BRINGING MEDICAL IMAGING DATA TO LIFE

Jan Margeta | jan@kardio.me | @jmargeta

KardioMe

DATA DELUGE AND AI

MORE DATA THAN EVER BEFORE

EVERY 18 SECONDS

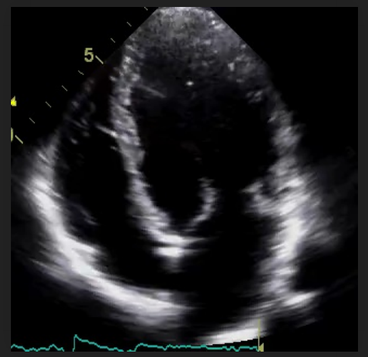
45%

IMAGING IN CARDIOLOGY

X-Ray

Kelly 2007

ultrasound



Carmo et al. 2010

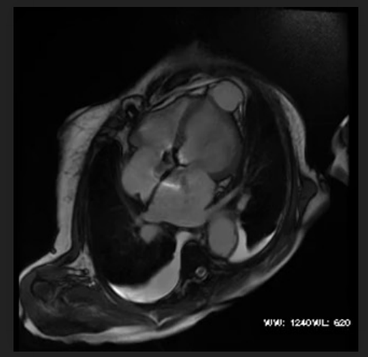
fluoroscopy

Arnold et al. 2008

computed tomography

Foley et al. 2010

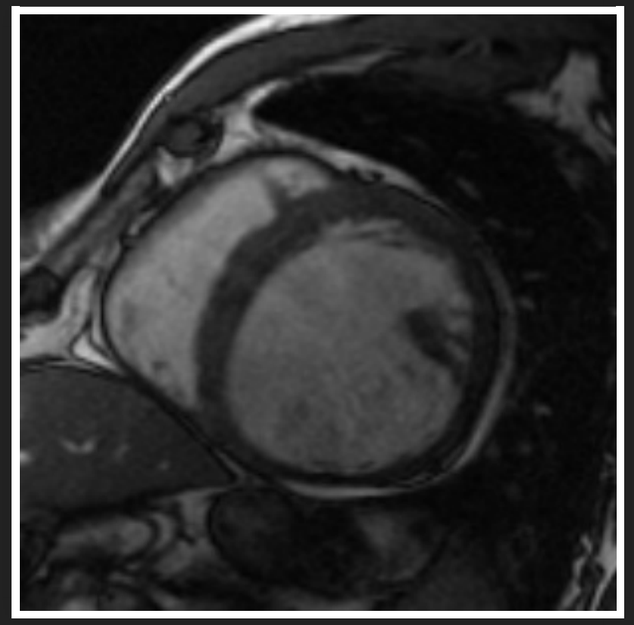
magnetic resonance



Vanezis et al. 2011

SPOT THE DIFFERENCES

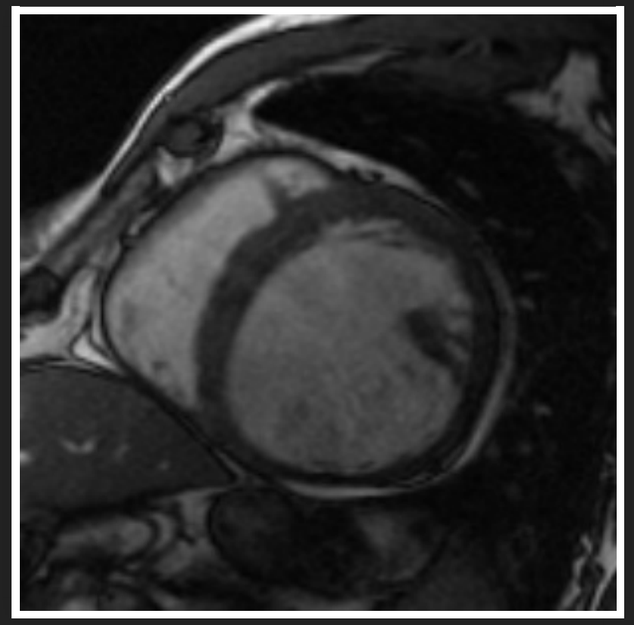
?



?

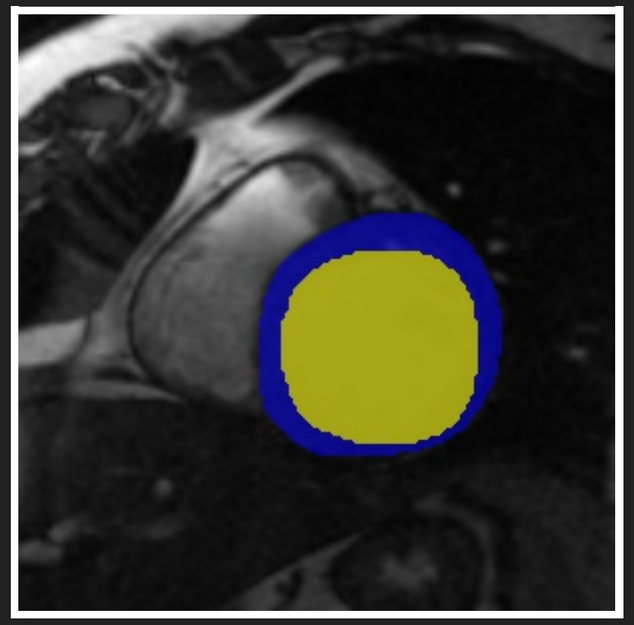
SPOT THE DIFFERENCES

HEALTHY

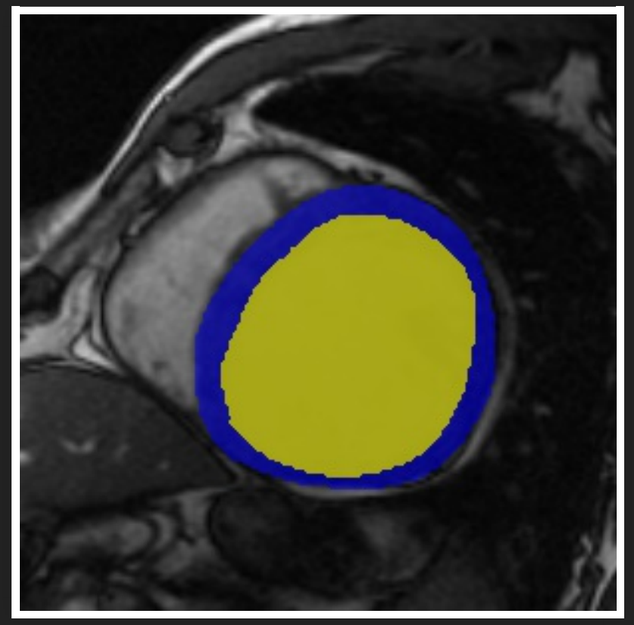


ISCHEMIC HEART FAILURE

MEASURE THE DIFFERENCES



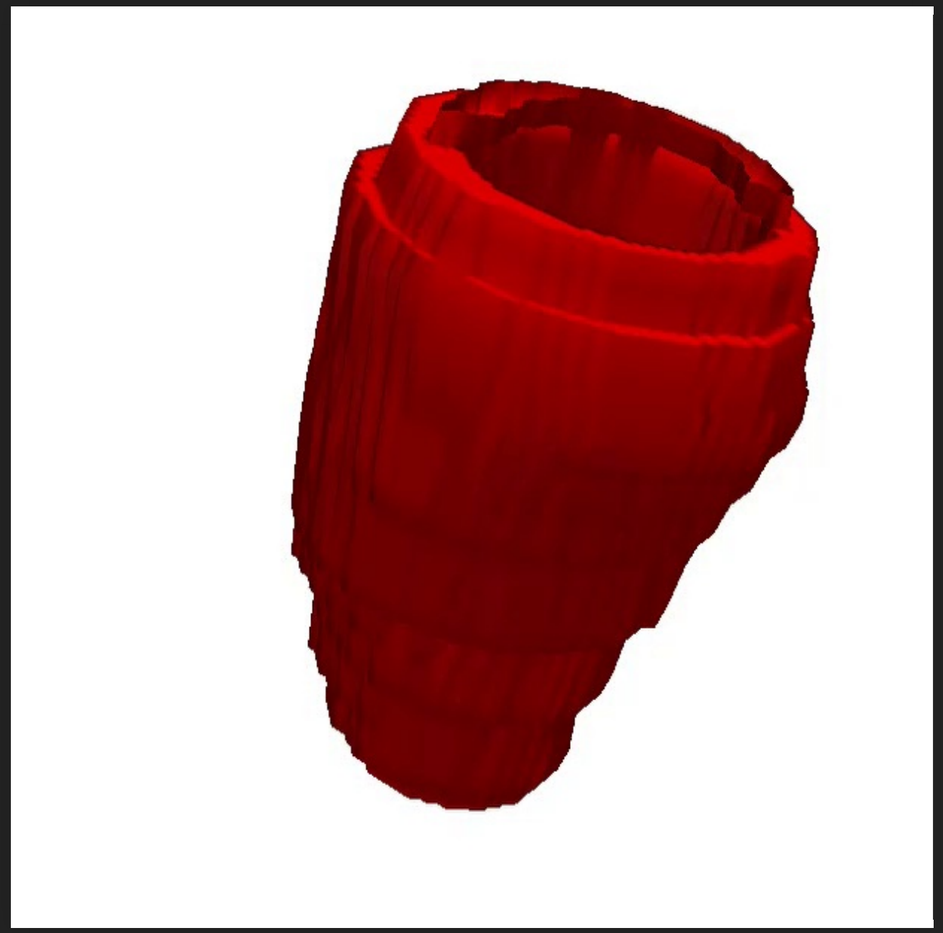
VOLUME: 142 ML



VOLUME: 212 ML

SEGMENTATION

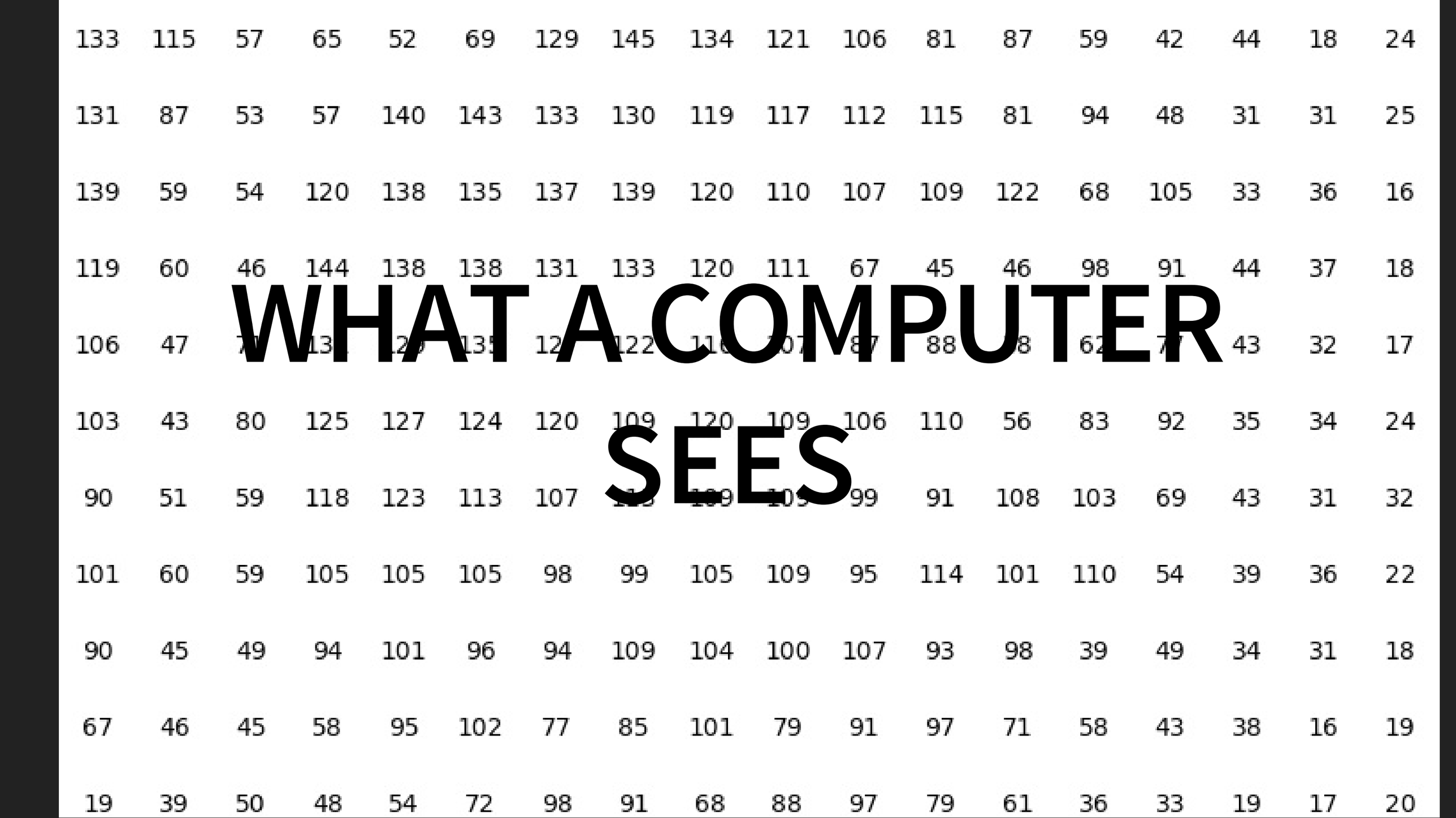
Xue et al. 2013



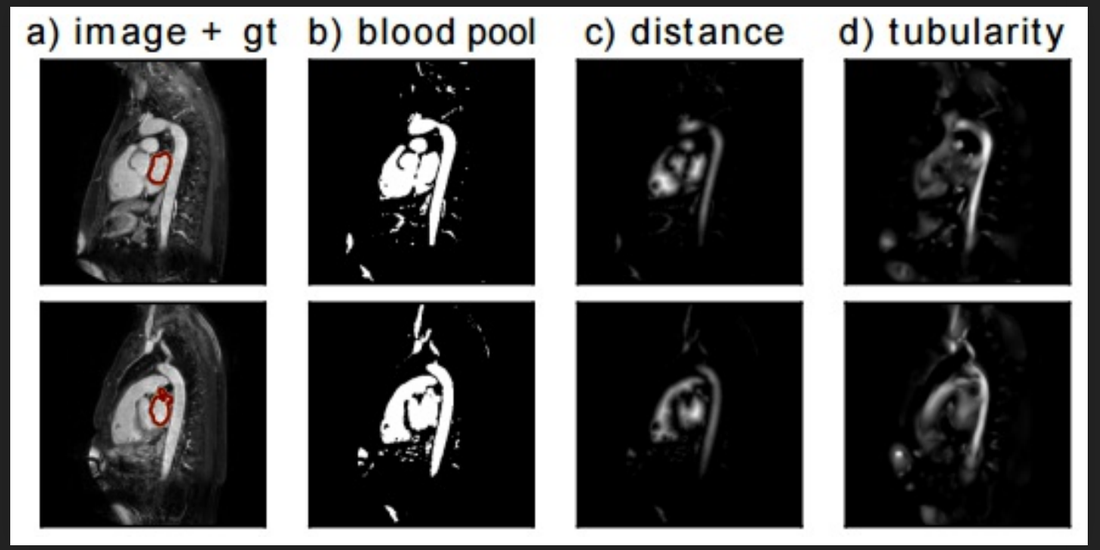
30 minutes to do manually


WHAT A HUMAN
SEES

WHAT A HUMAN SEES


133 115 57 65 52 69 129 145 134 121 106 81 87 59 42 44 18 24
131 87 53 57 140 143 133 130 119 117 112 115 81 94 48 31 31 25
139 59 54 120 138 135 137 139 120 110 107 109 122 68 105 33 36 16
119 60 46 144 138 138 131 133 120 111 67 45 46 98 91 44 37 18
106 47 43 32 17
103 43 80 125 127 124 120 109 120 109 106 110 56 83 92 35 34 24
90 51 59 118 123 113 107 99 91 108 103 69 43 31 32
101 60 59 105 105 105 98 99 105 109 95 114 101 110 54 39 36 22
90 45 49 94 101 96 94 109 104 100 107 93 98 39 49 34 31 18
67 46 45 58 95 102 77 85 101 79 91 97 71 58 43 38 16 19
19 39 50 48 54 72 98 91 68 88 97 79 61 36 33 19 17 20
WHAT A COMPUTER
SEES

WELCOME TO COMPUTER VISION



Margeta et al. 2013, Joint work with Inria and Microsoft Research Cambridge

Tobon-Gomez et al. 2013

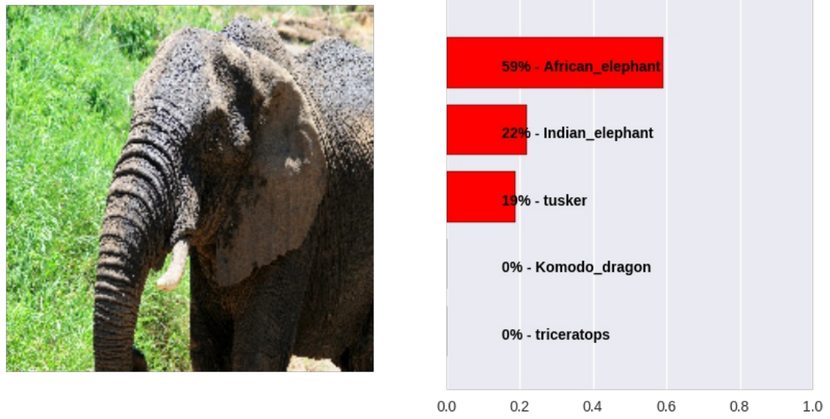
MACHINE LEARNING

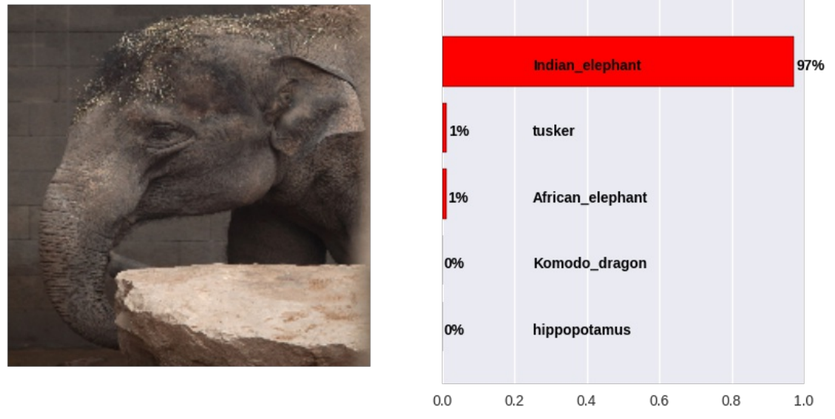
SOLVING PROBLEMS WITH DATA

prediction = *predict* (**data**, **model**)

IMAGE RECOGNITION IN 6 LINES OF CODE

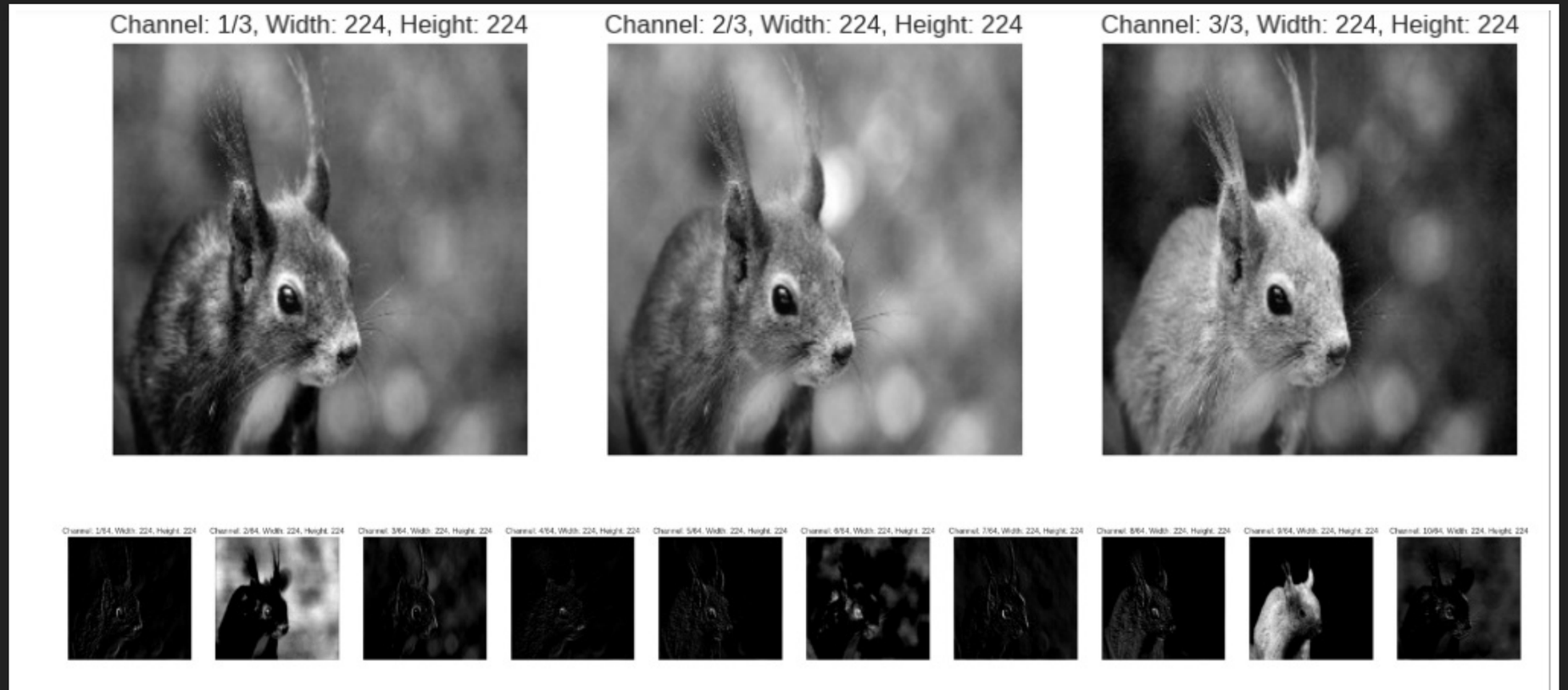
```
from keras.applications import imagenet_utils
from keras.applications.vgg16 import VGG16

# Load and prepare input images
images_raw = load_images()
images = imagenet_utils.preprocess_input(images_raw)

# Load a pretrained image classification model
model = VGG16(include_top=True, weights='imagenet')

# Do the prediction
predictions = model.predict(images)
```



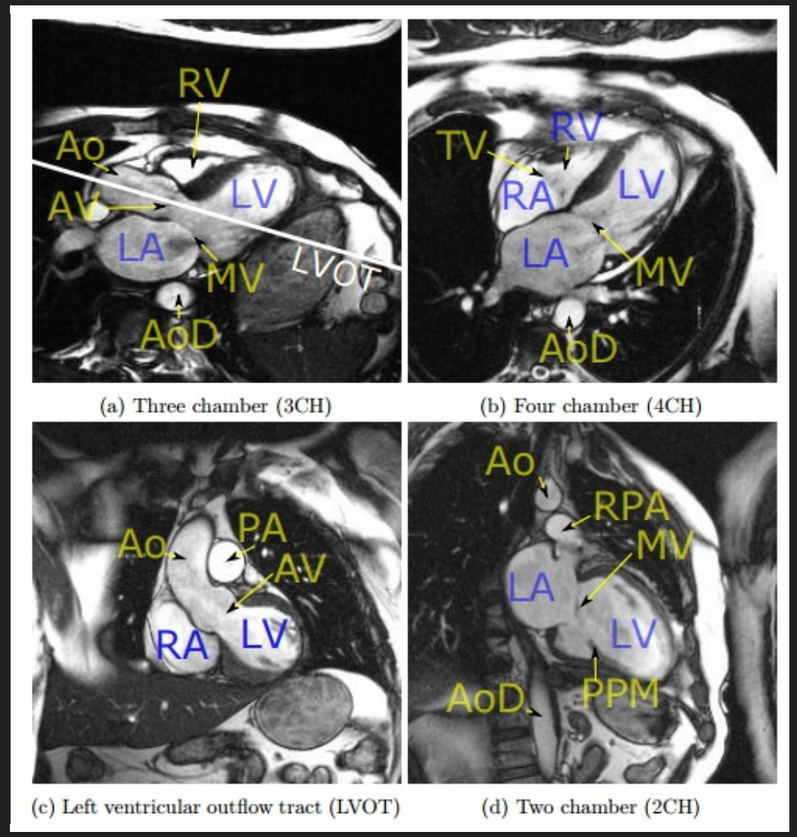


EXCELLENT FOR NATURAL IMAGES

FINDING THE IMAGE REPRESENTATION



CARDIAC VIEW RECOGNITION

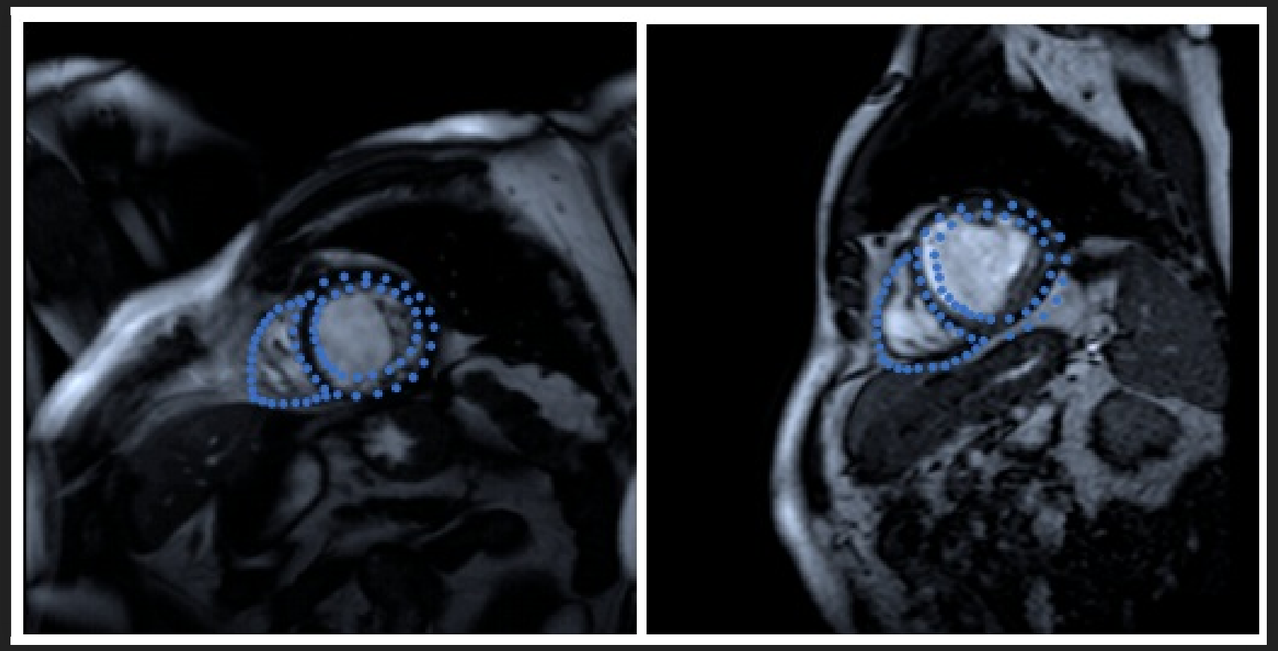


(a) Three chamber (3CH) (b) Four chamber (4CH)

(c) Left ventricular outflow tract (LVOT) (d) Two chamber (2CH)

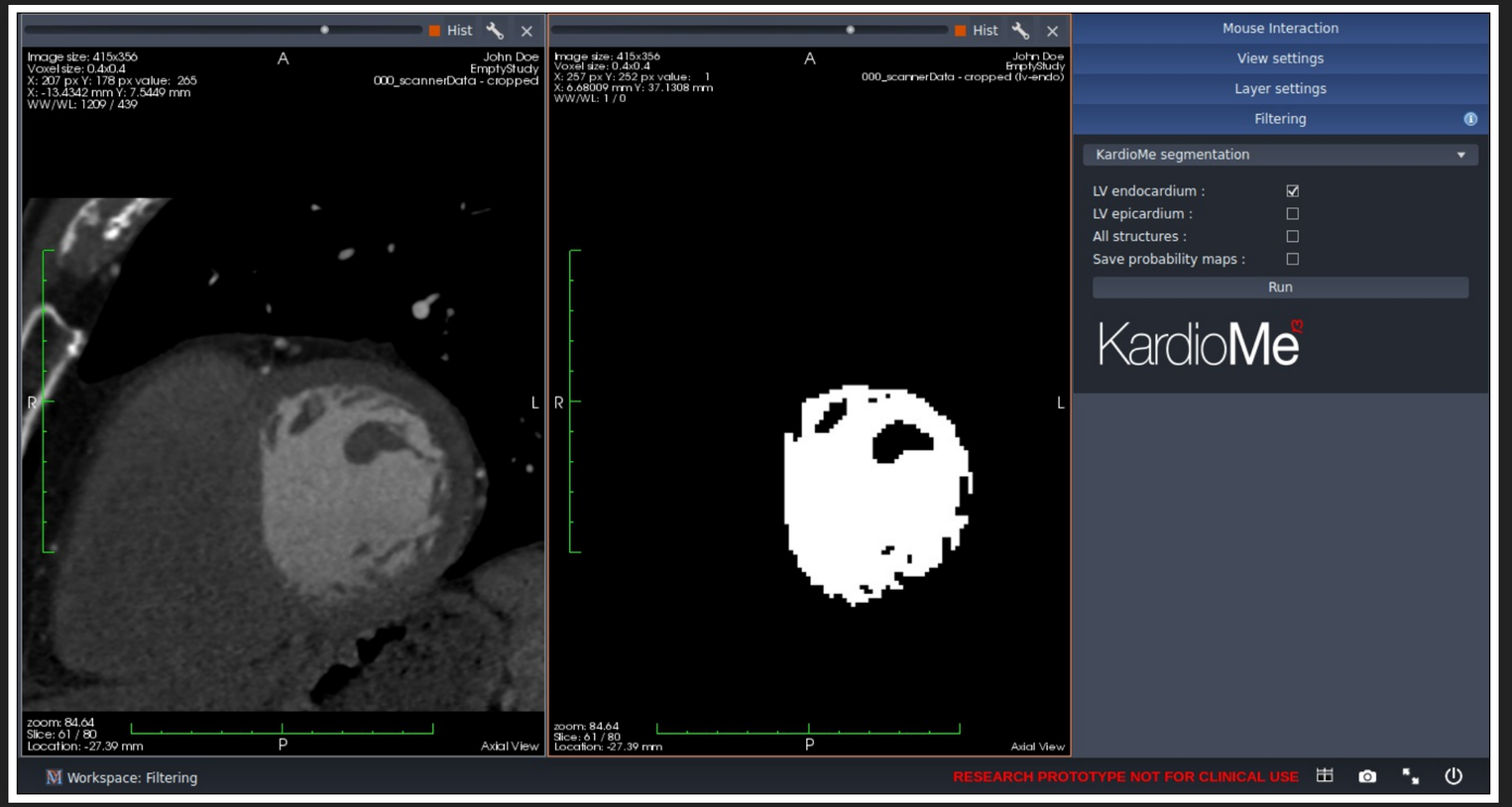
Margeta et al. 2015, Joint work with Inria and Microsoft Research Cambridge

LANDMARK REGRESSION



Margeta et al. 2015, Joint work with Inria and Microsoft Research Cambridge

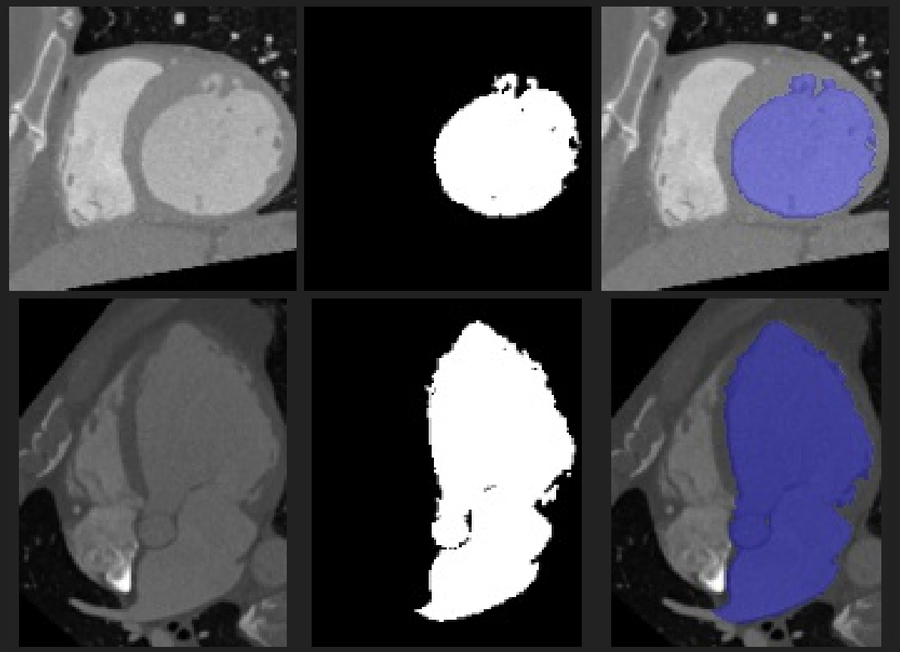
DRAW CIRCLES NO MORE



Joint work with Inria and IHU Liryc

FROM 30 MINUTES TO 12 SECONDS*

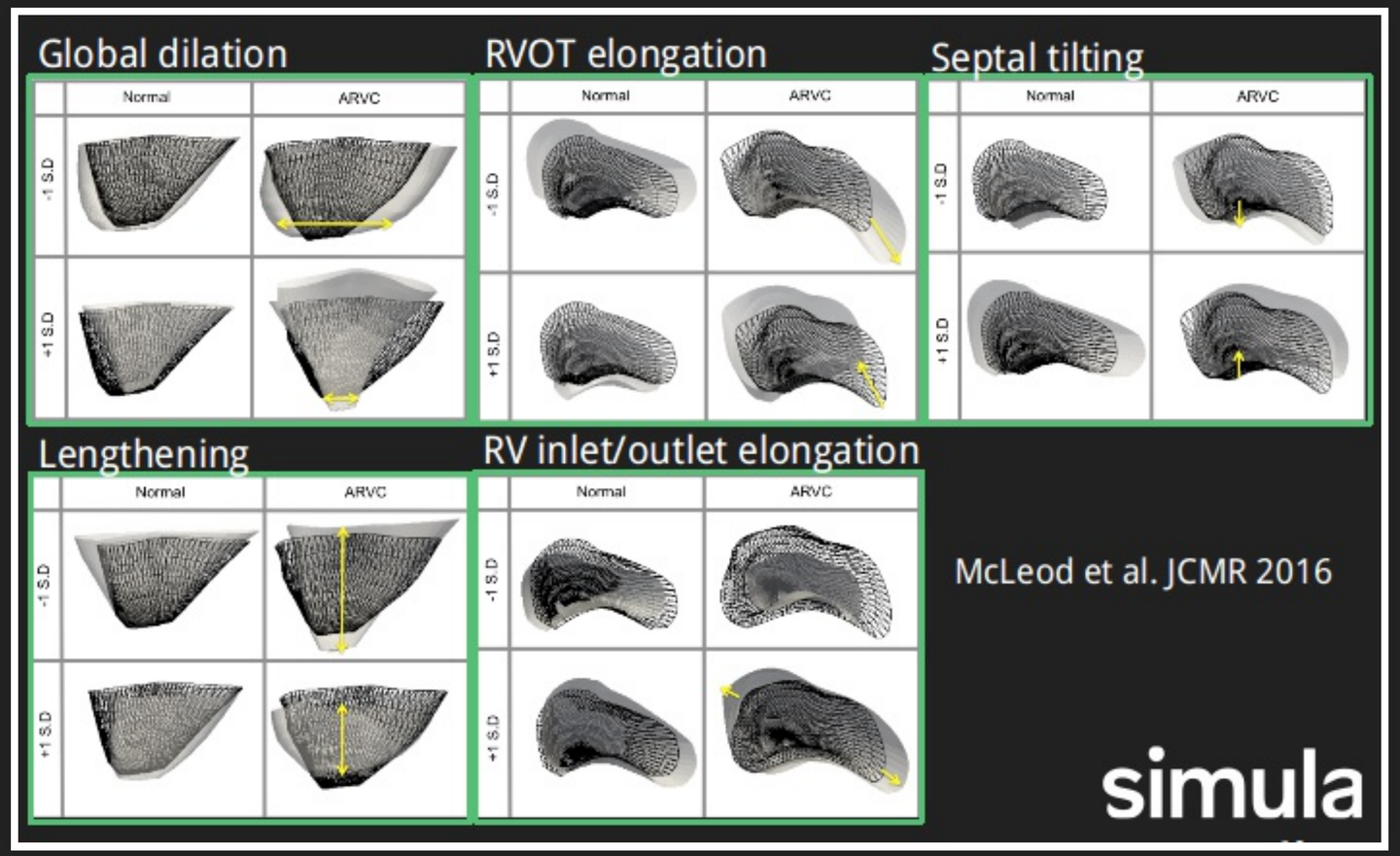
*on a GPU



Joint work with Inria and IHU Liryc

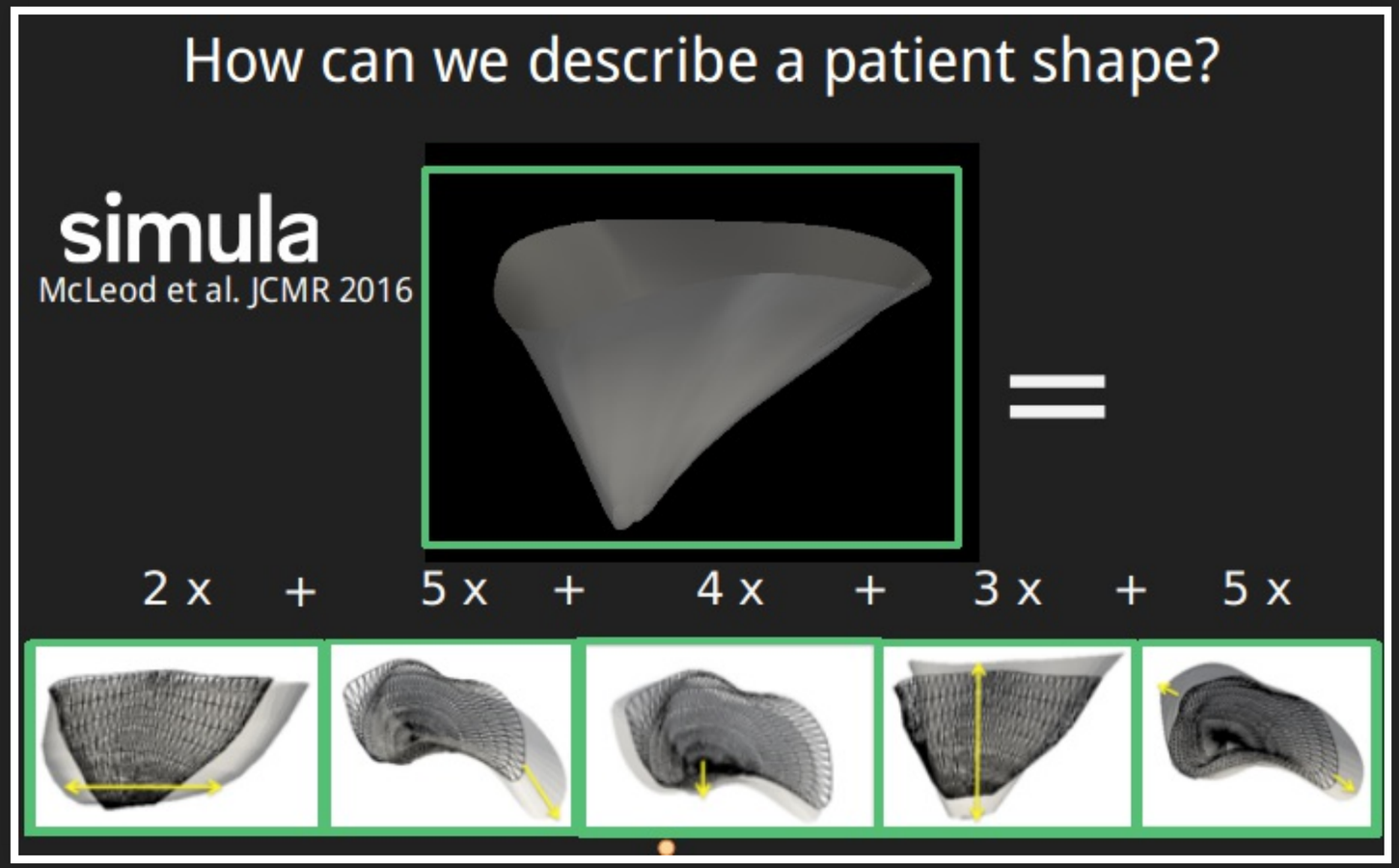
DESCRIBING THE HEARTS

Kristin McLeod et al. 2016, Simula research laboratory



DESCRIBING THE HEARTS

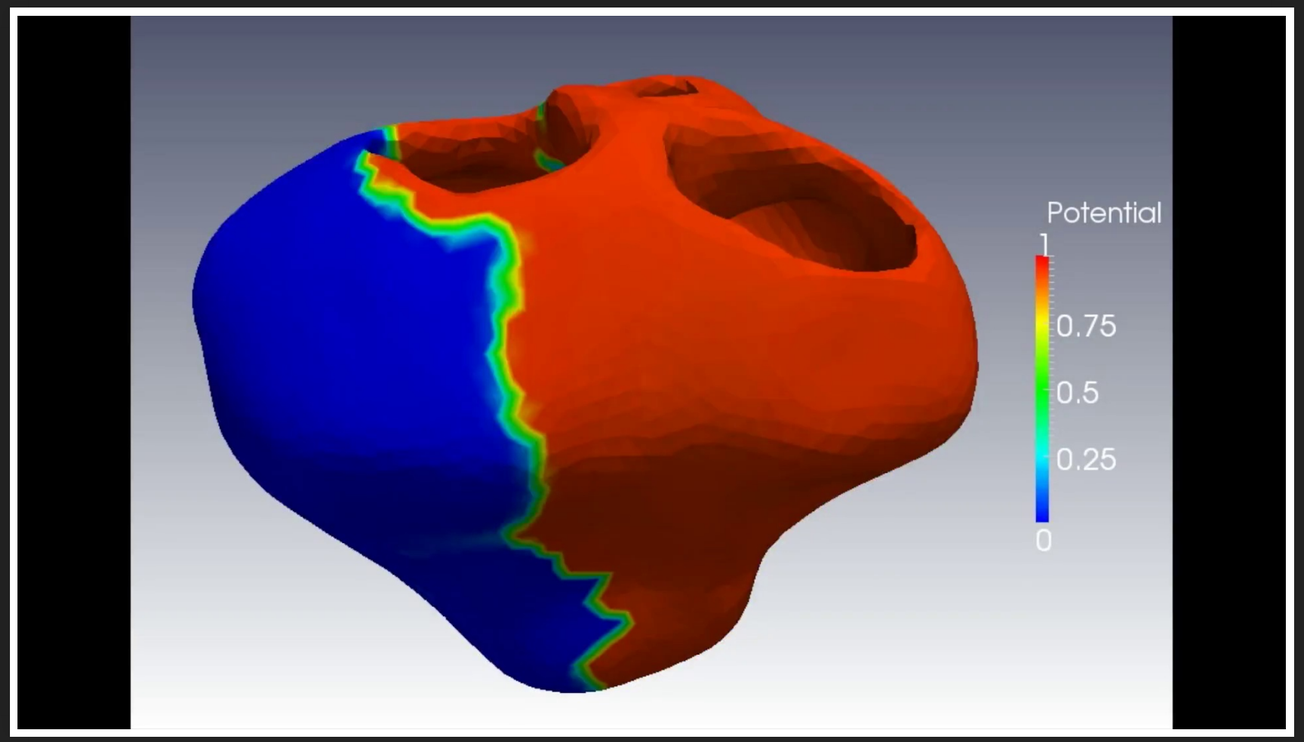
Kristin McLeod et al. 2016, Simula research laboratory



PREDICTING THE FUTURE

FRIENDS ARE WORKING HARD

ELECTROMECHANICAL COUPLING



More information

Hugo Talbot et al. 2012, Inria

CHECK OUT

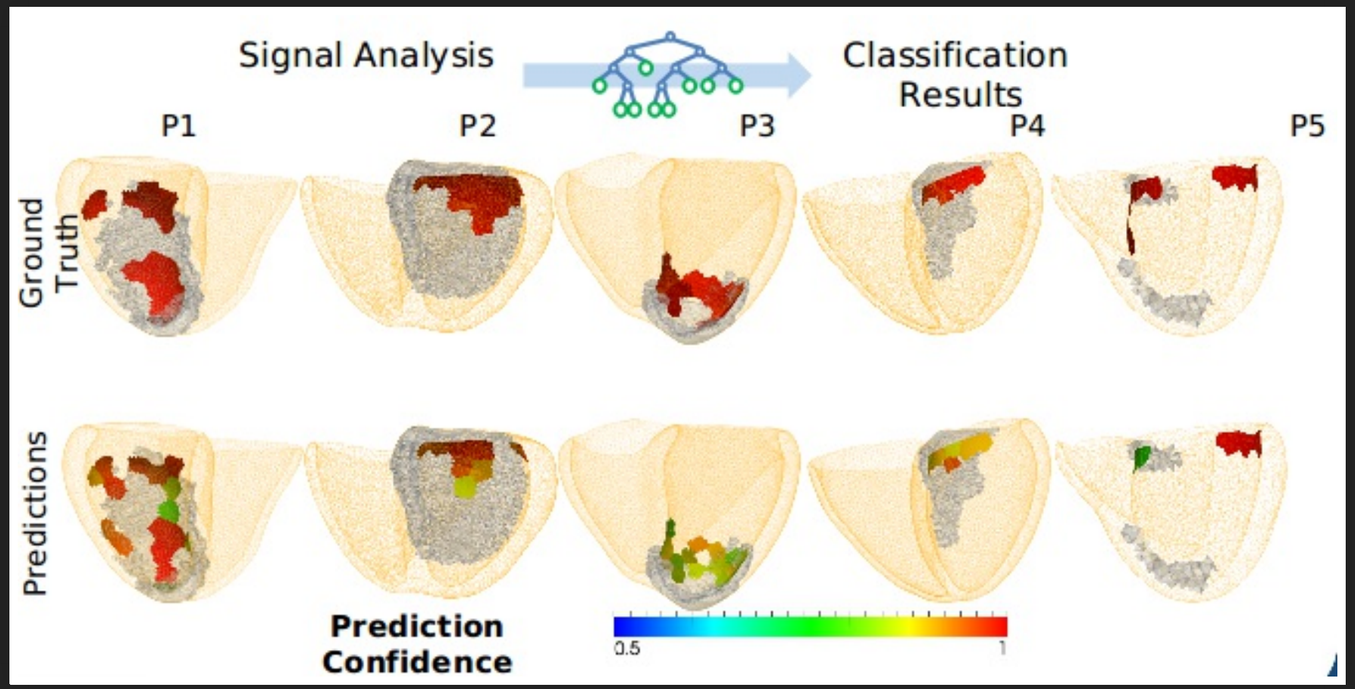
open-source simulation framework:

SOFA

THERAPY PLANNING

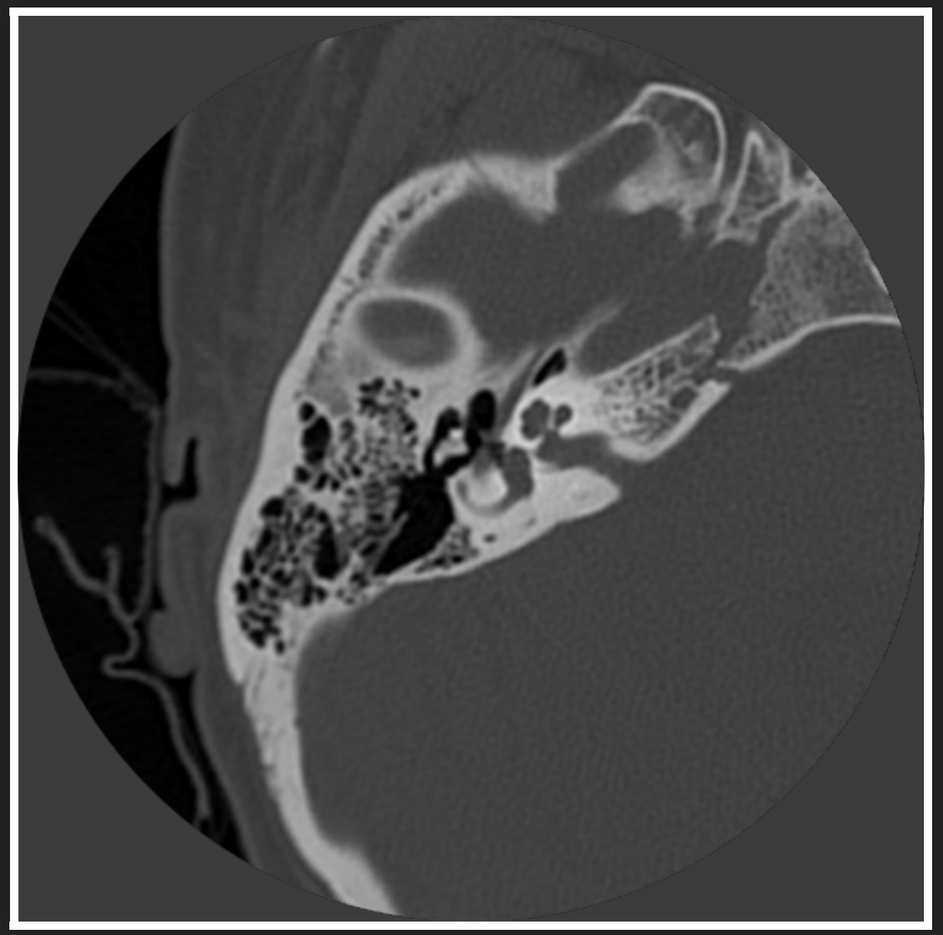
WITH MACHINE LEARNING

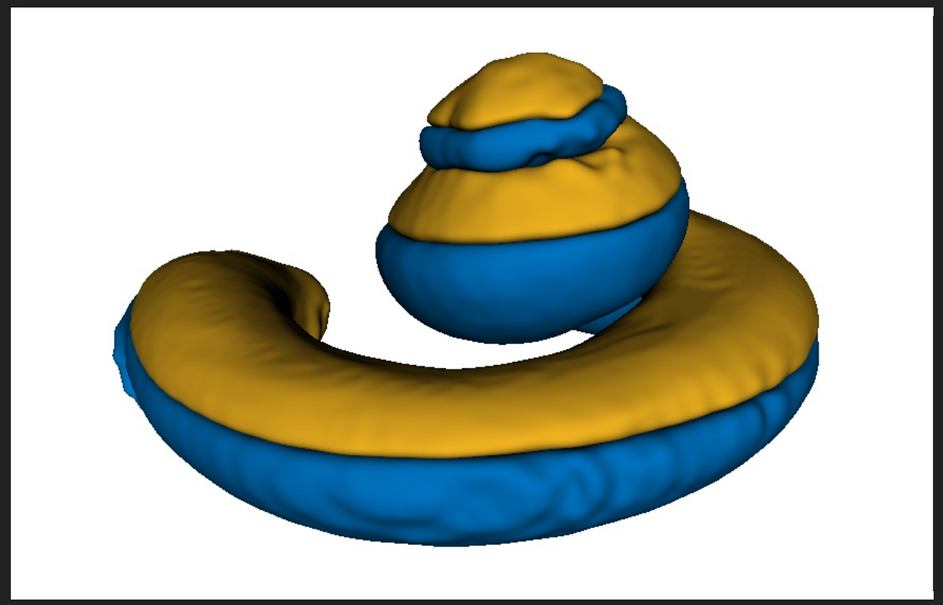
Rocío Cabrera Lozoya et al. 2015, Inria and IHU Liryc



FROM HEARTS TO OUR SENSES

COCHLEAR IMPLANT INSERTION PLANNING



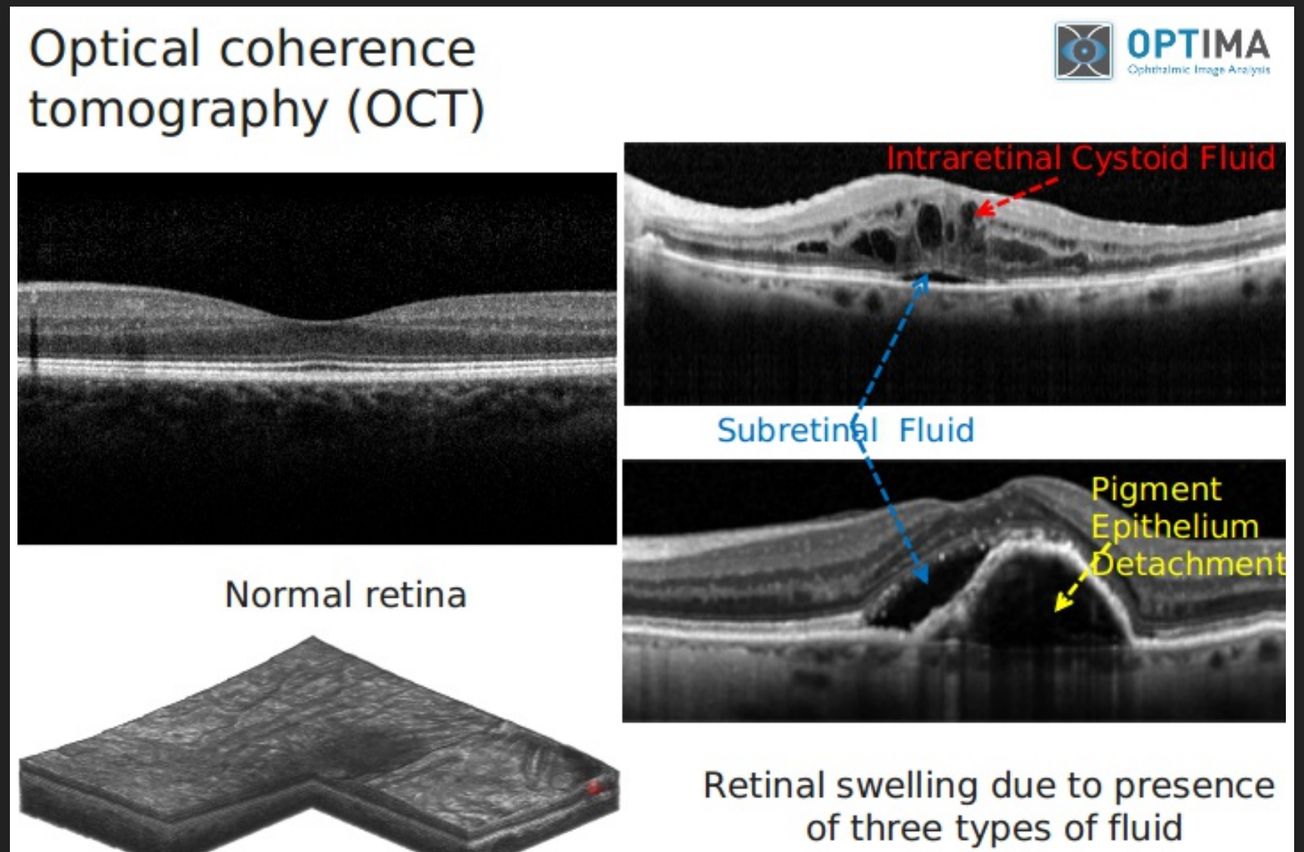


Thomas Demarcy et al. 2016, Inria and Oticon Medical

Demarcy, T., Vandersteen, C., Raffaelli, C., Gnansia, D., Guevara, N., Ayache, N., & Delingette, H. (2017). Automated Analysis of Human Cochlea Shape Variability from segmented µCT images. Computerized Medical Imaging and Graphics. To appear.

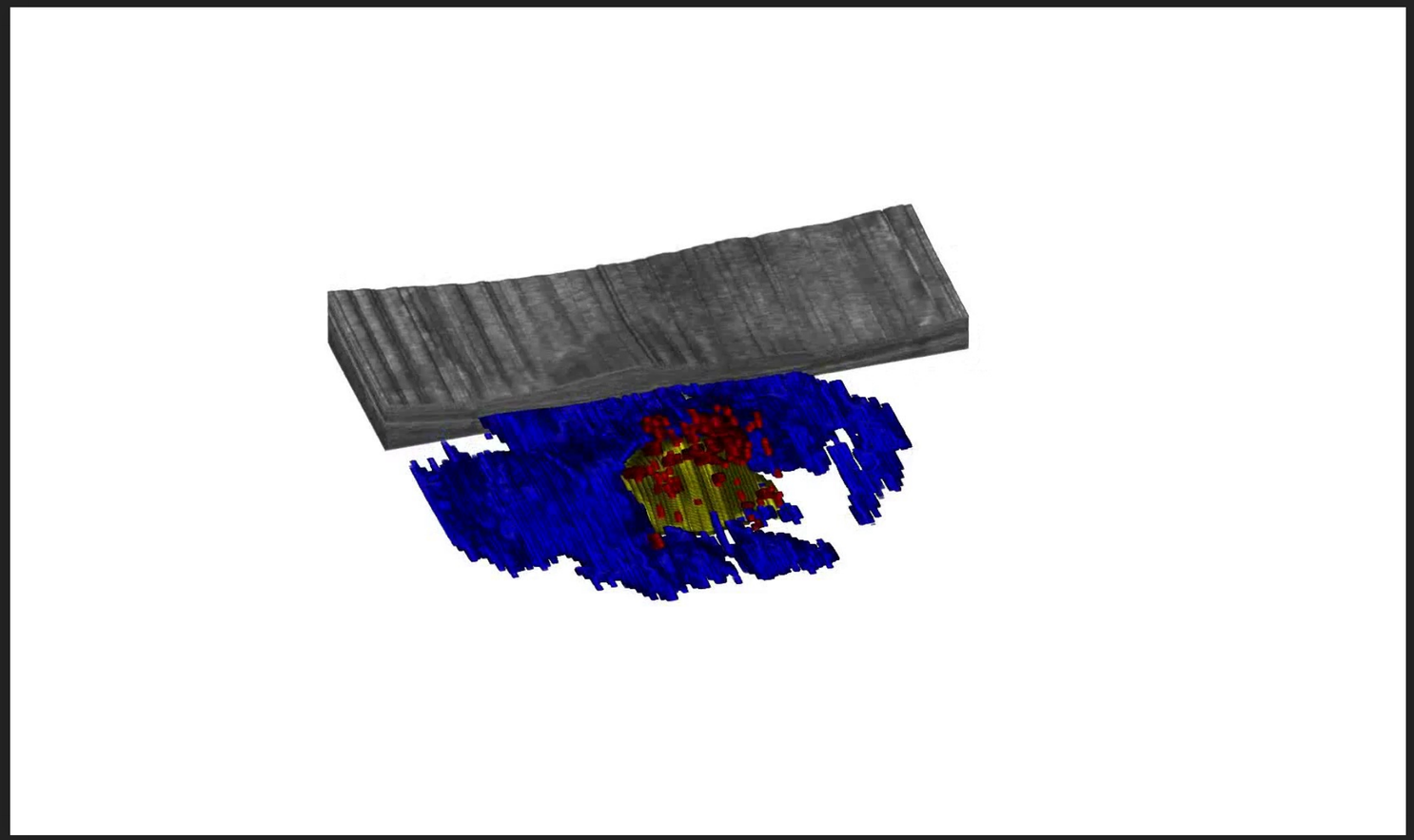
AGE-RELATED MACULAR DEGENERATION IMAGING

Hrvoje Bogunović et al. 2017, OPTIMA @ Medical University of Vienna



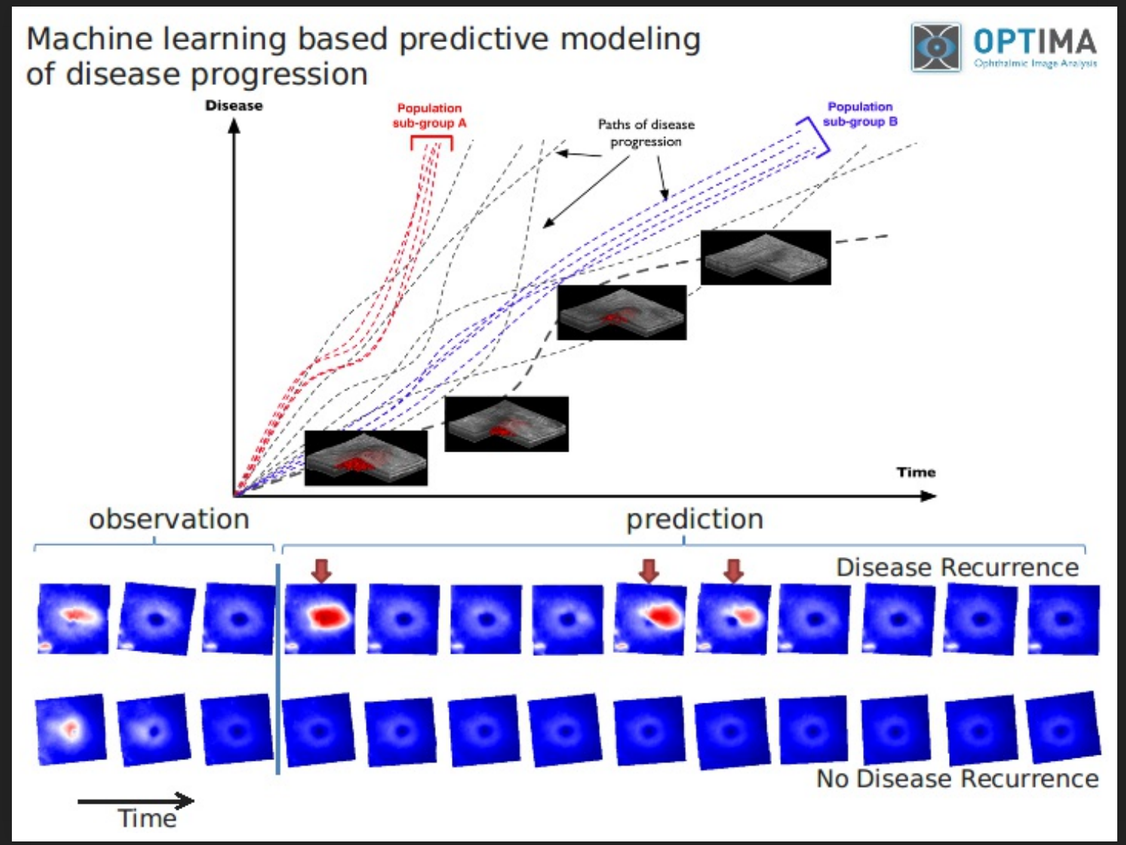
AGE-RELATED MACULAR DEGENERATION IMAGING

Hrvoje Bogunović et al. 2017, OPTIMA @ Medical University of Vienna



AGE-RELATED MACULAR DEGENERATION PREDICTION

Hrvoje Bogunović et al. 2017, OPTIMA @ Medical University of Vienna



TIPS AND TRICKS

ITERATE FAST

ONE METRIC TO RULE THEM ALL

PROGRESS WITH CONFIDENCE

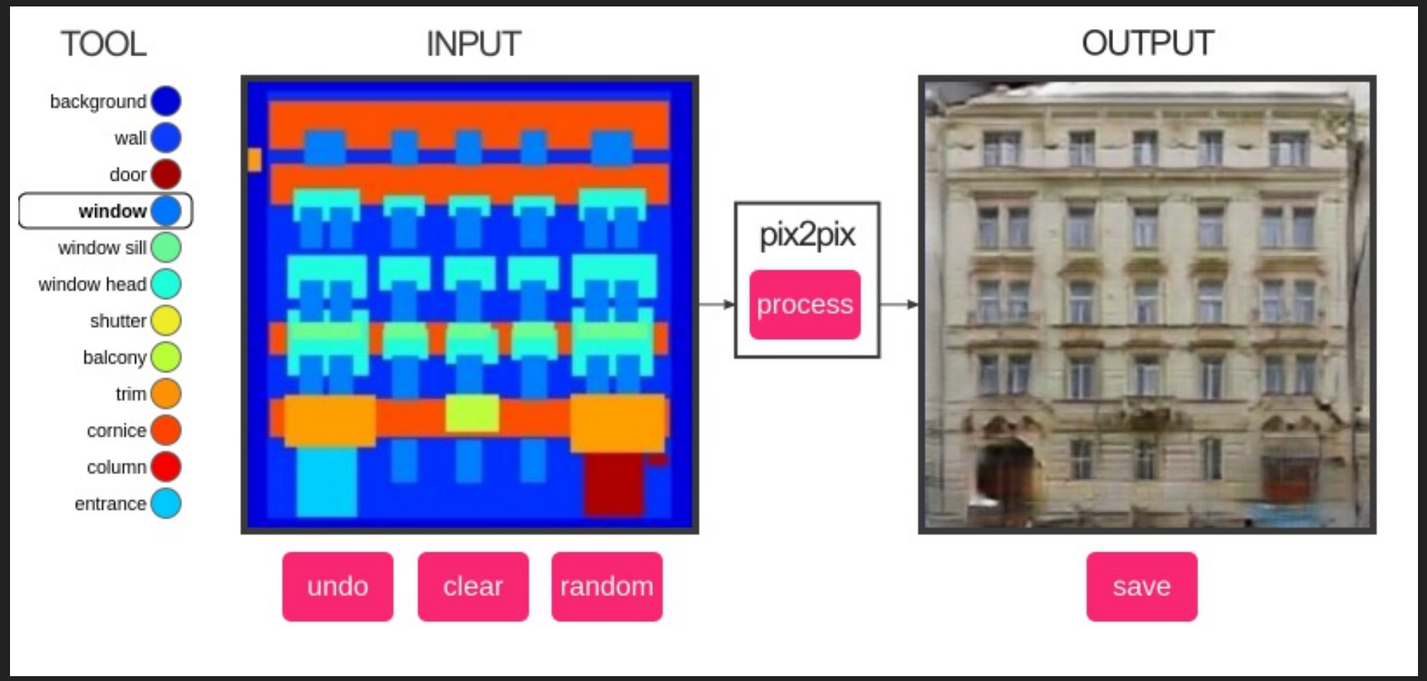
HAVE REPEATABLE PIPELINES

NO GLORY IN DATA PREPARATION

BUT IT MUST BE DONE

HAVING A SMALL DATASET?

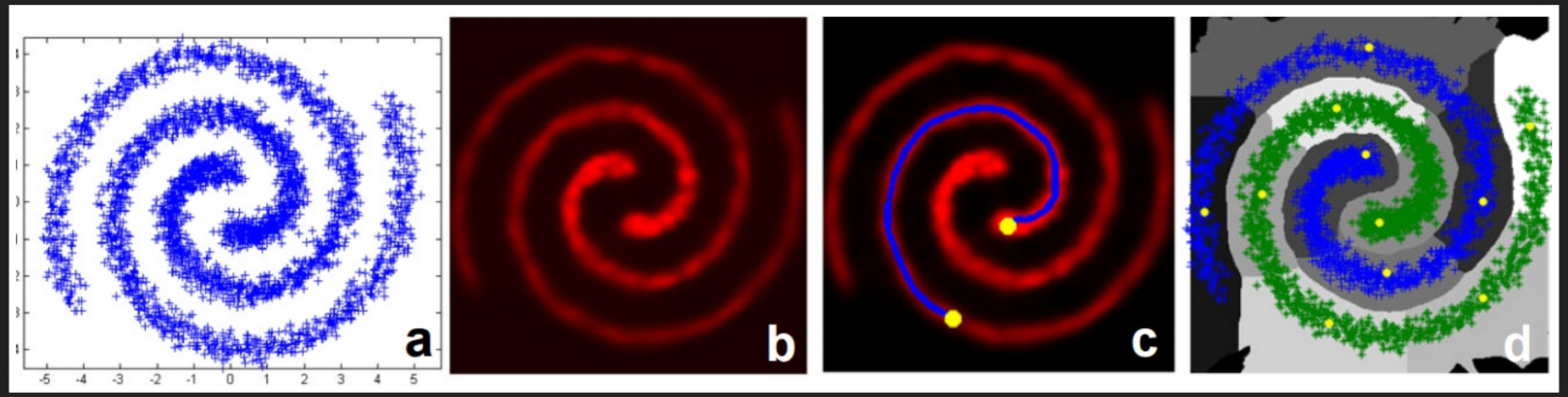
DO SOMETHING ABOUT IT



https://affinelayer.com/pixsrv/

GOT UNLABELED DATA?

DON'T BE LAZY, JUST ANNOTATE IT IF YOU CAN, THERE ARE TOOLS TO HELP YOU



Margeta et al. 2015, Joint work with Inria and Microsoft Research Cambridge

Check out also Scikit learn example on Label Propagation digits active learning

BE PRACTICAL

HAVE AN OPEN MIND

PYTHON + AI + MEDICINE = A⚕

LIBRARIES

MEDICAL DATA LOADING

- pydicom
- SimpleItk
- ITK
- nibabel

STORAGE OF LARGE INTERMEDIATE / PREPROCESSED IMAGING DATA

- bcolz
- h5py

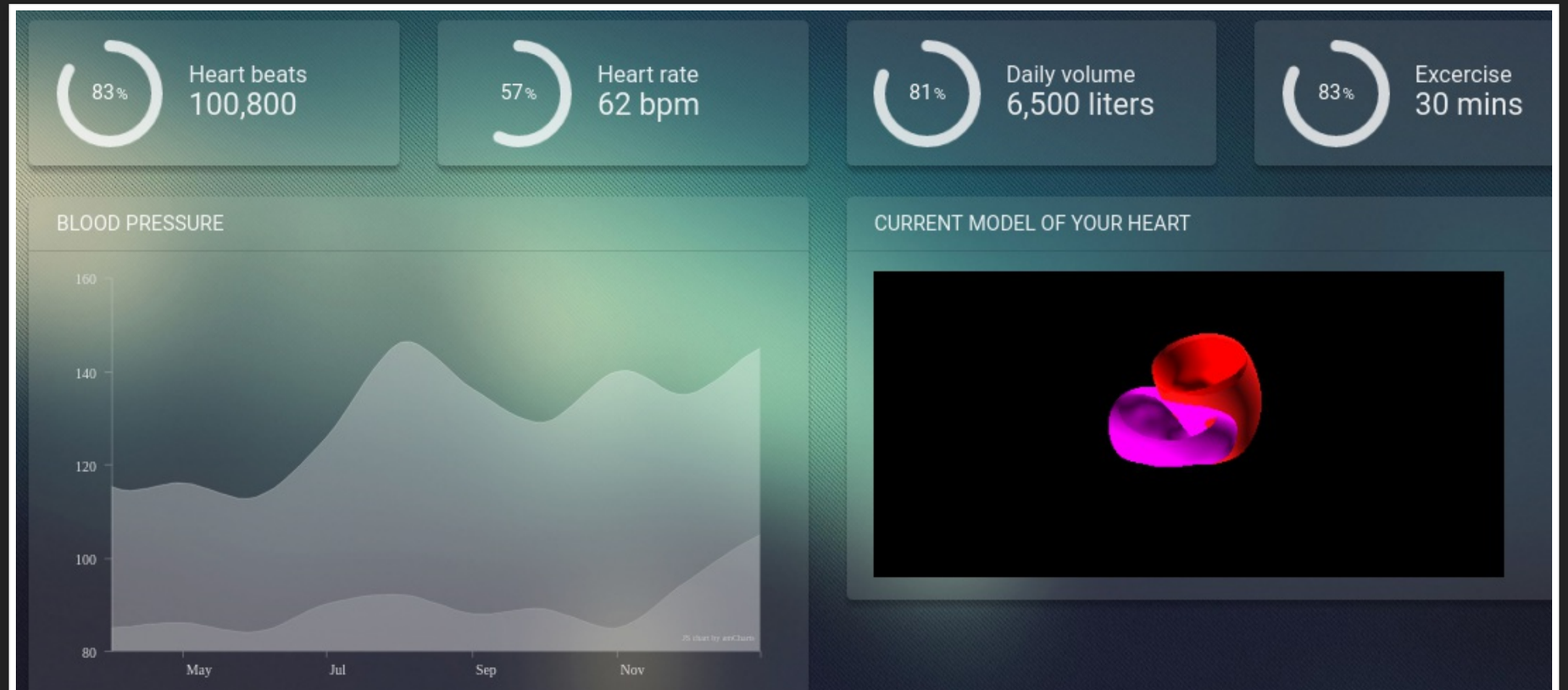
MACHINE LEARNING

- Keras
- Tensorflow
- MxNet
- MinPy/PyTorch

VISUALISATION

- matplotlib
- seaborn
- bokeh
- mayavi
- vtk
- paraview

YOUR HEALTH DASHBOARD



THANKS

Krissy, Hrvoje, Hubert, Hugo, Karol, Loïc, Maxime, Rado, Rocío, Thomas, Maggie, Asclepios, GapData Institute, IHU Liryc, Microsoft Research Cambridge, NumFOCUS, PyData, OPTIMA, Oticon Medical, Simula research laboratory

CONNECT WITH ME

Jan Margeta | jan@kardio.me | @jmargeta

CREDITS

- Statue of Asklepius, exhibited in the Museum of Epidaurus Theatre. By original file by Michael F. Mehnert CC BY-SA 3.0, via Wikimedia Commons
- Radau P, Lu Y, Connelly K, Paul G, Dick AJ, Wright GA. “Evaluation Framework for Algorithms Segmenting Short Axis Cardiac MRI.” The MIDAS Journal – Cardiac MR Left Ventricle Segmentation Challenge, http://hdl.handle.net/10380/3070

- Some results come from my PhD thesis funded by Microsoft Research through its PhD Scholarship Programme and by the ERC Advanced Grant MedYMA

RESOURCES

- PhD thesis - Jan Margeta
- PhD thesis - Rocío Cabrera Lozoya
- PhD thesis - Hugo Talbot
- Book From Andrew Ng
- Fast AI Notebooks and course
- Visualizing convnets
- Conv filter visualization

- Transfer learning with MNIST
- Label propagation with scikit learn
- Keras and pretrained models
- Staying organized - Templates for data science
- Cardiac atlas project
- Sunnybrook cardiac dataset
- UK biobank

- Mimesis team @ Inria
- Asclepios @ Inria
- SOFA - Opensource simulation framework
- Cardiovascular death stats
- Detecting cancer with deep learning
- Dermatologist-level classification of skin cancer with deep neural networks

REFERENCES

- Kelly, M. D. (2007). Laparoscopic repair of strangulated Morgagni hernia. World Journal of Emergency Surgery. Springer Nature. https://doi.org/10.1186/1749-7922-2-27
- Carmo, P., Andrade, M. J., Aguiar, C., Rodrigues, R., Gouveia, R., & Silva, J. A. (2010, December). Mitral annular disjunction in myxomatous mitral valve disease: a relevant abnormality recognizable by transthoracic echocardiography. Cardiovascular Ultrasound. Springer Nature. https://doi.org/10.1186/1476-7120-8-53
- Arnold, J. R., West, N. E., van Gaal, W. J., Karamitsos, T. D., & Banning, A. P. (2008, May 31). The role of Intravascular Ultrasound in the management of spontaneous coronary artery dissection. Cardiovascular Ultrasound. Springer Nature. https://doi.org/10.1186/1476-7120-6-24

- Foley, P. W., Hamaad, A., El-Gendi, H., & Leyva, F. (2010). Incidental cardiac findings on computed tomography imaging of the thorax. BMC Research Notes. Springer Nature. https://doi.org/10.1186/1756-0500-3-326
- Vanezis, A. P., Baig, M. K., Mitchel, I. M., Shajar, M., Naik, S. K., Henderson, R. A., & Mathew, T. (2011). Pseudoaneurysm of the left ventricle following apical approach TAVI. Journal of Cardiovascular Magnetic Resonance. Springer Nature. https://doi.org/10.1186/1532-429x-13-79
- Xue, H., Kellman, P., LaRocca, G., Arai, A. E., & Hansen, M. S. (2013). High spatial and temporal resolution retrospective cine cardiovascular magnetic resonance from shortened free breathing real-time acquisitions. Journal of Cardiovascular Magnetic Resonance. Springer Nature. https://doi.org/10.1186/1532-429x-15-102
- Margeta, J., McLeod, K., Criminisi, A., & Ayache, N. (2014). Decision Forests for Segmentation of the Left Atrium from 3D MRI. Statistical Atlases and Computational Models of the Heart. Imaging and Modelling Challenges. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-54268-8_6

- Tobon-Gomez, C., Geers, A. J., Peters, J., Weese, J., Pinto, K., Karim, R., … Rhode, K. S. (2015, July). Benchmark for Algorithms Segmenting the Left Atrium From 3D CT and MRI Datasets. IEEE Transactions on Medical Imaging. Institute of Electrical and Electronics Engineers (IEEE). https://doi.org/10.1109/tmi.2015.2398818
- Margeta, J., Criminisi, A., Cabrera Lozoya, R., Lee, D. C., & Ayache, N. (2015, August 13). Fine-tuned convolutional neural nets for cardiac MRI acquisition plane recognition. Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization. Informa UK Limited. https://doi.org/10.1080/21681163.2015.1061448
- McLeod, K., Wall, S., Leren, I. S., Saberniak, J., & Haugaa, K. H. (2016, October 14). Ventricular structure in ARVC: going beyond volumes as a measure of risk. Journal of Cardiovascular Magnetic Resonance. Springer Nature. https://doi.org/10.1186/s12968-016-0291-9

- Talbot, H., Marchesseau, S., Duriez, C., Sermesant, M., Cotin, S., & Delingette, H. (2013, February 21). Towards an interactive electromechanical model of the heart. Interface Focus. The Royal Society. https://doi.org/10.1098/rsfs.2012.0091
- Demarcy, T., Vandersteen, C., Raffaelli, C., Gnansia, D., Guevara, N., Ayache, N., & Delingette, H. (2016). Uncertainty Quantification of Cochlear Implant Insertion from CT Images. Clinical Image-Based Procedures. Translational Research in Medical Imaging. Springer International Publishing. https://doi.org/10.1007/978-3-319-46472-5_4
- Montuoro, A., Waldstein, S. M., Gerendas, B. S., Schmidt-Erfurth, U., & Bogunović, H. (2017, February 27). Joint retinal layer and fluid segmentation in OCT scans of eyes with severe macular edema using unsupervised representation and auto-context. Biomedical Optics Express. The Optical Society. https://doi.org/10.1364/boe.8.001874
- Demarcy, T., Vandersteen, C., Raffaelli, C., Gnansia, D., Guevara, N., Ayache, N., & Delingette, H. (2017). Automated Analysis of Human Cochlea Shape Variability from segmented µCT images. Computerized Medical Imaging and Graphics (to appear).

- Radau, P., Lu, Y., Connelly, K., Paul, G., Dick, AJ., Wright, GA. (2009). Evaluation Framework for Algorithms Segmenting Short Axis Cardiac MRI. The MIDAS Journal – Cardiac MR Left Ventricle Segmentation Challenge. http://hdl.handle.net/10380/3070
- Kadish, A. H., Bello, D., Finn, J. P., Bonow, R. O., Schaechter, A., Subacius, H., … Goldberger, J. J. (2009, September). Rationale and Design for the Defibrillators to Reduce Risk by Magnetic Resonance Imaging Evaluation (DETERMINE) Trial. Journal of Cardiovascular Electrophysiology. Wiley-Blackwell. https://doi.org/10.1111/j.1540-8167.2009.01503.x
- Fonseca, C. G., Backhaus, M., Do Chung, J., Tao, W., Medrano-Gracia, P., Cowan, B. R., … Young, A. A. (2010). The Cardiac Atlas Project: Rationale, Design and Procedures. Statistical Atlases and Computational Models of the Heart. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-15835-3_4