EEP 596: AI and Health Care || Lecture 4

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Logistics

- **Office Hours Today:** After class

Logistics

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- **Anything Else?**

Last Lecture

- **Spectrum of Data Pre-processing**
- Data Cleaning. Missing Data imputation. Data Normalization. Feature Engineering. Data Augmentation.

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- **Diabetes risk prediction Case Study**

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- **Decision Trees and Interpretability**

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- Data Cleaning. Missing Data imputation. Data Normalization. Feature Engineering. Data Augmentation.
- **Diabetes risk prediction Case Study**
- **Decision Trees and Interpretability**
- **Model Complexity and over-fitting in Decision Trees**

Today

- **Random Forests**

Today

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- **Case Study: Wearable Devices**

Today

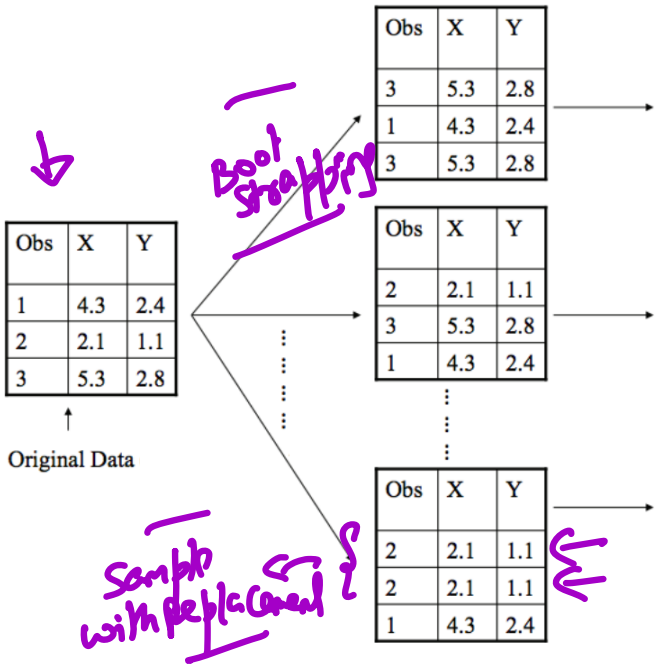
- **Random Forests**
- **Case Study: Wearable Devices**
- **Tracking Human Activity from wearables** → Assignment

* Anomaly detection ?

Bagging for Trees

If I just have one dataset, how could I learn more than one tree?

Solve this with **bootstrapping**! Can create many similar datasets by randomly sampling *with replacement*.



Bagging – Statistics for mean estimation

RF

DT 1

DT 2

DT 3

Majority vote on the predictions

Bootstrapping

Sample with replacement

Random Forest Algorithm

Training

- Create T sets of data by sampling with replacement to build T decision trees.
- Each data set also randomly samples features (this is key to improving performance of Random forest)
- Train T trees in parallel and this makes up the training of Random Forest!

Prediction

Random Forest prediction is a majority classifier on the T trees! So predict the majority class of the T trees' predictions.

Random Forest in Msft Kinect!

Microsoft used Random Forests in their Kinect system to identify the "pose" of a person from the depth camera.

Real-Time Human Pose Recognition in Parts from Single Depth Images

Jamie Shotton Andrew Fitzgibbon Mat Cook Toby Sharp Mark Finocchio
Richard Moore Alex Kipman Andrew Blake
Microsoft Research Cambridge & Xbox Incubation

Abstract

We propose a new method to quickly and accurately predict 3D positions of body joints from a single depth image, using no temporal information. We take an object recognition approach, designing an intermediate body parts representation that maps the difficult pose estimation problem into a simpler per-pixel classification problem. Our large and highly varied training dataset allows the classifier to estimate body parts invariant to pose, body shape, clothing, etc. *Finally we generate confidence-scored 3D proposals of several body joints by reprojecting the classification result and finding local modes.*

The system runs at 200 frames per second on consumer hardware. Our evaluation shows high accuracy on both synthetic and real test sets, and investigates the effect of several training parameters. We achieve state of the art accuracy in our comparison with related work and demonstrate improved generalization over exact whole-skeleton nearest

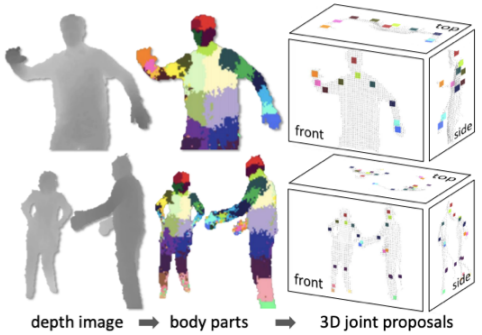


Figure 1. **Overview.** From an single input depth image, a per-pixel body part distribution is inferred. (Colors indicate the most likely part labels at each pixel, and correspond in the joint proposals). Local modes of this signal are estimated to give high-quality proposals for the 3D locations of body joints, even for multiple users.

Learning and Hyper-parameters in Random Forests

ICE #1 (2 mins)

What are hyper-parameters in the random forest?

a. Number of trees in the random forest
b. The order of features to split each tree in the random forest
c. Number of tress and number of features per tree
d. Number of features per tree and weight of each feature

Decision Trees vs Random Forests

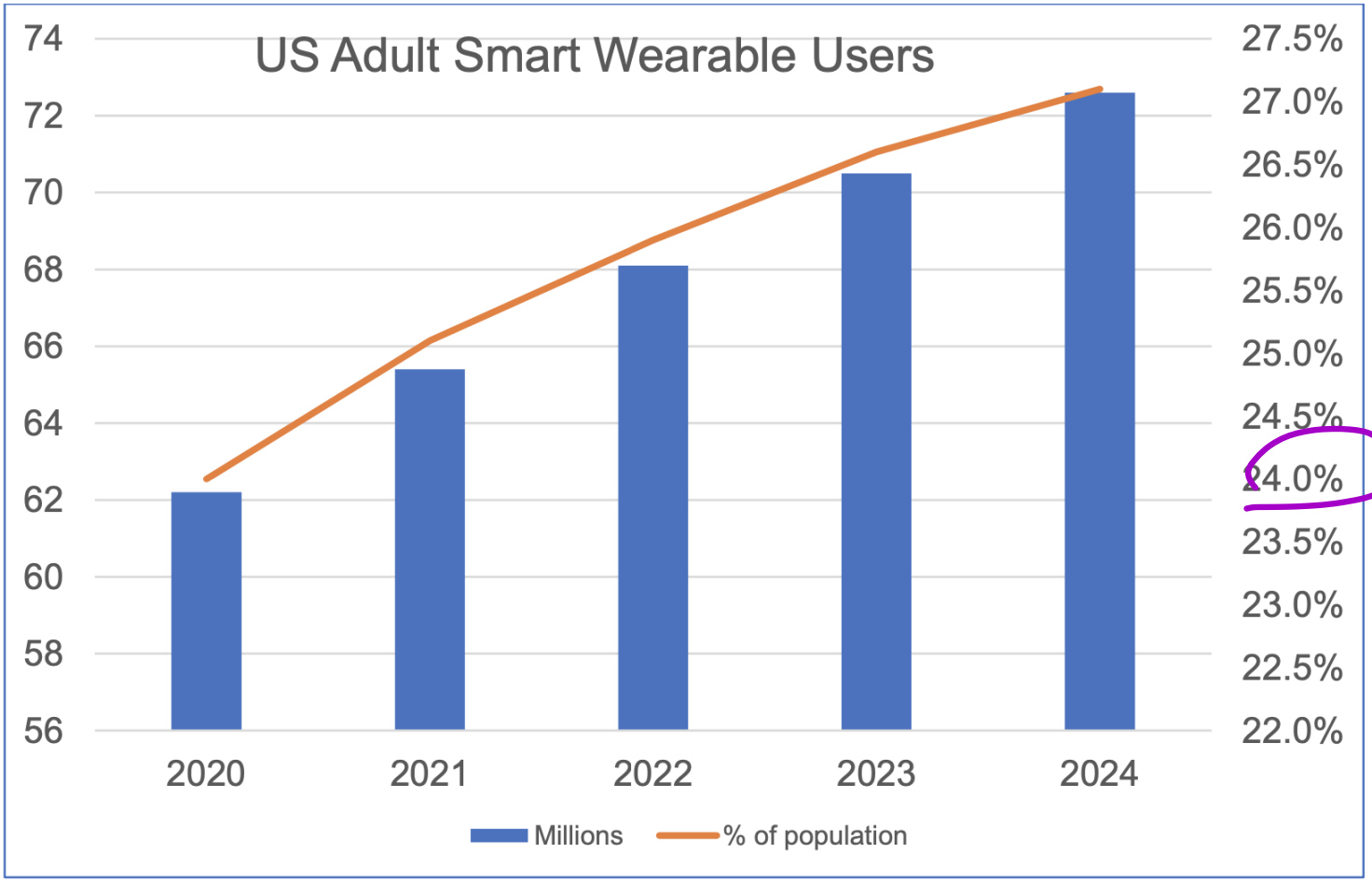
a. RF ← collection of DTs
b. DT can overfit, RF typically don't
c. DT & RF are interpretable.
d. RF does better perf. than a single DT!: ⟹ sub-sample the trees & explain

New Topic: Wearable Devices

Power of Wearables

Deanna Recktenwald, an 18-year-old high school senior, received a ping on her Apple Watch earlier this year that said, "Seek medical attention." Recktenwald is grateful for taking the message seriously, because emergency room procedures revealed that her kidneys were functioning at a mere 20% and needed immediate intervention. The Apple Watch, with the heart rate tracking function that alerted Recktenwald, is one of many wearable devices in the market that offer patients the ability to track their health, thereby improving their chances of better outcomes.

Case Study: Wearable Devices



Case Study: Wearable Devices

What consumers wanted to track next (CES 2020)
55% Would like to monitor blood pressure, up from 46% in 2016
49% Would like to monitor heart health
33% Would like to monitor blood sugar levels
50% Would like to monitor stress, down from 55% in 2016
SOURCE: Consumer Technology Association 2020

Case Study: Wearable Devices

Case Study: Wearable Devices

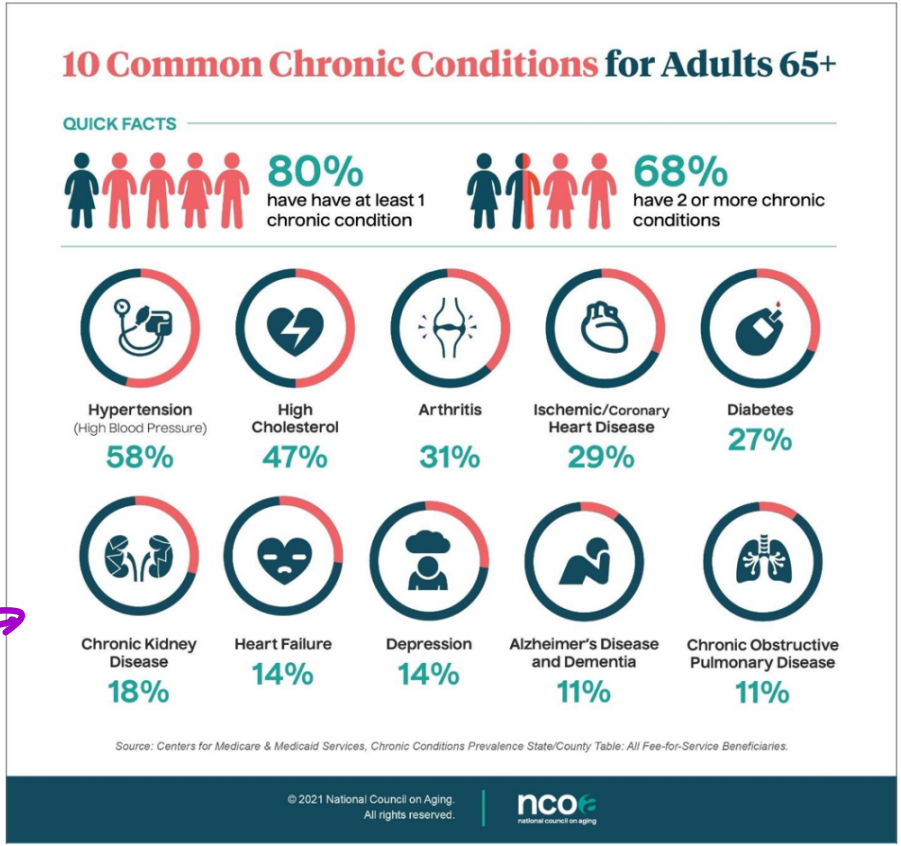


Figure 6 Ten Common chronic conditions for Adults Aged 65+ Source: NCOA

Case Study: Wearable Devices

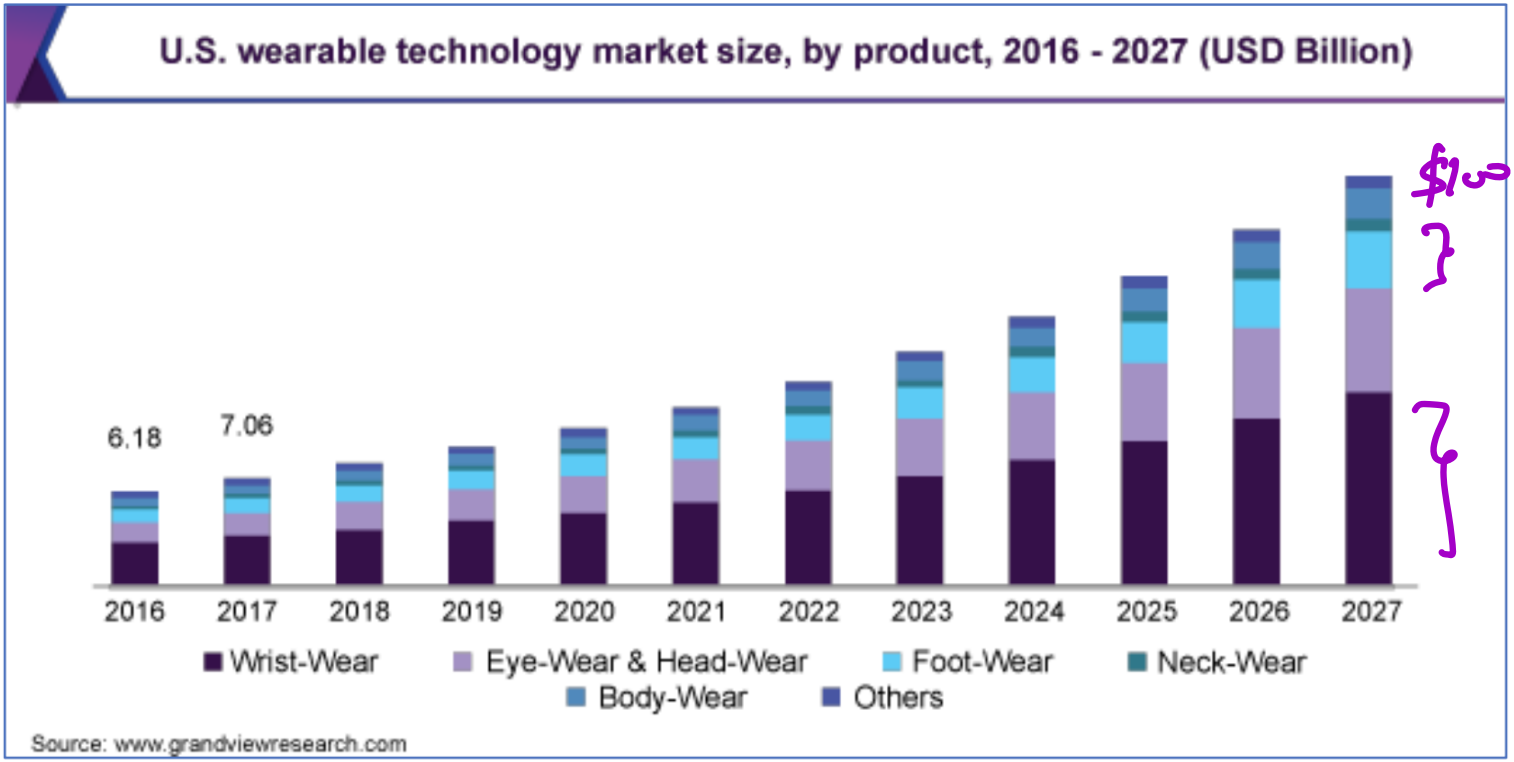


Figure 7 US Wearable Technology Market Will Pass $100 billion by 2027 Source: IDC

Case Study: Wearable Devices

Category	What it is	Examples
Hearables/earbuds	An amplification ear-worn wearable	Apple AirPods, WearandHear, Dime
Smartwatches	Smart watches monitoring activity, health metrics	Apple, Samsung, Fitbit, Garmin, Adapt
Headsets – AR/VR	Internet-connected glasses enable alternate views	MyndVR, Embodied Labs, Rendever
Fitness trackers (no watch)	Step counter, heart rate	Amazon Halo, Vivo, Whoop Strap 3, Fitbit One
Continuous diabetes wearables	Scans detect blood sugar level, patch injects insulin	FreeStyle Libre, Dexcom G5,
Sleep trackers	Wearables noted for sleep tracking	Ōura Ring, Whoop, Fitbit Versa
Wrist-worn Health	Low-sleep indicates risk of dementia	Omron HeartGuide, Amazon Halo, Whoop
Smart jewelry	Ring, Necklace	Trelaware, ADT invisiWear
Dementia zone trackers	Set a range – track movement outside range	MindMe Locate, PocketFinder
Medical Grade wearable, data collection	Blood pressure, mobile EKG, Diabetes patch	Omron HeartGuide, AliveCor, Tidepool
Medical Alert/PERS/Safety	Emergency call, fall detection – in home or out	Medical Guardian, Lively Wearable, UnaliWear

Figure 8 Examples of wearable categories and some of the offerings

Case Study: Wearable Devices

"We are working with people with Parkinson's. Our technology can facilitate a meaningful interaction between the wearer and care teams. The wearable can offer an understanding if a new medication is working or not." – Nicholas Constant, **EchoWear LLC**

"Most cases of mild-to-moderately-severe hearing loss can be managed by users themselves, if all the tools work well. The hearing aid advantage will not last more than two years from now." – Alexander Goldin, Founder and CEO, **Alango Technologies**

"We started with sleep. The impact it has, from cognitive function the next day, fasting glucose, hormones, T-cells that fight cancer – these are all linked to our sleep." – Harpreet Singh Rai, CEO, **Ōura Ring**

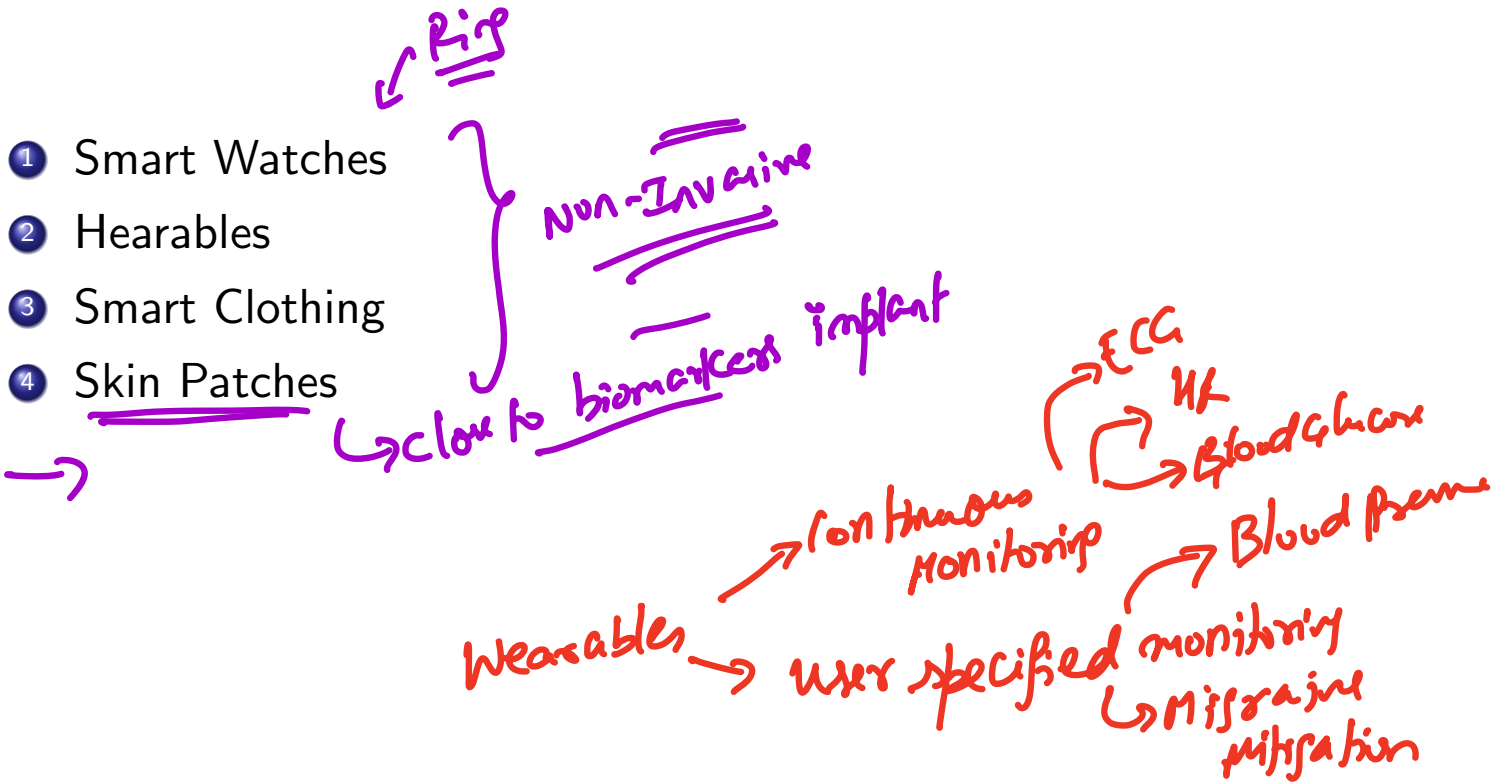
"Apple launched a revolution in the wearable industry and mainstreamed the device. The "smart" fall detection system that we built is a patented API. It can go into any wearable." – Shea Gregg, CEO, **FallCall Solutions**

History of Wearables

1960	Holter monitor used for recording ECG data
1970	Calculator watches developed
1977	Heart rate monitor worn on the fingertip
1982	Portable wirless heart rate monitorlaunched; invented by Polar Electro
1985	Steve Mann incorporated electronic devices in garments including fibre optic sweatshirts
1997	First electronic spectacles at Massachusetts Institute of technology
1997	Electrically-conducted fibre clothing to detect soldiers
2000	Cyberia survival suit (Heima) measures biometrics, comms
2003	Bioharness (developed by Zephyr Technology)chest strap
2003	Garmin launches 'Forerunner' sports tracker measuring distance, speed, and heart rate
2006	Nike and Apple launch Nike+ iPod incorporating a shoe-worn sensor for running data
2006	Fitbit launches its tracker for distance, calories, and sleep
2008	Celio Club suit with an embroidered fabric patch to control an Apple Ipod
2009	Zoll Lifevest launches monitoring device to predict sudden cardiac arrest
2010	Sensor prices start to drop as capabilities increase
2010	Apple Smartwatch developed
2011	Jawbone enters the wearable market with their first fitness tracker, Jawbone UP
2011	Duo Fertility launched for female health market
2012	Wider acceptance of fitness bands
2012	Biosensics LLC produces BalanSens for doctors to detect balance problems
2013	Google Glass with functions similar to smart phones launched
2014	Number of mobile devices exceeds world population
2015	Amazon releases Echo/Alexa
2015	Health Patch MD measures heart rate, respiratory rate, skin temp, body posture, and fall detection
2015	Freestyle Libre Flash wearable glucose monitor created by Abbot
2016	Unalivear launches smartwatch Kanega with more sophisticated functionality
2016	Google Alpha Go beats world Go champion highlighting scope of deep learning
2016	Sporting wearable products from Garmin, Vandrico Solutions, Moov, and Jawbone
2018	Google launches Google Home to compete with Amazon Alexa
2018	FDA approvals of wearable devices as medically accurate ECG/ EKG monitors (KardiaBand, Apple)
2019	Ambient computing and commerce to enter the media and Wall Street vocabularies
2020	Volume of health care data estimated to exceed 2,314 exabytes, increasing at least 48% annually
2020	Intel forecasts 200 billion connected devices vs Cisco's 50 billion
2021	More employers implement health and fitness trackers as a condition of employment
2025	The Hashtag generation, Generation Z will be the spearhead consumers

Organizing the wearables

1. Smart Watches
2. Hearables
3. Smart Clothing
4. Skin Patches



Smart watches

Smart Watches

Company Product	Function	Feature	Regulatory Clearance
AliveCor KardiaBand/Watch	ECG-monitoring equipment watch	KardiaBand with six-lead ECG to detect abnormal heart rhythm and AFib consistent with existing KardiaMobile products and wearable device	2019 US FDA 510(k); EU CE Marking
AppleWatch	Fitness and activity-tracking watch with ECG monitoring	Electrical heart sensor detects abnormal heart rhythm and AFib, along with fitness tracking, fall detection, and SOS	2018 US FDA 510(k); de novo (DEN180044)
Empatica Embrace 2	Wireless wrist watch for epilepsy management	Monitors physiological stress, arousal, sleep and activity; electrodermal response reaches a pre-set level (abnormal) alerts user/caregiver	2018 US FDA 510(k) (K172935); 2017 EU CE Marking
Garmin	Fitness and activity-tracking watch	Tracks and shares distance, pace, heart rate, and calories data	No
KinesiaU	Diagnosis of Parkinson's disease, tremor detection	Sensor measurement of tremor, slowness, and dyskinesia for movement disorders; tracks symptoms in real-time, in response to therapy and activities	2019 US FDA 510(k)
My SugarBEAT Watch by Nemaura	Continuous blood glucose monitor watch – diabetes	Sensor with daily disposable adhesive patch draws in glucose from the interstitial fluid and measures it at five-minute intervals; sends data to an application for analysis for diabetics, athletes, and intensive care	2016 EU CE Marking
Omron Heartguide	Clinically accurate blood pressure monitor and ECG – intended to prevent stroke and heart attack	Oscillometric blood pressure monitor provides clinically accurate heart data with a mobile app and Amazon Alexa Skill; blood monitors blood pressure, fitness and activity, and sleep patterns	2019 US FDA 510(k)
OnePulse Smartwatch	Health Monitor Watch	Monitors heart rate, activity, sleep patterns, and location with real-time alerts, medication reminders, and auto prescription refills; connects with EHR platforms	US FDA 510(k)
PKvitality	CGM Watch for Diabetes	Micro-points and biosensors detect glucose levels, track steps taken, distance, and calories	EU ETA 2022
Samsung	CardioBand ECG	Displays ECG rhythms and detects arrhythmias. Used for cardiac rhythm discrimination between normal/AFib/abnormal	2018 US FDA 510(k)
SmartMonitor	Watch Detects Repetitive Shaking Motion for Seizures	Monitors the wearer and detects repetitive shaking motions similar to those caused by seizures, alerting user and caregiver when necessary; detects heart rate, location, and activity	No
Study Watch by Verily Life Sciences	Wireless Monitor for Pulse, Heart Rate, Electrocardiogram (ECG) and Skin Temperature	Monitors pulse, heart rate, ECG, and skin temperature; tracks external changes the patient's body such as noise levels and light exposure, and provides a real-time data about a patient's activity and vital signs.	2019 US FDA 510(k) (K182456)
Viatom Checkme O2	Wireless Wrist Pulse Oximeter	Tracks and monitors heart rate, QRS duration, ST segment, and rhythm analysis; ECG SpO2, pulse oximeter, activity tracker, thermometer, and a sleep monitoring device	No
Withings	Fitness and Activity Tracking Watch with ECG Sensor	Heart rate and activity tracking with sensor measuring ECG for AFib	No

Fitness trackers

Table 8: Top Fitness Trackers

Company Product	Function	Feature	Regulatory Guidance
AliveCor KardiaBand/ Mobile	AI Headphones	Records, stores, and transfers single channel ECG rhythms wirelessly through the AliveECG application.	2015-2017 FDA 510(k)
Brain Sentinal	Seizure Detection	Detects the onset of generalized tonic-clonic seizures and provides a warning signal to alert caregivers that a seizure is occurring; placed on the biceps to measure muscle activity through the skin.	2017 US FDA de novo
Everist Health AngioDefender	Diagnosis of CVD	Assesses FMD (Flow Mediated Dilatation) by measuring changes in the brachial artery in response to a temporary occlusion of the artery; measures arteries; ability to widen by using a non-invasive, non-imaging technique based on analysis of pulse waves before and after an increase in blood flow.	Global
FitBit	Fitness Tracking	Tracks activity, heart rate, exercise, and sleep stages every day	Global: US FDA 510(k); EU CE Marking
iHealth	Wireless Blood Pressure Monitor	Blood pressure and pulse measurement using portable cuff with intelligent display to provide assistance on optimal arm position for precise results, connects with app for smartphones.	Canada MDL; US FDA 510(K); Europe CE Marking
Misfit	Patient Monitoring	Tracks steps and distances swum or cycled.	2012 EU FDA Class II
MOCACARE MOCACuff	Wireless Blood Pressure Monitor	Wearable cuff corresponds with the AHA blood pressure categories to monitor changes in blood pressure, alerts on device's interface; synching with smartphone; MOCAheart for heart rate, bloody oxygen, and blood velocity.	No
PAI Connect application	Measures PAI Scor: Fitness Tracking	Personal Activity intelligence (PAI) software provides a tracking metric based on heart rate data to manage health and prescribes exercise for optimal health	No
Spire Health Tag	Sleep Monitoring	Monitors the stress levels, sleep, heart rate, and breathing pattern; can be placed on clothes, is hypoallergenic and water-resistant.	EU CE Marking
Wavelet	Biostrap Wristband (shoe-pod and chest strap HRM)	Provides biometric insights using clinical-quality pulse oximeter. Heart rate, respiratory rate and in-depth sleep tracking synched to phone using cloud-based algorithms to analyze data.	No

Source: GlobalData

Hearables

Hearables

Cosinuss

Hearables

Company	Function	Features	Regulatory Clearance
Bose SoundSport Pulse	In-ear Activity Tracker	Heart rate monitoring	N/A
Cosinuss One	In-ear Activity Tracker	Body temperature and heart rate monitoring	N/A
Halo Sport	Neuropriming Headphones	Neuropriming for athletes using electric currents to control movement	N/A
iRiver On	Heart Rate Monitoring Earbuds	Monitors heart rate, tracks distance traveled, and other biometrics	N/A
Jabra (GN Group)	Fitness Tracking	Waterproof, personalized audio coaching, race pace calculator and recovery advice	N/A
Kuaiwear Kuai	Multisport Biometric Headphones	Monitors heart rate, VO2 max, speed, distance, cadence, calories burned	N/A
LifeBeam	AI-powered fitness tracking	Heart rate sensor, connected Vi Trainer for immersive training experiences	N/A
Mymanu	Voice Translation Earbuds	Translates voice in real-time with advanced audio quality	N/A
Nuheara	Amplification Earbuds	Analyzes hearing to ID unique hearing profile, amplifies sound for optimum sound delivery	N/A
Vinci	Artificial Intelligence Headphones	Heart rate monitoring, 32 GB storage, noise-canceling	N/A

Source: GlobalData

Smart Clothing Wearables

Table 9: Top Smart Wear/ Clothing

Company Product	Function	Feature	Regulatory Clearance
Bonbouton	Smart Insole-Diabetes	Monitors the skin's physiological signals to detect early signs of foot ulcers in diabetic patients.	US FDA 510k: ETA 2023
Hexoskin	Smart Clothing for Health Monitoring	ECG & heartbeat monitor, HRV (allowing stress monitoring, effort, load and fatigue assessments), QRS events, and heart rate recovery; breathing rate; activity.	No
LifeSense Group	Smartwear for urinary incontinence	Combination of smart textiles, wearable sensors, and tailored exercise programs.	No
NeoFect Rapael	Smart Glove for Rehabilitation	Sensor technology acts as variable resistor that changes as the glove is bent; 9-axis movement of 3 acceleration channels, 3 angular rate channels, and 3 magnetic field channels that measure movements for patients recovering from a stroke.	US 510(k); Europe CE Marking
NeuroMetrix Quell	Wearable Pain relief	Neurostimulation device for treating chronic pain is lightweight and can be worn during the day while active, and at night while sleeping; advanced sleep tracking.	Regulatory: 2016 CE Marking (93/42/EEC); US FDA 510(k)
Owlet Smart Sock	Pulse Oximetry for Infants	Tracks baby's oxygen and heart rate levels during sleep and wirelessly transmits data to a base station via Bluetooth.	US FDA 510(k)
Sensoria Smart Moore Balance Brace	Patient Activity	Detects patient adherence along with activity type, activity level, cadence, time on the ground, and gait speed; textile sensors, mobile application, and a cloud infrastructure for data analysis.	US FDA 510(k)
Siren Smart Sock	Monitoring - Diabetes	Tracks foot temperature and helps to find potential signs of diabetic foot ulcers; alerts users when inflammation is detected; fabric made with neurofabric and temperature sensors.	US FDA 510(k)

Owlet Smart Socks: Baby monitoring

Case Study: Wearable Devices

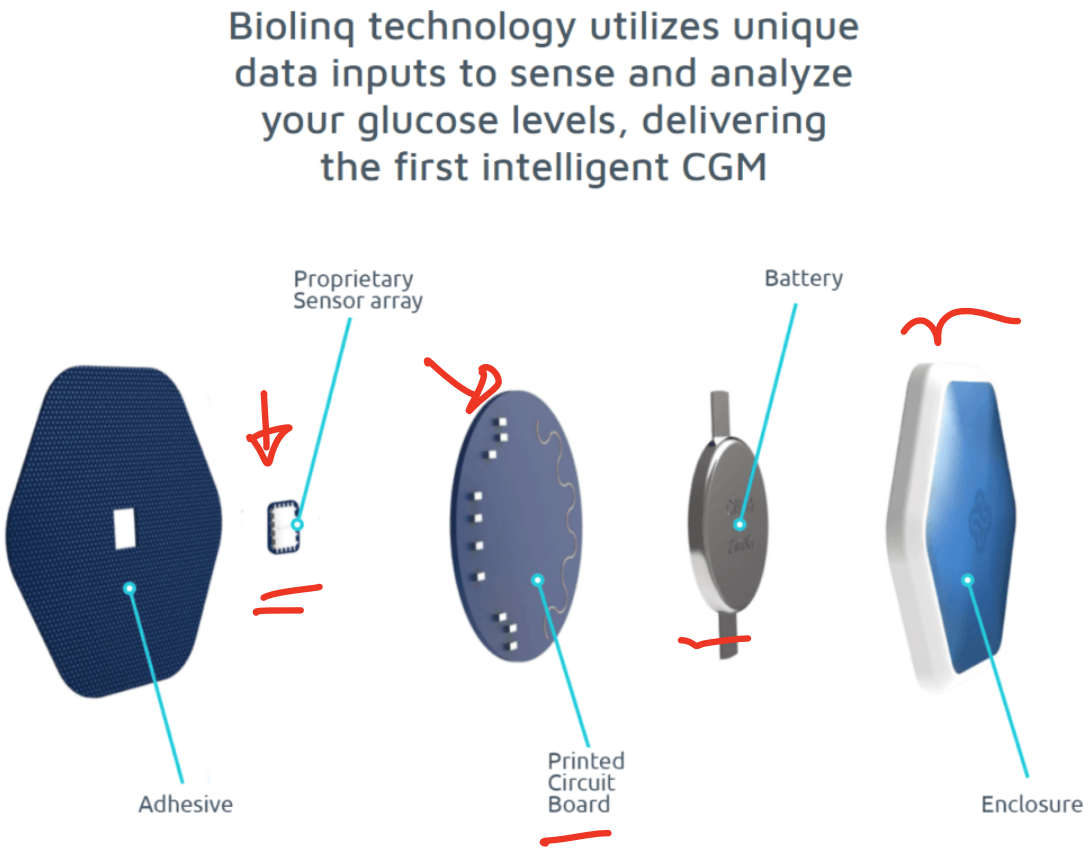
Siren Smart Socks - Diabetes monitoring

Skin Patches

Table 10: Top Skin Patches

Company Product	Function	Features	Regulatory Clearance
Biolinq	CGM	Intelligent Continuous Glucose Monitoring System is a needle free, wearable system intended for continuous glucose monitoring. It is designed to continuously monitor glucose levels by placing the sensor onto the skin. It is based on Micro-Array Technology.	FDA 510(k) ETA 2022
BioTelemetry	ePatch for CVD monitoring with ECG	Patch and sensor Technology incorporates detection capability into a lightweight, easy-to-use patch sensor. It adheres to the skin and is easily read out to a PC via a USB interface cable; the cardiac monitor is intended for cardiovascular monitoring.	E02018 FDA 510(k) (K171410); CE Mark
Eccrine Systems	Remote Patient Monitoring: Depression, CGM, Infectious Disease, Diabetes	Monitors sweat biomarkers; sends the data to a remote system through a transceiver. Sensors and arrays analyze sweat rate and other biomarkers. It features proprietary sensors, data processors, and management systems that can detect and manage sweat-sensor data including real-time data of glucose levels by absorbing sweat from a porous material.	FDA 510(k) ETA: 2023
Epicore Biosystems: Sweat Sensor	Remote Patient Monitoring: Sweat Analysis	Non-invasive, skin-like wearable fluidic sensor that is designed to measure prognostic biomarkers in real time, characterize skin hydration, and monitor patient response. It helps healthcare professionals to provide personalized treatment regimens for patients. It is capable of analyzing small droplets of sweat directly from the skin.	FDA 510(k) ETA 2024
Gentag	Diabetes Monitoring, Glucose Monitoring Patch	Pain-free diabetes monitoring patch is a smartphone-based diabetes patch intended for type II diabetes management. It is designed to facilitate pain-free measurement of glucose levels using tiny wireless battery-less glucose sensors placed on the skin.	FDA 510(k)
iRhythm	CGM and ECG	Water-resistant, single-use, wearable electrocardiogram patch intended for cardiovascular monitoring; data is sent to iRhythm's clinical app, which relies on algorithms to deliver results.	FDA 510(k); CE Marking

BioLinq Continuous Glucose Monitoring



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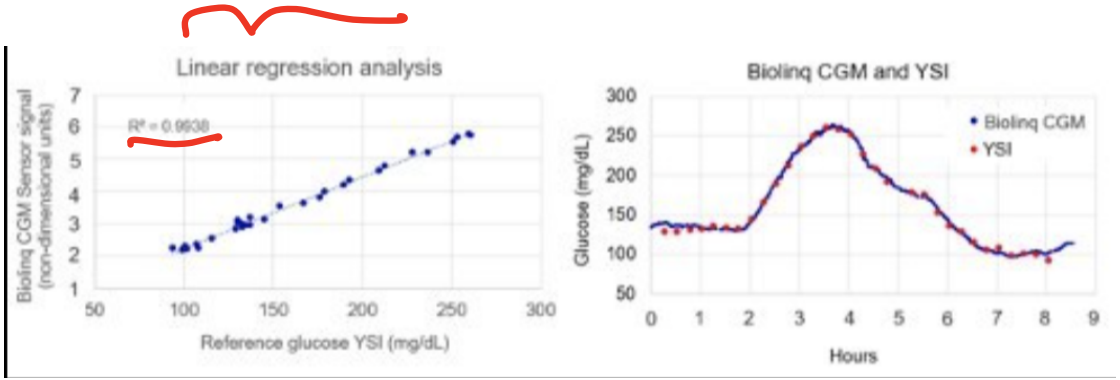
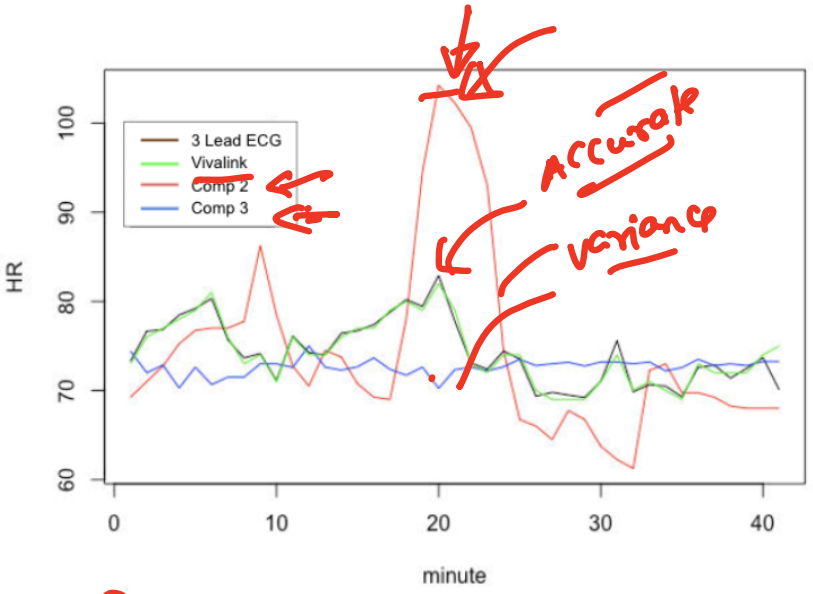


VivaLink ECG Wearable Patch

VivaLink Wearable ECG patch

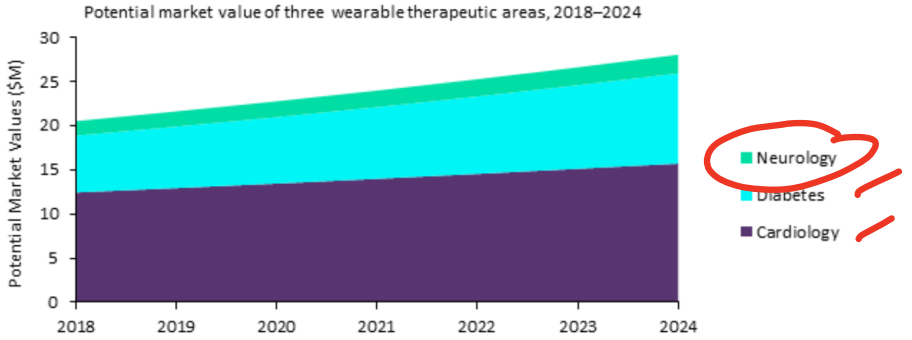
VivaLink ECG Wearable Patch



- Positions tested: sitting, standing, lying down;
  transition from lying to standing

Case Study: Wearable Devices

Figure 7: The Market Potential for Apps Connected to Medical Wearables Is Increasing

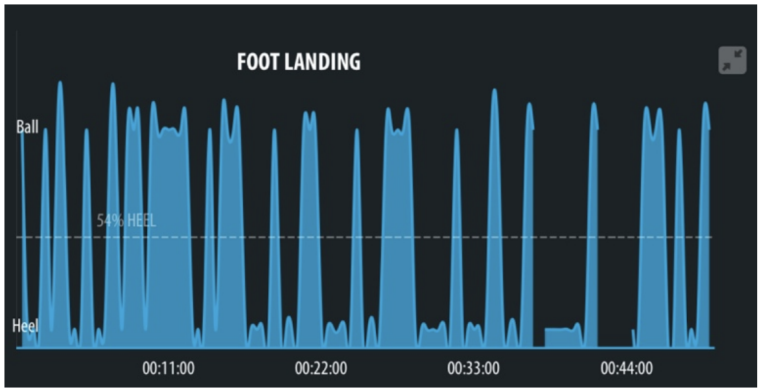


Source: GlobalData

Sensoria Smart socks

StandingTall PD program for Parkinsons

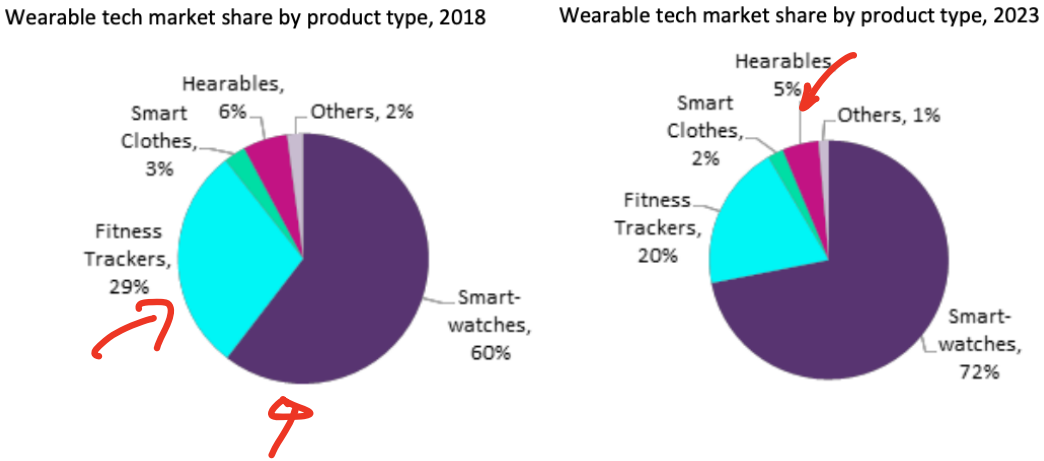
Sensoria repurposed to support falling in parkinsons!



Migraine Patch

Migraine pain mitigation patch

Market share of different wearables

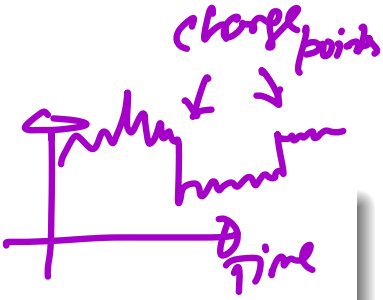


Case Study: Wearable Devices

ICE: Machine Learning Problem? (5 mins in Breakouts)

With all of these wearable devices for different health applications, many with continuous tracking and time-series data being produced on a daily basis - How would you use these data points to make predictions/recommendations? How would you model it as a machine learning problem and which machine learning models would work best? What would be some bottlenecks to get around with the data/models you will use? Pick any of the health issues - foot falls, heart issues, diabetes tracking, etc and any of the devices - smart watches, skin patches, smart clothing and brainstorm.

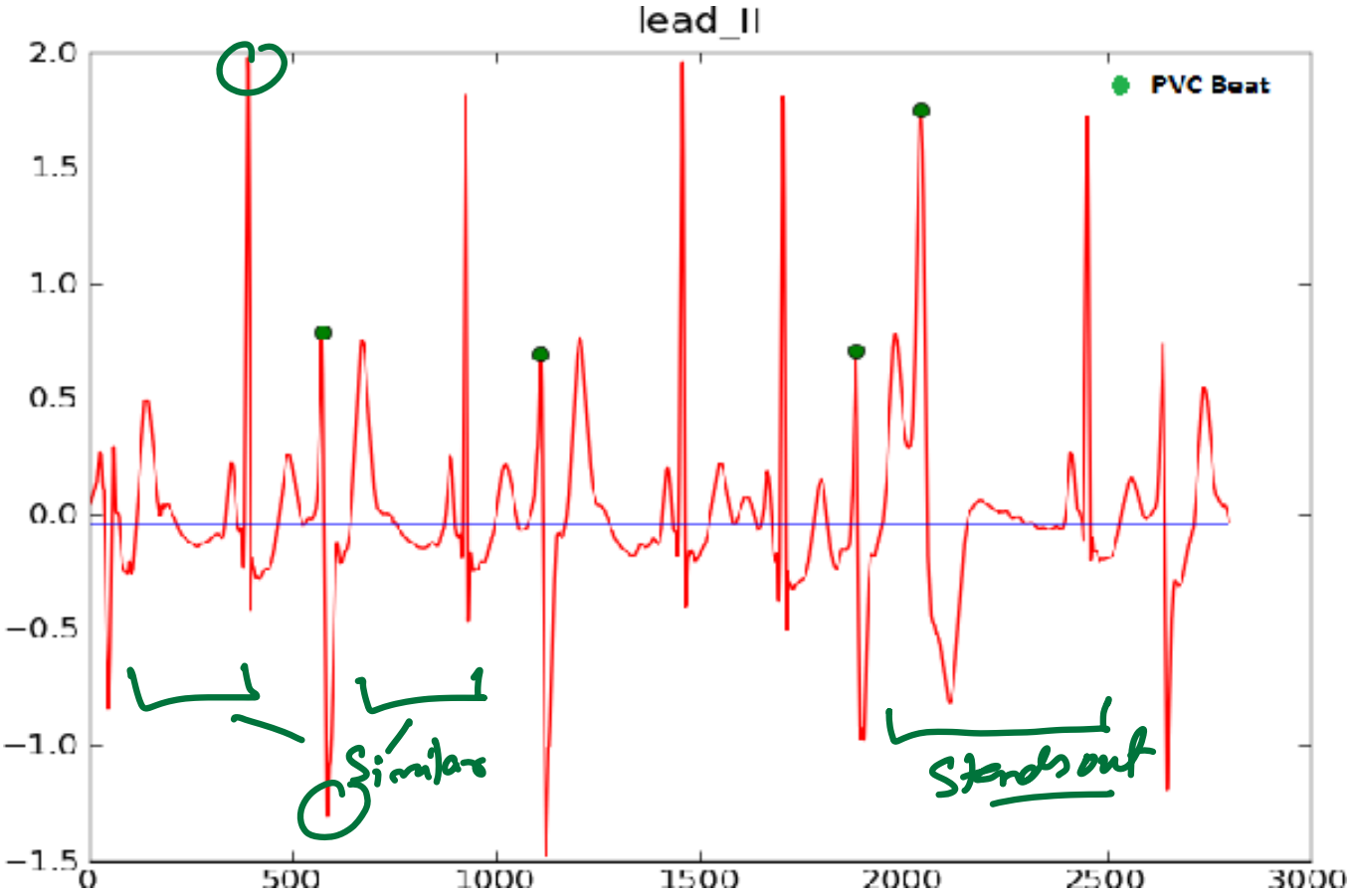
Case Study: Wearable Devices



Machine Learning for Wearables

- Real-time models with cloud support
- Anomaly Detection ⟷ Change Point detection
- classification (Fall Detection) = ACC? ↙ Foot ulcer?
- clustering (Activities)

Anomaly Detection: Arrythmia



Broad list of methods

Categorization

- Offline anomaly detection
- Real-time anomaly detection

Broad list of methods

Categorization

- Offline anomaly detection
- Real-time anomaly detection

Categorization

- Time-series data anomaly detection
- Regular anomaly detection

Anomaly Detection - Baselines

98.9

ICE #2 Temperature Control!

Let's say you have a thermometer that is pretty accurate but on an average is off by 0.5 degree Fahrenheit. You suspect a flu and measure your body temperature and it turns out to be 99.5. Would you say there is a cause for alarm and maybe a covid test?

1. Yes
2. Maybe
3. No
4. Don't know

Anomaly Detection Baselines

Baseline Algorithm

Classify a data point as an anomaly if your data point is α standard deviations (σ) away from the mean. Here α is typically greater than 3.

Anomaly Detection Baselines

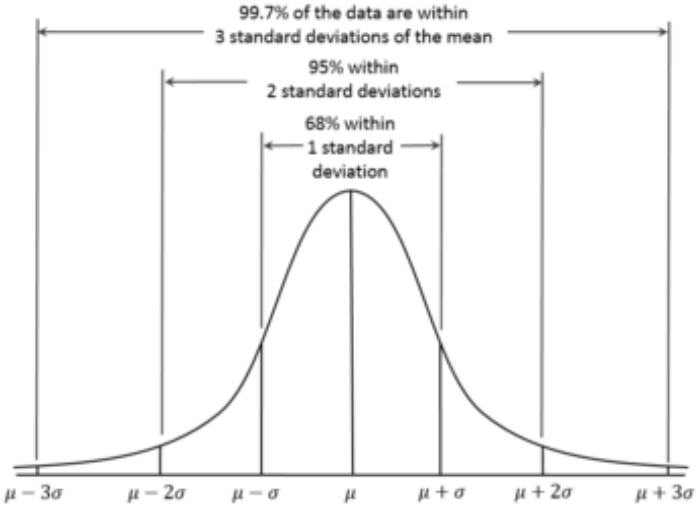
Temperature Example

The mean human body temperature is 98.4 F. Assume now that the thermometer is accurate but normal body temperature fluctuations are expected to be within 0.5 degrees F, then there is cause for concern if temperature deviates beyond 98.4 ± 1.5 for $\alpha = 3$.

Anomaly Detection Baselines

Temperature Example

The mean human body temperature is 98.4 F. Assume now that the thermometer is accurate but normal body temperature fluctuations are expected to be within 0.5 degrees F, then there is cause for concern if temperature deviates beyond 98.4 ± 1.5 for $\alpha = 3$.



Anomaly Detection Baselines

Temperature Example

	α	Outcome
1	2	Lots of false positives and un-necessary trips to urgent care
2	6	Almost no false positives. Might miss early signs of a flu
3	4	Fewer false positives. Get to urgent care at the right time!

Anomaly Detection Baselines

Faulty thermometer

Assume you only have a faulty thermometer to measure your body temperature. Sometimes its accurate and sometimes it is not. You get to know that its reading can fluctate up to 3 degrees over or below the true temperature. You measure your temperature and its 102 degrees F. Should you head to the urgent care?

Anomaly Detection Baselines

Faulty thermometer

Assume you only have a faulty thermometer to measure your body temperature. Sometimes its accurate and sometimes it is not. You get to know that its reading can fluctate up to 3 degrees over or below the true temperature. You measure your temperature and its 102 degrees F. Should you head to the urgent care?

False positives vs False Negatives

Anomaly Detection methods get caught between controlling false positives and not missing True positives (i.e. having false negatives). Would you rather flag a social media post as inappropriate and capture 95% of

Your choice of Wearable - Personalized Analytics Mid-Term Presentation

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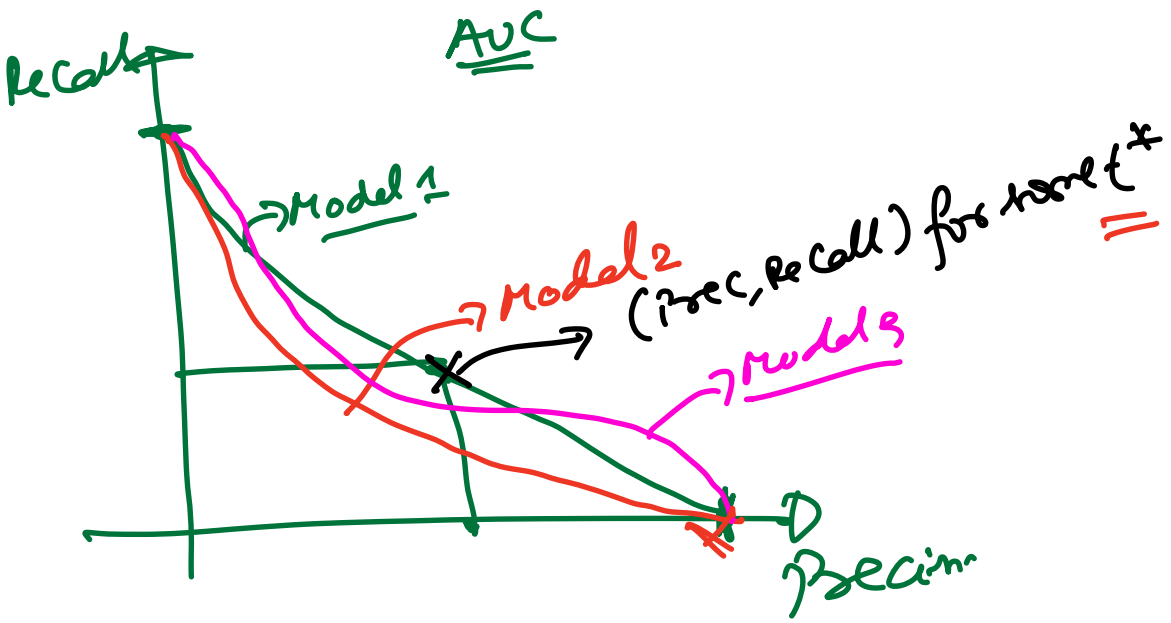
- Present in teams of 2 maybe end of April. How does that sound?

References for this lecture

1. The role of wearables in health care. 2018. Omnicom Health Group.
2. Wearable Technology in health care. 2019. Global Data.
3. Bioling glucose monitoring
4. Migraine pain mitigation patch
5. VivaLink Wearable ECG patch

AUC for LR & DT

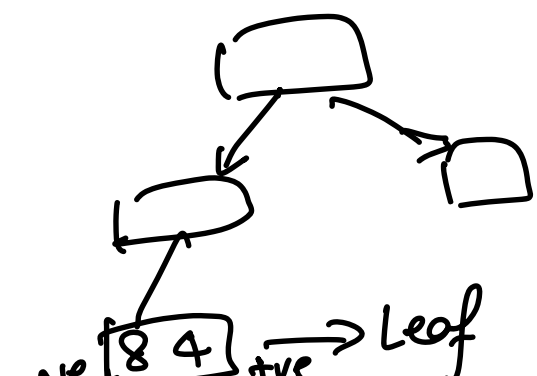


$P(\hat{y} = +1) = 0.6$

$t = 0.5$

$t = 0.5 \rightarrow 1$

$t = 0.7 \rightarrow 0$



Predict -ve (Deterministic)

Probabilistic :-

Predict -ve w.p. 8/12

Predict +ve w.p. 4/12!