

Spectral Imaging: Breast Density Measurement Using MATLAB Coder

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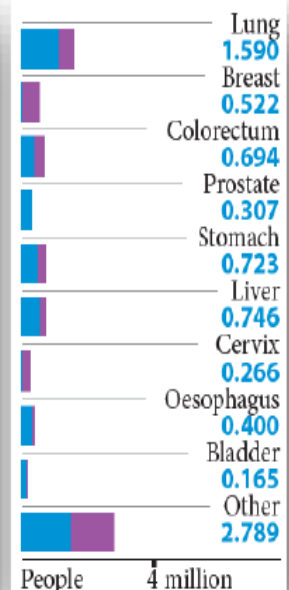
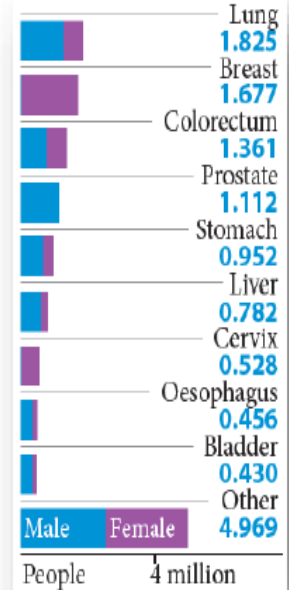
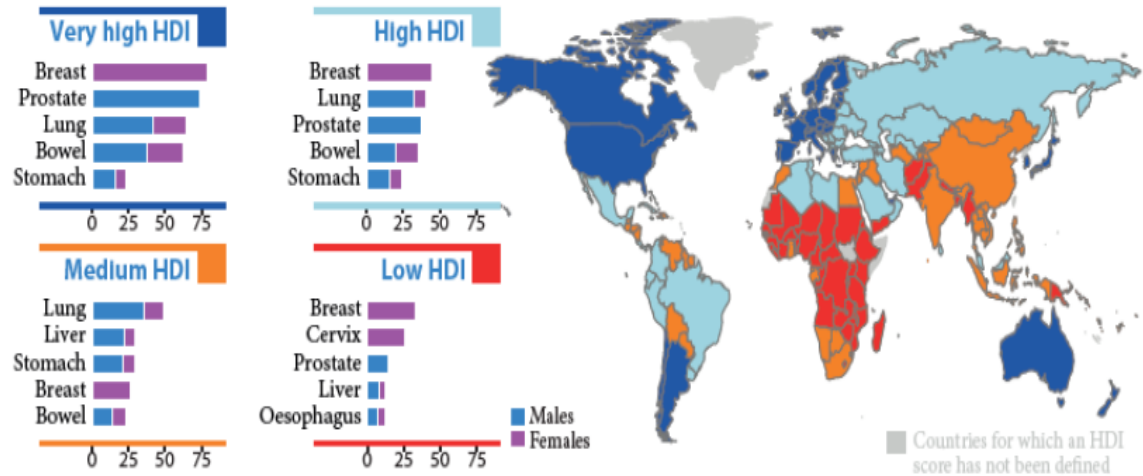
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Agenda

- Breast Cancer Burden overview
- Philips MicroDose Mammography
- Problem Definition
- Challenges Encountered
- Approach to Solution
- Conclusion

Most commonly diagnosed cancers by Human Development Index

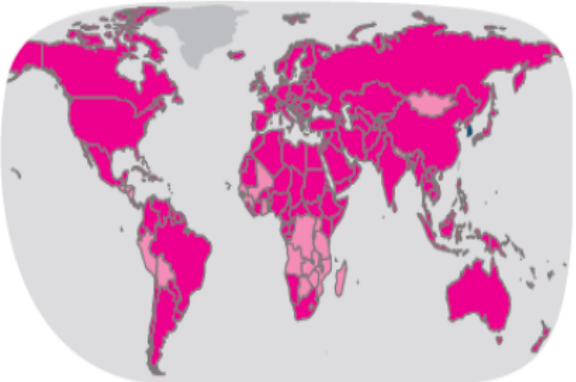
New cases per 100,000 population, age standardised



Prevalence 2012 // Most prevalent cancer by country

Males

Females

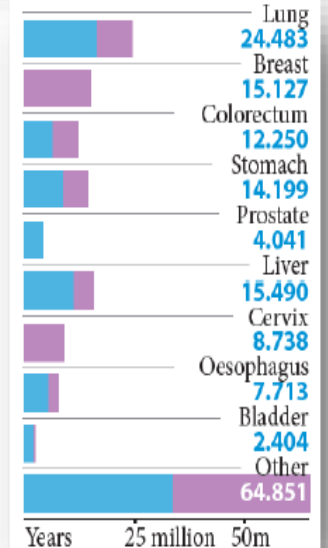


- 1 Prostate - 124 countries worldwide
- 2 Bowel - 23 countries in Africa, Asia and Eastern Europe
- 3 Stomach - 9 countries in Asia
- 4 Lip, Oral Cavity - 7 countries in South-Central Asia and Melanesia
- 5 Bladder - 7 countries in Northern Africa, Asia
- 6 Kaposi Sarcoma - Lesotho, Malawi, Mozambique, Swaziland, Zimbabwe, Zambia
- 7 Liver - Gambia, Laos
- 8 Lung - China, Vietnam
- 9 Pharynx - Bangladesh, Myanmar

- 1 Breast - 151 countries worldwide
- 2 Cervix - 30 countries in Africa, the Americas and Asia
- 3 Thyroid - South Korea

Incidence, 2012

Mortality, 2012



Healthy Years of Life Lost., 2008

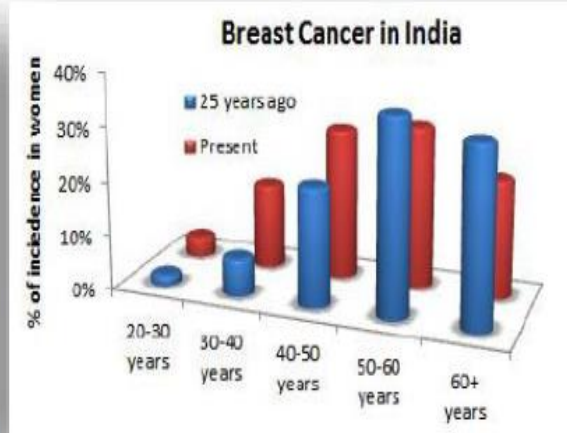
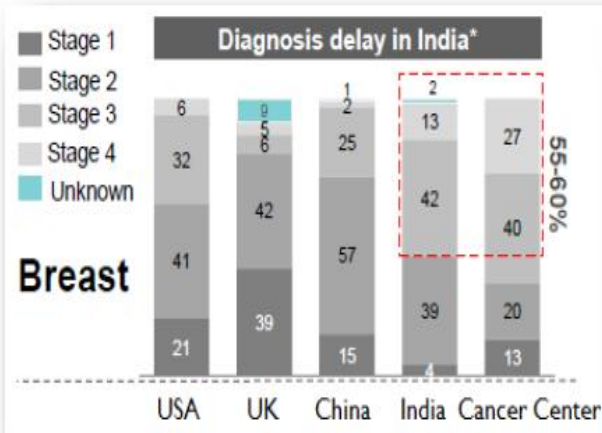


International Agency for Research on Cancer

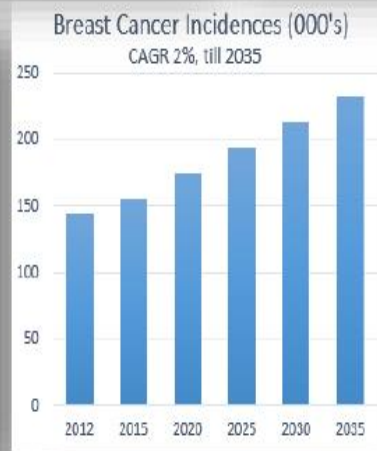
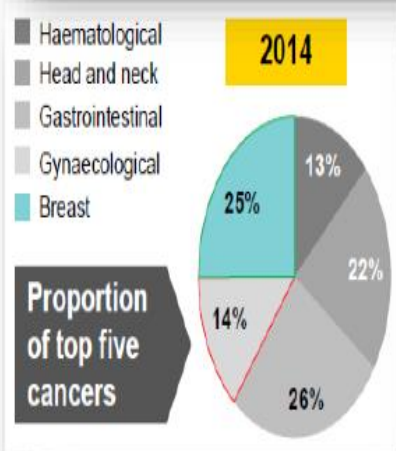


Disease Burden – India

Real cancer incidence estimated 1.5-2.0 times higher than reported incidence.



Reluctance in asymptomatic screening due to reactionary culture also leading to diagnosis at later stages



Risk factors

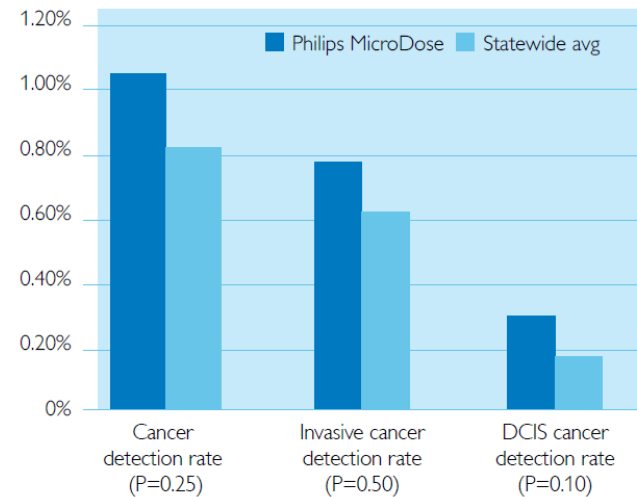
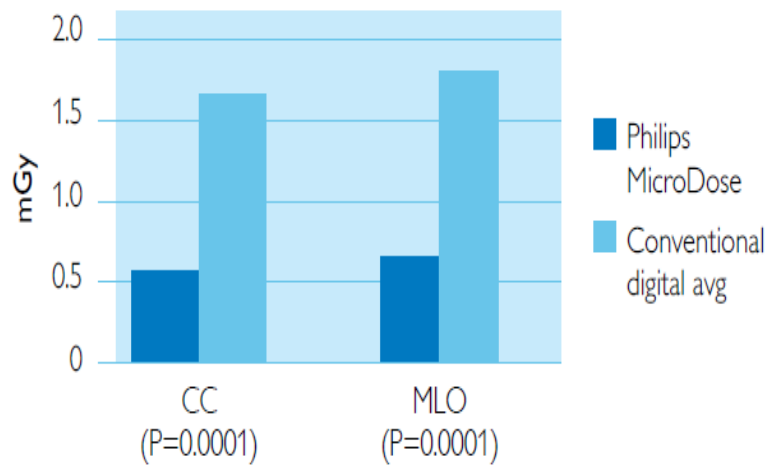
- Hormone replacement therapy
- Obesity
- Lack of exercise
- Later age at first child birth
- Lack of Breast-feeding
- Family history

5% (India) vs. 1.5% (USA) mortality among incidences

20% more breast cancers since 2010



MicroDose Mammography

- [MicroDose Mammography.mp4](#)
- Outstanding innovations
 - Low dose
 - High Image quality
 - Breast Density Measurement



Source : <http://www.usa.philips.com/healthcare/product/HC714047US/microdose-mammography-si>

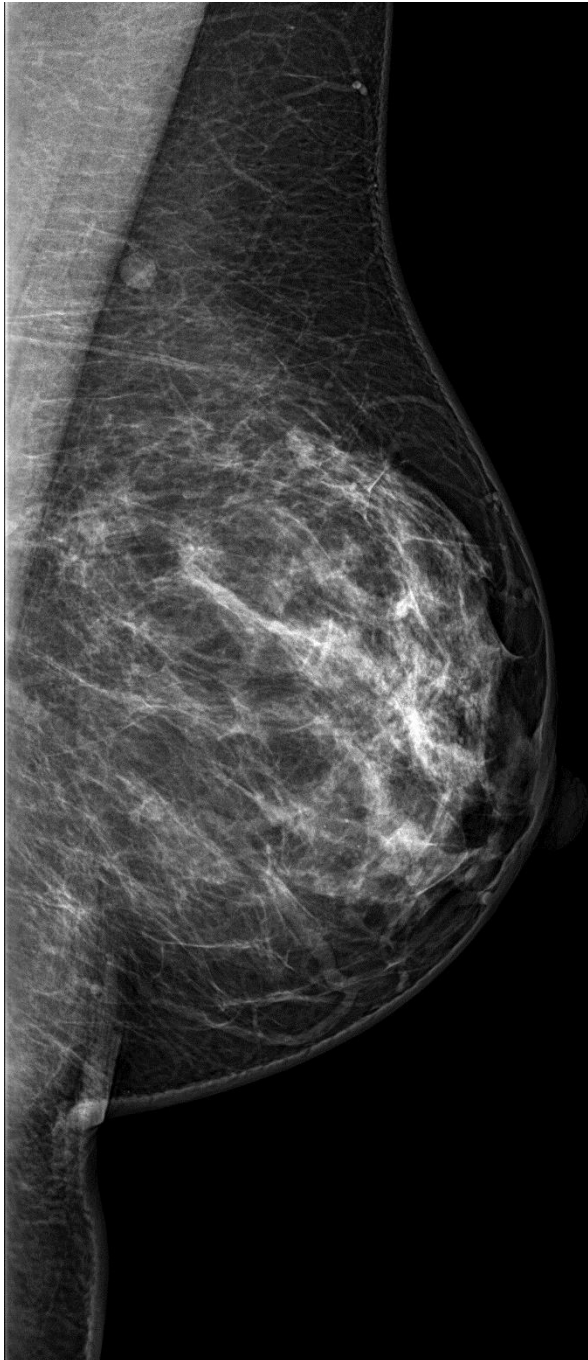
Tomosynthesis (3D Mammography)

- 3D Breast Imaging
 - Creates a 3D picture of the breast using X-rays
- Advantages
 - High Cancer detection rate 
 - Low Recall rate 
- Tomographic reconstruction algorithm used to generate 3D/2D images

References:

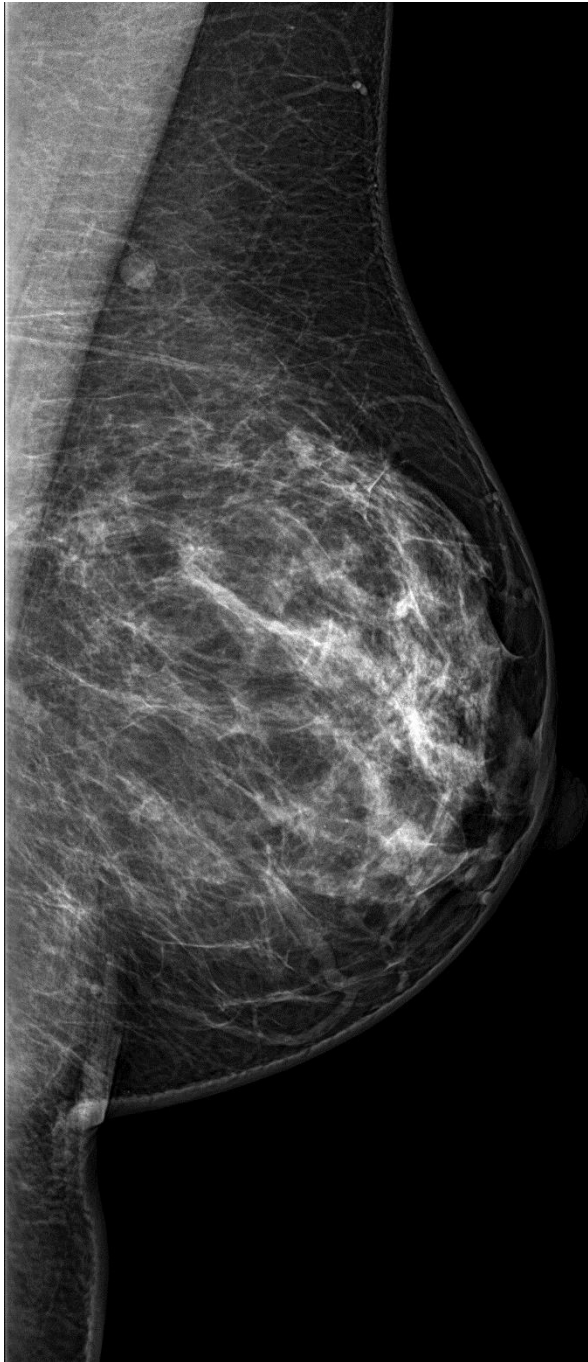
- i. Journal of the American Medical Association (JAMA) <https://www.itnonline.com/article/3-d-tomosynthesis-increases-breast-cancer-detection-rate>
- ii. <https://www.ncbi.nlm.nih.gov/pubmed/26458206>

BDM (Breast Density Measurement)



- What is it!
 - Identifies the Breast Composition
 - Dense Breast:
 - (i) Higher Risk
 - (ii) Lower Sensitivity and Specificity
- Traditionally:
 - Visual or computer-assisted assessment of 2D Mammogram (e.g. BIRADS score, Cumulus)
- Volumetric Density Assessment:
 - Estimation of actual Fibro-glandular tissues
 - Higher Consistency

BDM Advantages



Advantages:

- Improved risk estimates
- Personalized screening
- Temporal monitoring
- Therapy response
- Better dose estimates

Problem Definition

Problem Statement:

- Having a reliable & accurate BDM algorithm in MATLAB, how to get this into Production environment

Solution Options:

1. Get the MATLAB code directly in Product
2. Convert code from MATLAB to C++ manually from scratch
3. Or Look for some automated and Reliable option that can convert code from MATLAB to C++

Approach

- Option 1:
Ruled out, as further optimizations are required.
- Option 2:
Ruled out, as lot of Expertise, Resources and Time is required.
- Option 3:
Can check it out.
Found that MATLAB provides some tool known as MATLAB Coder to convert the code automatically

Tool Evaluation

So, lets check out 'MATLAB Coder' 😊

- Expectations from MATLAB Coder:
 - To get exactly same out put from C++ as from MATLAB.
 - To get the precision correct at least up to 6 decimal places.
- To start with MATLAB Coder we needed:
 - Huge Data set, to verify MATLAB Coder output
 - Boundary cases for code conversion.

Challenges

Challenges Faced:

- Regular updates in Original MATLAB code
- MATLAB Code not Coder Ready
- Instances when results were mismatching.
- Output validation (MATLAB output vs. C++ output)

MATLAB & MATLAB Coder

Benefits:

- Design issues resolved early in development
- Rapidly assessed and converted
- Development process overhead reduced
- Algorithm validated in days
- Consistent output
- High accuracy

Support from Mathworks:

During this exercise the support from the Mathworks technical support team was commendable.

MATLAB Vs. C++ Output

Matlab:						
Data Set No.	Param_1	Param_2	Param_3	Param_4	Param_5	Param_6
DataSet_1	3428.431051	751.14735	0.24507734	93.25448398	4	53.6
DataSet_2	3494.037088	768.8880127	0.24560828	93.21472127	4	54.6
DataSet_3	3516.300802	731.2674748	0.23194159	94.12901229	4	56.1
DataSet_4	6776.522997	709.4755733	0.11062978	45.22007409	3	112.2
DataSet_5	6657.98595	787.6263249	0.12512878	56.27330253	3	112.4
DataSet_6	524.9499993	131.6811727	0.28464215	98.08561729	4	51.5
DataSet_7	532.6392096	249.1433539	0.5399299	100	4	44.6
DataSet_8	2212.330836	1518.467263	0.82122653	99.75996582	4	33.1
DataSet_9	474.7710126	94.32399329	0.22938966	93.17705038	4	46.8
DataSet_10	512.5745911	97.83134811	0.2177852	94.14073592	4	50.2
C++:						
Data Set No.	Param_1	Param_2	Param_3	Param_4	Param_5	Param_6
DataSet_1	3428.431051	751.1473499	0.245077343	93.25448398	4	53.6
DataSet_2	3494.037088	768.8880126	0.245608276	93.21472127	4	54.6
DataSet_3	3516.300802	731.2674748	0.231941588	94.12901229	4	56.1
DataSet_4	6776.522997	709.4755733	0.110629775	45.22007409	3	112.2
DataSet_5	6657.98595	787.6263249	0.125128782	56.27330253	3	112.4
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DataSet_9	474.7710126	94.32399329	0.22938966	93.17705038	4	46.8
DataSet_10	512.574591	97.83134811	0.2177852	94.14073592	4	50.2

MATLAB Vs. C++ Output

Relative Error:

Data Set No.	Param_1	Param_2	Param_3	Param_4	Param_5	Param_6
DataSet_1	1.42019E-09	1.79685E-09	1.2807E-06	1.25217E-09	0	1.8559E-13
DataSet_2	1.57126E-09	1.4292E-09	1.67599E-06	4.41389E-09	0	1.8219E-13
DataSet_3	1.36167E-09	1.53979E-09	9.59598E-07	3.85005E-09	0	1.77319E-13
DataSet_4	1.43037E-09	1.69998E-09	4.41919E-06	5.49048E-09	0	8.99261E-13
DataSet_5	1.48183E-09	1.55302E-09	1.85415E-06	8.21312E-09	0	8.97661E-13
DataSet_6	7.31347E-11	2.6496E-09	2.44499E-07	9.56512E-10	0	0
DataSet_7	1.03803E-09	7.6302E-10	6.95508E-07	0	0	2.2304E-13
DataSet_8	1.38994E-09	1.75572E-09	2.47414E-07	3.84172E-09	0	3.00532E-13
DataSet_9	2.53177E-10	4.04673E-10	1.65012E-07	1.36578E-09	0	2.12556E-13
DataSet_10	6.94531E-10	3.79204E-09	1.5052E-07	4.72516E-09	0	1.98159E-13

Conclusion

- Highly interactive tool to use.
- Obtained optimal results using MATLAB Coder.
- Minimal relative error output between MATLAB & C++.
- Eliminated the C++ implementation effort significantly.

Recommend to use MATLAB Coder.

Appendix

The original BDM Algorithm in MATLAB is written by –
Sr. Scientist Erik Fredenberg, from Sweden.

