

(Computing with Signals)

classmate

→ ~~AI models generate~~ Date
it just utilisation of old dates Page

Day 1 (09/01/26)

How can it add to new data?

- unstructured data - not in form of tables
ex. audio, video

or is it because it is modified?

- data science, ML motivation: Large data what we can do about it
- predict → action = intelligence = doesn't need to have actions
↳ based on different modalities like visual, sonic, always haptic, odour {sensing mechanism?}

Q What do you mean by signal?

- some kind of sign to communicate with
- contains information
- changes over time, space
- it's a function of one or more variables - And change is observable in a quantifiable entity

• Signal Processing + Machine Learning

← Course all about!

Day 2 (12/01/26)

→ Fraunhofer

- MP3 creation

→ Google Ngram

- Click Signal

Processing and

Machine Learning

Signal

↓ how to derive it?

Data

↓

Information

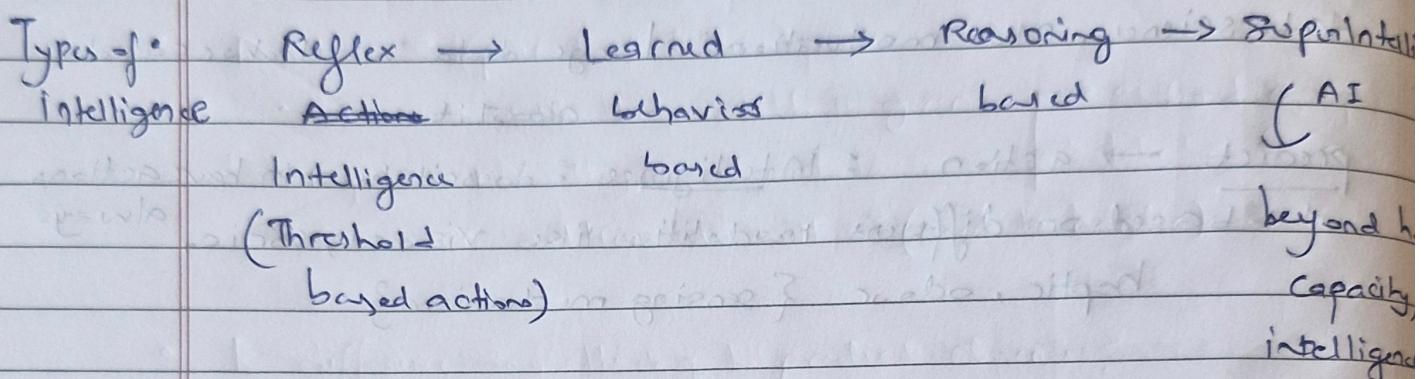
↓

Knowledge

• What intelligence is - how to engineer it?

↑ not binary; it's a spectrum (various)

- Intelligence is a gradient
ex. calculators before ↓
Chess engine → ChatGPT
- } ⇒ no single def of AI



- Components of intelligence: (i) Learning — ML (AI system req)
(ii) Thinking — ChatGPT (now)
(iii) Acting — Robotic system (Meta)

how are all these 3 achieved?

- Types / Evolution of Intelligence
 - (i) Phylogenetic intelligence
 - inherited by genes (DNA)
 - no background reasoning
 - there
 - (ii) Ontogenetic intelligence
 - acquiring intelligence from environment by observing
 - as (i) leads to little intelligence not complete
 - (iii) Social intelligence
 - interacting with people and acquiring

Car to Car comm.
Navigation: GPS
(check)

is it similar to
self driving
car? (No)

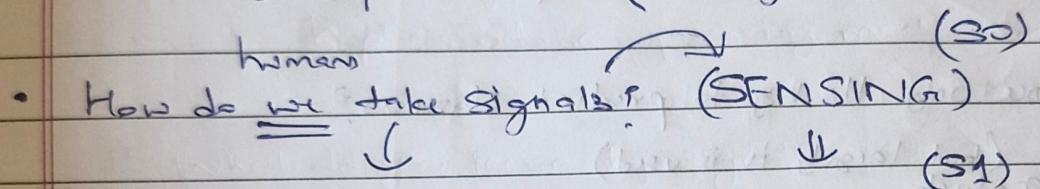
(iv) logical - mathematical intelligence

- mathematical framework for reasoning
- everything cannot be reasoned as just mere action → observation

(v) From logic to machines

- this was questioned as can machines think?
- led to AI!

- Learning requires data (or signals)



• How do we take Signals? (SENSING)

\equiv ↓

↓ (In machines, it is called feature extraction)

(S1)

Interpretation of signals = PERCEPTION

signals

↓ interpreting

(In machines, it is called feature extraction)

(In machines, it is called feature extraction)

(S2) Cognition - mental process involving

↓

{ understanding

top down

reasoning

Sensory system ←

decision making

to brain

learning } - on perceived

brain to sensory : bottom up

data

System

apply past experiences

(S3) Action {not every time it happens}

↓

• for lifeforms

• but for AI (it's req)

→ if digital system: then response happens

Day 3 (13/01/26)

- Modality - Specific approach for doing something
 - modes : manner or method
 - helps machine to (sense) though it cannot
- Data - (plural of datum)
 - datum - something which is given
 - requires recording to have data
 - can have outliers as well \therefore (need to handle)
- Is difference only the way to predict closeness?
 - \rightarrow No (but largely it is used)
 - \rightarrow dot products possible on vectors
 - \rightarrow ratio (on numbers)
 - \rightarrow so it depends on error function what $\&$ the operation is
- Minimising error sensitive to outliers
- Unimodal Data
 - one kind of data coming from one source
 - ex. photographs (image modality)

Data
↓

fit a model

- (no model is correct)
- error tolerance

(Paper)

What face body
shape can tell us
about height

Day 4 (16/01/26)

- Dataset integrate part of Pb solving
 - What data to collect
 - What question to answer

} (based on that collect data)
- Datasheet for dataset - Guideline for making a dataset
- Different dataset:
 - (i) TIMIT
 - funded by DARPA
 - 5 hours of speech - 630 speakers / 10 sentence
 - Time series data : What word uttered at what time
 - Manually intensive task compared to image
 - WER (Word error rate) : metric to evaluate speech recordings correctness
 - ~~Q~~ terms of
 - What?
 - Automatic speech R.S generates transcript which is compared to original one

(ii) NIST Handwritten Digits Dataset

→ later came MNIST

↳ Modified

NOTE: data though available may need to be formatted properly

fashion
recommendation?

(iii) Fashion MNIST - class overlap as 28X28

(iv) UCI Machine Learning Repository

→ Iris Dataset

→ Adult Dataset

↳ Yann LeCun
↳ check

~~Q~~ What do people get to make dataset?

* Check: Titanic: Dataset for disaster

Something - In Kaggle

(Meta currently)
founder father of

AI

Day 5 (19/01/26)

- 2 more datasets

v) Caltech 101 - image dataset {annotation done}

vi) AI Vision - Known as Dark Age (till 2008)

- handcrafted features previously

- to create a large dataset

→ used wordnet : network of words
{idea}

→ for creating the categories for images
Analog of subcrite similar words connected

vii) Coswara

- Sound and respiratory

System connected !

- Collected by website

→ audio taken

→ metadata collected - as

if in covid contact, else

if sold etc

- unsupervised clustering

shown (on fig)

(Check)

✓ Amazon Mechanical

✓ Turk

- Captcha Testing

{integrate image?}

{in website?}

{if something is coming

out from something,

there is a signature}

*

✓ Check Res App *

done

does NN do both regression

classification, clustering

? or any other algorithm?

? from supervised and unsupervised?

what is - multimodal

Day 6 (20/01/26)

- Data done!
- What now? - Modelling / Representation (like terms)

Signal \rightarrow Model \rightarrow Computation

or

Representation

Model (i) Taylor Series

$$f(n) = f(a) + \frac{f'(a)(n-a)}{1!} + \frac{f''(a)(n-a)^2}{2!} + \frac{f'''(a)(n-a)^3}{3!}$$

→ finding ⁿ derivative
at one point is difficult
→ but if we are able to, it's
very useful!

- Derivative is a global property of the function!

• NOTE: Derivative = Change
Step size
 \Rightarrow can't get to 0
 \Rightarrow therefore difficult!

- checks
- ✓ how does scientific calculator compute?
 - ✓ Casio no 1?
 - ✓ do they have lookup tables?
 - ✓ some sort of function simplification?

- Signal

(i) Represent measurable changes in quantity

↳ mathematically: as a function of one or more variables

Model (ii) Polynomial Series

$$f(n) = a_0 + a_1 n + a_2 n^2 + a_3 n^3 + \dots$$

$$y_i = a_0 + a_1 n_i + a_2 n_i^2 + a_3 n_i^3 + \dots$$

↳ find A: $y = XA$

NOTE: fitting a model to data \Rightarrow finding values of hyperparameters
 ↑
 (to reduce the error)

Q how many params should be present?
 \Rightarrow if more, overfitting
 \Rightarrow if less, too simple

Day 7 (23/01/26)

check

- Nature also follows sin-wave
 \rightarrow day and night \uparrow Mapping

- Sky map: for moon location

- Sampling rate = no. of samples/sec
 \rightarrow sort of signals here

- Speech signal

(Scaling) { Slow - Stretch the signal fast - Compress the signal } distortion happens in the process

how to verify if it's a good algo? \leftarrow Come up with an algo which introduces least distortion

- by listening to it

NOTE: preserving / doing Speech Signal processing in multi-modal system: Challenging

ex. A video sped up - hand gestures, lip movements and audio signals should match

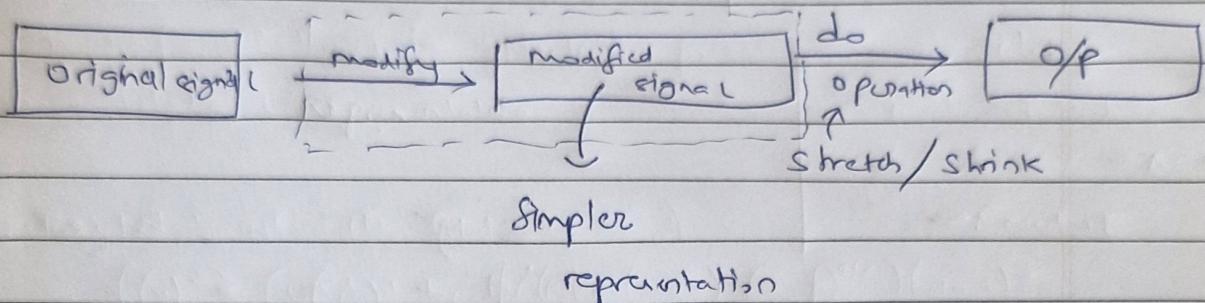
- how do we scale a signal? - (other than TSM method)
 - Interpolation - Stretch the signal, (and) fill (the) zeros by which signal stretched, can be replaced with interpolated value

What about shrink? - remove some samples!!

Challenge in Shrink/Stretch (how much the signal changes)

Q how to represent the signals in simpler form?

→ after which we can apply the changes



$$\text{ex. } x[n] = \sum_{k=1}^K x_k[n] = \sum_{k=1}^K a_k[n] \cos(\phi_k[n])$$

↑ amplitude ↑ phase

Similar to physics → where everything represented in terms of atoms

$b_i = 1 - g_i \rightarrow \text{DNA}$

(There 2 modified!!)

(how to change the phase without disturbing frequency = changing the signal without changing slope)
(Smtg)

(lossy compression)

(check)

✓ How does the image/video sending quality work?
(in WhatsApp or any messenger)

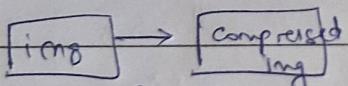
(platform)

What about the

video conference?

How some of them

works very well?



⇒ decompression also happens!

° Vector Spaces !!

→ helps in analyzing numbers together

another representation: Combination (smtg)