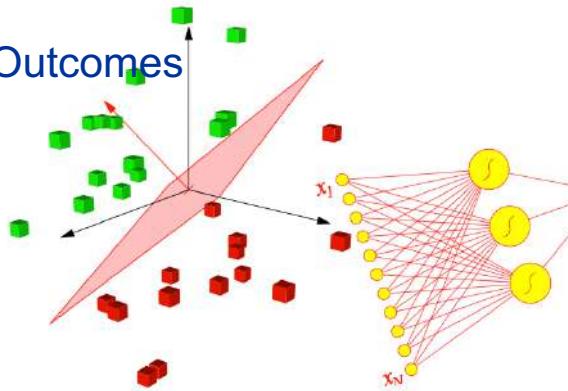


1

Outline

- My Introduction
- Applications of Machine Learning
- What's this course all about?
- Course Outline and Learning Outcomes



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2

2

Dedication



July 22 '19

**Professor Patrick Winston,
former director of MIT's Artificial
Intelligence Laboratory, dies at
76**



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4

4

My Introduction

- Did PhD in 2012 from University of Southampton
 - Area of research: Application of Machine Learning on Emotion Recognition from Speech



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5

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TEAM



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<https://sites.google.com/view/wiselabeme/team>



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6

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Current Research Areas

- EEG Signals
- Heart Sound Classification
- Fusion of different heart modalities
- Biometrics
- Gait Analysis
- IOTs
- Embedded IOTs



CURRENT RESEARCH PROJECTS

- Use of EEG for rehabilitation of stroke patients in collaboration with
 - New Zealand Centre for Chiropractic Research
 - Auckland University of Technology, NZ
 - University of Aalborg, Denmark
- Detection of chronic pain development Using Fluoroscopy images with
 - School of Health Sciences, University of Aalborg, Denmark



CURRENT RESEARCH PROJECTS

- CAD system for lesion and ulcer detection in Gastroenterology in collaboration with
 - Local Hospital in Pakistan
 - Centre for Advance Research and Engineering, Pakistan
 - APICTA Award 2013
- Detecting Melanoma in Dermoscopy Images in collaboration with
 - Vision Group, University of Porto, Portugal.



CURRENT RESEARCH PROJECTS

- Gait biomechanics for Rehab
 - New Zealand Centre for Chiropractic Research
 - Railway Hospital Riphah University
- TechsaC@re Pakistan / Malaysia
 - LLM based Skin Care Analysis
 - RADScans



TDF Recent Projects

- Use of IOTs in Industry 4.0
 - Mesh Network for IOTs
- Use of EEG for UX quantization
- Smart Gloves for Hansa Leather Industry
- Gait Biometrics Lab using Standard Cameras
- Digital Pakistan Lab



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ML/AI

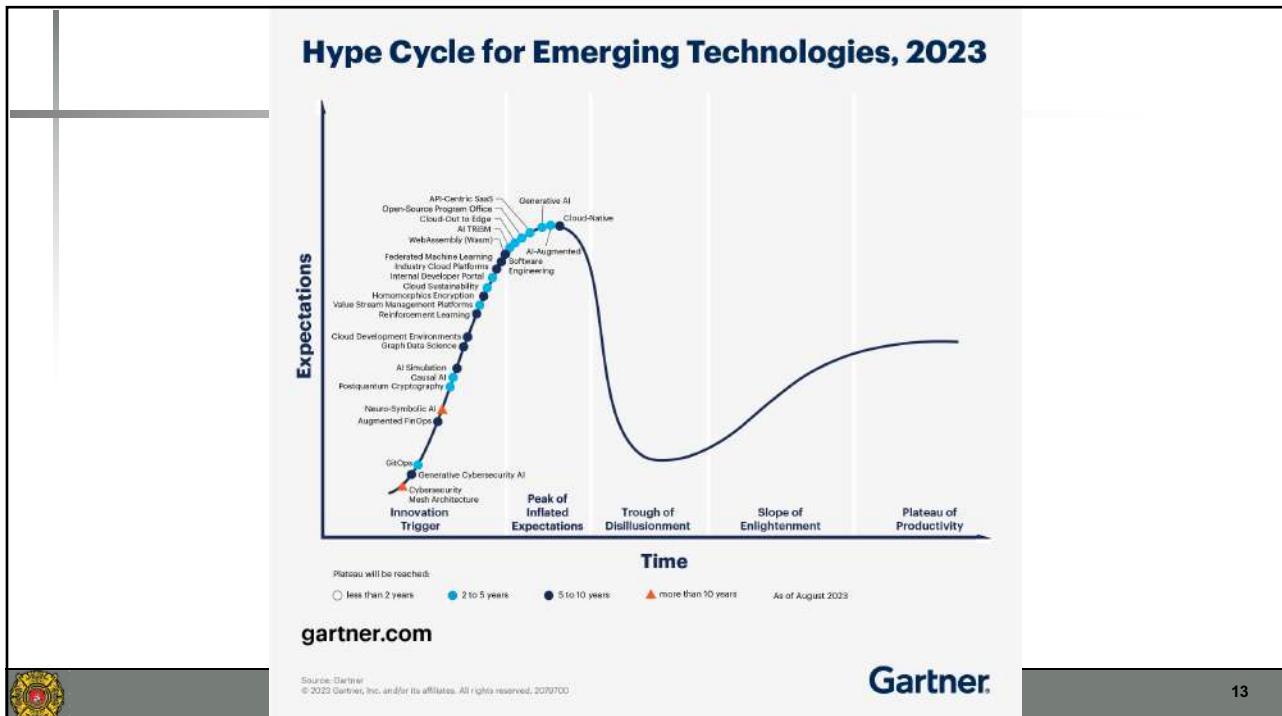
POTENTIAL IMPACT ON GLOBAL GDP



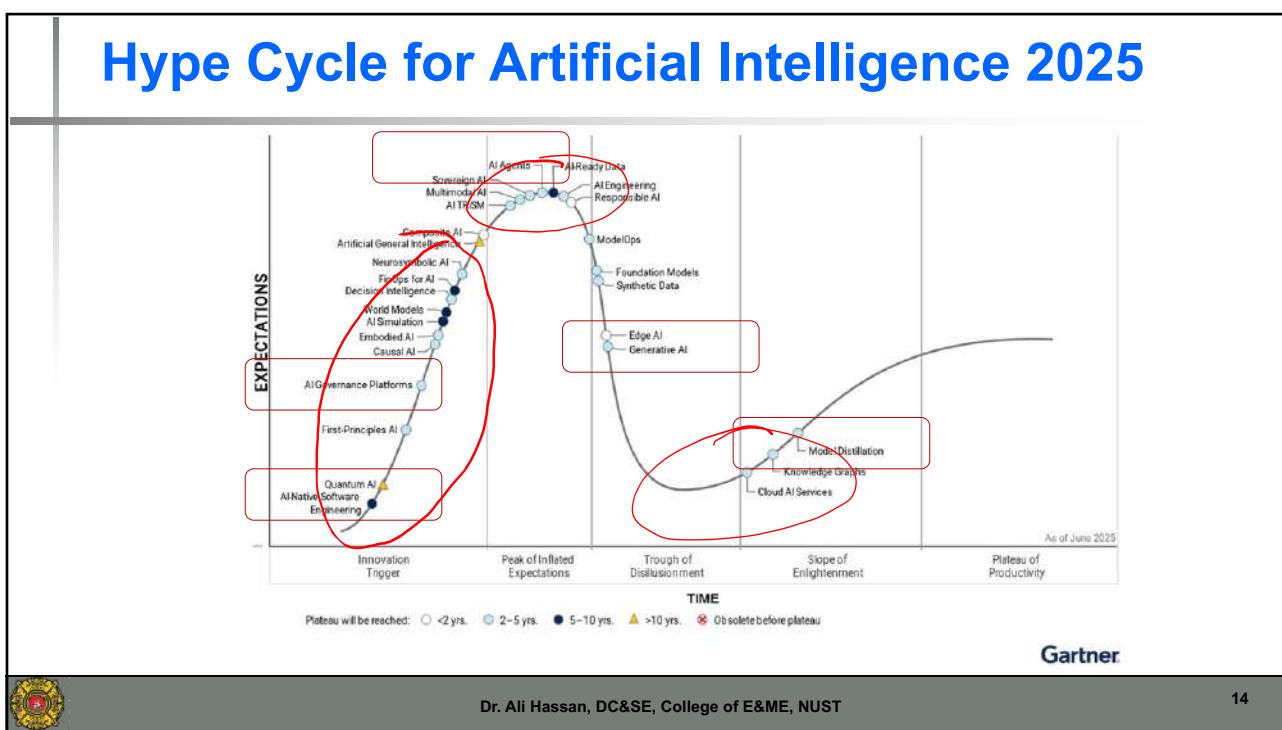
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Assignment 1(a)

- Short note on AI on the Gartner Hype Cycle of 2025
 - Do google searches/ chat GPT but then write in your own words, what you understand of these technologies
 - Each technology shall be explained in 200-400 words

10:24

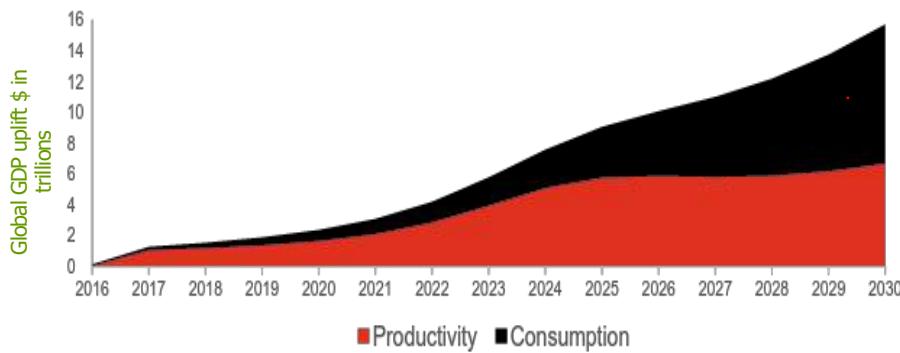
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Potential of ML/AI

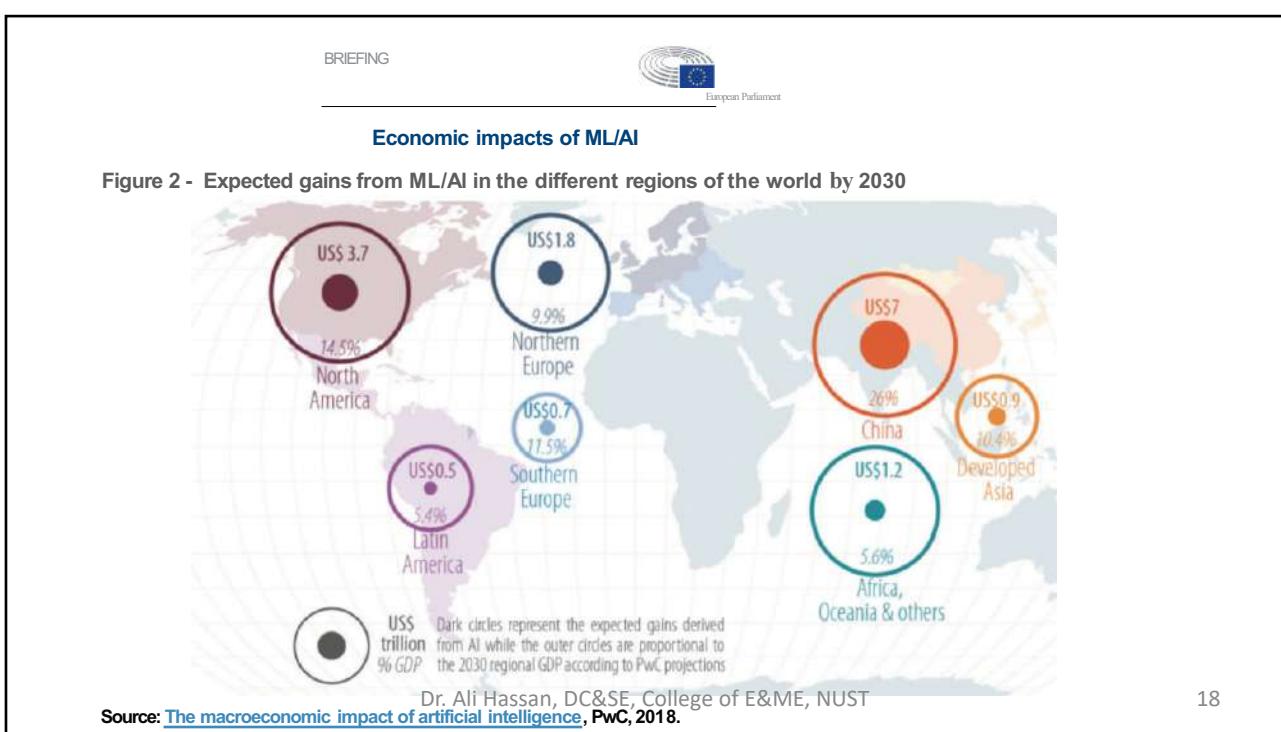
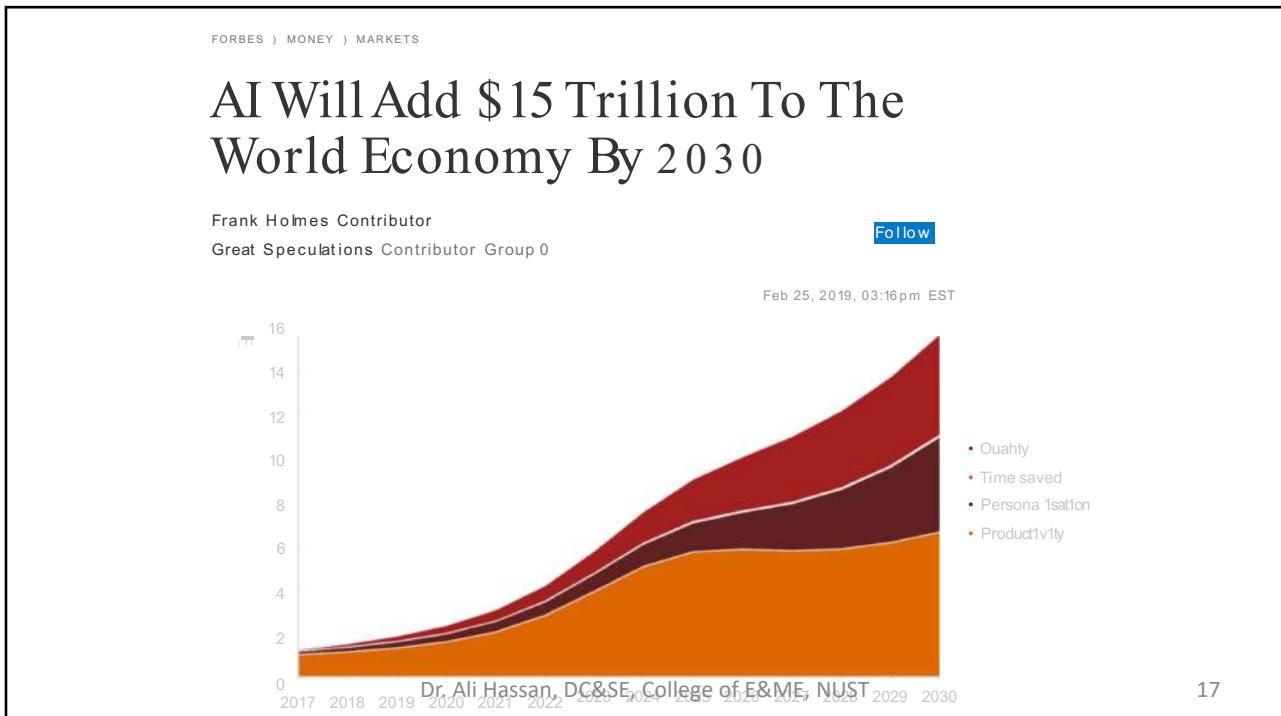
\$15.7 T Global GDP Impact of ML/AI through 2030



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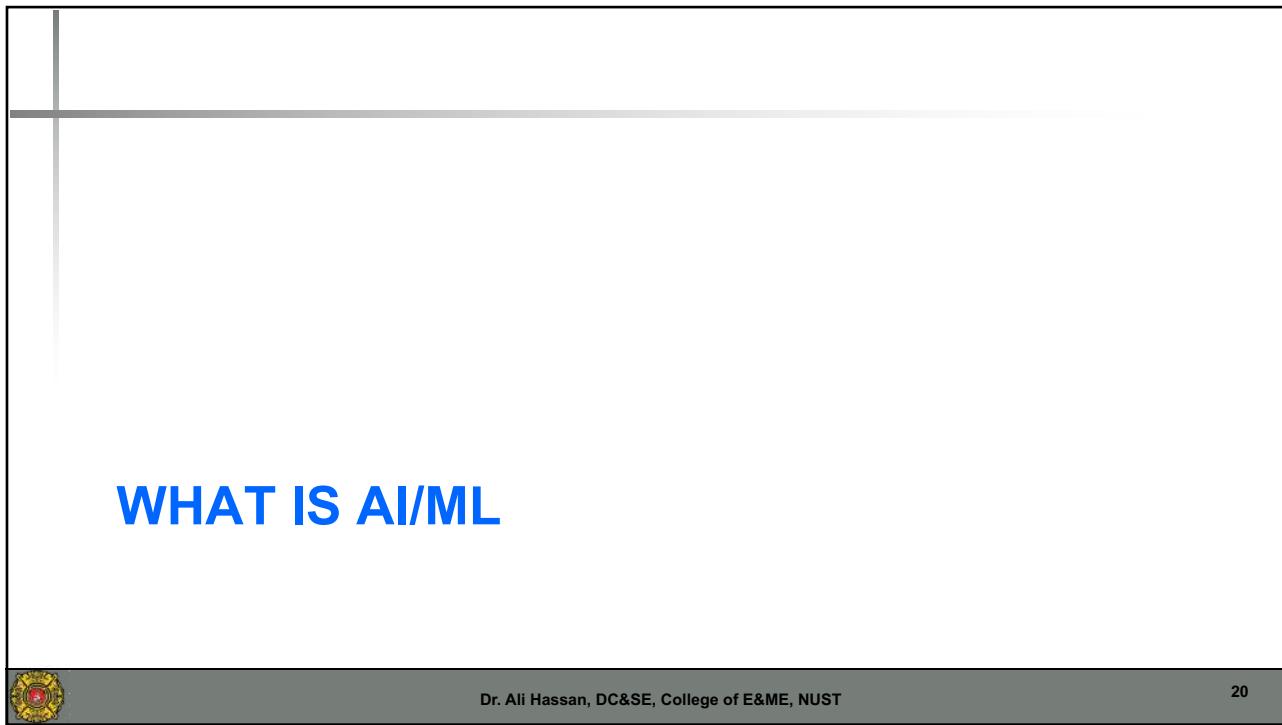
16

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How to Use ML to Solve Riddle from Our

- A Farmer wants to bring a Lion, a Goat, and Grass across the river. The boat is tiny and can only carry one passenger at a time.
 - If he leaves the Lion and the goat alone together, the Lion will eat the goat.
 - If he leaves the goat and the Grass alone together, the goat will eat the Grass.
- How can he bring all three safely across the river?

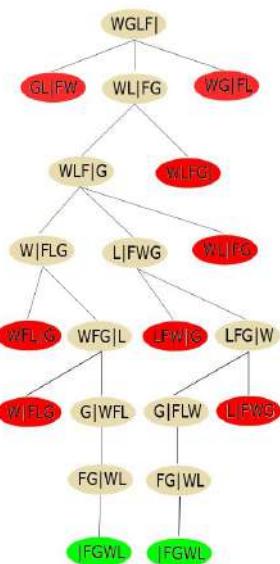


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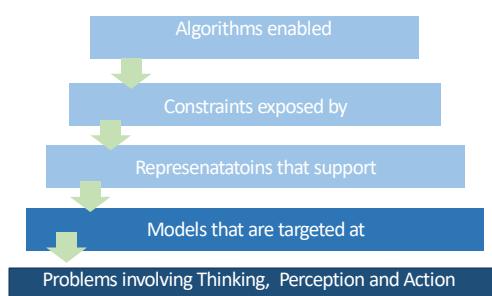
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ML Solving a Riddle?



]: left side and right side of the river
 W: Grass
 G: Goat
 L: Lion
 F: Farmer

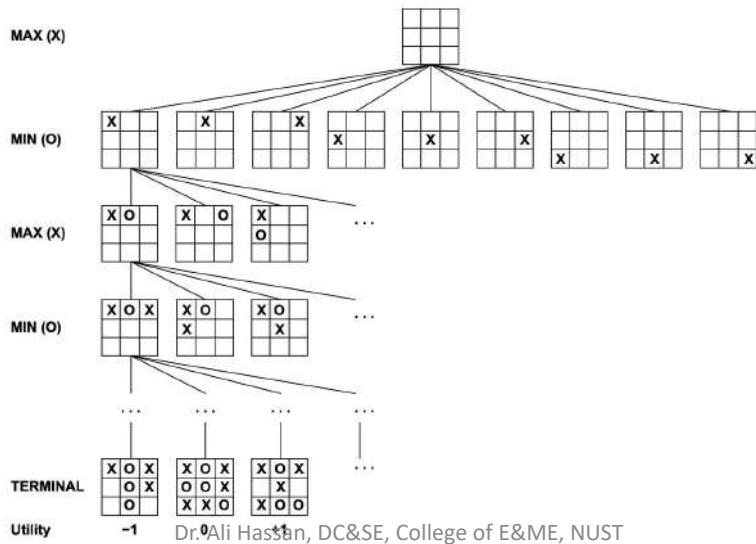


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Another Game from our Childhood



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IBM's Deep Blue Beat World Champion



May 11, 1997, an IBM computer called IBM® Deep Blue® beat the world chess champion after a six-game match: **two wins for IBM, one for the champion and three draws.**

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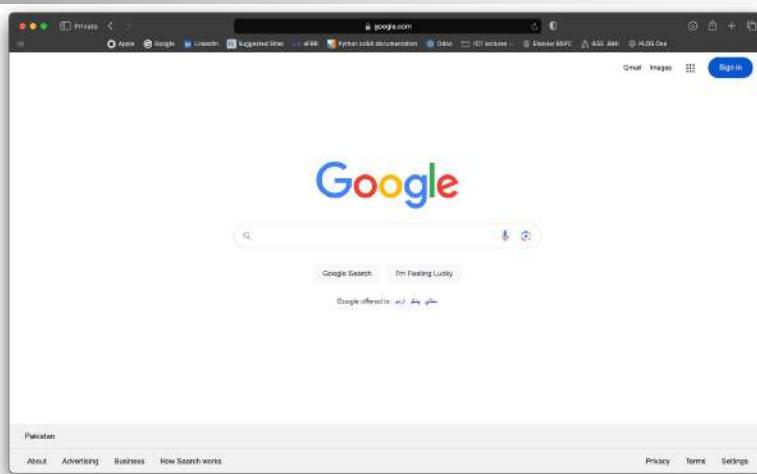
24

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Learning From Data

- This course is about learning “rules” from data
- Applications can’t program by hand.
- This is the **new AI**
- Has huge commercial applications

the field of study that gives
computers the ability to learn without
being explicitly programmed



Google News

Top stories >

- Dawn.com 5.7 magnitude earthquake felt in Punjab: PDMA 42 minutes ago • By Imran Sabir
- Dawn.com 5.7 magnitude earthquake felt in Punjab: PDMA 42 minutes ago • By Imran Sabir
- The Times of India Earthquake of magnitude 5.8 strikes Pakistan, tremors felt in Delhi, neighbouring areas 12 minutes ago
- WAM Earthquake Today: Tremors felt in Pakistan, Afghanistan 12 minutes ago
- Dawn.com President Jinnah calls on nation to uphold Guards' legacy 1 hour ago
- PTI's Official Web Portal Governor, CM Sindh Visit Quaid's Mausoleum; Nation Should Follow The Teachings of Quaid-e-Azam 53 minutes ago
- Geo News President, PM urge nation to embrace Quaid's 'vision' for stronger Pakistan 53 minutes ago

Local news >

- Three Dead After Consuming Toxic Alcohol in Islamabad 2 days ago
- Cases filed against PTI leadership over Islamabad rally violations 2 days ago
- Drigator Kathir Butting Pakistan's incredulous Kashmir Narrative 2 days ago • By Nadeem Khanwar

Picks for you

Sign in for personalised stories in your briefing and news feed

Sign in



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Google News

Pakistan

Top stories >

- Dawn.com US to help Pakistan protect people from impact of climate change, says Blome 5 hours ago • By Anis Ahmed
- PTI's Official Web Portal Recharge Pakistan Project Launched; Pakistan Grappling With Severe Climate Change Crisis 22 hours ago
- The News International Tracking floods, climate change: Pakistan launches landmark recharge project 12 hours ago • By Muhammad Waqar Shahid

Business Recorder

- ATC grants bail to PTI men,历史性

ARY NEWS

- Feering arrest, PTI's Zartaj Gul seeks transit bail from PHC 2 hours ago

The Nation

- Jinnah House attack: Court extends interim bails of Omer Ayub 1 day ago

SAMAA TV



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The screenshot shows the Google News homepage. At the top, there's a search bar and a weather widget for Rawalpindi (34°C). The main area features a "Your briefing" section for Monday, 9 September, with a "Top stories" section. One story from Al Jazeera discusses a large rally for the release of former PM Khan. Another story from DAWN.com talks about a polio drive in Punjab. To the right, there's a "Picks for you" sidebar with links to stories like "The e-bike 'revolution'" and "MPS Preview: SBP to slash policy rate by 150bps". A small watermark for "Dr. Ali Hassan, DC&SE, College of E&ME, NUST" is visible at the bottom.

29

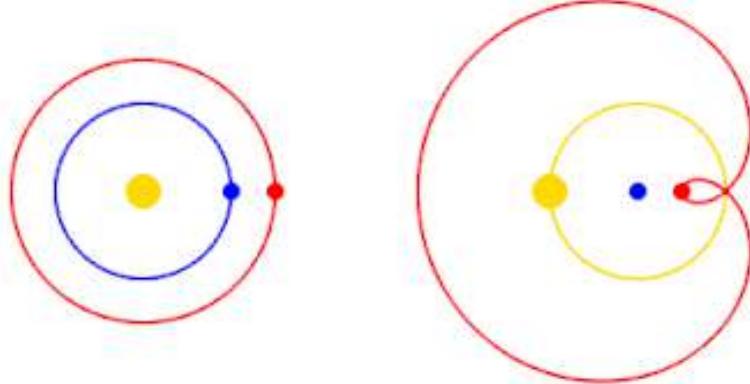
29

This screenshot shows a specific news section titled "News about polio" on the Google News homepage. It includes a "Top news" section with stories from Radio Pakistan, DAWN.com, and PTI. A prominent story from Radio Pakistan discusses a special anti-polio vaccination drive. Another story from The New York Times mentions a poll suggesting Biden is ahead of Trump. A "All coverage" section at the bottom shows additional stories from various sources, including The Nation and Pakistan Today. A watermark for "Dr. Ali Hassan, DC&SE, College of E&ME, NUST" is at the bottom.

30

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Ptolemaic and Copernican models of the solar system



See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/234083377>

Modeling the History of Astronomy: Ptolemy, Copernicus and Tycho

Article in *Astronomy Education Review* · January 2013 DOI: 10.3847/AER2013001 · Source: arXiv

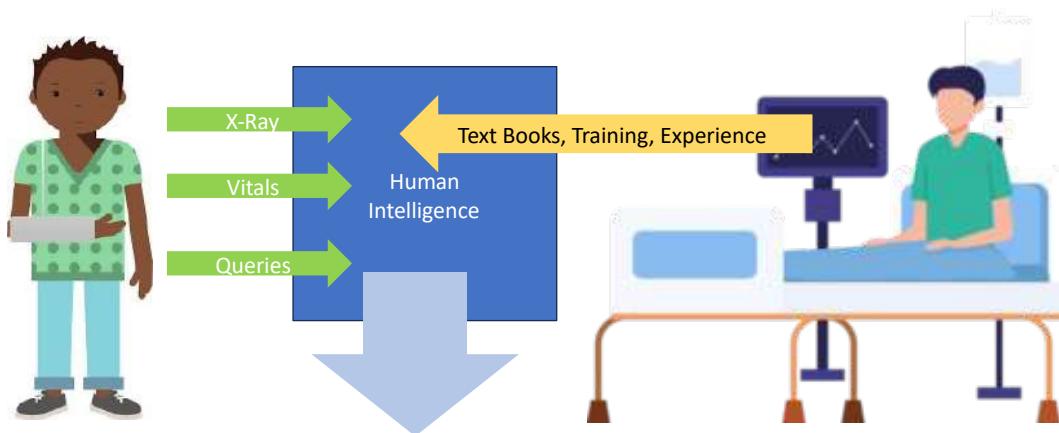


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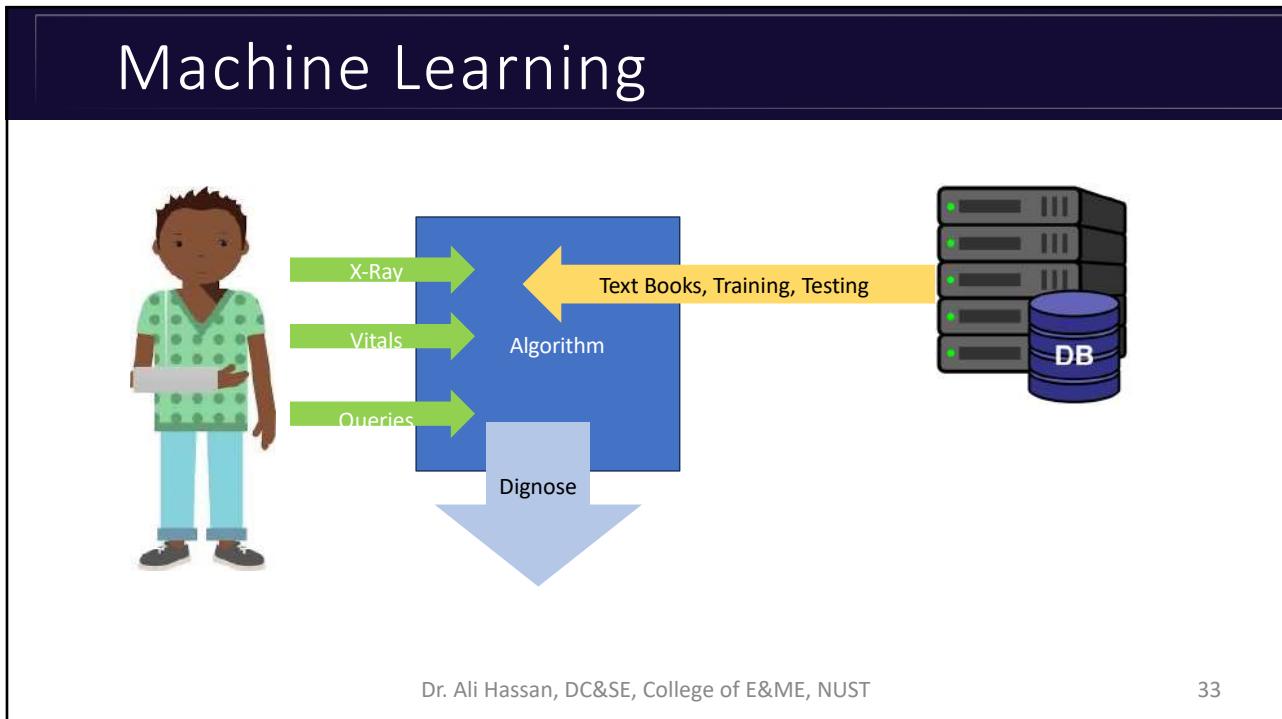
Human Intelligence



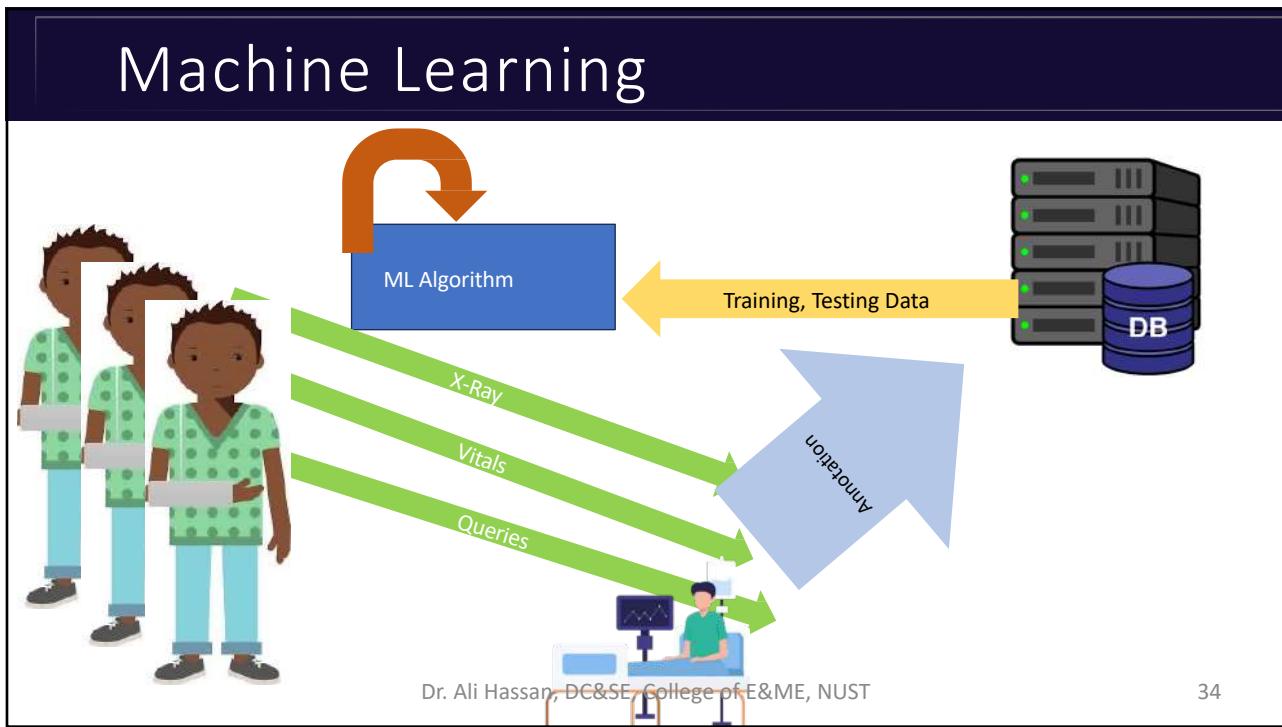
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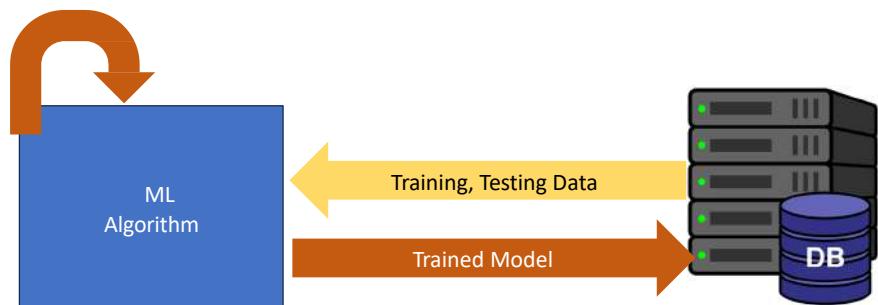


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Machine Learning Training

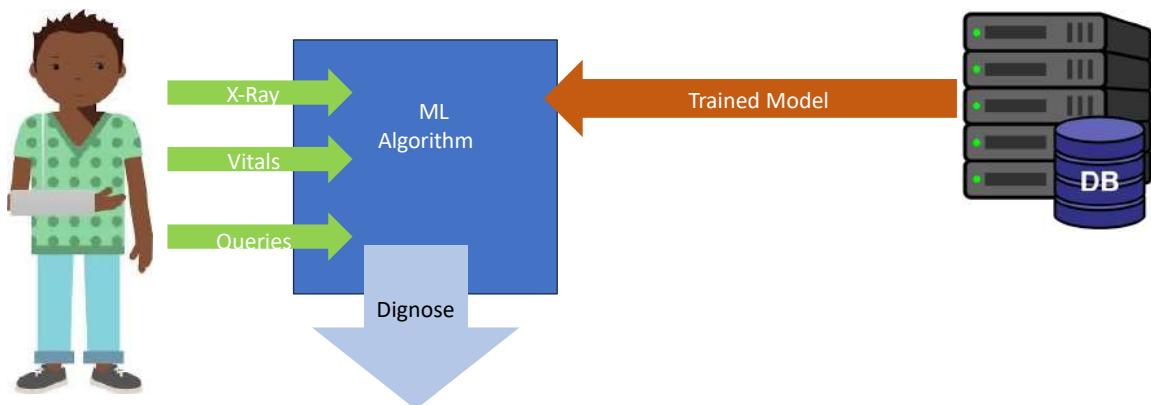


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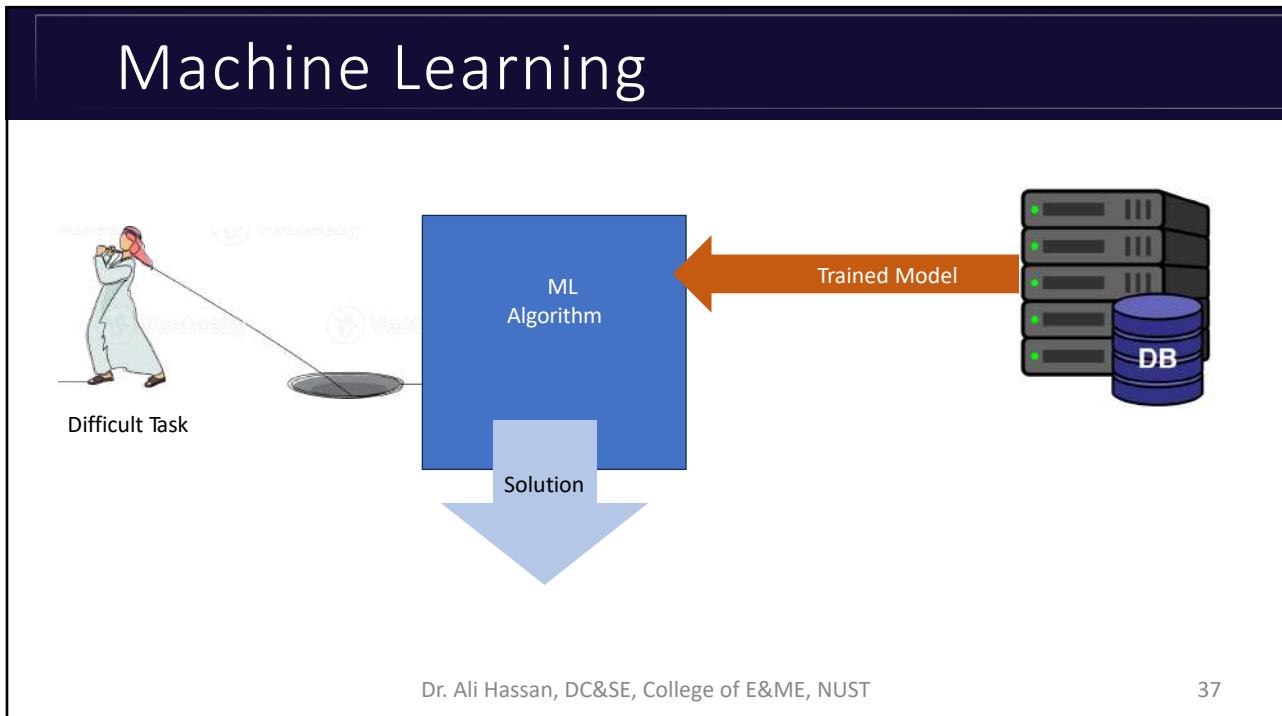
Machine Learning -- Testing



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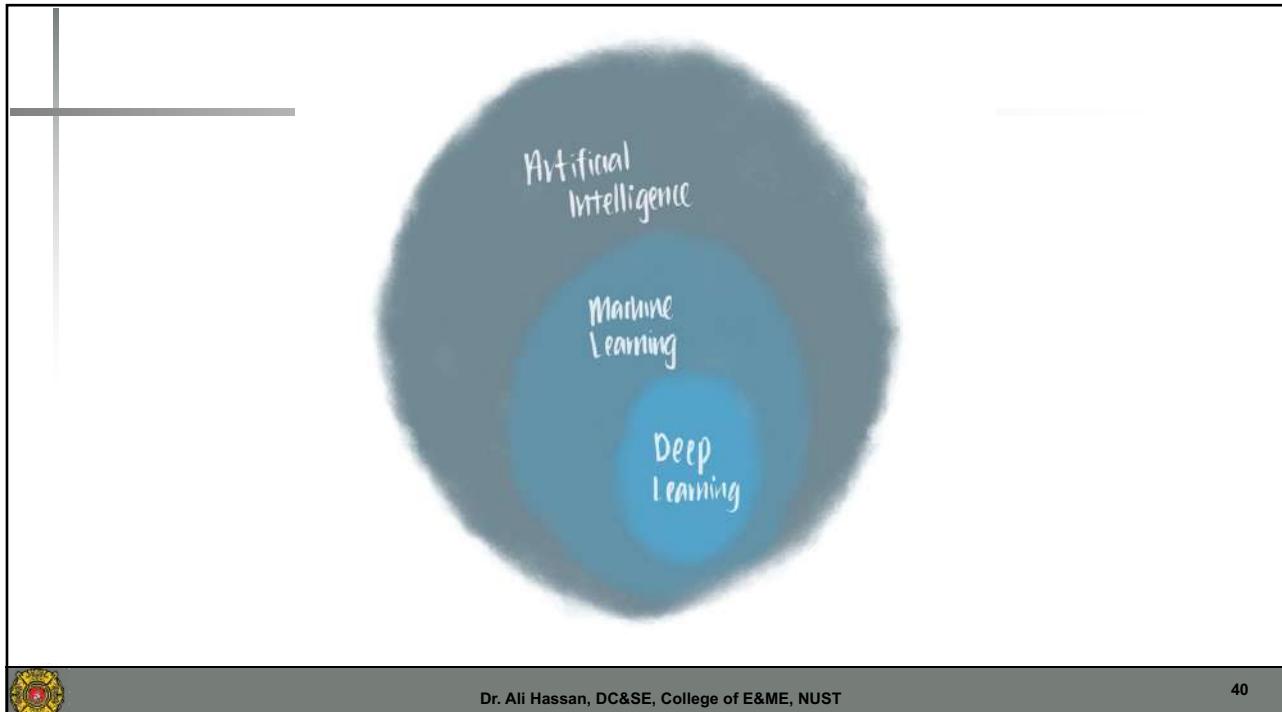
Arthur Samuel

- Arthur Samuel (1959). Field of study that gives computers the ability to learn without being explicitly programmed.

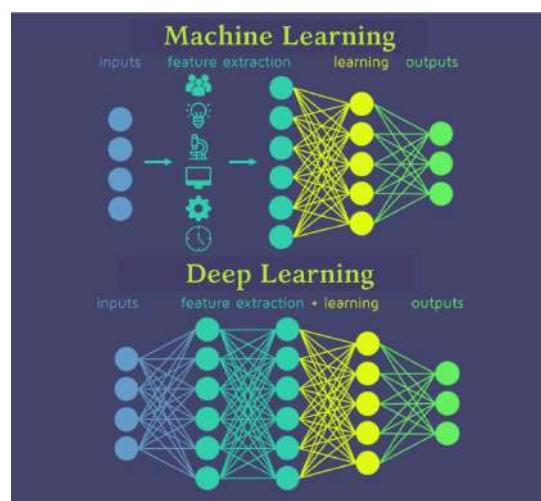
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Machine vs Deep Learning



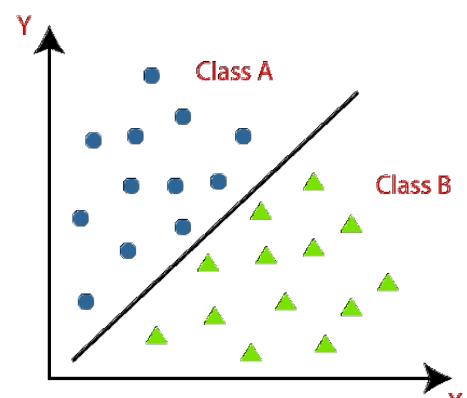
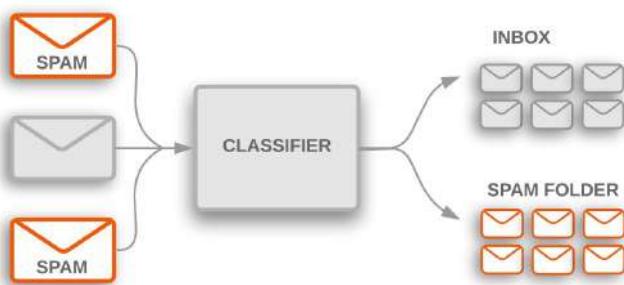
Historically AI Mostly Solves Classification Problems

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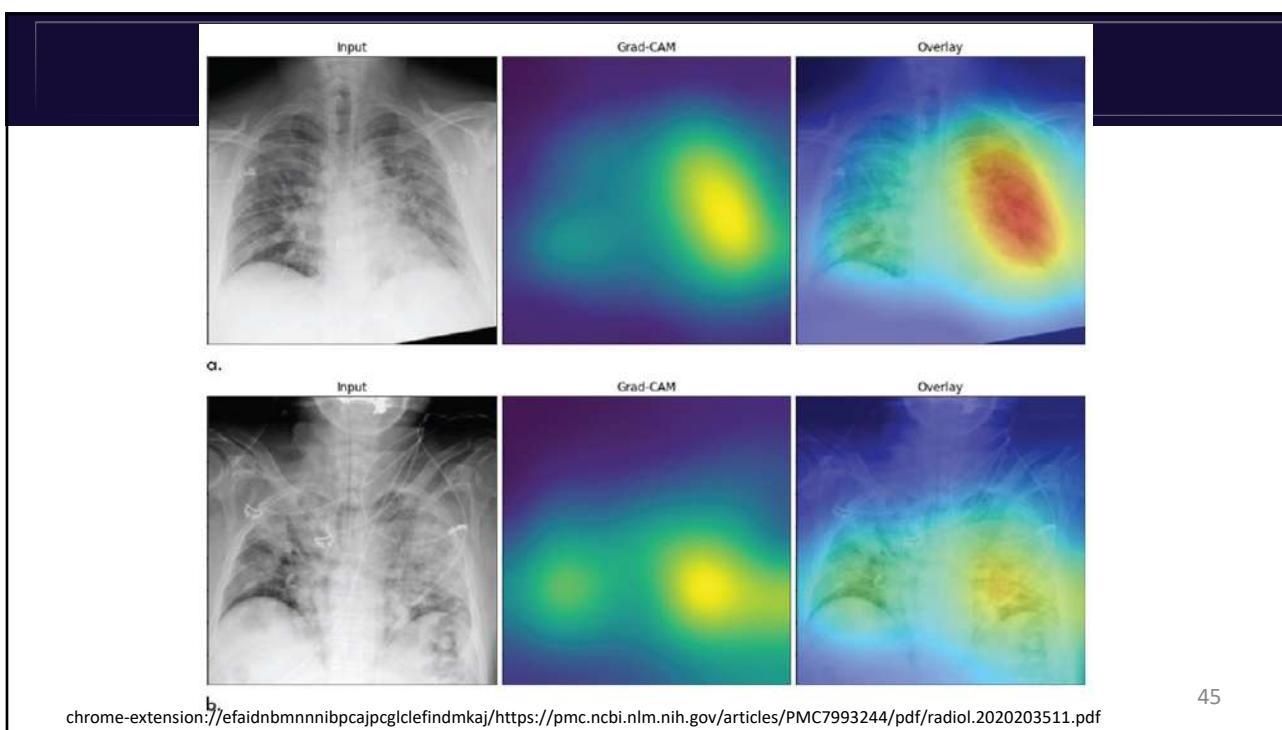
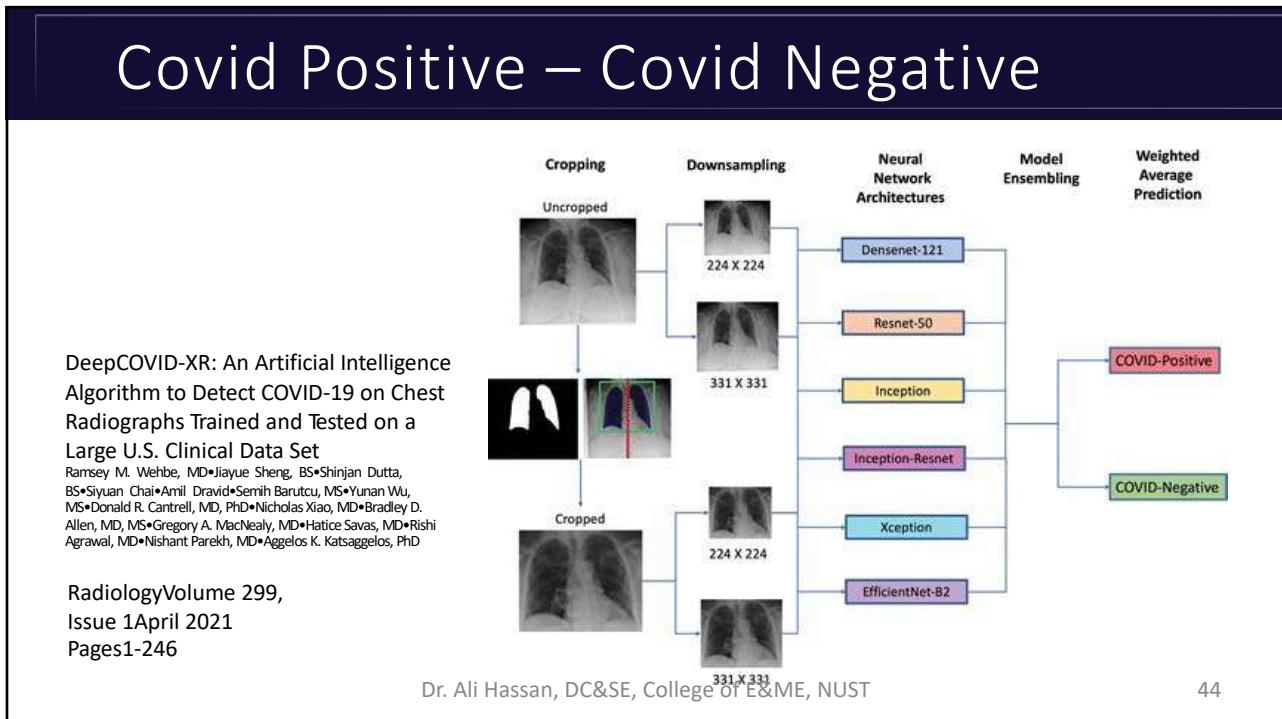
Classification with Two Classes: Good from Bad



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Binary vs Multi Classes

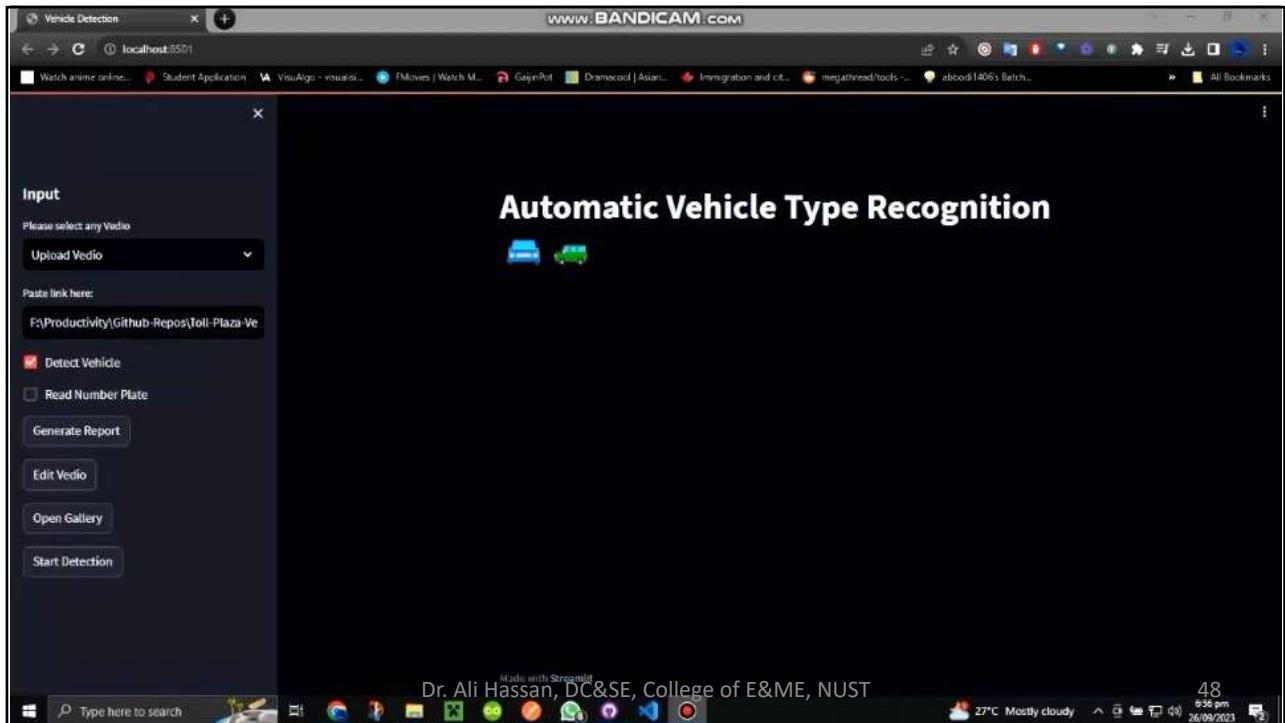
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Human Intelligence

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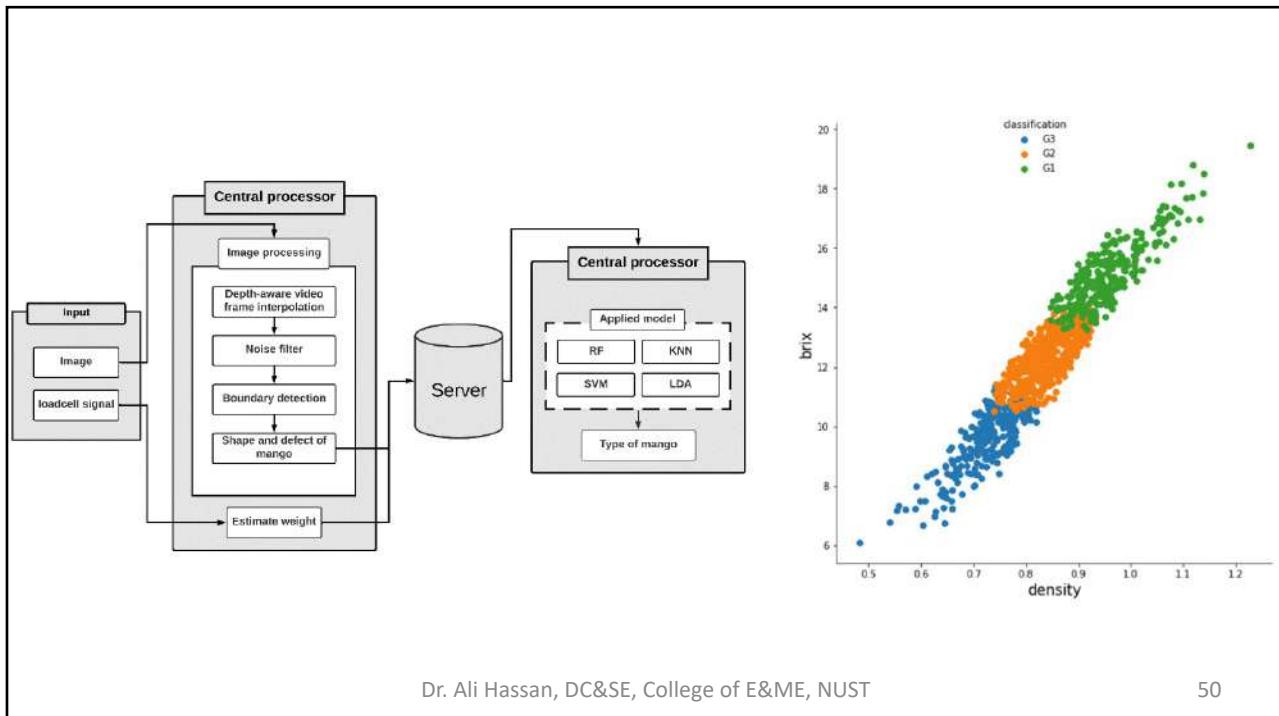
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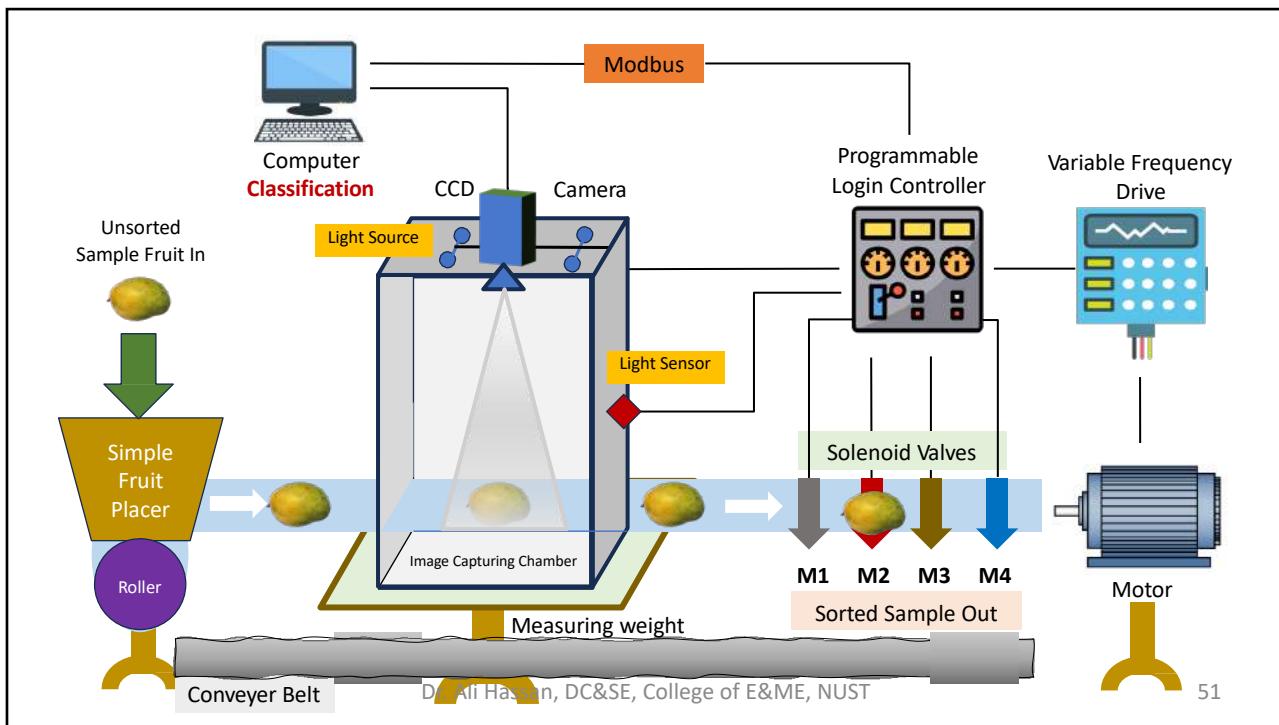
48



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Classification, Regression and Generative AI Artificial Intelligence

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Regression / Forecasting

US DOLLAR TO PAKISTANI RUPEE (USD/PKR) 5-YEAR FOREX CHART



Past performance is not a reliable indicator.

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Source: TradingView

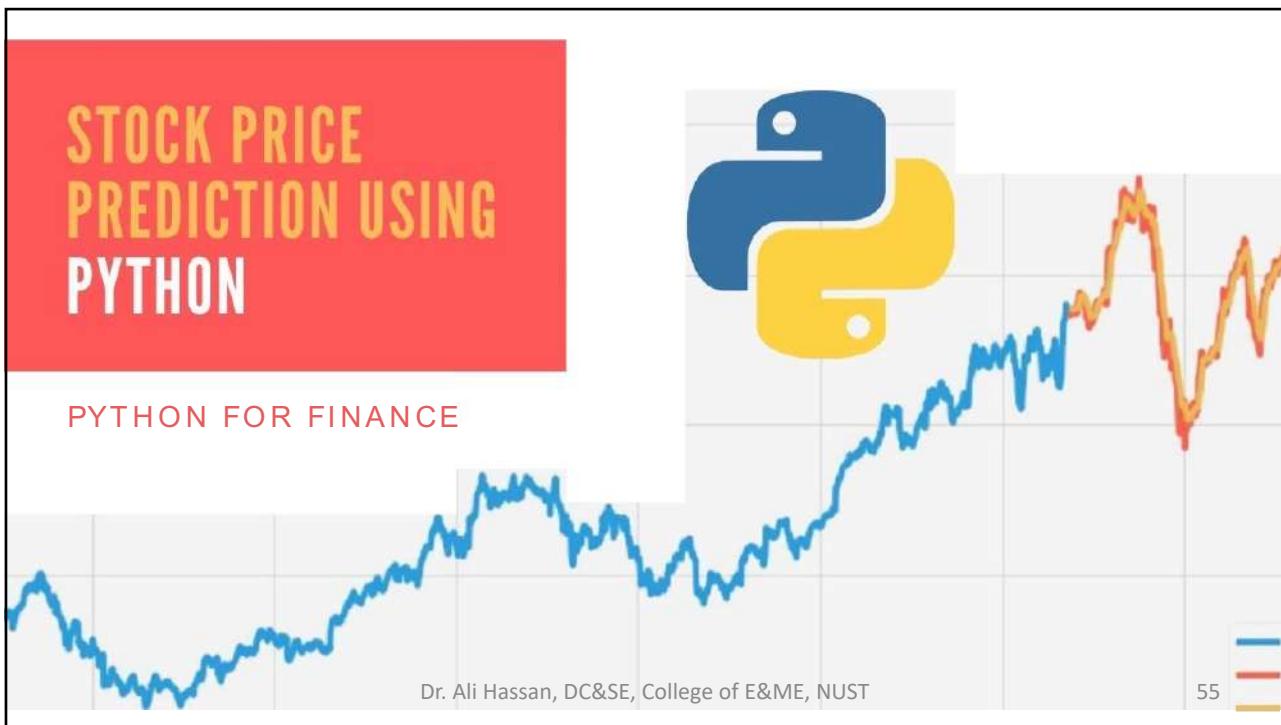
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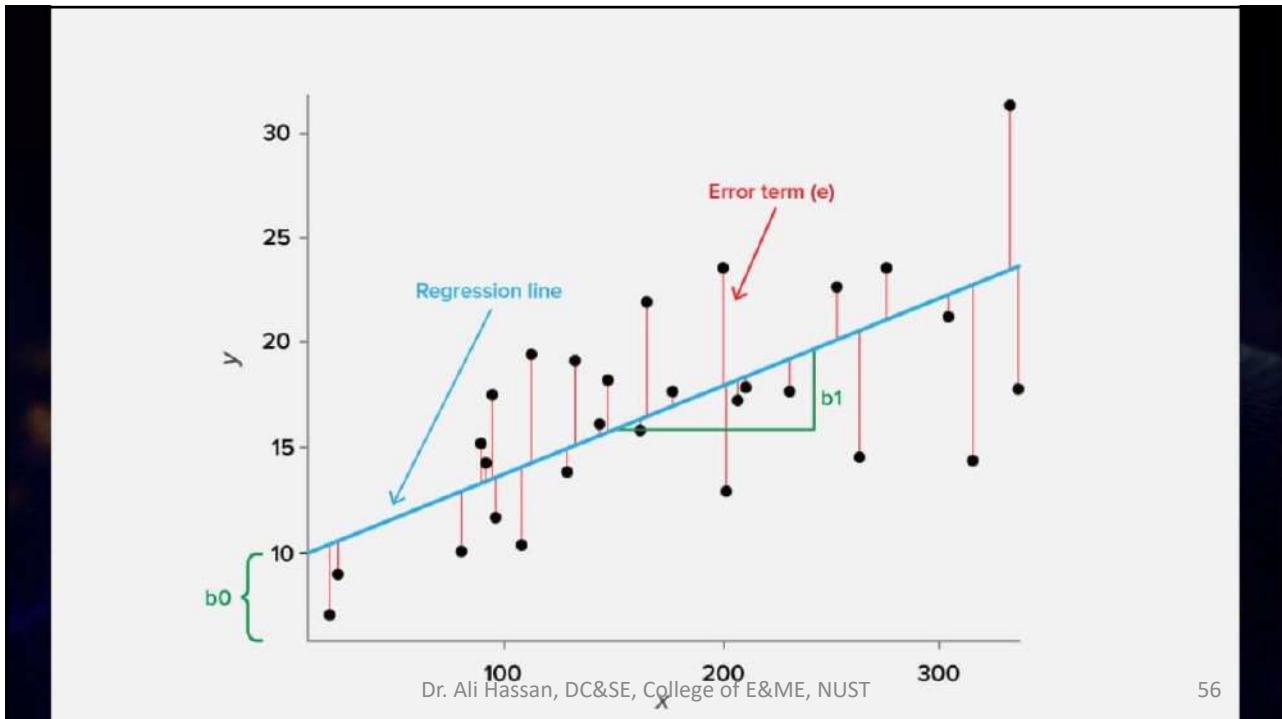
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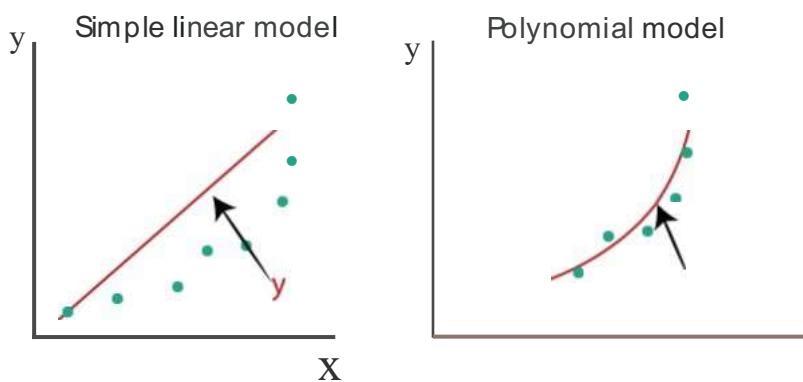
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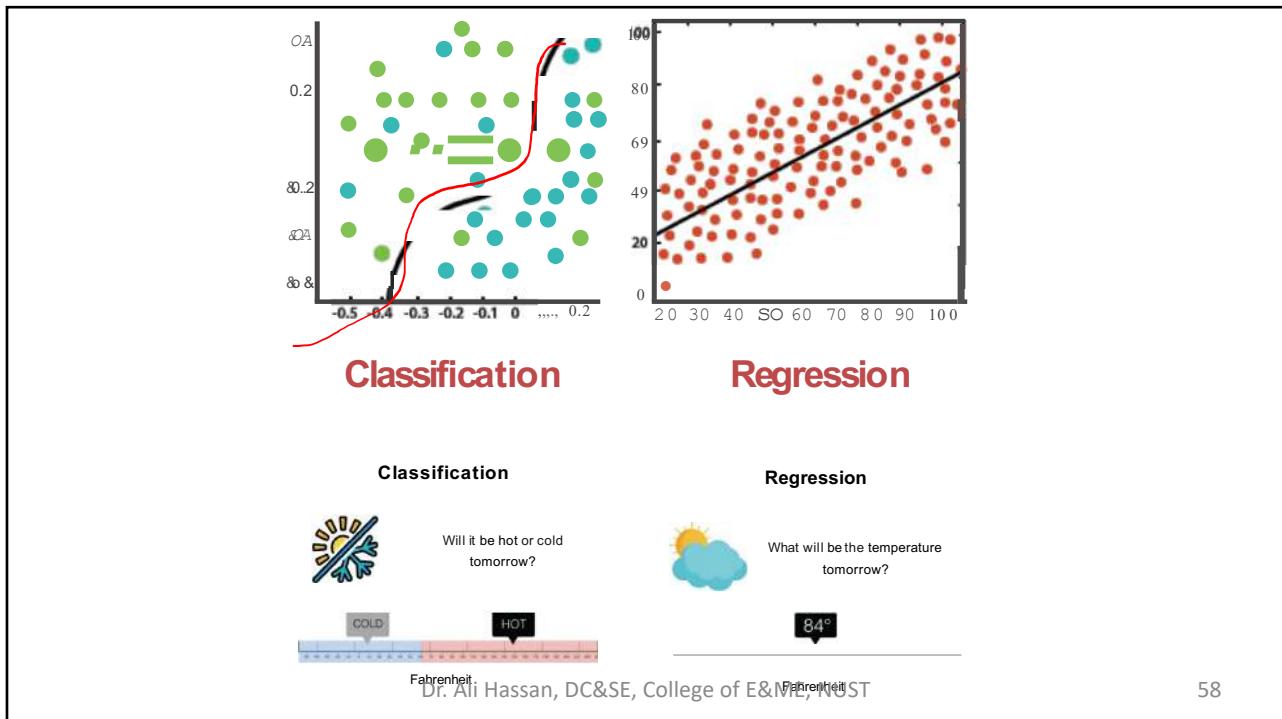
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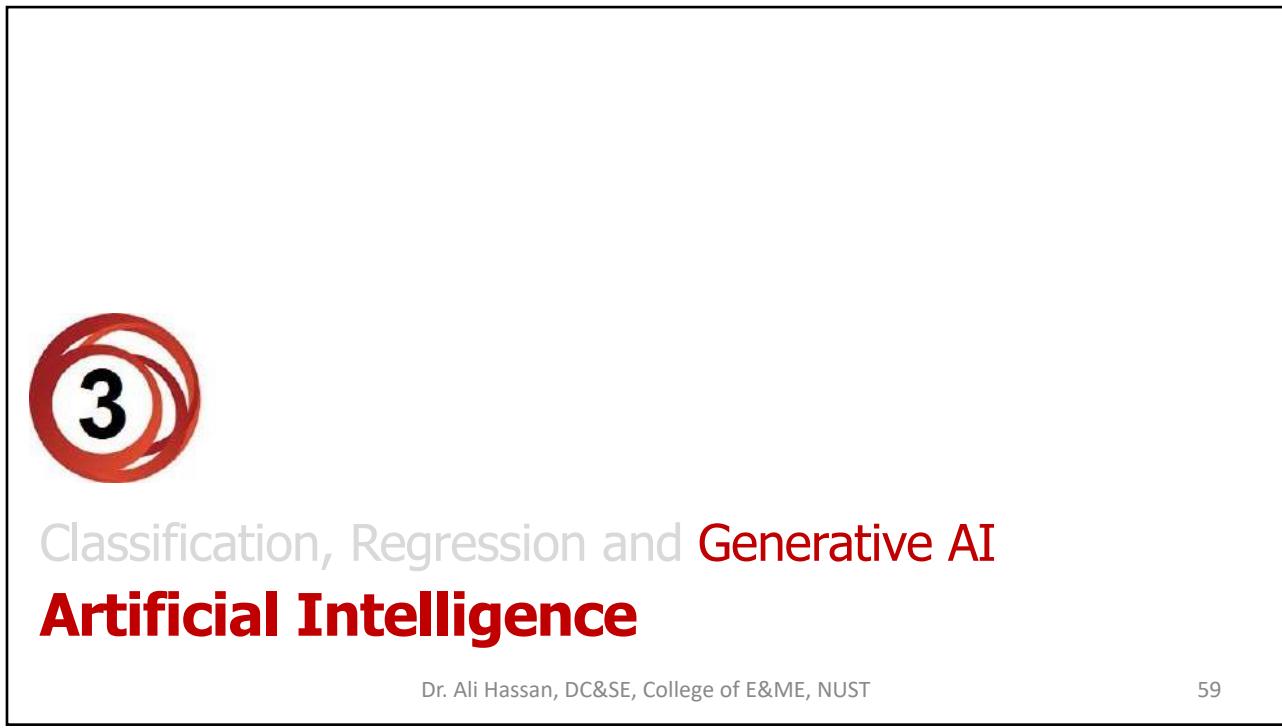
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Hi Ali Hassan! Ready to get creative?

💡 Change Facial Expression and Flux are now available.



+ Create Image



❖ Edit Image

Quick starts

 Choose a style
Start with a style you like

 Explore models
See 10+ fine-tuned models

 Train Model
Customize your creativity

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Who do you know in all these pictures?

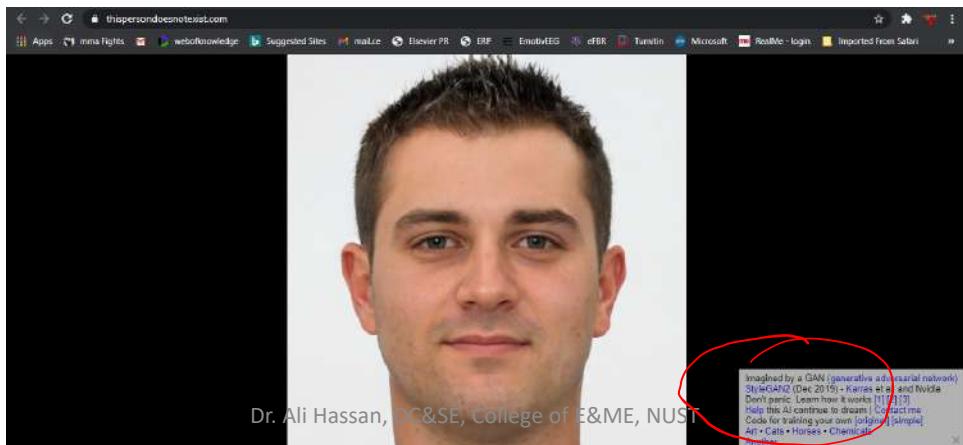
None is real !!!

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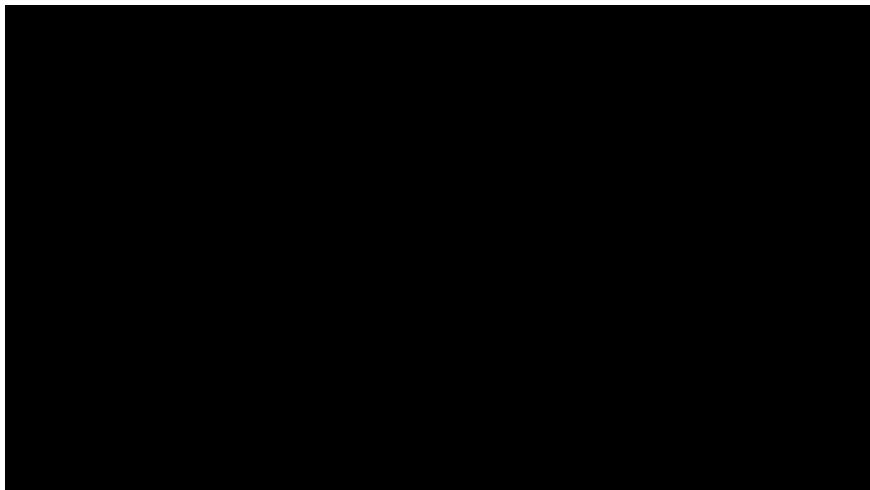
<https://thispersondoesnotexist.com/>

New AI Generates Freakishly Realistic People Who Don't Actually Exist



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Deepfake: We're entering an era in which anyone can make anyone say anything



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Deep Fakes



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CruiseDeepFake



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De-Age the Face

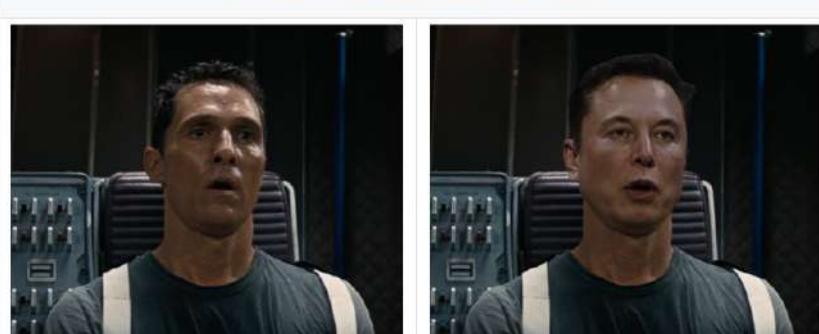


➡ <https://www.youtube.com/watch?v=Ddx5B-84ebo>

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Replace the Face



➡ <https://www.youtube.com/watch?v=RTjgkhMugVw>

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Deep Face Lab



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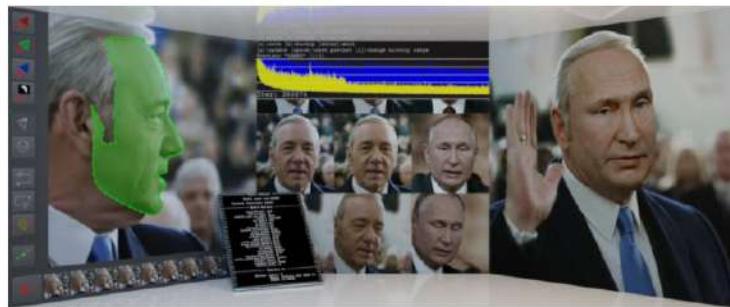
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DeepFaceLab

<https://arxiv.org/abs/2005.05535>

the leading software for creating deepfakes



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Deep Fakes

Done through Generative Adversarial Networks

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Video from one frame



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'Paint' Photos In
Style Of Any
Artist From Van
Gogh To Picasso



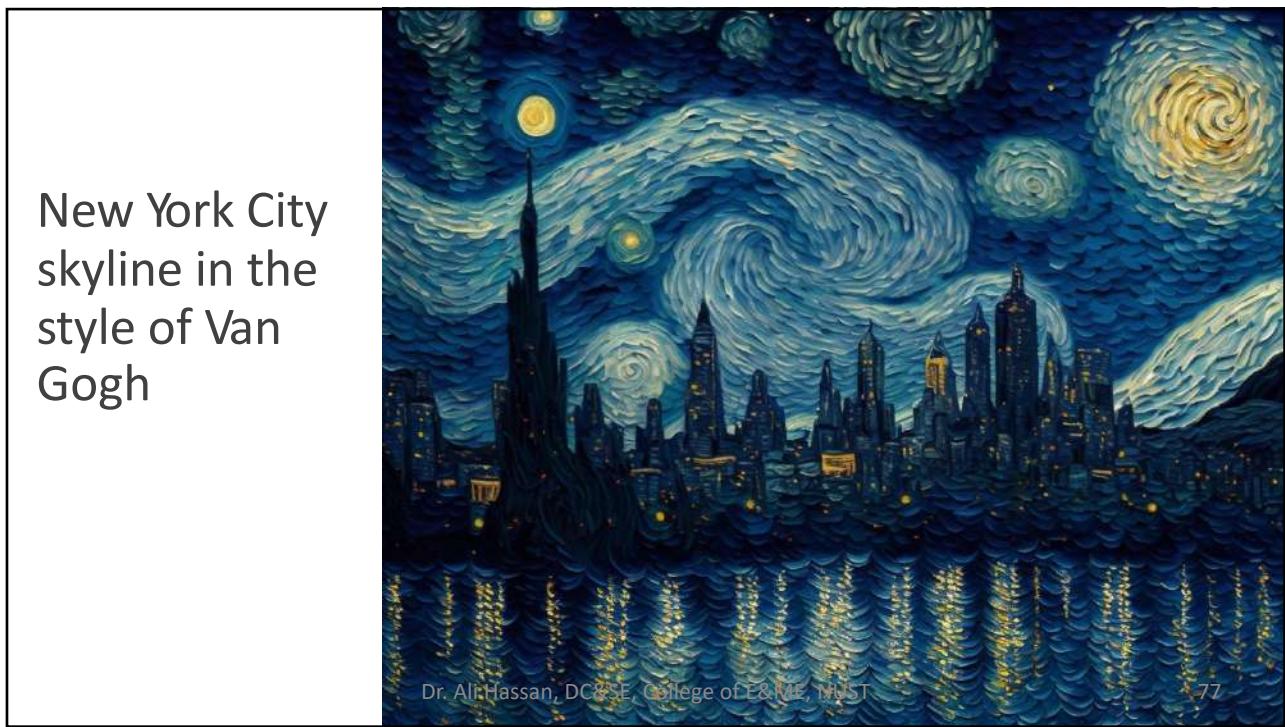
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Vincent Van Gogh (most famous and influential figures in the history of Western art)

76

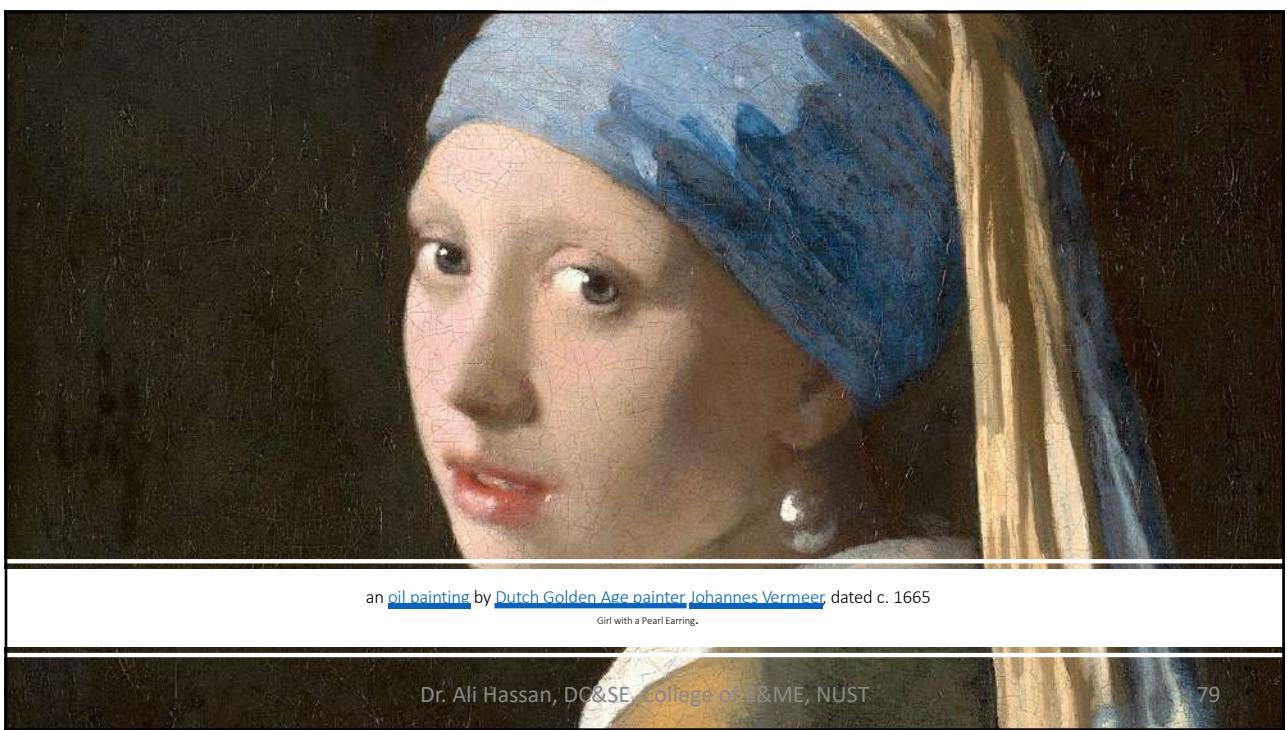


New York City
skyline in the
style of Van
Gogh

77



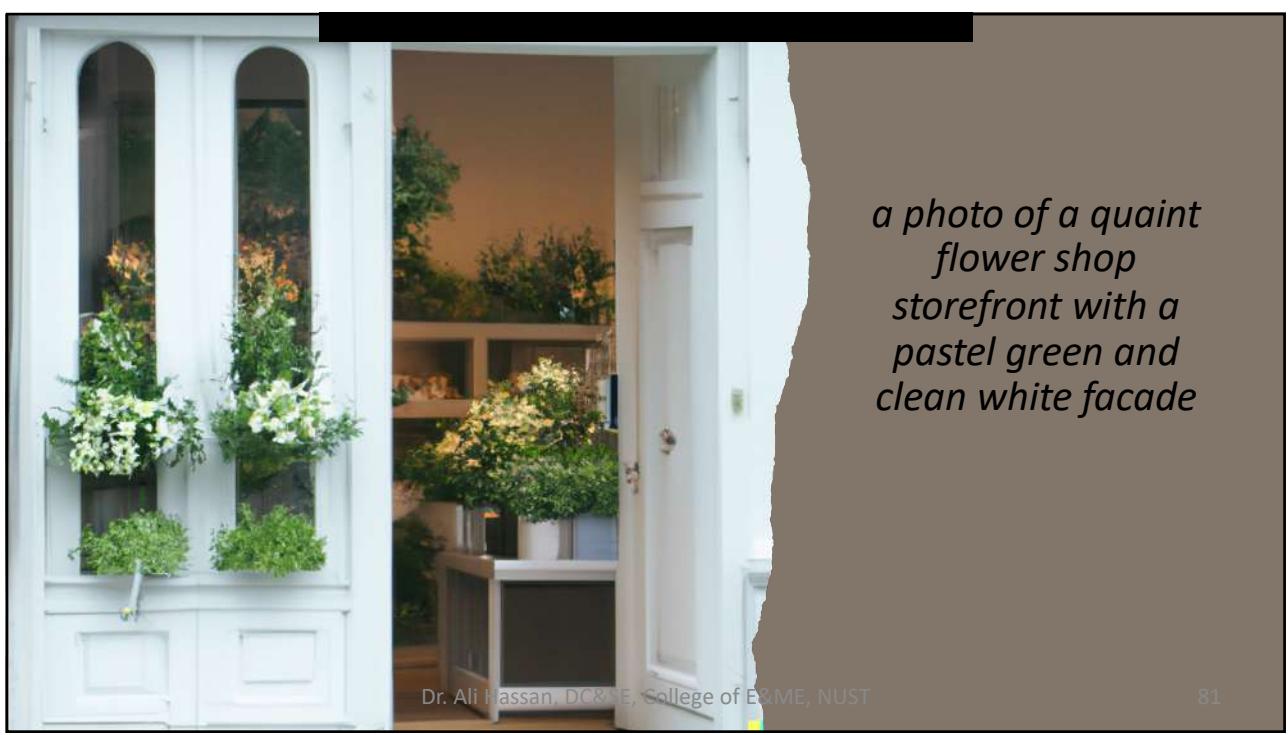
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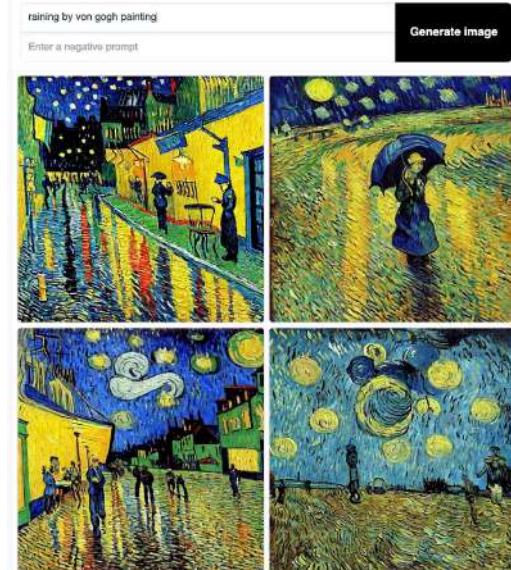


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Text to Image



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Google

AI knows that soup is usually hot, so it must melt the Google symbol. Another thing that it did is to take the yellow part of Google's symbol and make it similar to corn, which is also yellow.

we wrote google soup, and the image shown on the right is generated



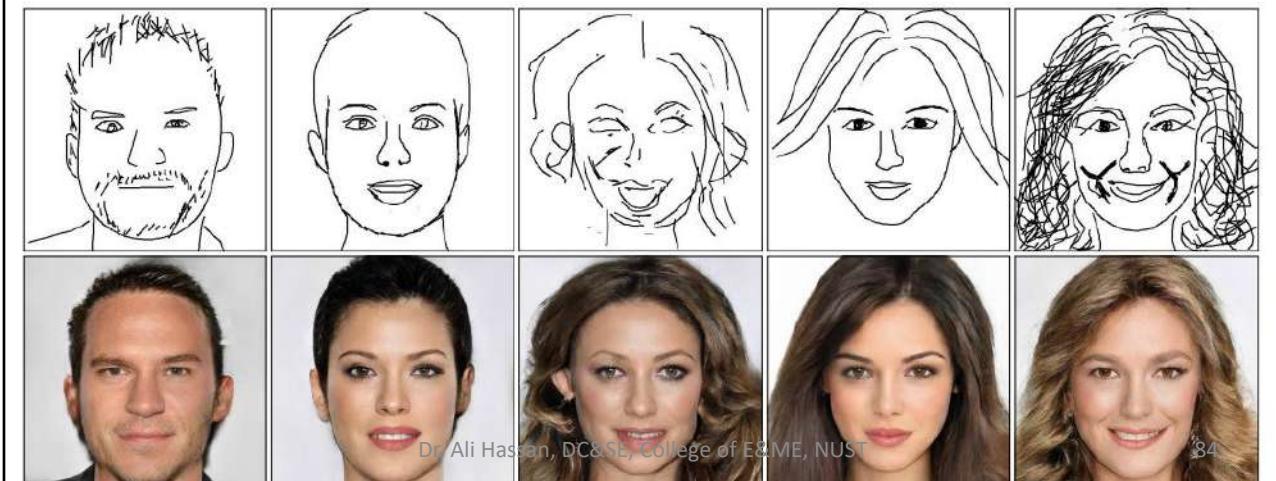
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Sketches-to-realistic images.

["DeepFaceDrawing: Deep Generation of Face Images from Sketches."](#)



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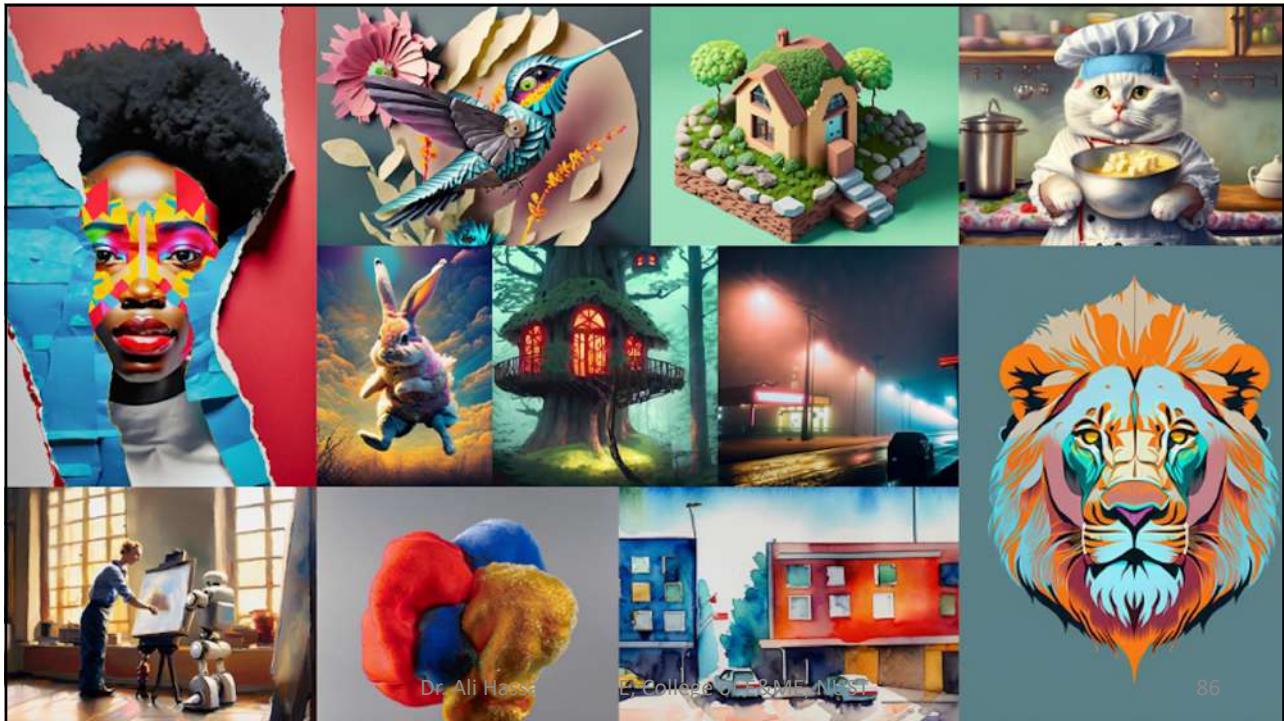
84



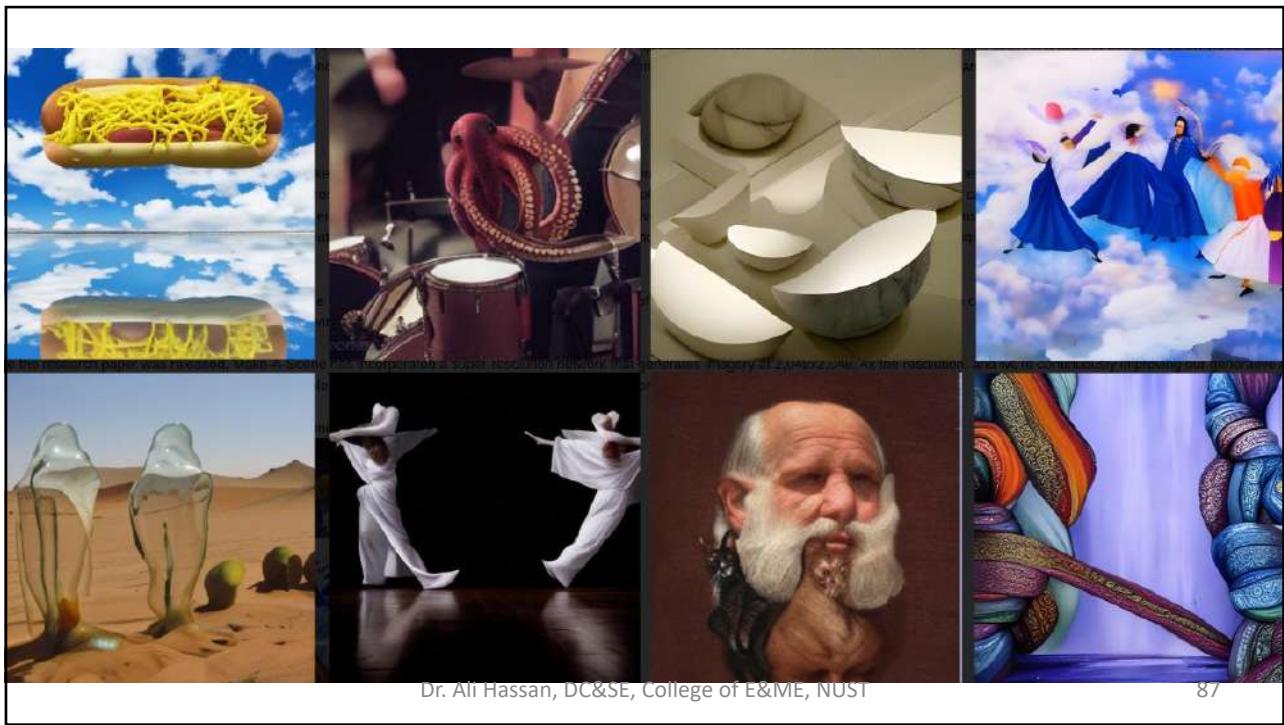
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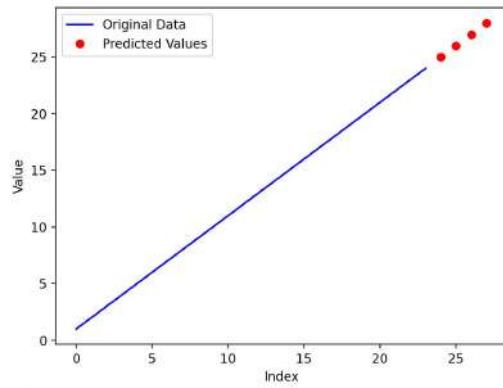
88

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Code Generation

```
From ChatGPT > ...
1 import numpy as np
2 import matplotlib.pyplot as plt
3 from sklearn.linear_model import LinearRegression
4
5 # Array with 24 values
6 data = np.array([1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24])
7
8 # Splitting the data into features (X) and target variable (y)
9 X = data[:-4] # Use all values except the last four as features
10 y = data[4:] # Use all values except the first four as target variable
11
12 # Reshape the data to 2D array for sklearn
13 X = X.reshape(-1, 1)
14 y = y.reshape(-1, 1)
15
16 # Create and train the linear regression model
17 model = LinearRegression()
18 model.fit(X, y)
19
20 # Predict the next four values
21 next_values = []
22 for i in range(1, 5):
23     next_value = model.predict([[data[-i]]])
24     next_values.append(next_value[0][0])
25
26 # Reverse the order of predicted values
27 next_values = next_values[::-1]
28
29 # Concatenate original and predicted values
30 all_values = np.concatenate((data, np.array(next_values)))
31
32 # Create x-axis values for the plot
33 x = np.arange(len(all_values))
34
35 # Plot original and predicted values
36 plt.plot(x[:len(data)], data, 'bo', label='Original Data')
37 plt.plot(x[len(data):], all_values[len(data):], 'ro', label='Predicted Values')
38 plt.xlabel('Index')
39 plt.ylabel('Value')
40 plt.legend()
41 plt.show()
```



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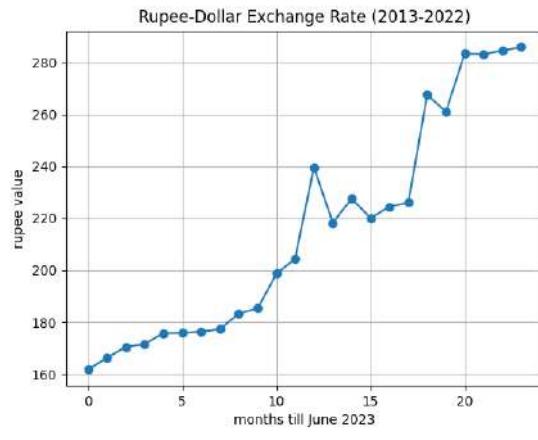
89

Generated Code with Relevant Data

```

❸ predictDollarValue = ...
❹     import numpy as np
❺     import matplotlib.pyplot as plt
❻     from sklearn.linear_model import LinearRegression
❼
➋     # Array with 24 values
⌽     data = np.array([
⌾         286.000,
⌿         284.550,
⌿         283.250,
⌿         283.410,
⌿         261.000,
⌿         267.500,
⌿         226.150,
⌿         224.500,
⌿         220.000,
⌿         227.650,
⌿         218.250,
⌿         239.568,
⌿         204.500,
⌿         198.700,
⌿         185.400,
⌿         185.400,
⌿         177.250,
⌿         176.320,
⌿         175.800,
⌿         175.720,
⌿         171.550,
⌿         178.500,
⌿         166.250,
⌿         161.750])
⌽
⌽     data = np.flip(data)
⌽
⌽     # Plotting the data
⌽
⌽     # Splitting the data into features (X) and target variable (y)
⌽     X = data[:-1] # Use all values except the last one as features
⌽     y = data[1:] # Use all values except the first one as target variable

```



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Many Professions will Become Obsolete



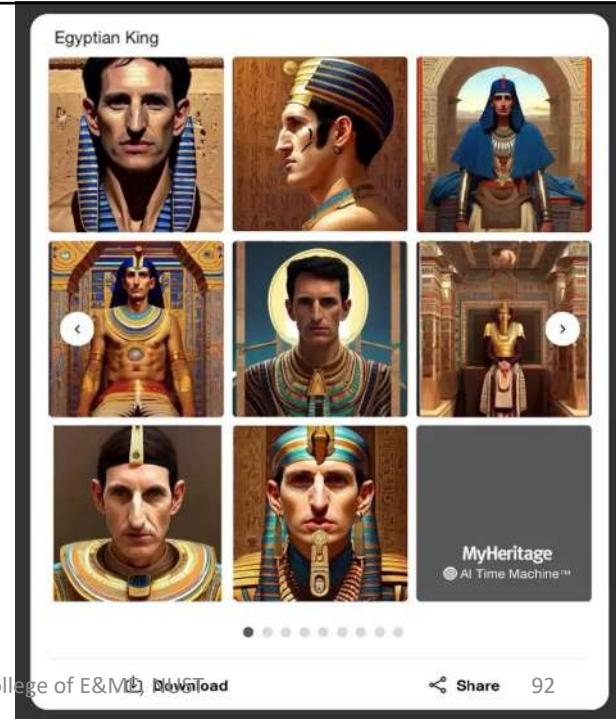
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With generative AI tools, you can easily be an astronaut, a 19th-century lord or lady, a medieval knight, or an Egyptian pharaoh!

- [Google Bard AI](#)
- [Bing AI](#)
- [Chinchilla](#)
- [Notion AI](#)
- [Google Apprentice Bard](#)
- [Chai](#)
- [NovelAI](#)
- [Caktus AI](#)
- [AI Dungeon](#)
- [YouChat](#)
- [Neeva AI](#)
- [Fake name generators](#)



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[Share](#) 92

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Assignment 1 (b)

- Be creative and generate an image using any text to image Generative AI tool
- Submit the image and also share it on whatsapp group (only your best image please). Let us find out who generates the most creative image
- Name the tool and the text prompt you used for image generation.

<https://labs.openai.com/>

<https://gencraft.com/generate>

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- futuristic college of Eme Pakistan leading the humanity in AI
- Generated using <https://app.leonardo.ai/image-generation>

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can you generate a futuristic image of nust college of electrical and mechanical engineering

Generated using Gemini

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What we want to do

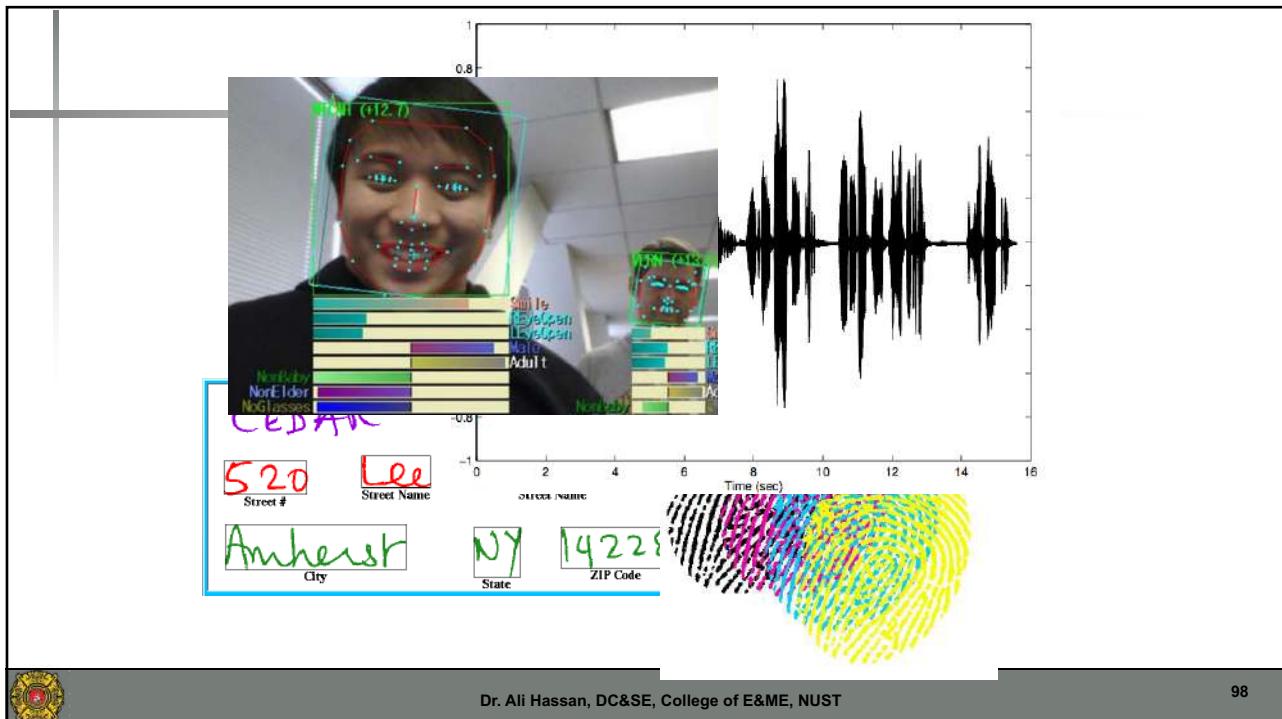
- Algorithms that can improve their performance using **training data**
- Typically the algorithm has a (large) number of parameters whose values are learnt from the data
- Can be applied in situations where it is very challenging (=impossible) to define rules by hand, e.g.:
 - Facedetection
 - Speechrecognition
 - Stockprediction



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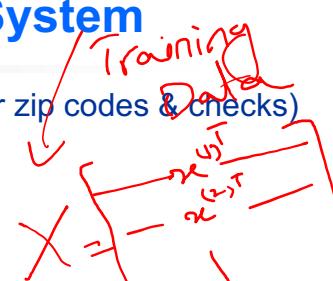
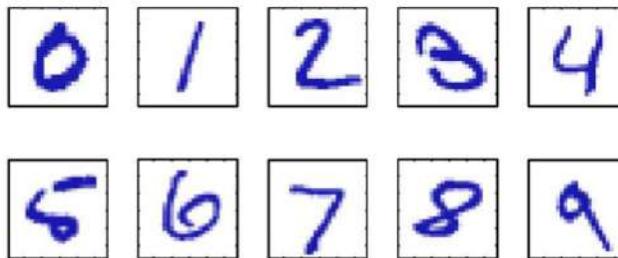


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Handwritten Address Interpretation System

- One of first commercial and widely used ML systems (for zip codes & checks)



- Images are 28x28 pixels
- Represent input image as a vector
- Learn a classifier $f(x)$ such that

$$\begin{aligned} \rightarrow x \in \Omega^{784} \\ f : x \rightarrow \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\} \end{aligned}$$



How to Proceed

- Collect some training samples for each digits
- Start learning and classifying
- Systems can achieve errors of 0.4%

0 0 0 1 1 1 1 1 2

→ 2 2 2 2 2 2 3 3 3

3 4 4 4 4 4 5 5 5

6 6 7 7 7 7 8 8 8

9 9 9 9 9 9 9 9

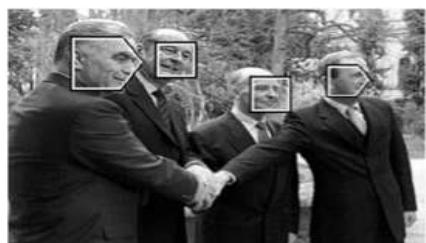


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Example 2: Face Detection

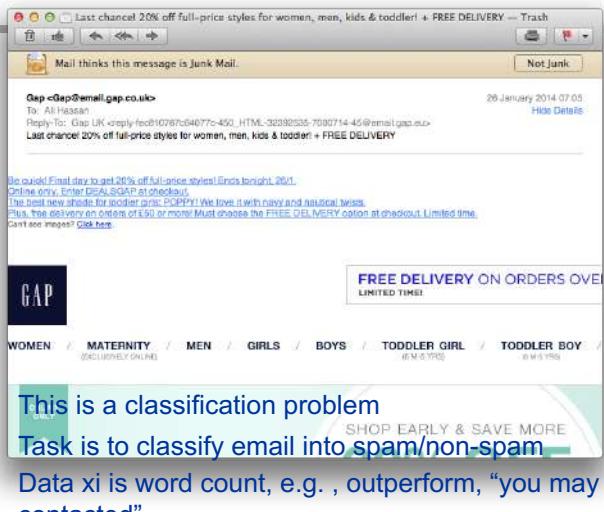


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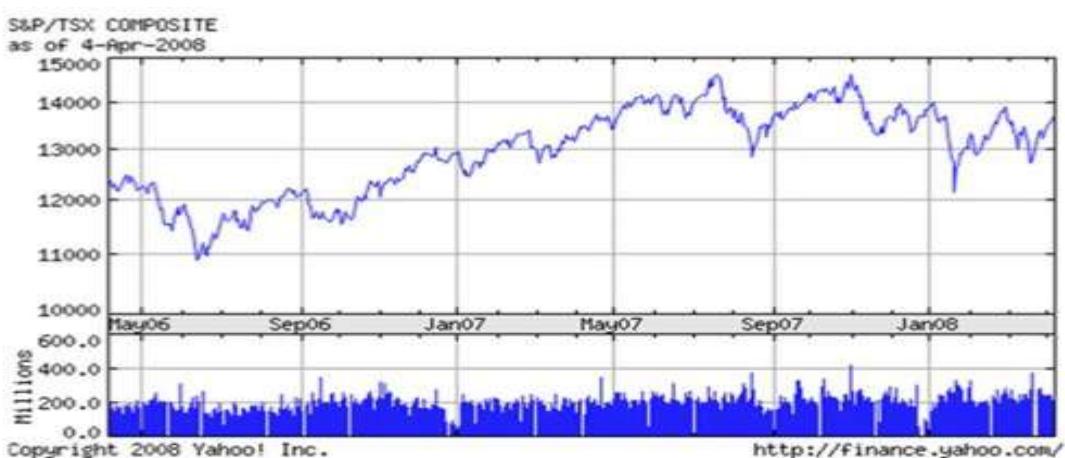
101

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Spam Detection



Stock Price Predictions



Language Translation

The screenshot shows the Google Translate interface. At the top, there are links for Web, Images, Maps, News, Shopping, Mail, more, Home, Text and Web, Translated Search, Dictionary, and Tools. Below that, a search bar says "Translate text or webpage" and "Enter text or a webpage URL." A text box contains the French sentence "En vertu des nouvelles propositions, quel est le coût prévu de perception des droits?" and its English translation "Under the new proposals, what is the cost of collection of fees?". Below the text box are dropdown menus for "French" and "English" and a "Translate" button. To the right, there's a link to "Suggest a better translation". At the bottom, there are links for "Google Home" and "About Google Translate", and the copyright notice "©2009 Google".



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Recommender Systems

The screenshot shows a product page for "Pattern Recognition and Machine Learning (Information Science and Statistics) (Information Science and Statistics)" by Christopher M. Bishop. It features a "Frequently Bought Together" section with two items: a book and a software box, both with a price of £104.95. There is a "Price For Both: £104.95" button and a "Add both to Basket" button. Below this, there is a "Customers Who Bought This Item Also Bought" section displaying four related books with "LOOK INSIDE!" buttons and "Show related items" links. The books are: "Pattern Recognition and Machine Learning (Information Science and Statistics)" by Christopher M. Bishop, "MACHINE LEARNING" by Thomas M. Mitchell, "Pattern Classification, Second Edition" by Richard O. Duda, and "Data Mining: Practical Machine Learning Tools and Algorithms" by Ian H. Witten.



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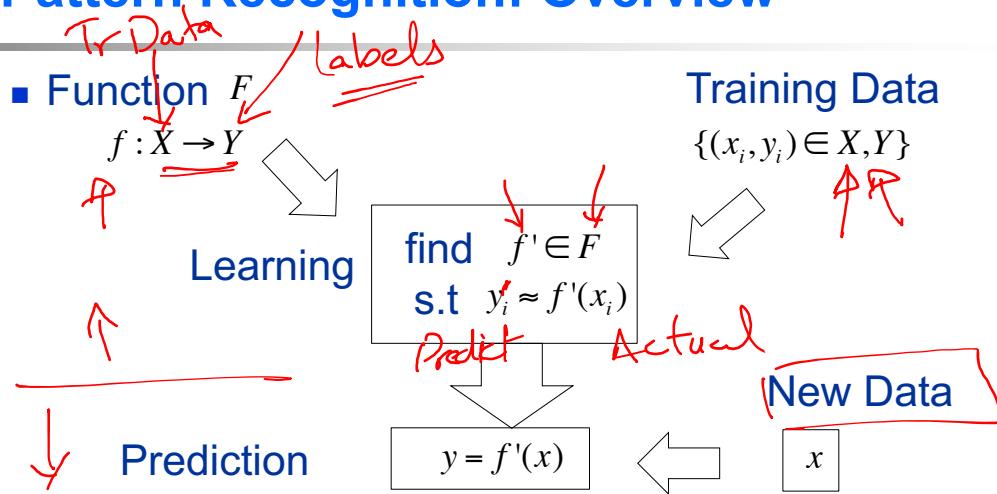
105

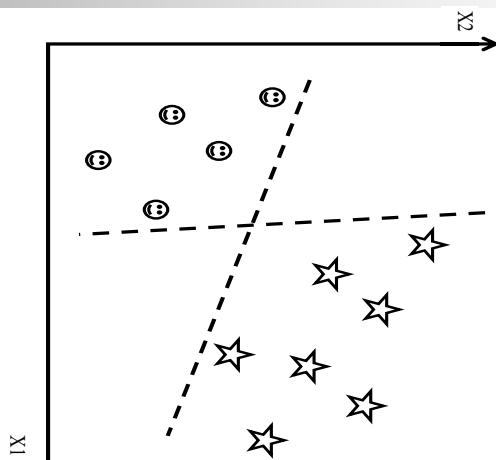
Applications

- Medical diagnosis
- Reading postcodes
- Autonomous vehicles
- Data mining
- Fraud detection
- Bioinformatics
- Text analysis
- Speech recognition
- Biometrics
- Fault detection
- Character recognition
- Cancer screening
- Financial modelling



Pattern Recognition: Overview





Common Techniques

- Linear Regressions
- Nearest-Neighbour Classifier
- Support Vector Machine (SVM)
- Perceptron
- Multi-Layer Perceptron (MLP)
- Radial-Basis Functions (RBF)
- Bayesian Inference
- K-Means Clustering
- Principle Component Analysis (PCA)



More Common Techniques

- Decision Trees: ID3/C4.5/CART
- Bayesian Optimal Classifiers
- Belief Networks
- Monte-Carlo Techniques (MCMC)
- Hidden Markov Models (HMM)
- Graphical Models
- Reinforcement Learning



Yet More Techniques

- Self-Organized Maps (Kohonen networks)
- Hopfield Models
- Gaussian Processes
- Maximum Entropy
- Q-learning
- Recurrent networks
- Kalman filters



And more ...

- Boltzmann Machine
- Helmholtz Machine
- Independent Component Analysis
- Kernel PCA
- Fisher Discriminant Analysis
- Neocognitron
- Genetic Programming
- Competitive Network



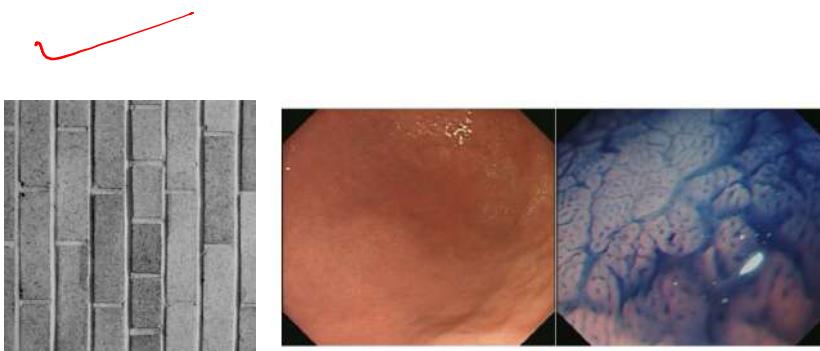
Aim of the Course

- I am not going to teach a long list of techniques
- Concentrate on a few representative techniques
- Provide a theoretical framework for understanding different techniques
 - Maths—linear algebra, optimization, probability
 - Learning theory
- Practical experience (Python)



Example 1

- Texture and Gastroenterology

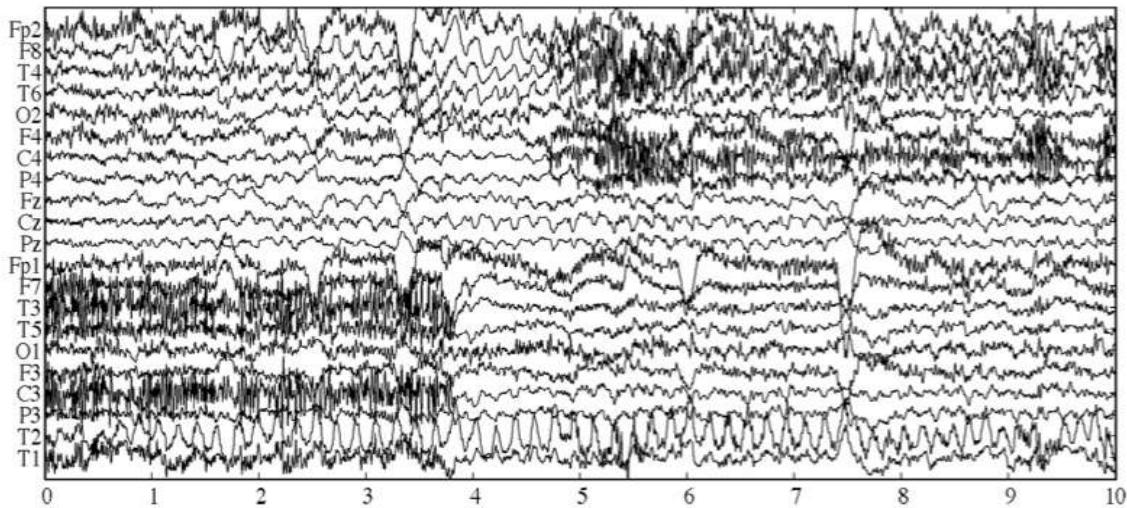


Example 2

- Source Separation Problem
 - Usually done via two sources and uses Doppler effect
 - Also known as BSS or ICA
- Can be directly applied to ECG or Heart Sounds



EEG: Source Separation

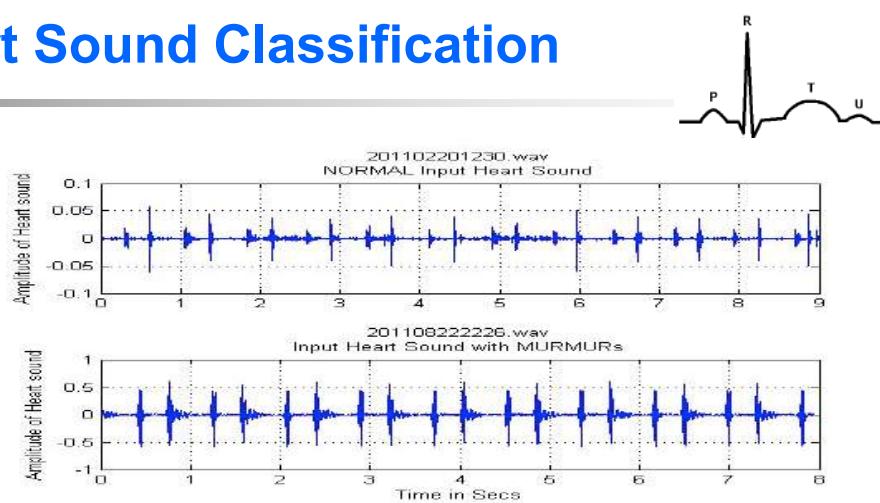


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Heart Sound Classification



- Issues:
 - How to classify first peak
 - How to detect murmurs

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Course Names

Machine
Learning

Neural
Networks

Learning from
Data

Statistical
Pattern
Recognition

Computational
Intelligence

Intelligent
Systems

Data Mining



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Prerequisites for this Course

- Knowledge of Digital Image Processing
- Working Knowledge of **Python**
- Mathematical knowledge
 - Linear Algebra
 - Derivatives, integration
 - Eigen values, eigen vectors
 - Matrix manipulations
 - Statistical Mathematics
 - Mean, variance, covariance, correlations
 - Probability Theory
 - Pdf, cdf, correlations, covariance



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<https://playground.tensorflow.org/>

Tinker With a **Neural Network** Right Here in Your Browser.
Don't Worry, You Can't Break It. We Promise.



Course Outline

Background Knowledge

- History
- Linear Algebra
- Optimisation

Data Handling

- Types of Data
- Analysis
- Pre-processing

Supervised Learning Machines

- Linear/Non-Linear Regression
- Logistic Regression
- Neural Networks
- SVMs

Learning Theory

- Generalisation
- Regularisation
- Bayes

UnSupervised Learning

- K-mean Clustering
- Mean Shift Clustering

Applications

- Anomaly Detection
- Collaborative Filtering
- Large Data



Books

- *Machine Learning: A Probabilistic Perspective* by Kevin Murphy (online version available)
- Hands-on Machine Learning with SciKit-Learn, Keras and TensorFlow by Aurelien Geron
- Reference Books
 - Google
 - Pattern Recognition and Machine Learning by Christopher Bishop
 - Pattern Classification (2nd Edition) by Richard Duda, Peter Hart and David Stork (online version available)



Grading Distribution

- Mid Term 1x 30%
- Final Term 1x 40%
- Quizzes 4x 10%
- Assignments 4x 10%
- Term Project 1x 10%



House Keeping Policies

- Class on
 - Thursday 18:00 – 21:00
 - CRC-16 Try to be on time
- You have to maintain > 75% attendance
- Quizzes – unannounced
- Assignments – No late submissions, LMS
- Best way to contact: alihassan@ceme.nust.edu.pk
- Lecture Slides/Notes: **NUST LMS**



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Software



Visual Studio Code



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Contact Details

- Dr Ali Hassan
 - alihassan@ceme.nust.edu.pk



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What do you need to do?

- REGISTER on Qalam within first ONE/TWO weeks



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LMS Code

■Code:426708913



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Acknowledgements for material used in creating these slides

- Duda Hart Stork lecture slides
- Andrew Ng Standford



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Good Material

- Machine Learning by Andrew Ng on Coursera
- You tube channel
 - <https://youtu.be/qeHZOdmJvFU?list=PLZ9qNFMHZ-A4rycrgOYma6zxF4BZGGPW>
- Neural Network Class by Hugo Larochelle
 - <https://youtu.be/SGZ6BttHMPw>
- Dr Shoab Lectures
 - <https://youtu.be/FW4eKlvuGnY?si=tA4O1J3nLdWIPHOt>



Refresher on Maths

- To know the rules of differentiation check out [Khan Academy's Differential Calculus classes](#).
- To know what are matrices and how to perform operations (transpose, arithmetic, dot product) on matrices, check out [Khan Academy's Linear Algebra playlist](#).



THANK YOU !!



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MY WORK



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EEG WORK



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EEG Work

- In collaboration with
 - University of Aalborg, Denmark
 - New Zealand Centre for Chiropractic Research
 - Auckland University of Technology, NZ

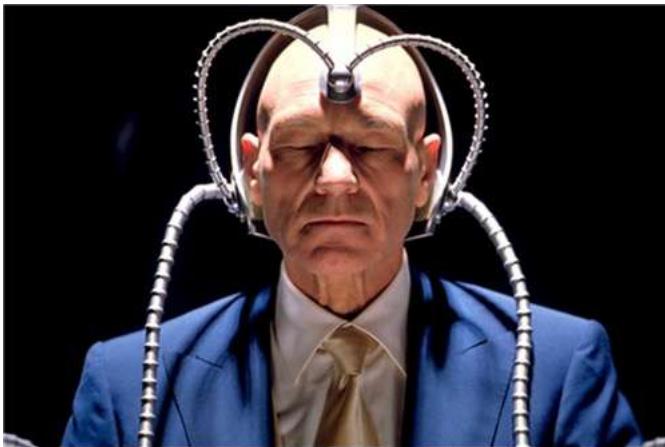


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EEG Signals Recording

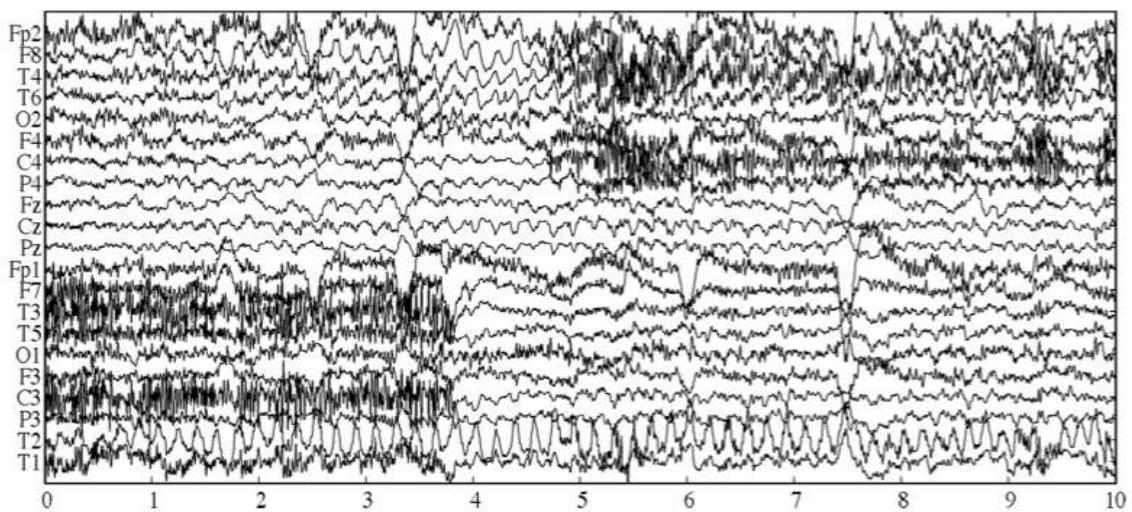


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EEG: Source Separation

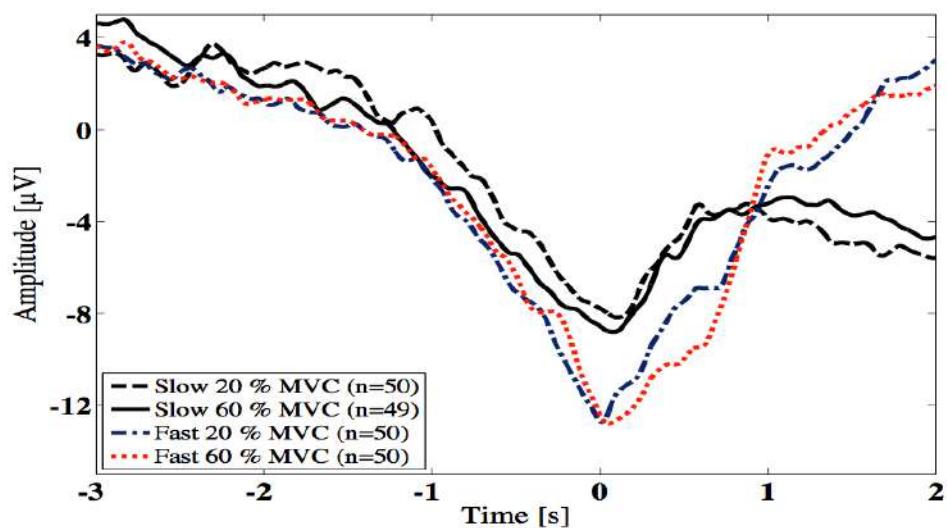


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EEG: Signal Classification



Hardware Implementation



PIC32 Micro-Controller
(PIC32MX360F512L) and Plug-In Module



Raspberry Pi



VERTEBRAE DETECTION AND TRACKING USING FLUOROSCOPY



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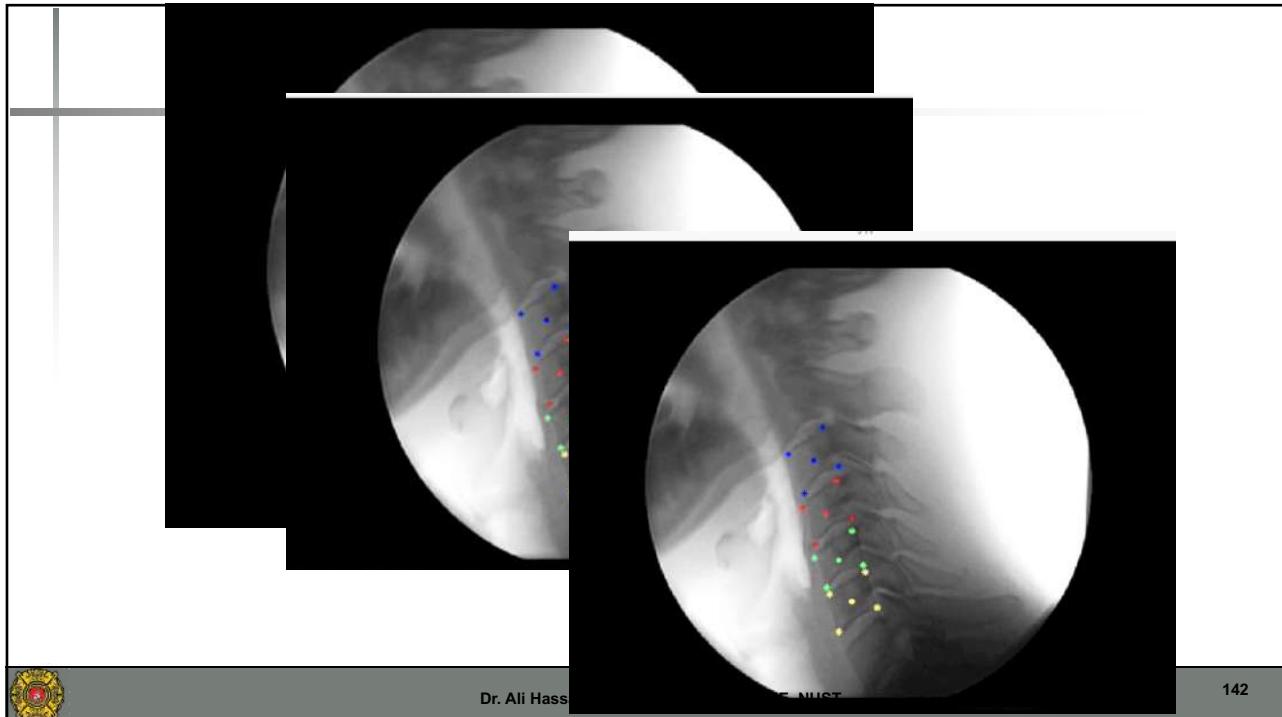
Cervical Vertebrae Detection/Tracking



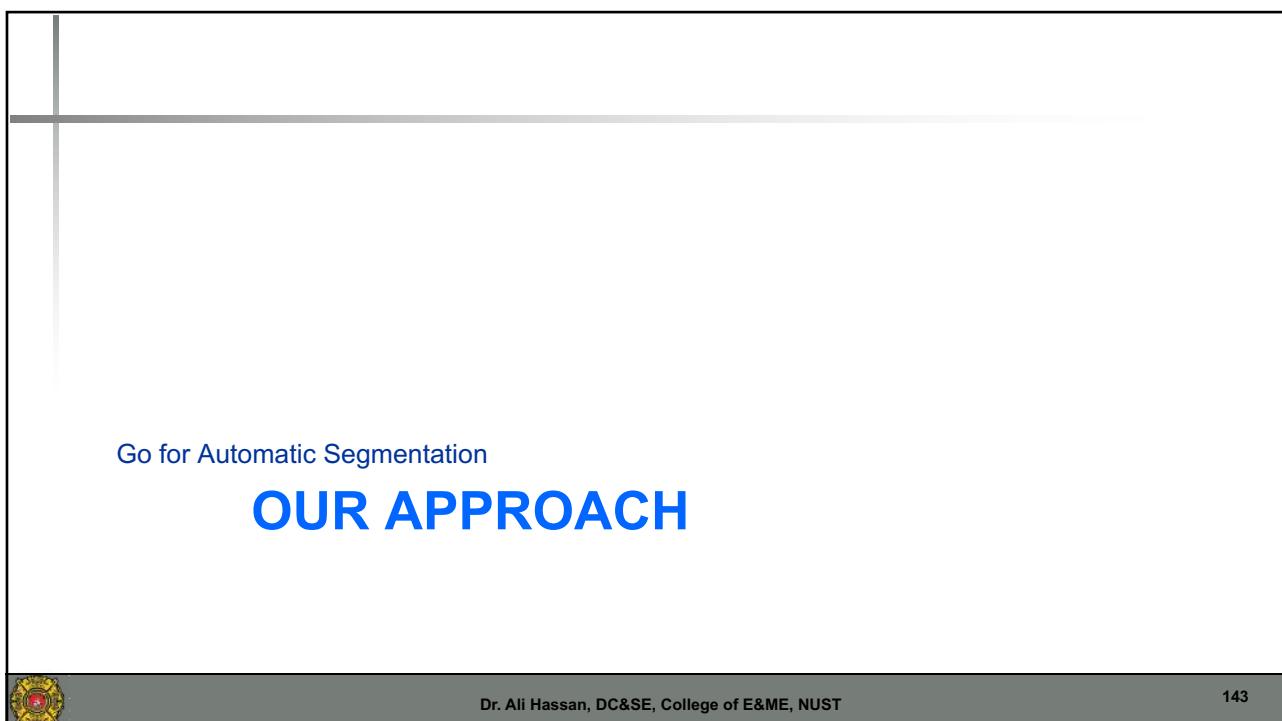
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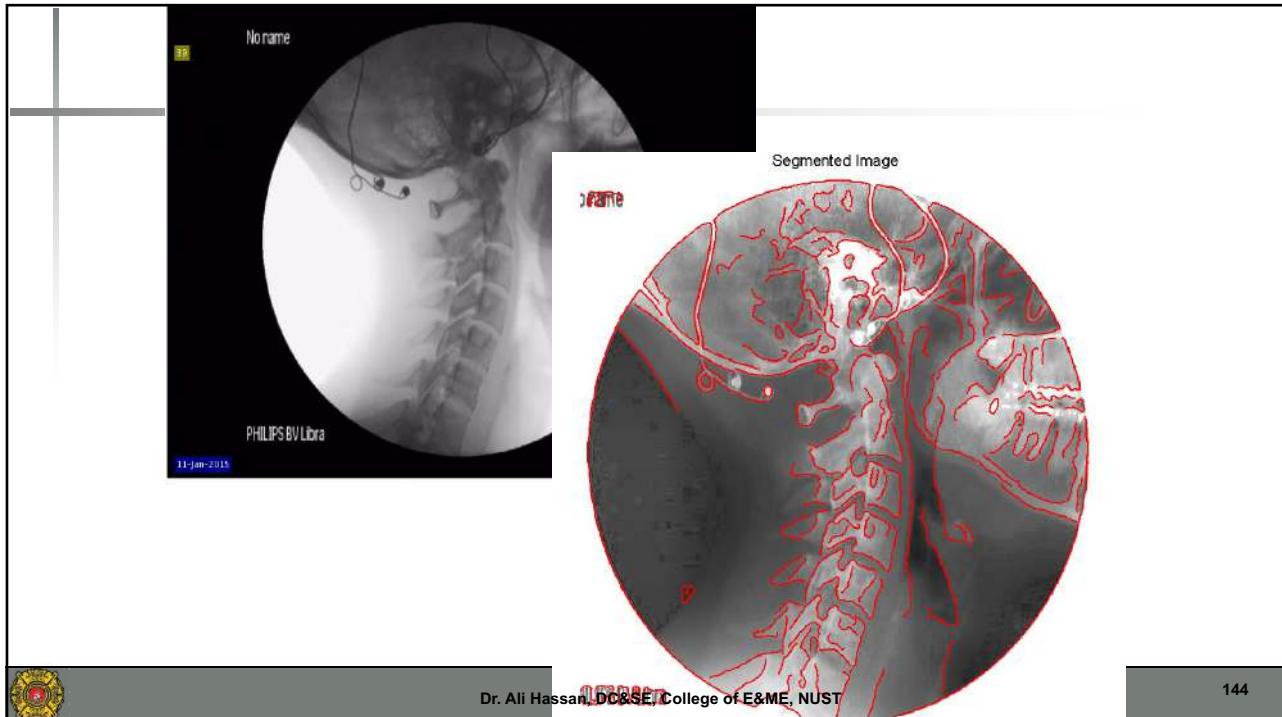
142



Go for Automatic Segmentation

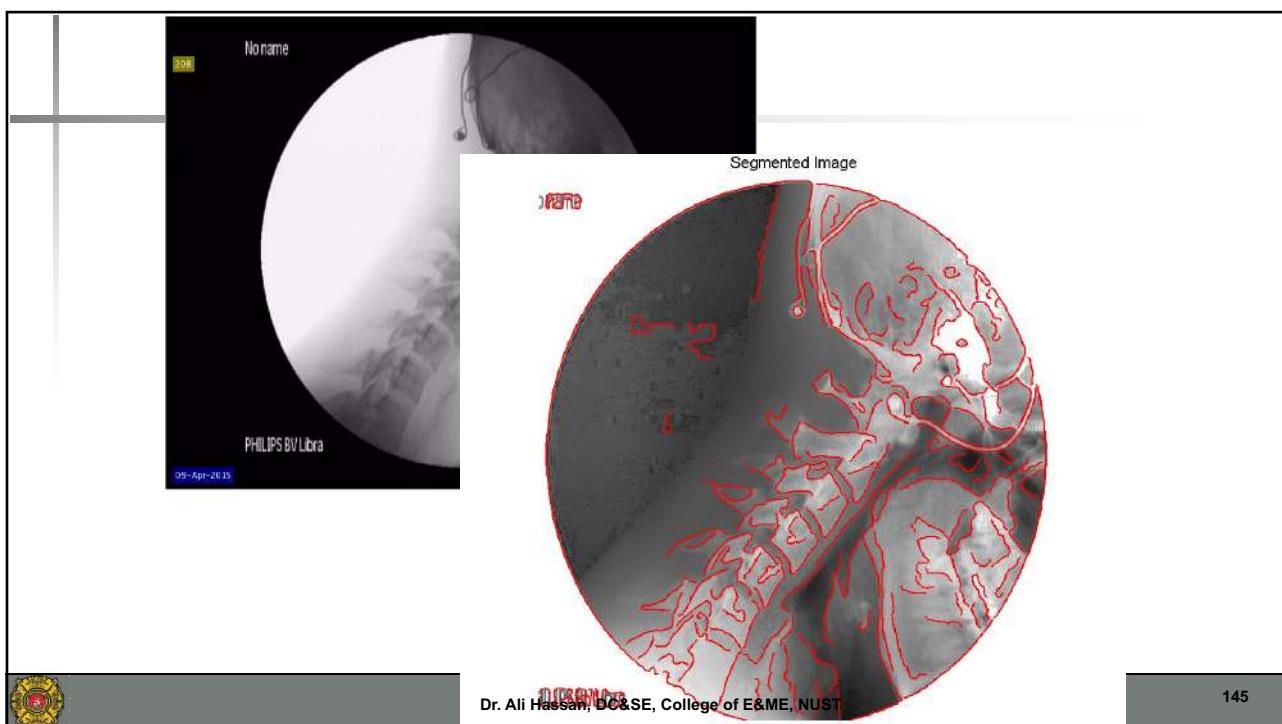
OUR APPROACH

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Fully Automated Segmentation

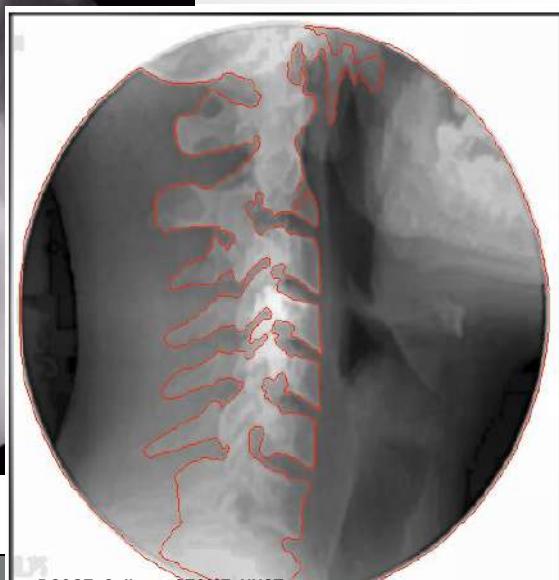
WHERE WE ARE NOW



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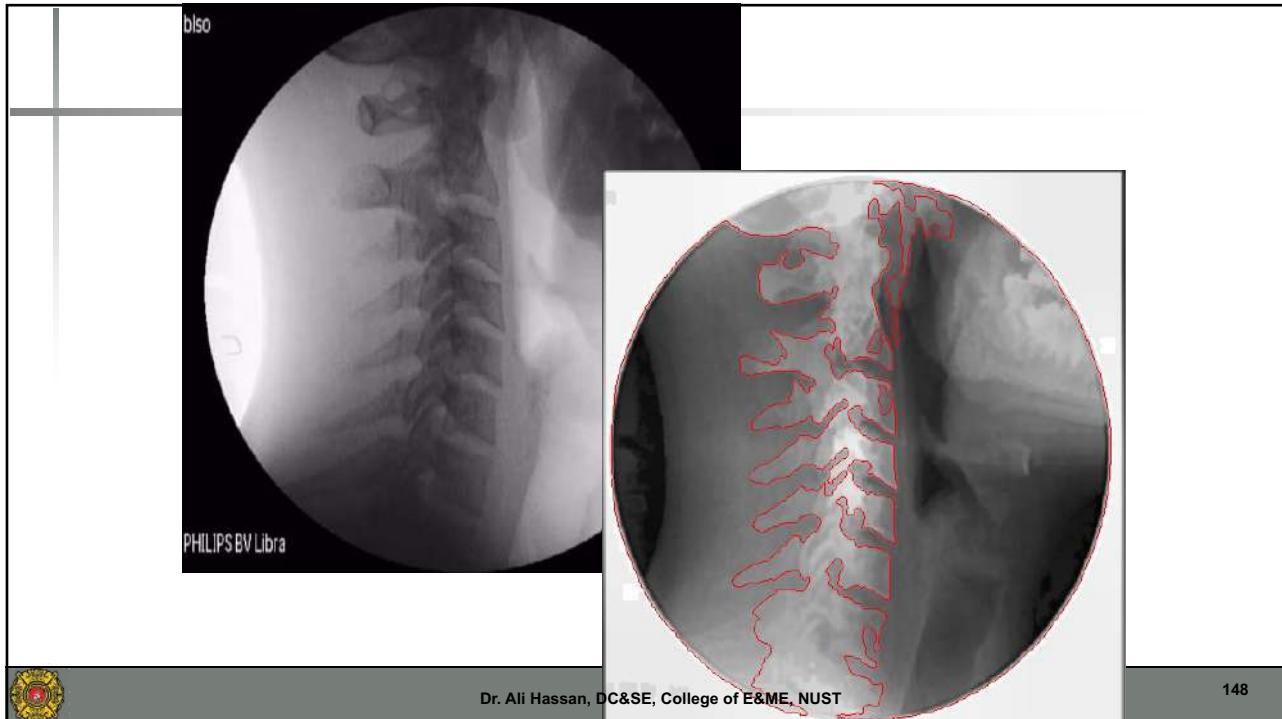
146



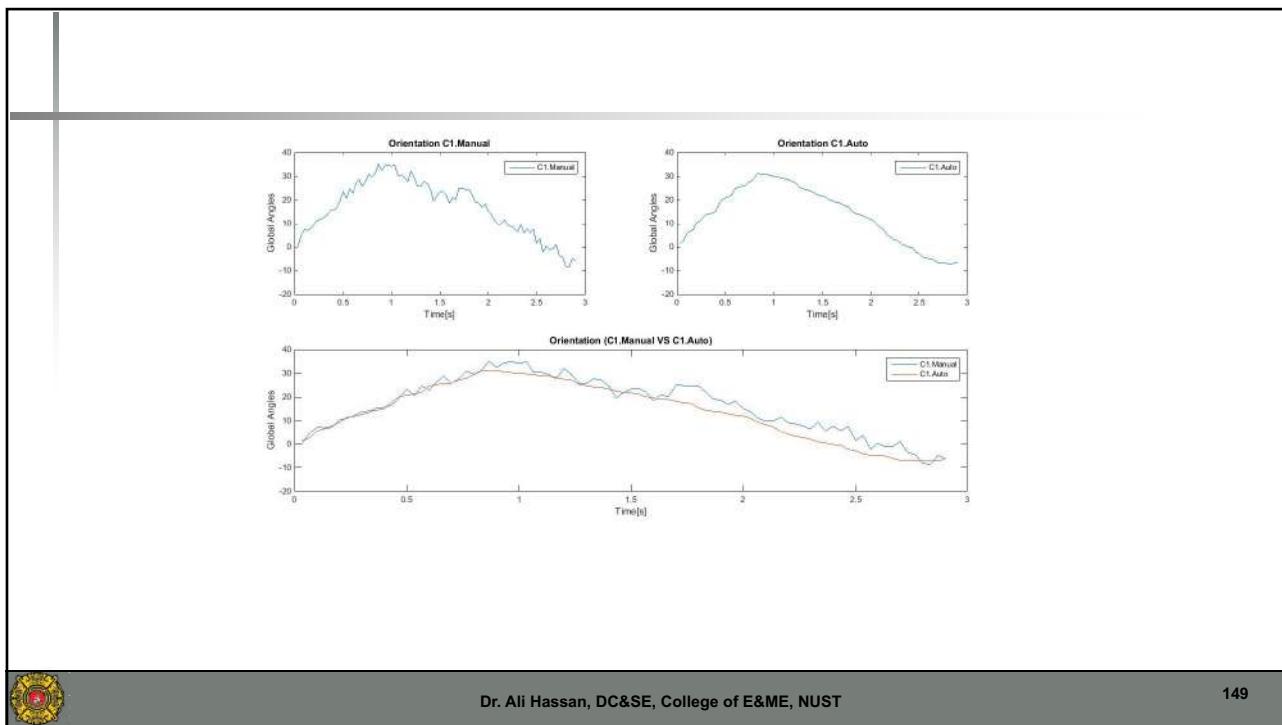
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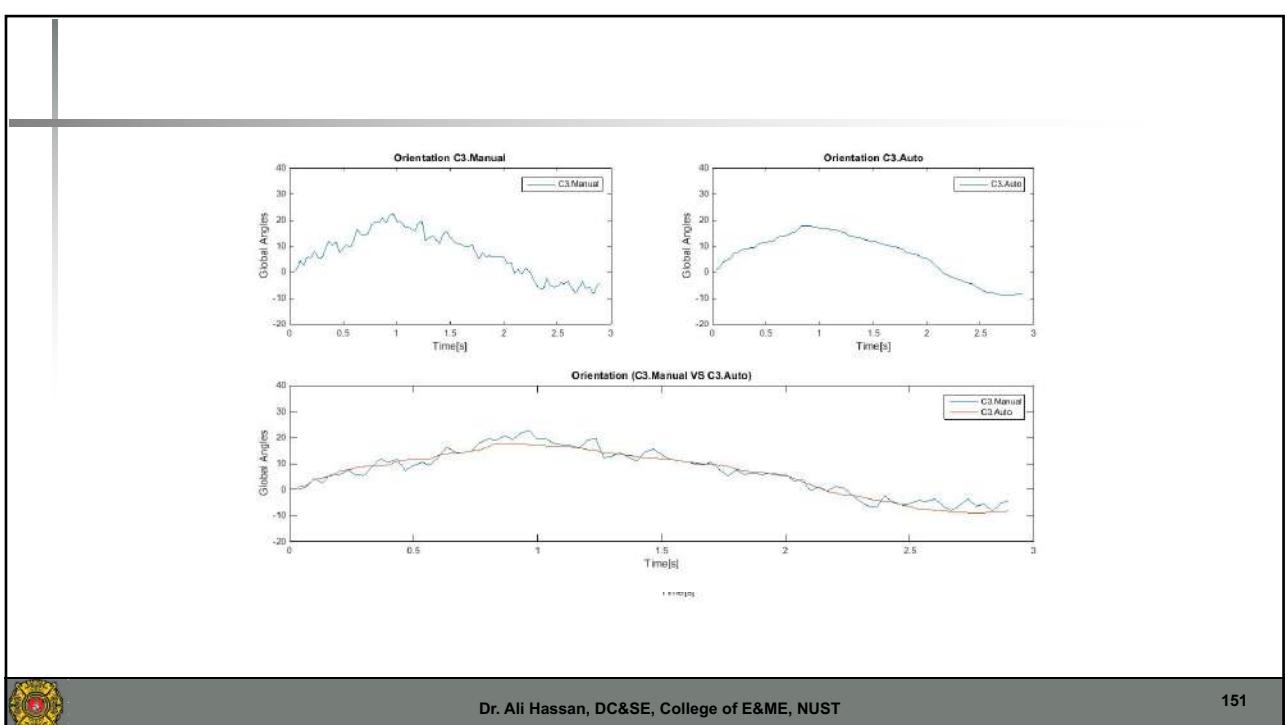
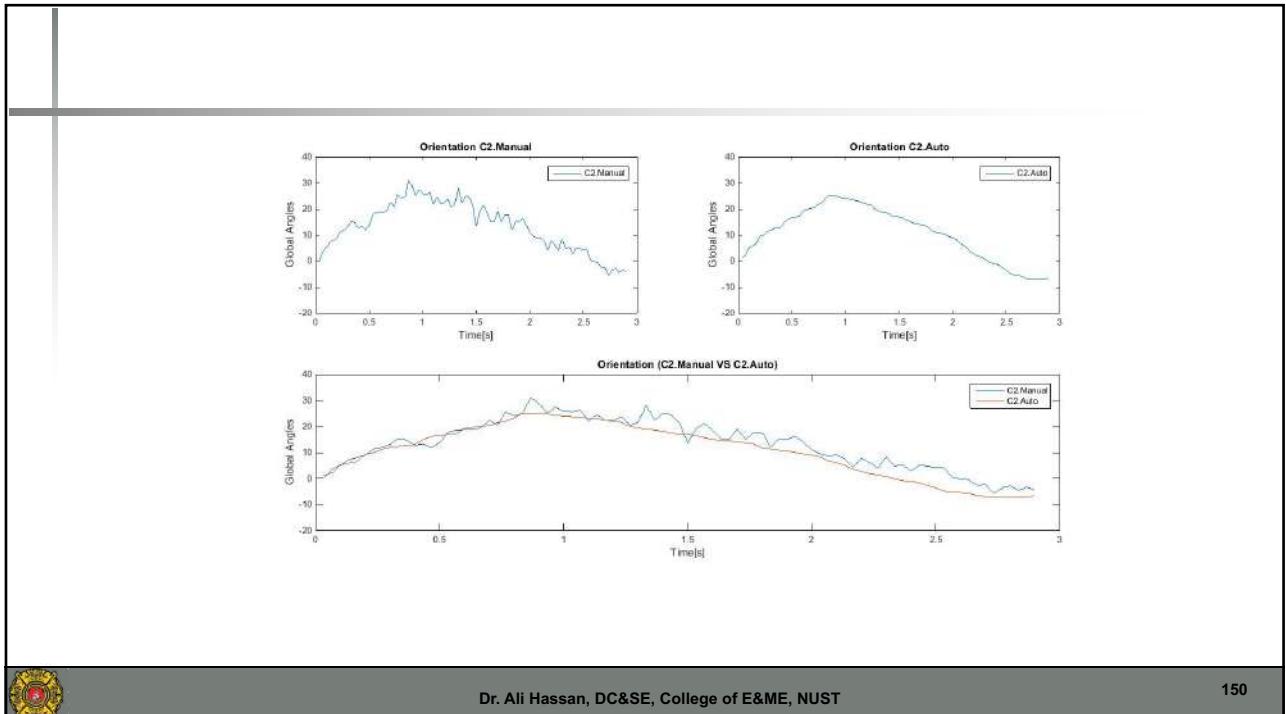
147

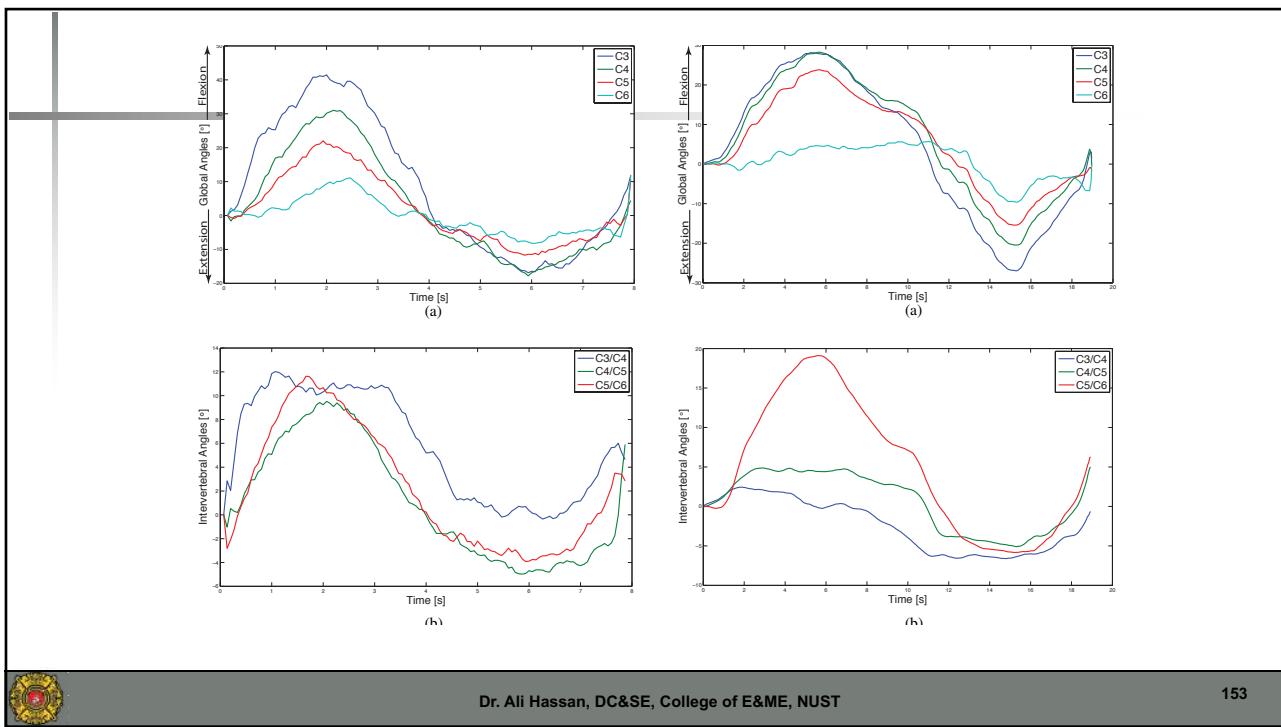
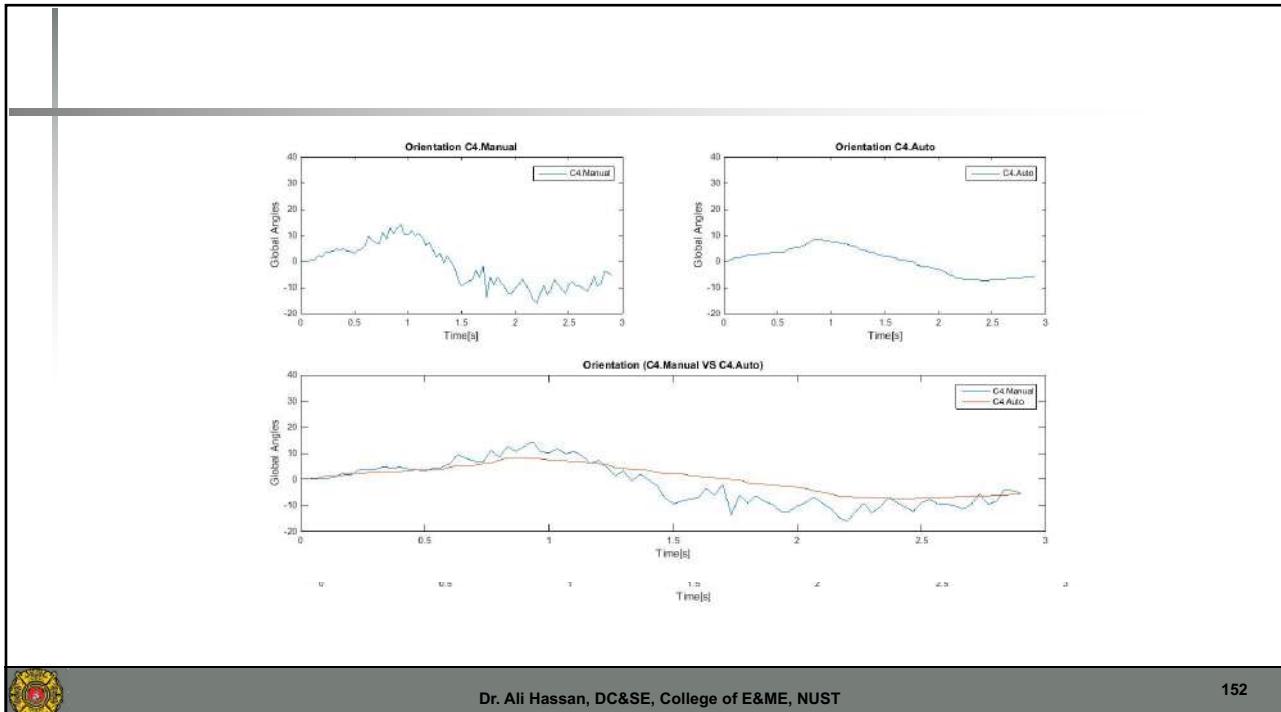


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Melanoma Detection

DERMOSCOPY



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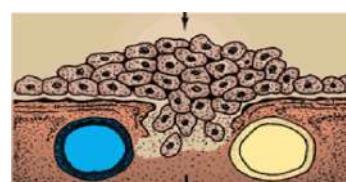
154

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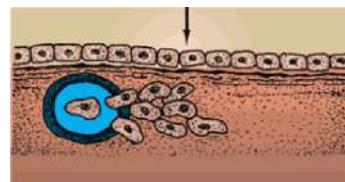
Early Detection of Cancer is Important



Stage I



Stage II



Stage III



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Dermoscopy



Dermoscopy procedure performed using a dermoscope.



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Image Obtained During Dermoscopy



Normal Images



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Image Obtained During Dermoscopy



Melanoma Images



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Research Challenges



Occlusion of tissues



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Research Challenges



Reflectance caused by

Gel

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Research Challenges



Quantification of Differential
Structures

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Requirements for Visual features

- Scale invariance
 - Dermoscopes can capture images at various resolutions. The image features should be invariant of the scale.



Requirements for Visual features

- Rotation invariance
 - Dermoscopes can capture images from various angles. The image features should be invariant of these visualizations.



GASTROENTEROLOGY

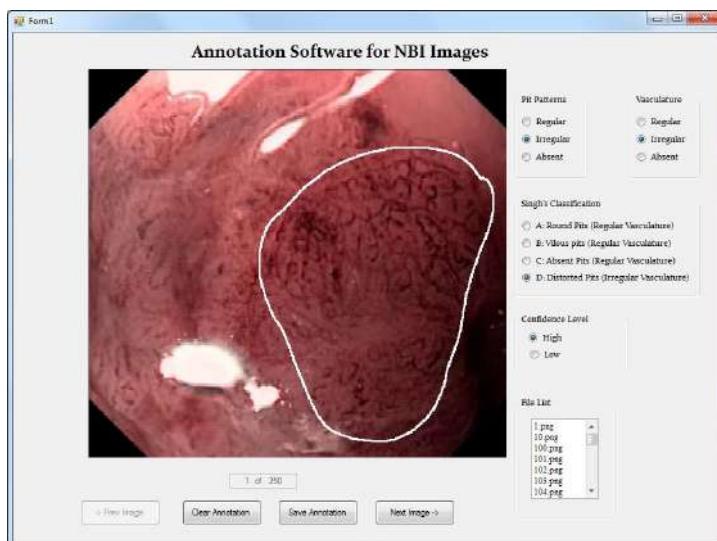


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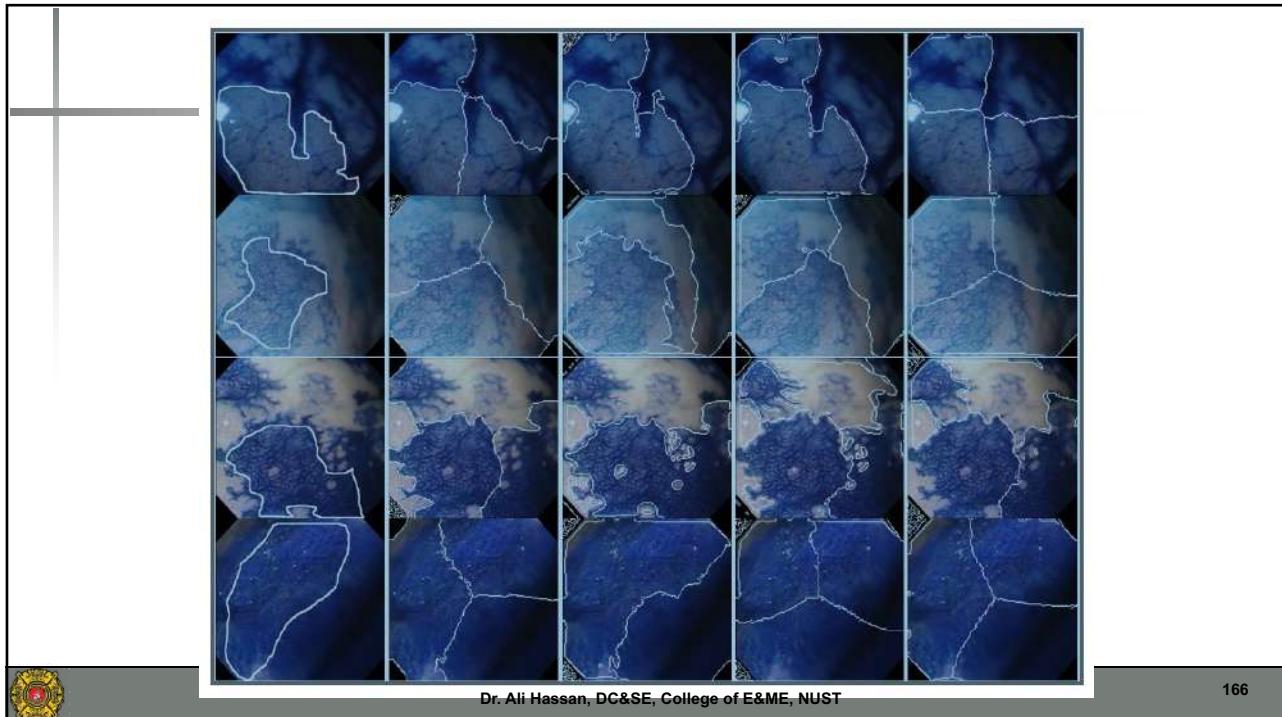
Software designed for obtaining annotations



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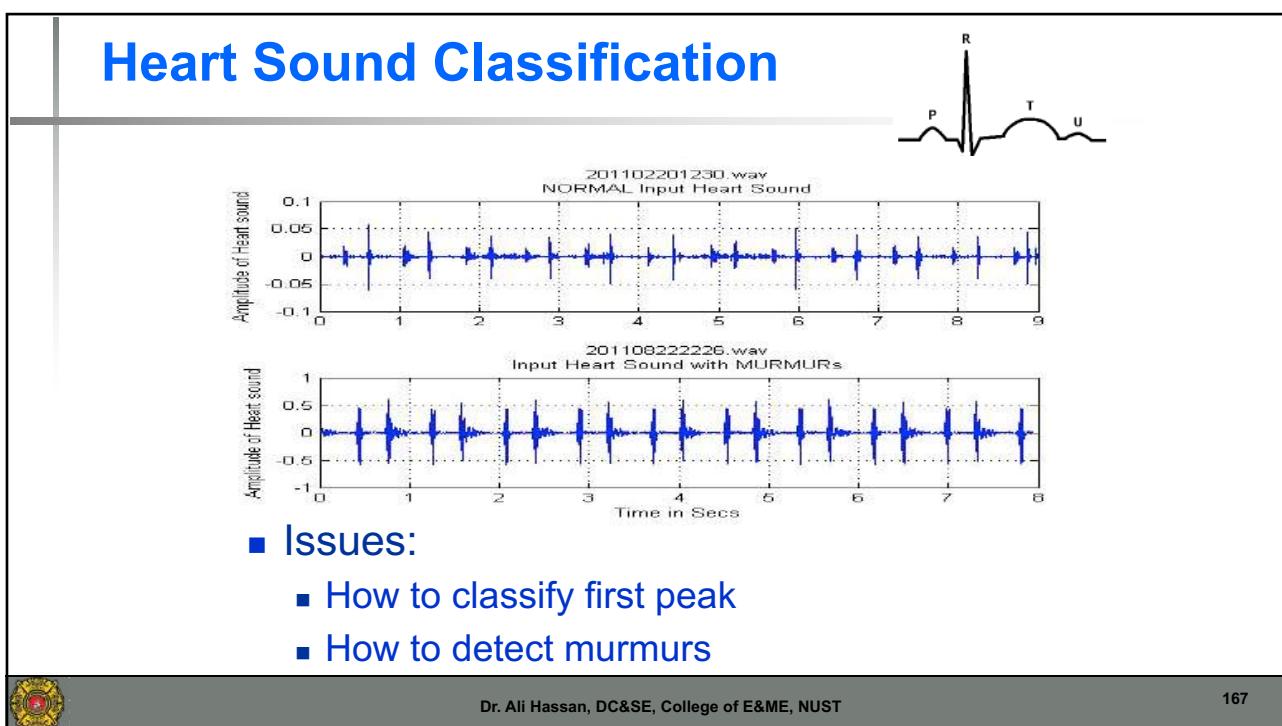
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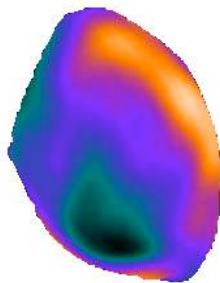
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Thallium+CT scan Images Fusion



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Thallium+CT scan Images Fusion

- Issues:
 - How to segment veins in the CT image
 - How to detect **thinness** of veins
 - How to segment left ventricle from CT image
 - How to classify different colours of Thallium scan
 - How to interpret information from both & **fused** images



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Using Kinect and Deep Learning

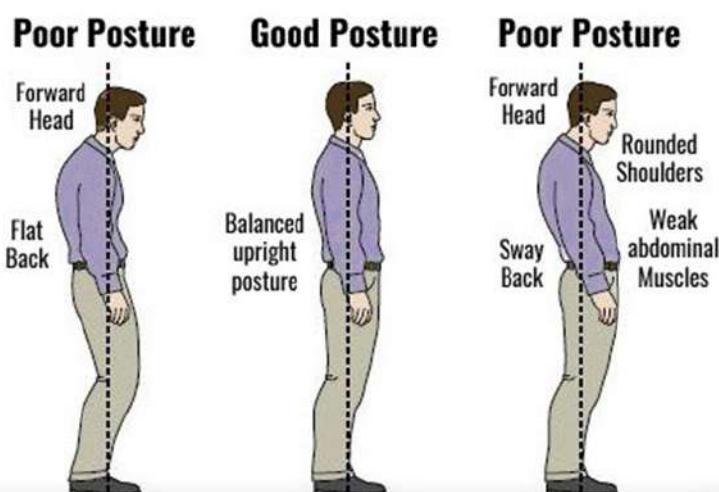
POSTURE RECOGNITION



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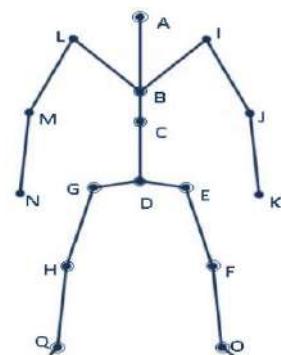


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Using Kinect and Deep Learning



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Where We want to be ...

Real-time Multi-Person 2D Pose Estimation Using Part Affinity Fields

Zhe Cao, Tomas Simon, Shih-En Wei, Yaser Sheikh
Carnegie Mellon University

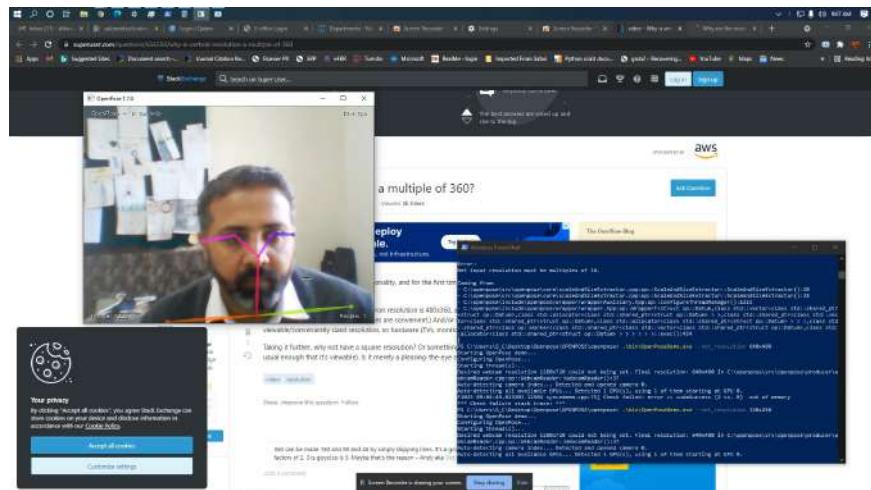


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Demo Video



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Gait Biomechanics

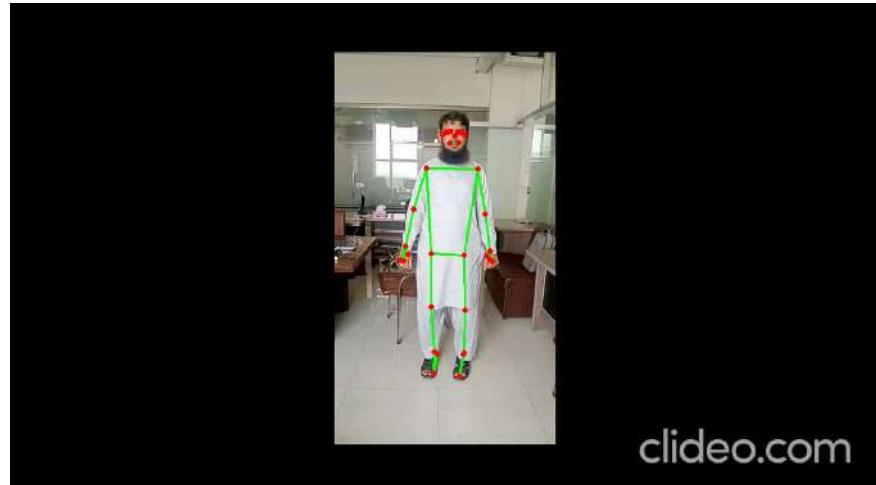


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Gait Biomechanics



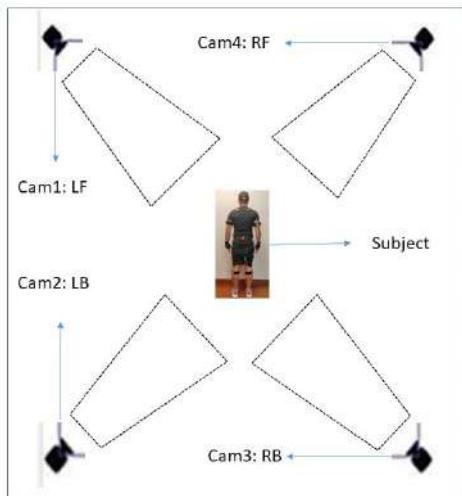
9/12/25

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Experimental Setup for Videos



9/12/25

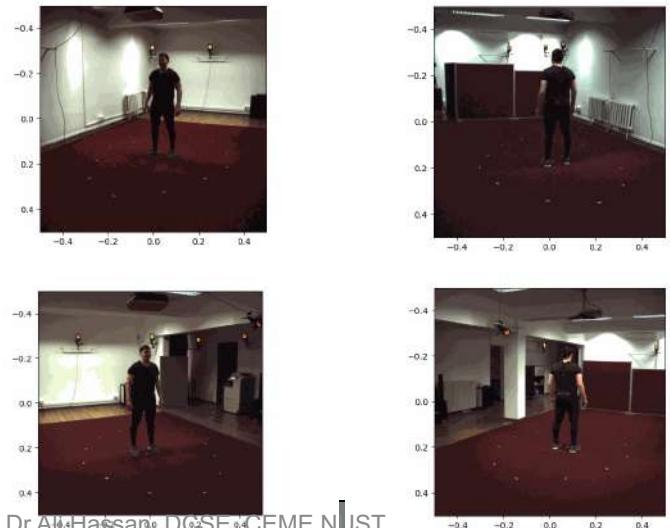
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DEMO-1

Subject videos from multiple angles



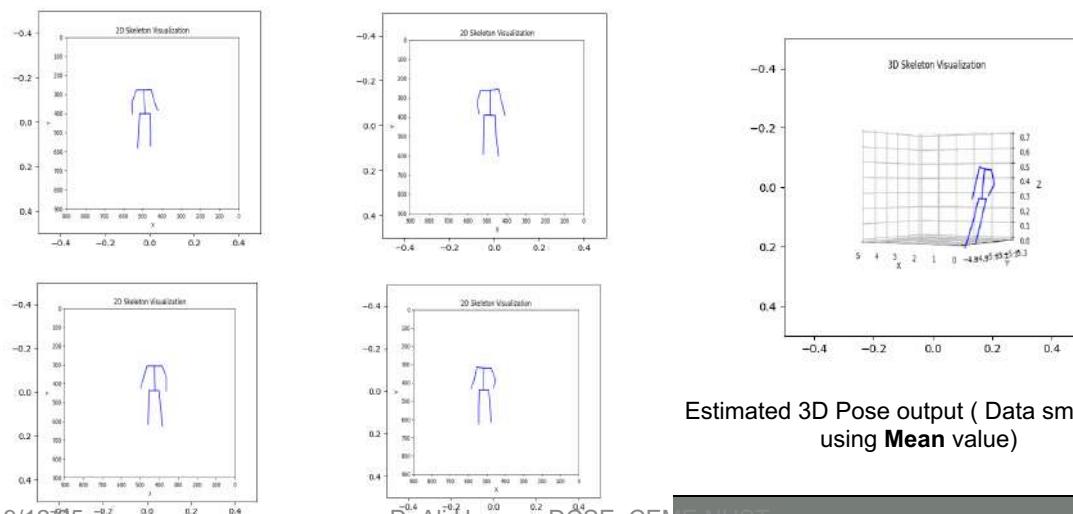
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DEMO-1 (Cont'd)



Estimated 3D Pose output (Data smoothing using **Mean** value)



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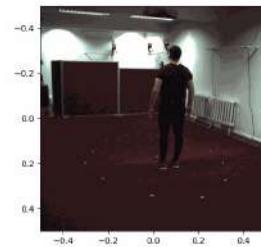
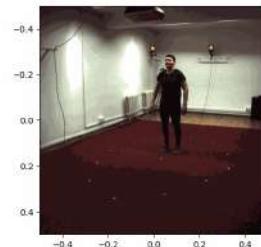
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DEMO-2

Subject videos from multiple angles



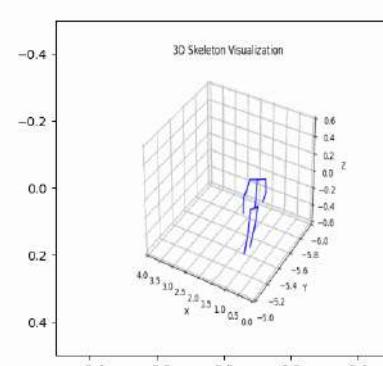
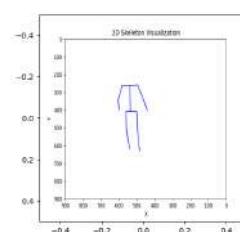
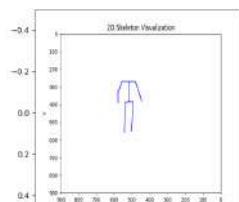
9/12/25

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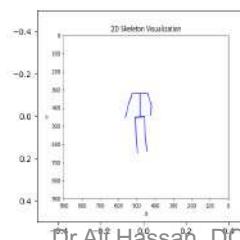
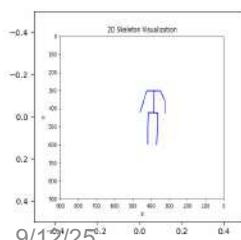
180 180

180

DEMO-2 (Cont'd)



Estimated 3D Pose output (Data smoothing using Mean value)



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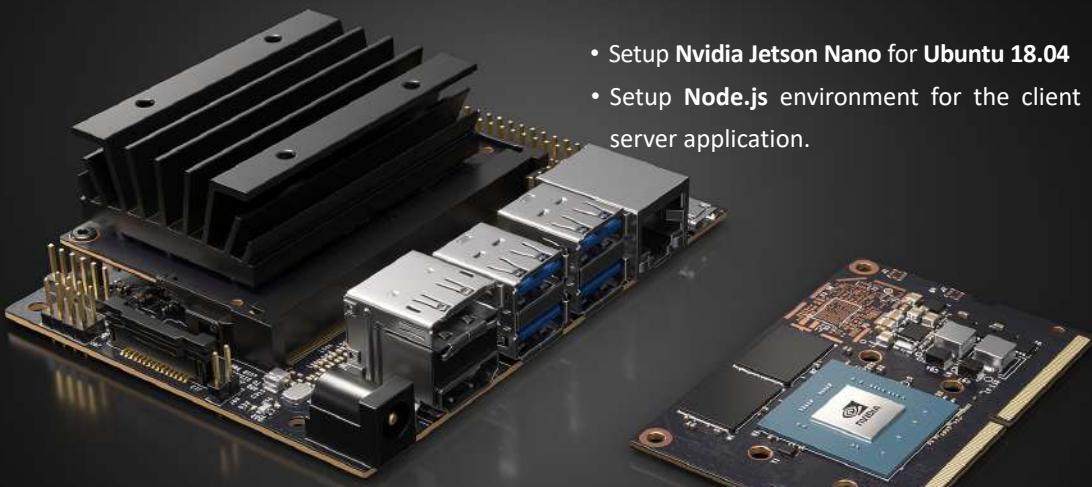
181 181

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Current Status

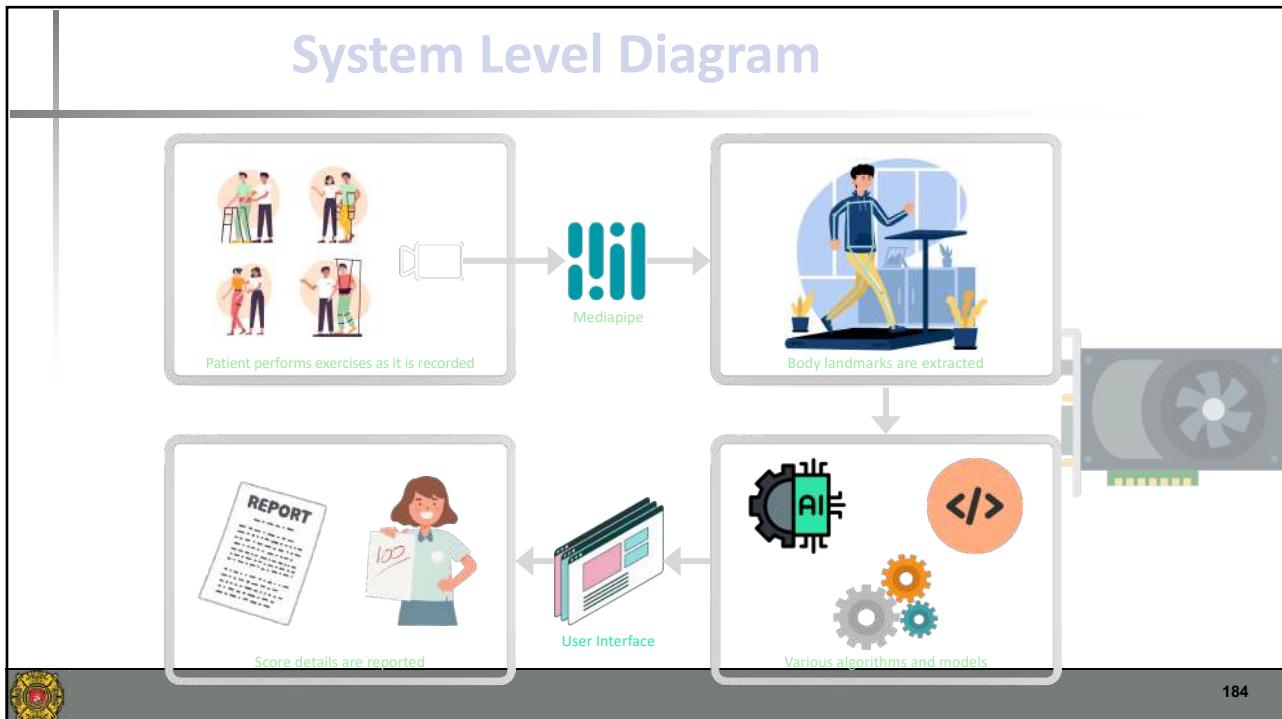
182

Deployment on JETSON NANO



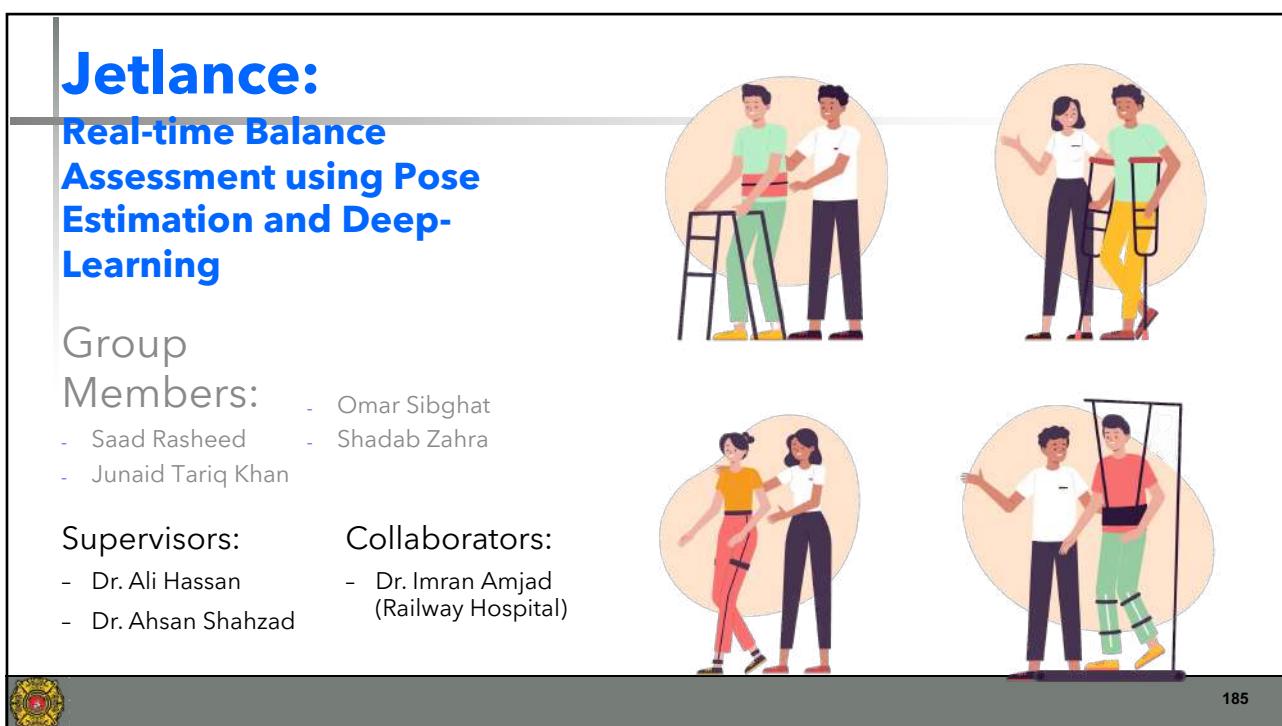
- Setup **Nvidia Jetson Nano** for **Ubuntu 18.04**
- Setup **Node.js** environment for the client and server application.
- Setup **Python Virtual Environment** for all the exercises scripts.
- Setup **MySQL Database** server for the users data.
- Every **Process** is running on different ports on **localhost**.

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What is the Berg Balance Test?

- Widely used clinical tool to assess balance and fall risk.
- Comprises 14 different tasks that challenge an individual's balance, such as one-leg standing or turning in a circle.
- Each task is scored from 0 to 4 based on the person's ability to complete it without losing balance or using external support.
- The total score ranges from 0 to 56, with scores of 45 or below suggesting an elevated risk of falling.
- Higher scores on the test indicate better balance and lower fall risk.



Deliverables

- Data Acquisition Protocol
- Dataset for Berg Balance Scoring
- A fully functional and user-ready system for Berg Balance Score assessment



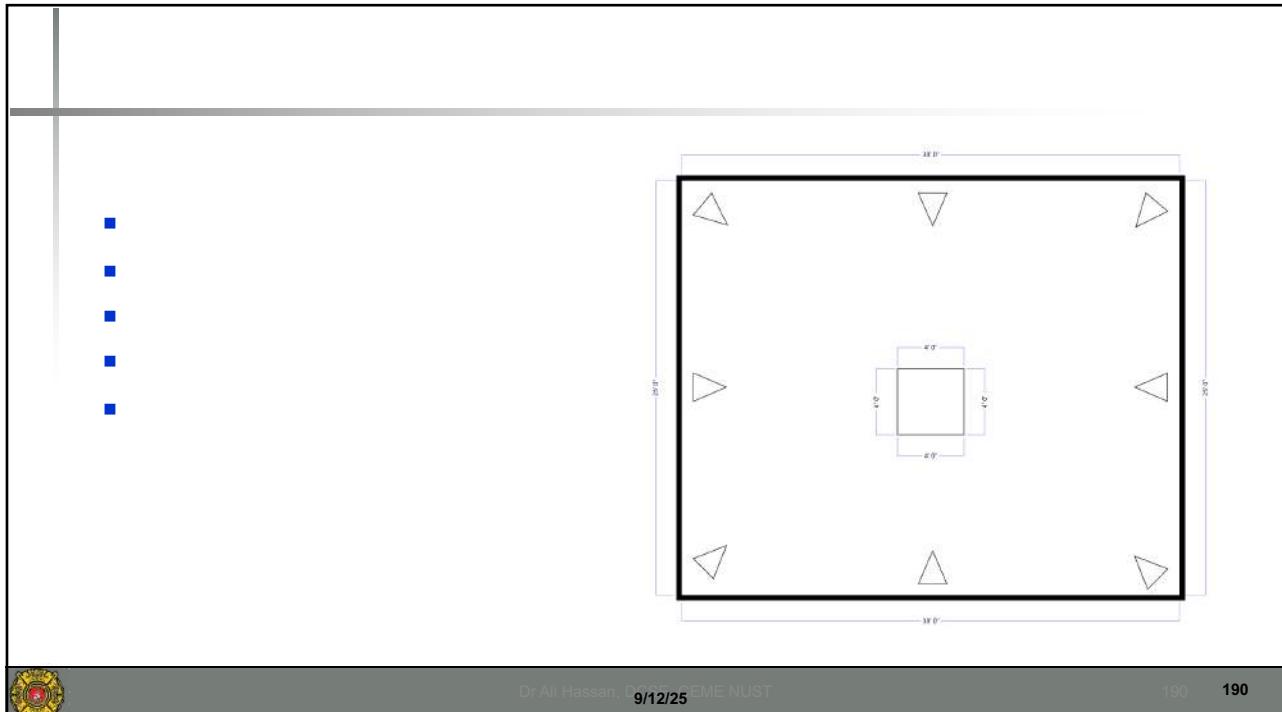
Technical Contributions and Challenges



Challenges

- Jetson unavailability
- Statistical features from pressure platform
- Hikvision network cameras
- NVR setup
- Webcams





Data Acquisition Setup



Data Collection



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Data Collection



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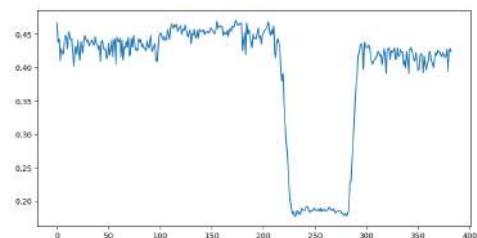
193 193

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Joint Extraction



Skeleton Frame 1



Removing Jitters

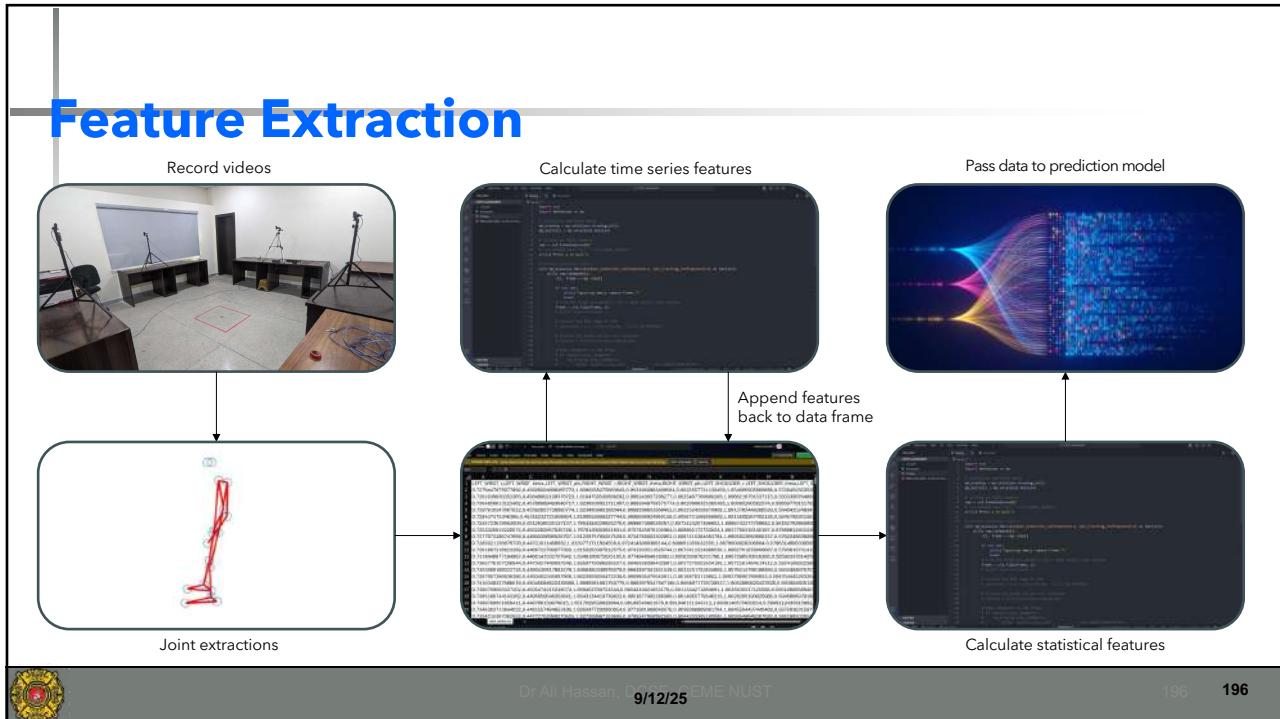
Skeleton Frame 1



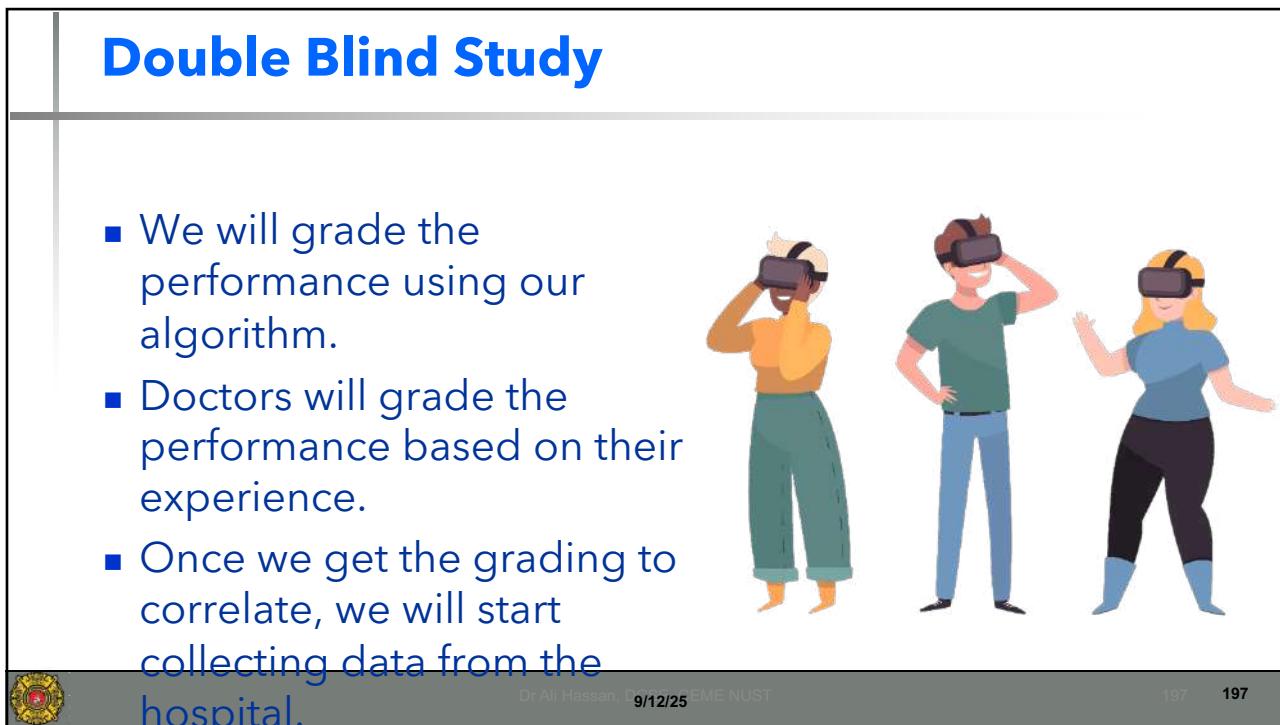
Moving Average

Skeleton Frame 1





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Hansa leather Smart Gloves

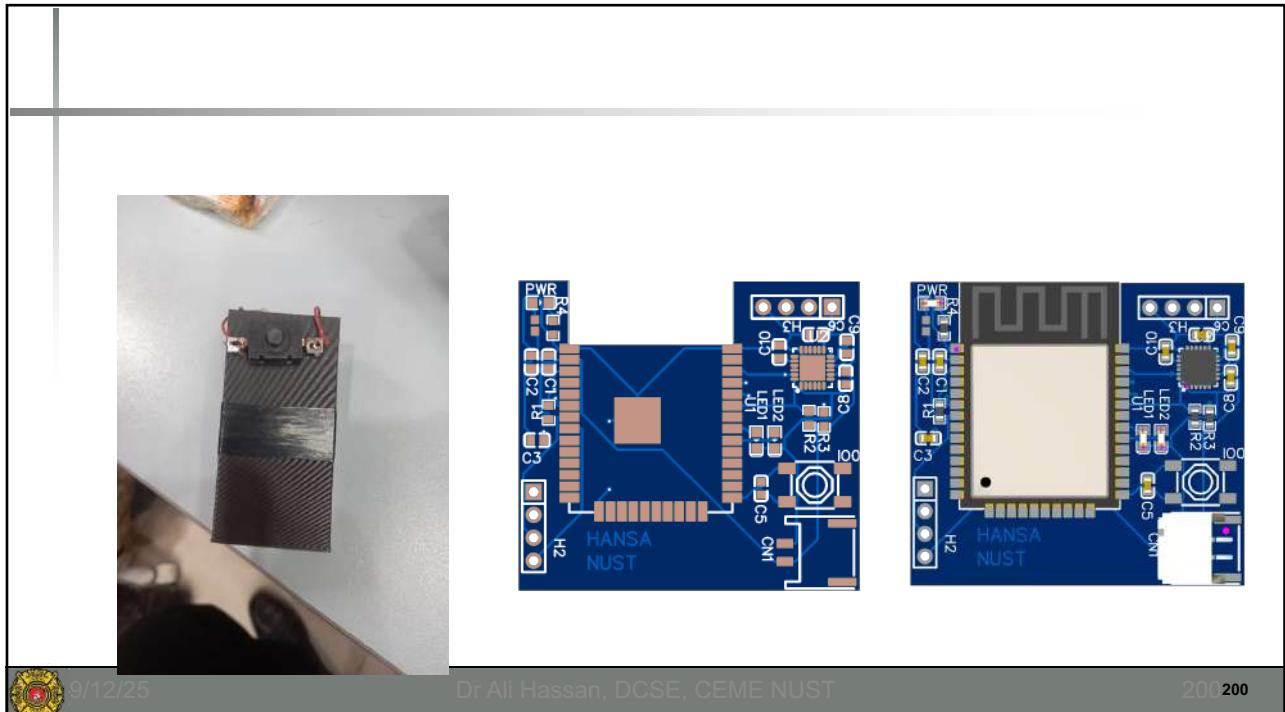


- Collaborators:
- Hansa Leather Garments (Pvt) Ltd.

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Digital Pakistan Lab

National Center of Data Analytics and Cloud Computing

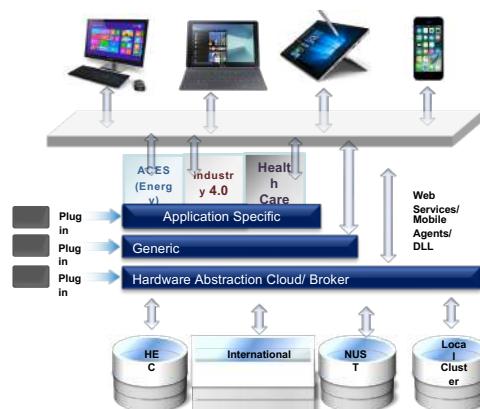


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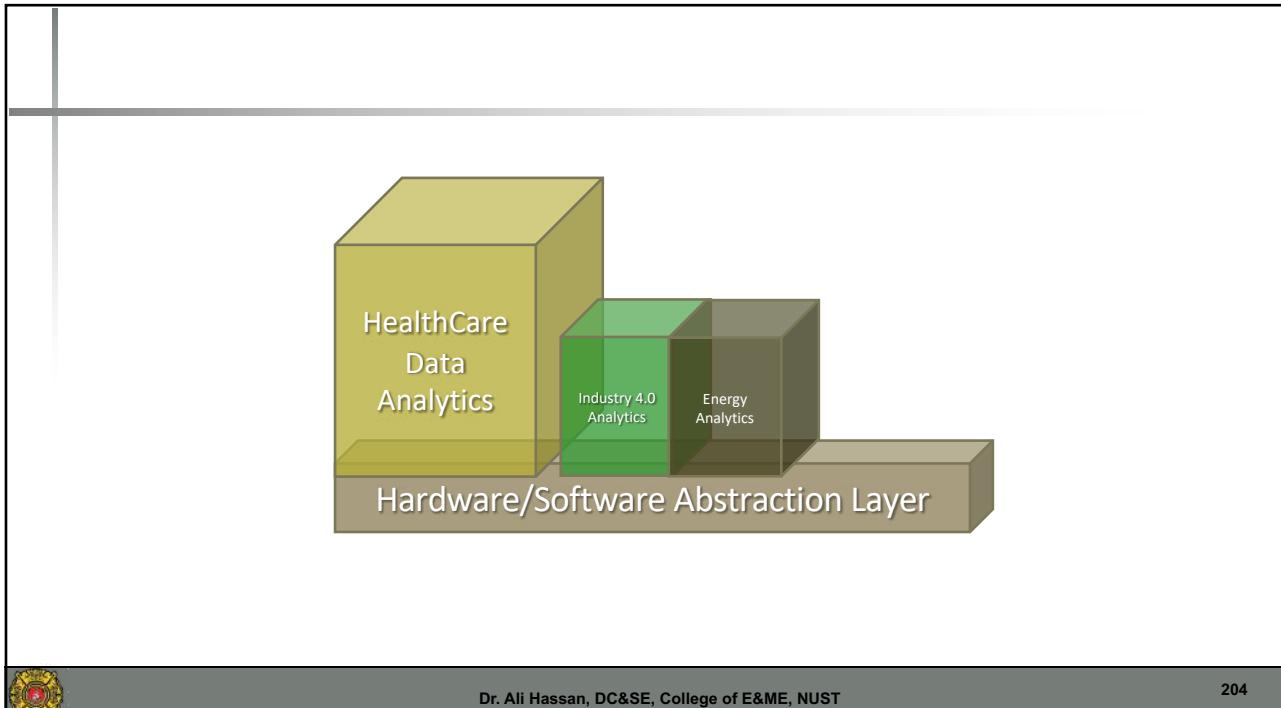
Digital Pakistan Lab Architectural View



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IntelliHealth: A medical decision support

- Knowledge and Data Science Research. Centre (KDRC), at EME College, developed this in collaboration with Pakistan Institute of Medical Sciences (PIMS), Islamabad

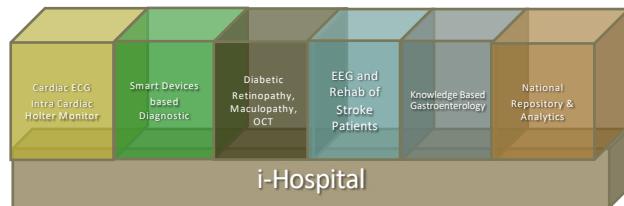
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Dr. Ali Hassan
NUST

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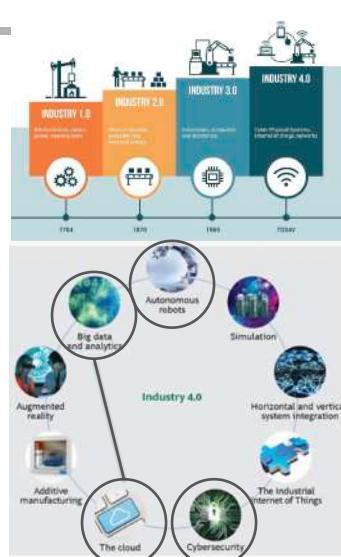
- Realize two components of intelligent hospital (i-Hospital) concept by
 - Developing an online repository of ECG signals and implementation of arrhythmia detection data processing and analytics
 - An EMR based data analytic utility for ophthalmology



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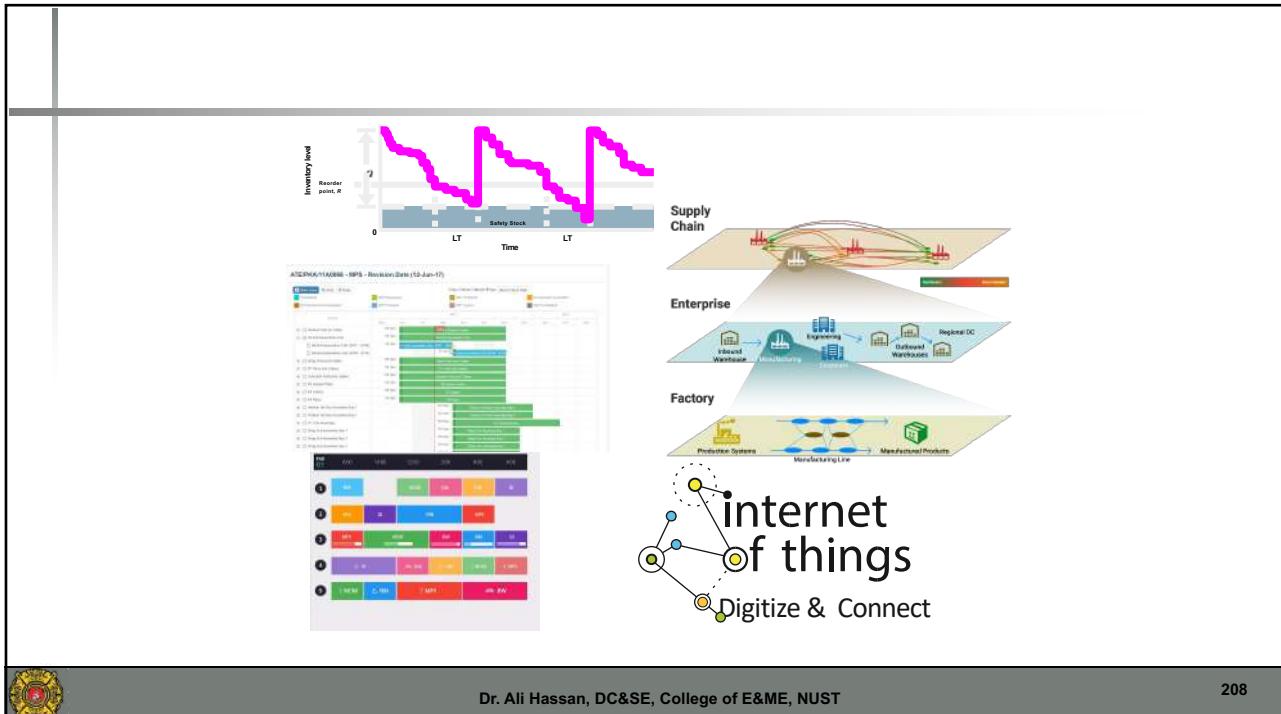
Industry 4.0 & its Technology Enablers



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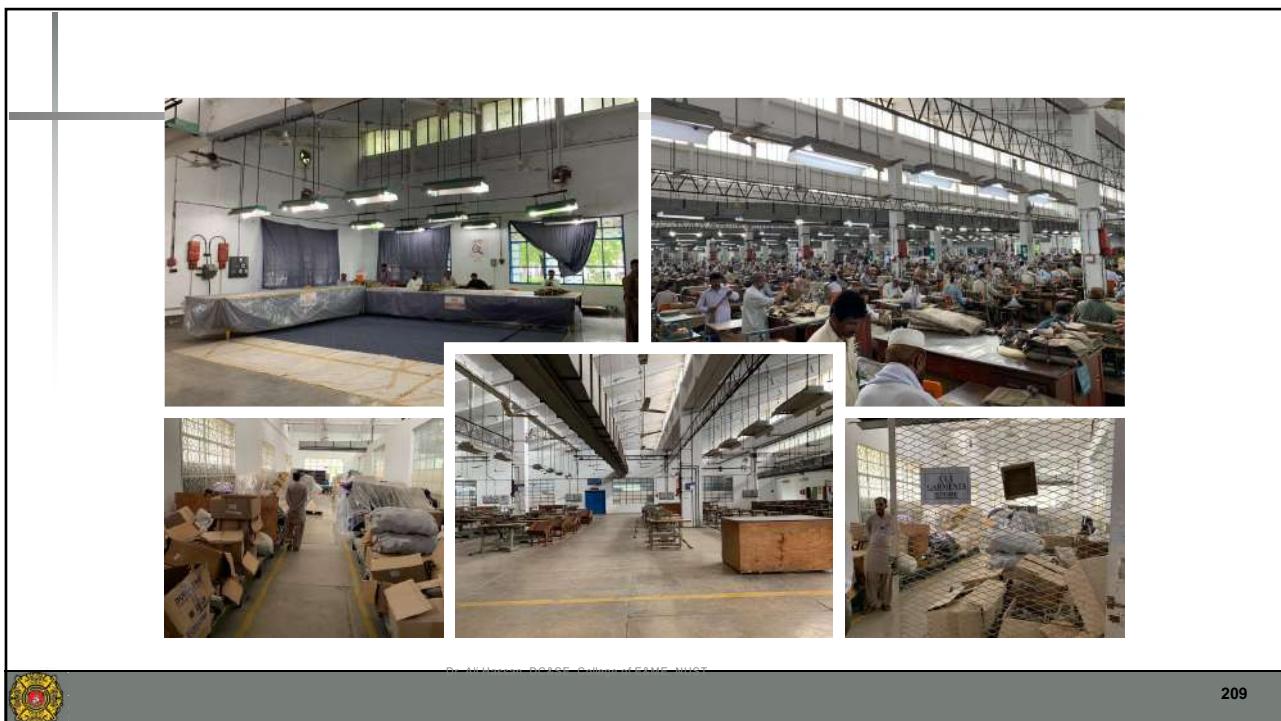
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The screenshot shows a machine learning dashboard interface. On the left, a sidebar menu includes Home, Charts, Favorites, Alerts, Settings, and Help. Below this is a 'Factory Section' with 'All Section Data' and a '+ Add Section' button. The main area displays two sections: 'Device 1' and 'Device 2'. Each section shows a pressure gauge icon, current value (0 Pa and 220 Pa), and temperature gauge icon, current value (1023 °F and 210 °F). To the right is a 'Control Panel' with three relay switches labeled Relay 1, Relay 2, and Relay 3. A 'Notification' section at the bottom right indicates 'No Notifications'.

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The screenshot shows a machine learning dashboard interface. On the left, a sidebar menu includes Home, Charts, Favorites, Setting, and Help. Below this is a 'Factory Dashboard' with 'All Section Data' and a '+ Add Section' button. The main area displays two charts: 'Current Hold' and 'Current Model II', both showing fluctuating data over time. To the right is a 'Control panel' with four toggle switches labeled Machine 1 through Machine 4. A 'Notifications' section at the bottom right lists three alerts: 'Alert 1' (Machine 1 has exceeded its maximum capacity), 'Alert 2' (Machine 2 has exceeded its maximum capacity), and 'Alert 3' (Machine 3 has exceeded its maximum capacity).

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- Add picture of Hansa Leather here

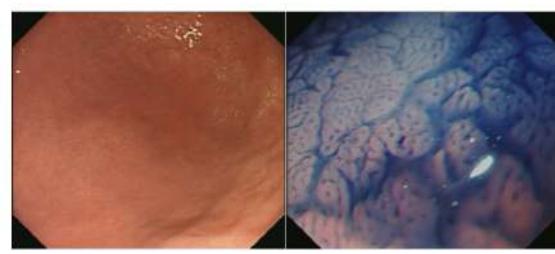
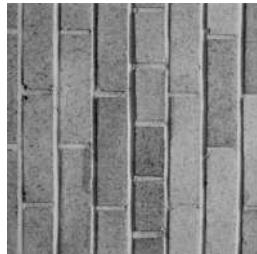


Research Interests

- Video Analytics and Biometrics



- Texture and Gastroenterology



What's the Point of this

- Motivate you that learning this course, you will also be able to do all of this
 - Atleast some of it ☺



Machine Learning Methods

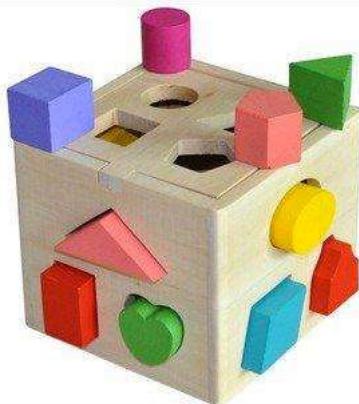
- Template matching
- Statistical approach
- Syntactic approach
- Neural networks



Template Matching

- A template (typically a 2D shape) or a prototype of the pattern to be recognized is available.
- Compute the similarity between the template and the pattern to be matched.
- Take into account pose (rotation, translation) and scale changes.





A typical template matching problem



Issues of concern

- Take an example of an image of size 28x28 pixels.
- You have to use all $28 \times 28 = 784$ pixels
- Computational complexity
- **Rigidity** assumption (use deformable template models)
- Choice of template



Statistical Approach

- Each pattern is represented in terms of **d- features**, and is viewed as a point in a d-dimensional space
- The goal is to choose those features that allow pattern vectors belonging to **different categories** to occupy **compact and disjoint regions** in a d-dimensional feature space.

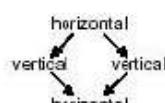


Statistical

Number of segments : 4
Number of horizontal segments : 2
Number of vertical segments : 2
Number of diagonal segments : 0



Structural



Statistical

Number of segments : 3
Number of horizontal segments : 1
Number of vertical segments : 0
Number of diagonal segments : 2



Issues of concern

- Usually $d \ll D$ (dimensions of image/signal)
- What should be the value of d ??
- We might encounter **curse of dimensionality**



Syntactic Approach

- Use hierarchical structures to represent complex patterns.
- The simplest unit is called: ***primitives***
- Complex pattern is represented in terms of the interrelationships (***grammars***) between the primitives.
- Learn Grammatical rules from Data
- Trend analysis using tweets

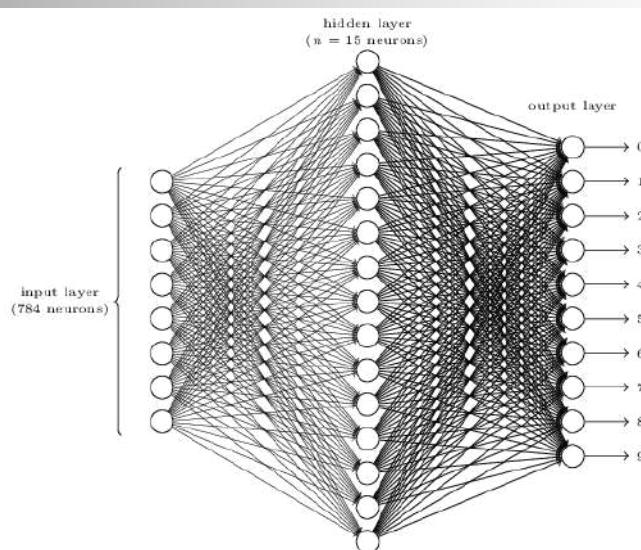


Issues of concern

- However, it's usually difficult to segment noisy patterns and infer grammar from the training set.
- May yield a combinatorial explosions of possibilities to be investigated.



Neural Networks



Neural Networks

- Massively parallel computing systems consisting of an extremely large number of simple processors with many interconnections.
- Can learn complex *non-linear* input-output relationships.
- Feed-forward networks such as multilayer perceptron and Radial Basis Function network are useful for pattern classification.



Separating Salmon from Sea Bass

MACHINE LEARNING EXAMPLE



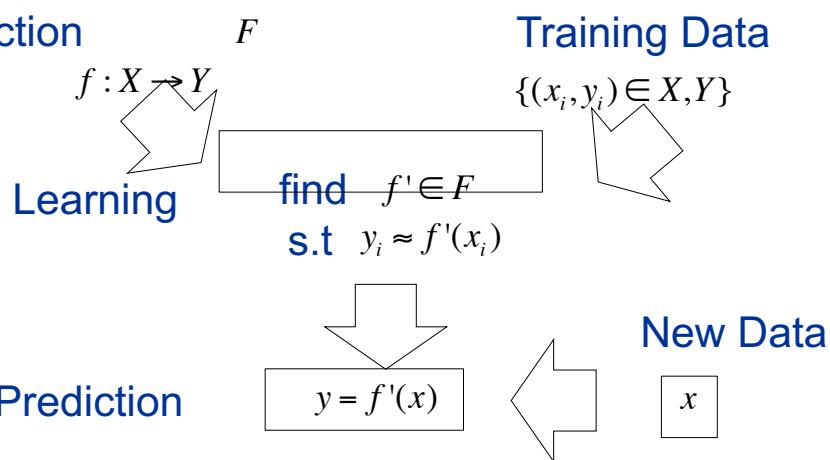
An Example

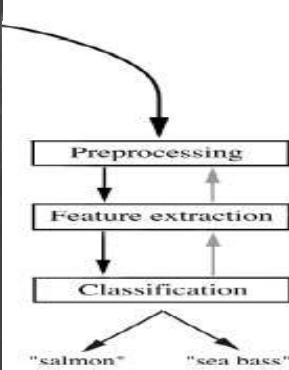
- “Sorting incoming Fish on a conveyor according to species using optical sensing”



Pattern Recognition: Overview

- Function

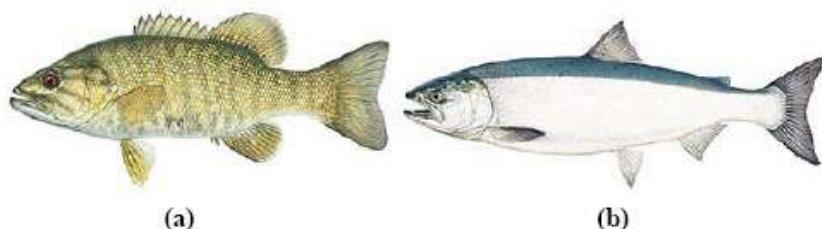




Pre-Processing

- Use a **segmentation** operation to isolate fishes from one another and from the background
- Information from a single fish is sent to a **feature extractor** whose purpose is to reduce the data by measuring certain features
- The features are passed to a **classifier** or decision maker





The objects to be classified; (a). Sea bass,
and (b). salmon.



Problem Analysis

- Set up a camera and take some sample images to extract features
 - Length
 - Lightness
 - Width
 - Number and shape of fins
 - Position of the mouth, etc...
- This is the set of all suggested features to explore for use in our classifier!



System Design Process

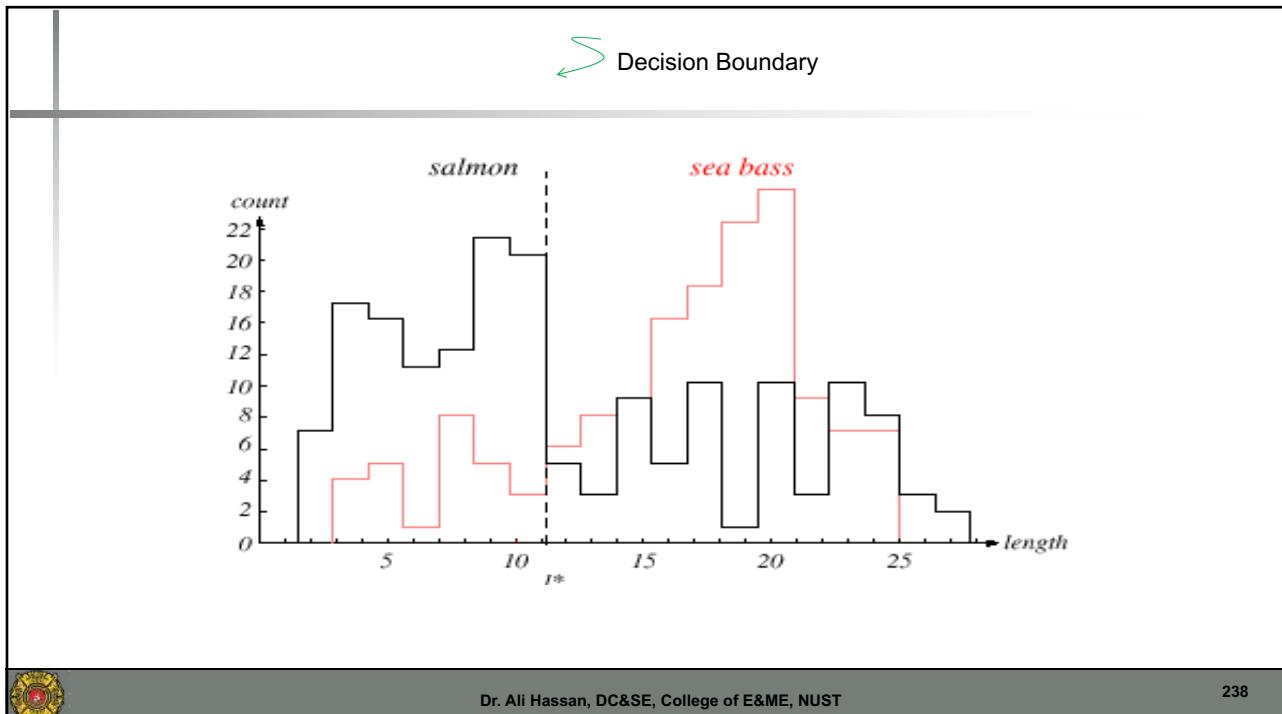
- Domain knowledge:
 - a sea bass is generally longer than a salmon
- Selected Feature
 - Select the **length** of the fish as a possible feature for discrimination
- Model:
 - Sea bass have some typical length, and this is greater than the length of a salmon



System Design Process

- Classification Rule
 - $f' = \begin{cases} \text{If } Length \geq l^* \text{ then sea bass} \\ \text{otherwise salmon} \end{cases}$
- How to choose l^* ???
- Use **Training Data**

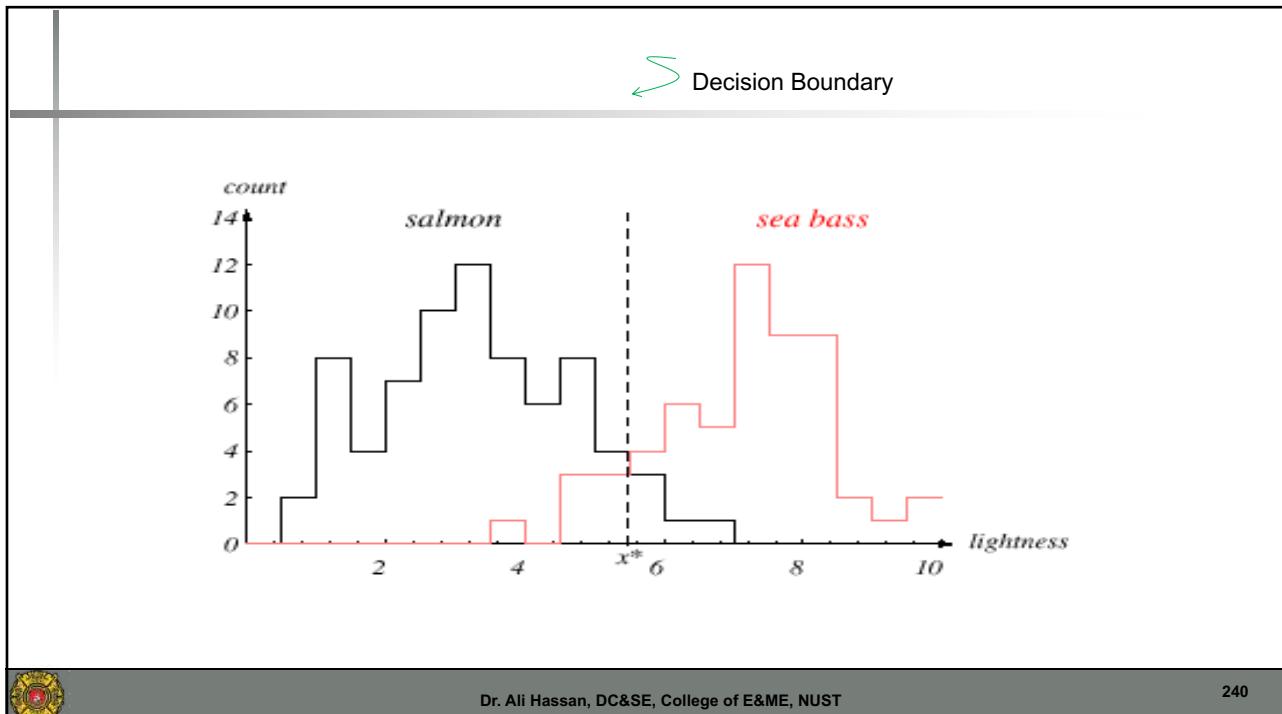




Analysis

- The **length** is a poor feature alone!
- New Feature:
 - Select the **lightness of fish** as a possible feature





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Adding More Features

- Adopt the lightness and add the width of the fish

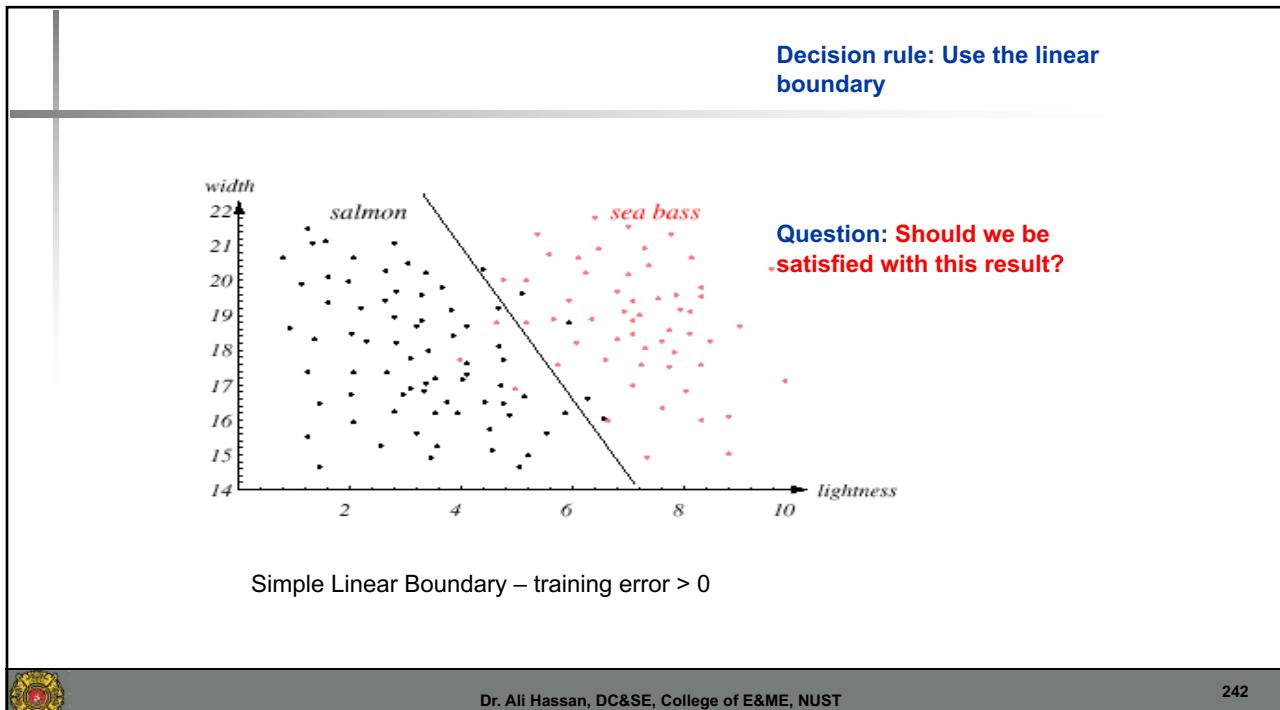
$$\text{Fish} \rightarrow \mathbf{x}^T = [x_1, x_2]$$



Lightness Width

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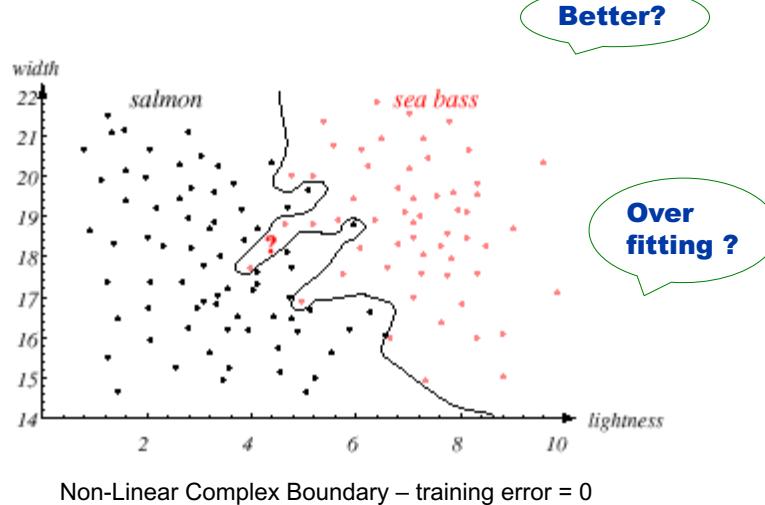
241



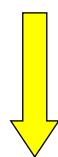
- We might add other features that are not correlated with the ones we already have. A precaution should be taken not to reduce the performance by adding such “noisy features”
- Ideally, the best decision boundary should be the one which provides an optimal performance
- Use a **more complex model**



Optimal Separation Boundary



- However, our satisfaction is premature because the central aim of designing a classifier is to correctly classify novel input

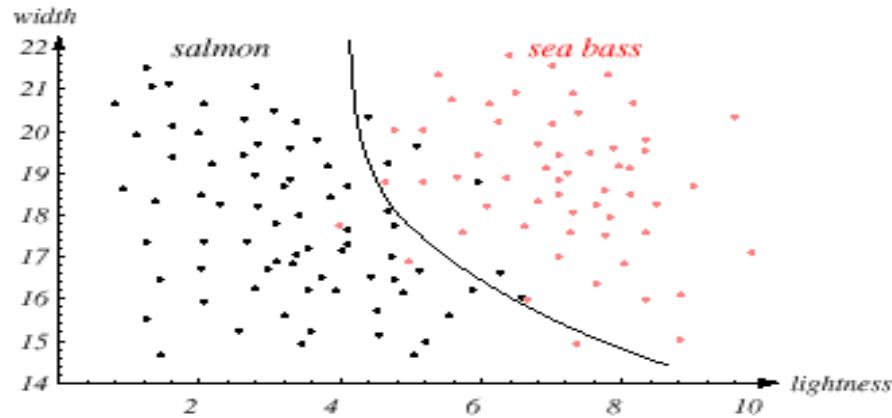


Issue of generalization!



Generalization

- The classifier should capture the underlying characteristics of the categories
- The classifier should NOT be tuned to the specific (accidental) characteristics of the training data
- A good classifier should be able to generalize, i.e. perform well on unseen data
- Training data in practice contain some noise



Simpler non-Linear Boundary – training error > 0



Decision Costs

- A classifier, intuitively, is designed to minimize classification error, the total number of instances (fish) classified incorrectly.
 - Is this the best objective (cost) function to minimize?
 - What kinds of error can be made? Are they all equally bad? What is the real cost of making an error?
 - Sea bass misclassified as salmon: Pleasant surprise for the consumer, tastier fish/ manufacturer lose money for selling expensive fish for the cost of inexpensive fish
 - Salmon misclassified as sea bass: Customer upset, paid too much for inferior fish

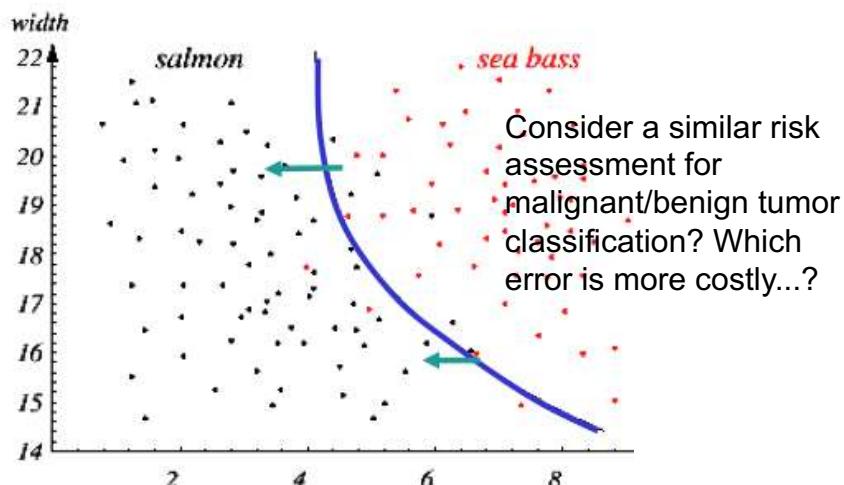


Decision Costs ...

- Threshold decision boundary and cost relationship
 - Move our decision boundary toward smaller values of lightness in order to minimize the cost (reduce the number of sea bass that are classified salmon!)

Task of decision theory

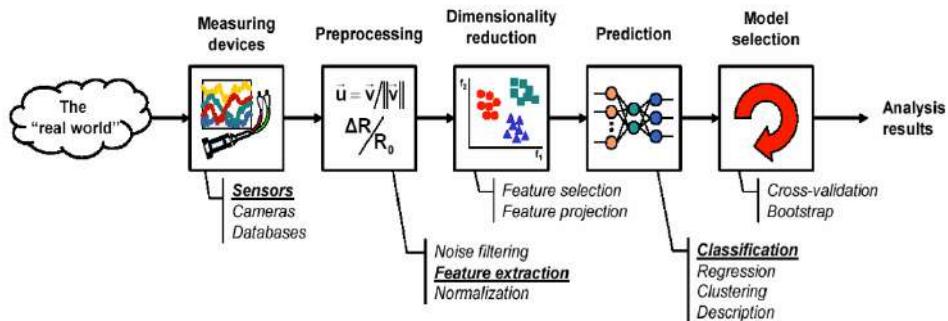




MACHINE LEARNING DESIGN CYCLE



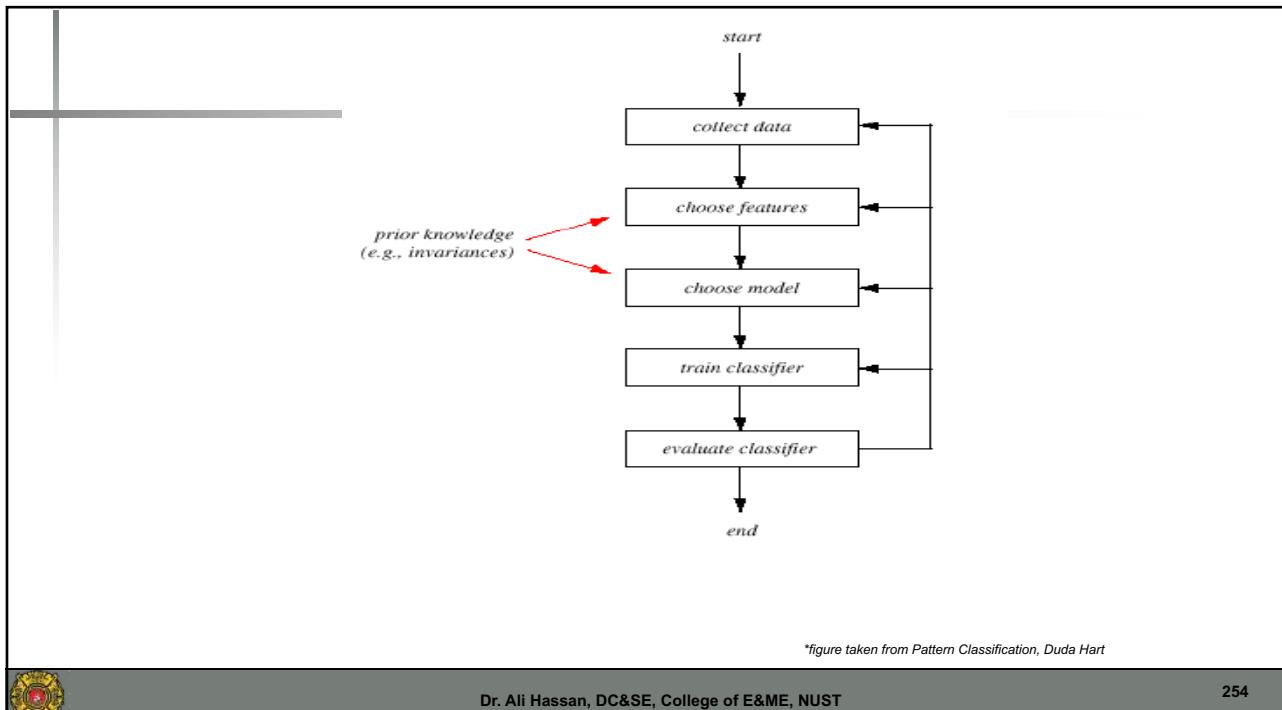
The Design Cycle



The Design Cycle

- Data collection
- Feature Choice
- Model Choice
- Training
- Evaluation
- Computational Complexity





*figure taken from *Pattern Classification*, Duda Hart



■ Data Collection

- How do we know when we have collected an adequately large and representative set of examples for training and testing the system?

■ Pre-Processing

- Filtering
- Normalisation
- How many examples of each class should be obtained



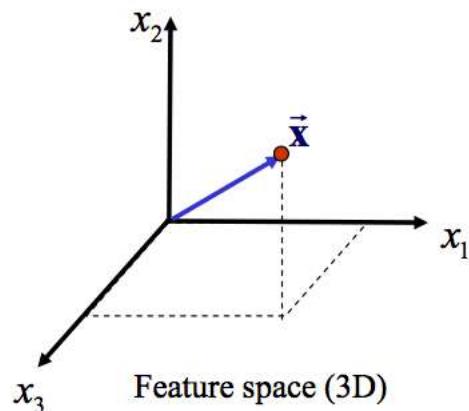
Features

- **Features:** a set of variables believed to carry discriminating and characterizing information about the objects under consideration
- **Feature vector:** A collection of d features, ordered in some meaningful way into a d- dimensional column vector, that represents the signature of the object to be identified.
- **Feature space:** The d-dimensional space in which the feature vectors lie. A d-dimensional vector in a d-dimensional space constitutes a point in that space.



Features

$$\mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_d \end{bmatrix} \begin{array}{l} \text{feature 1} \\ \text{feature 2} \\ \vdots \\ \text{feature } d \end{array}$$



Features

- Feature Choice
 - Good Features
 - Ideally, for a given group of patterns coming from the same class, feature values should all be similar
 - For patterns coming from different classes, the feature values should be different.
 - Bad Features
 - irrelevant, noisy, outlier?
- Bottom Line
 - In any PR problem, you get what you put in: **garbage in – garbage out!**



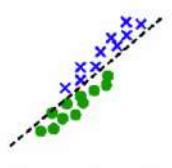
"Bad" features



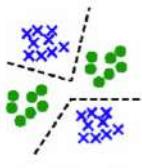
Linear separability



Non-linear separability



Highly correlated features



Multi-modal



■ Model Choice

- What type of *classifier* shall we use? How shall we select its parameters? Is there best classifier...?
- How do we train...? How do we adjust the parameters of the model (*classifier*) we picked so that the model fits the data?



■ Training

- Use data to determine the *classifier*. Many different procedures for training classifiers and choosing models



- Evaluation

- Measure the error rate (or performance and switch from one set of features to another one)



- Computational Complexity

- What is the trade-off between computational ease and performance?
- (How an algorithm scales as a function of the number of features, patterns or categories?)

