IIT RTC Conference
Illinois Tech @ Chicago
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IEEE

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

@nikkidashrae

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

Agenda

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

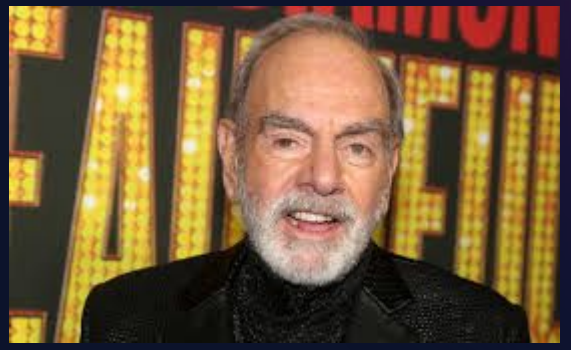
A Common Thread

Michael J. Fox

Alan Alda

Mohammed Ali

Ozzy Osbourne



Neil Diamond

Richard Lewis

Janet Reno

Brian Grant

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

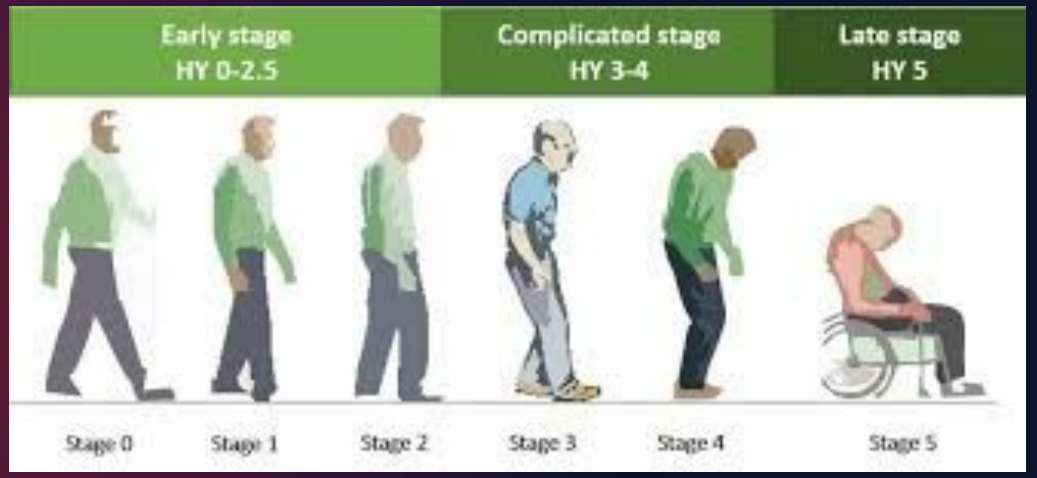
Was Shoulder Pain the Real Problem?

- *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

What is Parkinson's Disease? [1,2]

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

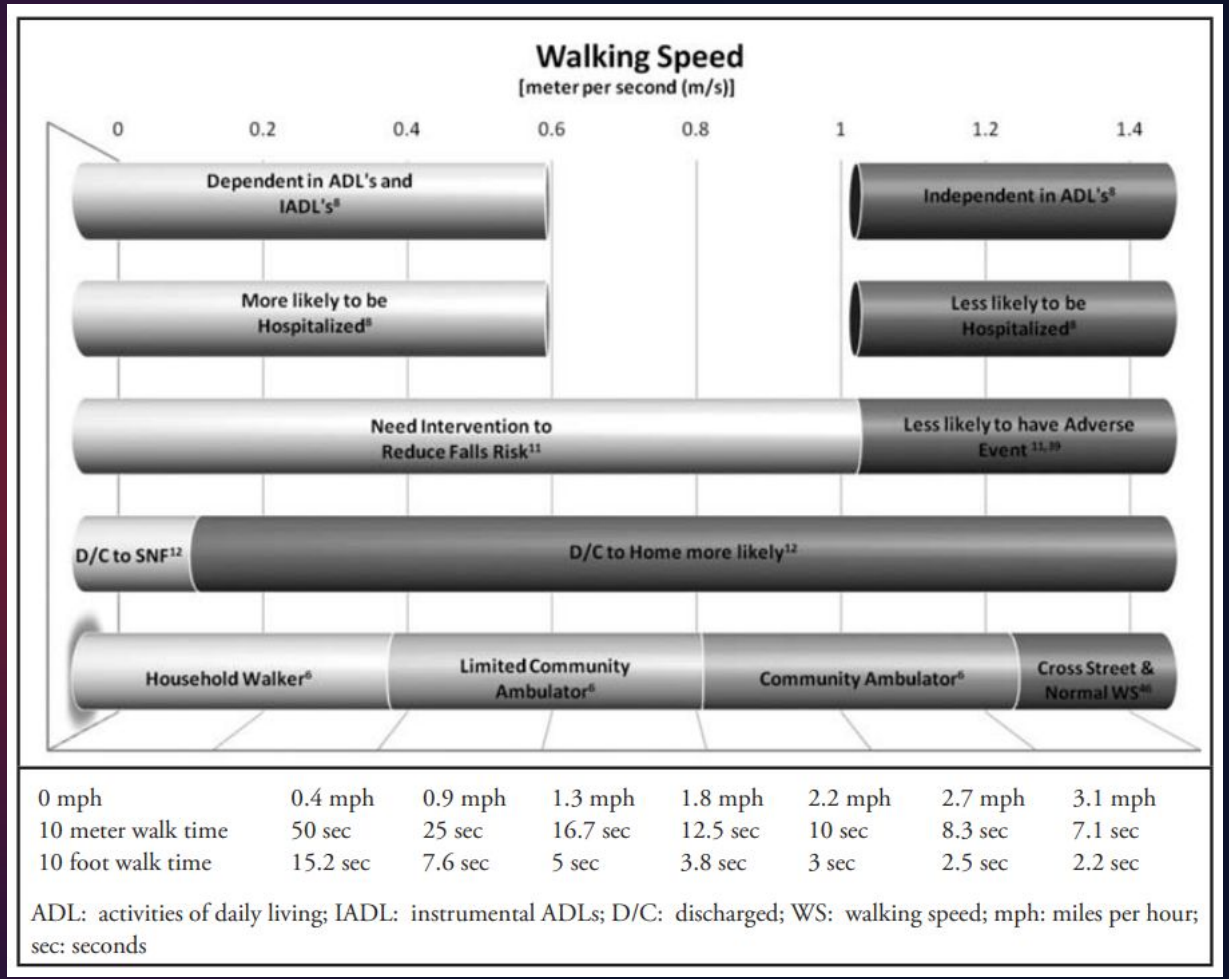


Why Parkinson's Disease?

- 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
    - Examples: 1) gait, 2) articulation/speech

What is Gait? [3,4]

- 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



0 mph	0.4 mph	0.9 mph	1.3 mph	1.8 mph	2.2 mph	2.7 mph	3.1 mph
10 meter walk time	50 sec	25 sec	16.7 sec	12.5 sec	10 sec	8.3 sec	7.1 sec
10 foot walk time	15.2 sec	7.6 sec	5 sec	3.8 sec	3 sec	2.5 sec	2.2 sec

ADL: activities of daily living; IADL: instrumental ADLs; D/C: discharged; WS: walking speed; mph: miles per hour; sec: seconds

Gait Analysis

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

Parkinson's Gait [5]

- 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…

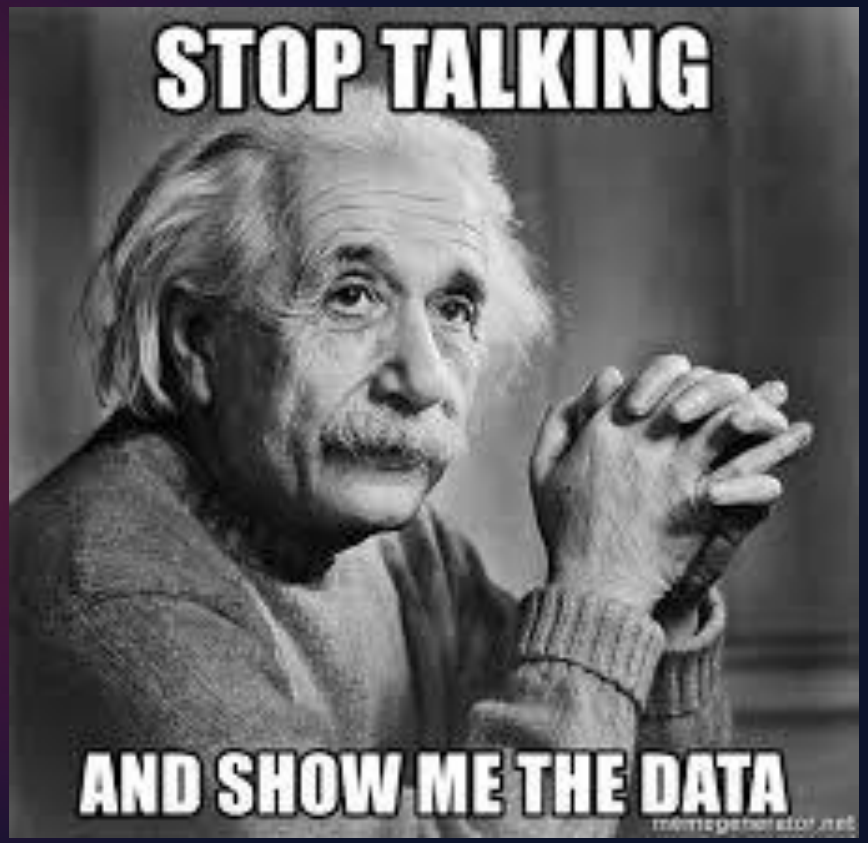
Translating Into a ML Model

How Would You Build This Model?

Show Me the Data!?!

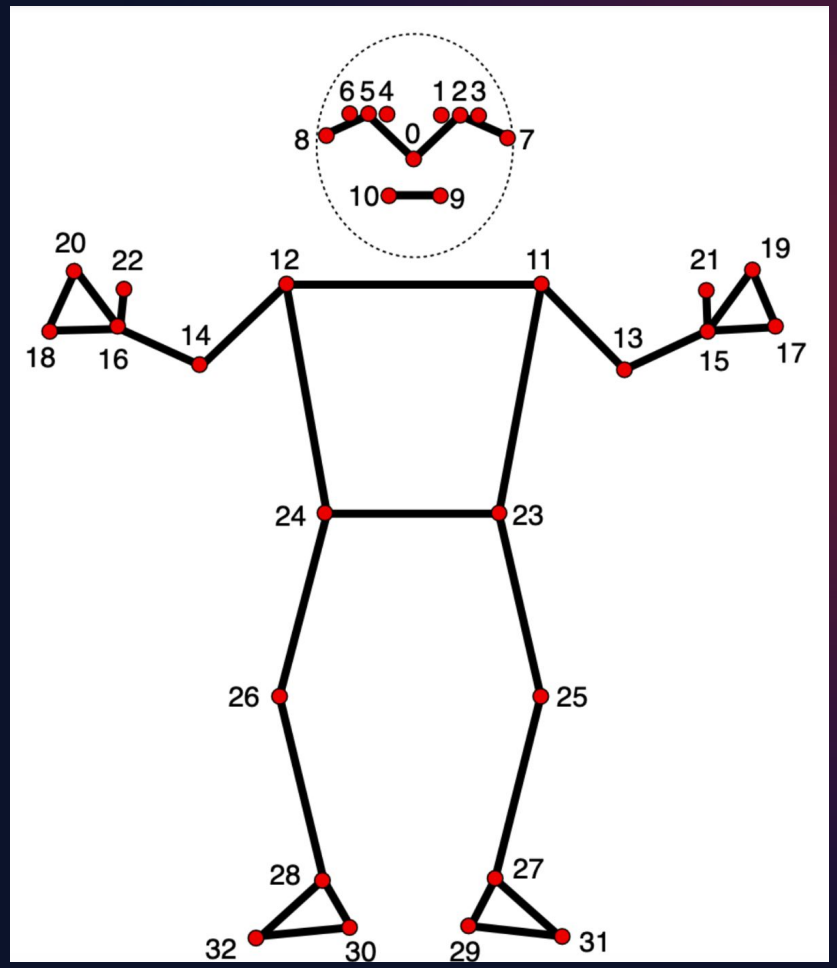
I Want to Build a Model, Where Do I Get the Data?

- 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



Convert Video to Data

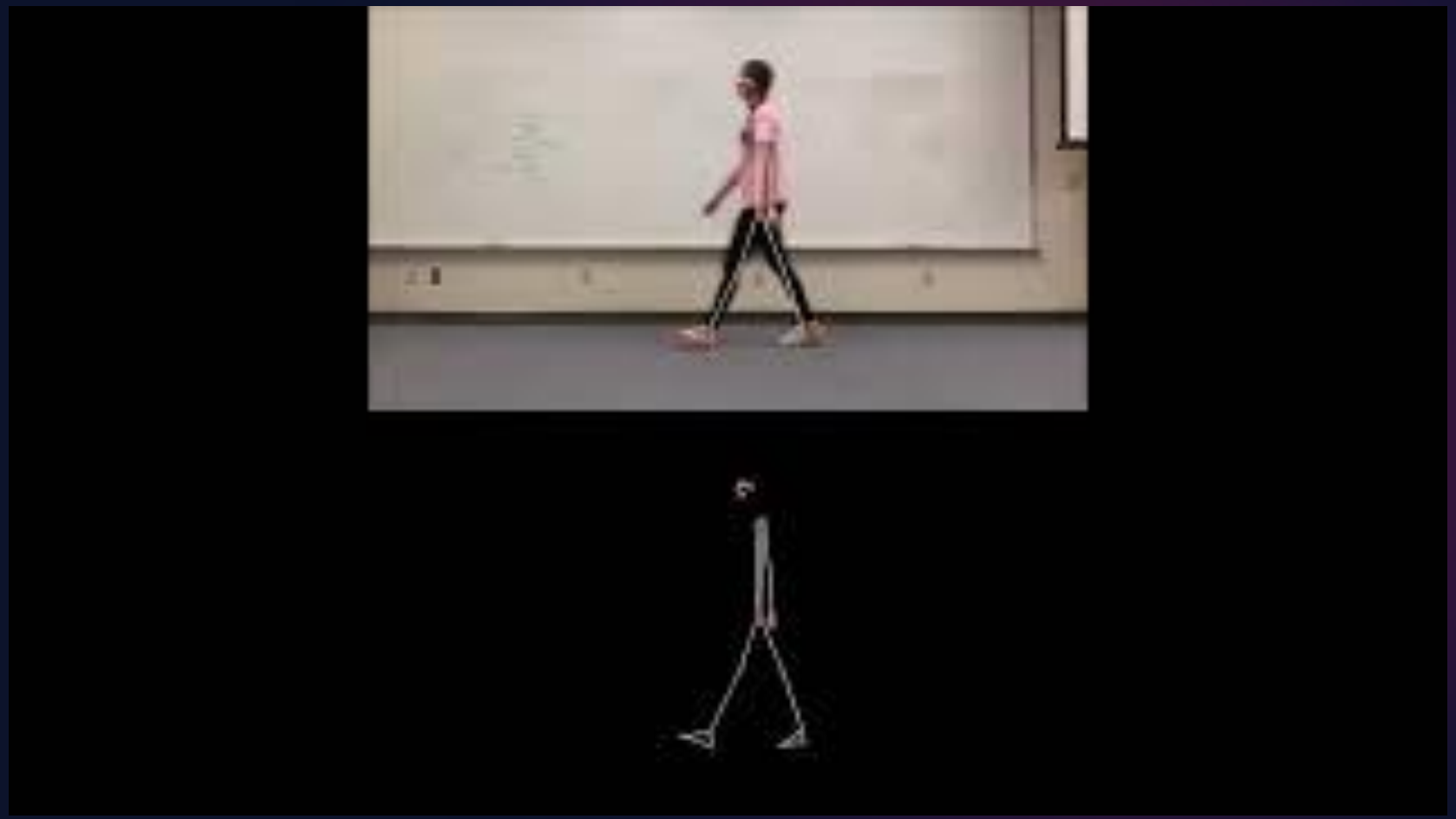
Google AI Edge: MediaPipe Pose Landmarker




```
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
```

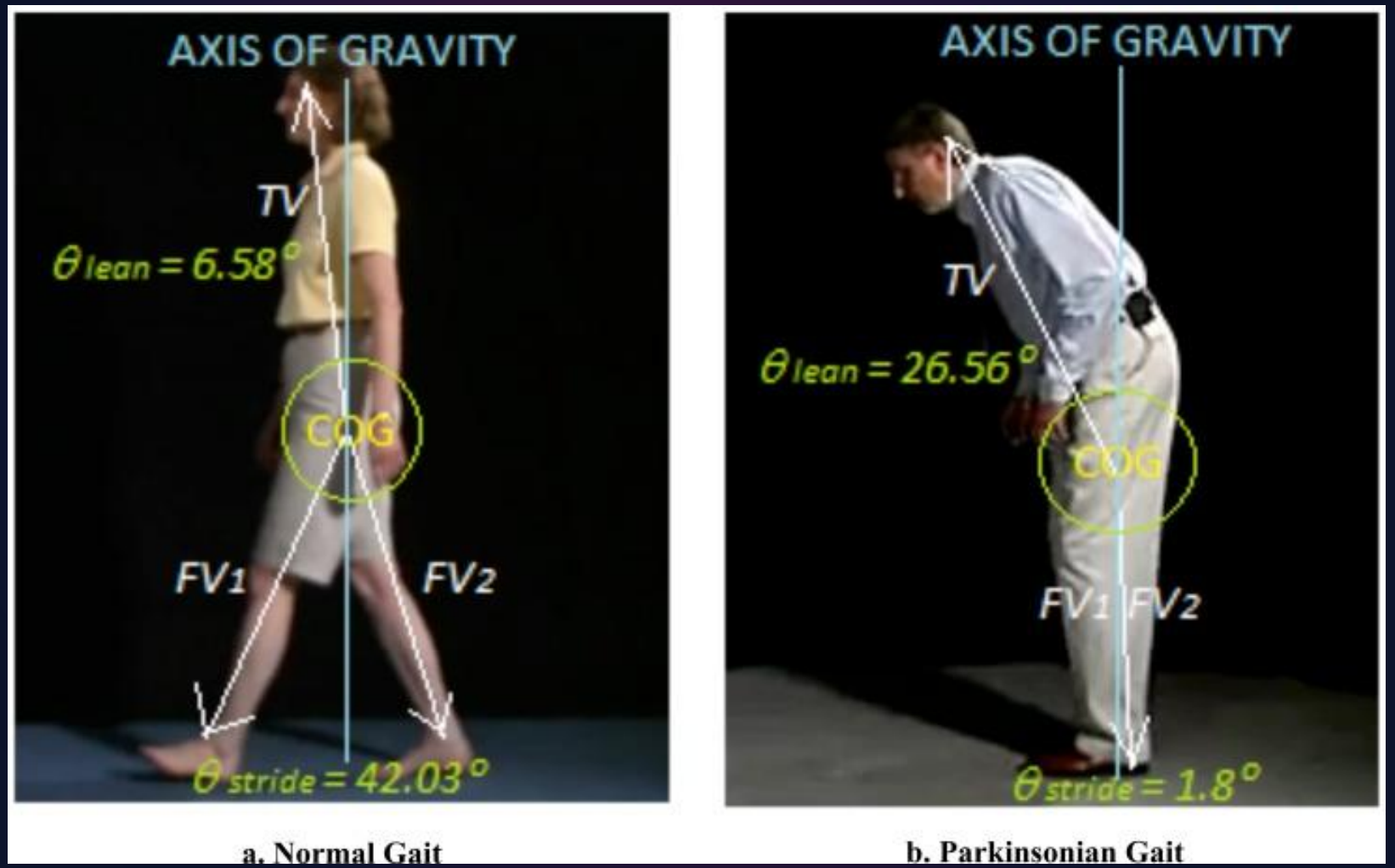
```
17 - left pinky
18 - right pinky
19 - left index
20 - right index
21 - left thumb
22 - right thumb
23 - left hip
24 - right hip
25 - left knee
26 - right knee
27 - left ankle
28 - right ankle
29 - left heel
30 - right heel
31 - left foot index
32 - right foot index
```

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)
```

Characteristics to Code



a. Normal Gait

b. Parkinsonian Gait

Image Credit:
Motion Cue Analysis for Parkinsonian Gait Recognition
Taha Khan, Jerker Westin, Mark Dougherty

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

Multi-Modal/Model Problem Solving

Parkinson's and Speech

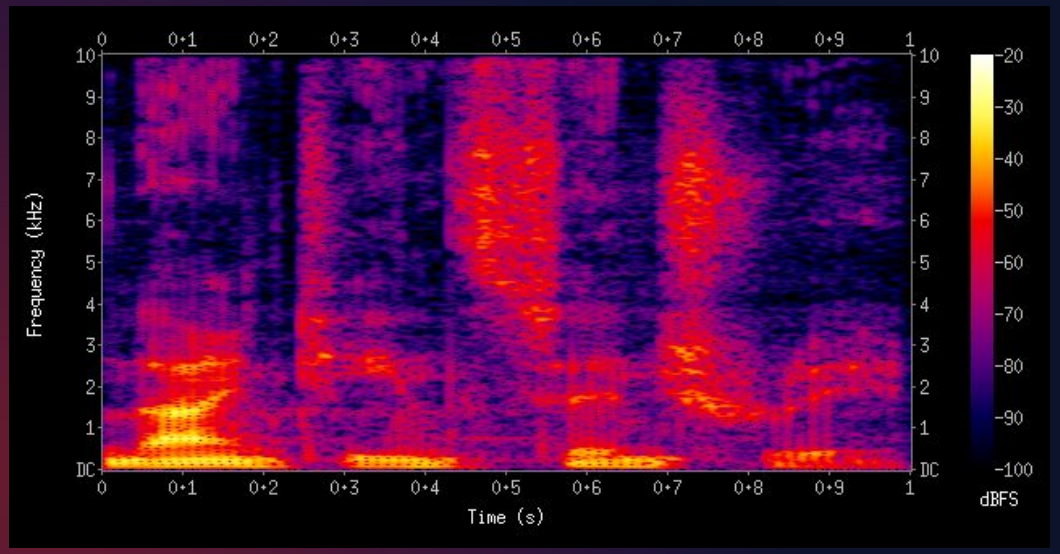
- Changes in tone, clarity, breathiness, facial emoting, gesturing, posture, enunciation (i.e. Alan Alda)

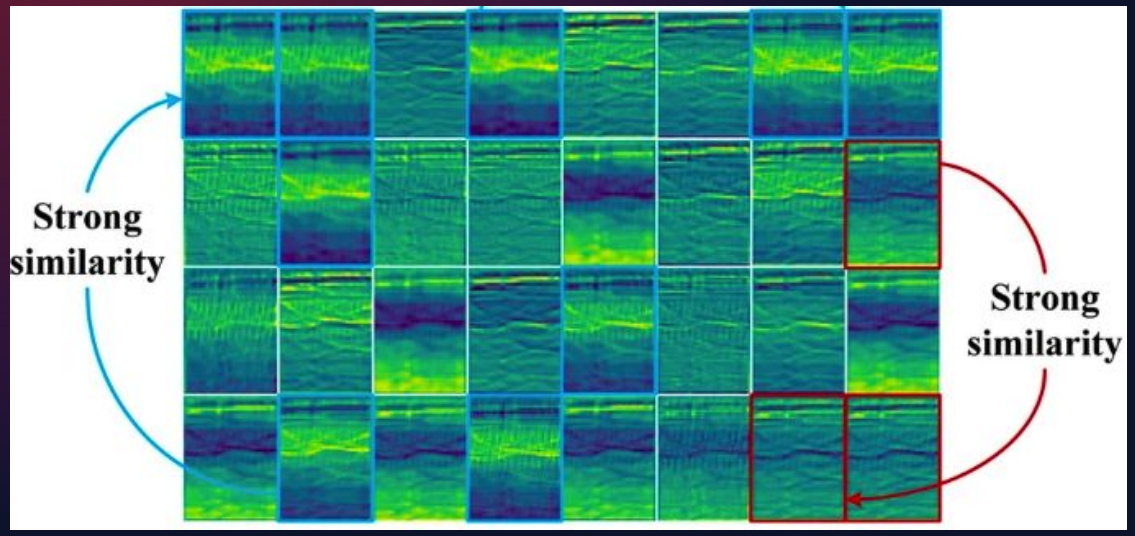
January 21, 2018
Screen Actors Guild Awards

March 5, 2024
Everything Happens Podcast with Kate Bowler

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, Breathes… etc…
- 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!*

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

Questions?

Thank You!

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