

From Analysis Method to Quantitative Imaging Biomarker

Developments in Healthcare Imaging –
Connecting with Industry

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Disclosures

- Consultant to GE Healthcare and GSK
- This talk is sponsored by GSK

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Motivation

3 Yule-Walker System of Equations

The conventional Yule-Walker equations are given by [1][6]

$$\sum_{i=0}^{p_1} \sum_{j=0}^{p_2} a[i, j] r_{yy}[i - k, j - l] = -r_{yy}[-k, -l] \quad (4)$$

for $k = 0, \dots, p_1$ and $l = 0, \dots, p_2$, where $[k, l] \neq [0, 0]$, $[i, j] \neq [0, 0]$, $a[i, j]$ is the AR model coefficient, $1 \leq m \leq M$, $1 \leq n \leq N$, $M \times N$ is the size of the given image and $r_{yy}[i, j] =$

Equation (4) can

4 Yule-Walker System of Equations in the Third-Order Statistical Domain

The equations that relate the AR model parameters to the third-order moment

The mini-MIAS database of mammograms

By popular request, the original MIAS Database (digitised at 50 micron pixel edge) has been reduced to 200 micron pixel edge and clipped/padded so that every image is 1024×1024 pixels. You are free to use the database in your scientific research but you must abide by the [licence agreement](#) when using the imagery.

Credits

Organiser:

J Suckling

Truth-Data:

C R M Boggis and I Hutt

Co-Workers:

S Astley, D Betal, N Cerneaz, D R Dance, S-L Kok, J Parker, I Ricketts, J Savage, E Stamatakis and P Taylor

Special Thanks:

N Karrsemeijer

PEIPA Maintainer:

A Clark

Reference:

J Suckling *et al* (1994): *The Mammographic Image Analysis Society Digital Mammogram Database* Excerpta Medica. International Congress Series 1069 pp375-378.

$$D[i, i] = \begin{cases} \dots & \dots \\ [50\sigma_x^2] & \text{for } (p_1 + 1)(p_2 + 1) \leq i \leq 2(p_1 + 1)(p_2 + 1) - 2 \end{cases} \quad (12)$$

where $[x]$ denotes rounding toward infinity.

Refs: Sarah Lee and Tania Stathaki (2005) "Mammogram analysis using two-dimensional autoregressive models: sufficient or not?" *Proc. 13th International Conference on Image Analysis and Processing*, pp. 900-906, LNCS 3617.

MIAS website: <http://peipa.essex.ac.uk/info/mias.html>

Introduction to QIB

“Quantitative imaging biomarkers (QIBs) are objective characteristics derived from *in vivo* images as indicators of normal biological processes, pathogenic processes, or response to a therapeutic intervention (Sullivan et al., 2015)”

Reference:

Sullivan et al. (2015) Metrology Standards for Quantitative Imaging Biomarkers. *Radiology* 277:813:25.

Quantitative image biomarkers

QIBs can be

- anatomical, e.g.,
 - Oncology: tumour size
 - Alzheimer's disease: size of hippocampus
 - Neurological disorders: white matter lesions (hyperintensity)
- functional, e.g.,
 - Physiological aspects of the tumours in the image such as cellularity or vascularity
 - Brain responses in a controlled experiment

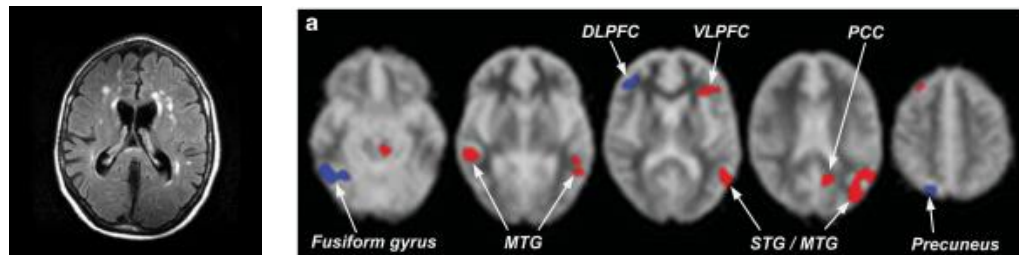


Image sources:

White matter hyperintensity: WMH Segmentation Challenge <http://wmh.isi.uu.nl/data/>

Fig 2 from YS Cheah, S Lee et al. (2014) Ageing diminishes the modulation of human brain responses to visual food cues by mean ingestion. *International Journal of Obesity* 38:1186-92.

From Analysis Method to QIB

Analysis Method



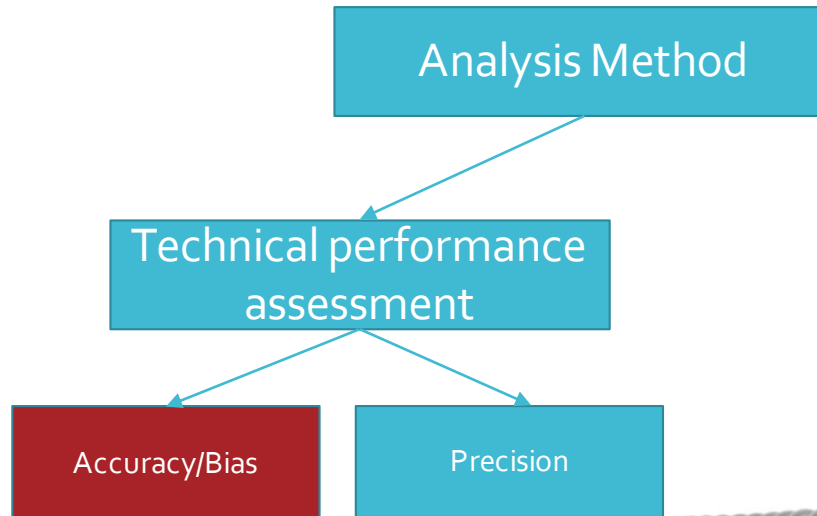
Diagnostic or prognostic

Predictive

Response

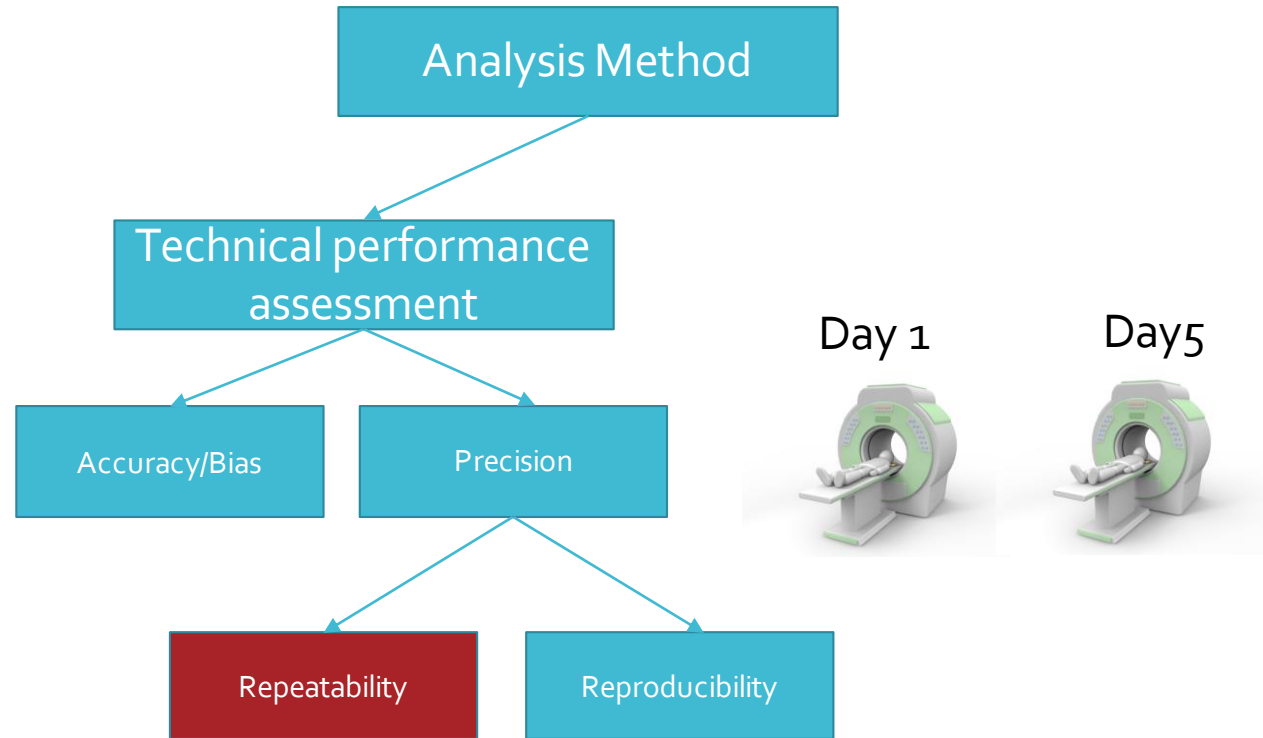
Monitoring

From Analysis Method to QIB



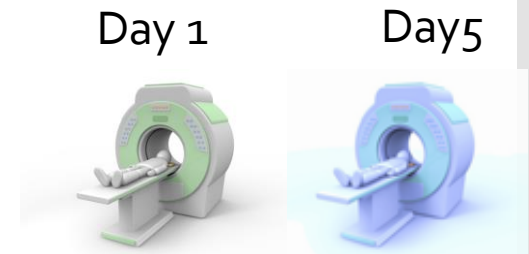
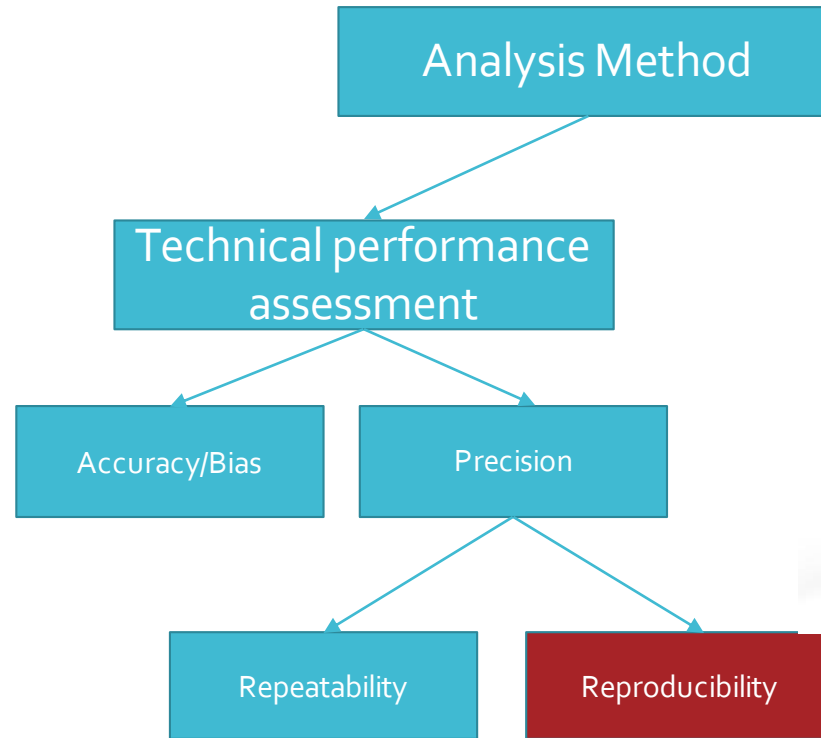
- Is ground truth available?
- Is application-specific phantom available?
- What is considered as outlier?
- How does your algorithm deal with outlier?

From Analysis Method to QIB



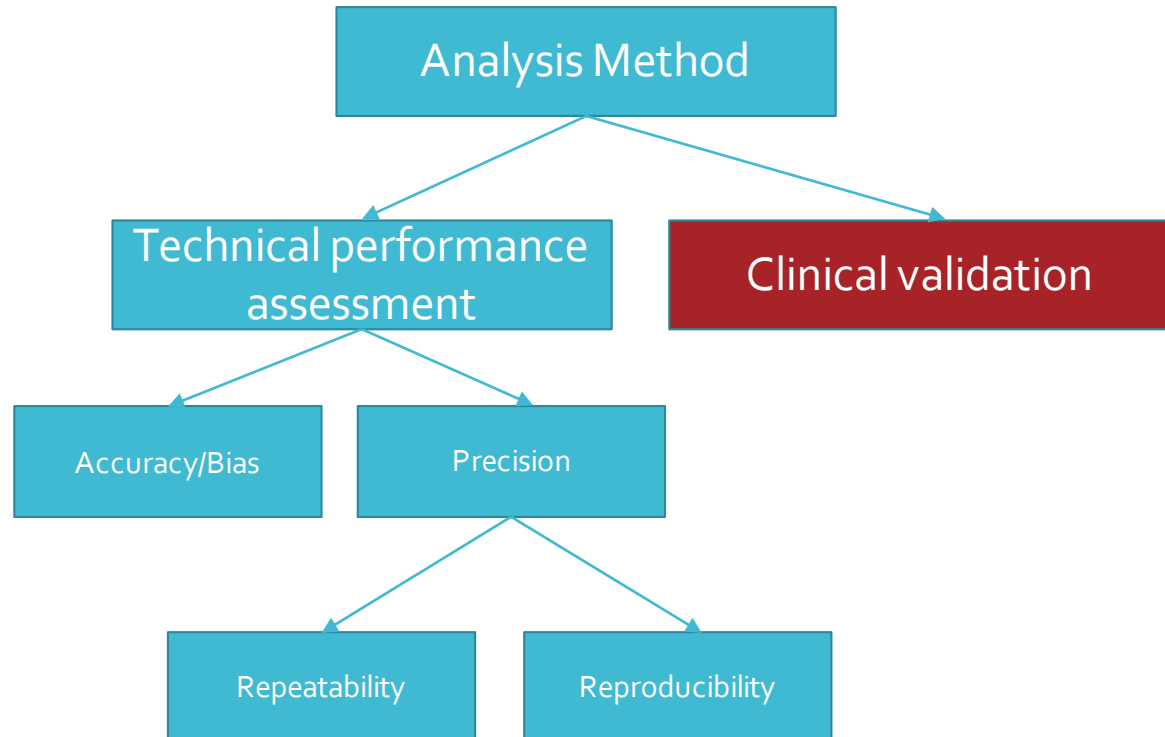
- Test/re-test
- Repeatability coefficient

From Analysis Method to QIB



- Different scanners
- Different days
- Different operators
- Reproducibility coefficient

From Analysis Method to QIB



- Demonstrating that a biomarker is associated with a clinical endpoint
- The QIB is a measurable indicator of a pathological process, a biological process or response to an intervention

- Validate your algorithm using a wide range of relevant data
 - From different scanners
 - From a larger cohort
 - From different cohorts
- Open source data

“Bigger data”

The mini-MIAS database of mammograms

By popular request, the original image is 1024 x 1024 pixels. This image is clipped/padded so that every image is 1024 x 1024 pixels. Please contact the maintainer for more information and agreement when using the imagery.

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N Karsemeyer

Special Thanks:
PEIPA Maintainer:
A Clark

Reference:
J Suckling *et al* (1999) *IEEE Transactions on Medical Imaging* 18(12):1375-1378.

ELCAP Public Lung Image Database

and clipped/padded so that every image is 1024 x 1024 pixels. Please contact the maintainer for more information and agreement when using the imagery.

VIA Vision and Image Analysis Group

Welcome to the VIA/ELCAP Public Access Research Database.

Access Database

PARKINSON'S PROGRESSION MARKERS INITIATIVE

Play a Part in Parkinson's

About PPMI

The privacy of the data and the user's consent are essential for the use of this web site, this causes most browsers to display a warning message. Please ignore these messages and click on the "accept" or "allow" buttons as appropriate. If you do not do this, the lock icon will appear. At this time the lock icon will appear. To access the public database click [here](#)

biobank^{uk}
Imaging study

The UK Biobank Imaging Study is one of the most ambitious and exciting health research opportunities in recent years. It will provide an unprecedented level of information to help scientists and doctors working on a wide range of illnesses.

Get in touch

Sources:

Lung CT database: <http://www.via.cornell.edu/lungdb.html>

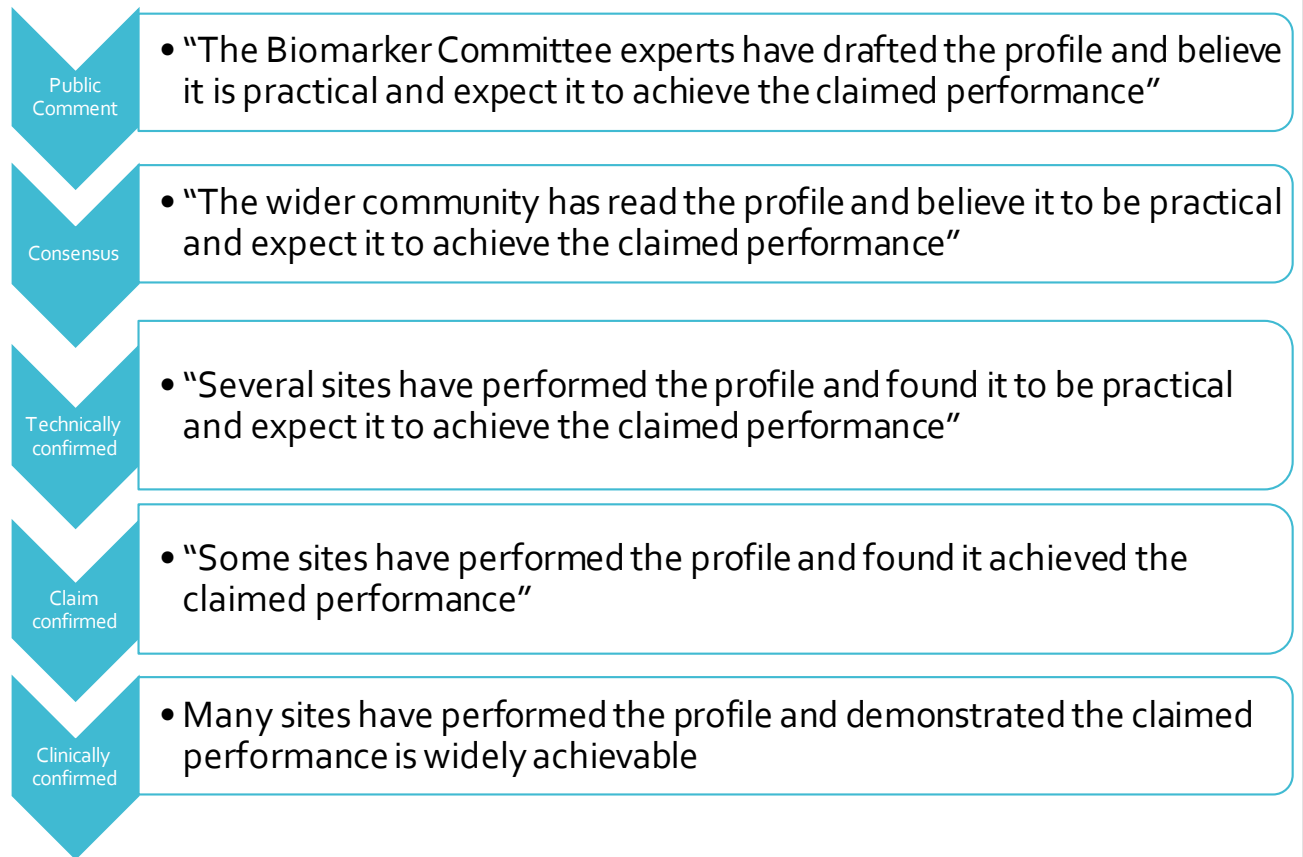
The Alzheimer's Disease Neuroimaging Initiative (ADNI): <http://adni.loni.usc.edu/>

Parkinson's Progression Markers Initiative (PPMI): <http://www.ppmi-info.org/>; UK Biobank: <http://imaging.ukbiobank.ac.uk/>

Quantitative Imaging Biomarker Alliance® (QIBA)

- An Radiological Society of North America (RSNA) initiative
- **Mission:** To improve the value and practicality of QIBs by reducing variability across devices, patients, and time
- To produce a description of a QIB in sufficient detail that it can be considered as a validated assay
 - The measurement bias and variability are both characterised and minimised

QIBA[®] Profiles Development



QIBA® Profile:
FDG-PET/CT as an
Imaging Biomarker
Measuring
Response to Cancer
Therapy

- Stage 3: Technically confirmed profile

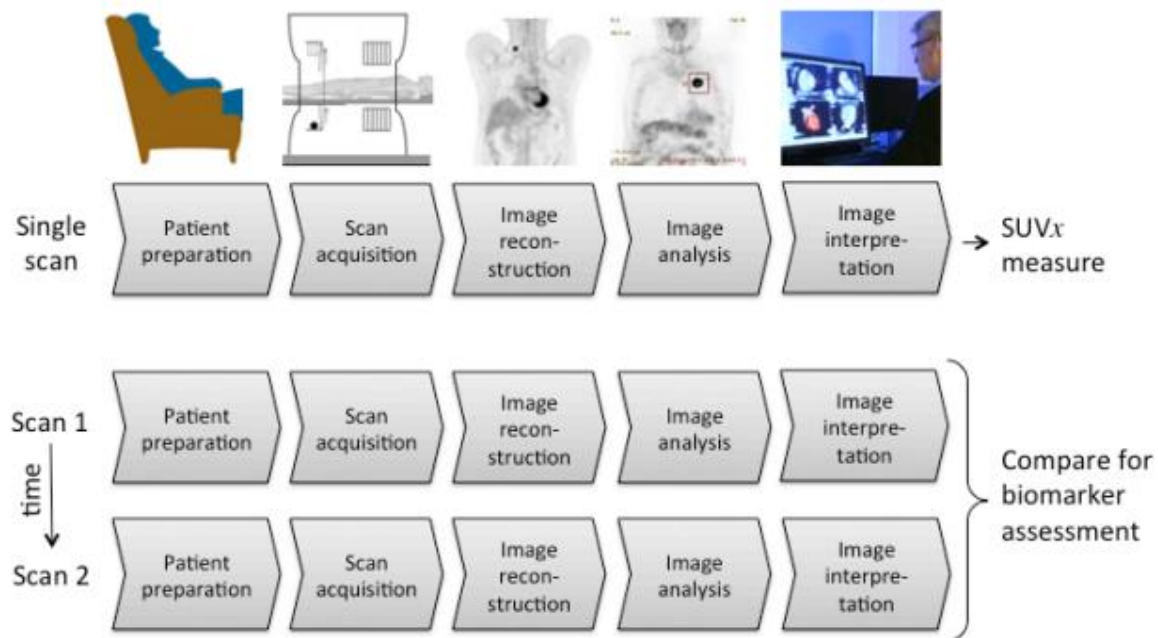


Image Analysis: Detailed description of
(1) ROI extraction
(2) Standard uptake value computation

Summary

- Quantitative imaging biomarkers have been increasingly used in clinical trials and clinical practices
- The advances of QIB also rely on analysis method development
- The technical performance of QIBs should be considered while developing analysis methods
- Initiatives such as QIBA[®] have profiles set up that bridge analysis method and QIB