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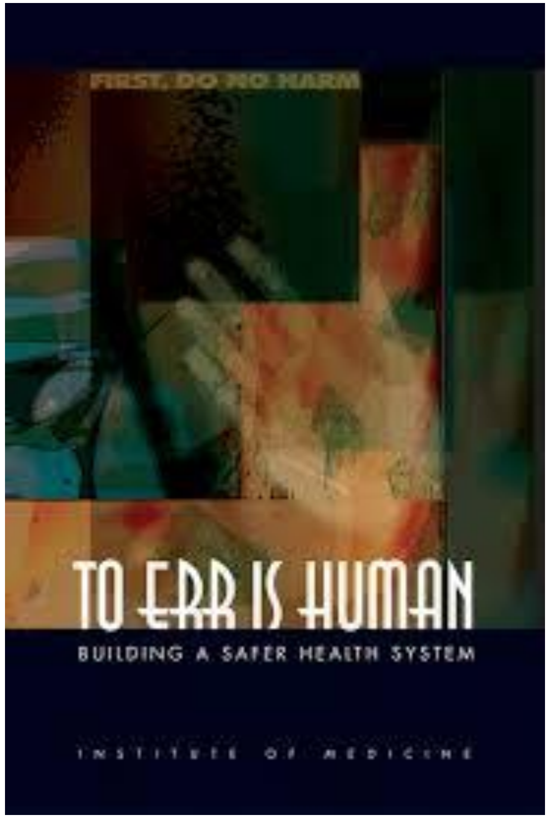
Chief Medical Officer Digital
GE Healthcare

AI in healthcare
Beyond deep learning in imaging

May 09, 2017

Healthcare is dangerous and wasteful

IOM 1998/2012:
98.000 deaths



30% excess Medicare spending
$690 billion IOM 2012

Estimates of Waste in US Health Care Spending in 2011, by Category

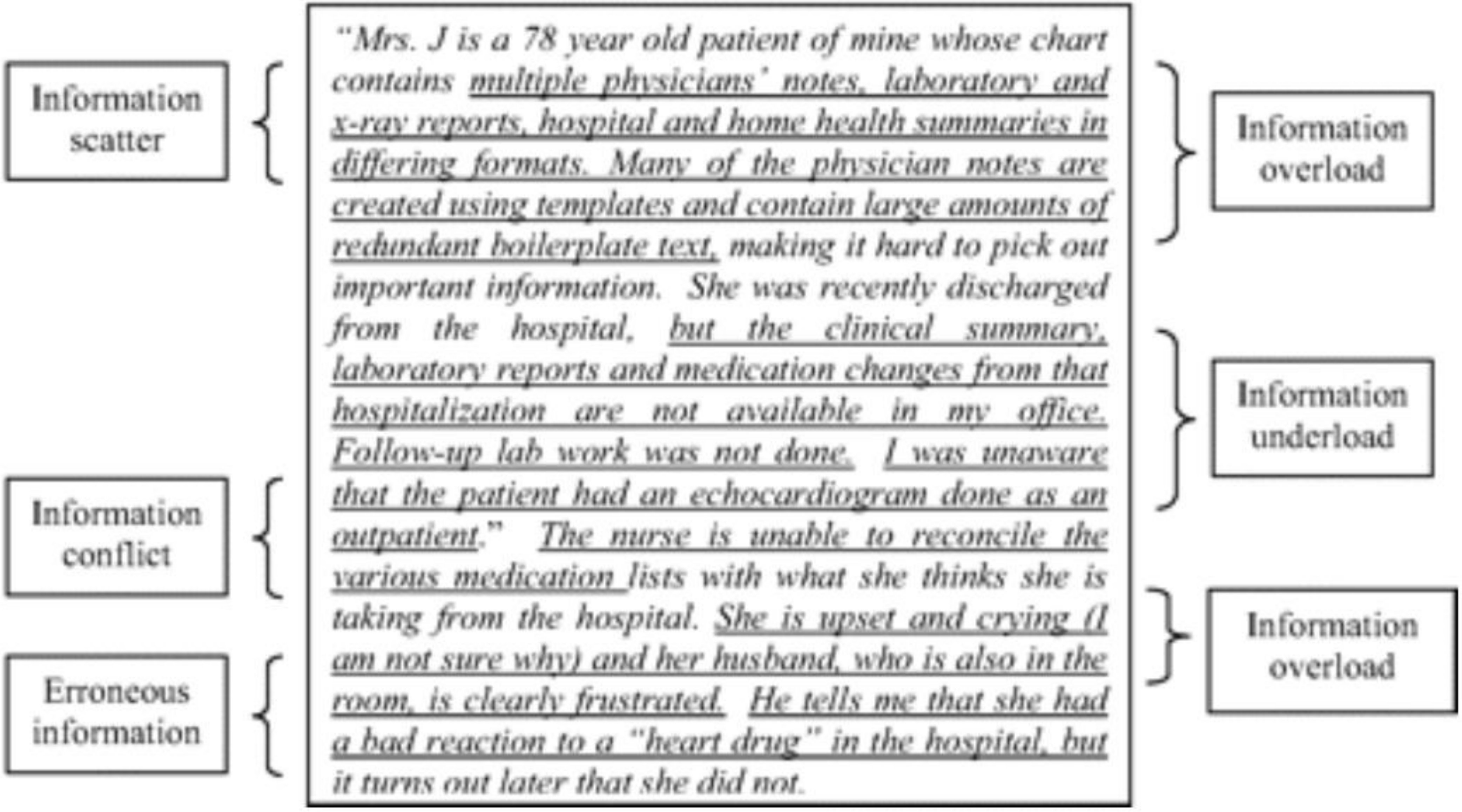
	Cost to Medicare and Medicaid[a]			Total cost to US health care[b]		
	Low	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Failures of care delivery	$26	$36	$45	$102	$128	$154
Failures of care coordination	21	30	39	25	35	45
Overtreatment	67	77	87	158	192	226
Administrative complexity	16	36	56	107	248	389
Pricing failures	36	56	77	84	131	178
Subtotal (excluding fraud and abuse)	166	235	304	476	734	992
Percentage of total health care spending	6%	9%	11%	18%	27%	37%

SOURCE Donald M. Berwick and Andrew D. Hackbarth, "Eliminating Waste in US Health Care," *JAMA* 307, no. 14 (April 11, 2012):1513–6. Copyright © 2012 American Medical Association. All rights reserved. **NOTES** Dollars in billions. Totals may not match the sum of components due to rounding. [a]Includes state portion of Medicaid. [b]Total US health care spending estimated at $2.687 trillion.

Information overload

70	Min time spent on alarm management
240	Information categories in ICUs
5	Times increase # of sophisticated tests
100	Times increase of archival capability

Likelihood of missing information increased 200-500%



Beasley et al, doi: 10.3122/jabfm.2011.06.100255

Work overload

46%	report symptoms of physical burnout
22%	ordered unneeded tests due to time
5%	Patients suffered adverse events
100	Times increase of archival capability

Likelihood of missing information increased 200-500%

Data accuracy in healthcare

33%	Data in EMRs are not accurate
69%	Patient records are incomplete
70%	Semantically incorrect when from other sources

Healthcare data is difficult

Heterougenous biology - Precision medicine

Digital Health =
advanced analytics based on multi-modal data

Health Care Internet of Things =
sensors, apps, and remote diagnostic or care delivery

Preventive Medicine =
Digital Twin for a Person's Health based on multiple data types

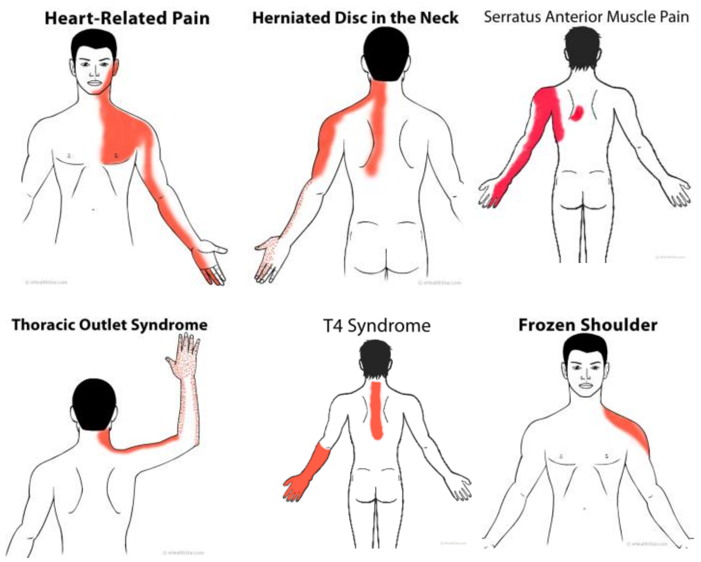
genomic data, i.e. nucleotide polymorphisms, whole human or exome sequencing, epigenetics, RNA expression data, metabolomics, microbiomics, environmentalomics, and diseasomics, personal and family health history, images, blood test data and other laboratory results, and prescription histories, sensors - wearable or implantable, and diagnostics raw data

Optimism bias and decision making

Patient with pain in his left arm

Cardiologist:	Coronary
Neurosurgeon:	Cervical Disc
Orthopaedic:	Shoulder, Muscle
Angiologist:	Vascular

……



Modric, 2015: http://www.ehealthstar.com/arm-pain.php

Healthcare decision making's complex

Efficiency in healthcare

- 1/3 expenditure don‘t improve health
- US #50/55
- Germany #37/55
- Throughput 1/5 compared to aviation, automotive

Current Rank	2009 Rank	Change	Country/Region	Efficiency Score	Life Expectancy	Relative Cost %	Absolute Cost $
1	1	–	Hong Kong	88.9	83.98	5.40	2,021
2	2	–	Singapore	84.2	82.65	4.92	2,752
3	8	5	Spain	72.2	83.80	9.03	2,658
4	7	3	S. Korea	71.5	82.16	7.37	2,060
5	3	-2	Japan	68.2	83.59	10.23	3,703
6	5	-1	Italy	67.7	82.69	9.25	3,258
7	4	-3	Israel	66.8	82.15	7.81	2,910
8	15	7	Chile	65.2	81.50	7.79	1,137
9	9	–	U.A.E.	64.3	77.37	3.64	1,611
10	6	-4	Australia	62.0	82.25	9.42	6,031
11	33	22	Argentina	59.8	76.16	4.79	605
12	11	-1	Taiwan	59.7	80.20	6.34	1,389
13	22	9	Greece	59.0	81.29	8.08	1,743
14	10	-4	Switzerland	57.8	82.85	11.66	9,674
15	21	6	France	56.8	82.37	11.54	4,959
16	24	8	Canada	56.1	81.96	10.45	5,292
17	20	3	Mexico	55.3	76.72	6.30	677
18	27	9	Poland	54.6	77.25	6.35	910
19	19	–	China	54.3	75.78	5.55	420
20	13	-7	Norway	54.0	81.75	9.72	9,522
21	26	5	U.K.	52.9	81.60	9.12	3,935
22	16	-6	Malaysia	52.2	74.72	4.17	456
23	29	6	Czech Rep.	51.5	78.28	7.41	1,379
24	25	1	Finland	51.1	81.13	9.68	4,612

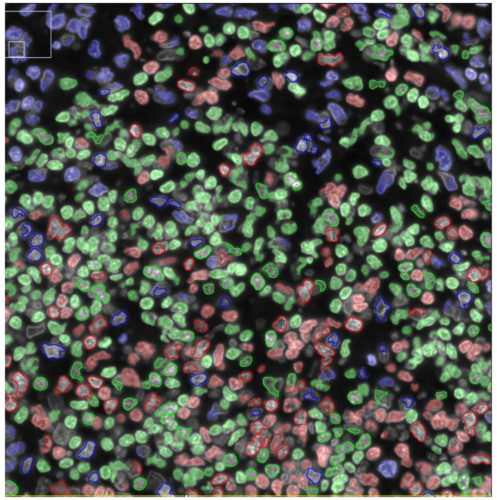
Healthcare & AI: three main pillars

1. Imaging related decision making
2. Multi-modal Clinical Decision Support
3. Healthcare assets & predictive optimization

Deep Learning for Cell Classification

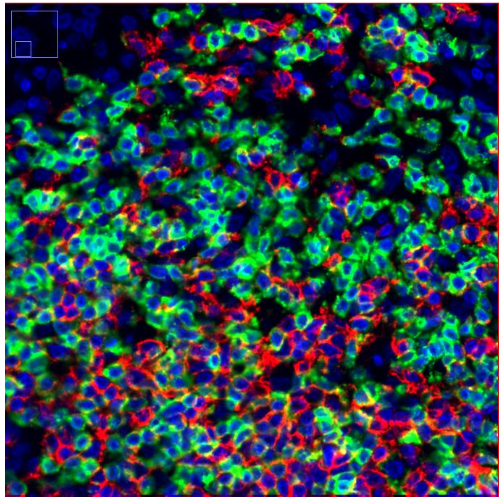
Example of cell classification in tissue samples using CD20 (B Cells) and CD3 (T Cells) markers

Image Tissue Biopsy



Markers: CD20 (red), CD3 (green), cell nuclei (blue)

Classification

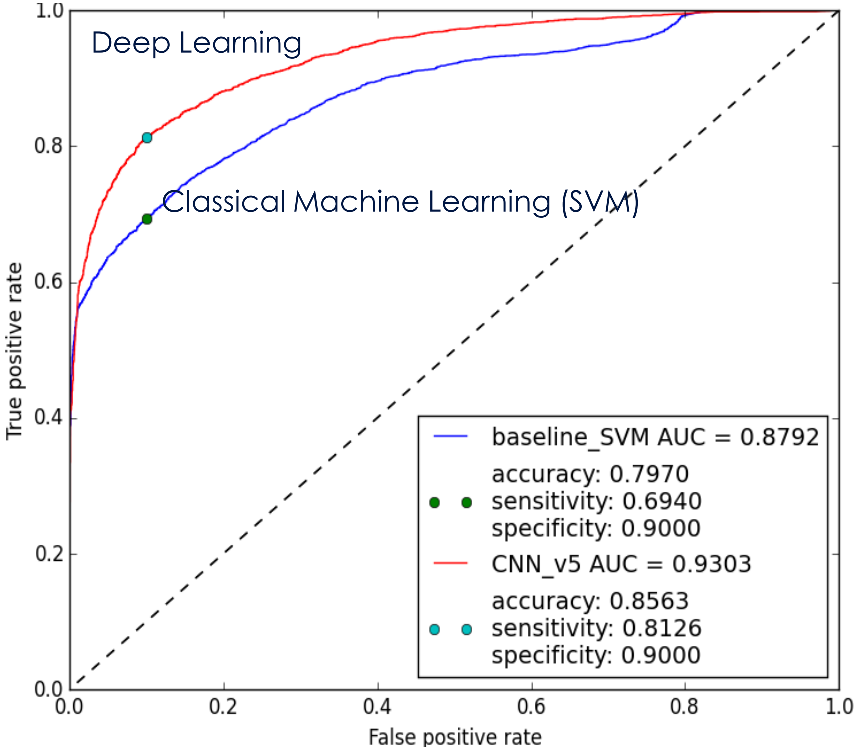


Classified CD20 (red) , CD3 (green), double negative (blue)

Deep learning classification based on convolutional neuronal networks

Classified MultiOmyx® imaging data from cancer tissue from 747 colorectal cancer patients

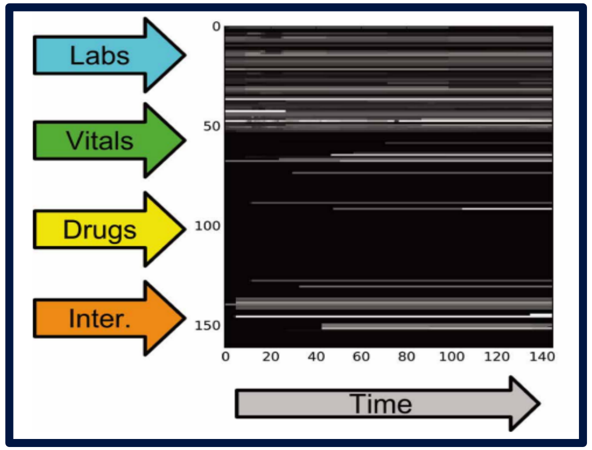
ROC Curve

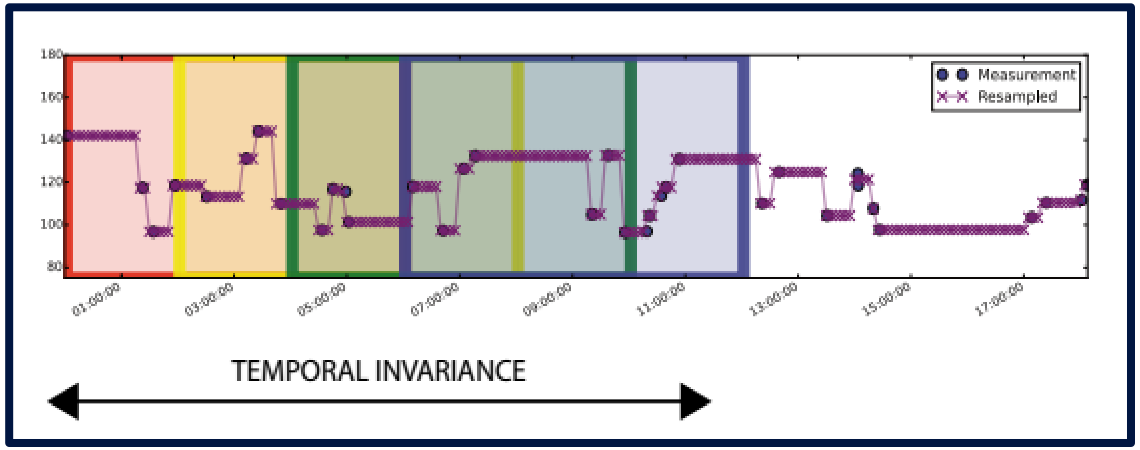


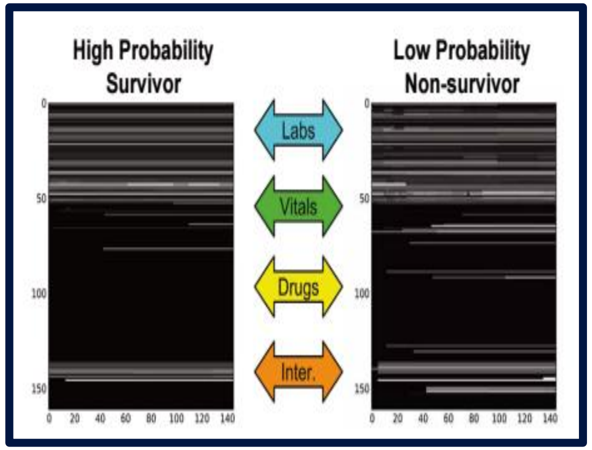
Performance comparison of learning-based methods

GE internal research, 2016

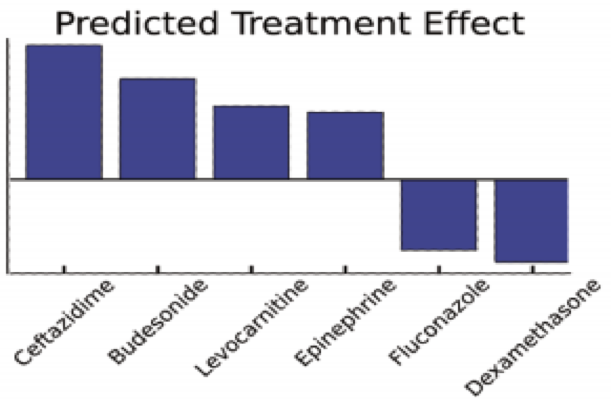
ICU's personalized recommendation for the most effective treatment





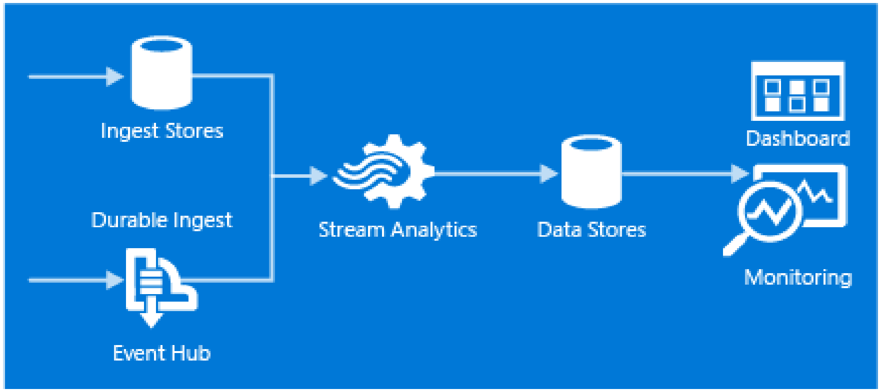


- Patient diagnosed with:
  - Cardiac Arrest
  - Cardiomyopathy
  - Epileptic Seizures
  - Pneumothorax
- Patient eventually treated with:
  - Piperacillin
  - Vancomycin
  - Epinephrine
  - Phenylephrine

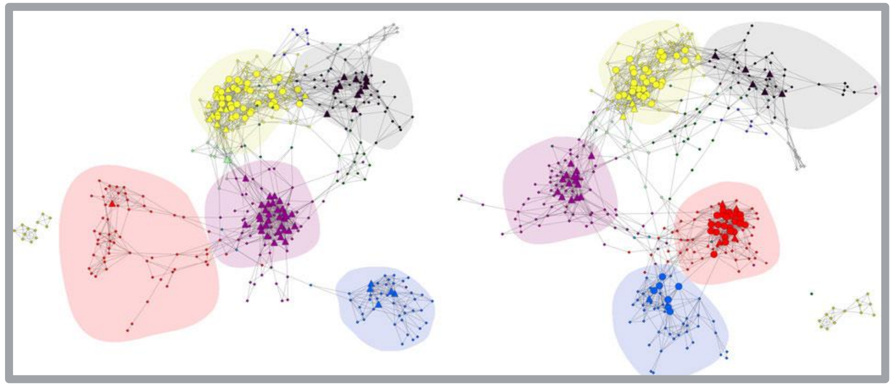


Deep learning Recommendation of Treatment from Electronic Data
David Ledbetter, Melissa Aczon
Virtual Pediatric Intensive Care Unit, Children's Hospital Los Angeles

Deep Learning and Streaming Analytics for Prediction of Adverse Events in the ICU



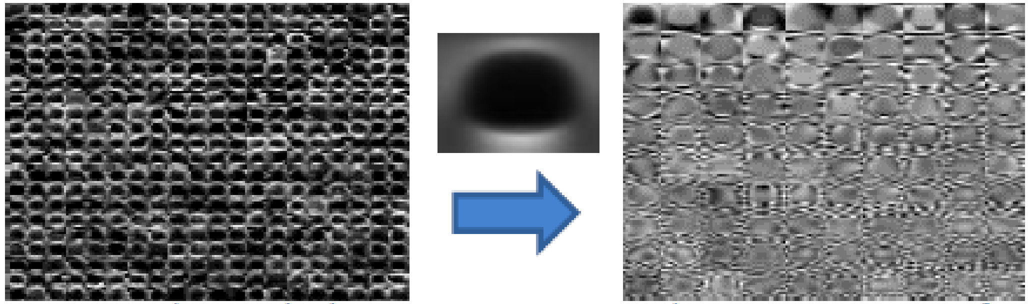
Transmits over 100,000 real-time data points per 100 beds, per second



In-flight deep learning prediction model for onset of HAI, hypovolemia, sepsis

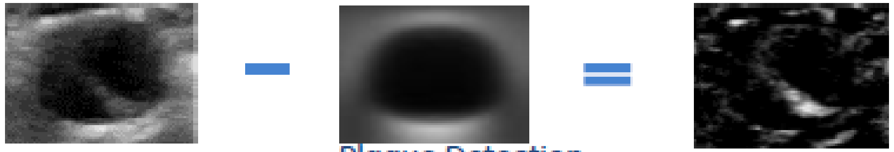
http://tools.niehs.nih.gov/portfolio/index.cfm/portfolio/grantDetail/grant_number/K01ES025445

Ultrasound Carotid Plaque Analysis & Cardiac Risk Assessment



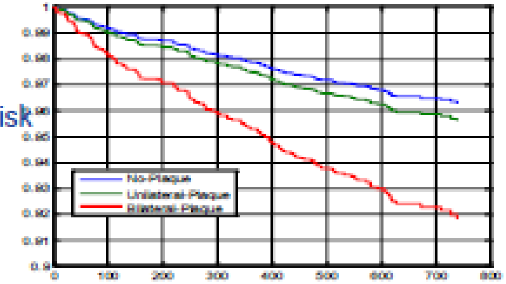
700K carotid images (without plaque)

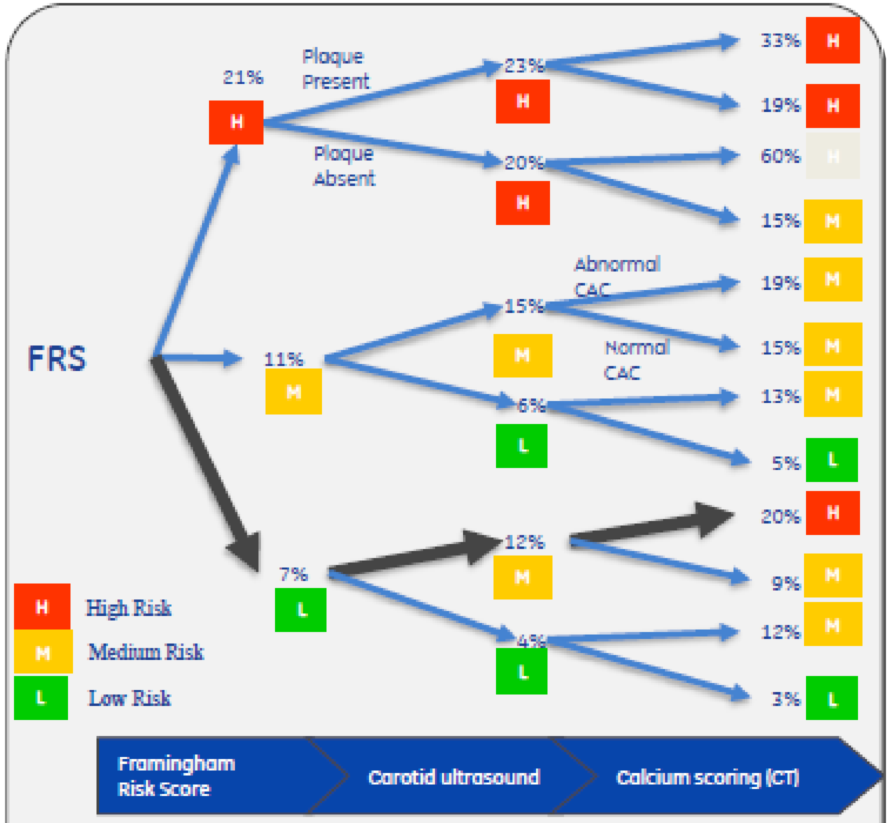
Subspace representation of "normal" carotid



Plaque Detection

Risk assessment
(Ultrasound + Framingham risk factors)

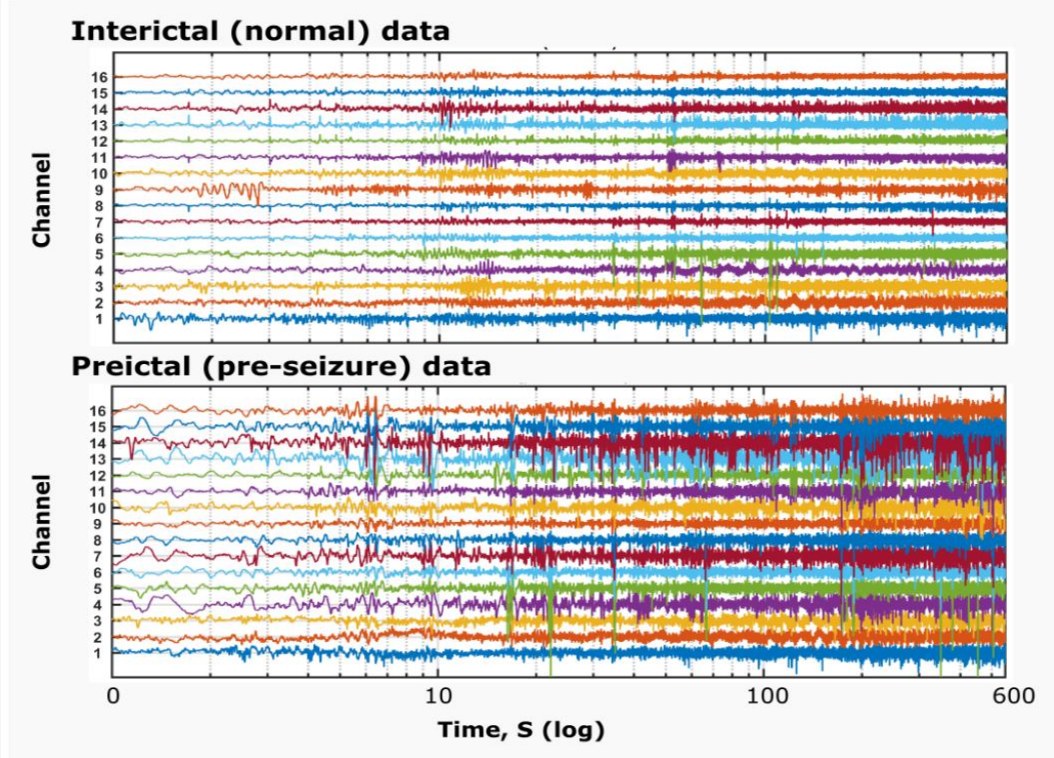


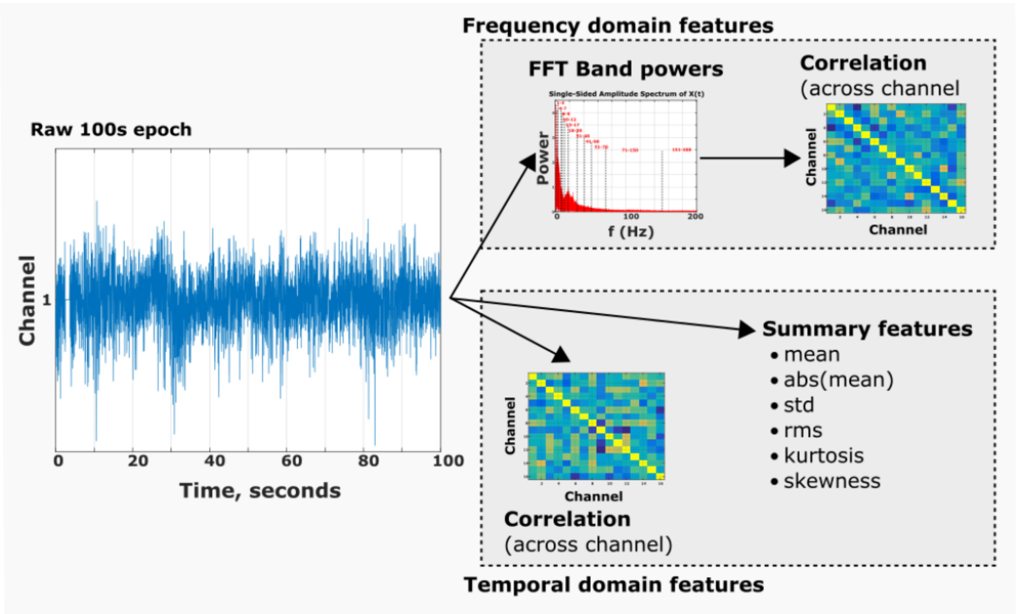


Inference engine for decision support

GE internal research, 2016

Deep learning seizure prediction





forecast the occurrence of seizures using intracranial EEG recordings
deep learning networks stand out as a promising approach for neurological diagnosis on EEG data

Gareth Jones, http://bit.ly/2iJCqVF

Asset optimization using Deep Learning

Command Center based hospital throughput prediction

Digital Twin of CTs optimizes Radiation Dose

DL algorithm predicts likelihood of reimbursement denial

One thing for sure: 20 years from now (and hopefully sooner) we won't be saying "deep learning in medicine", "precision medicine "clinical decision support", "personalized medicine", "digital medicine" and "genomic medicine"— it'll just be "medicine."

Dr. Eric Topol June 27, 2015

"I predict that within 10 years no medical imaging study will be reviewed by a radiologist until it has been pre-analyzed by a machine"

2002 RSNA President Dr Nick Bryan, May 1, 2016