



IIT RTC Conference  
Illinois Tech @ Chicago  
Oct 8-10, 2024



# Training Machine Learning Classification Models

## Creating Real-Time Data Points of Medical Conditions

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# Dr. Nikki-Rae Alkema, PT, DPT

- Licensed Physical Therapist (CA)
- Movement is medicine!
- Special interests: biomechanics, technology in healthcare

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# David vonThenen

- Are you Human or an AI?
- I want 5 Kubernetes
- Virtual Machines are Real
- Replacing Myself with Bots...
- Cloudy, cloudy, cloudy...
- There is storage for that!

  [@davidvonthenen](https://www.linkedin.com/in/davidvonthenen)



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# Agenda

- **Clinical Case Study**
- **How To: Building a Model**
  - **Characteristics to Code**
  - **Creating a Dataset Format**
  - **Live Demo!**
- **Multi-Modal/Model Problem Solving**
- **Q&A**





# A Common Thread



**Michael J. Fox**



**Alan Alda**



**Mohammed Ali**



**Ozzy Osbourne**



**Neil Diamond**



**Richard Lewis**



**Janet Reno**



**Brian Grant**



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# Clinical Case Study

# 74M Presents with R Shoulder Pain

- Initial complaint:
  - Pain in R shoulder after a fall at home
  - Difficulty with reaching, lifting, pushing, and transfers
- Relevant contextual factors:
  - Recent balance issues
  - Caretaker for his ill wife



# Was Shoulder Pain the Real Problem?

- Not ONE but TWO problems
  - Rotator cuff tear
  - Balance and gait issues\*
- Clinical observation
  - Using walker, slow gait, shuffling steps, neutral affect, soft voice, resting hand tremor



\*Cause of fall → undiagnosed Parkinson's Disease



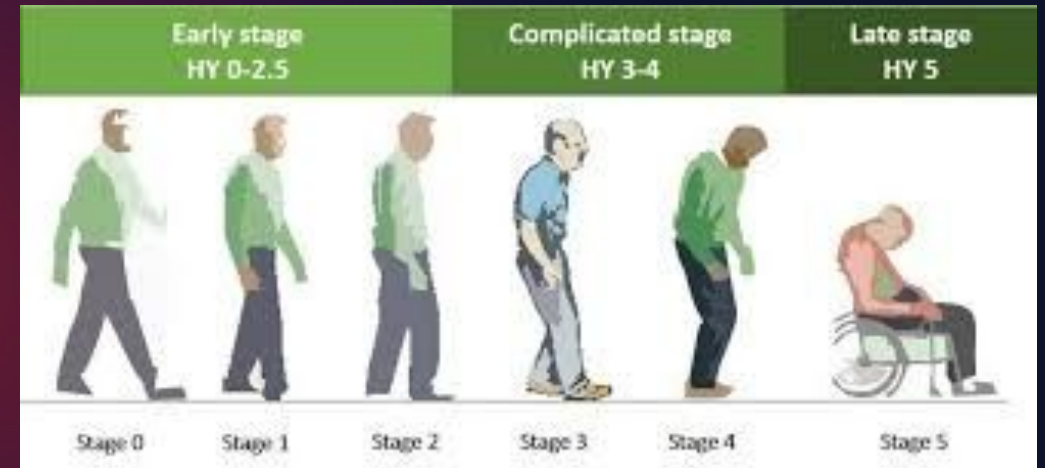
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# What is Parkinson's Disease? <sup>1,2</sup>

- Progressive movement disorder
- No cure
- Diagnostic tests uncommon
  - Mostly clinical diagnosis
  - Minimum criteria:
    - Bradykinesia, plus
    - Resting tremor, stiffness/rigidity, or postural instability



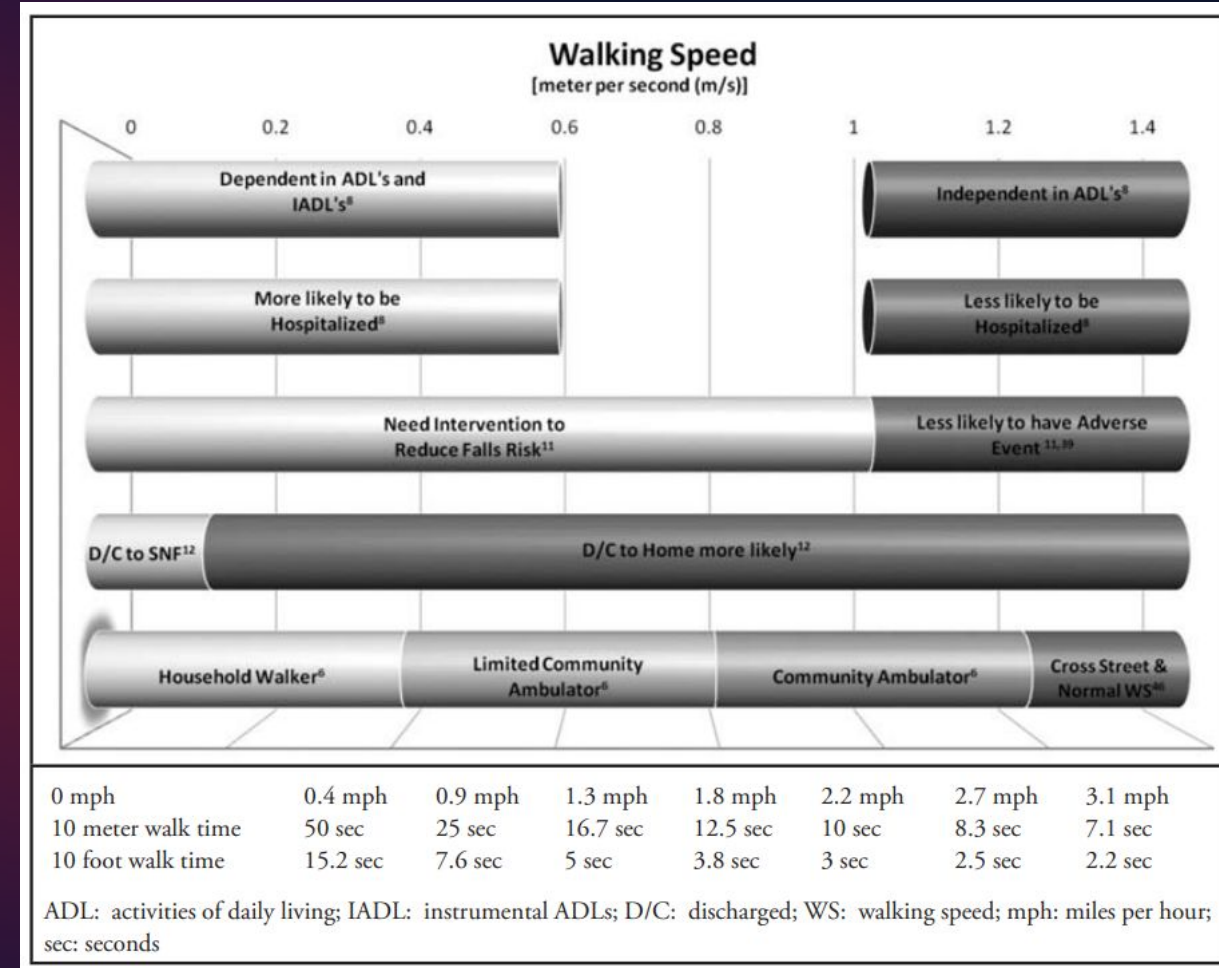
# Why Parkinson's Disease?

- It's about...MOVEMENT!
  - Physical therapists are movement experts
  - Parkinson's Disease is a movement disorder
  - Movement analysis is pattern recognition
- Parkinsonian movement
  - Very characteristic manifestations of diagnostic criteria
    - Gait
    - Articulation/speech



# What is Gait? <sup>3,4</sup>

- Gait = an individual's unique pattern of walking
- Functionally important measure
  - Mobility, independence, fall-risk
  - Gait speed often considered the "sixth vital sign"
  - Predictive of mortality



# Gait Analysis

- Normal Gait
  - Relative symmetry
  - Vertical alignment
  - Fluid motion
  - Biomechanics of the gait cycle
    - Speed, cadence, step length, joint angles
- Clinical vs. lab analysis





# Parkinson's Gait <sup>5</sup>

- Forwardly flexed posture
- Slow overall speed, small step length, changing cadence
  - Shuffling steps, freezing, turning "en bloc"
- Reduced trunk rotation and arm swing
- Tremors



# A Trained Eye vs. Trained AI?

- PT training heavily emphasizes movement analysis
- Movement analysis is *PATTERN RECOGNITION*
  - So...a machine could do it?
    - (Un)popular opinion? → YES, and possibly better
      - Enter AI...



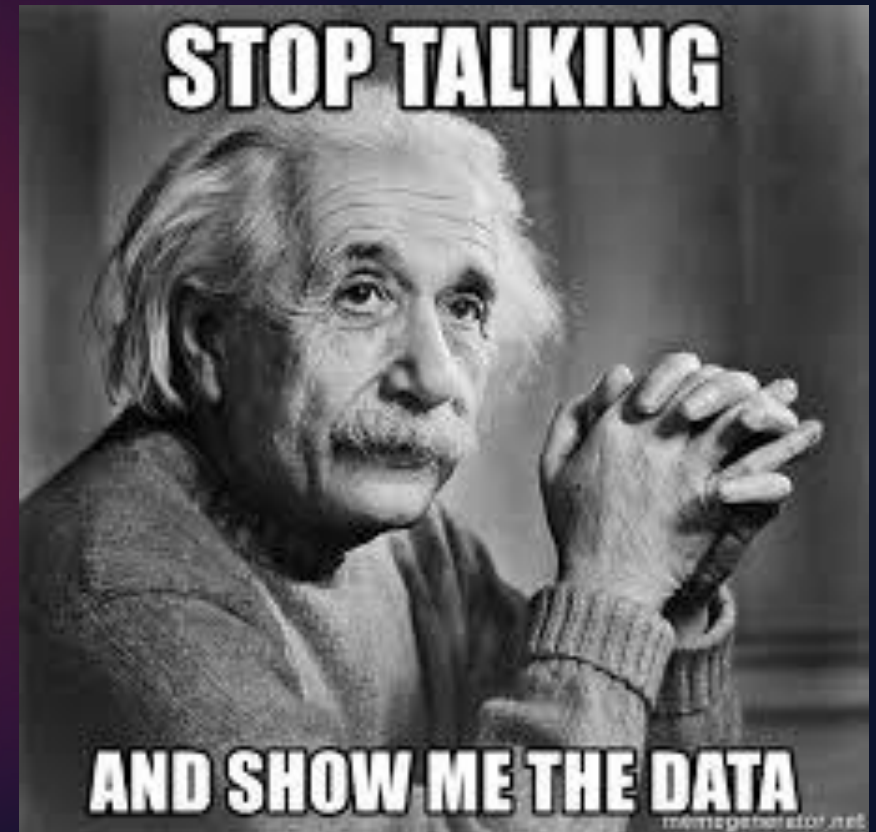
# Translating Into a ML Model

How Would You Build This Model?

# Show Me the Data!?!

I Want to Build a Model, Where Do I Get the Data?

- You Have Access to that Data
  - Work in Medical Research
  - Work at a Medical Institution
  - Data Broker – Google, Meta, etc
- That Isn't Me, Now What?
  - Look for Public Datasets
    - Kaggle, AcademicTorrents, etc
  - Get Creative!
    - YouTube, Instagram, TikTok, etc



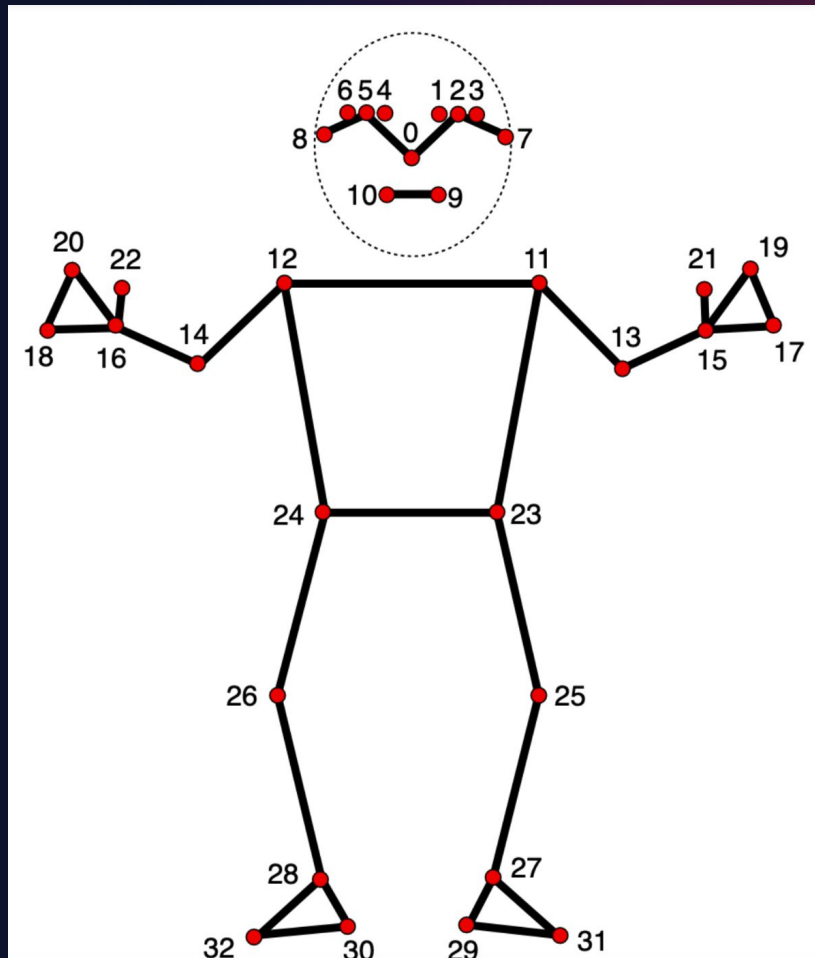
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# Convert Video to Data

Google AI Edge: MediaPipe Pose Landmarker



0 - nose  
1 - left eye (inner)  
2 - left eye  
3 - left eye (outer)  
4 - right eye (inner)  
5 - right eye  
6 - right eye (outer)  
7 - left ear  
8 - right ear  
9 - mouth (left)  
10 - mouth (right)  
11 - left shoulder  
12 - right shoulder  
13 - left elbow  
14 - right elbow  
15 - left wrist  
16 - right wrist

17 - left pinky  
18 - right pinky  
19 - left index  
20 - right index  
21 - left thumb  
22 - right thumb  
23 - left hip  
24 - right hip  
25 - left knee  
26 - right knee  
27 - left ankle  
28 - right ankle  
29 - left heel  
30 - right heel  
31 - left foot index  
32 - right foot index



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# Convert Video to Data



PoseLandmarkerResult:

Landmarks:

Landmark #0:

x : 0.638852  
y : 0.671197  
z : 0.129959  
visibility : 0.9999997615814209  
presence : 0.9999984502792358

Landmark #1:

x : 0.634599  
y : 0.536441  
z : -0.06984  
visibility : 0.999909  
presence : 0.999958

... (33 landmarks per pose)

WorldLandmarks:

Landmark #0:

x : 0.067485  
y : 0.031084  
z : 0.055223  
visibility : 0.9999997615814209  
presence : 0.9999984502792358

Landmark #1:

x : 0.063209  
y : -0.00382  
z : 0.020920  
visibility : 0.999976  
presence : 0.999998

... (33 world landmarks per pose)



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# Characteristics to Code

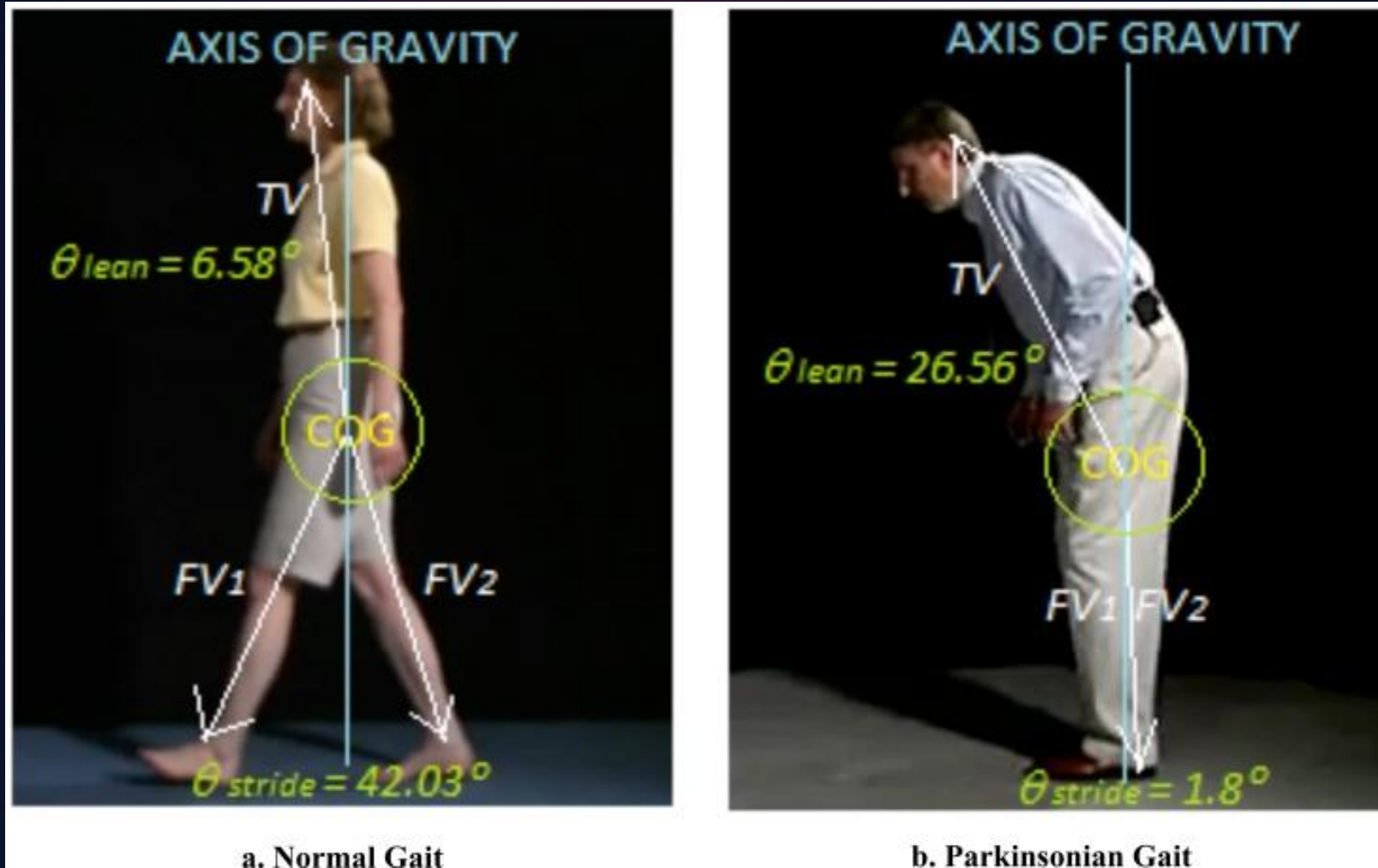


Image Credit:

[Motion Cue Analysis for Parkinsonian Gait Recognition](#)

Taha Khan, Jerker Westin, Mark Dougherty

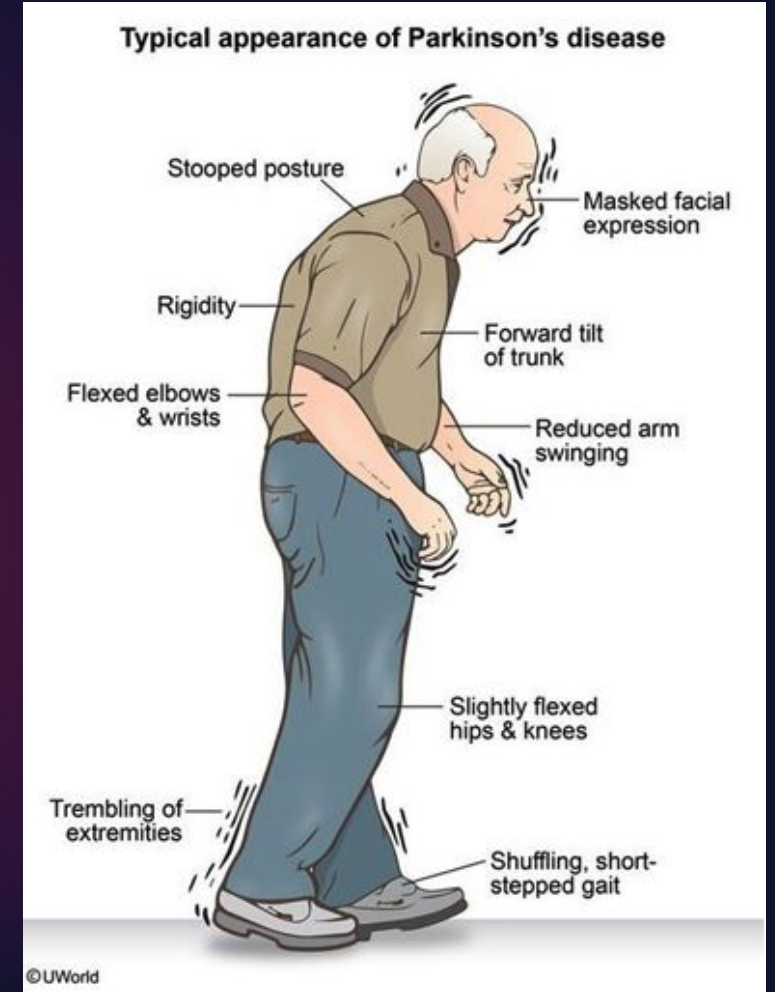


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# Creating a Dataset Structure

- Acceleration/Velocity of Landmarks
  - Reduce Movement, Rigidity, etc
- Body–Arm Angle (Elbow–Shoulder–Hip)
- Arm Angle (Shoulder–Elbow–Wrist)
- Leg Angle (Hip–Knee–Ankle)
- Step Angle (Knee–Hip–Knee)
- Step–Length





# Code Walkthrough and Demo

[https://youtu.be/nWr44ye\\_1pg](https://youtu.be/nWr44ye_1pg)



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# **Multi-Modal/Model Problem Solving**

# Parkinson's and Speech

- Changes in tone, clarity, breathiness, facial emoting, gesturing, posture, enunciation (i.e. Alan Alda)



January 21, 2018  
Screen Actors Guild Awards



March 5, 2024  
Everything Happens Podcast with Kate Bowler

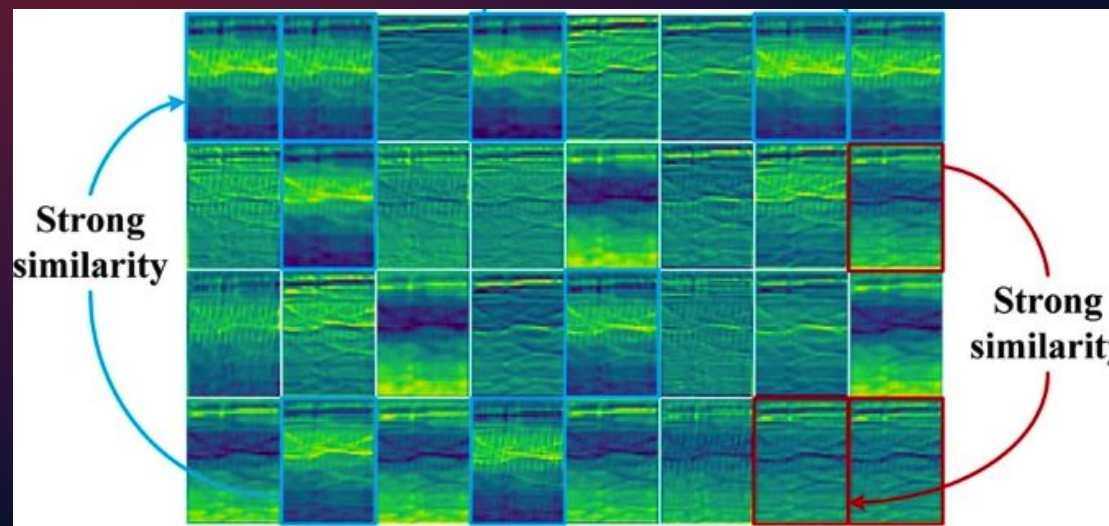
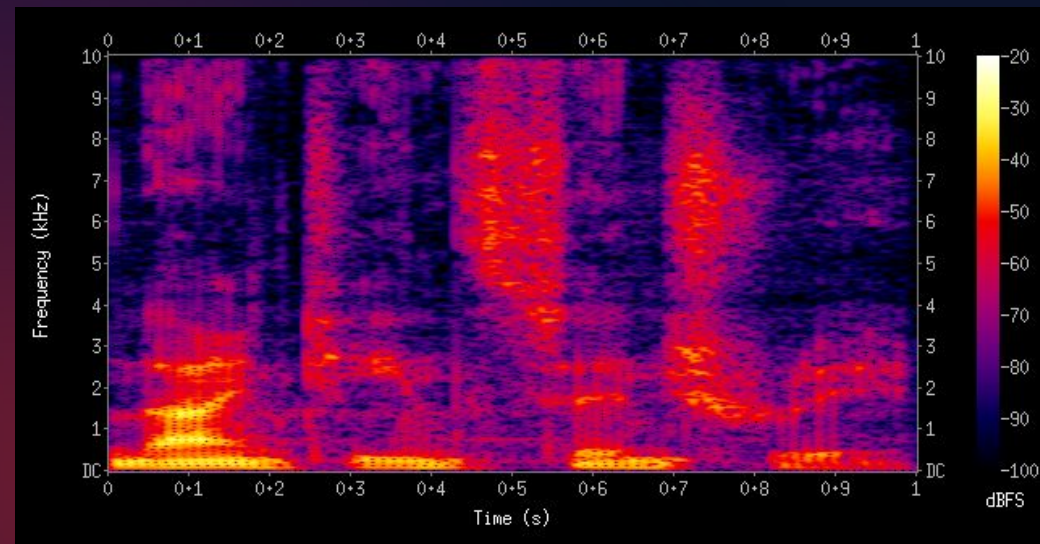


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# Models for Audio Classification

- Classifying Audio
- Easier?
  - Select Phrase
- Better? (But Harder?)
  - Any Phrase
  - LARGE Dataset
    - Languages
    - Accents
- Gait + Audio + More...





# Future of AI in Medicine

- Build All of the Models
  - Don't Rely on a Single Model for Analysis
  - Walk Like a Duck, Talk Like a Duck, Looks...
- *AI is* (and Will Continue) Changing Medicine
  - Tools to Improve Clinical Efficiency
  - Increase Access to Diagnostics and Treatment Interventions (i.e. Telehealth)

→ *Be Part of the Change...We Need You!*



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# Presentation Resources

# Medical Resources/Citations

1. McCormack, R. Understanding the Five Stages of Parkinsons. Parkinson's NSW. Accessed October 7, 2024. <https://www.parkinsonsnsw.org.au/understanding-the-five-stages-of-parkinsons>.
2. Yun, J. Movement Symptoms. Parkinson's Foundation. Accessed October 7, 2024. <https://www.parkinson.org/understanding-parkinsons/movement-symptoms>.
3. Middleton A, Fritz SL, Lusardi M. Walking speed: the functional vital sign. J Aging Phys Act. 2015;23(2):314–322. doi 10.1123/japa.2013-0236.
4. Fritz, Stacy PT, PhD1; Lusardi, Michelle PT, PhD2. White Paper: "Walking Speed: the Sixth Vital Sign." Journal of Geriatric Physical Therapy 32(2):46–9.
5. Moore, K. Trouble Moving or Walking. Parkinson's Foundation. Accessed October 7, 2024. <https://www.parkinson.org/understanding-parkinsons/movement-symptoms/trouble-moving>.



# AI/ML Resources

[\[CLICK HERE\] for All Material Contained in this Session \[CLICK HERE\]](#)

Code with Instructions for:

- Part 1: [Processing Videos Using MediaPipe](#)
- Part 2: [Building a Parkinson's GAIT Model](#)
- Part 3: [Final Demo Used in this Presentation](#)

Other Resources:

- [Deepgram Speech-to-Text: API and Docs](#)
- [Deepgram Text-to-Speech: API and Docs](#)
- [Google Edge AI: MediaPipe Project](#)



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# Questions?



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# Thank You!

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