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IEEE

Training Machine Learning Classification Models

Creating Real-Time Data Points of Medical Conditions

Dr. Nikki-Rae Alkema, PT, DPT
Licensed Physical Therapist
@nikkidashrae

David vonThenen
Software Engineer/Developer Advocate
@davidvonthenen

Dr. Nikki-Rae Alkema, PT, DPT

- Licensed Physical Therapist (CA)
- Optimizing movement to improve the human experience
- Special interests: biomechanics, tech in medicine

@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: Building a Model
  - Translating to the Real-World
  - Characteristics to Code
  - Creating a Dataset Format
  - Live Demo!
- Multi-Modal/Model Problem Solving
- Q&A

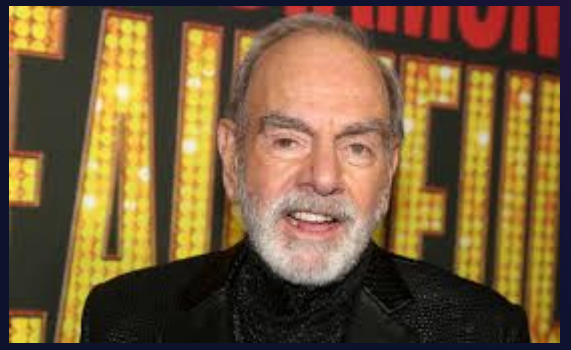
A Common Thread

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

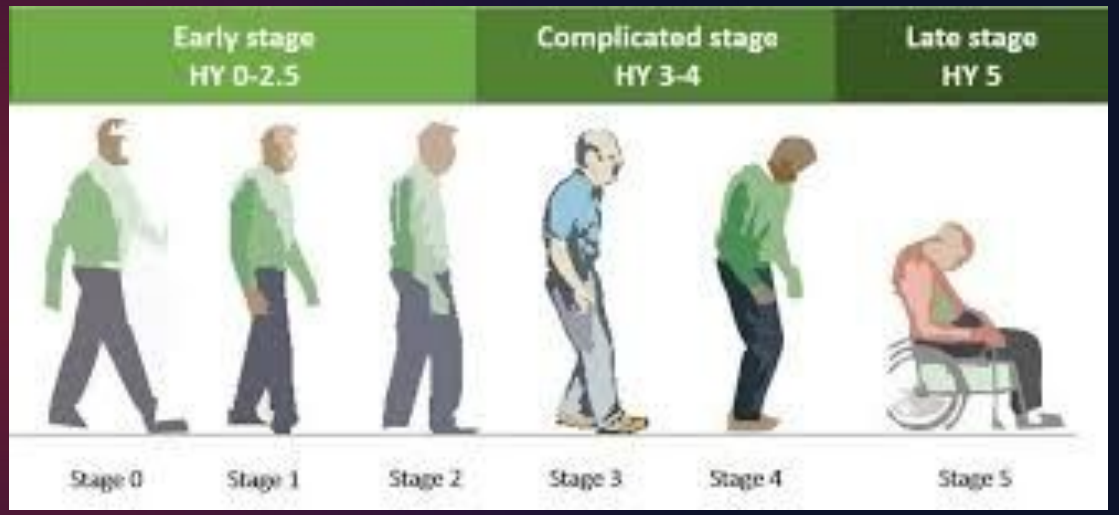
Was Shoulder Pain the Real Problem?

- *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?

- Progressive movement disorder
- No cure
- No definitive tests
  - Diagnosis of exclusion
  - Minimum criteria:
    - Bradykinesia, *plus*
    - Resting tremor, stiffness/rigidity, or postural instability



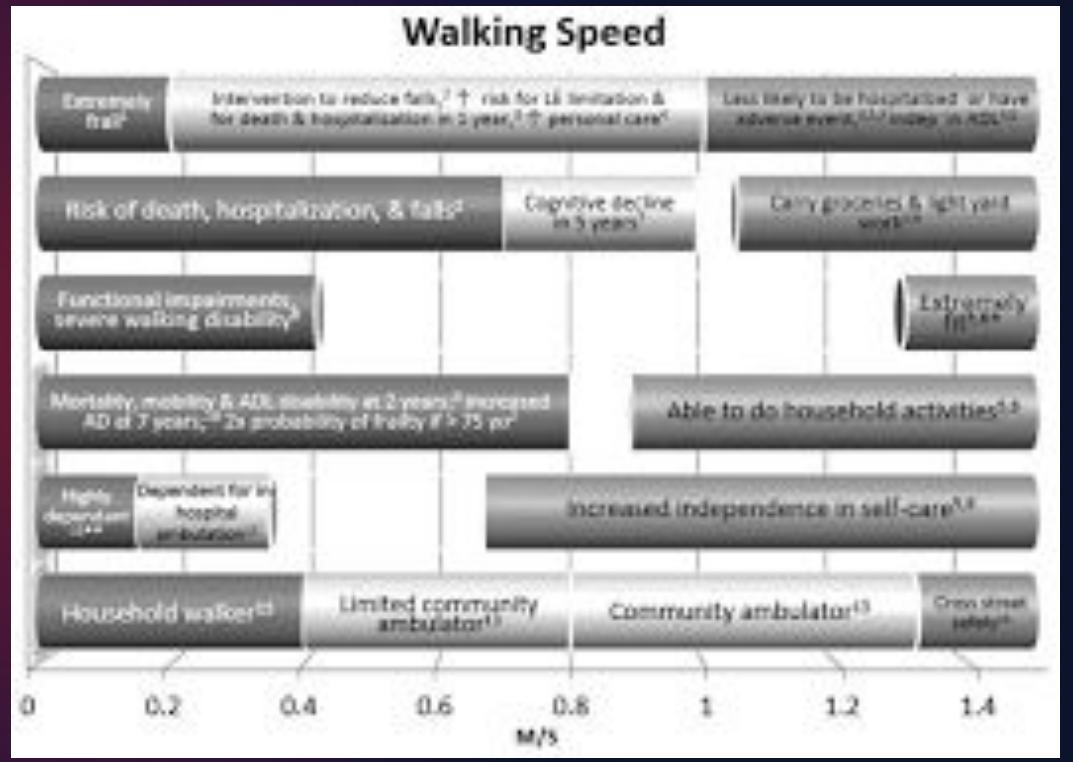
Why Parkinson's Disease?

- 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, easy to study

→ CLASSIC EXAMPLE...PARKINSON'S GAIT

What is Gait?

- 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

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

A Trained Eye vs. Trained AI?

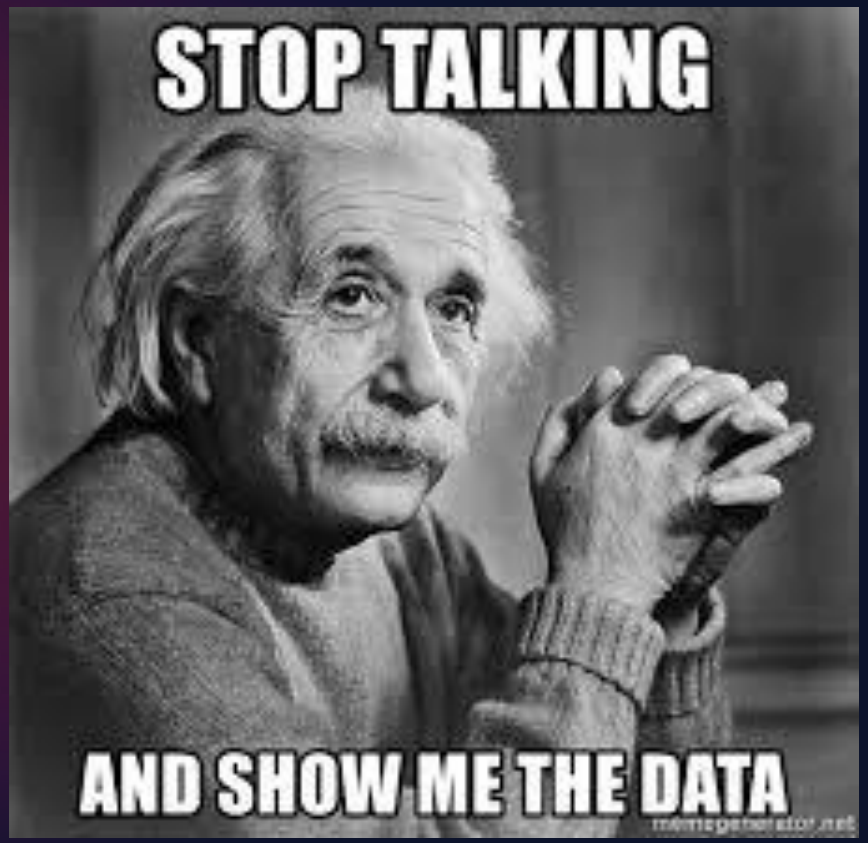
- PT training heavily emphasizes movement analysis
- Movement analysis is *PATTERN RECOGNITION*
  - So…a machine could do it?
    - (Un)popular opinion? → YES, and possibly better
      - Enter AI…

Translating to the Real-World

Show Me the Data!?!

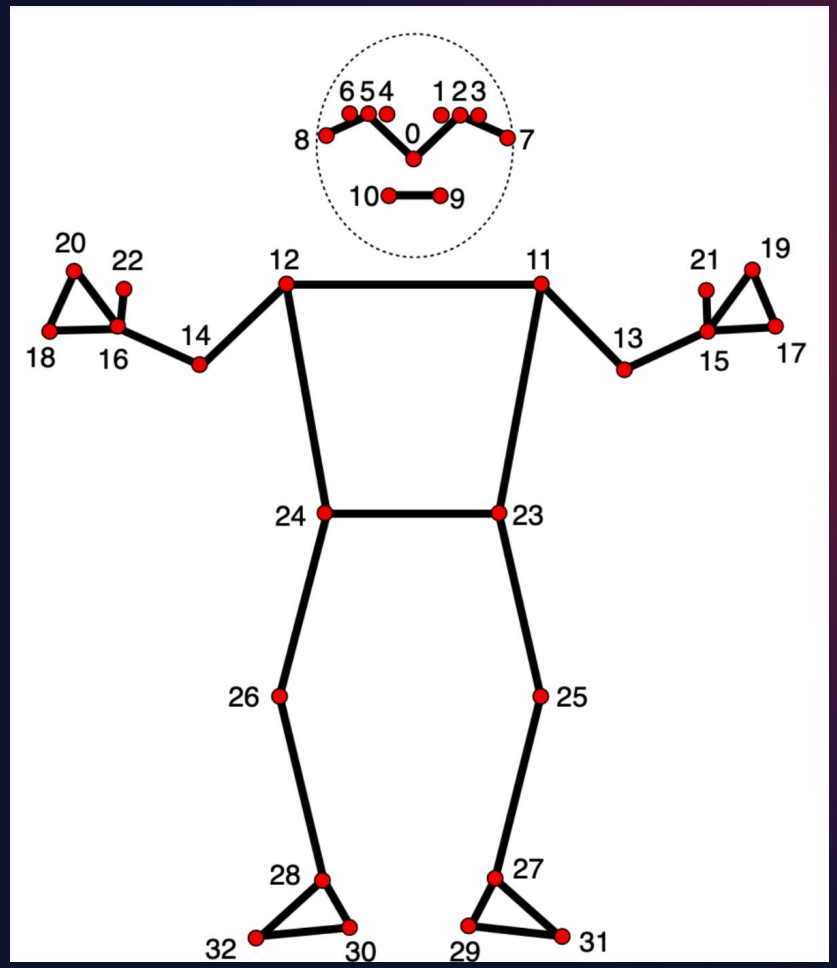
I Want to Build a Model, Where Do I Get the Data?

- 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

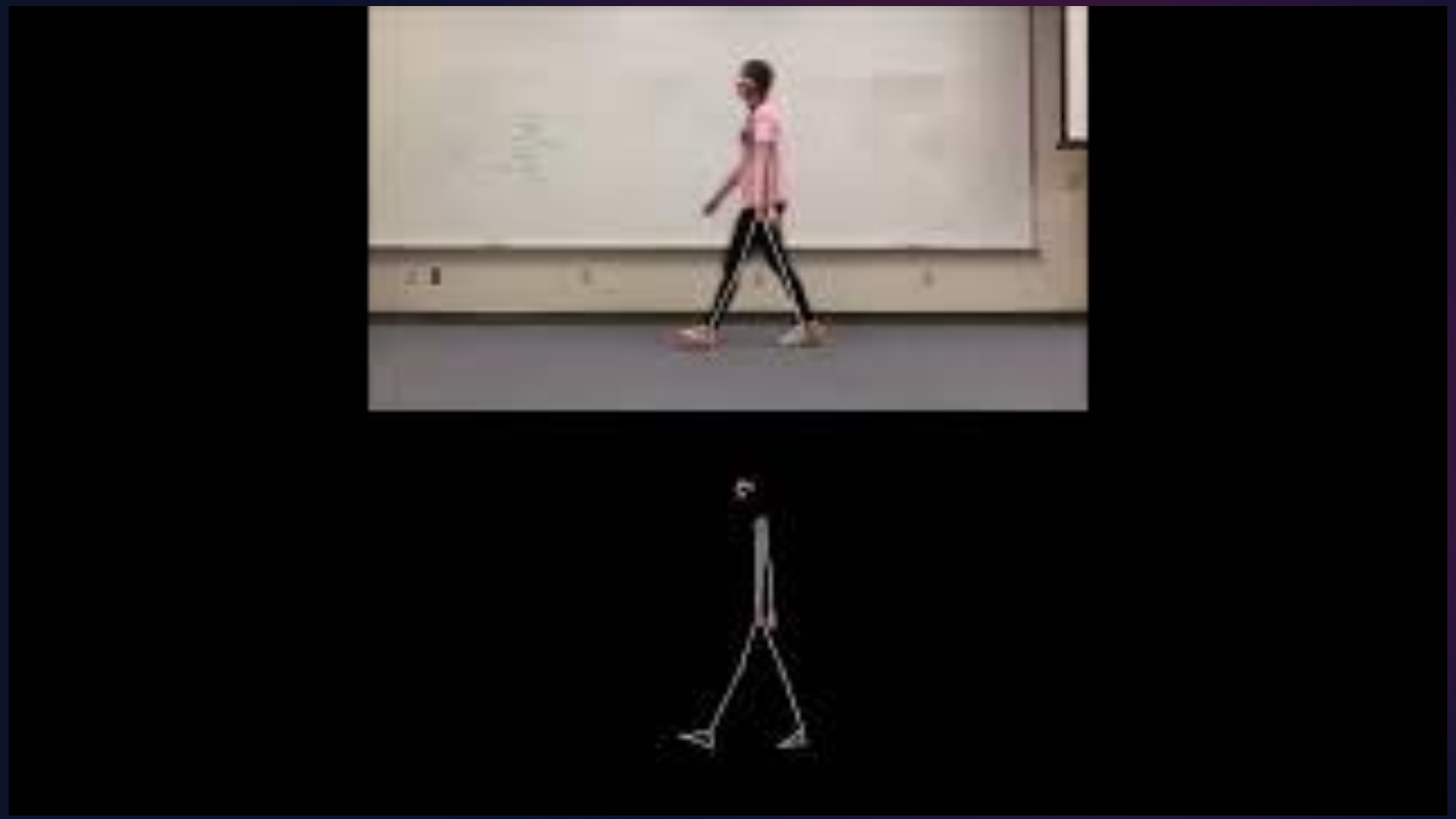
Google AI Edge: MediaPipe Pose Landmarker




```
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
```

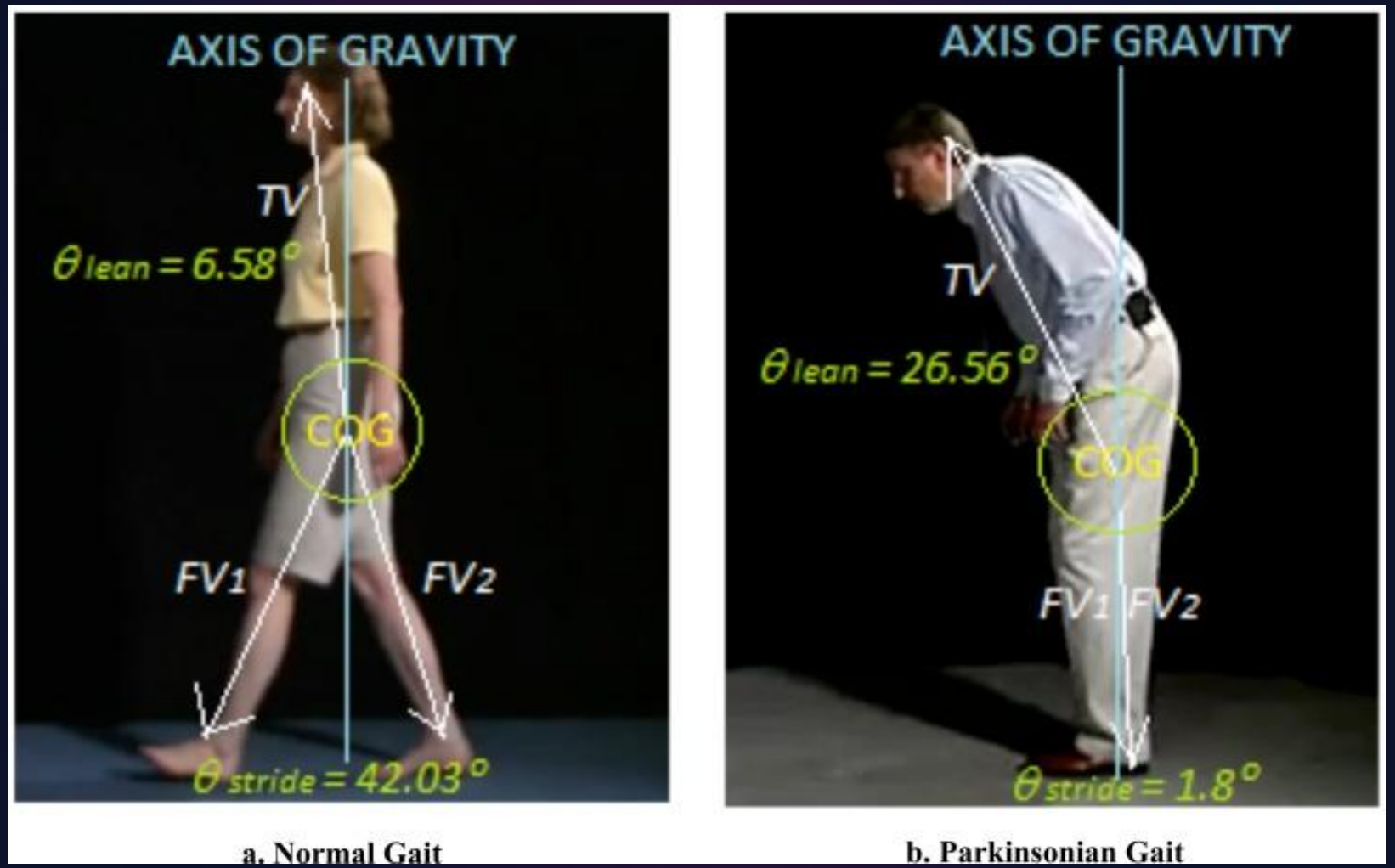
```
17 - left pinky
18 - right pinky
19 - left index
20 - right index
21 - left thumb
22 - right thumb
23 - left hip
24 - right hip
25 - left knee
26 - right knee
27 - left ankle
28 - right ankle
29 - left heel
30 - right heel
31 - left foot index
32 - right foot index
```

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

Multi-Modal/Model Problem Solving

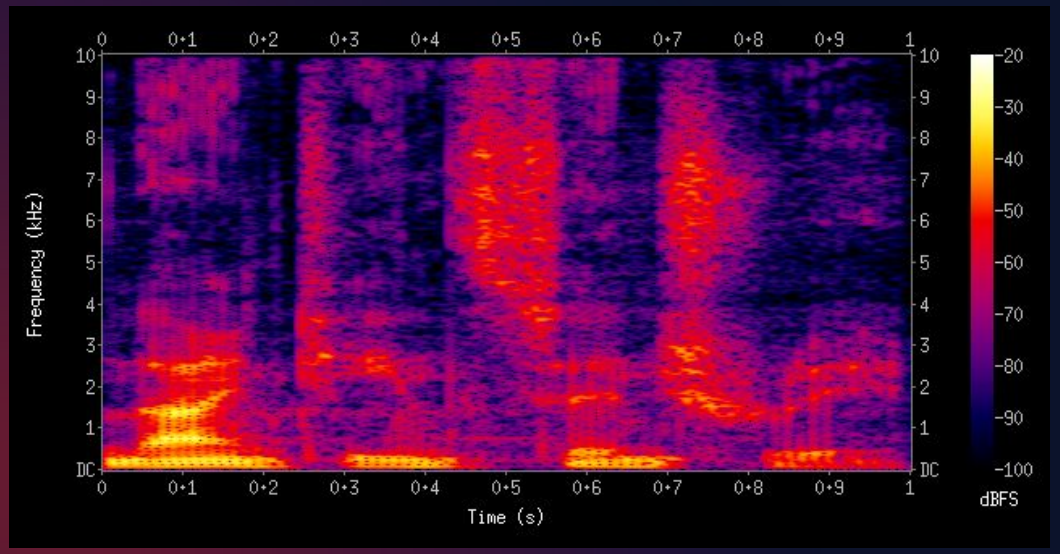
https://youtu.be/nWr44ye_1pg

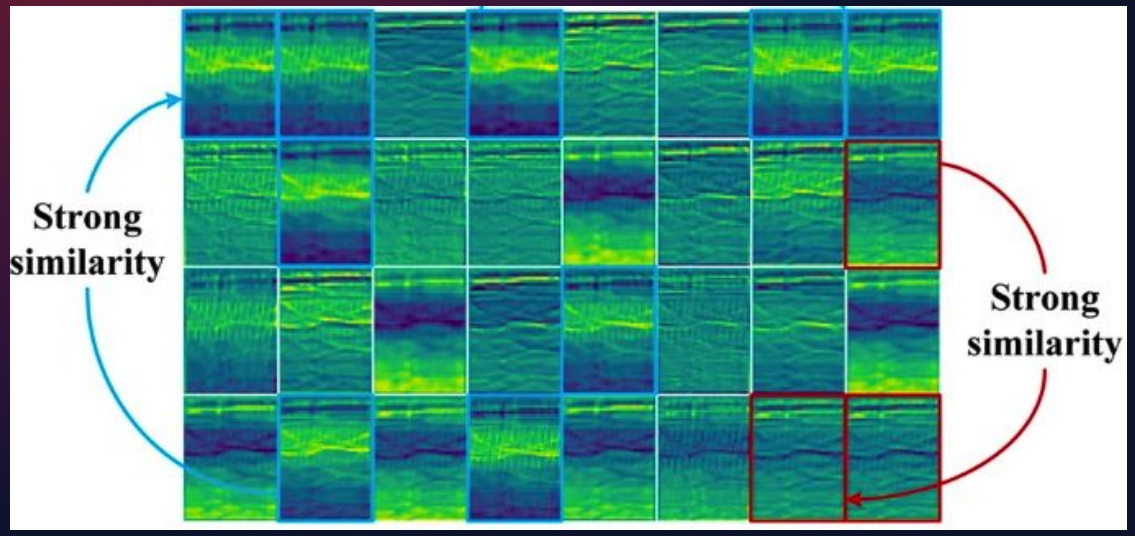
Parkinson's and Speech

- TODO: Two Videos BEFORE and AFTER

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...
- TODO... (nik copy/paste from notes)

Presentation Resources

Medical Resources/Citations

- TODO

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!

Nikki-Rae Alkema
@nikkidashrae
https://linktr.ee/nikkidashrae

David vonThenen
@davidvonthenen
https://linktr.ee/davidvonthenen