Using Machine Intelligence for Healthcare

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Niramai Health Analytics Pvt. Ltd. is a Bangalore based startup with a mission to create a Universal Screening Method that can save lives by detecting cancer at an early stage.
Data is Everywhere!

- 1M transactions per day - Walmart
- Google processes 24PB a day
  - 1.2 trillion searches per day!
- AT&T transfers 30 PB of data per day
- 90 trillion emails sent per year
- Facebook: 1 billion users per day!
  - 31.25 million msgs 2.77 million videos
- Huge volumes of data in electronic medical records, ..

PLUS

- Machine generated data volumes growing exponentially

Data Analytics is defining a new computing era!
Where is the Data?

- Claims
- Health Plans
- Pharmacy
- Providers
- Patient
- Supply Chain
- Charts
- Lab Tests
- Adverse Event
- Finance
- EMR
- Research
- Devices
- Digital Hosp.
- Social
Big Data Characteristics

**Volume**
- *Data at Rest*
  - Terabytes to exabytes of existing data to process

**Velocity**
- *Data in Motion*
  - Streaming data, milliseconds to seconds to respond

**Variety**
- *Data in Many Forms*
  - Structured, unstructured, text, multimedia

**Veracity**
- *Data in Doubt*
  - Uncertainty due to data inconsistency & incompleteness, ambiguities, latency, deception, model approximations

Source: www.datasciencecentral.com
Machine Learning

Descriptive Analytics

What Happened?

Predictive Analytics

What will happen?

Prescriptive Analytics

What should I do?

Diagnostic Analysis

Why did it happen?
Technical Challenges of ML for Healthcare

- Imbalanced Datasets
- Missing and Noisy Data
- Heterogeneous Sources
- Feature Dependencies

Volume
Variety
Veracity
Velocity
Machine Learning

A quick introduction
## Some Generic ML Approaches

### Predictive and Descriptive techniques
- Classification
- Clustering
- Association Rule Discovery
- Sequential Pattern Discovery
- Regression
- Collaborative Filtering
- ANN
- Deep Learning (CNN, RNN,..)
- ...

### Diagnostic and Prescriptive Techniques
- Bayesian and Graphical models
- Anomaly detection
- Causal networks
- Explainable techniques
- Semantic modeling
- Constrained Optimization
- Integer Linear Programming
- ...

![Image](Niramai)
Quick Intro to Machine Learning

Supervised Learning

Unsupervised Learning

\( x_2 \)

\( x_1 \)

income

education

age
Classification

(a) Training

- Input
- Feature extractor
- Features
- Machine learning algorithm
- Classifier model

Label
Discriminatory Classifiers

Learning Classifier Model = Learning the classifier boundaries
Decision Tree Classifier

Learning Classifier Model = Learning the Tree from Data
Random Forest - Simplified

Random Forest

Instance

Tree-1

Class-A

Tree-2

Class-B

Tree-n

Class-B

Majority-Voting

Final-Class
A Real Application
Breast cancer is the leading cause of cancer deaths in women

- Worldwide ~ 500,000 deaths per year
- 1 in 17 women develop some form of breast cancer in their lifetime
- Developing World at Higher Risk and Low Survival rates
- More than 60% of world’s new cases occur in Africa, Asia and Central & South America.

Early detection is key to survival
Characteristics of an Effective Screening Test

- Good Accuracy
- Catch Early
- All Women
- Annual check-up
- Low cost
- Portable
- Non-invasive

Mammography
Ultrasound
Clinical Breast Examination
Gaps in Current Breast Cancer Screening Tests

**Sono Mammography**
- Correlation Modality; Requires location of lump for diagnosis
- Automated Breast US (ABUS) very expensive

**Mammography**
- Low sensitivity in younger women
- Pressure of 20 kg applied on the breast is painful
- Risk of radiation increases chances of developing cancer

**Clinical Breast Examination**
- Only palpable lumps detected (> 1 cm)
- Not able to differentiate malignant versus benign

**NIRAMAI Breast Cancer Solution**
- An Innovative solution for early-stage breast cancer detection
- Non-contact, Radiation-free, Portable
- Accurate, Automated and Applicable to women of all ages

Breast MRI, PET/BSGI, FNAC/Biopsy are further invasive procedures

Thermalytix
Thermography has the potential to detect cancer much earlier than any other modality

Thermography detects infra-red radiation from the body generated due to heat

>500 Thermography clinics in US

Limitation of Manual Thermography:

>25% Interpretation errors even by experts

FDA Approved for cancer screening
Our Solution for Breast Cancer Screening
Automatic Screening using thermal Images

A clinician capturing thermal images

Real time screening using NIRAMAI’s Cloud Diagnostic Software
Privacy-aware screening
ML Algorithms to accurately detect malignancy

A Dataset of 300 patients

10 patents filed in USPTO, 2 granted
NIRAMAI Screening Test

- Good Accuracy
- Catch Early
- Non-invasive
- Annual check-up
- Portable
- Low cost
- All Women
- Low cost
- Annual check-up
What are the right features for my problem?
Overall Workflow

Is Image Good/Bad?

ROI segmentation

Tumour Segmentation

Feature Extraction

Final Classification

Prognosis Hormonal Positive?

Diagnostic Report
1. SYSTEM AND METHOD FOR DETECTING CANCEROUS TISSUE FROM A THERMAL IMAGE [TO BE ISSUED SHORTLY]

2. SOFTWARE INTERFACE TOOL FOR BREAST CANCER SCREENING

3. DETECTING TUMOROUS BREAST TISSUE IN A THERMAL IMAGE [GRANTED]

4. AUTOMATIC SEGMENTATION OF BREAST TISSUE IN A THERMOGRAPHIC IMAGE

5. A SOFTWARE TOOL FOR BREAST CANCER SCREENING

6. CONTOUR-BASED DETERMINATION OF MALIGNANT TISSUE IN A THERMAL IMAGE

7. PRIVACY BOOTH FOR BREAST CANCER SCREENING

8. THERMOGRAPHY-BASED BREAST CANCER SCREENING USING A MEASURE OF SYMMETRY

9. BLOOD VESSEL EXTRACTION IN TWO-DIMENSIONAL BREAST THERMOGRAPHY

10. CLASSIFYING HORMONE RECEPTOR STATUS OF MALIGNANT TUMOROUS TISSUE FROM BREAST THERMOGRAPHIC IMAGES
International Conference Publications


5. “Initial evaluation of human supervised automated breast cancer screening using thermography,” Quantitative InFraRed Thermography Asia Conference, July 6-10, 2015, Mamallapuram

6. “Method for classifying cancerous and normal regions in breast thermography for small size tumors,” Quantitative InFraRed Thermography Asia Conference, July 6-10, 2015, Mamallapuram
Concluding Remarks
Risk Assessment during Disease Progression

- Early intervention
- Opportunities identification

Health status

Healthy low risk → At risk → High risk → Early clinical symptoms → Active disease

Healthcare spending

Time

Early intervention Opportunities identification

20% of people generate 80% of costs

70% of US deaths are from chronic diseases

Risk Assessment using Machine Learning
Tiered Approach to Healthcare

Wellness programs for prevention
Personalized messaging

Health Monitoring and Screening
- Non-contact sensing of body vitals
- Breast Cancer Screening

Primary Healthcare Center
- Decision support for triage

Secondary/Tertiary Healthcare Center
- Hospital Readmission Prediction
- ICU admission prediction
- Treatment Planning

ICU within Hospital
- Medical complication prediction (AHE)
- Mortality Prediction

Credits: Xerox Research
Acknowledgements

Geetha
Nidhi
Himanshu
Siva Teja
Thara S

Krithika
Arun
LK Meshta
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