WELCOME

RIGAKU WEBINAR SERIES X-RAY COMPUTED TOMOGRAPHY FOR MATERIALS SCIENCE – DATA ANALYSIS George and

IS STARTING NOW.





Presenter: Aya Takase

Senior Scientist Rigaku Americas Corporation



Host: Tom McNulty

Senior Vice President Rigaku Americas Corporation





You can send us questions during the presentation. They will be addressed at the end of the presentation.





A recording of this webinar will be available. You will receive an email with a link to it tomorrow.



X-RAY COMPUTED TOMOGRAPHY FOR MATERIALS SCIENCE Data Analysis



2 -2

1 1 5

Repetitive Strain Injury























WHAT EXACTLY ARE X-RAY CT IMAGES?



3D rendering













TIFF stack











WHAT DO "WE" SEE?









WHAT ABOUT COMPUTERS?





File format: TIFF File size: 512 x 512 x 512 200 239 229 195 66 147 247 218 98 95 138 93 238 176 11 20 242 157 62 18 214 93 200 117 202 144 242 119 231 24 77 32 236 227 254 124 234 183 246 121 23 213 168 133 219 142 161 162 203 183 11



HOW ARE WE GOING TO WORK TOGETHER?



Do you speak binary?







Do you speak numbers?



Yes.





I know histograms.



Histograms?





WHAT IS A HISTOGRAM?





















LET'S GO THROUGH AN EXAMPLE









Segmentation


























Segmentation (Pixel labeling)

Object labeling

Quantitative analysis



QUANTITATIVE ANALYSES

- Volume %
- Object size / volume
- Object surface area
- Object aspect ratio
- Fiber orientation
- Layer thickness

Rigaku











WHAT IS IMAGE QUALITY?



- Resolution
- Contrast
- Noise level



- Resolution
- Contrast
- Noise level



Low resolution Blur





High resolution Sharp





- Resolution
- Contrast
- Noise level





Low contrast

Low dynamic range





High contrast High dynamic range





- Resolution
- Contrast
- Noise level





High noise

Low noise









- Resolution
- Contrast
- Noise level



Reality









Ideal situation

























WHAT IS IMAGE PROCESSING?



CONTRAST ENHANCEMENT







NOISE REDUCTION



Original



Gaussian blur



P1	P2	Ρ3	
Ρ4	P5	P6	
Ρ7	P8	P9	

 $P5 = \frac{1}{9} \sum_{j=1}^{9} P_j$



NOISE REDUCTION



Original



Gaussian blur



EDGE ENHANCEMENT





Gaussian blur

Unsharp mask





Original

Smoothing (Median 3 px)

Unsharp mask



Two phase segmentation



Original







HOW DO YOU SEGMENT IMAGES?



IMAGE SEGMENTATION

- Histogram thresholding
- Machine learning
- Deep learning
- Manual painting





IMAGE SEGMENTATION

- Histogram thresholding
- Machine learning
- Deep learning
- Manual painting



















MORPHOLOGICAL OPERATIONS

- Erode
- Dilate
- Open
- Close

















"Close" connects objects, cleans up holes Dilate Erode


MORPHOLOGICAL OPERATIONS

- Erode
- Dilate
- Open
- Close







Phase A pixels



Phase A objects







Histogram thresholding Morphological operation Property filtering





CAN WE TRY THOSE TECHNIQUES ON AN ACTUAL CT DATA?









Thresholding





"Close" on blue/air pixels





"Close" on blue/air pixels





"Close" on yellow/polymer pixels





"Close" on yellow/polymer pixels





Eliminate small objects









Raw image





Polymer

Air



CAN YOU SEPARATE INDIVIDUAL CELLS?





DRVISION AIVIA



Distance transform





Watershed







Watershed







Watershed























- Thresholding
- Close operation x 2
- Volume filtering
- Object separation





ISN'T THERE AN EASIER WAY?



IMAGE SEGMENTATION

- Histogram thresholding
- Machine learning
- Deep learning
- Manual painting





Can you recognize objects?

No. Not yet.







But I can learn.







WHAT IS MACHINE LEARNING?























HOW DOES THIS APPLY TO IMAGES?




Input features

















Raw image





Polymer

Air



Orally disintegrating tablet

Single particle CT



Segmented volumes



Cu anode, 0.54 µm/voxel

















WHAT IS DEEP LEARNING?



Logistic Regression Decision Tree Random Forest K-Nearest etc.









Biological neural network

Artificial neural network





















TO LEARN MORE ABOUT DEEP LEARNING



DEEP LEARNING CHAPTER 1 INTRODUCTION

by Ian Goodfellow





INTRODUCTION TO DEEP LEARNING

by Mike Marsh



Introduction to Deep Learning Posted 2018.08.29



NEURAL NETWORKS

by 3Blue1Brown



Neural networks

4 videos • 710,862 views • Last updated on Aug 1, 2018



WHAT KIND OF SOFTWARE ARE OUT THERE?



COMMERCIAL

- Dragonfly (ORS) <u>theobjects.com</u>
- Avizo (Thermo Fisher): <u>fei.com</u>
- VG STUDIO (Volume Graphics): <u>volumegraphics.com</u>
- AIVIA (DRVISION): <u>drvtechnologies.com</u>
- I2S (DigiM): <u>digimsolution.com</u>



OPEN SOURCES

- Fiji (ImageJ NIH): <u>fiji.sc/</u>
- WEKA (via Fiji): <u>cs.waikato.ac.nz/ml/weka/</u>

Waikato Environment for Knowledge Analysis



















ALL IMAGES WERE COLLECTED ON...



nano3DX CT Lab HX CT Lab GX







To learn more ...



Rigaku.com → Contact





Next on X-ray computed tomography *Food and Pharmaceutical Applications*

September 25th Wednesday 11:00 am PDT / 2:00 pm EDT



Q & A SESSION



Aya Takase



Tom McNulty











We'll follow up with your questions.

Recording will be available tomorrow.

Register for the 3nd webinar.



THANK YOU FOR JOINING US SEE YOU NEXT TIME!

