CS 725: Foundations of Machine Learning

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Machine Learning

- Give a computer the ability to learn to perform tasks without explicit programming

    - Tasks: labeling images, recognizing faces, converting voice to text, forecasting, translation, editing grammar,..

- Learn how?

    - Collect examples of (input, output) pairs

    - Train a model or a function to fit the examples

- Perform tasks how?

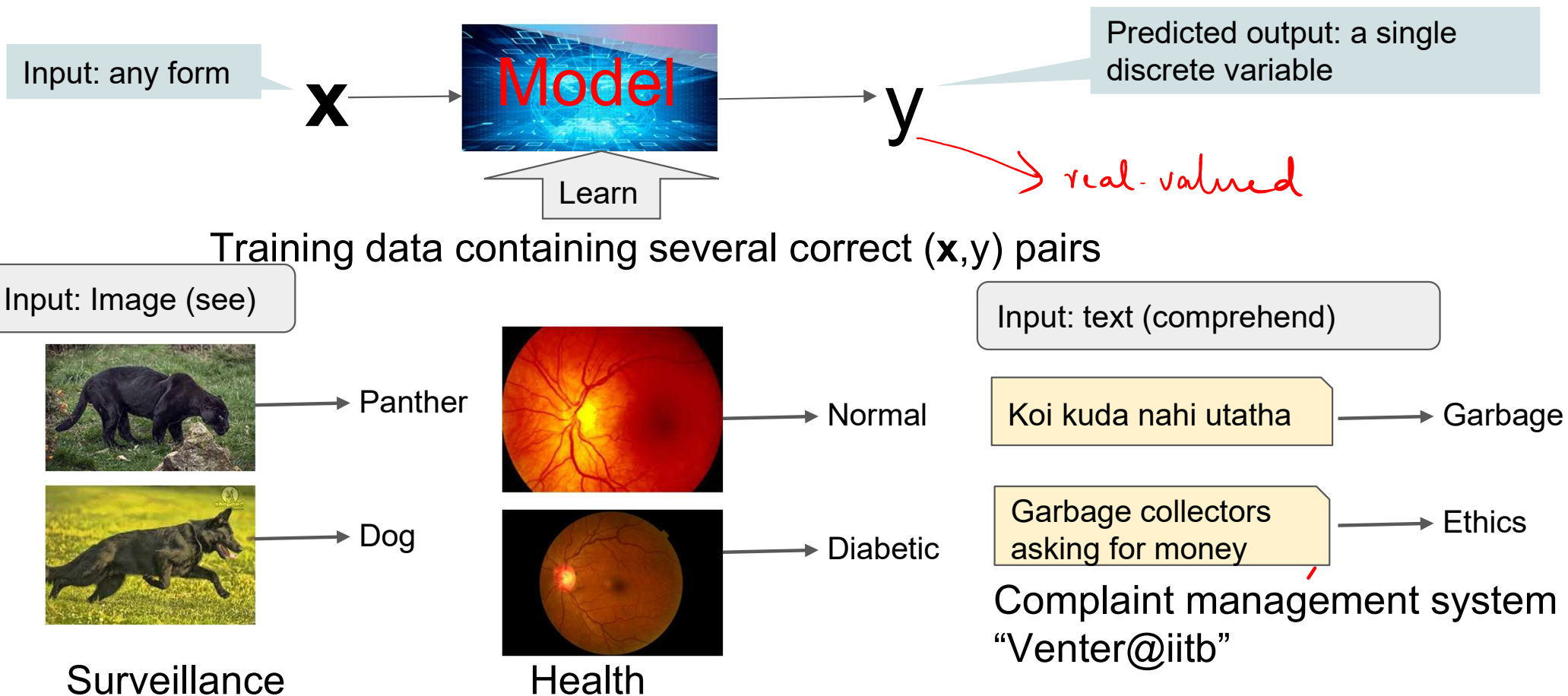   - Given a new input, invoke the model and reads its output

Why learn from examples instead of writing programs?

Example isn't another way to teach, it is the only way to teach.
— Albert Einstein —
AZ QUOTES
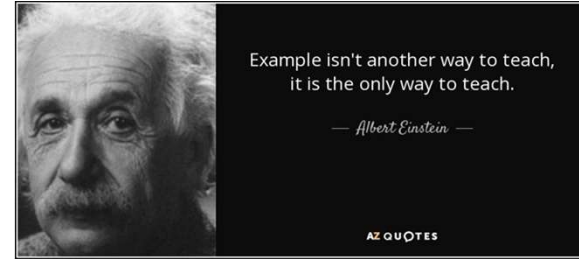
Difficult for a programmer to express perfect input-output relationship but easy for humans to label, example:

- Labeling an audio sample as "Alexa" is easier than writing programs

- Humans can easily draw outline of an object but cannot write program for drawing outline in an arbitrary image
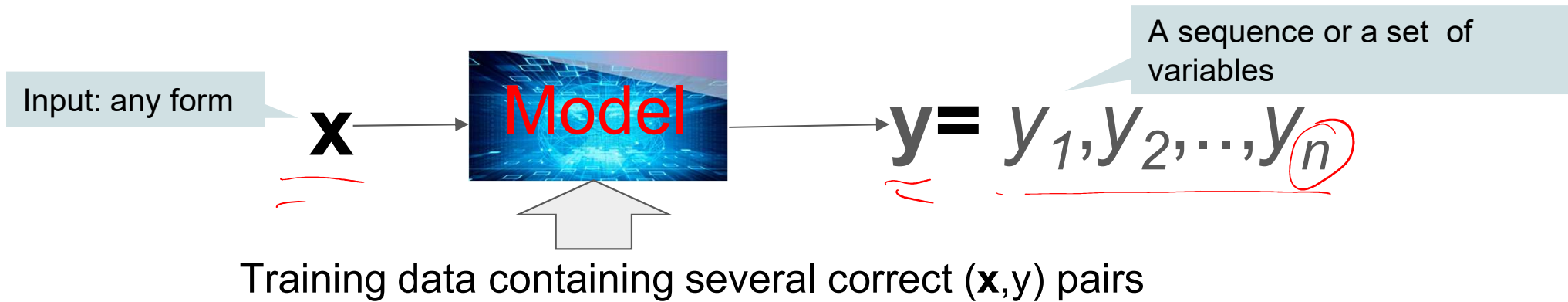
A simple task: Classification / Regression

Input: any form

x → Model → y

Predicted output: a single discrete variable

→ real-valued

Learn

Training data containing several correct (**x**,y) pairs

Input: Image (see)

 → Panther

 → Dog

Surveillance

 → Normal

 → Diabetic

Health

Input: text (comprehend)

Koi kuda nahi utatha → Garbage

Garbage collectors asking for money → Ethics

Complaint management system "Venter@iitb"

And thousands of others: forecasting, recommendation, advertising, science, languages, vision…..

Innumerable Applications

- Ad placement in search engines

- Inventory management: Predict sale of soft drinks in outlets based on weather, events (sport)

- Scheduling: predicting traffic, flight arrival times.

- Fraud detection: telecommunications, financial transactions

  - from an online stream of event identify fraudulent events

- Banking: loan/credit card approval

  - predict good customers based on old customers

- Customer relationship management:

  - identify those who are likely to leave for a competitor.

- Targeted marketing:

  - Recommendation of Movies, Books, Products on E-commerce sites

More complex tasks

Input: any form

$\mathbf{x}$

Model

$\mathbf{y} = y_1, y_2, \ldots, y_n$

A sequence or a set of variables

Training data containing several correct ($\mathbf{x}$,y) pairs

Translation

Input: x

Output: y

Where can I find healthy and traditional Indian food? →

स्वस्थ और पारंपरिक भारतीय भोजन कहां मिल सकता है?

$y_1 \quad y_2 \quad y_3 \quad y_4 \quad y_5 \quad y_6 \quad y_7 \quad y_8 \quad y_9$

Speech recognition
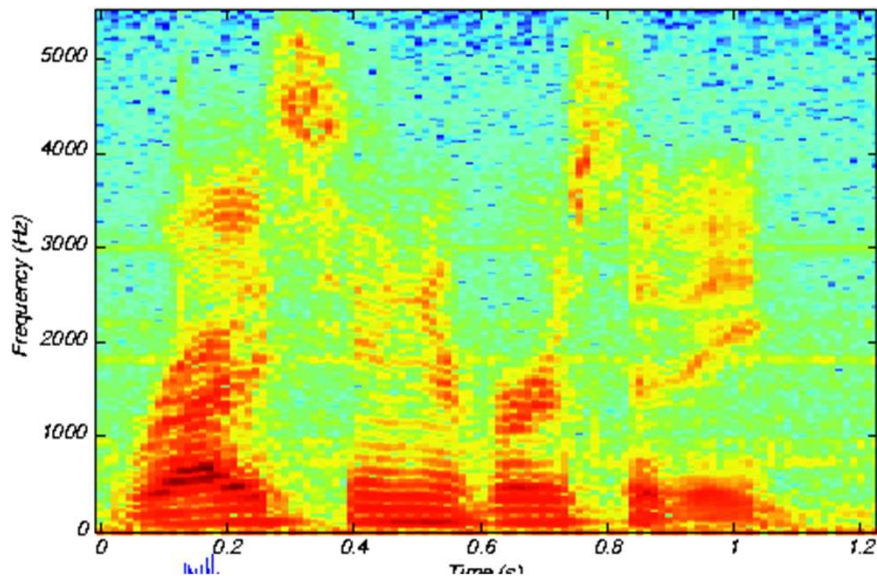
Ri   ce   Uni   ver   si   ty

Gives machines the power to "listen"
and respond to voice commands

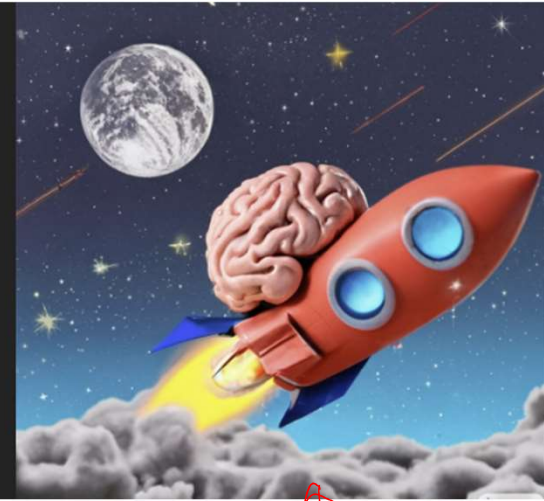# Grammar Error Correction

Context: x

Predicted sequence: y

She see Tom is catched by policeman in park at last night. → She saw Tom ~~being caught~~ by a policeman in the park ~~at~~ last night.

Image Generation

A brain riding a rocketship heading towards the moon.

- Imagen: https://imagen.research.google/
- Dall-E: https://labs.openai.com/
- Stable Diffusion https://stablediffusionweb.com/

Large Language Models (E.g. ChatGPT)

- Write a poem
- Design a marketing strategy
- Solve a math problem
- Write code
- Take law exams
- Converse on diverse topics
- .

- [2307.10169.pdf (arxiv.org)](#)

Scope of the course

- This course is not about using ML to solve cool tasks but about understanding the underlying *foundational principles and methodologies* behind learning from examples so that

  - You can teach machines to solve more such tasks using your knowledge of the founding principles

  - You can intelligently drive the design and training of ML models

  - Debug non-performance

Questions that we will address in this course
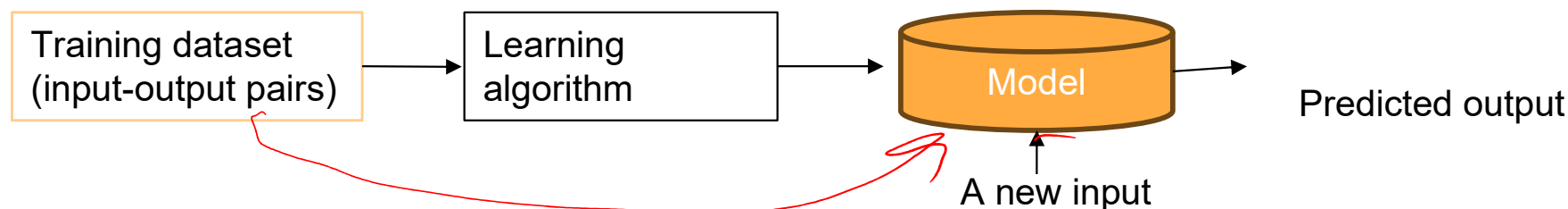
- What is the form of the model?
- How does the learning algorithm work?
- How do we make ensure generalization so the model will produce (mostly) correct outputs on test/deployment data?
- How to tractably handle complex inputs and outputs?
- What if we do not have enough labelled examples for each task? Can we share learning across tasks?

Course information

- Course Web page
  - http://www.cse.iitb.ac.in/~sunita/cs725

Instructor

- Sunita Sarawagi: faculty in IITB since 1999, teaching ML courses for 20+ years
- Current research

  – Actionable recourse on ML models

  – Reliable models for training and inference for sequence generation tasks

  – Foundation model for spatio-temporal datasets

  – LLMs for querying and analyzing structured data

TAs

Lokesh. CSE PhD.
Causal Inference to the Aid
of Machine Learning.

Vishak. CSE PhD.
Neural Architecture
Search.

Meet. CSE M.Tech.
Large Language Models
and Multimodal ML.

Krishnakant, CSE MS
Multilingual Machine
Translation

Study material

- Unfortunately, no single text.

- The most relevant text books mentioned on the course webpage

- Each topic will contain pointer to reading material on that topic

- My slides and/or board work on the tablet will be available for reference.

- Exams will be open notes, but you cannot xerox someone else's notes or my board work.

The study process

- Pay attention to the class: don't hesitate to ask questions
    - (Old Chinese proverb)
        - The one who asks a question is stupid only once, the one who does not ask questions is stupid forever.

- For every 1.5 hours of lectures, spend at least 1.5 hours in revising the lecture after class

- Do the homework yourself

- If you have difficulty, come to instructor's office hours early on in the semester

- Be Calm
- Be Organized
- Enjoy the process..