Society for Anesthesia & Sleep Medicine

Top 5 Technologies in Sleep and Anesthesia

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Artificial Intelligence and Sleep Medicine: Hope or Hype?

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Are Robot Zombies Going to Take Over Medicine?

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Goals and Objectives

• Understand the context for the development of artificial intelligence in health care
• Explain how neural networks work
• Describe applications of AI in health care
  – Top 5 Technologies in Sleep and Anesthesia
• Describe limitations of the artificial intelligence
We live in the future

AI Everywhere
Moore’s Law

“The number of transistors that can be packed into a given unit of space will roughly double every two years.”

Health Information Technology for Economic and Clinical Health Act (HITECH Act)

- Part of the American Recovery and Reinvestment Act of 2009 (ARRA)
- Created to motivate the implementation of electronic health records (EHR)
AI: The theory and development of computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.

Machine Learning: Algorithms and statistical models that computer systems use to progressively improve their performance on a specific task.

Deep Learning: Learning data representations, as opposed to task-specific algorithms.


Measuring Classification:

AUC ROC

- True Positive Rate = Sensitivity
- False Positive Rate = 1 - Specificity
- AUC = Area under the curve
- ROC = Receiver operating characteristics

AUC=0.5 is chance separation
AUC=1 is perfect separation
AUC=0 has no separation
Roadmap

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Early AI in Medicine

• Initial approach
  – Manipulation of symbolic expressions with rules of interference
  – Expert systems to automate reasoning process of experts

RULE 85
IF
1) The site of the culture is blood, and
2) The Gram stain of the organism is negative, and
3) The morphology of the organism is rod, and
4) The patient is a compromised host
THEN
There is suggestive evidence (9.6) that the identity of the organism is pseudomonas aerugonosa.

How Actual Intelligence Works

• Layers of neurons
  – Information from outside world
  – Information transfer between neurons
    • Synaptic input can be strong or weak, connections can develop or be pruned
  – Transfer of information between layers of neurons

Neural Networks

• Artificial neural networks
  – Mimic neurons
  – Neural networks (1960s)
    • Then computers got fast

• Hidden layers
  – Can represent dataset features
  – Number of hidden factors is specified
    • Inputs to those are not limited

• Convolutional neural network
  – Copies of features are made and averaged
  – Generalizes feature detection from one image area to another
Logistic Regression and NN

\[
\text{logit}(p_t) = \ln \left( \frac{p_t}{1 - p_t} \right) = \beta_0 + \beta_1 x_1 + \cdots + \beta_M x_M
\]

Logistic regression is essentially a single-layer feed forward neural network

How to recognize a dog

- **Training**
  - Images with labels are fed to an untrained neural network
    - Wolves
    - Dogs
  - Weights are tweaked with back-propagation
- **Validation**
  - Images without labels are fed to network
    - Initial layer finds small features
    - Higher layer finds structural features
    - Highest layer represents concepts
  - Model performance is analyzed

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Diabetic retinopathy

• Deep convolutional neural network
  – Trained on 128,175 retinal images
  – Separate validation datasets
• Images graded by 54 ophthalmologists
  – Diabetic retinopathy
  – Macular edema
  – Image quality
• Results
  – AUC 0.991, Sensitivity 93%, Specificity 97.5%

Breast Cancer Metastases

- **Image data sets**
  - 399 whole-slide images
    - 270 training
    - 129 test
  - Metastases: None, Macro, Micro
- **Competition of**
  - 32 machine learning algorithms
  - 11 pathologists
- **Results**
  - Varied from AUC 0.556 to 0.994
  - Top 5 algorithms were as good as pathologist without time constraints


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Melanoma Diagnosis

- **Image data sets**
  - 400 whole-slide images
    - 300 training
    - 100 test
  - Melanoma vs benign nevi
- **Competition of**
  - Google Inception v4 convoluted neural network
  - 58 pathologists
- **Results**
  - Neural network: AUC 0.86
  - Average pathologist: AUC 0.79

Echo Interpretation

- Image data sets
  - 14,035 echo exams
- CNNs developed to
  - Identify viewpoints
  - Cardiac chamber segmentation in 5 views
  - Calculate volume, LV mass, EF
- Results for diagnostic accuracy
  - HOCM: AUC 0.93
  - Cardiac amyloidosis: 0.87
  - Pulmonary arterial HTN: 0.85

Circulation. 2018;138:1623–1635. DOI: 10.1161/CIRCULATIONAHA

Stroke Detection

- Surely we’re not using this machine learning stuff yet, right?
Fracture Detection

• But probably just for that stroke stuff, no?

Automated Sleep Scoring

• Data sets
  – 10,000 clinical PSGs
  – 5804 research PSGs
• RCNNs developed to identify
  – Sleep stages
  – Sleep disordered breathing
  – Limb movements
• Results for diagnostic accuracy
  – 87.6%, 88.2%, 84.7%
  – All comparable to human experts
  – Almost as good with limited channels (i.e., at-home monitoring)
Narcolepsy Diagnosis

• Data sets
  – 3,000 PSGs

• Multiple approaches to identify
  – Sleep stages
  – Type-1 Narcolepsy

• Results for accuracy
  – 87%
  – Better than any one scorer
  – For T1N, 96% specific, 91% sensitive

Sleep Sound Signatures

• Smartphone sonar
  – Emits frequency-modulated sounds
  – Listens to reflections, tracks chest/abd movement
  – Identifies obstructive, central and hypopnea events

• Accuracy of ApneaApp
  – 37 patients, 296 hours of observation
  – 99.57%, 98.70, 95.33% (correlation coefficient vs PSG)
Attack of the Sleep Apps!

- Sleep.ai
  - Track your snoring
  - Track your grinding
    - One scientific app for Grinding, Snoring and Obstructive Sleep Apnea
    - Proof that you grind or snore
    - Send the sound samples to your dentist or doctor for official sleep bruxism diagnosis

CPAP Compliance

- Somnoware
  - Prediction modeling for short and long-term compliance
  - Data fed from EHR
    - Demographics
    - Comorbidities
    - Prior labs
    - Questionnaire data
AI-Powered Mattress?!?

• Switching over to full AI hype mode...

Are you sleeping on a Dead Bed?

The majority of beds used today are built on 19th-century technology (latex foam, springs, etc.). Imagine the impact better sleep technology could have on your health, productivity, and happiness.

We took an everyday object and created an intelligent sleep platform that will transform your sleep experience and your life. (You’ll never want to sleep on a dead bed again.)

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AI-Powered Mattress?!?

<table>
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<th>BED FEATURE</th>
<th>DEAD BED</th>
<th>DEAD BED + BASIC TECH</th>
<th>BRYTE BED</th>
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<td>Foam, Springs or Air Bed</td>
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<td>200 Dynamic Cells &amp; 16 Zones with over 2000 support adjustments</td>
<td>200 Dynamic Cells &amp; 16 Zones with over 2000 support adjustments</td>
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ADD TO CART
AI in Medicine

• Faster, cheaper computers have enabled cool technology
• Good algorithms exist for image interpretation and complex pattern recognition (i.e., PSG)
• Likely will make sleep studies more efficient
• Unclear if they will make your mattress work better

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The Barrier of Meaning

• AI still doesn’t understand the meaning of things
  – “The bareheaded man needed a hat”
  – “The bear headed man needed a hat”


Hackable

• Minor changes can disrupt AI-based systems

Using this methodology, we evaluate the efficacy of physical adversarial manipulations on real objects. With a perturbation in the form of only black and white stickers, we attack a real stop sign, causing targeted misclassification in 100% of the images obtained in lab settings, and in 84.8% of the captured video frames obtained on a moving vehicle (field test) for the target classifier

Confusable

- AI-systems may not be able to deal with the unexpected

The Elephant in the Room. arXiv:1808.03305

The Black Box

- What hidden factors are being used?
  - Large numbers of complicated, weak connections
  - Not interpretable, in general
  - Initial weights are set randomly, so same NN with same data set will generate different features
  - No correct NN, just modeled relationship between inputs and outputs
AI Taking Over

• “People worry that computers will get too smart and take over the world, but the real problem is that they’re too stupid and they’ve already taken over the world.”
  – Pedro Domingos

AI and Healthcare

• What’s driving adoption of AI?
  – Digital imaging > Human interpretation
  – Digitization of health-related data and sharing
  – Adaptability of deep learning to heterogeneous data
  – Capacity of deep learning for hypothesis generation
  – Potential to streamline workflow / empower patients
  – Rapid diffusion of deep learning tools
  – Better, faster technology

Are Robot Zombies Going To Take Over Medicine?

- Seems unlikely
  - Technology solves problems narrowly
  - No “generalized AI” on horizon
  - No capacity for reasoning
  - Output is really a statistical prediction
  - Doesn’t work well outside of trained data
- Physicians fundamentally trained to reason and act under uncertainty
- Best approach is to augment human intelligence in health care
  - AI = Augmented Intelligence


Thanks!

Questions?