Deep Learning in a Clinical Context: The Big Picture From "Big Data"

Regional Downscaling of Climate Data using Deep Learning and Applications for Drought / Rainfall Forecasting

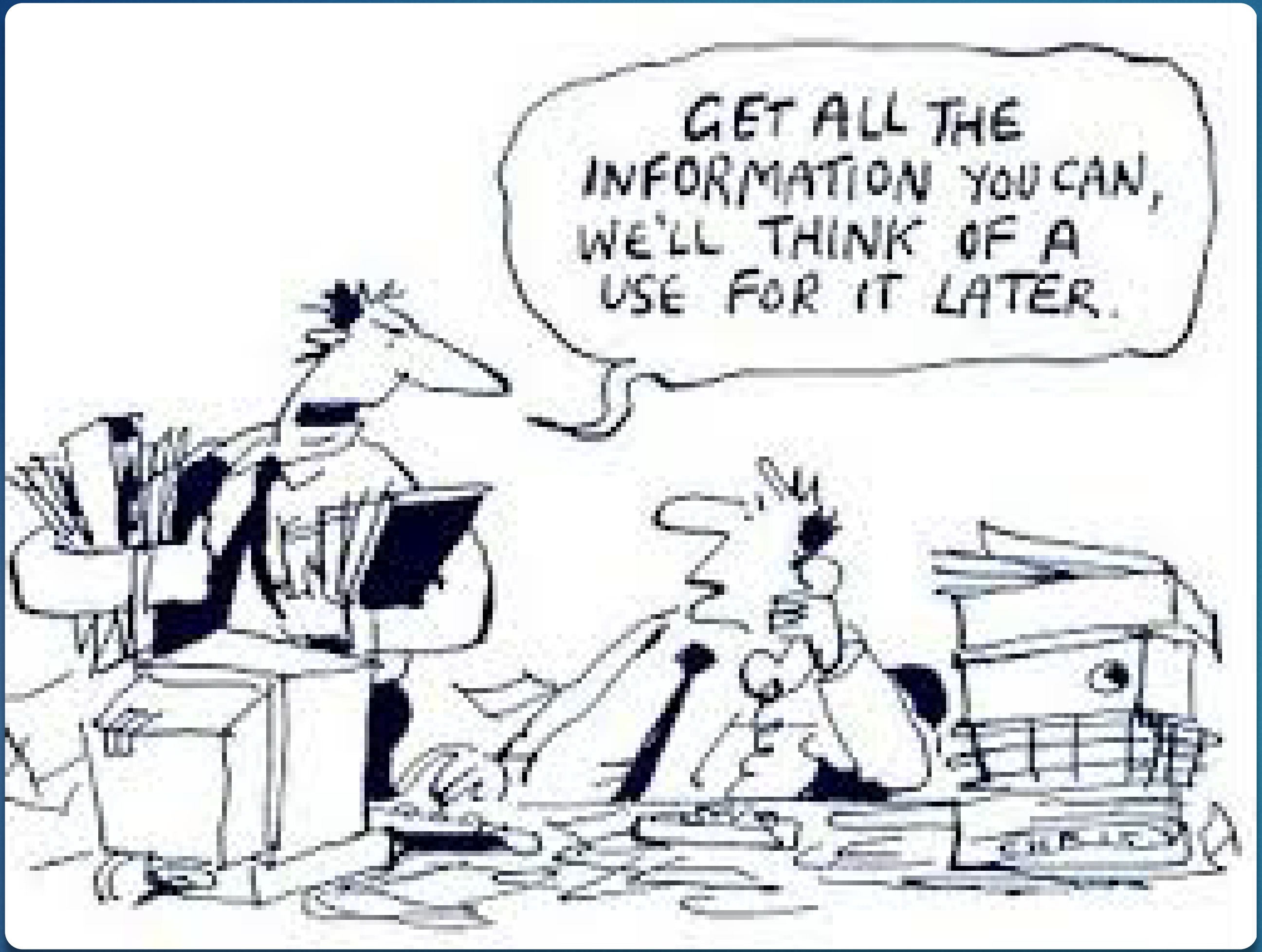
Wellington School of Medicine & Health Sciences

SAPERE AUDE

E/S/R Science for Communities

NATHAN RUSSELL

(1ST YEAR PHD STUDENT)



Clinical Data Overload

“Big Data” keeps getting “Bigger”

- “Big data” is a dataset with a large number of attributes
- Clinical data is a major source of “Big data"
- The amount of collected information is continuing to grow.

<u>If this data isn’t utilised, then it is being collected and stored at an unnecessary cost.</u>

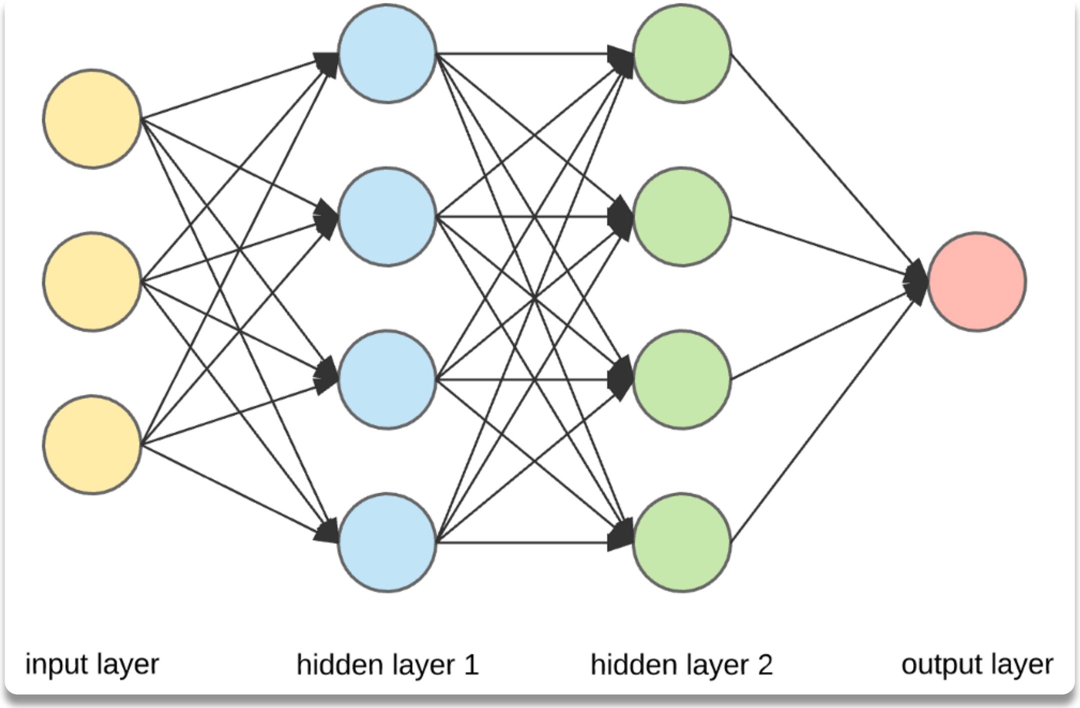
Machine Learning in 60secs (Sorry no robots here)

"The Four Ingredients of Machine Learning"

- T) A task to solve
- M) A performance metric
- P) A computer program
- E) A source of experience

Deep Learning: Neural Networks are Onions?

WELL NO… BUT THEY BOTH HAVE LAYERS!



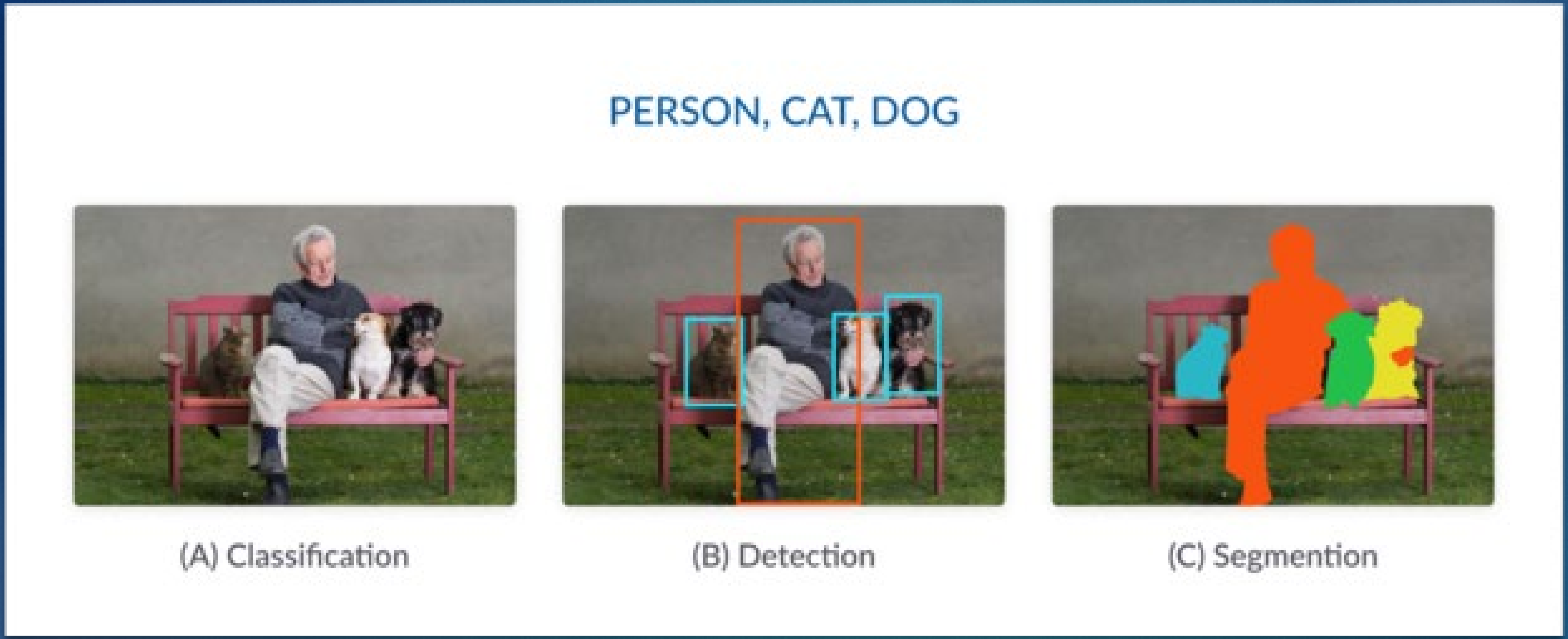


Image Segmentation

Deep Learning in Healthcare

INSILICO MEDICINE

BEAUTY.AI

Deep Learning Models and Diverse Populations

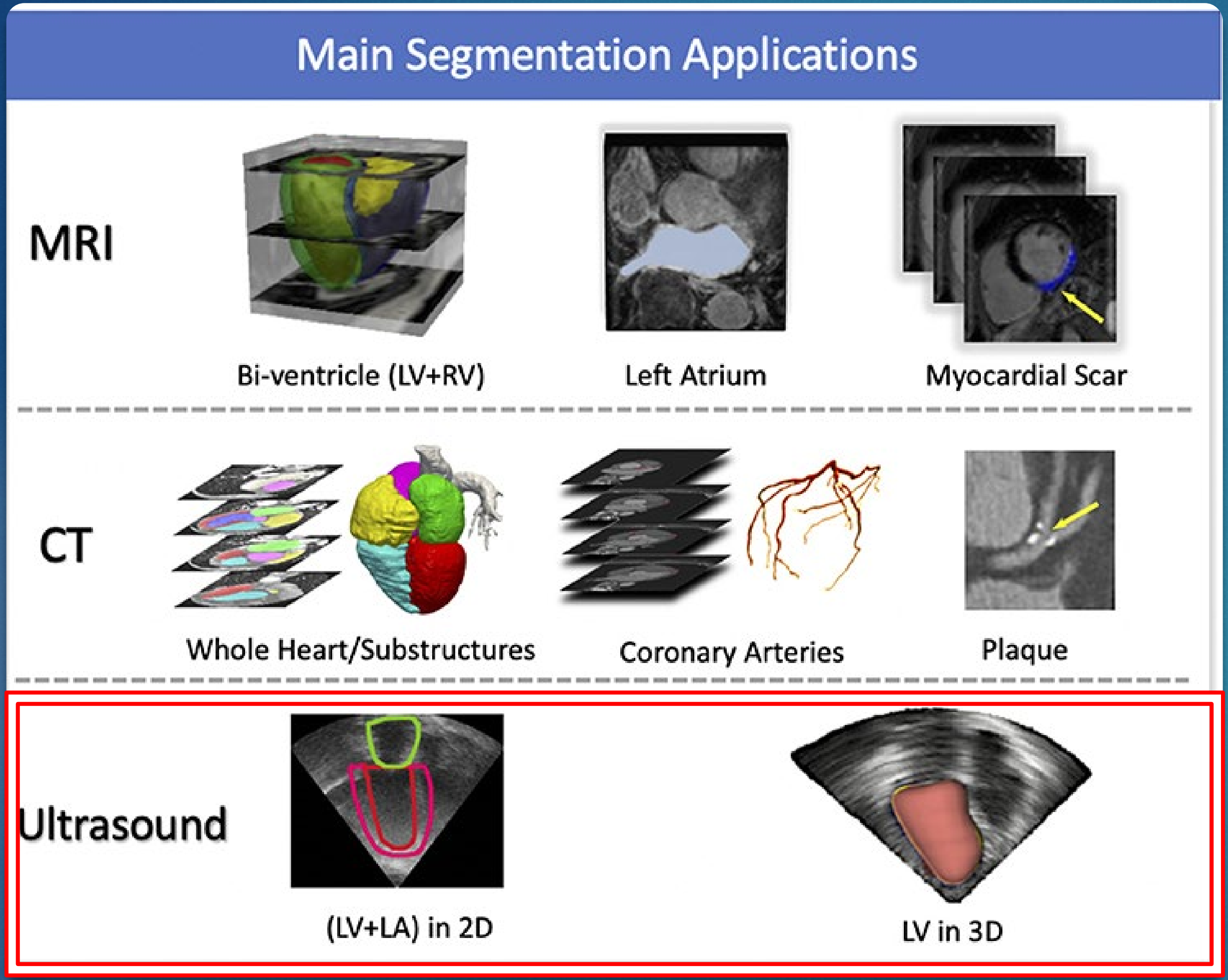
PhD Aims

To aid the development of tools and pipelines that facilitate improved data processing and analysis.

To develop tools interfaces for data exploration and visualisation, for integration in a medical decision-making framework.

Ensure developed tools are accessibly designed and clinician friendly as possible whilst maintaining research capabilities.

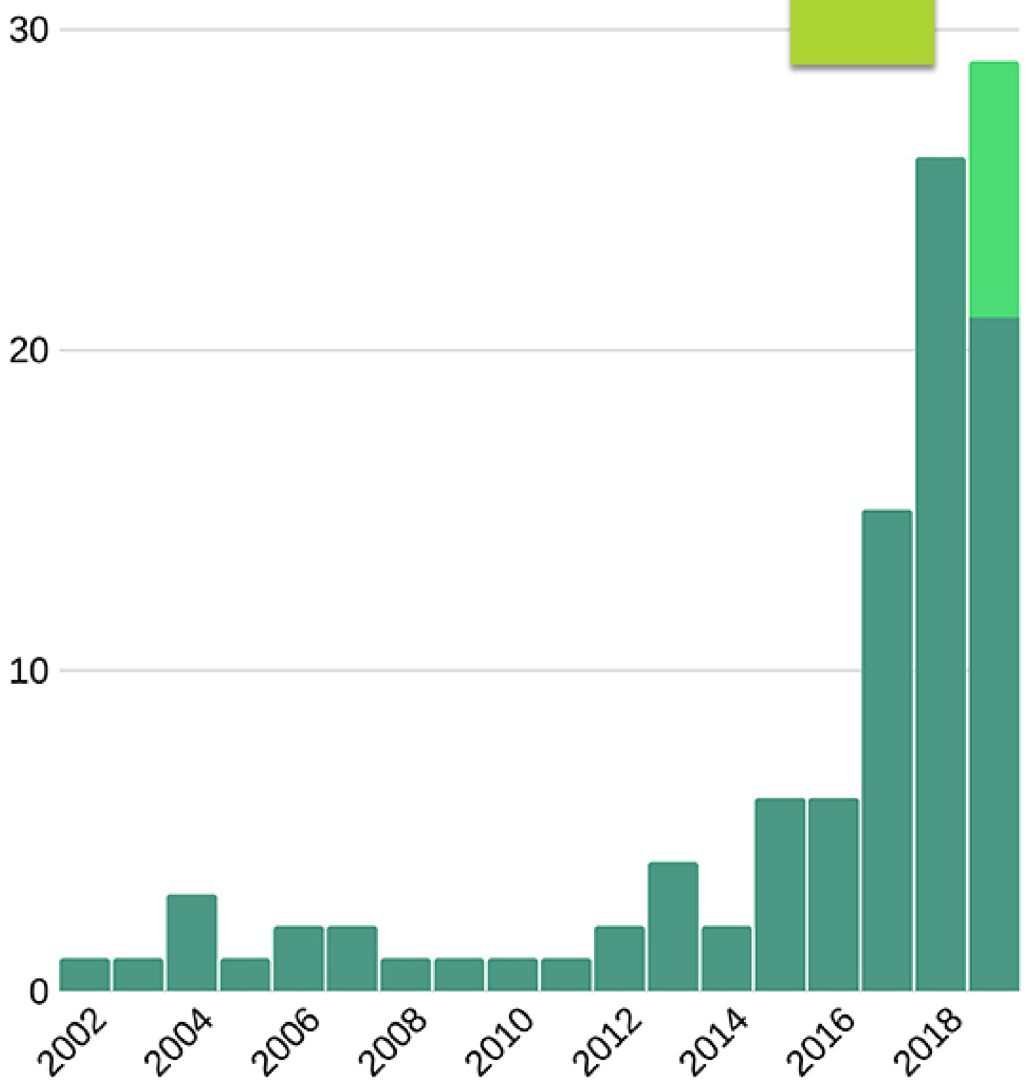
Improving the Clinical Decision-Making Process Through implementation of Deep Learning Tools for "Big Data" Integration, Analysis and Visualisation

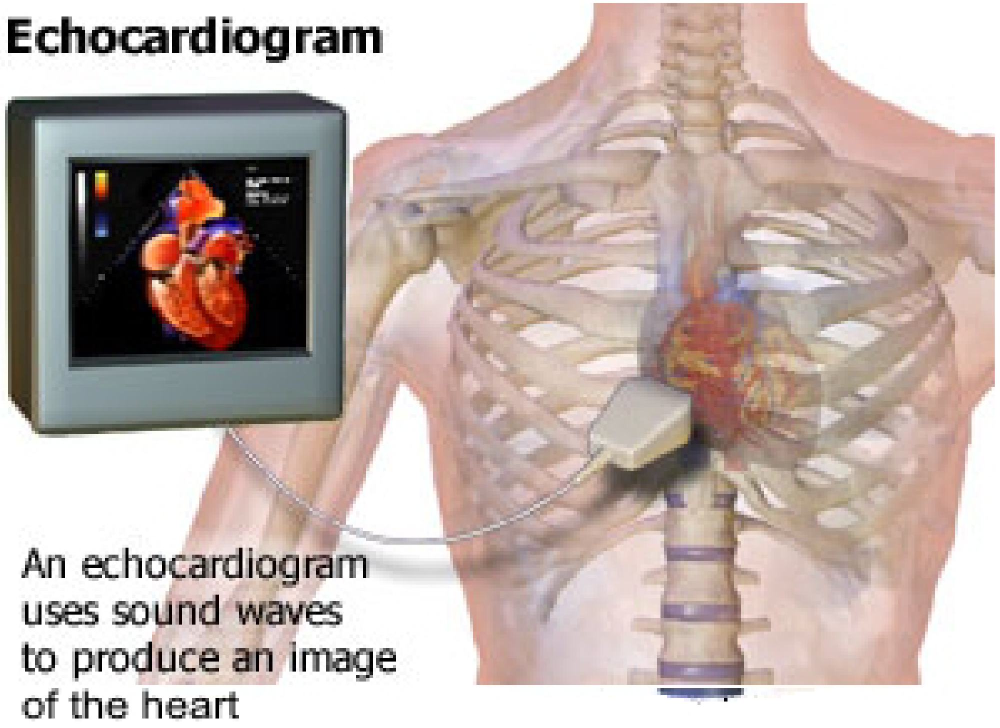


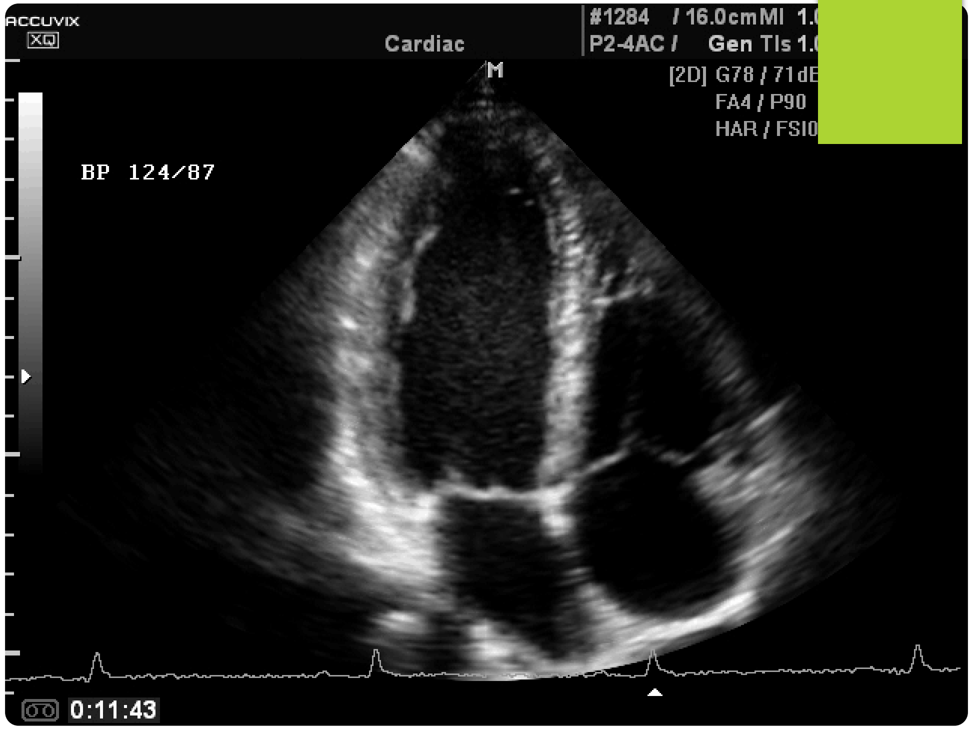
Our Starting Point

Cardiac Imaging and Machine Learning in Publication

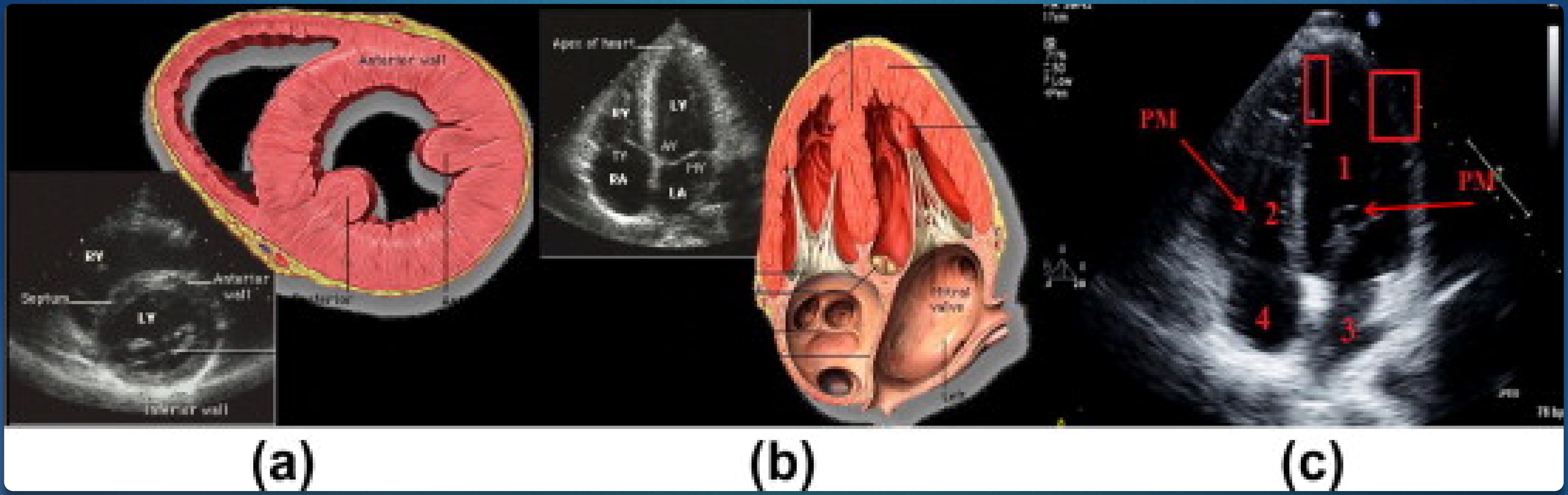
- The number of publications on machine learning and cardiac imaging per year.







Echocardiogram 101



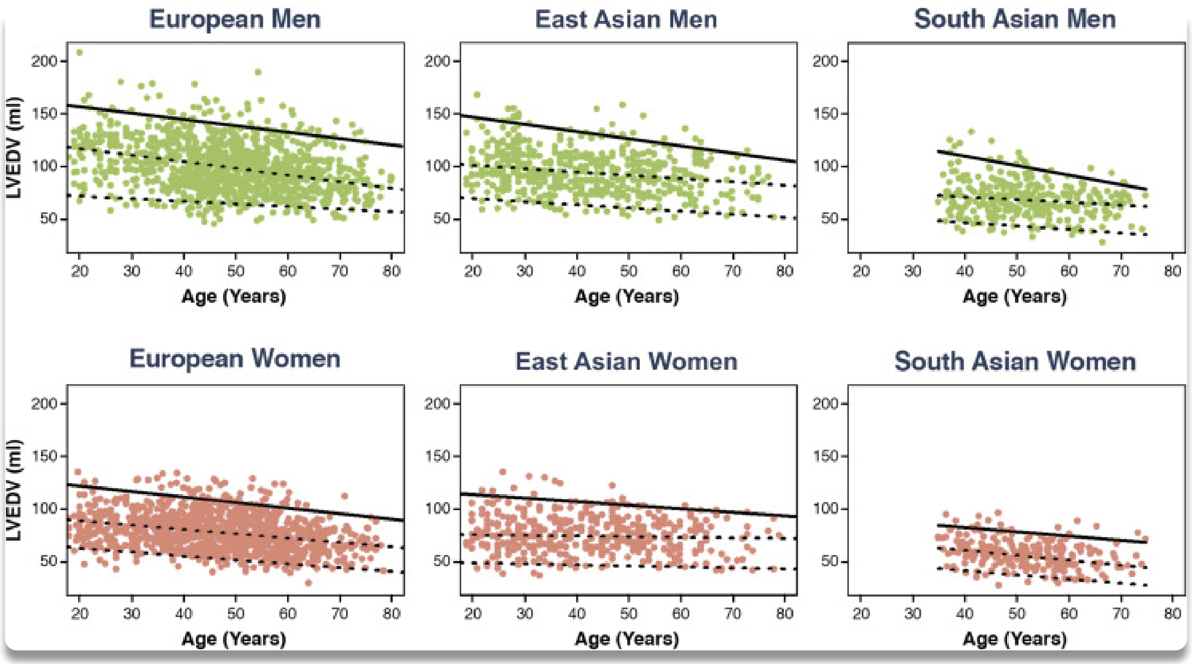
Echocardiogram 101

Existing Models

- View classification
  - Madani, A., Arnaout, R., Mofrad, M. *et al.* Fast and accurate view classification of echocardiograms using deep learning. *npj Digital Med* **1**, 6 (2018).
- Pathology identification
  - Madani, A., Ong, J.R., Tibrewal, A. *et al.* Deep echocardiography: data-efficient supervised and semi-supervised deep learning towards automated diagnosis of cardiac disease. *npj Digital Med* **1**, 59 (2018).
- Risk prediction
  - Kwon, Joon-myoung, et al. "Deep learning for predicting in- mortality among heart disease patients hospitalbased on echocardiography." *Echocardiography* 36.2 (2019): 213-218.

Evidence of Ethnic Variation in Heart Parameters

The ECHOnormal Study (2015)



Evidence of Ethnic Variation in Heart Parameters

Table 1. Comparison of Left Heart Chamber Size and Race

	Caucasian n=17,342	African American n=1,676	Hispanic n=156	Asian n=720	Native American n=64	p
Demographics						
Age	50.5±15.5	44.0±15.2*	44.4±13.8*	46.5±14.5*	48.1±13.6*	<0.001
Female gender	55.6%	65.4%*	75.6%*	57.8%	56.3%	<0.001
BSA (m2)	1.9±0.3*	2.0±0.3*	1.8±0.2*	1.7±0.2*	2.0±0.3	<0.001
Dimensions (mm) or Mass (gm)						
LV End-Diastolic Diameter	46.9±5.5	46.4±5.5*	45.7±5.1	44.7±4.7*	48.0±6.4	<0.001
LV End-Systolic Diameter	30.1±5.2	29.6±5.2*	28.8±4.6*	28.5±4.6*	30.2±6.0	<0.001
Interventricular Septum	9.2±2.3	9.7±2.5*	8.7±1.6	8.5±1.8*	9.7±2.0	<0.001
Posterior Wall	9.0±1.7	9.5±2.0*	8.8±1.6	8.3±1.4*	9.3±1.8	<0.001
LV Mass	147.9±51.8	156.0±58.2*	133.3±42.8*	121.7±37.8*	163.6±62.0	<0.001
Left Atrial Diameter	36.8±6.7	36.0±6.1	35.2±6.3*	33.8±5.6*	38.1±8.0	<0.001
Dimensions (mm/m2) or Mass (gm/m2) indexed to BSA						
LV End-Diastolic Diameter/BSA	24.6±3.3	23.8±3.3*	25.4±3.0*	26.2±3.3*	24.8±3.2	<0.001
LV End-Systolic Diameter/BSA	15.8±2.9	15.2±2.9*	16.0±2.7	16.7±3.0*	15.6±2.7	<0.001
Interventricular Septum/BSA	4.8±1.1	5.0±1.3*	4.8±0.8	5.0±1.0*	5.0±1.0	<0.001
Posterior Wall/BSA	4.7±0.9	4.9±1.0*	4.9±0.8	4.9±0.9*	4.85±0.9	<0.001
LV Mass/BSA	75.9±22.3	78.8±25.6*	73.0±19.4	70.5±19.5*	82.9±26.3	<0.001
Left Atrial Diameter/BSA	19.2±3.1	18.4±3.0*	19.4±3.1	19.8±3.2*	19.6±4.0	<0.001

*p<0.05 vs. Caucasian race. BSA, body surface area; LV, left ventricle.

Ethnicity is Associated With Differences in Left Heart Dimensions on Echocardiography. (2018)

Our Project

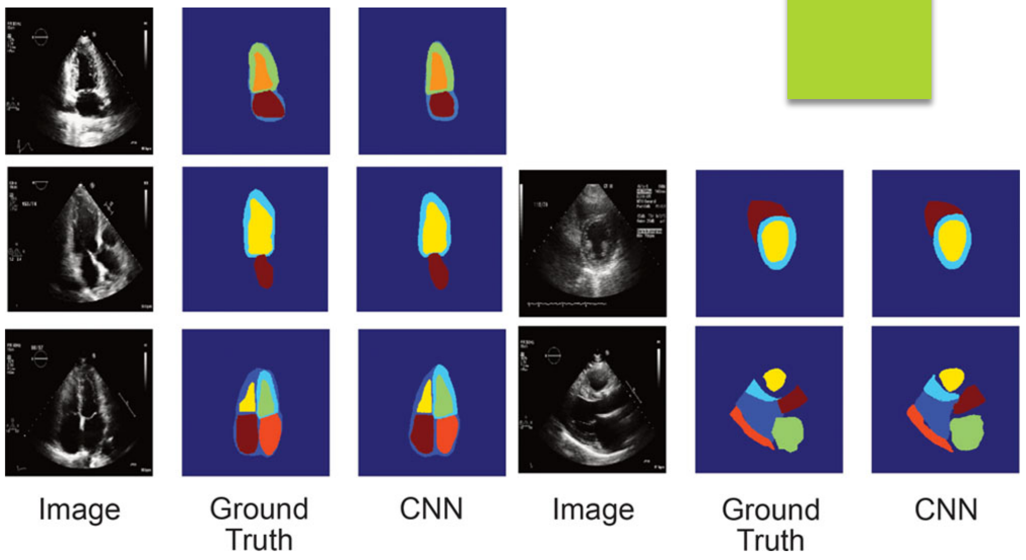
<u>We propose the development of suitable convolutional neural network architecture from current models in order to allow for identification of ethnicity specific features within echocardiograms</u>

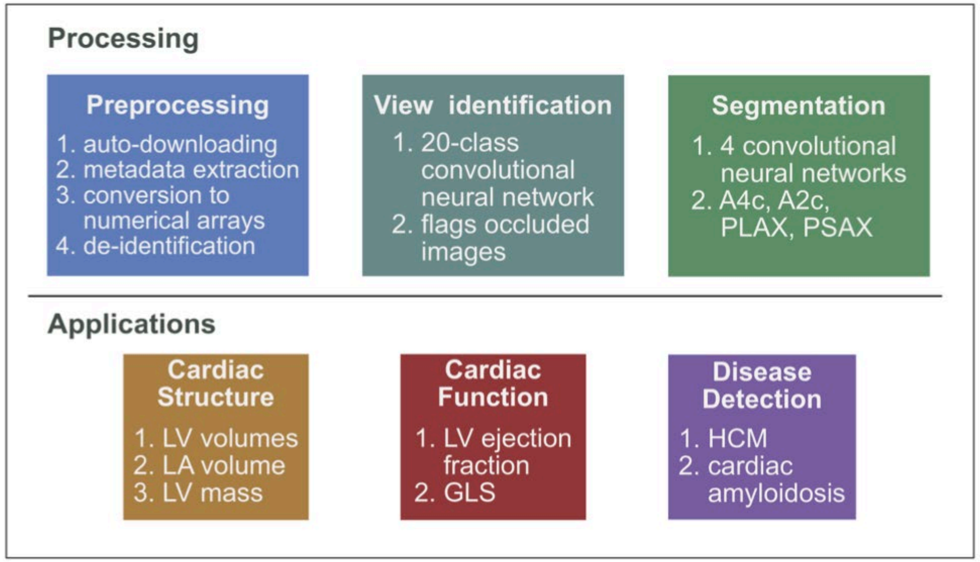
- Data from Wellington Hospital Cardiology Dept.
- A model representative of New Zealand's ethnic diversity
- Research is lacking in the area of variation in echocardiograms of people of a pacific island ethnicity

Our Progress: EchoCV (adapting)

"EchoCV": A Web-Based Fully Automated Echocardiogram Interpretation System (2017)

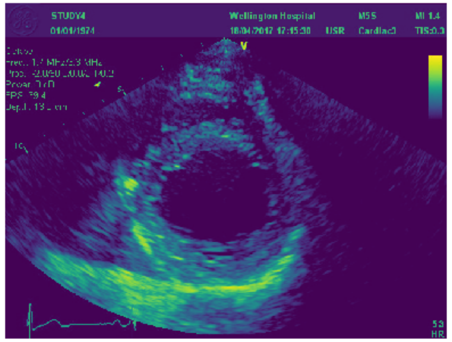
- Deep Learning group UCSF
  - Uses VGG Neural Network Architecture for image classification
  - A CNN based on the U-net architecture for image segmentation
  - View classification, segmentation and disease detection.
  - Written using Python 2.7



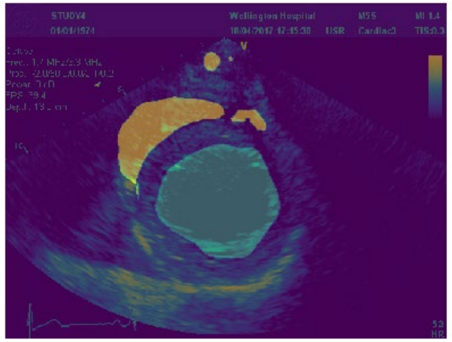


Our Progress: EchoCV:

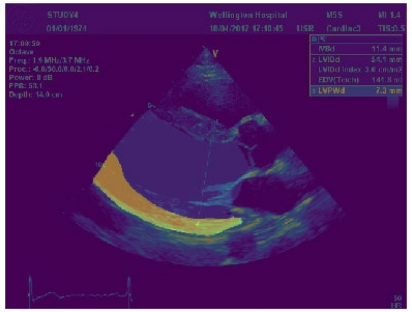
- NeSI consultancy
  - Successfully enabled GPU recognition
  - Using Nesi Mahuika GPUs: P100s
  - Added additional customization options for segmentation and classification
- Begun analysis on images from Wellington hospital
  - Implementing a preprocessing pipeline

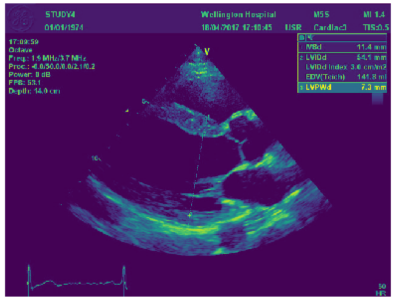


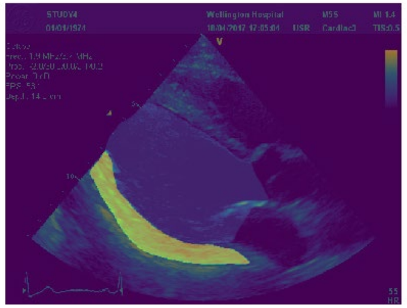
PSAX View

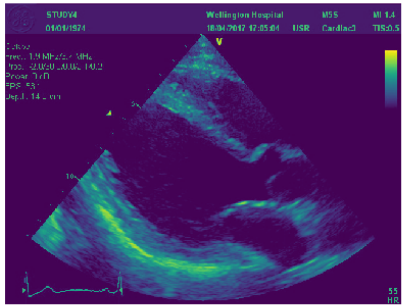


An Example of Our Images (PLAX)





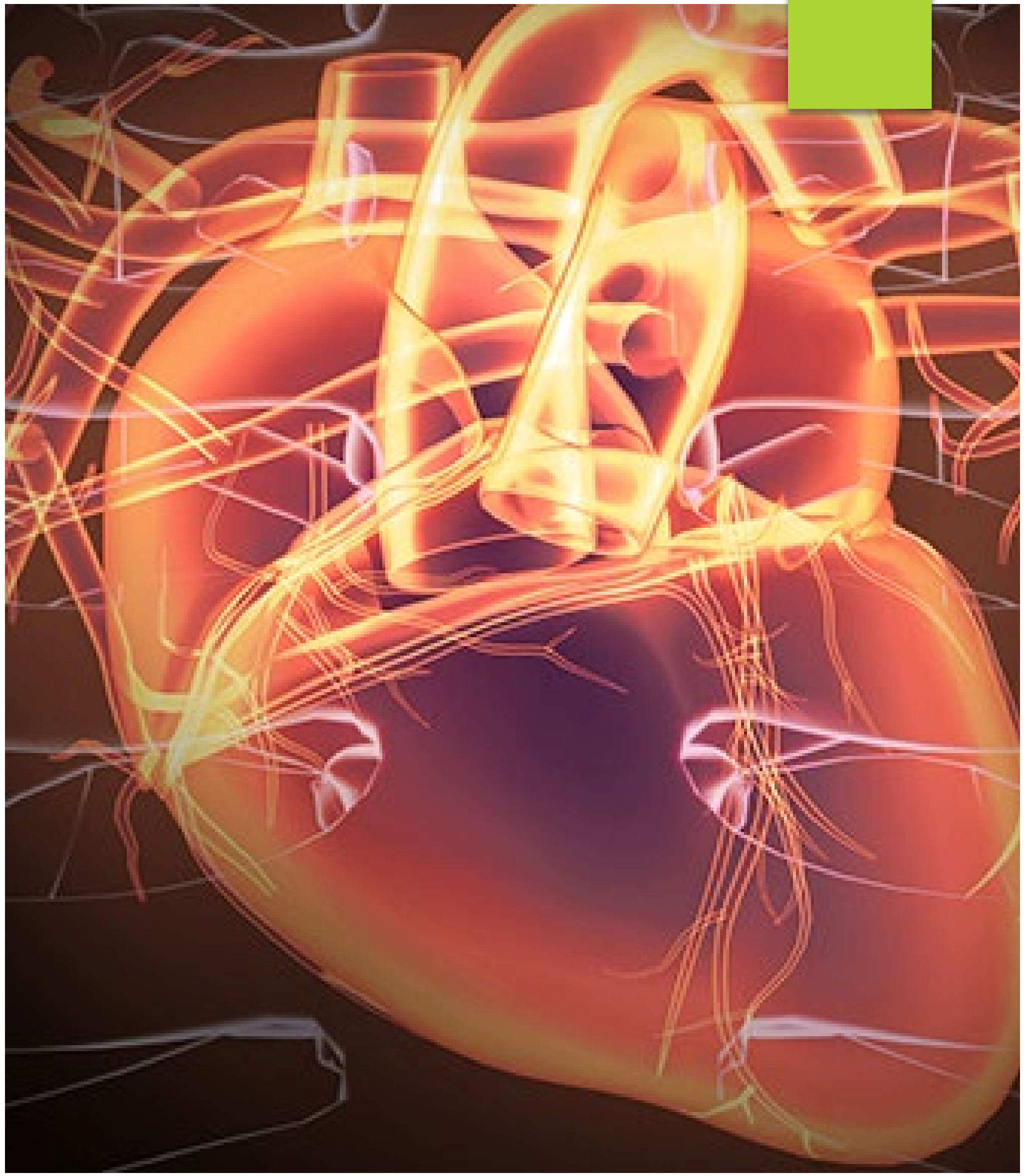




Precision Medicine (The Future)

- The ambition of precision medicine is to design and optimize the pathway for diagnosis, therapeutic intervention, and prognosis.
- This offers clinicians the opportunity to more carefully tailor early interventions.

Taking advantage of high performance computer capabilities, using deep learning models and embracing diversity in these models allows for a individualised course of care.



Acknowledgements

- Supervisory Team:
  - Associate Professor Mik Black (University of Otago)
  - Dr Miles Benton (ESR)
  - Associate Professor Peter Larsen (University of Otago & Wellington Hospital)
- Advisory Role:
  - Dr Donia Macarteny-Coxson (ESR)
- NeSI Consultancy:
  - Maxime Rio
  - Dinindu Senanayake

E/S/R Science for Communities

UNIVERSITY of OTAGO Te Whare Wānanga o Otāgo NEW ZEALAND SAPERE AUDE

NeSI New Zealand eScience Infrastructure

Thank You

References (in order of appearance)

- Martin-Isla, C., Campello, V. M., Izquierdo, C., Raisi-Estabragh, Z., Baeßler, B., Petersen, S. E., & Lekadir, K. (2020). Image-based cardiac diagnosis with machine learning: a review. *Frontiers in cardiovascular medicine*, *7*, 1.
- Sengupta, P. P., & Adjeroh, D. A. (2018). Will artificial intelligence replace the human echocardiographer? Clinical considerations.
- EchoNoRMAL (Echocardiographic Normal Ranges Meta-Analysis of the Left Heart) Collaboration. (2015). Ethnic-specific normative reference values for echocardiographic LA and LV size, LV mass, and systolic function: the EchoNoRMAL study. *JACC: Cardiovascular Imaging*, *8*(6), 656-665.
- LaBounty, T. M., Bach, D. S., Bossone, E., & Kolias, T. J. (2017). Race is Associated With Differences in Left Heart Dimensions on Echocardiography. *Circulation*, *136*(suppl_1), A15955-A15955.
- Madani A, Arnaout R, Mofrad M, Arnaout R. Fast and accurate view classification of echocardiograms using deep learning.