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

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(1ST YEAR PHD STUDENT)
Clinical Data Overload
“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.

If this data isn’t utilised, then it is being collected and stored at an unnecessary cost.
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
Deep Learning Models and Diverse Populations
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.

Main Segmentation Applications

**MRI**
- Bi-ventricle (LV+RV)
- Left Atrium
- Myocardial Scar

**CT**
- Whole Heart/Substructures
- Coronary Arteries
- Plaque

**Ultrasound**
- (LV+LA) in 2D
- LV in 3D

**Our Starting Point**
The number of publications on machine learning and cardiac imaging per year.

ERNZ Nathan Russell 2021
Echocardiogram 101
Existing Models

- **View classification**

- **Pathology identification**

- **Risk prediction**
Evidence of Ethnic Variation in Heart Parameters

The ECHOonormal Study (2015)
**Table 1. Comparison of Left Heart Chamber Size and Race**

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Caucasian n=17,342</th>
<th>African American n=1,676</th>
<th>Hispanic n=156</th>
<th>Asian n=720</th>
<th>Native American n=64</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>50.5±15.5</td>
<td>44.0±15.2*</td>
<td>44.4±13.8*</td>
<td>46.5±14.5*</td>
<td>48.1±13.5*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Female gender</td>
<td>55.6%</td>
<td>65.4%*</td>
<td>75.6%*</td>
<td>57.8%</td>
<td>56.3%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BSA (m²)</td>
<td>1.9±0.3*</td>
<td>2.0±0.3*</td>
<td>1.8±0.2*</td>
<td>1.7±0.2*</td>
<td>2.0±0.3</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

**Dimensions (mm) or Mass (gm)**

<table>
<thead>
<tr>
<th></th>
<th>Caucasian</th>
<th>African American</th>
<th>Hispanic</th>
<th>Asian</th>
<th>Native American</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVEDD</td>
<td>46.9±5.5</td>
<td>46.4±5.5*</td>
<td>45.7±5.1</td>
<td>44.7±4.7*</td>
<td>48.0±6.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LVESD</td>
<td>30.1±5.2</td>
<td>29.6±5.2*</td>
<td>28.8±4.6*</td>
<td>28.5±4.6*</td>
<td>30.2±6.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>IVS</td>
<td>9.2±2.3</td>
<td>9.7±2.5*</td>
<td>8.7±1.6</td>
<td>8.5±1.8*</td>
<td>9.7±2.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PW</td>
<td>9.0±1.7</td>
<td>9.5±2.0*</td>
<td>8.8±1.6</td>
<td>8.3±1.4*</td>
<td>9.3±1.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LV Mass</td>
<td>147.9±51.8</td>
<td>156.0±58.2*</td>
<td>133.1±42.8*</td>
<td>121.7±37.8*</td>
<td>163.6±62.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LAD</td>
<td>36.8±6.7</td>
<td>36.0±6.1</td>
<td>35.2±6.3*</td>
<td>33.8±5.6*</td>
<td>38.1±8.0</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

**Dimensions (mm/m²) or Mass (gm/m²) indexed to BSA**

<table>
<thead>
<tr>
<th></th>
<th>Caucasian</th>
<th>African American</th>
<th>Hispanic</th>
<th>Asian</th>
<th>Native American</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVEDD/BSA</td>
<td>24.6±3.3</td>
<td>23.8±3.3*</td>
<td>25.4±3.0*</td>
<td>26.2±3.3*</td>
<td>24.8±3.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LVESD/BSA</td>
<td>15.8±2.9</td>
<td>15.2±2.9*</td>
<td>16.0±2.7</td>
<td>16.7±3.0*</td>
<td>15.6±2.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>IVS/BSA</td>
<td>4.8±1.1</td>
<td>5.0±1.3*</td>
<td>4.8±0.8</td>
<td>5.0±1.0*</td>
<td>5.0±1.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PW/BSA</td>
<td>4.7±0.9</td>
<td>4.9±1.0*</td>
<td>4.9±0.8</td>
<td>4.9±0.9*</td>
<td>4.8±0.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LV mass/BSA</td>
<td>75.9±22.3</td>
<td>78.8±25.6*</td>
<td>73.0±19.4</td>
<td>70.5±19.5*</td>
<td>82.9±26.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LAD/BSA</td>
<td>19.2±3.1</td>
<td>18.4±3.0*</td>
<td>19.4±3.1</td>
<td>19.8±3.2*</td>
<td>19.6±4.0</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

* 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)
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.

- 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
An Example of Our Images (PLAX)
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
Thank You
References

( in order of appearance)


