



Defence Research & Development Organisation

Defence Geoinformatics Research Establishment

AI Transforming Defence & Security Operations

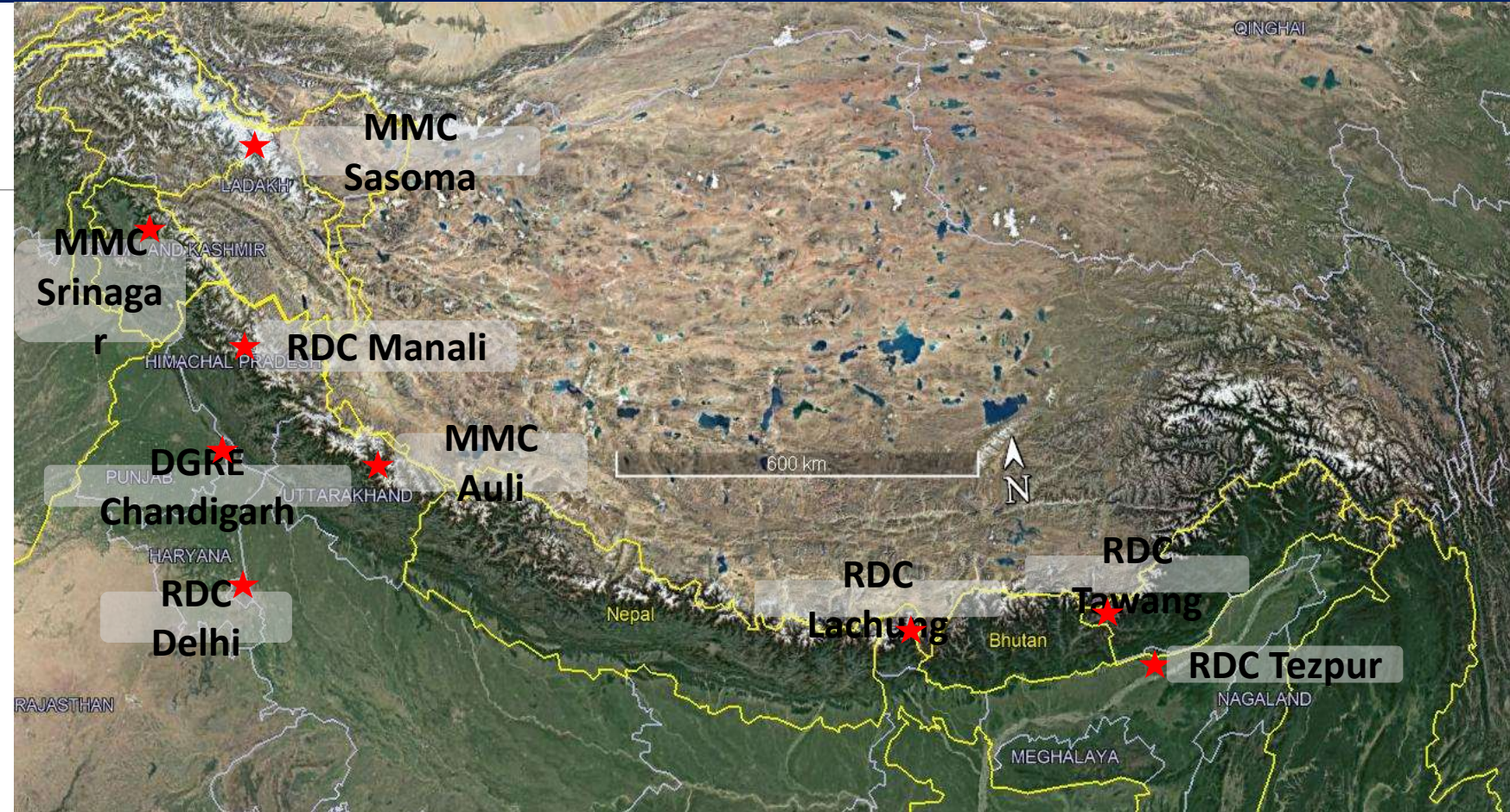
Tribhuvan Singh Rawat

Scientist-F, DGRE

GEO-INTELLIGENCE 2022 14TH & 15TH JUNE 2022

About DGRE

- Defence Geoinformatics Research Establishment (DGRE) has been raised on 15 Nov 2020 at Chandigarh.
- Imbibes the responsibilities of erstwhile two DRDO labs viz. Snow & Avalanche Study Establishment (SASE) Chandigarh and Defence Terrain Research Laboratory (DTRL) Delhi.



Geoinformatics Technologies and Products

Terrain & Snow Characterization

- Elevation, slope and aspect maps
- Geomorphological maps
- Vegetation, Soil, Rock maps
- Snow cover, depth, temp. maps
- Trafficability maps

Remote Sensing and Field Measurement

- Terrain data (DEM)
- Satellite images
- Multi/Hyper spectral RS data
- Geo-surface properties
- Pre and post event survey

Snow-met measurement

- Sensor development
- AWS Network
- Snow-met data
- Sensor Calibration Lab

Geo-Intelligence

- HS image processing
- Material characterization
- Spectral library for military targets
- Decision Support System

Geo-Hazard Mitigation Technologies and Products

Hazard Mapping

- Identification
- Geo-flow modeling
- Simulation
- Mapping

Safety/Rescue

- Training/ awareness
- Victim detection
 - UAV based
 - Harmonic radar, RF Tag

Structural Control

- Mitigation schemes
- Structural layout
- Design loads
- Relocation/alignments

Weather Forecasting Models

- Statistical, Physical, Numerical
- AI, Deep learning etc.
- Expert systems

Early Warning Systems

- Terrestrial/space/aerial
- AE, Infrasonic
- Seismic, Geophones
- Doppler radar

Safety Audit of Location, Infrastructure

- Protective Measures
- Hazard Analysis of Routes and Tracks
- Avalanche and landslides zones identification

Artificial Triggering of Avalanches

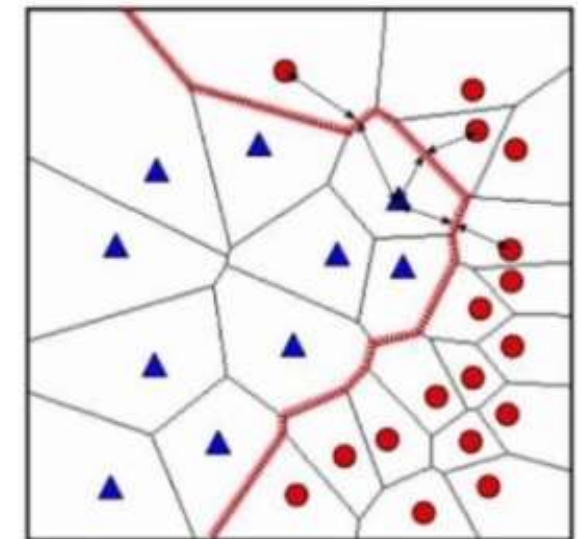
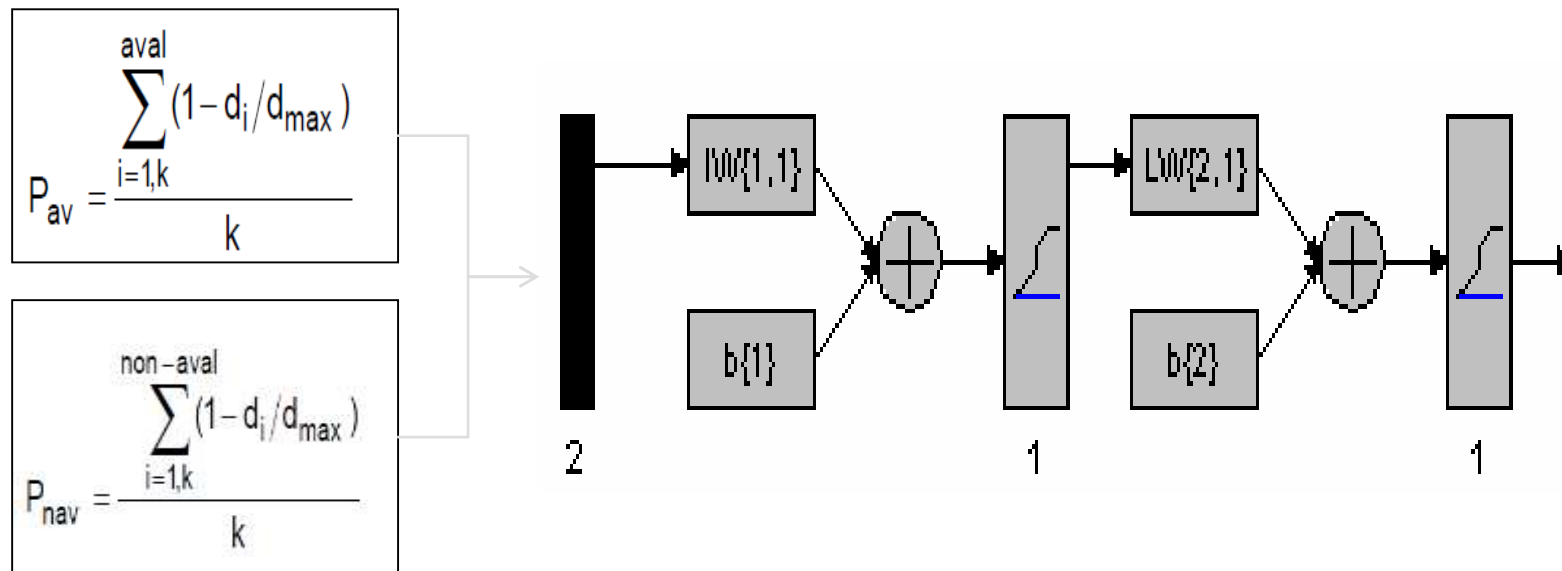
- Platforms: Drones, Guns etc.
- Ammunition

“Domain specific customization and development of AI-ML tools rather than a black-box approach to problem solving for better performance and interpretability”

Operational Avalanche Prediction

Salient features

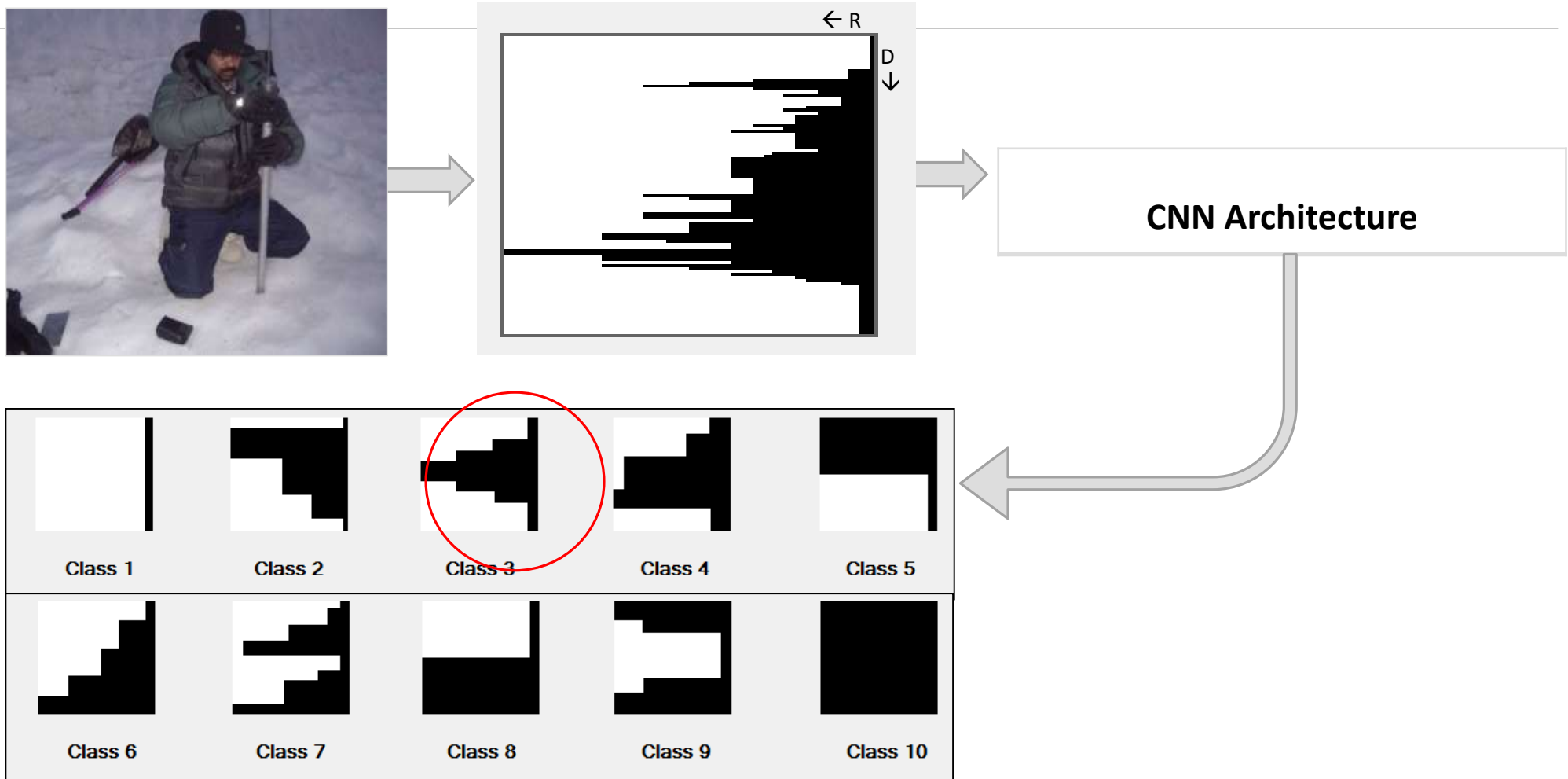
- Exploits the non-linear decision boundary
- Features' weights by Artificial Bee Colony (ABC) algorithm
- Artificial Neural Networks at terminal stage for final decision



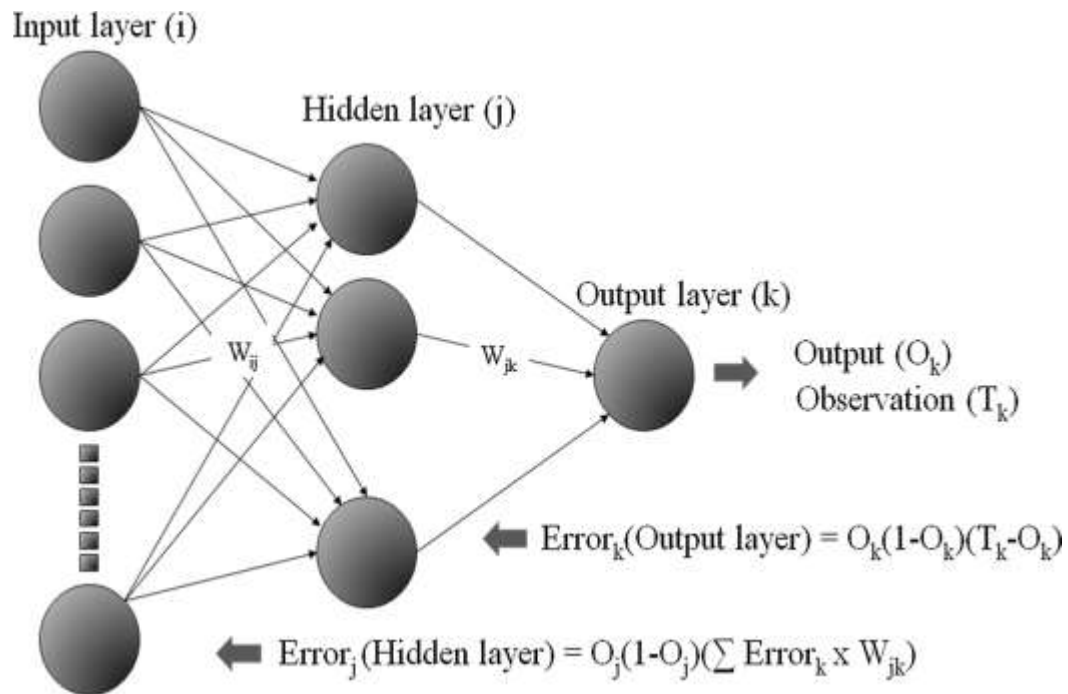
Snowpack ram profile classification

Salient features

- Based upon Convolutional Neural Network (CNN) technique for image classification



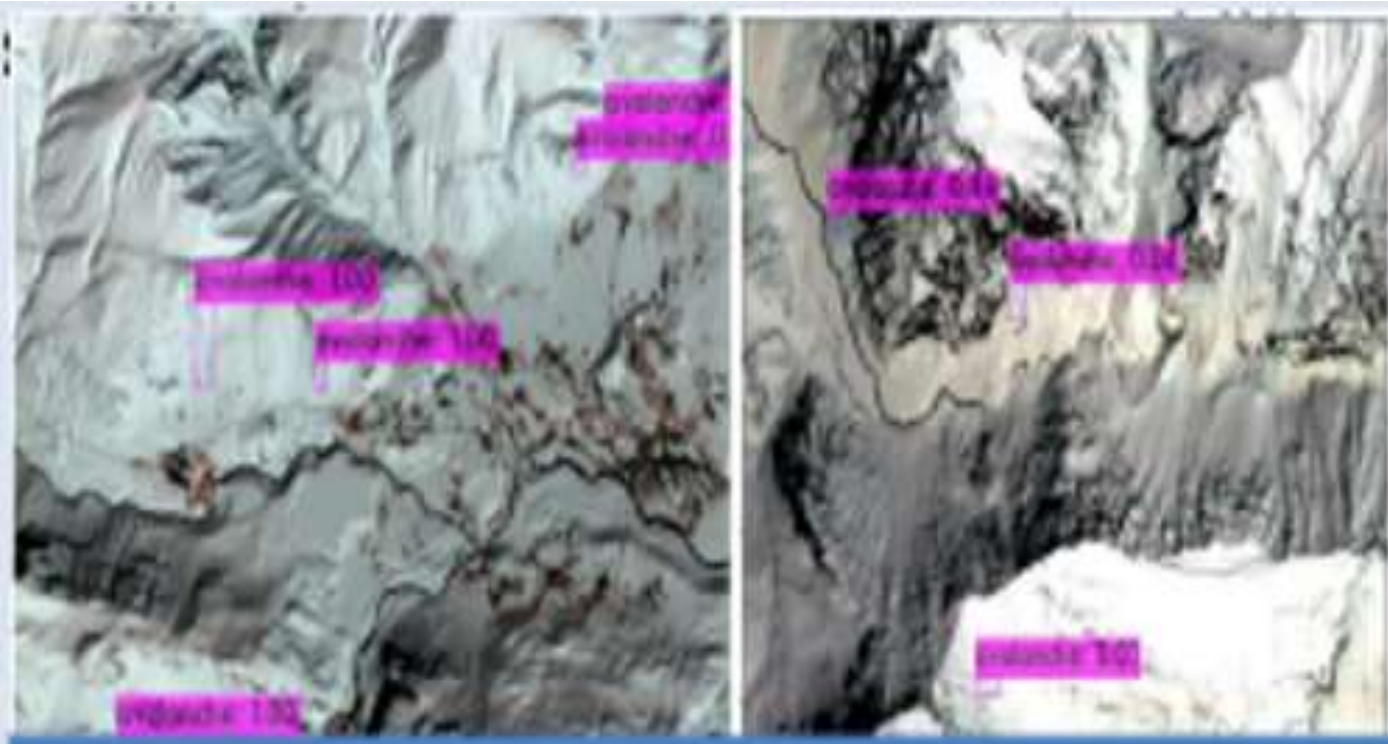
Snowpack Simulation



Features

- A neural network-based model for snow cover simulation and avalanche hazard prediction.
- Validated through RMSE computation of simulated snowpack parameters and accuracy, bias, false alarm rate and Heidke Skill Score.

Avalanche Occurrence detection



	Method	Accuracy
1	SVM (RBF)	93.66%
2	SVM (Linear)	89.83%
3	SVM (Polynomial)	92.78%
4	Decision Tree	88.25%
5	Random Forest	97.99%
6	K Nearest Neighbourhood	95.69%
7	CNN	60%
8	YOLO v4	82%
9	YOLO v4 with Augmented Data	99%

- Most machine learning methods work well because of **human-designed representations and input features**
- ML becomes just **optimizing weights** to best make a final prediction

Image Understanding

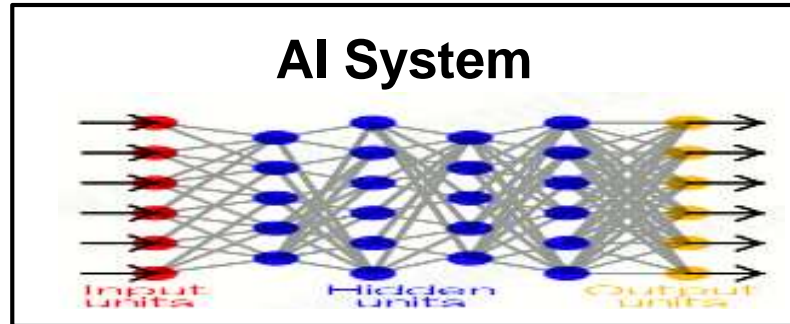
- To provide the capability to a machine or computer to sense the world around.
- Automatic Extraction, Analysis and understanding of useful information from a single image or a sequence of images
- Unified theme is the multiscale geometric structure of signal and image families and manifolds.
- For Instance: Learn the natural image manifold directly from data using a generative adversarial neural network.

Compressive sensing

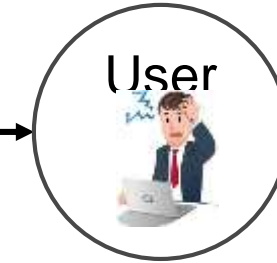
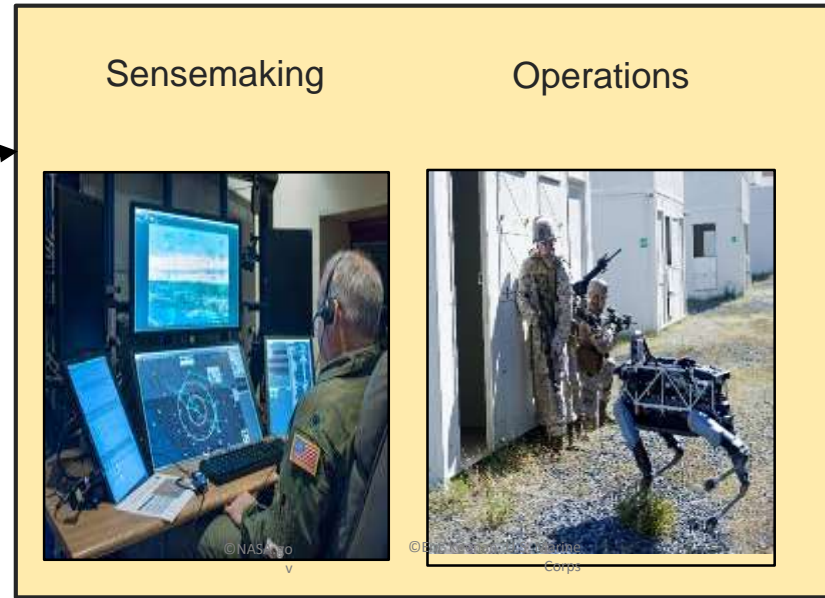
With increased high-resolution sensor development for remote sensing, comes an enormous amount of earth observation data.

- CS exploits the sparsity of the remote sensing data and also allows for reduced sampling.
- It can considerably simplify the data acquisition design for remote sensing systems and
- Speed up the process of extracting the desired information from a large amount of data.
- Future remote sensing systems may make extensive use of CS as part of system design.

Machine Learning & AI : Relevance and Trust



- Machine learning models are not always transparent, intuitive, and comprehensible.



- Why did you do that?
- Why not something else?
- When do you succeed?
- When do you fail?
- When can I trust you?
- How do I correct an error?

- AI systems offer tremendous benefits, but their effectiveness is limited by the machine's inability to explain its decisions and actions to users.

Explainable AI

Explainable AI : for Users to understand, appropriately trust, and effectively manage this incoming generation of artificially intelligent partners.

Model Builders and ML OPs

- Improves training data, refine features
- Update model architecture

End Users

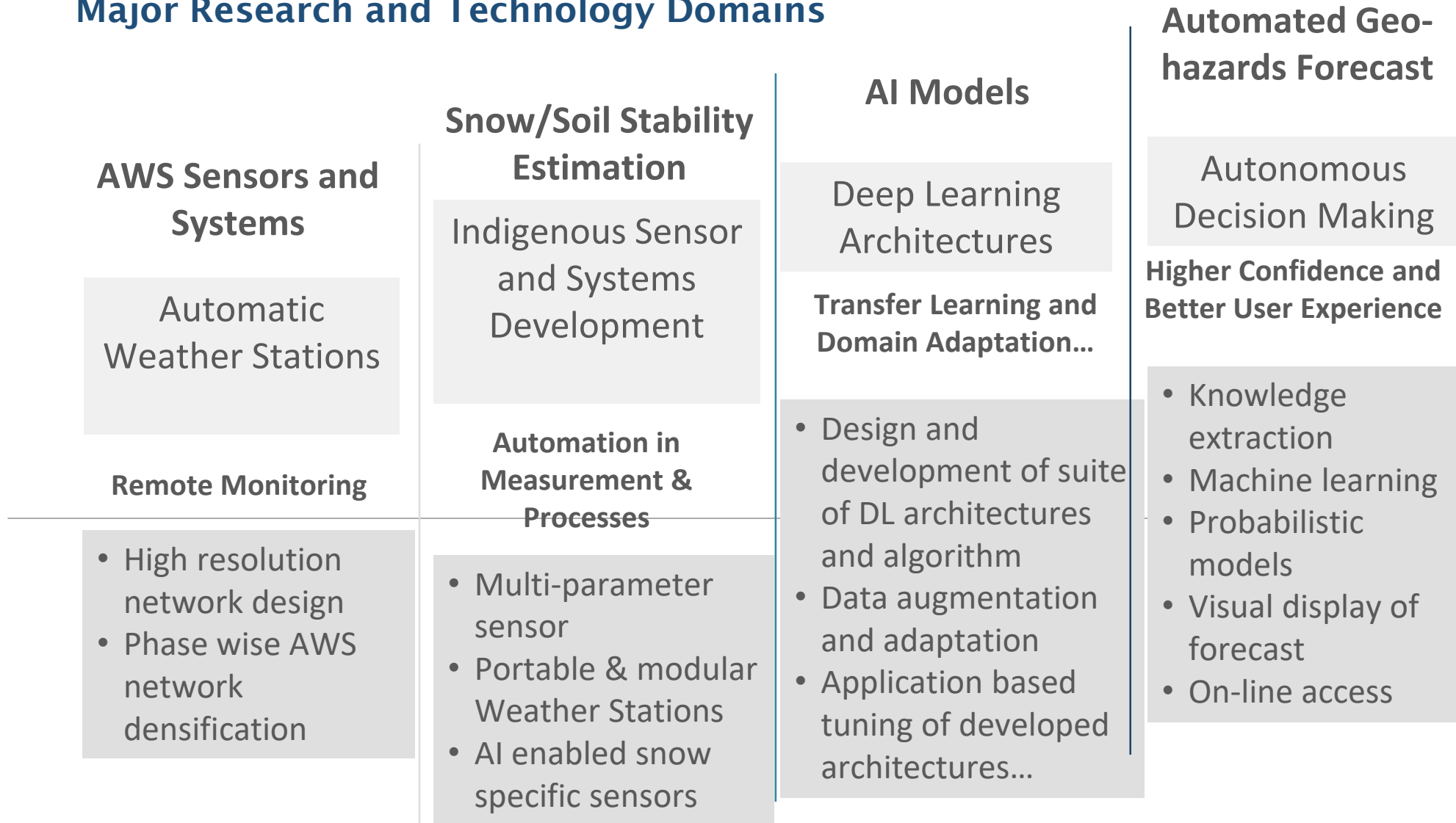
- Making Informed decisions
- Identify new areas for model development

Public Stakeholders

- Develop guidance/ advisory on responsible use of AI

Geo-Hazard Management – Way ahead

Major Research and Technology Domains



Geo-Hazard Management – Way ahead

Major Research and Technology Domains



Concluding Remarks

AI-ML have been adopted with the Human-in-loop/ Man-machine framework:

- Generation of warning/ alerts for avalanches.
- Geo-intelligence from Remote Sensing Images
- Safety and Rescue Training
- Simulation
- Weather Forecasting

AI-ML is contributing towards Risk minimization from avalanche, weather forecast and geoinformatics as service and product to enhance the combat effectiveness of Indian Armed Forces.

An aerial photograph of a high-altitude mountain valley. The landscape is dominated by snow-covered slopes and rocky terrain. In the center of the valley, there is a small cluster of buildings, including a prominent white structure with a dome, likely a religious or administrative building. The sky is a deep blue with some light clouds. The text "Jai Hind" is overlaid in the center of the image.

Jai Hind