the Anaconda distribution for **Python version 3** (available on OSX, Linux and Windows). Or, feel free to use your favorite distribution, but please ensure the requirements below are met:

- `numpy` >= 1.11
- `scipy` >= 0.18
- `matplotlib` >= 2.0
- `skimage` >= 0.12
- `sklearn` >= 0.18
- `dask` >= 0.14
- `keras` >= 1.2
- `tensorflow` >= 1.0
- `notebook` >= 4.0

In Anaconda, install these packages with:

```
conda install numpy scipy matplotlib jupyter scikit-image scikit-learn dask
pip install conda tensorflow  # or tensorflow-gpu if you have an Nvidia graphics card
```

In any other Python distribution, use pip:

```
pip install numpy scipy matplotlib jupyter scikit-image scikit-learn dask keras tensorflow  # or tensorflow-gpu if you have an Nvidia gra
phics card
```

In the next section below, we provide a test script to confirm the version numbers on your system.

Test your setup

Please run this test script to verify your package versions.

Source: http://www.imagexd.org/2017/03/20/tutorial-materials.html

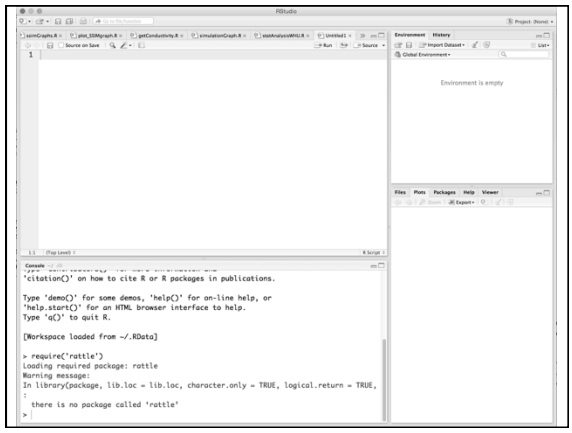
FEATURE EXTRACTION METHODS

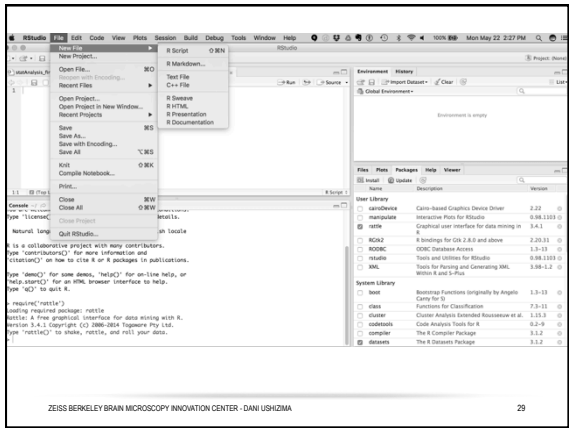
- Signature = index = feature vector = descriptors;

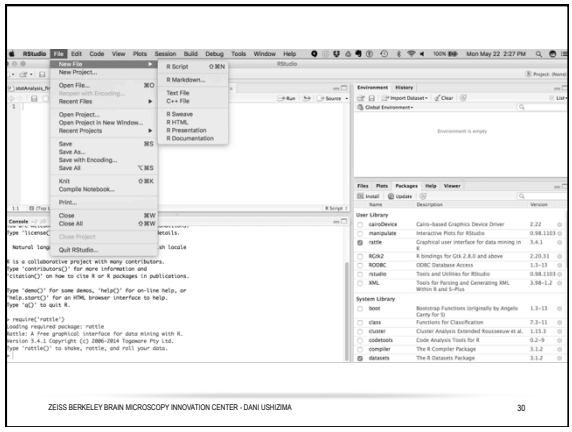
1. Gray Level Co-Occurrence Matrix;
2. Histogram of Oriented Gradient;
3. First Order Texture Features;
4. Local Binary Pattern;
5. Convolutional Neural Network.

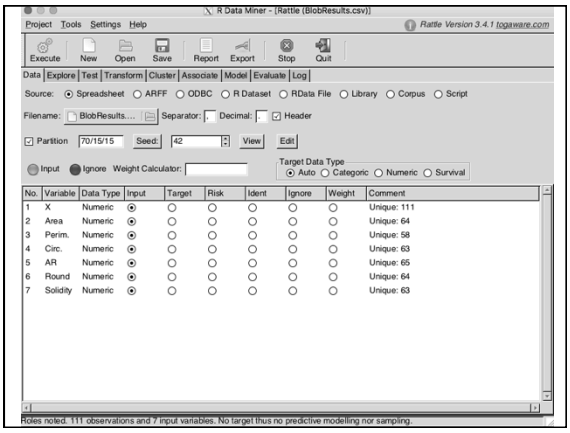
6. OBJECT CLASSIFICATION

Representation:	Learning:	Recognition:
how to encode an object category	how to construct a classifier from prototypes (training data)	how a classifier will be used on novel data


RStudio
Environment is empty
'citation()' on how to cite R or R packages in publications.
Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.
[Workspace loaded from ~/.RData]
> require('rattle')
Loading required package: rattle
Warning message:
In library(package, lib.loc = lib.loc, character.only = TRUE, logical.return = TRUE,
there is no package called 'rattle'

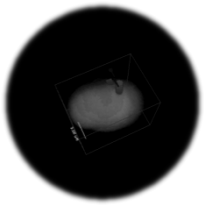

ZEISS BERKELEY BRAIN MICROSCOPY INNOVATION CENTER - DANI USHIZIMA
29

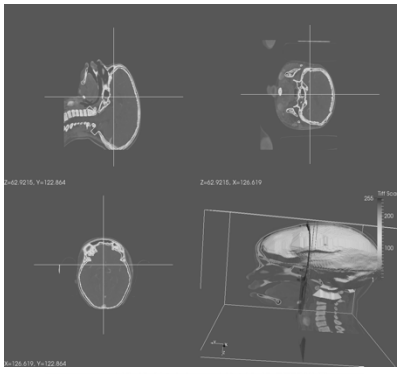

ZEISS BERKELEY BRAIN MICROSCOPY INNOVATION CENTER - DANI USHIZIMA
30



7. OBJECT VISUALIZATION

a)2D plots
b)2D images
c)3D volumes
d)Dynamic 3D volumes





SEARCHING VISUALLY: NOW AND THE FUTURE

- Searching visually will become virtually interface-free;
- Search within context: science domain.

Made in UC Berkeley

pyCBIR

IDEAL

Institute for Data Science

Applied Math

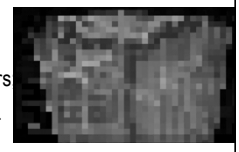
TAKE HOME MESSAGE

New data regimes:

- High-throughput, high-resolution instruments;
- Multimodal experiments and massive datasets;
- Searching, ranking, benchmarking, reproducibility;

New computing infrastructures:

- Laptop, servers, super computers
- Cloud: AWS, Azure, Google, etc.



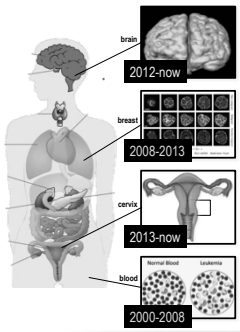
DISCLAIMER

BERKELEY INSTITUTE FOR DATA SCIENCE

SELECTED JOURNALS

- Alegro, Theofilas, Nguy, Castruita, Seeley, Ushizima, Grinberg, *Classification in Human Brain Fluorescent Microscopy Images Using Dictionary Learning and Sparse Coding*, Journal of Neuroscience Methods, 2017.
- Ushizima, Bale, Bethel, Ercius, Helms, Krishnam, Grinberg, Haranczyk, Macdowell, Odziomek, Parkinson, Perciano, Ritchie, Yang. *IDEAL: Images across Domains, Experiments, Algorithms and Learning*, Journal of Minerals, Metals and Materials, 2016, 68(11), 2963-2972.
- Odziomek, Ushizima, Oberbek, Kurzydlowski, Puzyn, *Scanning electron microscopy image representativeness: morphological data on nanoparticles*, Journal of Microscopy, 2016.
- Santos, Bianchi, Ushizima, Pavinatto, Bianchi, *Ammonia gas sensor based on the frequency-dependent impedance characteristics of ultrathin polyaniline films*, Sensors and Actuators A: Physical, 2016.
- Venkatakrishnan, Mohan, Beattie, Correa, Dart, Deslippe, Hexemer, Krishnan, MacDowell, Marchesini, Patton, Perciano, Sethian, Stromsness, Tierney, Ushizima, Parkinson, *Making Advanced Scientific Algorithms and Big Scientific Data Management More Accessible*, Electronic Imaging, 19, pp.1-7, 2016.
- Wills, Michalak, Ercius, Rosenberg, Perciano, Ushizima, Runser, Helms, *Block Copolymer Packing Limits and Interfacial Reconfigurability in the Assembly of Periodic Mesoporous Organosilicas*. Advanced Functional Materials, 2015.
- Donatelli, Haranczyk, Hexemer, Krishnan, Li, Lin, Maia, Marchesini, Parkinson, Perciano, Shapiro, Ushizima, Yang, Sethian. *CAMERA: The Center for Advanced Mathematics for Energy Research Applications*. Synchrotron Radiation News, 28:2, 2015.

COMPUTATIONAL HEALTH SCIENCE - @DANI_LBNL



- Problem:
  - Quantification from images;
- Approach:
  - Bio: detect and track biomarkers associated to the progression of diseases;
  - Math: schemes for image representation, segmentation, characterization, classification, ML;
- Expected impact:
  - Software to measure and reproduce experiments;
  - Develop new treatments that target individuals more precisely.