Emerging Tech and Municipal WASH Services

Center for Water and Sanitation - CRDF

CWAS CENTER FOR WATER AND SANITATION | CRDF CEPT RESEARCH AND DEVELOPMENT FOUNDATION | CEPT UNIVERSITY

Why do we want computers to do our work?

Never make a mistake

- A Machine will follow instructions to the letter

Do things faster & Never get tired

- Machines not limited by restrictions of the human body.

Never get bored

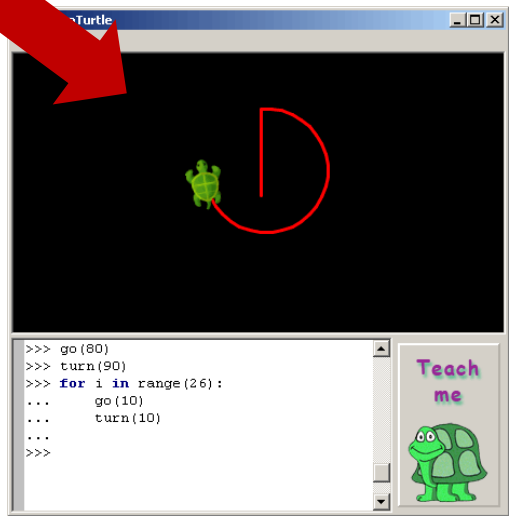
- Not limited by things like human emotional needs

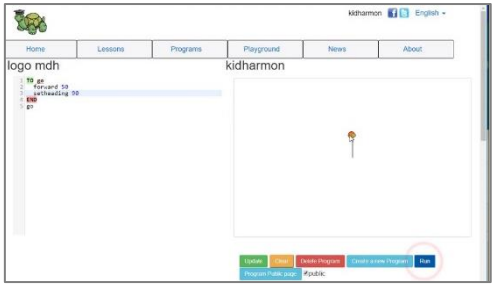
Free up human resource for more "creative" tasks

- Live to work or work to live?

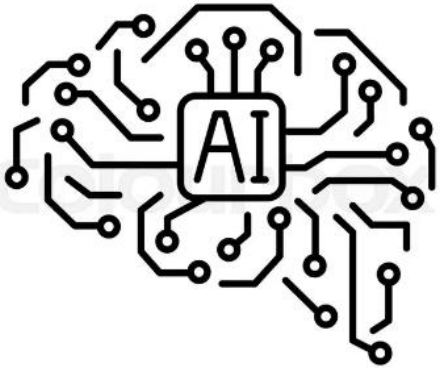
The limitations!

"GIGO" stands for "Garbage In, Garbage Out," a principle in computer science
- the output's quality is directly determined by the quality of the data fed into the system





Will only do what is expressly written or "coded"



Artificial Intelligence (AI)
Capable of mimicking the intelligence or behavioral pattens of human or any other living entity

AI terminology

Artificial Intelligence (AI)
Capable of mimicking the intelligence or behavioral pattens of human or any other living entity

Machine learning (ML)
Technique by which a computer can "learn" from data, without using a complex set of rules or being specifically programmed. Based on training a "model" on big datasets through "supervised / unsupervised / reinforcement" type learning

Algorithm based and human interventi on-based learning

Deep learning
Technique to perform machine learning inspired by our brain's own network of neurons or "neural network" (ANN = artificial neural networks)

Generative AI (GenAI)
Type of ML model that can generate data similar to the data it was trained on.

Chatbots – ChatGPT (OpenAI), Copilot(Microsoft), Gemini/Bard (Google), LLaMA (Meta), Claude(Anthropic)

Text to image – Stable Diffucions, Midjourney, DALL-E (OpenAI)

Text to video – Sora (OpenAI)

Large Language models (LLM)
Type of ML model notable for its ability to achieve general-purpose language generation and other natural language processing typically used in "chatbot" format through feeding "prompts"
NLP = Natural language processing: Ability of AI achieved through deep learning to understand and interpret human conversational language
GPT = Generative Pre-trained LLM based on "Transformer" type architecture

Big data: data sets that are too large or complex to be dealt with by traditional data-processing application software. "High volume, velocity, veracity"

Data mining: process of extracting and discovering patterns in large data sets involving methods at the intersection of machine learning, statistics, and database systems. The term "data mining" is a misnomer because the goal is the extraction of patterns and knowledge from large amounts of data, not the extraction (mining) of data itself.

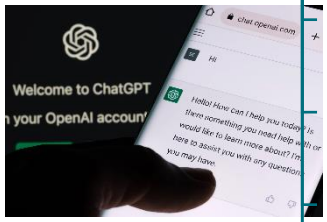
Internet of Things (IoT)
Devices, processing ability or software that enable exchange of information (translating data from the physical world to digital) over communication networks

How does AI mimic human intelligence?

Natural language processing to comb through large datasets and remove requirement of coding

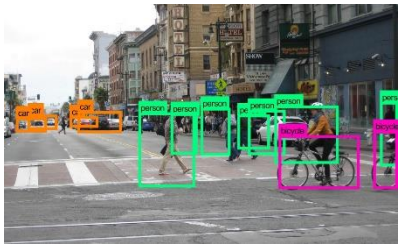
Converting to “actionable information” - – image recognition, Speech recognition

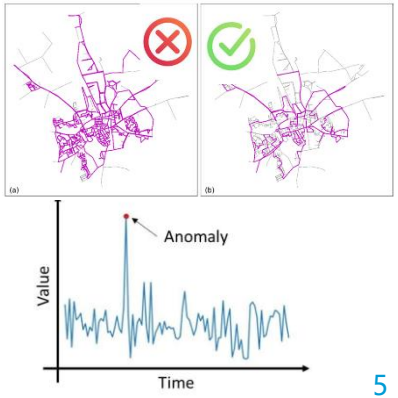
Finding trends and connections that may be missed by human



instead of

- **Natural language processing (NLP)**
  - Context extraction
  - Classification
  - Translation
  - Question answering
  - Text generation
- **Computer vision (images and videos)**
  - Edge detection (raster to vector)
  - Object recognition and classification
  - Face recognition
  - Movement analysis and object tracking
  - Generated images
- **Speech recognition**
  - Speech to NLP
  - Language translation
  - Text to speech generation
- **Pattern recognition**
  - Latent trends
  - Anomaly detection





Can we apply to challenges in urban sector?

Scale and variability of problems is huge!

Human resource limited

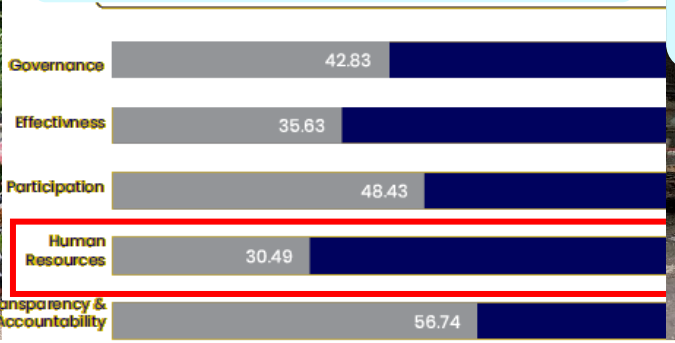
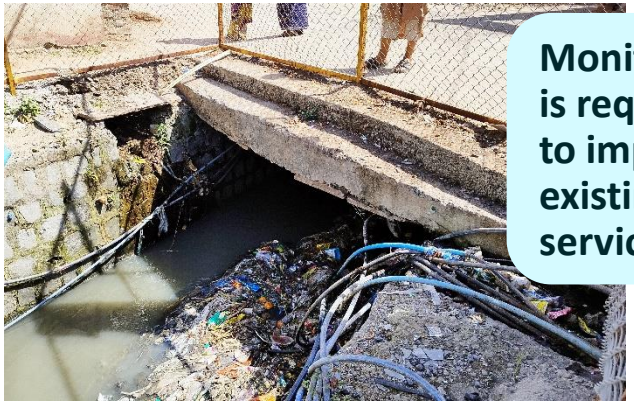


Figure 27: National Average scores of Governance vertical, and its sectors

Some problems are decision intensive and human resource intensive – segregation?

Need to move away from human intervention in some aspects!



Monitoring is required to improve existing services

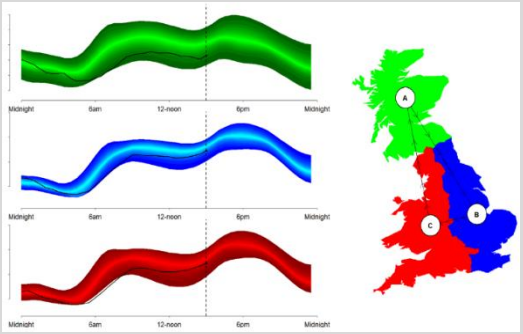
There is a need to go from "firefighting mode" to "predictive management"

Emerging Applications for urban services

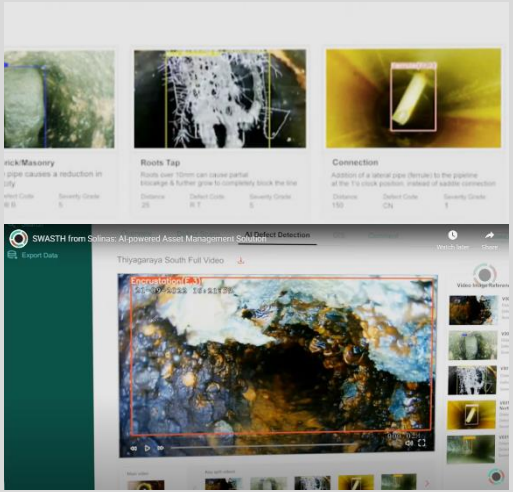
In Dubai, 99% accuracy in sorting mixed recyclables was achieved by using AI for segregation.

Tuas South Desalination Plant Optimization:

AI helps detect potential equipment failures, The real time data helps optimize energy consumption by 10%



Use of AI to predict water demand in UK from Alan Turing Institute

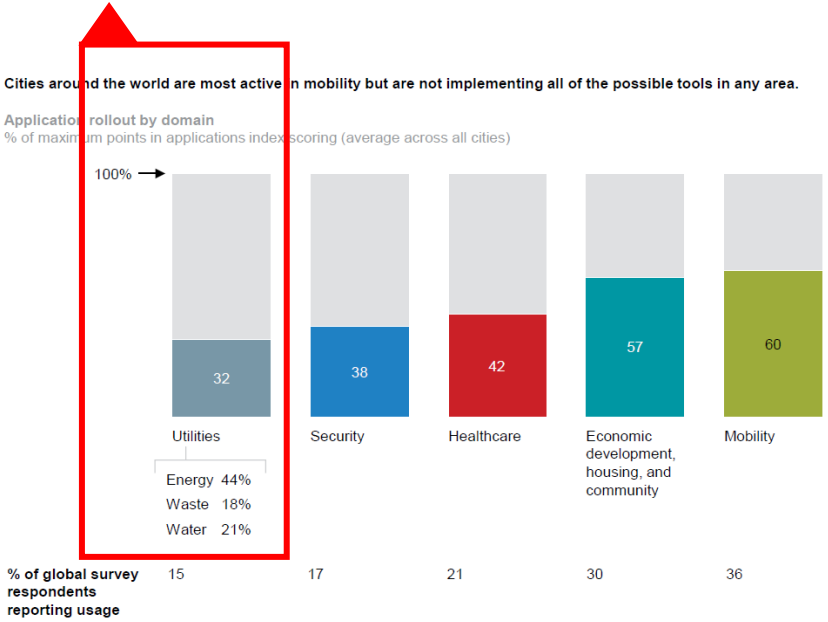


Swasth AI based diagnostic tools capable of detecting and mitigating water contamination, wastages, and sewer overflows, often unnoticed due to underground issues like leaks, blockages, and tree roots

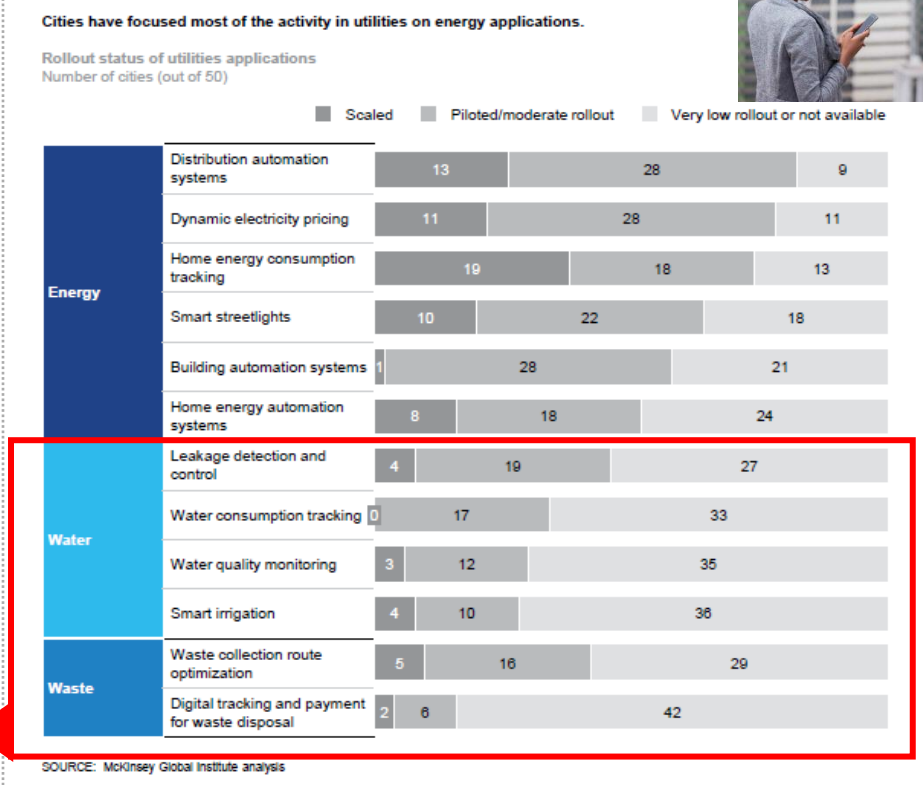
Source:Gulf Business. (2023, August 16). Gulf Business. Retrieved from Artificial intelligence harnessed for waste management with BEEAH's AI City Vision: https://gulfbusiness.com/beeah-ai-city-vision-waste-management/ ABB. (2021, August 23). ABB. Retrieved from ABB's technology in Singapore's first dual-mode desalination plant helps tackle water scarcity in region: https://new.abb.com/news/detail/81568/abbs-technology-in-singapores-first-dual-mode-desalination-plant-helps-tackle-water-scarcity-in-region SOLINAS. (2023). SOLINAS. Retrieved from REVOLUTIONIZING PIPELINE AND SANITATION INDUSTRY: https://www.solinas.in/# , Sharma, M. (2023, September 26). Hindustan Times. Retrieved from Cities switching to robots to tackle water, sanitation issues: https://www.hindustantimes.com/cities/delhi-news/cities-switching-to-robots-to-tackle-sanitation-issues-101695579476196.html

....but slow uptake in WASH?

AI tools are being rapidly utilized in several public services, but WaSH services are catching up slowly



Several Pilot scale applications have been implemented, but scaling at the city level is yet to be done.



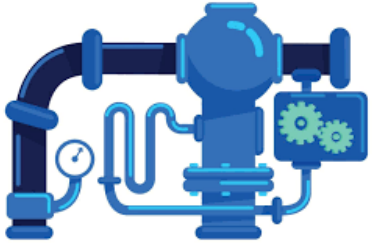
Source: McKinsey Global Institute, 2018

Use of AI in various municipal services

Wastewater and Sanitation

Waste management

Safety and security



Water supply

Urban mobility and public transport

Street lights

Urban health

Use cases for the WASH sector

Clearbot robot : Lake cleaning and pollution detection-trash, water hyacinth

Endobot robot + Swasth GIS: crawls inside the water pipelines in the area and helped identify contamination points, cracks, leaks, encrustations, and broken pipe walls

SmartTerra: NRW reduction, loss reduction even in intermittent supply, abnormal meter reading detection

San Francisco, Copenhagen, Arhus | real-time data from sensors to optimize treatment process - water quality (dissolved oxygen, organic matter, pollutants), flow rates, and energy consumption to adjust energy usage, chemical dosing, and maintain disposal standards

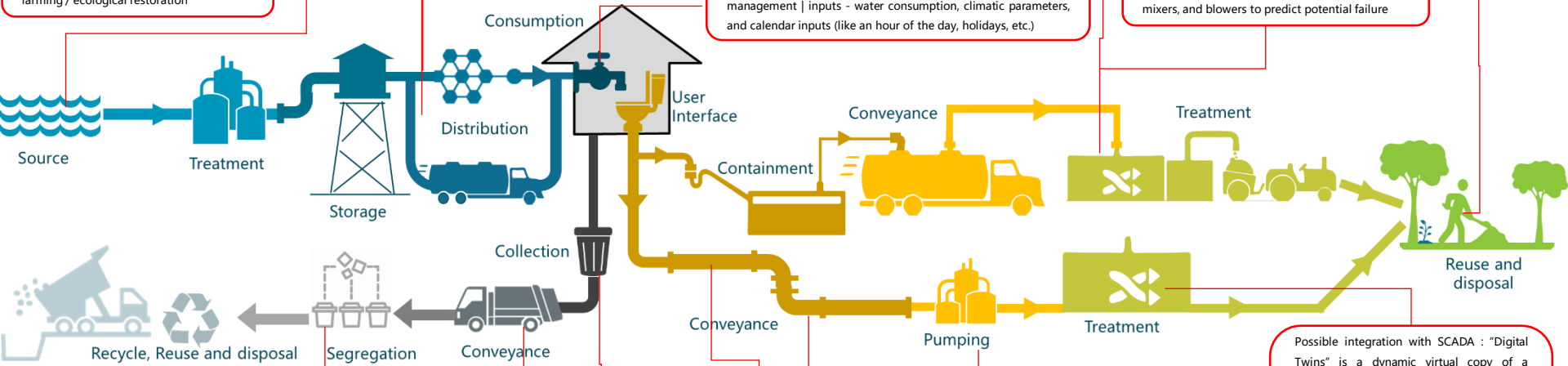
Singapore | Waste to energy – optimize anaerobic digestion parameters through sensor input to maximise biogas yield

AquaNurch (India) digital twin models for water bodies – weather and climate data + water quality data form sensors to maintain health of water body for improving fish farming / ecological restoration

Bengaluru | IoT + AI model for autonomous municipal pumping of groundwater

Hubli, Karnataka | Study on short term water demand forecast modelling using artificial intelligence for smart water management | inputs - water consumption, climatic parameters, and calendar inputs (like an hour of the day, holidays, etc.)

Toronto | Predictive maintenance of WW plant by analysing data from sensors installed on pumps, mixers, and blowers to predict potential failure



Possible integration with SCADA : "Digital Twins" is a dynamic virtual copy of a physical asset, process, system or environment that looks like and behaves identically to its real-world counterpart. A digital twin ingests data and replicates processes so you can predict possible performance outcomes and issues that the real-world product might undergo.

BEEAH Recycling, Sharjah | AI image recognition on conveyor belt coupled with robotics to automatically detect, identify and separate different types of waste

RCD, a pre-trained dataset meticulously curated from historical records of the recycling company Remondis | detect plastic bags in collected waste

Vishakhapatnam, Singapore | volumetric senor IoT | detect waste level in bin and alert collection vehicle, vehicle route allocation, reduce unnecessary trips

Varanasi | Camera IoT | Littering detection and waste bin full/empty status detection

Stormharvester Intelligent sewer suite | IoT sensors under access covers and at outlers | alerts about blockgaes and potential poullutants

Bandicoot robot: equipped with human-like arms and a range of gas sensors to identify and assess sewage conditions inside drainage chambers

Stormharvester Smart tank – manage water levels in local level attenuation tanks through analytics on rainfall forecasting to prevent local level flooding – reduce sewer discharge and promote reuse onsite

1

- Computer vision - Combining AI, Camera inputs and robots to automate waste segregation
- The facility reported a 76% waste diversion rate

Sharjah

BEEAH Launches Recycling Facility with Robotics & AI to reinforce Zero Waste to Landfill Ambitions

BACK TO ARTICLES

automatically detect, identify and separate different types

2

- Household waste trapped in plastic bin bags makes segregation difficult
- Remondis Contamination Dataset (RCD), a pre-trained dataset meticulously curated from historical records of the recycling company Remondis
- Use camera footage directly from trucks and detect plastic bags in collected waste

Illawarra, Australia,

3 VISAKHAPATNAM

Creating a Healthy Metropolis using AI

23.1 Problem Identification

Solid Waste has been a major concern in Visakhapatnam city. Due to the vast area of the city, monitoring the garbage collection from each and every bin was a herculean task. The officials of GVSCCL aimed to create "A Resilient and Healthy Metropolis for People" by addressing the problem.

23.2 Role of AI in Solution

To address the problem identified, IOT sensor-based semi-underground bins were installed across the ABD area with volumetric sensors. These sensors are used to detect the level of waste in the bin. Waste collection monitoring by using RFID tags for compactor bins and GPS for the garbage weighing machines. Smart Bin Utilization to monitor the waste generated.

The bins are integrated into the COC application. Once the volume reaches above

- Combining IoT and AI
- IoT to sense 90% full bin
- AI to optimize collection route – dynamic route allocation
- Efficiency – reduce unnecessary trips

4 VARANASI

Efforts to make the city cleaner using AI

22.1 Problem Identification

To make any city cleaner, at first, the pressing issue of Solid
make its city cleaner has planned for better monitoring and
to have better control over the spaces.

22.2 Role of AI in Solution

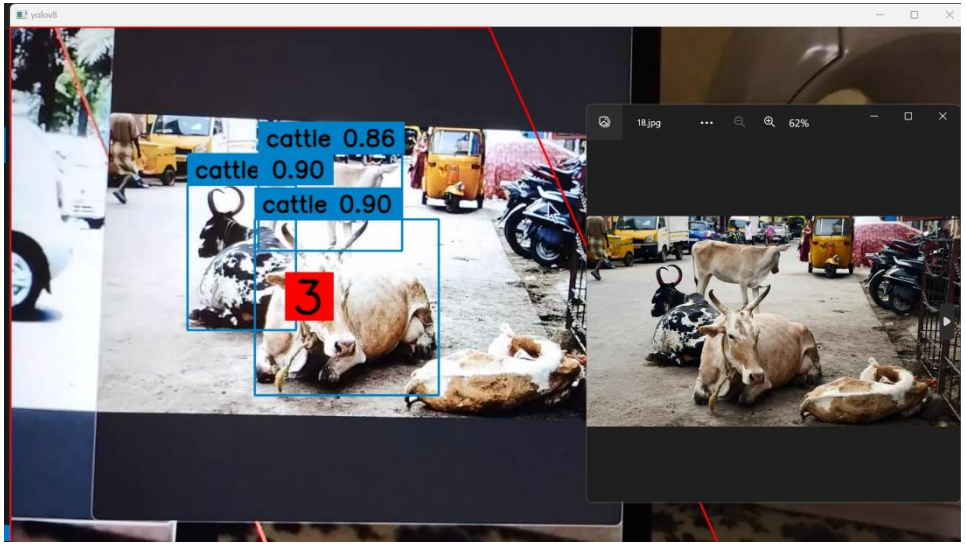
Video analytics application takes the streaming data as inpu
streams over RTSP, and uses AI and computer vision to
understanding of the environment. This design can be the fo
solutions and is also used for monitoring solid waste in cities. Helps in detecting the littering on roads
and identifying the status the of waste bin (Full/empty).

The framework comprises stream and batch processing capabilities. Every component of the Analytics layer, Message Broker, Streaming, NoSQL, and Search Indexer can be horizontally scaled. The streaming analytics pipeline c
like traffic flow rat
a period of time,
management, e.g.
This also provides
time-series analyti
standard API for v
on the use case. Th

- CCTV cameras and computer vision
- Littering detection and full bin detection through cameras
- Alerts to authorities through SMS / email

5 Surat

Surat is exploring AI with CCTV for cattle management on road..



The technology uses COMPUTER VISION to detect cattle as well as their behavior and body language. It is popularly used in large farms in USA.

6 Stormharvester Intelligent sewer suite - Wessex, UK

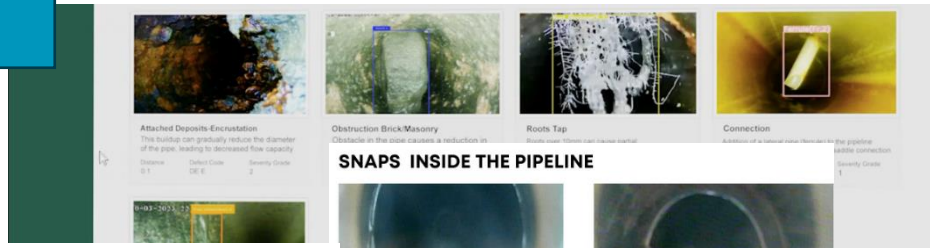
- IoT sensors under access covers and at outlets
- Alerts about blockages and potential pollutants
- Anomaly detection

SMS: Near real-time predictions and alerts

7 Bandicoot robot – Kerala

- Equipped with human-like arms and a range of gas sensors to identify and assess sewage conditions inside drainage chambers
- Machine Vision: It uses machine vision technology for operators to see inside manholes, even in low-light conditions.

8 Endobot robot and Swasth AI – Chennai, Goa



- Crawls inside the water pipelines in the area and helps identify contamination points, cracks, leaks, encrustations, and broken pipe walls
- Inclination calculations / network mapping for old infrastructure

9 Bangalore - AI for groundwater

AI-based groundwater monitoring system to revolutionize water management in city

TNN / Apr 23, 2024, 04:03 IST

SHARE AA FOLLOW US

Bengaluru: To tackle water scarcity in the city, BWSSB has annc based advanced Developed in coll Indian Institute Water Board (CG Authority, it pron and managemen city.

Bengaluru water board bets big on AI and IoT; floats tender for real-time monitoring system for borewells

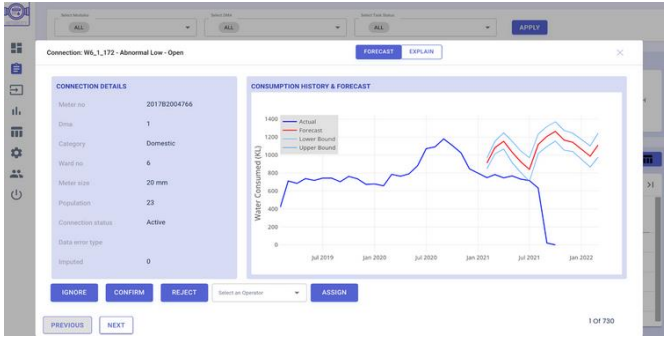
Bengaluru Water Supply and Sewerage Board chairman said that the first phase of the project will cover 1,000 public borewells across the city, with the remaining 10,000 in the second phase.

CHRISTIN MATHEW PHILIP | MAY 17, 2024 / 20:56 IST

Join Us Follow Us

10 SmartTerra: NRW reduction - Indonesia

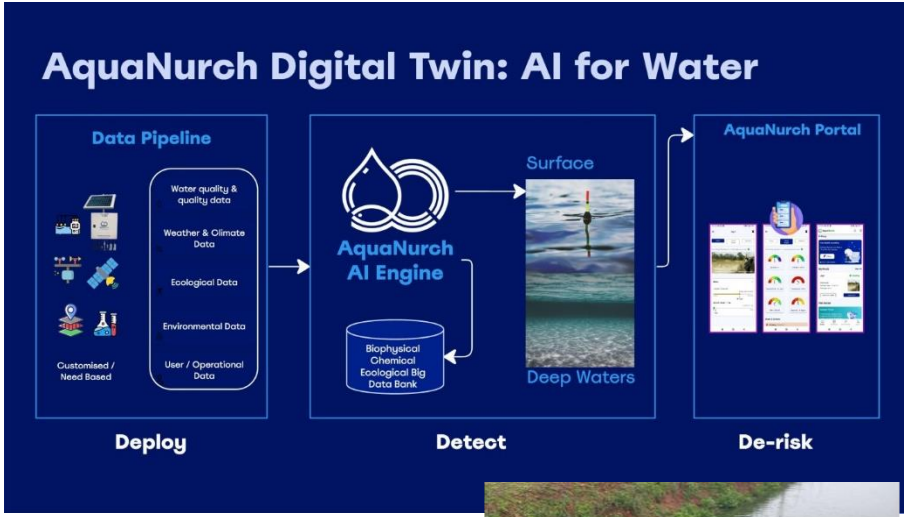
- Detect water loss even in intermittent supply
- abnormal meter reading detection



11 Clearbot robot

- Lake cleaning and pollution detection-trash, water hyacinth
- Autonomous – swim on its own
- One robot is able to collect a metric ton of trash a day
- Computer vision - "We generate data about what's in the water, what's the make-up of the stuff that's there, how much of it is recyclable and what materials we should be focusing on."

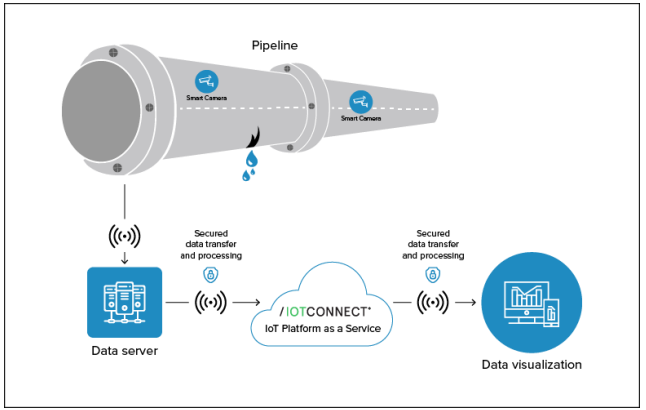
12 AquaNurch (India) digital twin models for water bodies



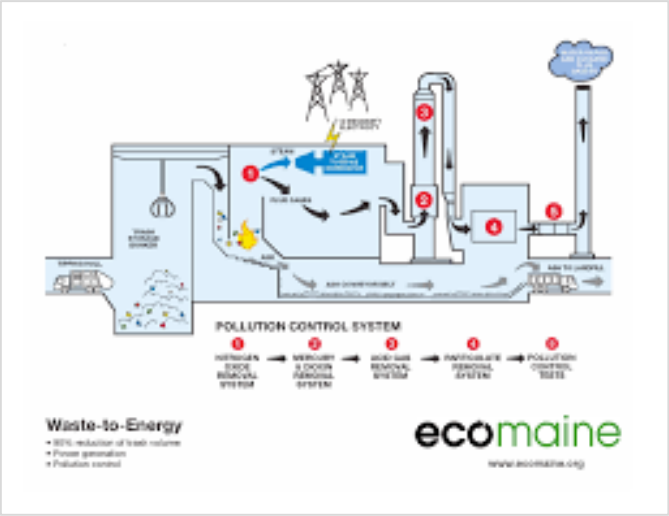
- Weather and climate data + water quality data from sensors to maintain health of water body for improving fish farming / ecological restoration

13 Real-time Detection of Pipe Bursts in Water Distribution Networks

- Adopted by a major UK water company and **in use since 2015**
- Monitors data from **7,000+ pressure and flow sensors** every **15 minutes**.
- Ensures **high true** and **low false** alarm rates
- Identifies **equipment failures** (e.g., pressure reducing valve issues) to prevent burst events – Torronto
- Analyzes **sensor data patterns** for deviations.
- Achieved **major operational cost savings** and **managing NRW**



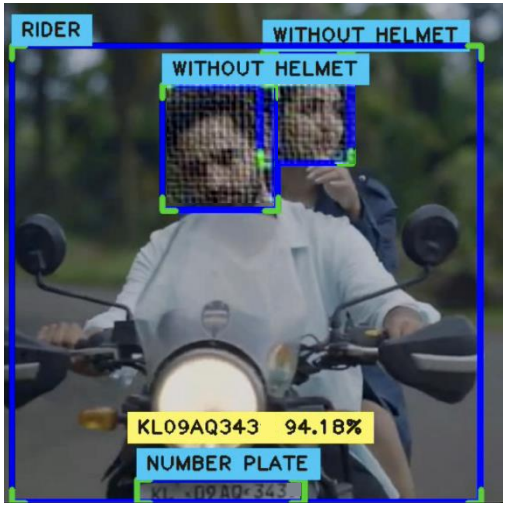
14 Toronto - AI for optimizing treatment facilities



- AI models can predict chemical dosing requirements in treatment plants based on influent quality data.
- AI can optimize aeration systems in STPs to reduce energy consumption.
- Integration of AI-driven models to enhance process efficiency and to maximize biogas yield from waste in Singapore.

15 Use of AI in Mobility and Urban transport

- Ahmedabad, Jabalpur, Nagpur, PCMC, Ranchi, Tumakuru, Vishakhapatnam etc. are using
- Use of computer visioning for traffic management
- Better traffic management – assessing average wait time at signal and improving signaling system
- Automatic number plate recognition and challan issuing
- Enforcing traffic rules by automatic detection of
  - over-speeding
  - no seat-belt
  - no helmet
  - wrong way
  - illegal parking etc.



Use of AI for improving E-Governance system

16 BENGALURU

Adopting AI to enhance Law enforcements services

26.1 Problem Identification

To register multiple department grievances, citizens need to various departments or websites or dial various numbers. Chatbot facilitates Data dissemination and Grievance redressal from a single platform, without human intervention.

26.2 Role of AI in Solution

By using AI technology, the following services would be facilitated.

- Multi department grievance registered and pushed to the respective department for redressal.
- Status of the complaints of various departments which are integrated into this system, can be fetched from this platform.

Key Highlights of the implementation

- Accurate Chatbot functionality has been integrated into Bengaluru Smart City Web Portal. Deployment into Bengaluru Smart City mobile app and Open Data Portal is underway.
- A citizen can either get information or register a grievance and get it redressed without human intervention.

26.3 Implementation Process

The project was implemented through RFP process and it was for full deployment without any POC.

Support Ecosystem

Azure, Bengaluru smart city Ltd. (BenSCL).
Infrastructure Development Corporation (Karnataka). iDeck

Tech Providers:

Fluent Grid

Scale of Deployment

- At present deployed as Web portal, Mobile app, Open Data Portal.

17 PUNE

AI boosting efficiency in Property Tax Assessment

29.1 Problem Identification

Pune Municipal Corporation identified a challenge to sort out the discrepancies in the collection of property tax and identification of the unassessed properties within the corporation area. The main idea is to achieve continuous improvement in property tax database and to develop a process that optimizes tasks automatically without human intervention.

29.2 Role of AI in Solution

AI technology-based Property revenue/tax assessment is an introductory initiative and is unique to the problem statement of PMC. Reduces failures caused by human limitations. The geo-tagged properties database which is updated every 6 months is fed into AI based engine, where the discrepancies (properties leakages) are identified basis which the team inspects such properties on ground.

Key Highlights of the implementation

- Finds out the leakages in property tax collection.

29.3 Implementation Process

Deployment of SI was done through RFP. The bidder who demonstrated better functionality of Machine Learning (ML) and the different ML techniques such as Deep Learning (DL) was qualified for implementing the solution.

Support Ecosystem

SI - M/s. La Mere Business Private Ltd,
Consultant- Ernst and Young LLP,
Municipal teams – IT Department PMC, Property Tax Department, PMC.

Tech Providers:

Fluent Grid

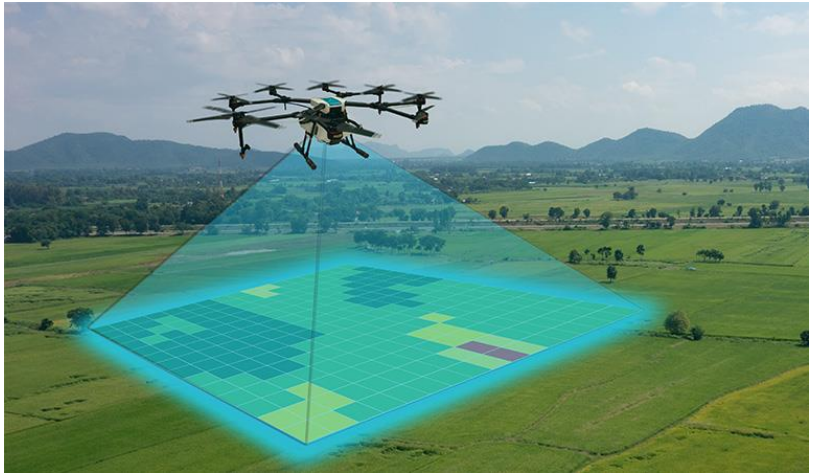
Scale of Deployment

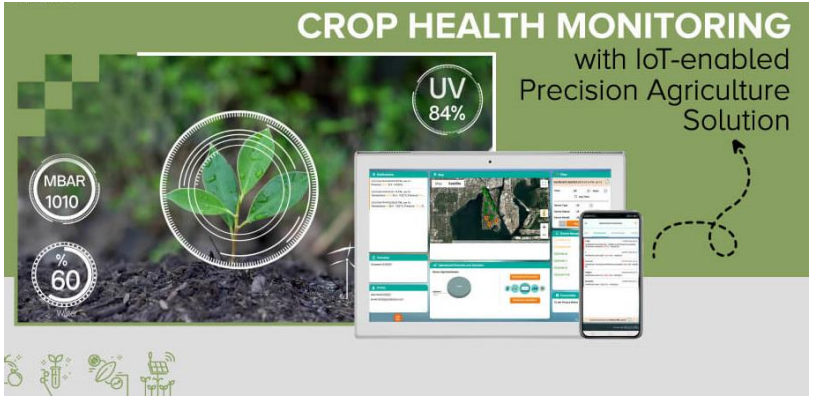
- At present, the solution is deployed at PMC Jurisdiction, initially started with 2 wards of PMC.

- Integrated grievance redressal system in Bangaluru
- Easy integration and access to all complaints by all the departments
- Chatbot functionality has been integrated into Bengaluru Smart City Web Portal for remotely accessing complaints and knowing its status
- Pue- Finds out the leakages in property tax collection.

18 Use of AI and Satellite Imagery in Agriculture

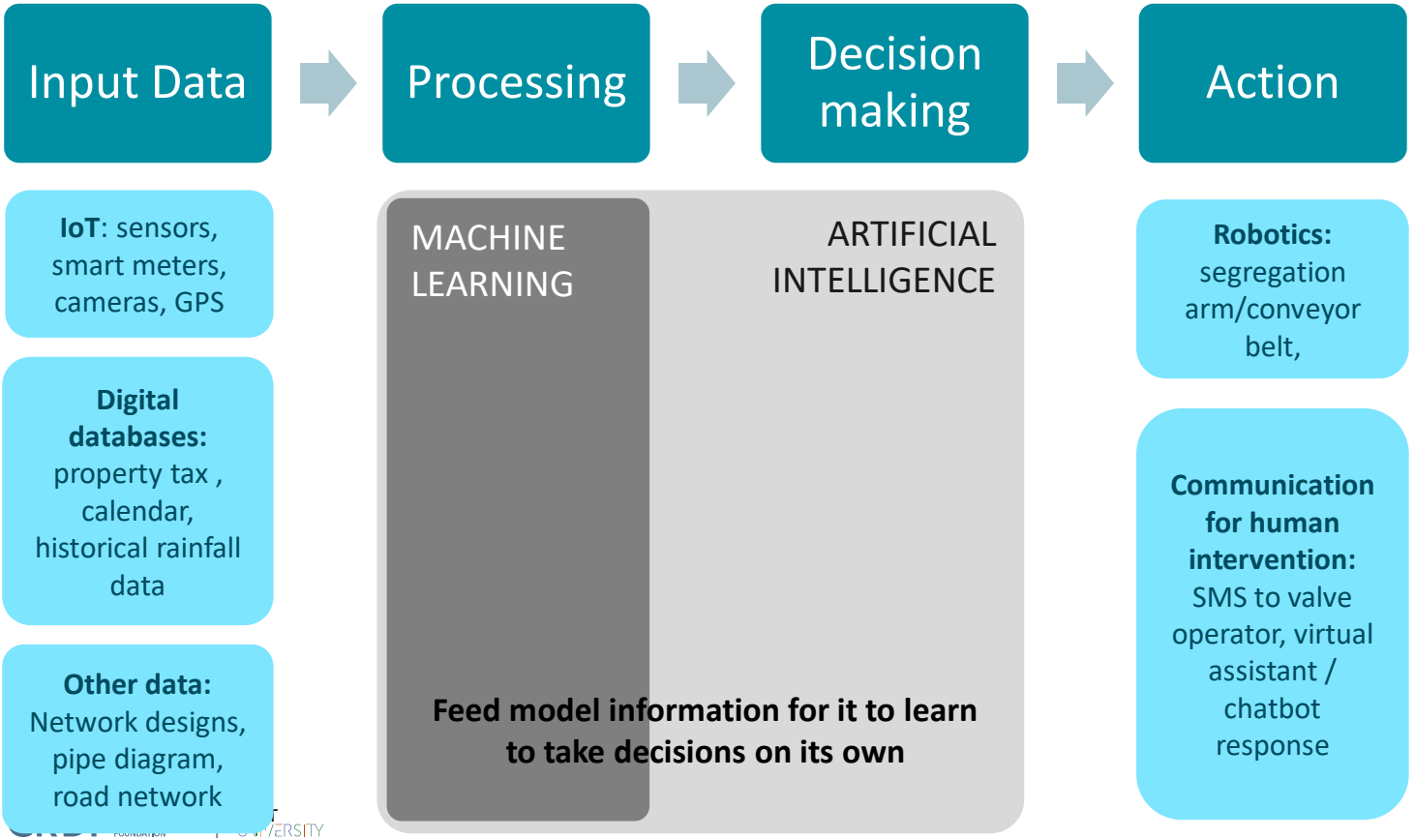
- **Crop Monitoring** and Yield Prediction
- **Satellite Imagery and Drones:** AI models analyze images to assess crop health and detect nutrient deficiencies.
- **Yield Forecasting:** AI uses weather data, soil conditions, and crop growth patterns to predict crop yields.
- **Early Warning Systems:** Predicts droughts, floods, or pest outbreaks.
- **Soil Analysis:** AI analyzes soil composition to recommend optimal fertilizers, reducing overuse.
- **Irrigation Management:** AI-based models predict water needs based on weather patterns and crop types.





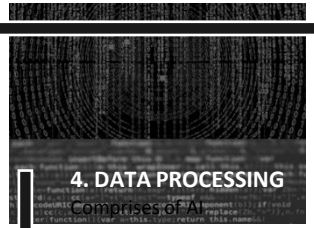
ARE INDIAN CITIES GEARED UP FOR THIS?

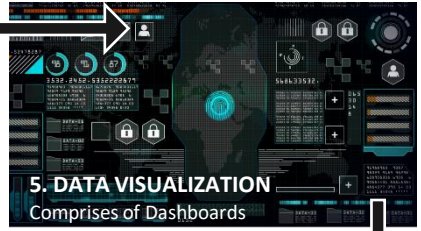
AI is only processing algorithms – cannot perform practical functions alone

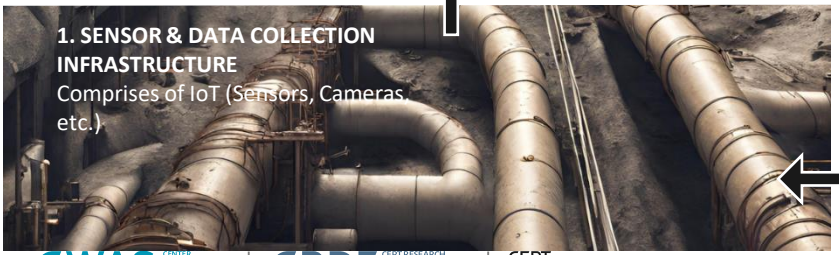


AI requires infrastructure

Comprises of Storage Hardware







Human Intervention → Checking for errors → By AI

Anomaly detection

Error Diagnoses

Error Prediction

Human intervention can be reduced after several cycles

Automated Maintenance

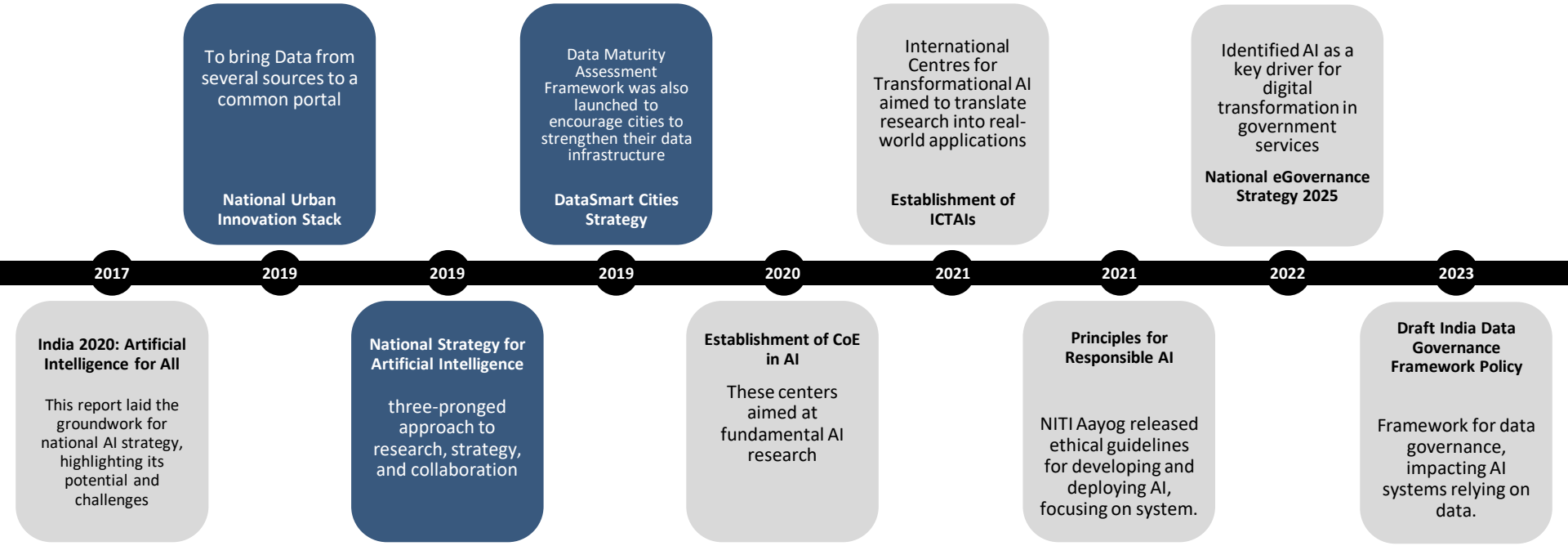
Robotics to execute tasks such as cleaning etc.

Asset requirement Prediction

Often the reality in Indian cities is this ....

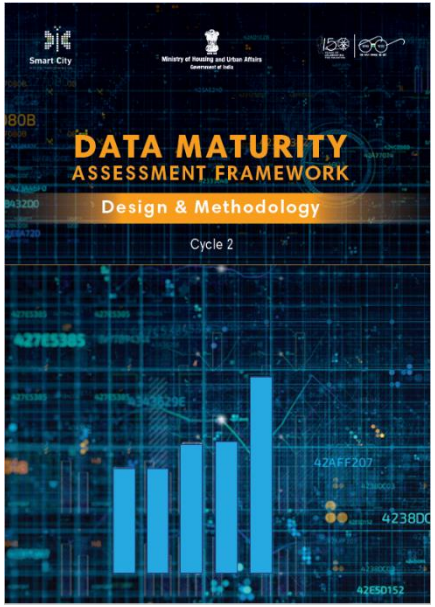
- No digital data for AI to work on!!
- Where to put the sensor??

Budding policy ecosystem in India



SourceNITI Aayog. (2018). National Strategy for Artificial Intelligence - #AIforALL. https://niti.gov.in/sites/default/files/2019-01/NationalStrategy-for-AI-Discussion-Paper.pdf Approach Document for India Part 1 – Principles for Responsible AI https://www.niti.gov.in/sites/default/files/2021-02/Responsible-AI-22022021.pdf Ministry of Electronics and Information Technology, Government of India. (2022). National eGovernance Strategy 2025. https://www.meity.gov.in/e-governance India AI 2023 – Towards Leading the AI Revolution. https://www.goodtidenews.com/dailycurrentaffair-detail/565

Data Maturity Assessment Framework



DMAF serves as a strategic tool to evaluate the readiness of cities to effectively leverage the potential of data to address complex urban challenges in 100 Mission Cities.

Systemic Maturity	Sectoral Maturity
Focuses on foundational aspects of data governance, infrastructure, and capacity building	Assesses data maturity across various city sectors (e.g., mobility, health, education)
Policy	Data Availability
People	Data Usage
Process	Data Shareability
Technology	Data Management
Outcomes	

Still a wealth of information possible with satellite images…

Spain : Municipal planning, taxation and swimming pools

A Platform for Swimming Pool Detection and Legal Verification Using a Multi-Agent System and Remote Image Sensing

Héctor Sánchez San Blas, Antía Carmona Balea, André Sales Mendes, Luís Augusto Silva*, Gabriel Villarrubia González

Expert Systems and Applications Lab—ESALAB, Faculty of Science, University of Salamanca - Plaza de los Caídos s/n, 37008 Salamanca (Spain)

Received 30 September 2021 | Accepted 21 October 2022 | Published 11 January 2023

unir LA UNIVERSIDAD EN INTERNET

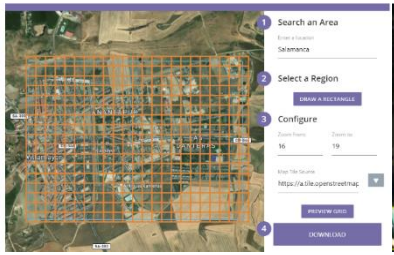
ABSTRACT

Spain is the second country in Europe with the most swimming pools. However, the legal literature estimates that 20% of swimming pools are not declared or irregular.The administration has a corps of people who manually analyze satellite or drone images to detect illegal or irregular structures. This method is costly in terms of effort and time, and it is also a method based on the subjectivity of the person carrying it out. This proposal aims to design a platform that allows the automatic detection of irregular pools. Using geographic information tools (GIS) based on orthophotography, combined with advanced machine learning techniques for object detection, allows this work. Furthermore, using a multi-agent architecture allows the system to be modular, with the possibility of the different parts of the system working together, balancing the workload. The proposed system has been validated by testing it in different towns in Spain. The system has shown promising results in performing this task, with an F1-Score of 97.1%.

KEYWORDS

Deep Learning, GIS Detection, Illegal Pools Detection, Pool Aerial Recognition.

DOI: 10.9781/ijimai.2023.01.002



VEDAS @SAC-ISRO: Land use insights

AI-Extracted Built-up Area for 500 AMRUT cities

Built-up area serves as an important indicator of socio-economic growth of a country. Several studies require built-up area for quantifying anthropogenic impacts on environment and climate change. The built-up surfaces are very dynamic and therefore require regular monitoring. The 5.8 m spatial resolution of Resourcesat-2/2A LISS-4 sensor is not only suitable for mapping core urban areas, but is also effective in capturing small scattered growth in urban periphery. The built-up area of 500 cities of India (identified under AMRUT programme) was extracted from Resourcesat-2 LISS-IV data for 2023-2024 timeframe using Artificial Intelligence (AI). The AI-model uses Convolutional Neural Network (CNN) architecture based on UNet and Atrous Spatial Pyramid Pooling (ASPP) concept. A web-based application on VEDAS portal was created to enable visualisation and analysis of built-up area. It enables state and national level comparison of built-up area of cities.

Click here to go to Urban Sprawl Information System

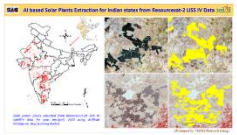
Click here to Know more
(PDF Size:2.5MB Language: English)

AI based Solar power plants extraction for Indian states from Resourcesat LISS IV data

Solar power plants are extracted for ten Indian states (Haryana, Punjab, Gujarat, Madhya Pradesh, Rajasthan, Maharashtra, Karnataka, Telangana, Andhra Pradesh and Tamil Nadu). Combined installed capacity of solar power for these states is 81.87GW which is about is 90.2% of India's total solar capacity (90.76GW) . Automatic extraction of these Solar power plants are done using artificial intelligence based deep learning neural networks for the year (Jan-April) 2023. Indian Remote sensing (IRS) Resourcesat-2A LISS IV satellite data is used with 5m ground spatial resolution and three spectral bands green, red and NIR. The study also includes temporal change analysis of Solar Plants from 2018 till 2023. It is found that in the past five years solar power plants inventories have increased nearly 6.3 times in Rajasthan, 2.5 times in Gujarat, 1.5 times in Madhya Pradesh, 1.57 times in Maharashtra, 1.25 times in Karnataka, 0.3 times in Telangana, 1.87 times in Andhra Pradesh and 2.31 times in Tamil Nadu. This work is carried out under TDP-202302021, titled "Deep learning Based Solar Plants Identification using high-resolution remote sensing data".

Click here to go to New and Renewable Energy

Click here to Know more
(PDF Size:1.20MB Language: English)



So AI is coming to take our jobs???

What we humans can still do better than AI

Emotional intelligence and empathy

Social skills

Creativity

Physical coordination

Sensory perception

Perspective and imagination

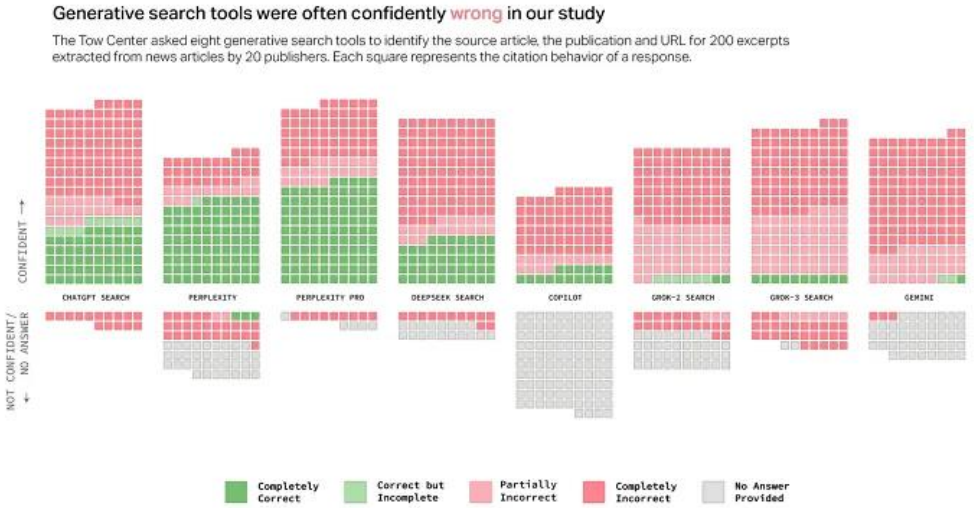
Natalie Laderas-Kilkenny

The Bloke. (2024). Mistral Instruct (1.7B) [Large language model]. https://huggingface.co/mistralai

Current case of Grok

Grok AI trains using data on X – formerly known as twitter (such as public posts by users) to provide “up-to-date information and insights.”

A dangerous game – user comments may contain bias and cannot be taken as fact !



Thank you

CWAS CENTER FOR WATER AND SANITATION | CRDF CEPT RESEARCH AND DEVELOPMENT FOUNDATION | CEPT UNIVERSITY

cwas@cept.ac.in

cwas.org.in

About us

The Center for Water and Sanitation (CWAS) is a part of CEPT Research and Development Foundation (CRDF) at CEPT University. CWAS undertakes action-research, implementation support, capacity building and advocacy in the field of urban water and sanitation. Acting as a thought catalyst and facilitator, CWAS works closely with all levels of governments - national, state and local to support them in delivering water and sanitation services in an efficient, effective and equitable manner.

cwas.org.in

cwas@cept.ac.in

CEPT_CWAS

cwas.cept

cwas.cept

cwas.cept