Frugal AI solutions for India from IITK

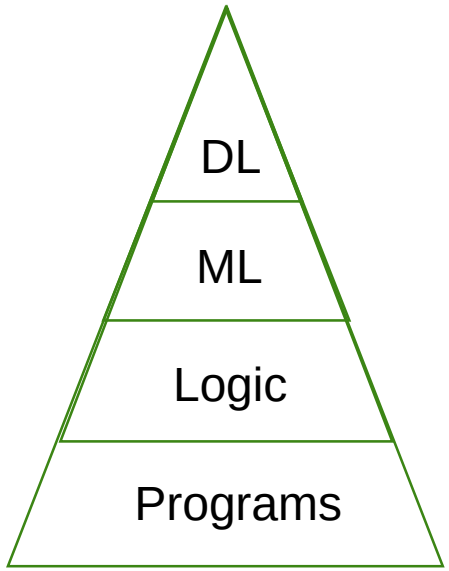
IIT Kanpur
AI for India

Nitin Saxena
(joint works with Nisheeth, Sruti, Aditya, Sayak)

Coordinator, Center for Developing Intelligent Systems +
Dean, Wadhwani School of AI & Intelligent Systems +
N.Rama.Rao.Chair Professor (HAG), CSE +
Founding Director, CDIS Private Limited
IIT Kanpur

What is machine intelligence?

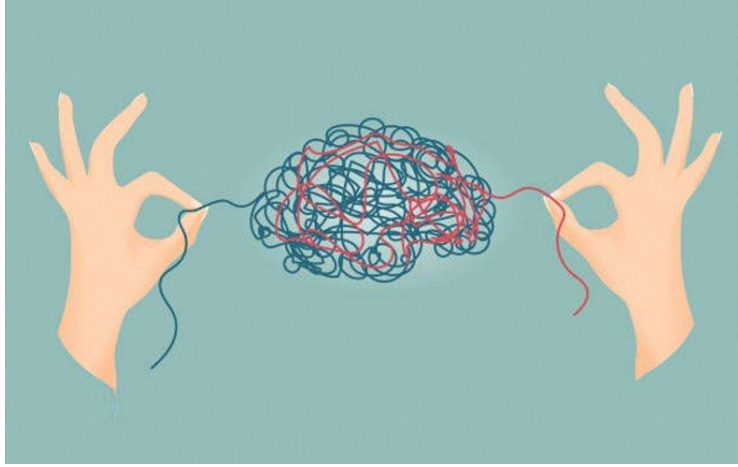
- **Simple programs**
  - If the password matches the database entry, let the person in
- **Logical reasoning**
  - If someone tries to buy a ticket, make sure there are tickets available before charging them
- **ML** (Machine Learning)
  - If your database row has this mean/average, you collect it
- **DL** (Deep Learning)
  - Just give me labelled data and get out of my way



AI – a layperson's definition

- Any computing system that
  - does something that machines couldn’t do before.
- *Corollary*: the AI effect
  - Anytime machines start doing something intelligent, *en masse*, it is no longer considered AI!
- Examples of AI systems that are no longer considered AI
  - Chess solvers
  - OCR (Optical character recognition)
  - Automated assembly lines
  - Automated CNC lathes (Computer Numerical Control)

AI and complexity



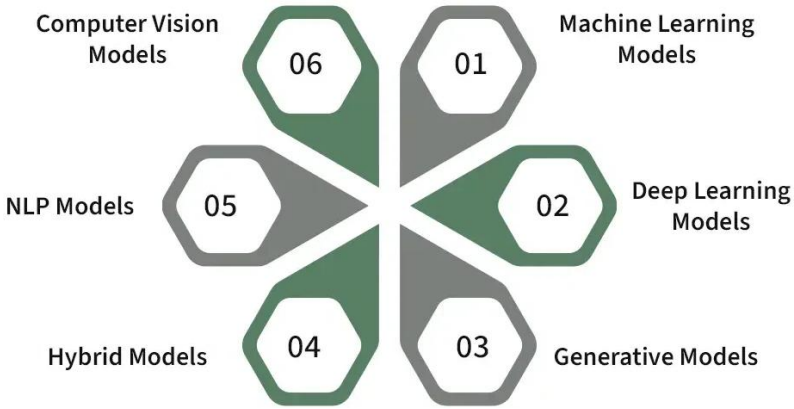
- The AI effect: if you understand it, it isn't AI.
- Consequence: apply AI to everything we don't understand how to do.
  - AI for health-care
  - AI for mental-health
  - AI for music-writing
  - AI for governance
- Apparent logic:
  - We don't understand AI +
  - We don't understand how to do X →
  - AI will understand how to do X.

(a) Three samples in criminal ID photo set S_c.

(b) Three samples in non-criminal ID photo set S_n

Figure 1. Sample ID photos in our data set.

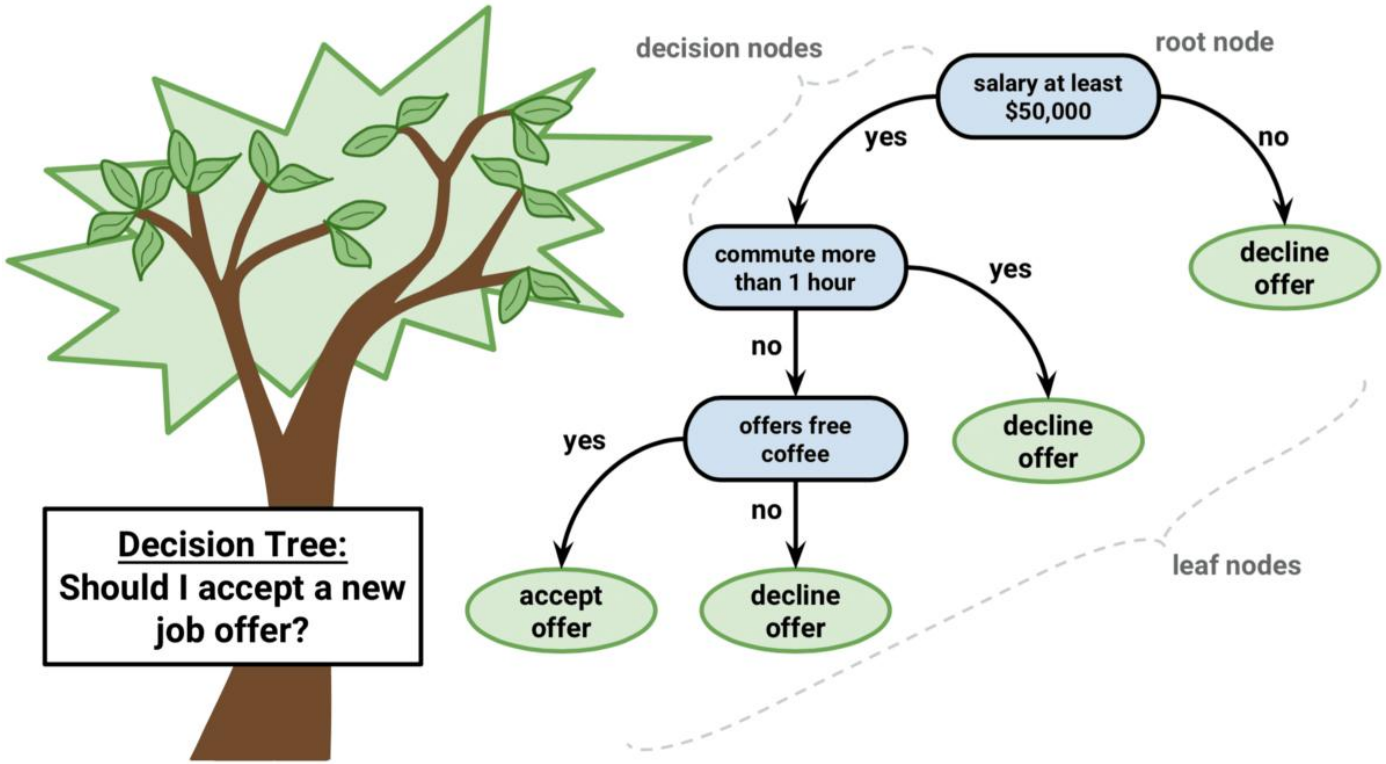
What does the AI see?



- It sees **models** of the world
- Models can be simple or COMPLEX
- Simple programs see simple models
- COMPLEX programs see COMPLEX models

- All models are wrong, some are useful.
- Understanding and fixing simple models is easier than doing this for complex models.

Example 1 →



Simple model: Decision tree

Example 2 →

```python
import numpy as np
import pandas as pd
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense

data = {
    'feature1': [0.1, 0.2, 0.3, 0.4, 0.5],
    'feature2': [0.5, 0.4, 0.3, 0.2, 0.1],
    'label': [0, 0, 1, 1, 1]
}

df = pd.DataFrame(data)

X = df[['feature1', 'feature2']].values
y = df['label'].values

model = Sequential()

model.add(Dense(8, input_dim=2, activation='relu'))
model.add(Dense(1, activation='sigmoid'))

model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])

model.fit(X, y, epochs=100, batch_size=1, verbose=1)

test_data = np.array([[0.2, 0.4]])

prediction = model.predict(test_data)
predicted_label = (prediction > 0.5).astype(int)
print(f"Predicted label: {predicted_label[0][0]}")
```

Activation functions introduce non-linearity into the network enabling it to learn and model complex data patterns.

Common activation functions include:

Sigmoid: $\sigma(x) = \frac{1}{(1+e^{-x})}$

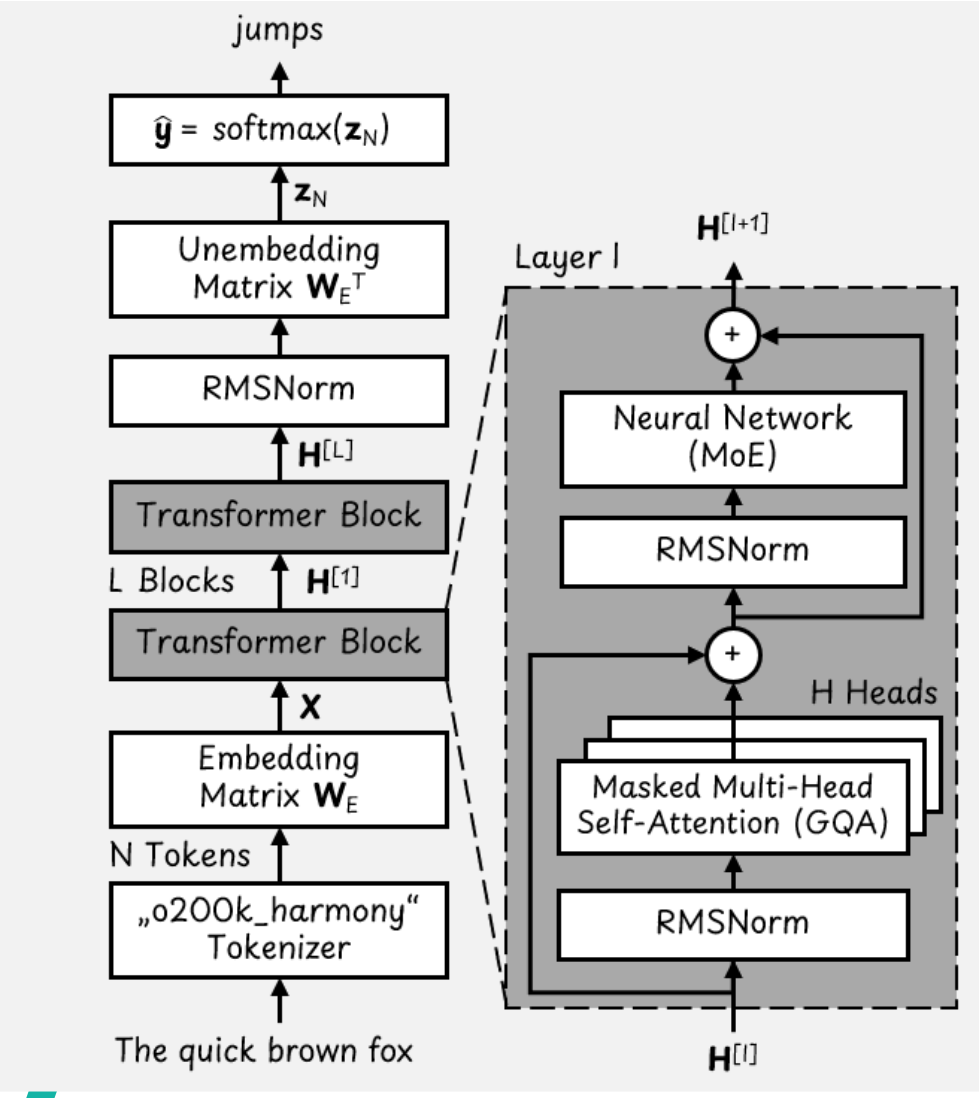
Hyperbolic tangent: $\tanh(x) = \frac{(e^{x}-e^{-x})}{(e^{x}+e^{-x})}$

Rectified Linear Unit: $\mathrm{ReLU}(x) = \max(0, x)$

Complex model: Neural Network

Example 3 →

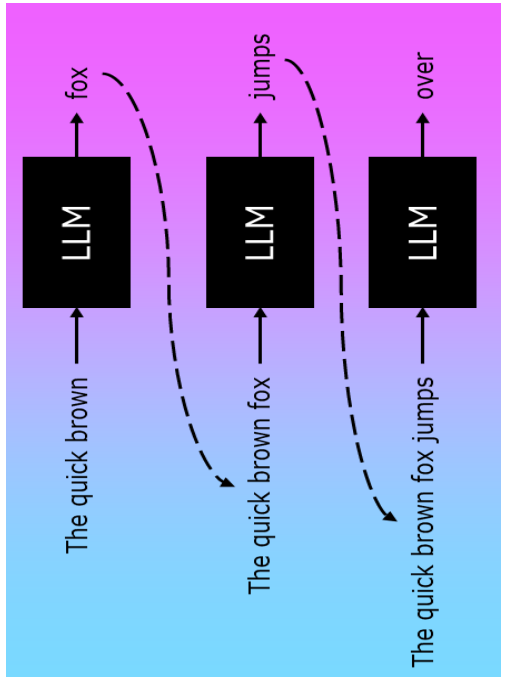
Highly-Complex model: LLM Architecture

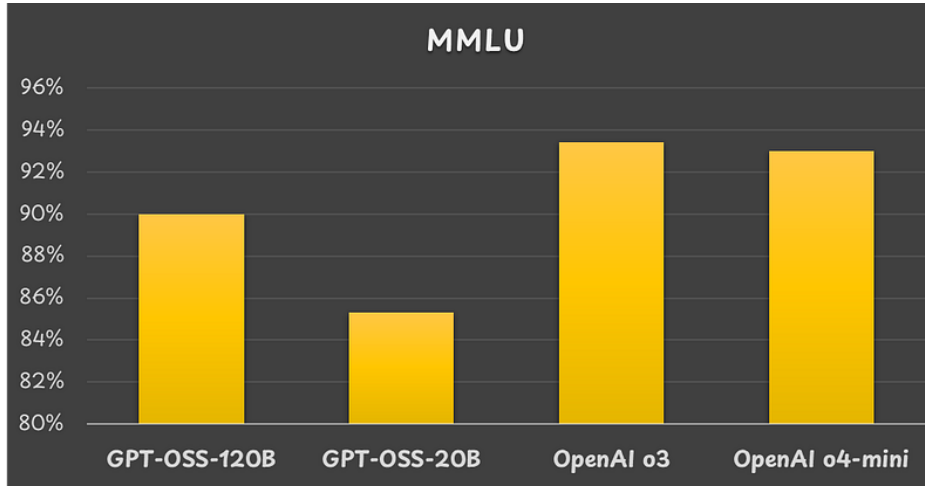


Tokenizer: converts the input sentence into a list of tokens.
Embedding: transforms the list of tokens into a dense matrix.

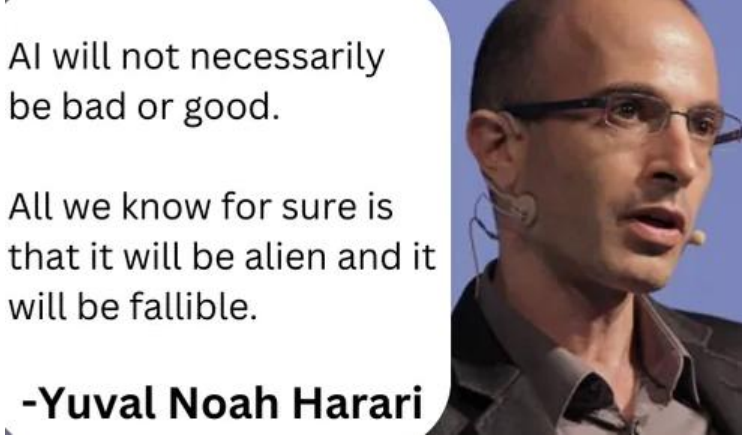
Self-attention mask: tells the model which words to pay attention to and which ones to skip over.
MoE (mixture of experts): the router selects multiple experts with different weights.

Unembedding: transforms the embedding vectors back into token space.
Softmax: converts each of the probable tokens (=logits) into **probabilities**.





Massive Multitask Language Understanding (MMLU) benchmark results.

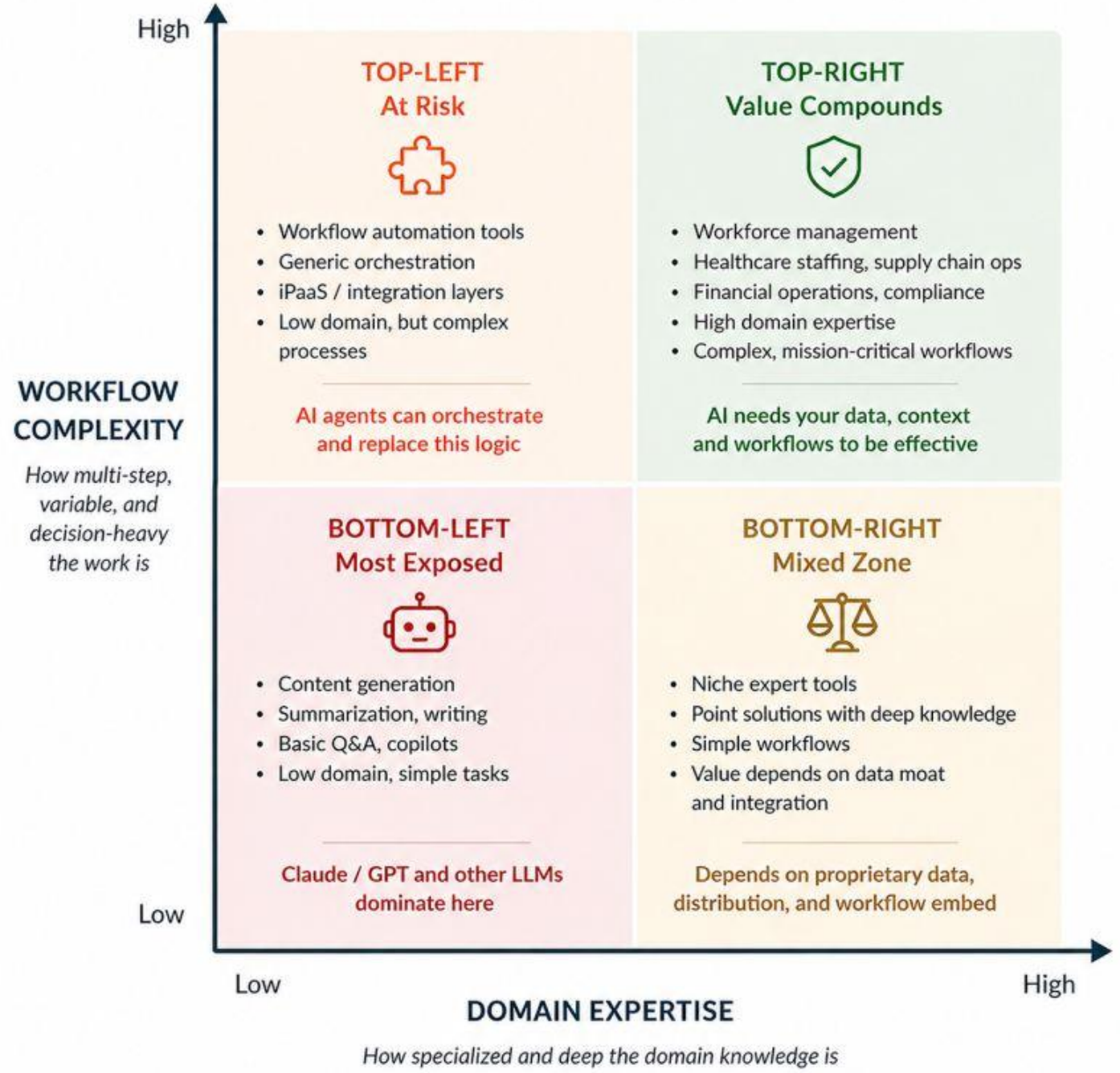


Could AI be trusted?

- AI systems *cannot* be evaluated using software engineering quality testing
  - Governance of AI systems must recognize this basic fact
- Modern AI systems can sometimes fail in unexpected ways

- AI systems must demonstrate that they do what they claim to do, to show they are trustworthy

Could AI eat Software?

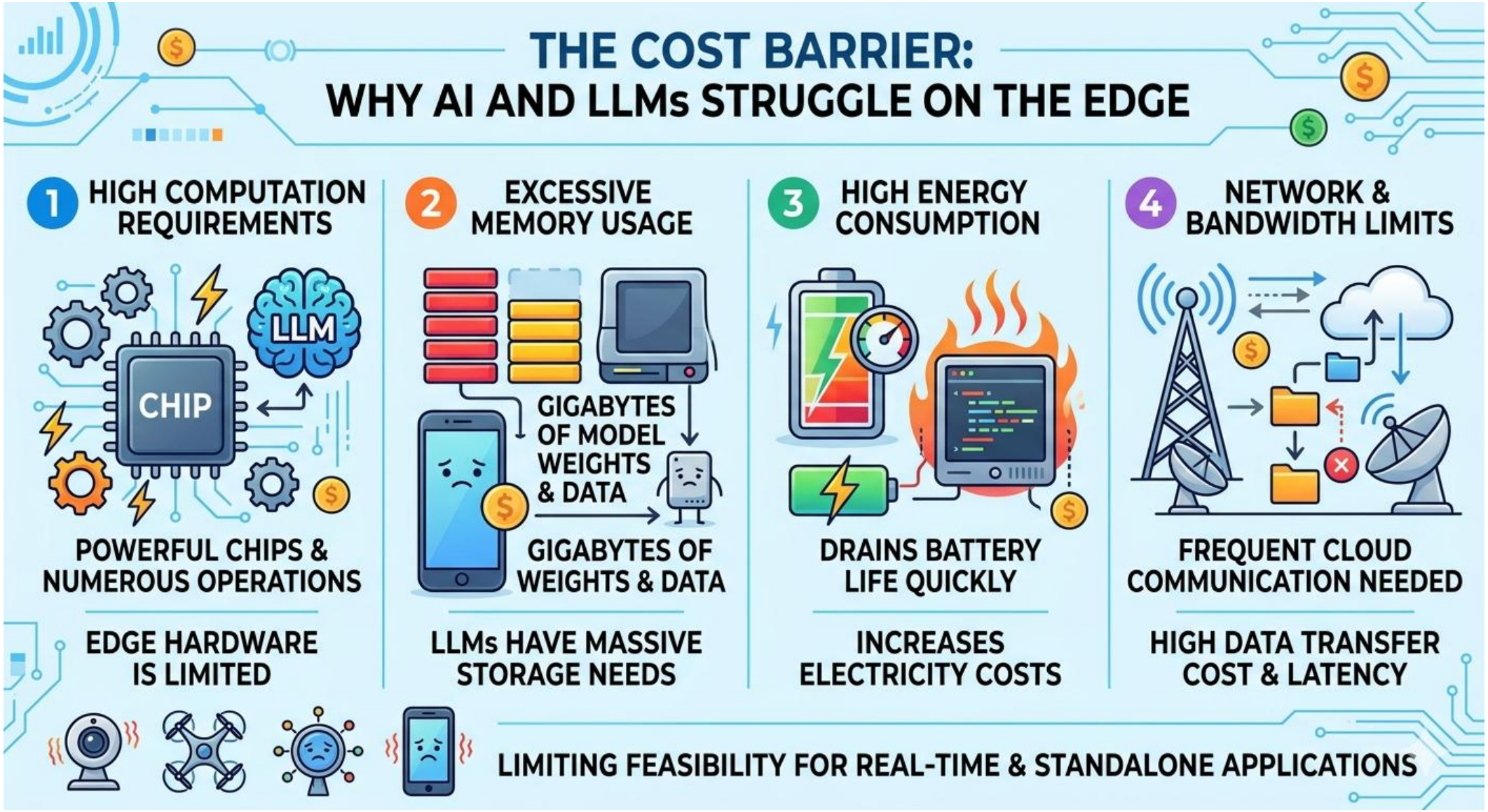


There's a take going around that AI will "eat software."
That's directionally right but dangerously ...more

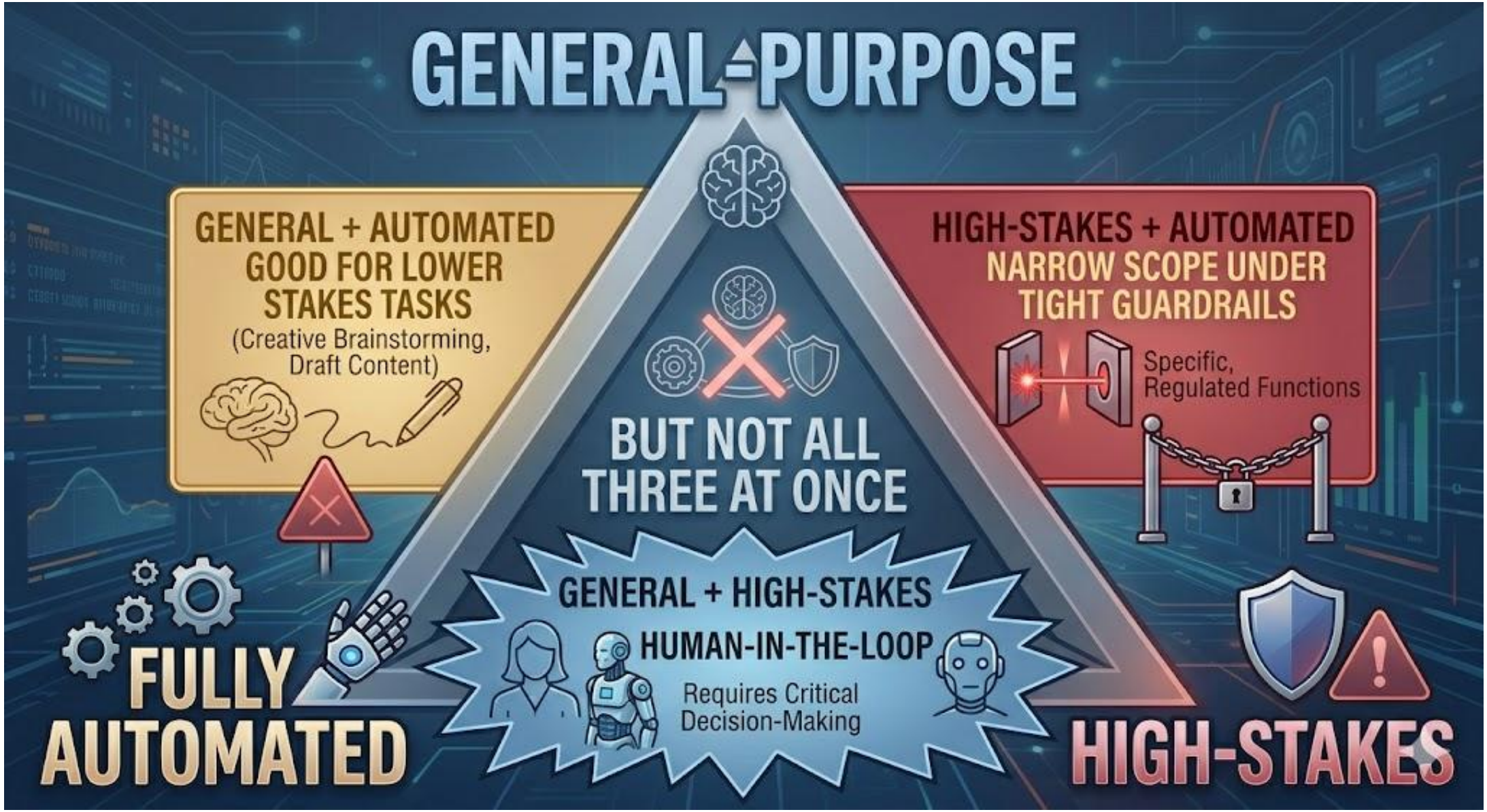
Suresh Vittal in • 2nd
Chief Product Officer & EVP at UKG | HC...
1d •

+ Follow

Could AI reduce cost?



The AI Agents Trilemma



- Arvind Narayanan

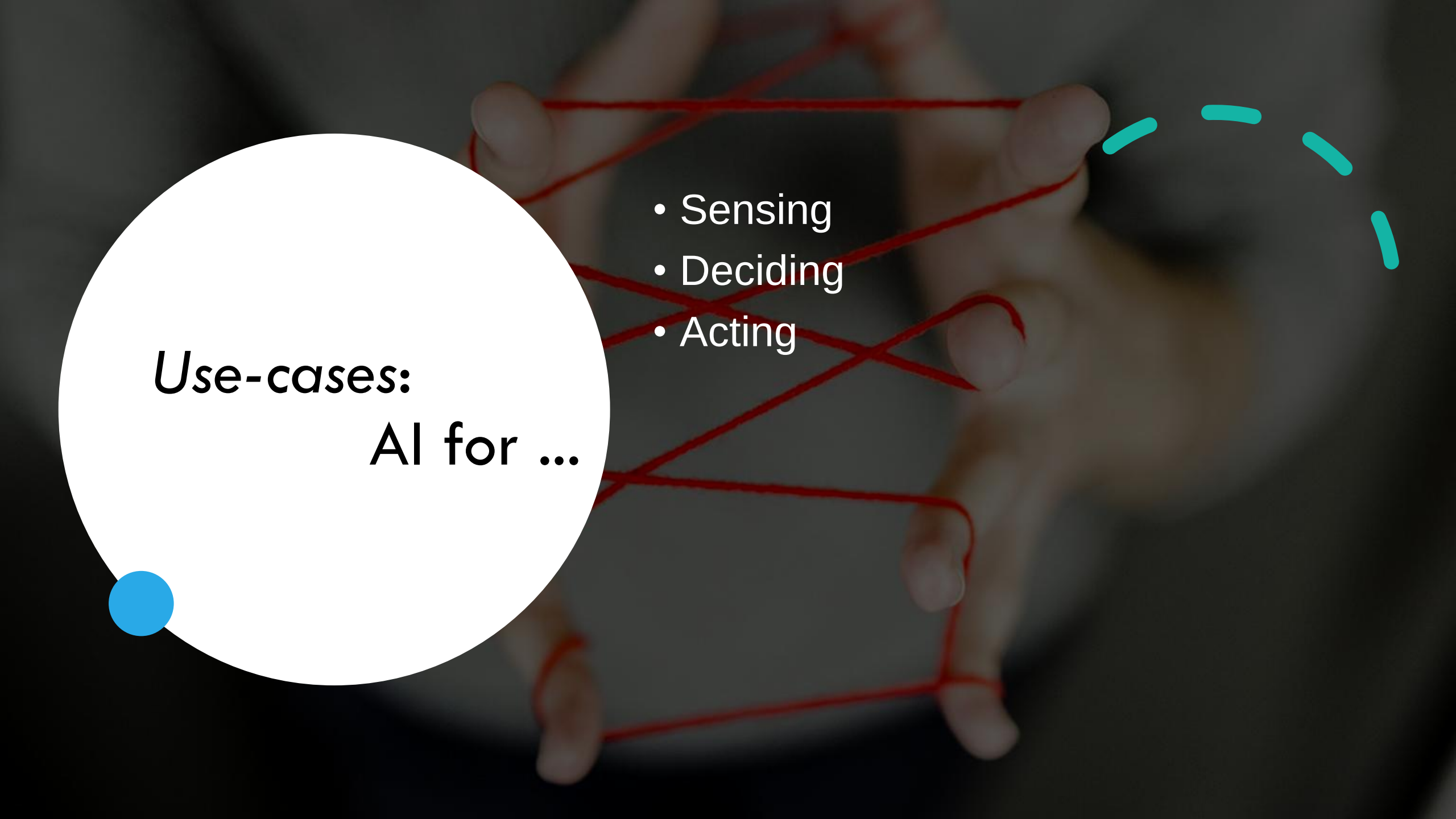
What's IIT Kanpur doing?

WSAIS: Wadhwani School of AI & Intelligent Systems

- Department of Intelligent Systems (DIS)

1. Wadhwani Center for Developing Intelligent Systems (CDIS)
2. Wadhwani Center for Cybersecurity and Cybersecurity of Cyber-physical Systems (C3i)
3. Wadhwani Center for Robotics (CR)
4. Wadhwani Center for AI Policy and Outreach (CAPO).

- Sustainable Cities AI-CoE (ARF)
- Cybersecurity CoE (C3iHub)



Use-cases:

AI for ...

- Sensing
- Deciding
- Acting

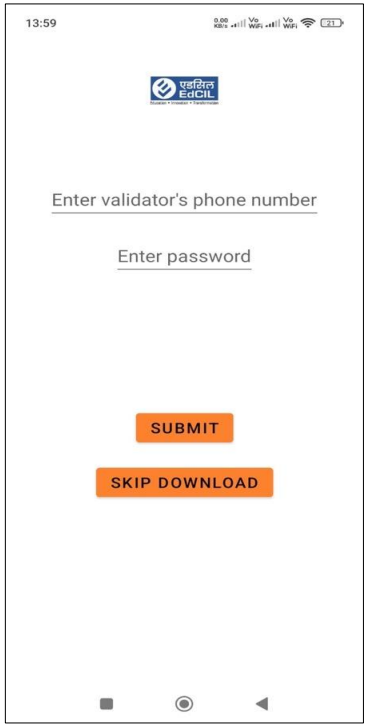
AI for sensing

Face Recognition App (Edge-AI, High-stakes)

- Runs on local smartphone, no internet.
- Uses Tensor-Flow-Lite for lightweight, fast inference.
- Face data processed locally.
- Reduces cloud usage and latency.

Work Flow (FR App)

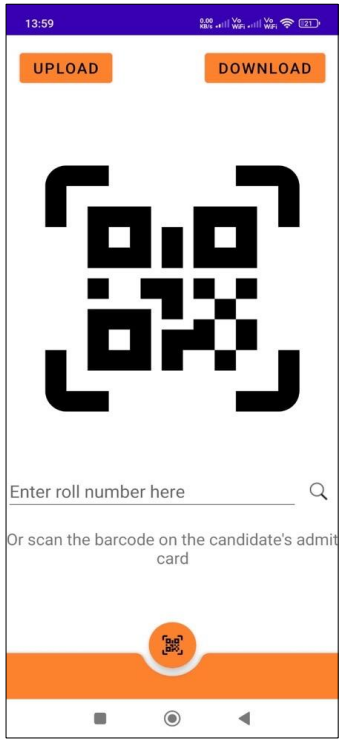
Log In Screen



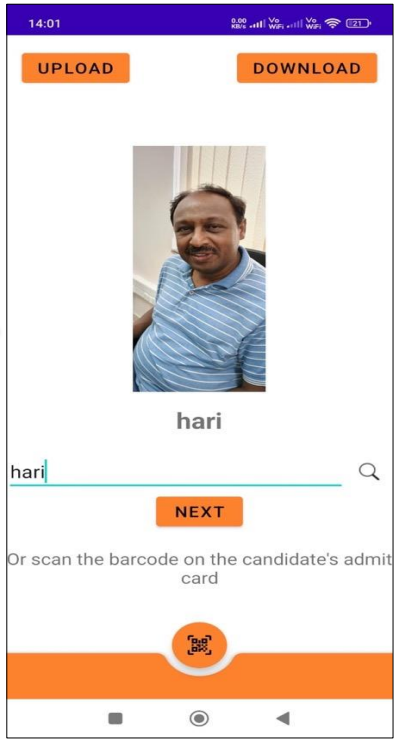
START

Enter login credentials to download images from server and click on "SUBMIT".

Application Interface



Scan the barcode on candidate's admit card or manually enter candidate's roll/ name.



After candidate's application image is displayed, click on "NEXT" to capture the live image.

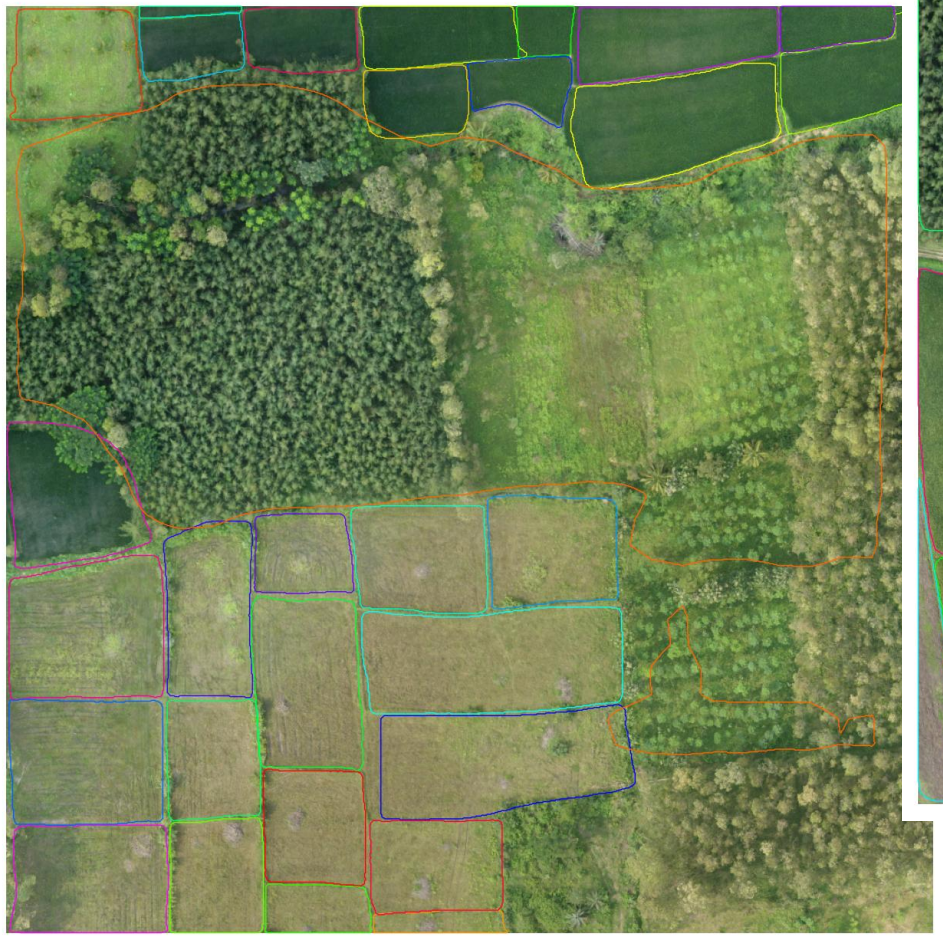
Live Process

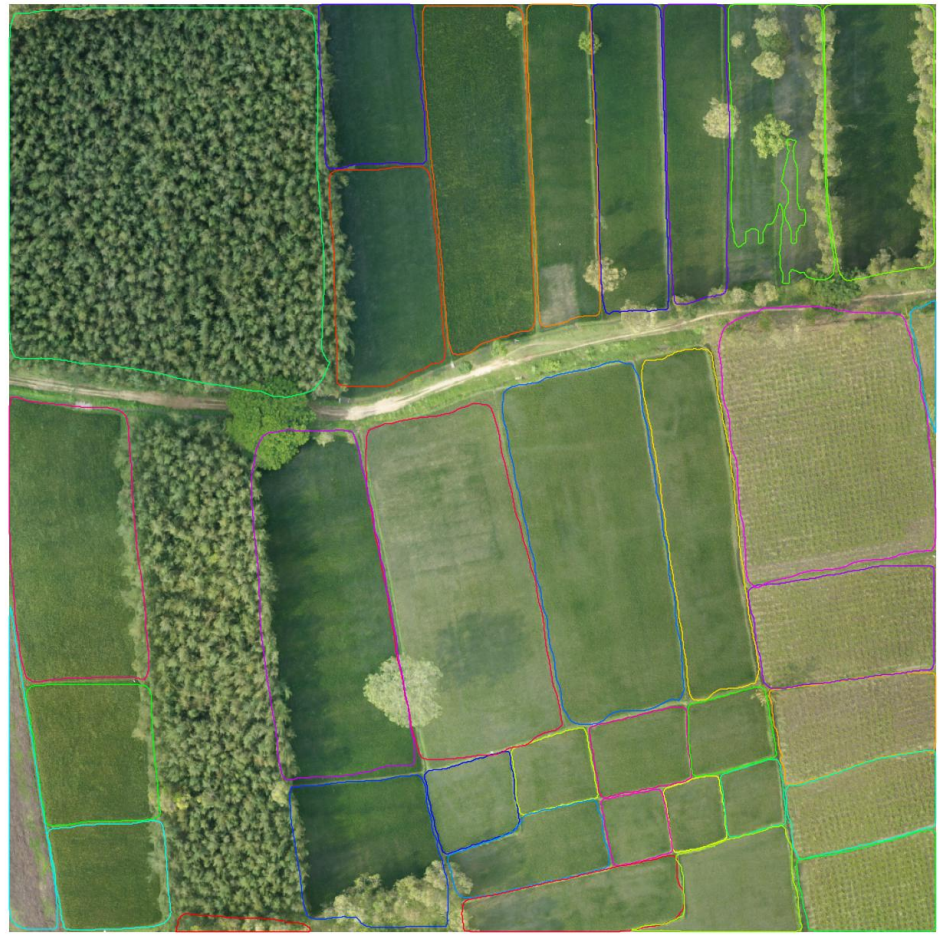
The captured live image of the candidate will be compared with the application image and a match or mismatch status will be indicated.

END

Automated Land Parcel Detection (General-purpose)

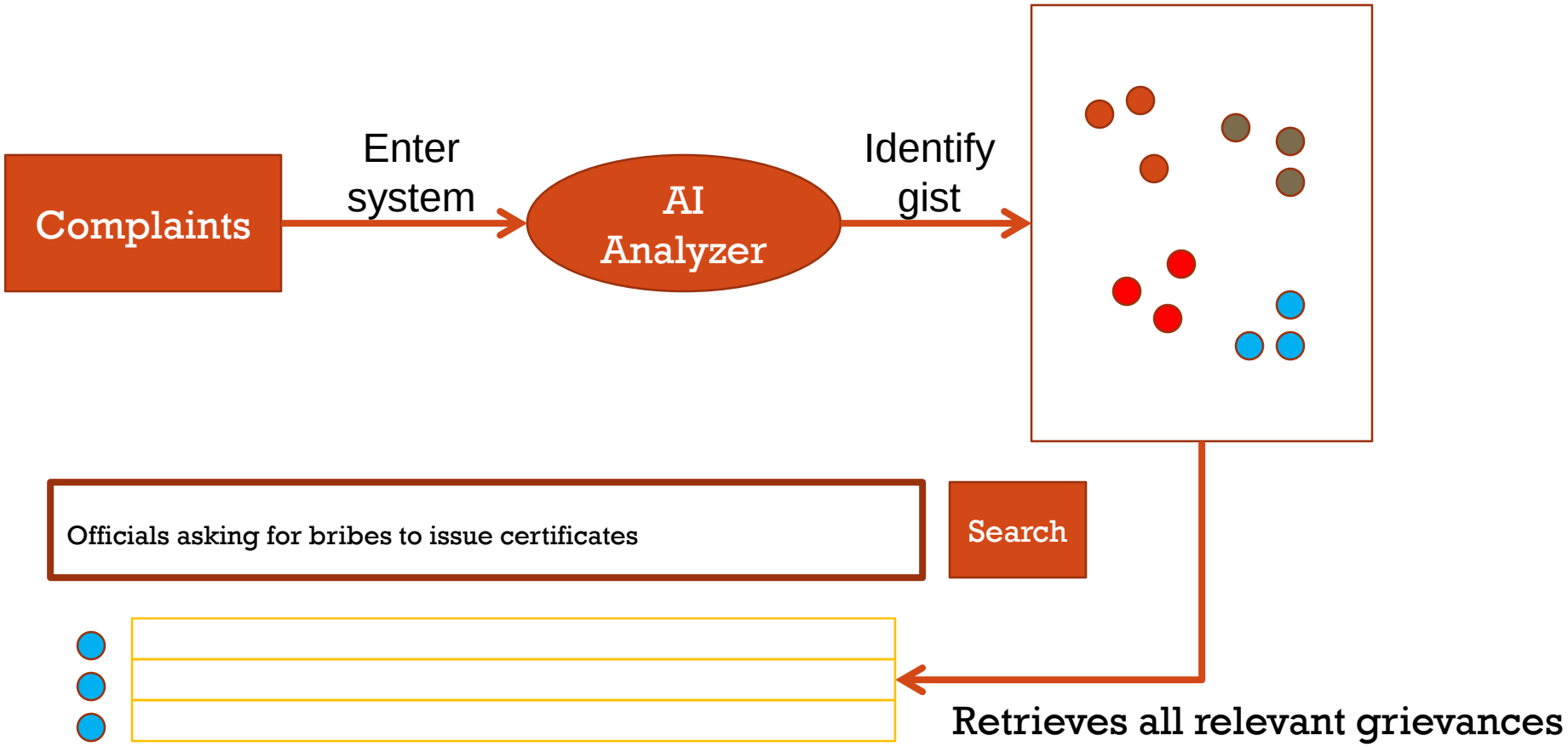
Land **Parcel Detection** from drone imagery





Sensing citizens' **intent** (General-purpose)

PM INDIA



Deployed for all central government departments and ministries since Feb 2023

Detecting **structure** within documents (General-purpose)

RAJRATAN
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INDIA | THAILAND
RAJRATAN GLOBAL WIRE LIMITED
www.rajratan.co.in
ORIGINAL FOR RECIPIENT
CIN No. L27106MP1988PLC004778

SUPPLY CUM TAX INVOICE

GSTIN: 23AABCR4530Q1Z8
PAN No. AABCR4530Q

Ack No.	162110494814881	Eway Bill No.	:		
Ack Date	31-03-2021 4:09:00 PM	Eway Bill Date	:		
IRN	c1fa5f402c41187046ac5881baac996a08b1ee5eece4c2b96ec3f2dfcafb3f04				

Place of Supply	MAHARASHTRA	L.R No.	5155418	Date of Supply	31/03/2021
Details of Receiver \ Shipped to		Transporter	PITHAMPUR BOMBAY ROADWAYS	Invoice No.	SIFA20212977
GANGOTRI CORP LLP		Vehicle No.	MP09GH6921	Invoice Date	31/03/2021
GROUND FLOOR, GALA NO 4		P.O. No.	EMAIL	State	MADHYA PRADESH
SNEHA IND ESTATE,EKVIRA GAS GODOWN,		Date	05-03-2021	State Code	23
MAHARASHTRA		Destination	BHAYANDAR	DO. No.	SDFAC0 1469
Pin No. 401105		State	MAHARASHTRA	Date	09-03-2021

Buyers GSTIN No. 27AARFG1763H1Z3
Shipping Address :
Ship Gstin :

Name of Product / Service	HSN / ACS	Quantity in Nos.		Quantity in MT	Rate / MT	Amount
BLACK WIRE 1.83MM	72171020	COILS	25	2.222	71300.00	158428.60
BLACK WIRE 1.50 MM	72171020	COILS	25	2.257	71800.00	162052.60
BLACK WIRE 1.63MM	72171020	COILS	32	2.915	71800.00	209297.00
PATENTED BASE WIRE 2.60MM	72171030	COILS	13	2.368	65100.00	154156.80

Taxable Value	683935.00
CGST %	0.00
SGST %	0.00
IGST 18.00%	123108.30
TCS @ 0.075%	605.29
Round Off	0.41

Gross Wt: 9.795
Packing: 0.033
Net Wt: 9.762

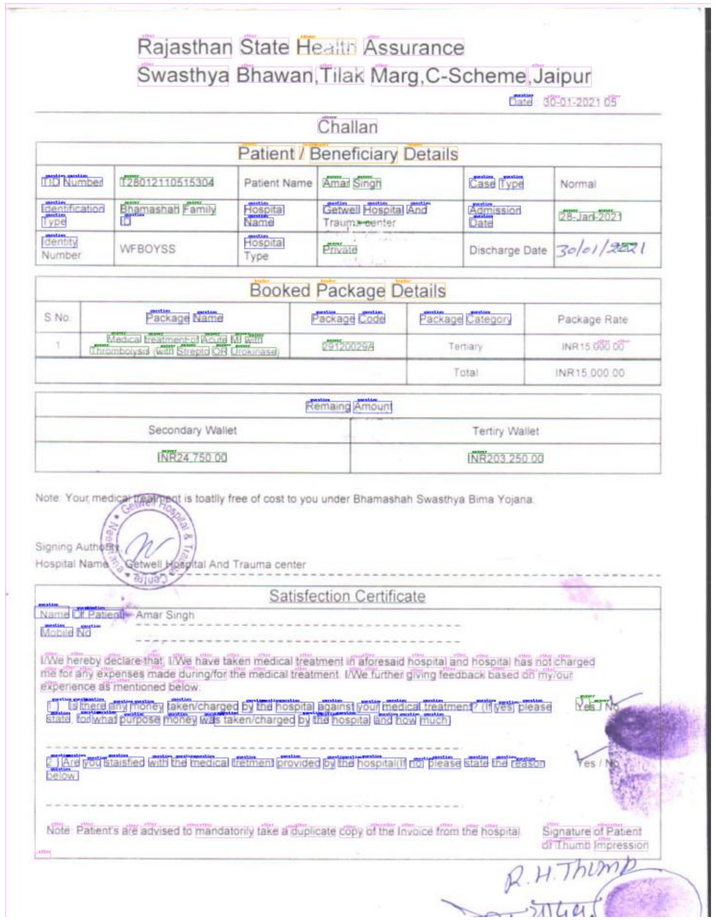
GST Payable on Reverse Charge: No
Rupees: Eight Lacs Seven Thousand Six Hundred Forty Nine only — 807649.00

Remarks:
For: RAJRATAN GLOBAL WIRE LIMITED

Certified that the particulars given above are true and correct and the amount indicated represents the price actually charged,and that there is no flow of additional consideration directly or indirectly form the buyer.

Payment Terms:
1. Interest will be charged @16%, if invoice is not payed by due date.
2. All Disputes shall be subject to Jurisdiction of Indore (M.P.) Courts.
3. Interest on Late Payment will attract to GST.

AUTHORISED SIGNATORY



Rajasthan State Health Assurance
Swasthya Bhawan,Tilak Marg,C-Scheme,Jaipur
Date 30-01-2021 05

Challan

Patient / Beneficiary Details

TID Number	T28012110515304	Patient Name	Amar Singh	Case Type	Normal
Identification Type	Bhamashah Family ID	Hospital Name	Getwell Hospital And Trauma center	Admission Date	28-Jan-2021
Identity Number	WFBOYSS	Hospital Type	Private	Discharge Date	30/01/2021

Booked Package Details

S No.	Package Name	Package Code	Package Category	Package Rate
1	Medical treatment of Acute MI with Thrombolysis with Strepto OR Urokinase	291200294	Tertiary	INR15,000.00
			Total	INR15,000.00

Remaing Amount

Secondary Wallet	Tertiry Wallet
INR24,750.00	INR203,250.00

Note: Your medical treatment is toatlly free of cost to you under Bhamashah Swasthya Bima Yojana.

Signing Authority
Hospital Name : Getwell Hospital And Trauma center

Satisfaction Certificate

Name Of Patient : Amar Singh
Mobile No

I/We hereby declare that I/We have taken medical treatment in aforesaid hospital and hospital has not charged me for any expenses made during/for the medical treatment. I/We further giving feedback based on my/our experience as mentioned below.

Is there any money taken/charged by the hospital against your medical treatment? If yes, please state for what purpose money was taken/charged by the hospital and how much. Yes / No

Are you satisfied with the medical tretment provided by the hospital? If no please state the reason below. Yes / No

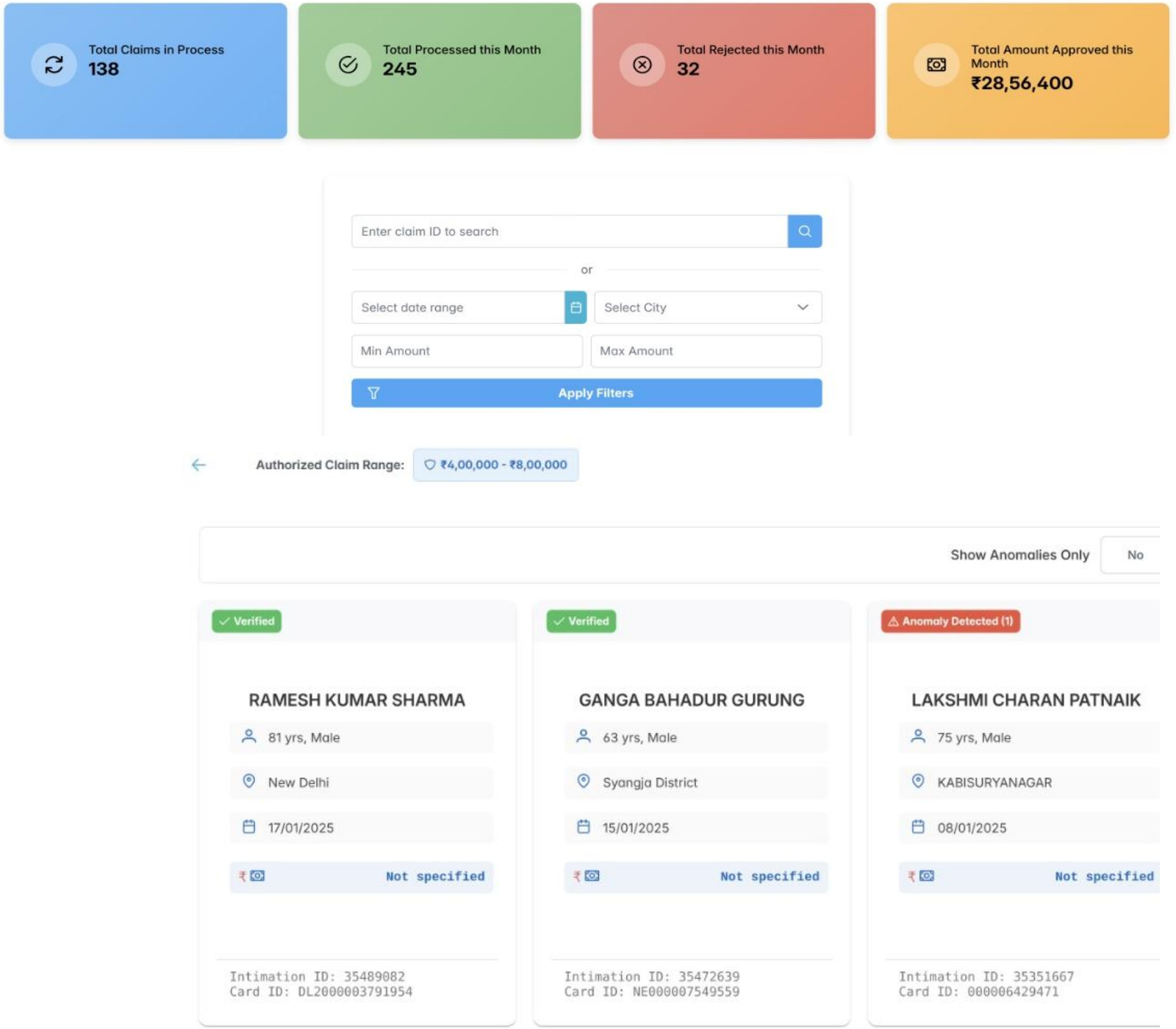
Note: Patient's are advised to mandatorily take a duplicate copy of the Invoice from the hospital

Signature of Patient or Thumb Impression

AI for deciding

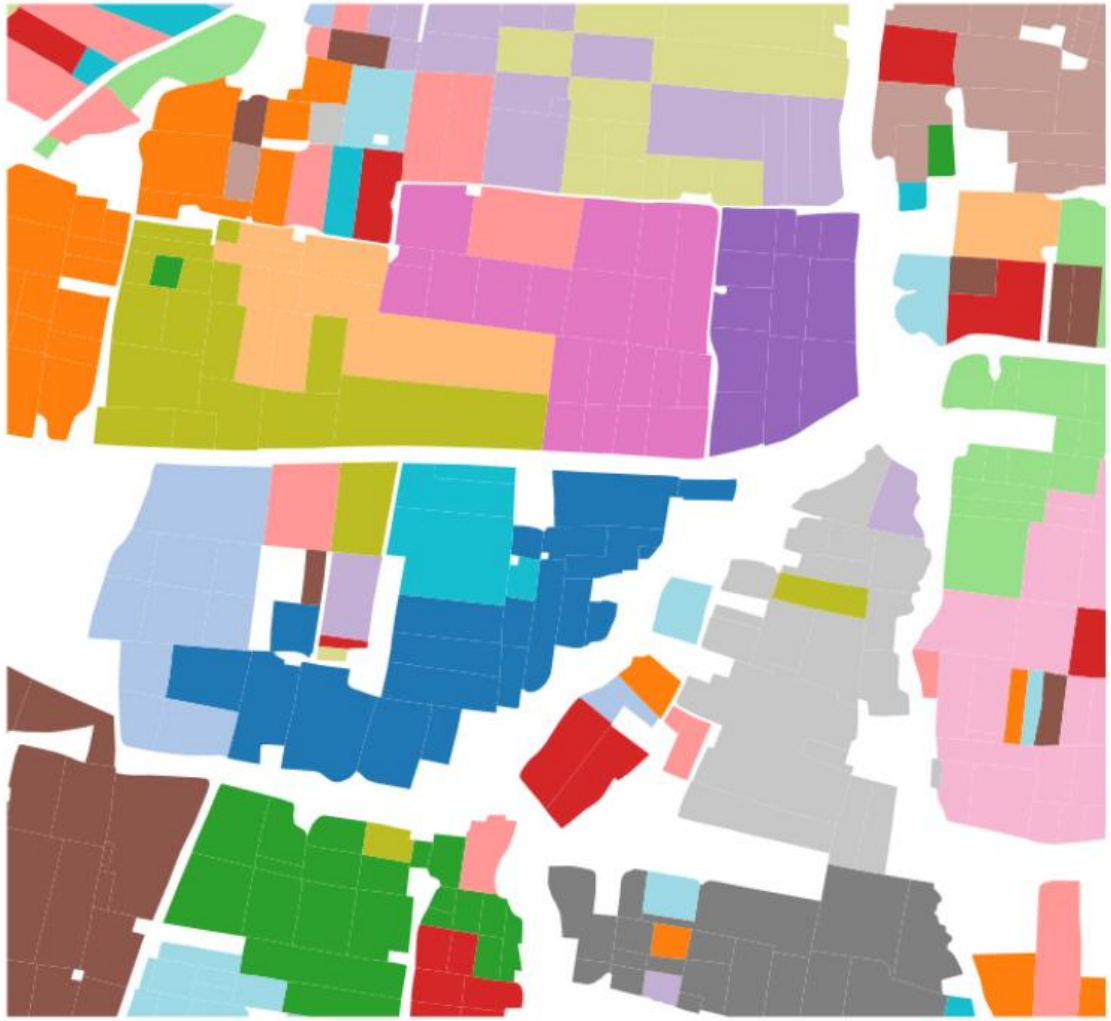
ECHS (Edge-AI)

- ECHS (Ex-Servicemen Contributory Health Scheme), with *document labeling* as one module.
- Classifies documents *locally*, minimizing server compute.
- OCR extracts text from PDFs/ images; *lightweight preprocessing* ensures efficiency.
- Keyword-based *labeling* reduces heavy ML model requirements, with optional scoring for accuracy.



Automated Land Consolidation (General-purpose)

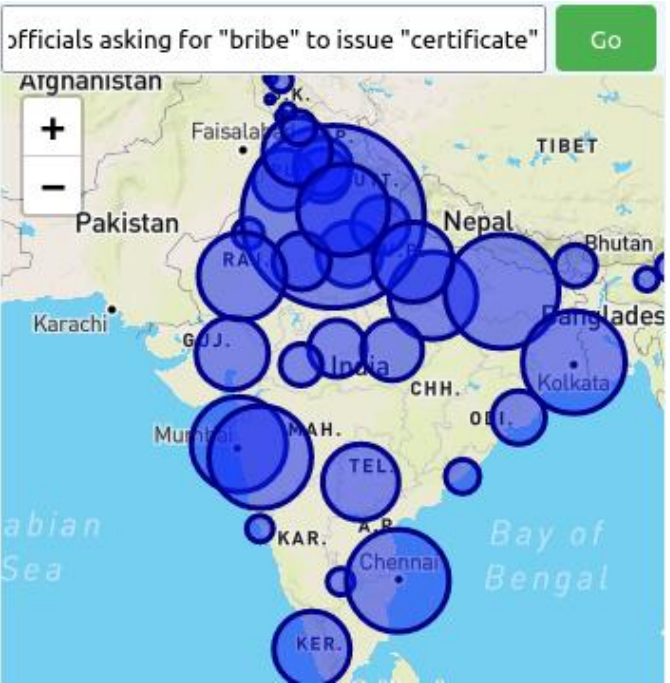
Land **Consolidation** using breadth-first search based on administrative criteria



Root-cause analysis (General-purpose)

PM INDIA

- Automated detection of topics in grievance streams
  - Hierarchical labeling of topics using bags of words

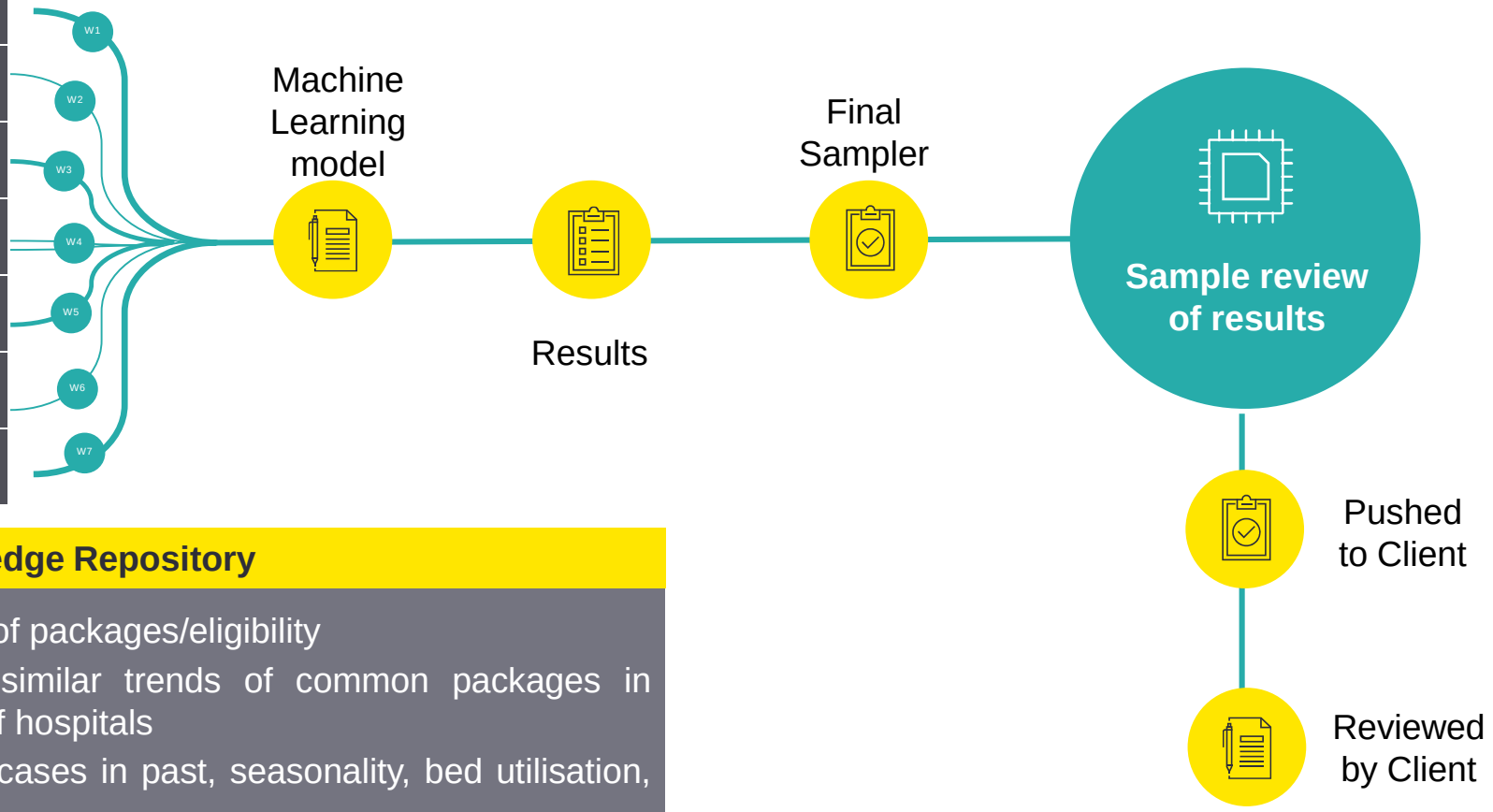


Topic
,per,slum,occupier,law,building,parking,chs,hut
ia,god,lord,epfo,family,respect,members,true,pm,since
nplaint,station,cpgrams,mumbai,maharashtra,accused,money,mof, rrm
loan,crop,fule,bank,provide,collector,action,skims,karjmukti,neglect
pf,salary,pension,agrawal,office,uan,epfo,etc,date,india
electricity,bill,meter,power,connection,mseb,consumer,complaint,msedcl,maharashtra
refund,amount,rs,gst,account,apple,bank,deposit,money,concentrate
subsidy,application,pmay,gratia,id,ex,approved,covid,applied,cov
endent,mumbai,suburban,district,police,population,districts,commissionerate,better,administration
road,roads,condition,work,traffic,pune,area,bad,village,porwal
water,supply,drainage,drinking,road,karrm,cidco,last,municipal,connection
shah,mewalal,respondent,sra,dated,jointly,order,sunita,read,rent
mh,kg,cm,mho,td,puc,mumcm,rte,ae,swift

NHA: Health insurance fraud detection (General-purpose)

EY solution has more than 50 rules which are broadly bifurcated in following categories:

- Clinical based rules
- Trend based rules
- Machine learning rules
- Statistical Anomaly Detection
- Model based Anomaly Detection
- Risk scoring models
- Image based analysis

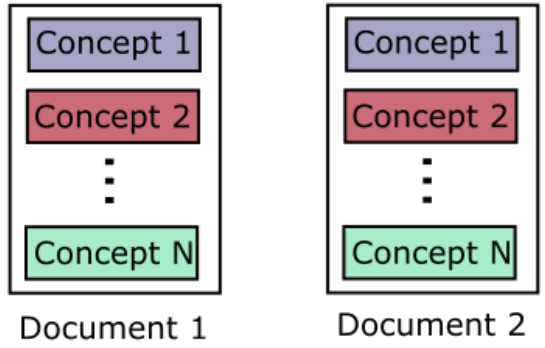


EY Knowledge Repository

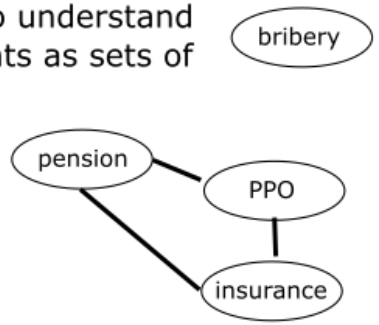
- **Age Preponderance** to variety of packages/eligibility
- **Prevalence** of diseases and similar trends of common packages in different districts and standard of hospitals
- **Hospital** related trend (type of cases in past, seasonality, bed utilisation, package budget utilisation)
- **Ground intelligence** from ground network
- Photographs, metadata, etc.

Cybersecurity assessments: AI potential

- In the last five years, LLMs have shown great promise
- Reading documents and extracting information, answering questions based on documents (RAG), etc.
- Reduces tedium on people
- Allows for objectivity especially when there is ambiguity
- Reduces effort, more frequency



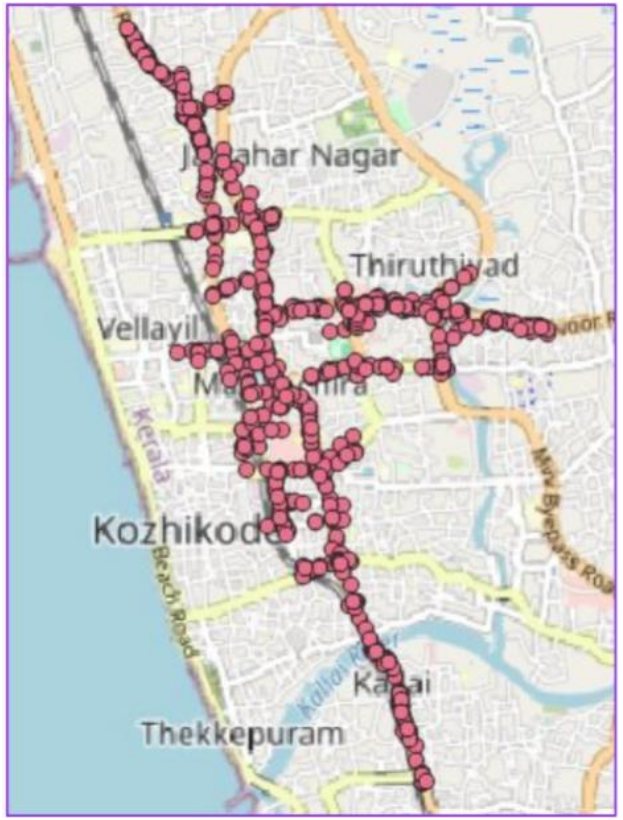
Use AI to understand documents as sets of concepts



Accident Zone Identification System

सड़क परिवहन
एवं राजमार्ग मंत्रालय
MINISTRY OF
ROAD TRANSPORT
AND HIGHWAYS
सत्यमेव जयते

- AI identifies accident-prone 'black spots' on national highways
- Fuses road geometry, traffic, weather and historical crash data
- GIS visualization for highway planners and engineers
- Directly prevents deaths through pre-emptive road engineering for 1.4 lakh km
- MoU signed with Ministry of Road Transport & Highways (MoRTH) — national-level deployment

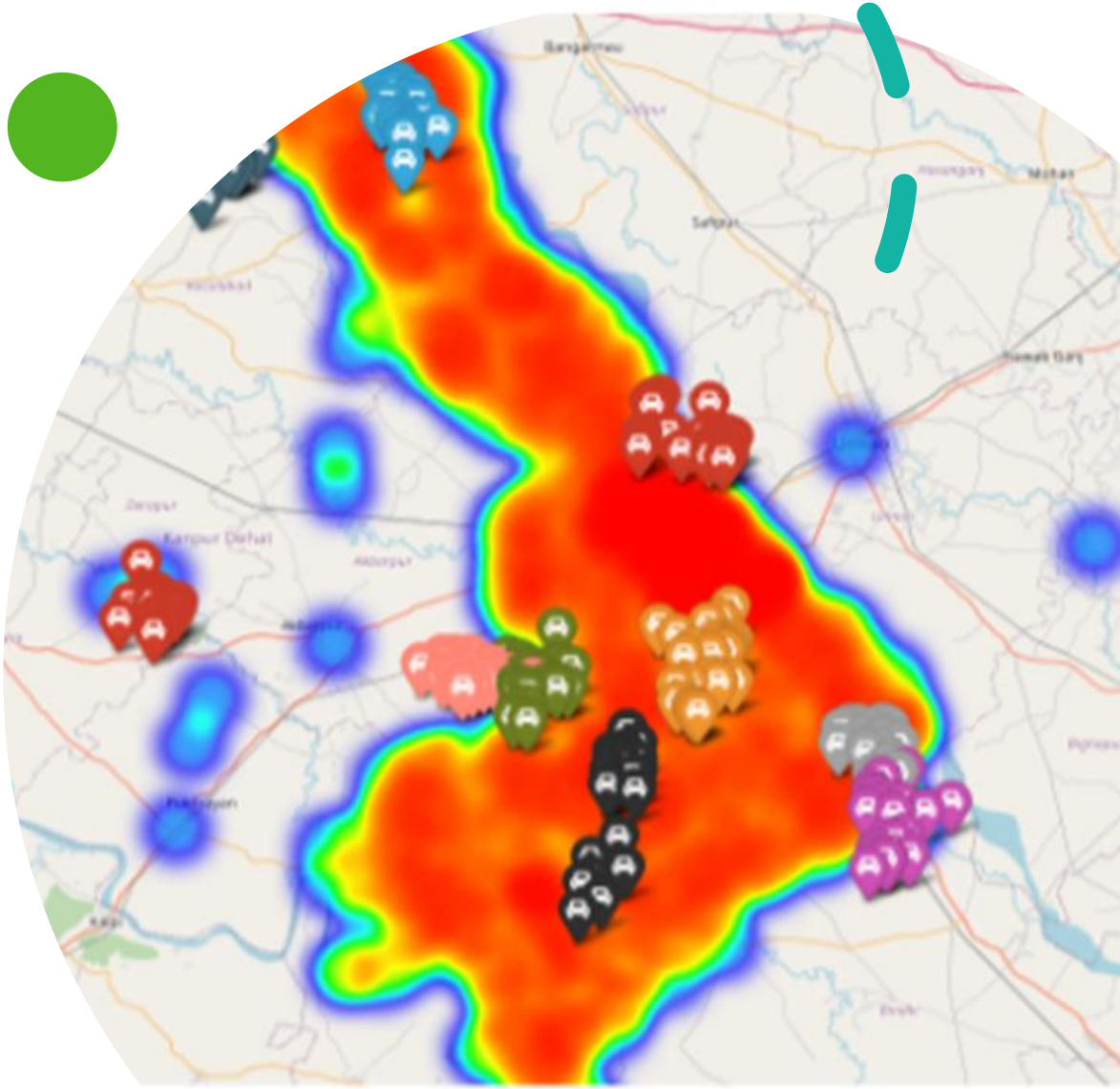


High-density cluster in Kozhikode

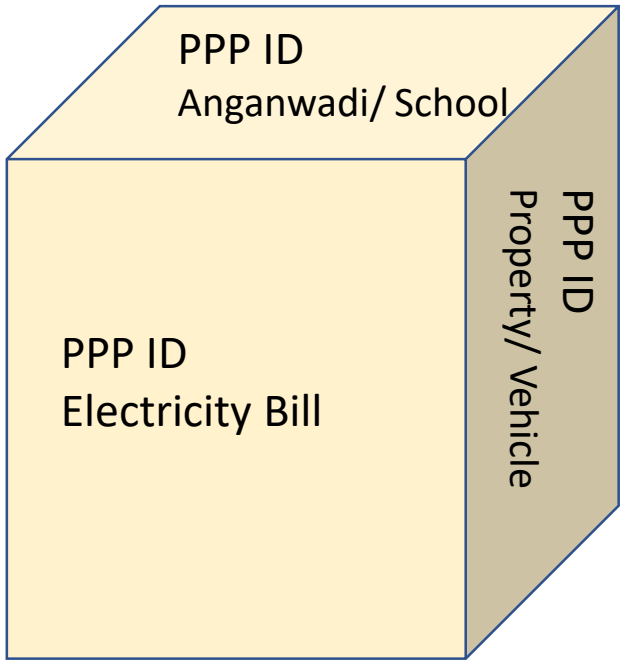
AI for acting

Predictive patrolling

- UP112 has about 700 patrol vehicles that collectively serve a population of about 220 million people
  - UP112 currently receives 50000 calls each day, of which about 10% result in an emergency response
- Average first response times – 20 minutes
  - Average distance driven per patrol vehicle per day – 70 kms
- A **predicting patrolling** system reduces response times by 20% and fuel consumption by 25%
  - Similar idea being used in *allocating* the field engineers in a Bengaluru Internet Provider!

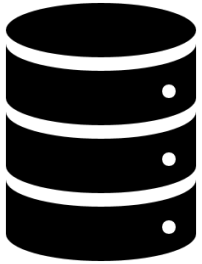


Income assessment



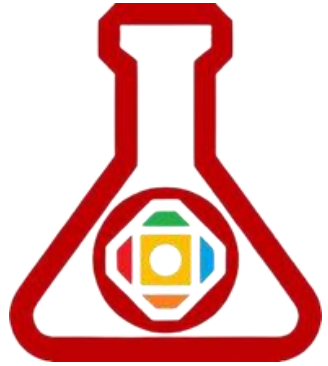
Inference

HRMS (Salary labels)



- Use regression modelling to **predict income** levels of households
- **Validate** against held out sample from HRMS, labor, contracts
- **Out-of-sample** validation with **survey** using 2200 respondents from all districts


प्रशासनिक सुधार और लोक शिकायत विभाग
DEPARTMENT OF
ADMINISTRATIVE REFORMS &
PUBLIC GRIEVANCES
Dashboard
Category Analysis
Spatial Analysis
Root Cause Analysis
History
Saved
Dashboard / Home
Home
LOG O
Fresh
12,321
+55% than last week
Normal
24,231
+55% than last week
Spam
2,300
+3% than last month
Repeat
3,462
-2% than yesterday
+5% than yesterday
Select Ministry
ALL
From
21/07/2023
To
21/08/2023
Top 20-States / UT's Grievances
24.7%
3.0%
3.1%
3.4%
3.9%
4.0%
Uttar Pradesh
Maharashtra
West Bengal
Delhi
Gujarat
Bihar
Daily Grievances
7000
6000
5000
14/8/2023
15/8/2023
16/8/2023
40000
IGMS 2.0
Automated spam, repeat filtering and trend analysis



Nitin Saxena, nitin@iitk.ac.in
Nisheeth Srivastava, nsrivast@iitk.ac.in

CSE & WSAIS & CDIS & CDIS Pvt Ltd & AIRAWAT CoE
IIT Kanpur

https://iitk.ac.in/cdis/