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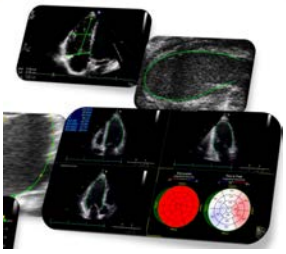
Knowledge and Compassion
Focused on You



Artificial Intelligence (AI) and Machine Learning:
Will it Replace Us?

NO!...it's Already in Your Echo Machine

Neil J. Weissman, M.D.
Chief Scientific Officer, MedStar Health
Professor of Medicine, Georgetown University

1

1

Disclosures

- Academic CV Imaging core lab with multiple commercial sponsors (including AI)
- Scientific Advisory Board/consultant - BayLabs

2

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AI in Already on Your Echo Machine

1. What is AI / ML?
2. How is it being applied in Echo today?
3. What's next for AI/ML in Echo?
4. Adjunct to other AI Medical Applications?

3

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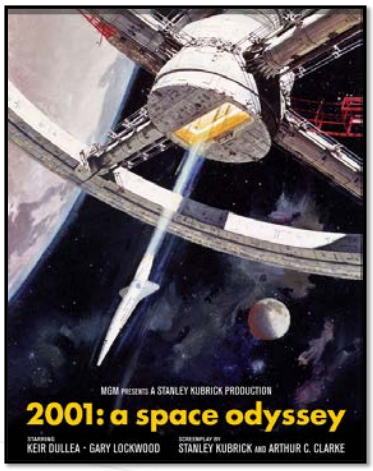
Artificial Intelligence



Provides computers with the ability to mimic human intelligence using logic,
if-then rules,
machine learning,
deep learning

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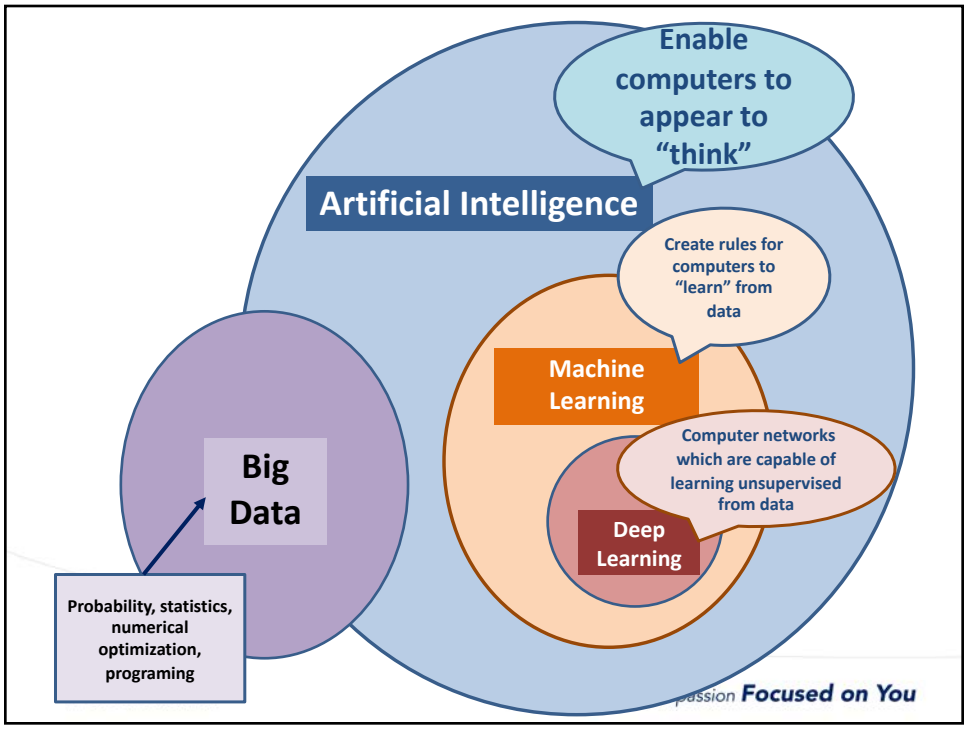
Enable computers to appear to "think"
Artificial Intelligence
Create rules for computers to "learn" from data
Machine Learning
Computer networks which are capable of learning unsupervised from data
Deep Learning
Big Data
Probability, statistics, numerical optimization, programing
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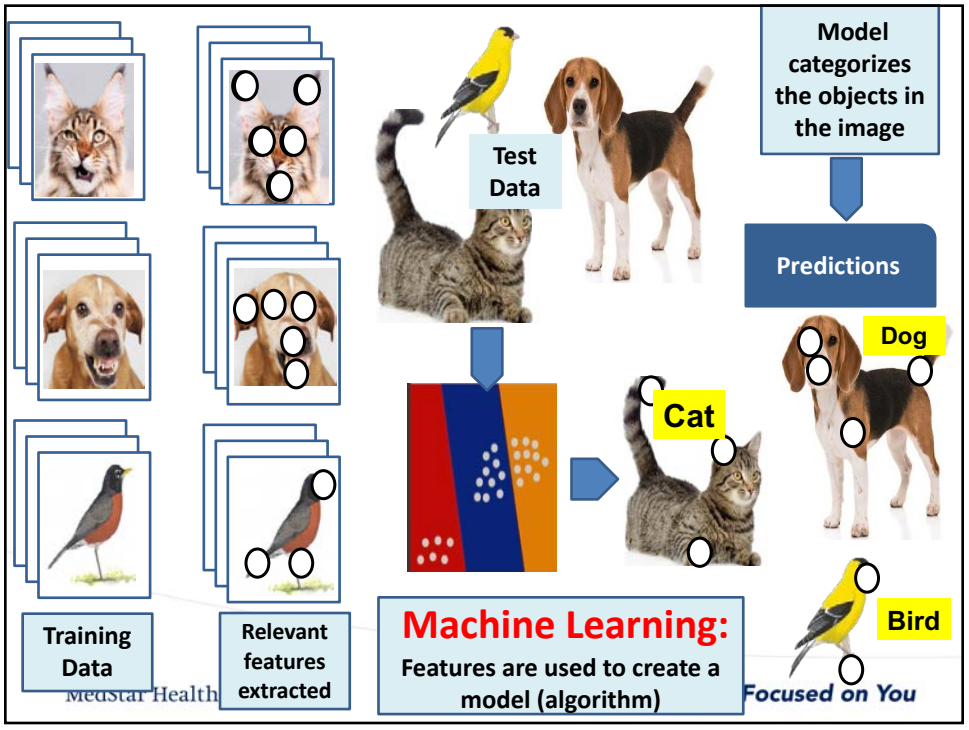
Model categorizes the objects in the image
Test Data
Predictions
Dog
Cat
Bird
Training Data
Relevant features extracted
Machine Learning:
Features are used to create a model (algorithm)
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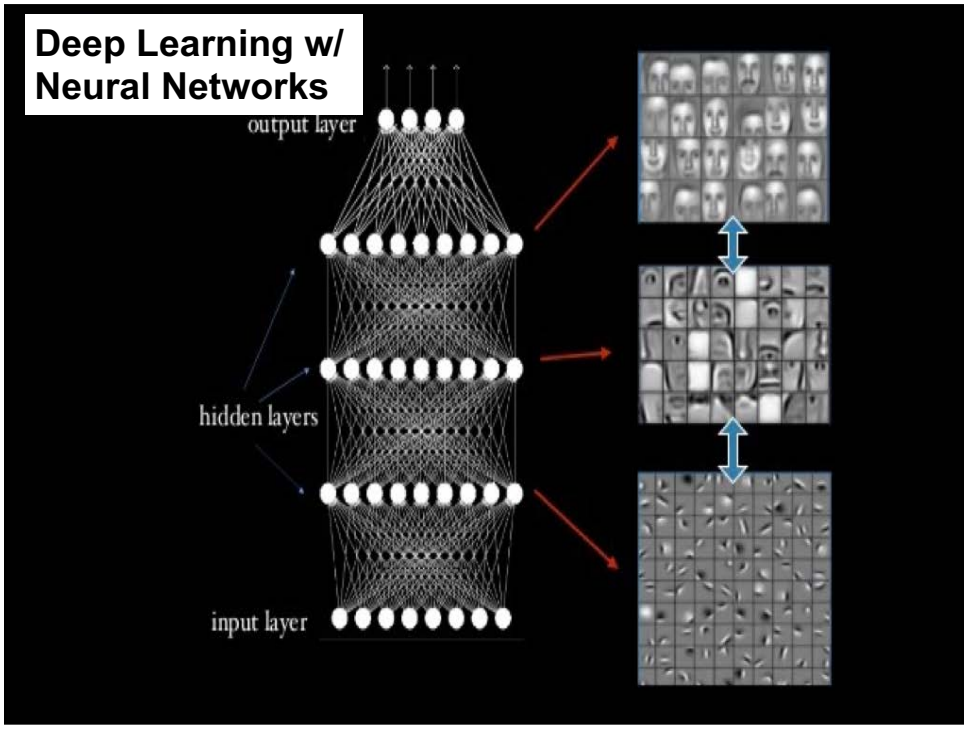
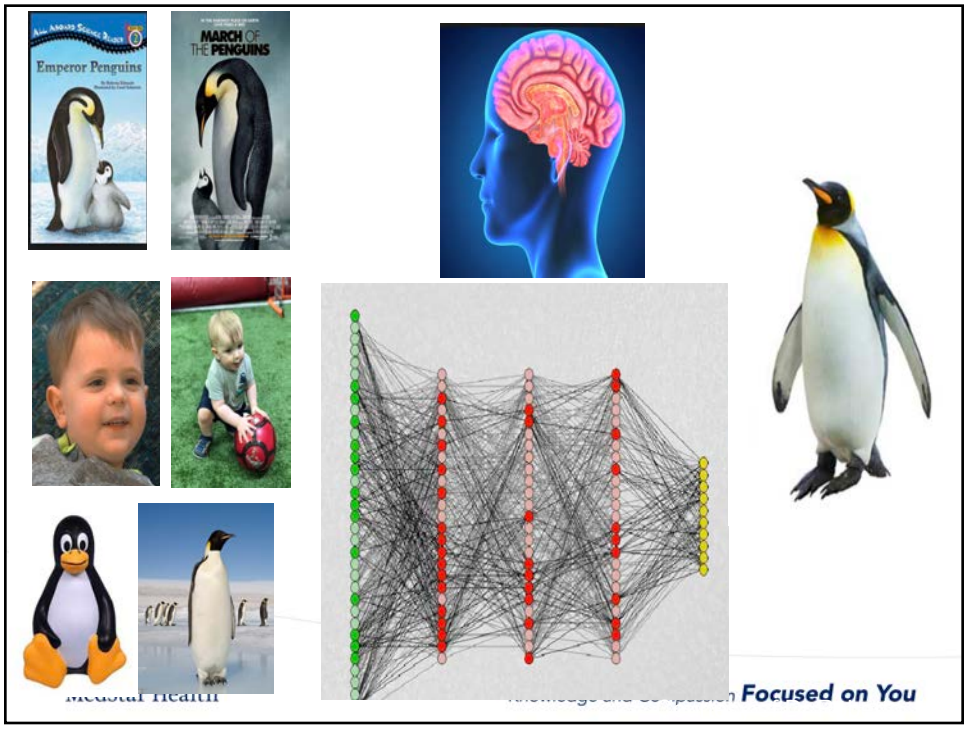

Deep Learning w/
Neural Networks
output layer
hidden layers
input layer

7


Emperor Penguins
MARCH OF THE PENGUINS
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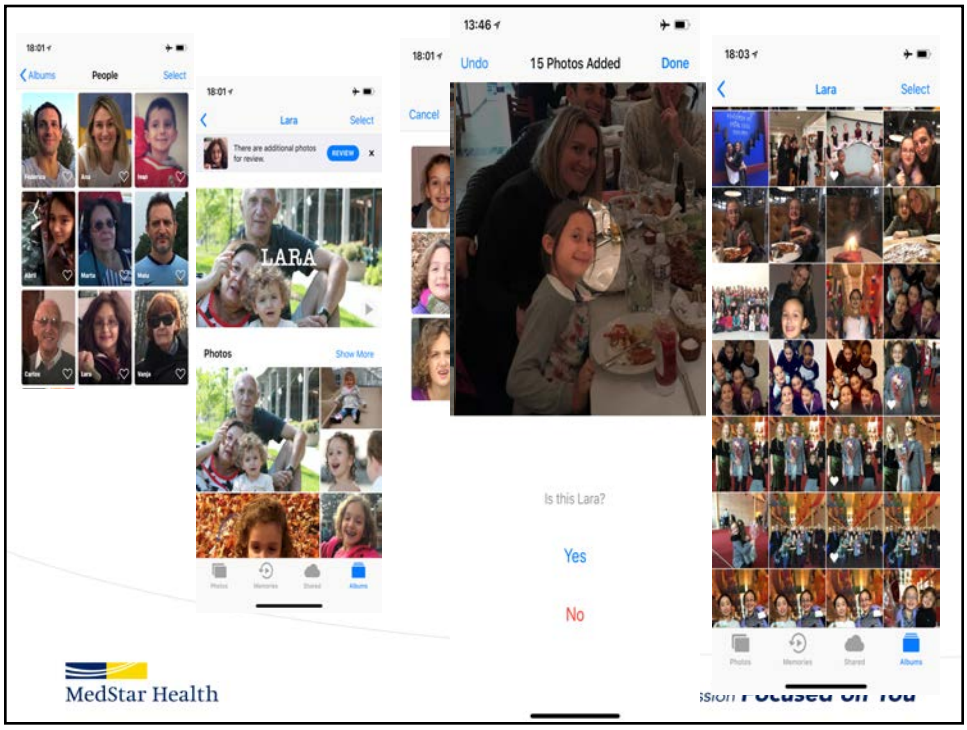

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Deep Learning

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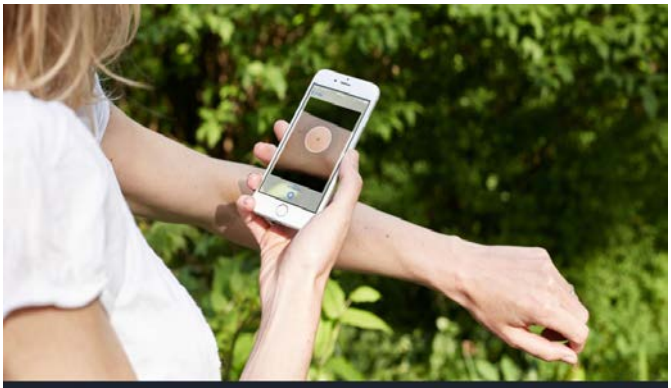
Smart Apps: *Future of Dermatology*



A SMARTPHONE DERMATOLOGIST AT YOUR SERVICE

Amsterdam-based SkinVision **developed a smartphone app to easily evaluate risk factors for skin cancer** and keep track of potentially problematic moles. So far, the app was downloaded in over 1.2 million instances globally, with the most downloads coming from the UK, Australia, the Netherlands, New Zealand, and Germany. **The smart algorithm coupled with dermatologists' expertise has found over 27,000 cases of skin cancer**. The company works closely with Generali in Germany, Central Health Insurance in the Netherlands, providing their entire insured population with the service. These partnerships naturally led to the expansion into Dutch and German versions of the originally English-language app in late 2018.

The Medical Futurist asked **Matthew Enevoldson, PR Manager at SkinVision** about their app, the algorithm behind it and how they see the future of dermatology.

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Smart Mirror: *Future of Dermatology*

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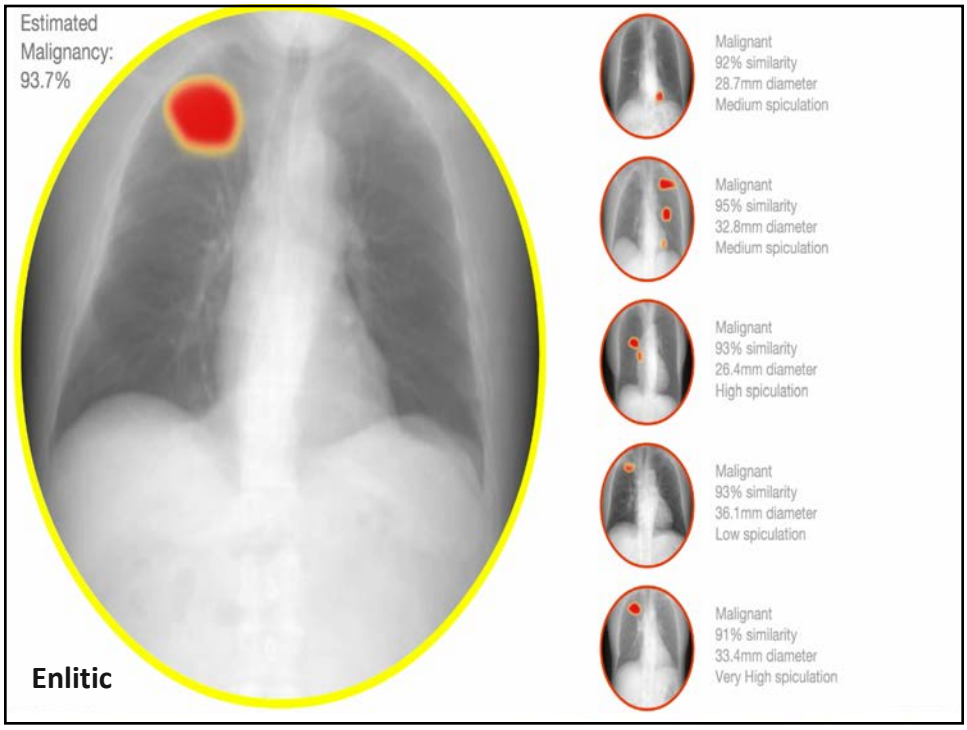

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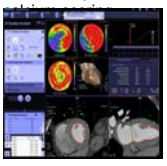
Comprehensive Cardiac Quantification in Multi-modality Data

- Image-based diagnosis, therapy planning, and guidance
- Deep Learning and Machine Learning based technology for comprehensive and efficient cardiac quantification:
  - detection, segmentation, classification, & tracking of cardiac anatomy in multi-modality data (CT, MRI, Echo, Dyna CT)
  - functional quantification - strain, flow, perfusion, EP, tissue characterization
  - Derived from over 500M images!

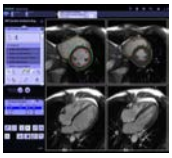
Cardiac CT

- *syngo*.CT Cardiac Function
- *syngo*.CT Coronary Analysis
- *syngo*.CT Valve Pilot
- *syngo.CT* Vascular
- PACS-ready coronaries,



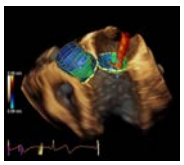
Cardiac MRI

- *syngo* Inline VF
- Cardiac 4D Ventricular Function
- AutoAlign Heart



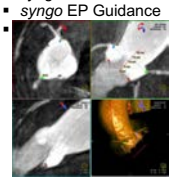
Echocardiography

- eSie Valves
- eSie LVA
- eSie Left Heart
- eSie PISA
- eSie Measure
- eSie Flow



Interventional

- CLEARstent, CLEARTstent Live
- *syngo* Aortic Valve Guidance
- *syngo* CTO Guidance
- *syngo* EP Guidance



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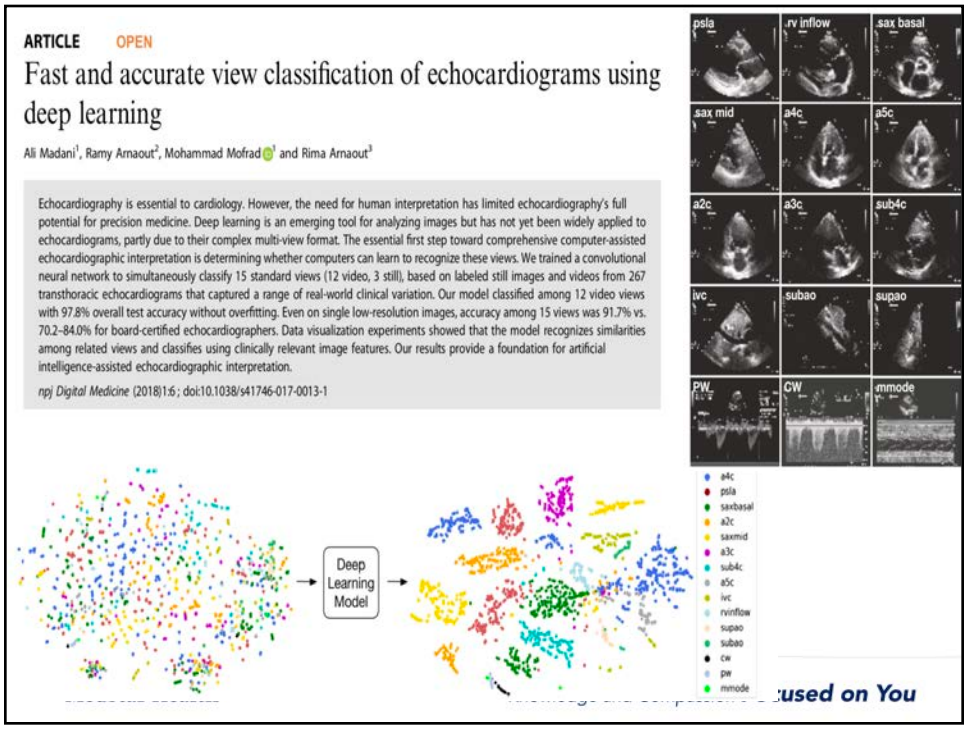
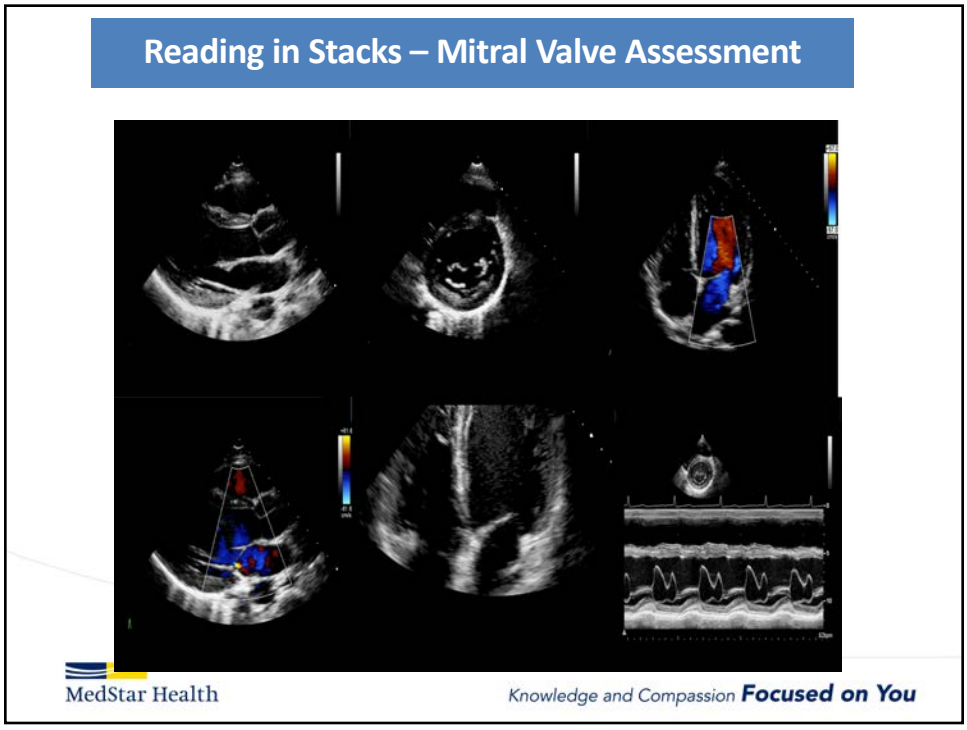

ARTICLE OPEN
Fast and accurate view classification of echocardiograms using deep learning
Ali Madani[1], Ramy Arnaout[2], Mohammad Mofrad[1] and Rima Arnaout[3]
Echocardiography is essential to cardiology. However, the need for human interpretation has limited echocardiography's full potential for precision medicine. Deep learning is an emerging tool for analyzing images but has not yet been widely applied to echocardiograms, partly due to their complex multi-view format. The essential first step toward comprehensive computer-assisted echocardiographic interpretation is determining whether computers can learn to recognize these views. We trained a convolutional neural network to simultaneously classify 15 standard views (12 video, 3 still), based on labeled still images and videos from 267 transthoracic echocardiograms that captured a range of real-world clinical variation. Our model classified among 12 video views with 97.8% overall test accuracy without overfitting. Even on single low-resolution images, accuracy among 15 views was 91.7% vs. 70.2–84.0% for board-certified echocardiographers. Data visualization experiments showed that the model recognizes similarities among related views and classifies using clinically relevant image features. Our results provide a foundation for artificial intelligence-assisted echocardiographic interpretation.
npj Digital Medicine (2018)1:6; doi:10.1038/s41746-017-0013-1
psla
rv inflow
sax basal
sax mid
a4c
a5c
a2c
a3c
sub4c
ivc
subao
supao
PW
CW
mmode
Deep Learning Model
a4c
psla
saxbasal
a2c
saxmid
a3c
sub4c
a5c
ivc
rvinflow
supao
subao
cw
pw
mmode
used on You

15


Reading in Stacks – Mitral Valve Assessment
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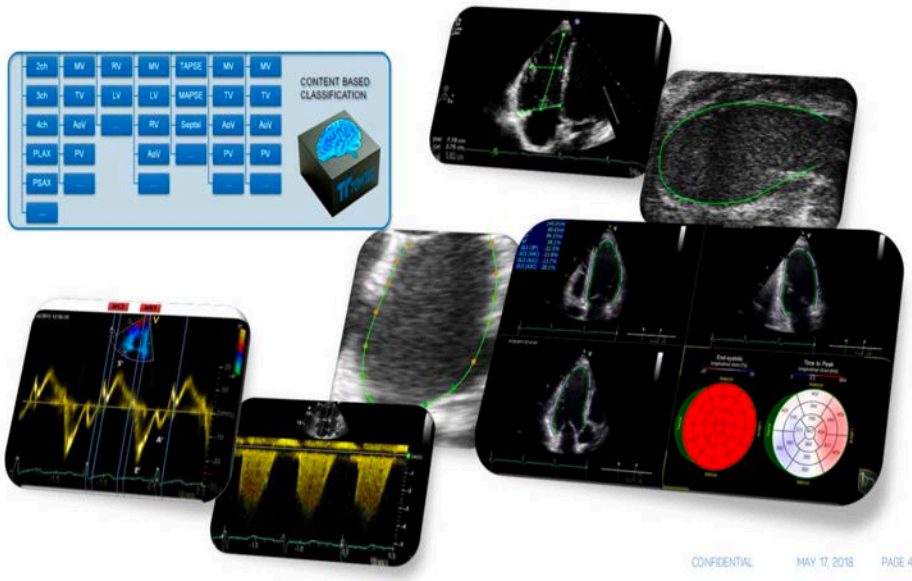
AUTOMATED MEASUREMENTS ON CLASSIFIED DATA TYPES



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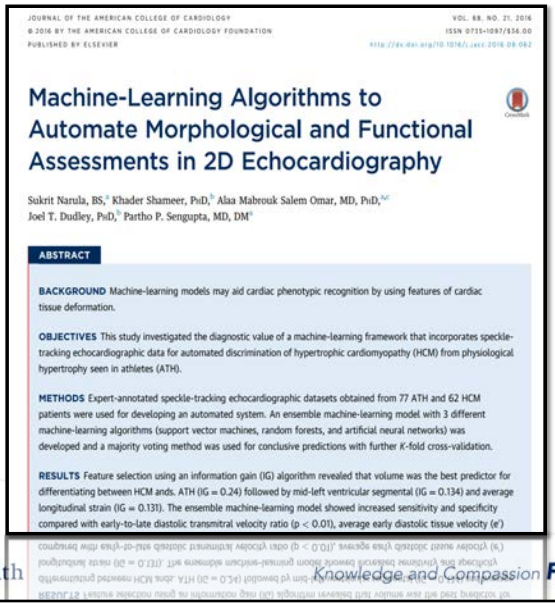
Machine Learning for Echo Dx for HCM



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VOL. 68, NO. 21, 2016
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Machine-Learning Algorithms to Automate Morphological and Functional Assessments in 2D Echocardiography

Sukrit Narula, BS,[a] Khader Shameer, PhD,[b] Alaa Mabrouk Salem Omar, MD, PhD,[b,c]
Joel T. Dudley, PhD,[b] Partho P. Sengupta, MD, DM[a]

ABSTRACT

BACKGROUND Machine-learning models may aid cardiac phenotypic recognition by using features of cardiac tissue deformation.

OBJECTIVES This study investigated the diagnostic value of a machine-learning framework that incorporates speckle-tracking echocardiographic data for automated discrimination of hypertrophic cardiomyopathy (HCM) from physiological hypertrophy seen in athletes (ATH).

METHODS Expert-annotated speckle-tracking echocardiographic datasets obtained from 77 ATH and 62 HCM patients were used for developing an automated system. An ensemble machine-learning model with 3 different machine-learning algorithms (support vector machines, random forests, and artificial neural networks) was developed and a majority voting method was used for conclusive predictions with further *K*-fold cross-validation.

RESULTS Feature selection using an information gain (IG) algorithm revealed that volume was the best predictor for differentiating between HCM ands. ATH (IG = 0.24) followed by mid-left ventricular segmental (IG = 0.134) and average longitudinal strain (IG = 0.131). The ensemble machine-learning model showed increased sensitivity and specificity compared with early-to-late diastolic transmitral velocity ratio ($p < 0.01$), average early diastolic tissue velocity (e')

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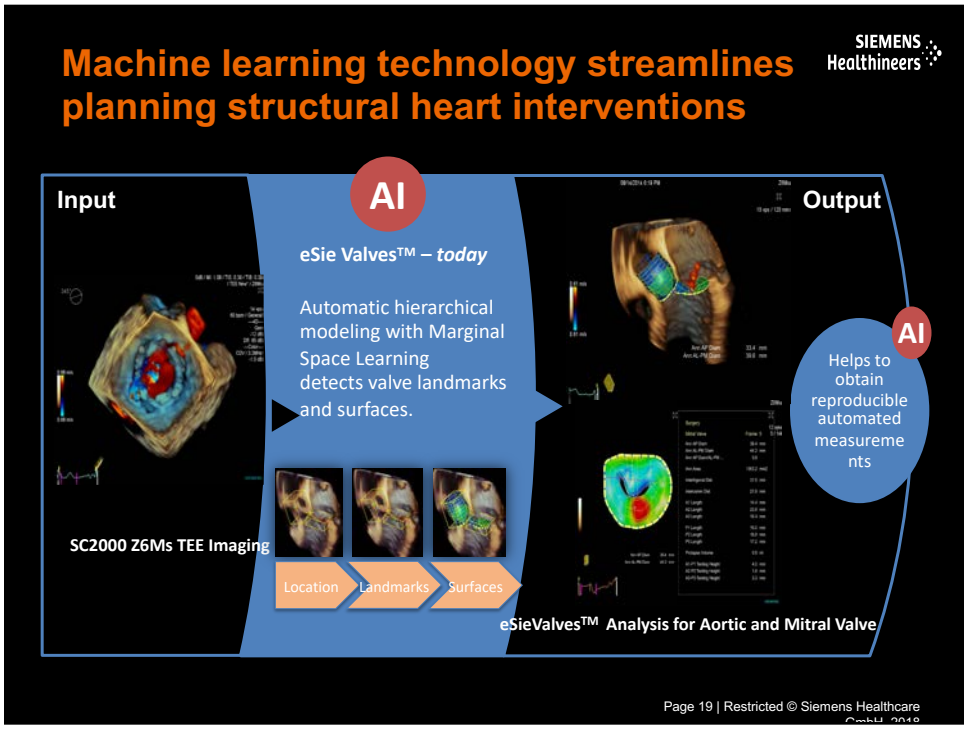

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AI in Already on Your Echo Machine

1. What is AI?
2. How is it being applied in Echo today?
3. What's next for AI in Echo?
4. Adjunct to other AI Medical Applications?

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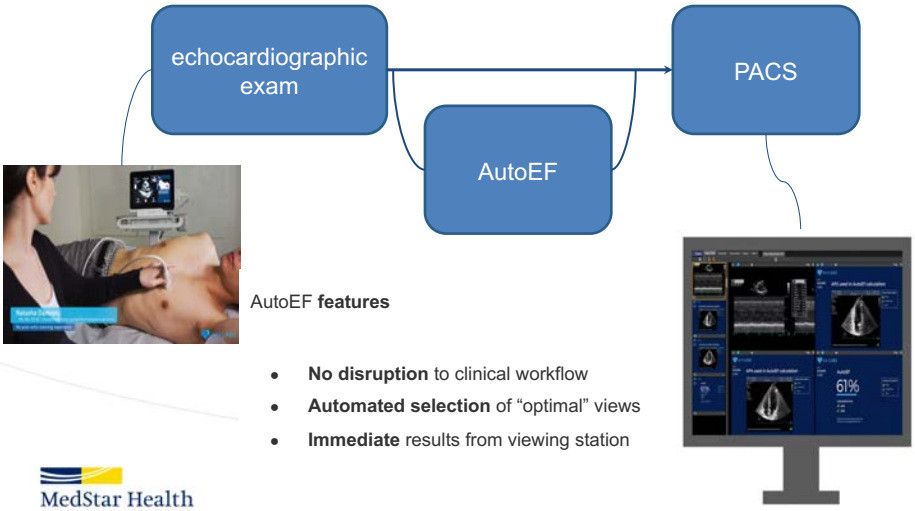
BayLabs

AutoEF in practice



AutoEF **features**

- **No disruption** to clinical workflow
- **Automated selection** of "optimal" views
- **Immediate** results from viewing station

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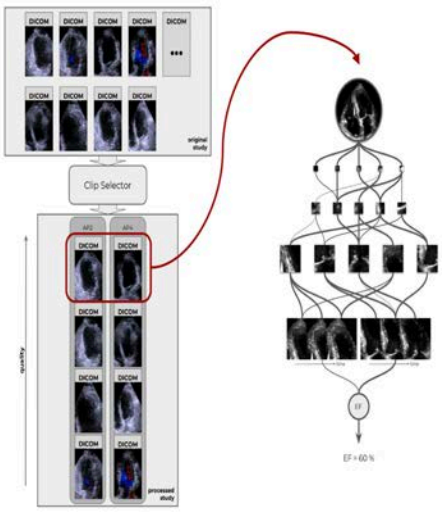
Our 1st Algorithm AutoEF: How it Works?

- Auto EF works in two stages. and includes two neural networks:
  - **Stage 1**: A clip selector
  - **Stage 2**: ejection fraction estimator
- By exposing these Bay Labs neural networks to vast amounts of data, the networks learn from data and use a deep hierarchy of layers to make predictions.
- No clip selection or tracing is needed



Stage 1. Clip Selection

Stage 2. Ejection Fraction computation

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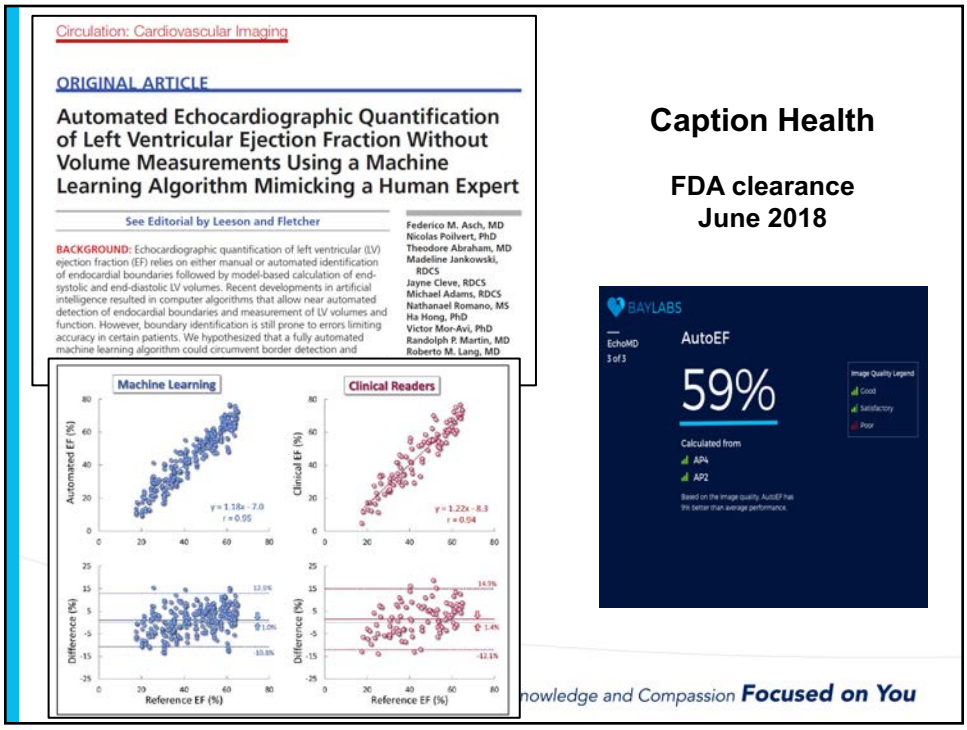
Circulation: Cardiovascular Imaging
ORIGINAL ARTICLE
Automated Echocardiographic Quantification of Left Ventricular Ejection Fraction Without Volume Measurements Using a Machine Learning Algorithm Mimicking a Human Expert
See Editorial by Leeson and Fletcher
Federico M. Asch, MD
Nicolas Poilvert, PhD
Theodore Abraham, MD
Madeline Jankowski, RDCS
Jayne Cleve, RDCS
Michael Adams, RDCS
Nathanael Romano, MS
Ha Hong, PhD
Victor Mor-Avi, PhD
Randolph P. Martin, MD
Roberto M. Lang, MD
BACKGROUND: Echocardiographic quantification of left ventricular (LV) ejection fraction (EF) relies on either manual or automated identification of endocardial boundaries followed by model-based calculation of end-systolic and end-diastolic LV volumes. Recent developments in artificial intelligence resulted in computer algorithms that allow near automated detection of endocardial boundaries and measurement of LV volumes and function. However, boundary identification is still prone to errors limiting accuracy in certain patients. We hypothesized that a fully automated machine learning algorithm could circumvent border detection and
Machine Learning
Clinical Readers
Automated EF (%)
Clinical EF (%)
Difference (%)
Reference EF (%)
Caption Health
FDA clearance
June 2018
BAYLABS
AutoEF
59%
Calculated from
AP4
AP2
Image Quality Legend
Good
Satisfactory
Poor
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SOCIETY OF
Ultrasound
IN MEDICAL EDUCATION
WINFOCUS
World Interactive Network Focused on Critical Ultrasound
EMERGENCY
ACEP ULTRASOUND
SECTION
Society of
Critical Care Medicine
The Intensive Care Professionals
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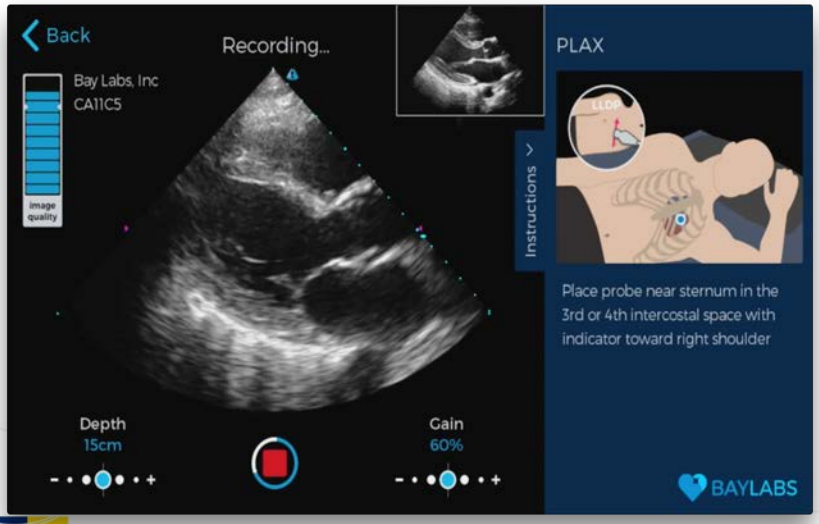
BayLabs / Caption Health



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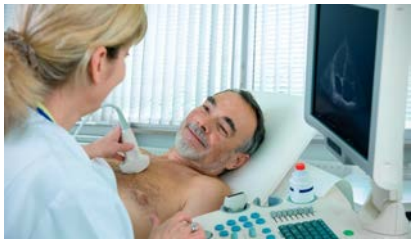
BayLabs / Caption Health



In this study, eight registered nurses (RNs) with no prior cardiac ultrasound experience used Caption Guidance to acquire a total of 240 limited exams, following a short training course. Patients were stratified to include a wide range of body-mass index and cardiac pathologies. The RNs acquired limited echo exams of 10 views each. Each exam was assessed by a panel of 5 expert cardiologists to determine if the exam was of sufficient quality to make a set of specific qualitative visual assessments.

Caption Guidance successfully met all four primary endpoints, meeting the pre-specified criteria for study success. The criteria for study success was that greater than 80% of exams provided sufficient quality for specific clinical assessments. Namely, the RNs successfully acquired limited echo exams for qualitative visual assessments of left ventricular size: 98.8%, 95% CI [96.7, 100]; left ventricular function: 98.8% [96.7, 100]; right ventricular size: 92.5% [88.1, 96.9]; and pericardial effusion: 98.8% [96.7, 100].

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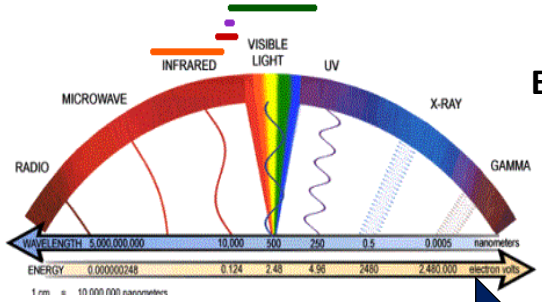
The Future: A Spectrum of CV Ultrasound

Comprehensive and Complete Exam

Focused Exam @ POC



Advanced Exam – New Modalities

Miniature, wireless, holographic, machine (deep) learning, fusion

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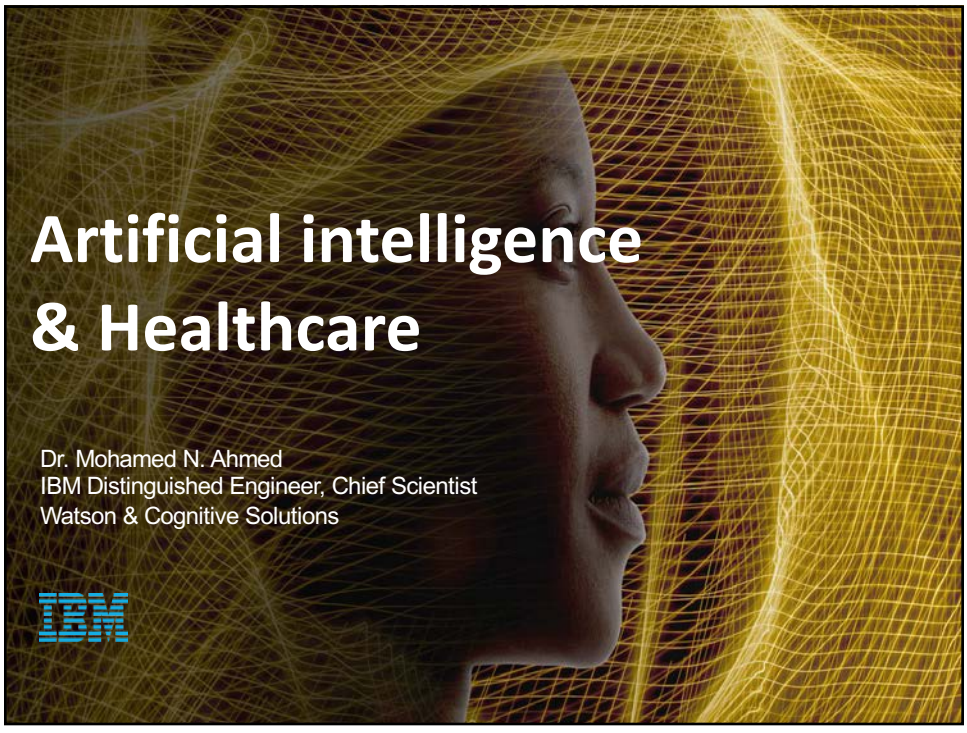

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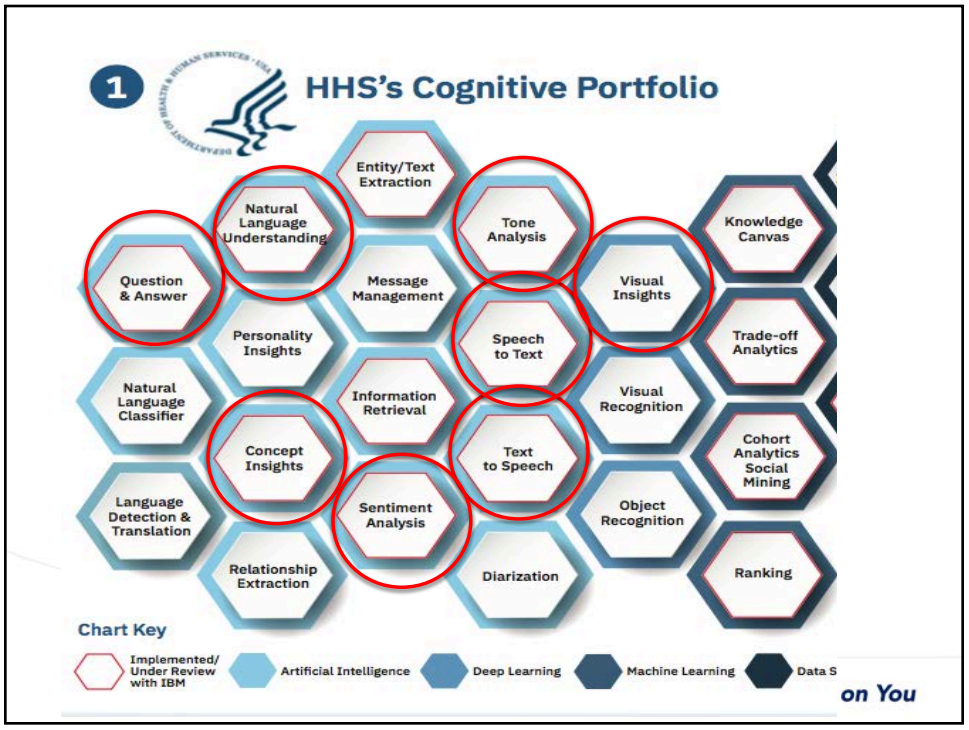
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HHS's Cognitive Portfolio
Entity/Text Extraction
Natural Language Understanding
Tone Analysis
Knowledge Canvas
Question & Answer
Message Management
Visual Insights
Personality Insights
Speech to Text
Trade-off Analytics
Natural Language Classifier
Information Retrieval
Visual Recognition
Concept Insights
Text to Speech
Cohort Analytics Social Mining
Language Detection & Translation
Sentiment Analysis
Object Recognition
Relationship Extraction
Diarization
Ranking
Chart Key
Implemented/ Under Review with IBM
Artificial Intelligence
Deep Learning
Machine Learning
Data S
on You

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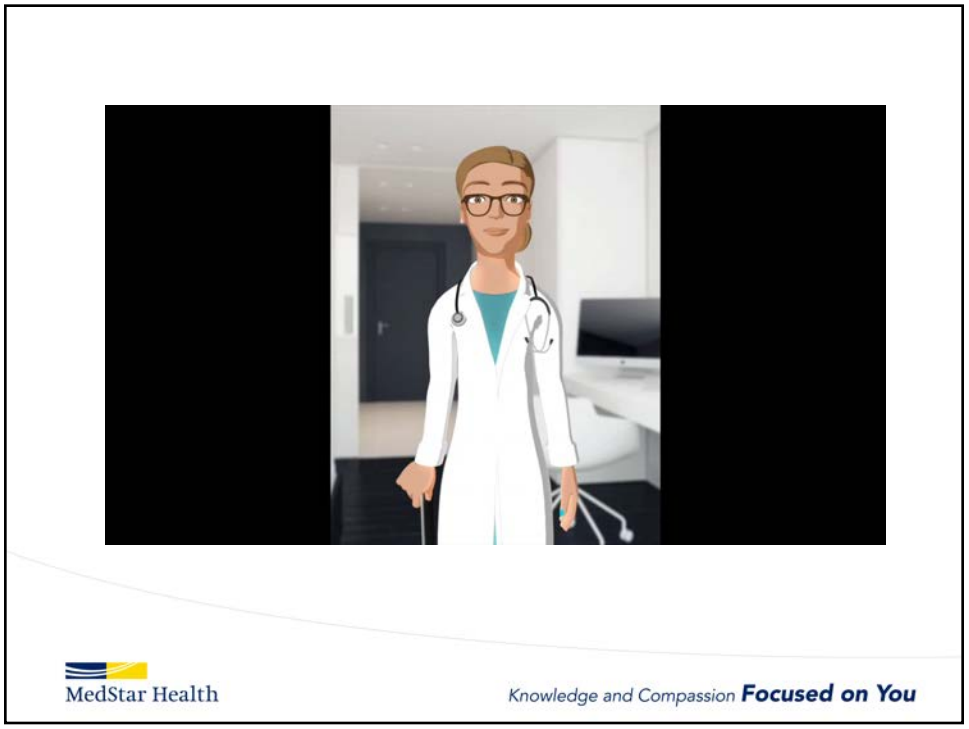
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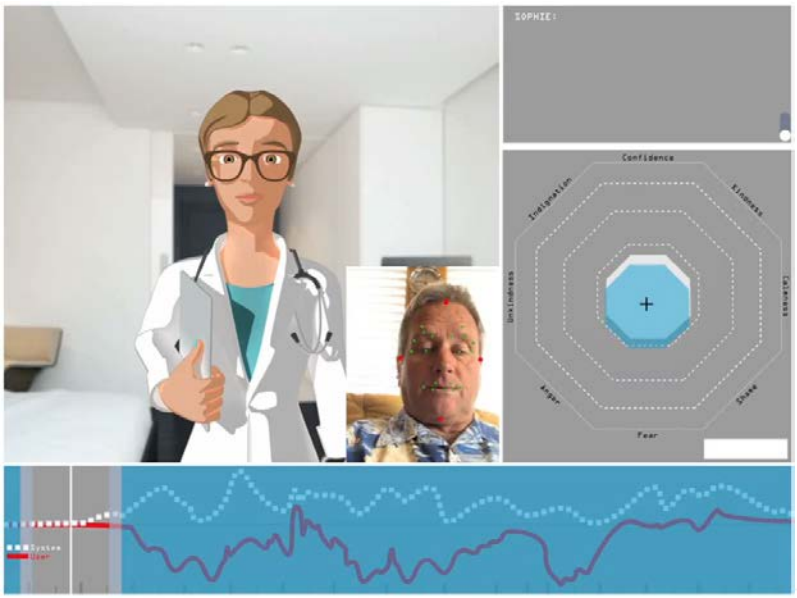

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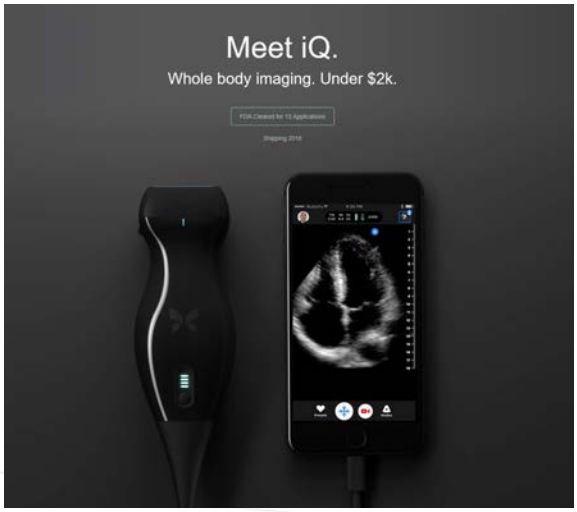
Butterfly and AI: Will it Democratize Echo?



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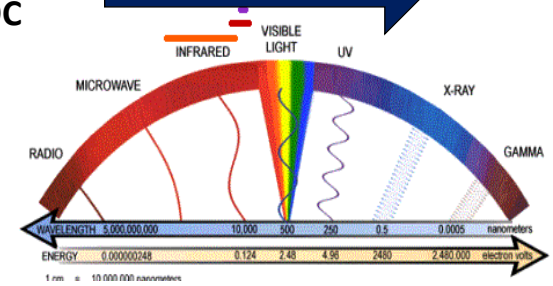
The Future of CV Ultrasound ?????

Focused Exam @ POC

Machine learning?

Complete Exam



Miniaturize and machine learning

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Today AI and Cardiac Imaging - Summary

- AI and Machine Learning can be used to:
  - Facilitate image acquisition even in less experienced hands
  - Optimize efficiency and work flow
  - Minimize errors and interpretation variability
  - Standardize processes and reporting

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"AI won't replace radiologists, but radiologists who use AI may replace the ones who don't."

Dr. Mark Michalski, MGH/Brigham

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DISCOMFORT IS NATURAL

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Thank You!

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