Machine Learning in Humanitarian Relief Through Employing Rule Based Verification on Multispectral Aerial Imagery

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Are we prepared to deal
with the next disaster ???

Climate change will bring more frequent natural hazards !!!!!!!

Global mean **Sea Level** is projected to increase by 50 cm by 2080-2100

Global mean **Temperature** is projected to increase by 2.6-4.8 °C by 2080-2100

Climate change is altering **Rainfall Patterns** worldwide, increasing the likelihood of **flood** incidences

In past two decades, **90** percent of major disaster events have been weather-related

Global disasters in last year costed over **$155** billion loss

Natural hazards are **increasing** in frequency and intensity (UN Report)

Limitations…

- No dedicated, smart and automated system for disaster.
- No automated system for identification of key infrastructures
- Delayed and inaccurate results from GPS technology
- Lack of data about flood affected regions
- Loss of telecommunication services at the time of crisis leading to communication barriers.

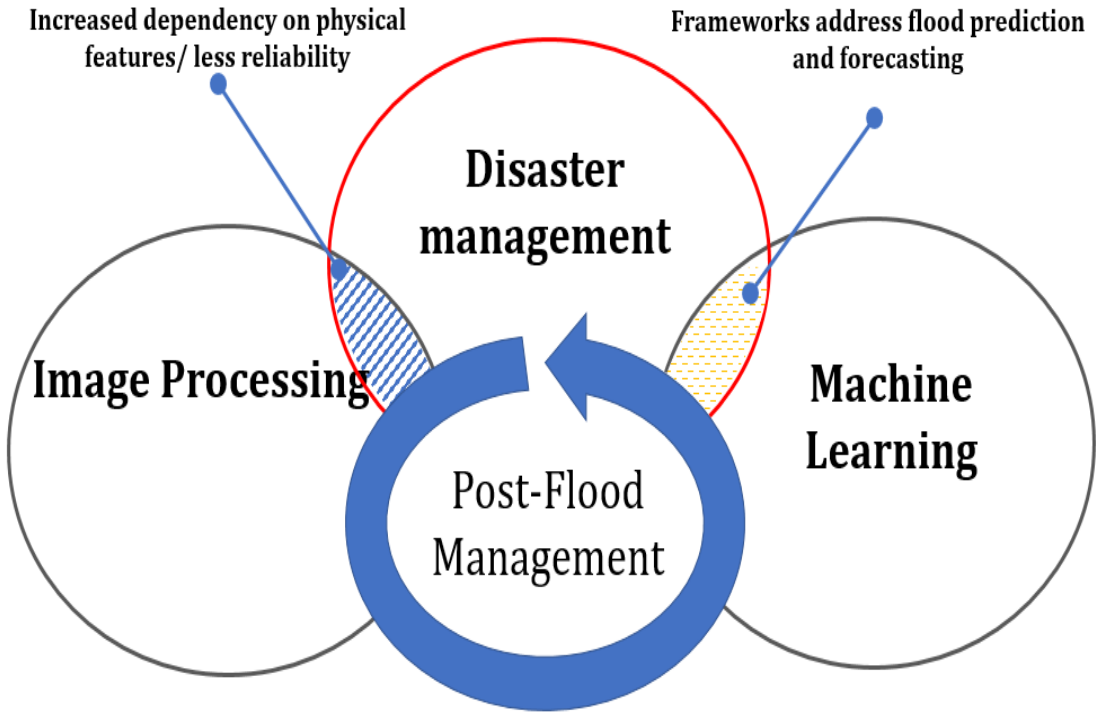
Results

Delay in rescue services due to:

- Unavailability of location maps of all flooded areas
- Late identification of flooded areas
- Life losses, delay in operational/rescue strategies.

Global Flood Management Goals

Research Gap...



No dedicated, smart and automated multispectral system that combines aid for the disaster relief missions.

Drones can help in saving lives when disaster strikes, but only when they're SMART and AUTOMATED to do so..

Objectives of the Study..

Maximizing Disastrous Region Coverage

Minimizing UAVs (Resources) and Optimizing battery Performance

Solving Evacuation Problem for Disasters Victims

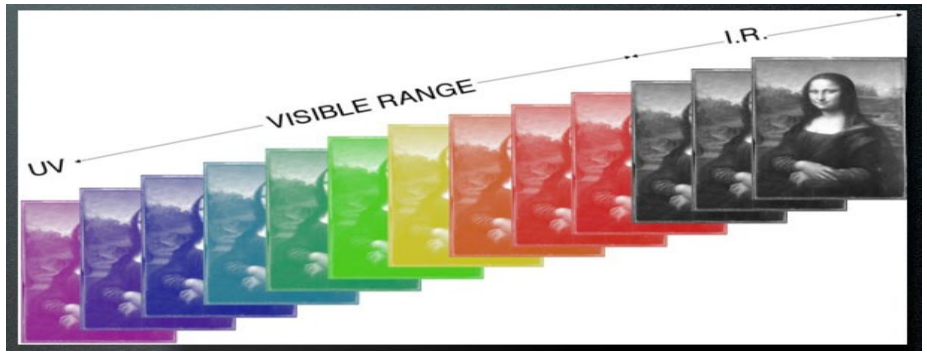
Infrastructure Damage Detection after Disaster (Roads, Bridges)

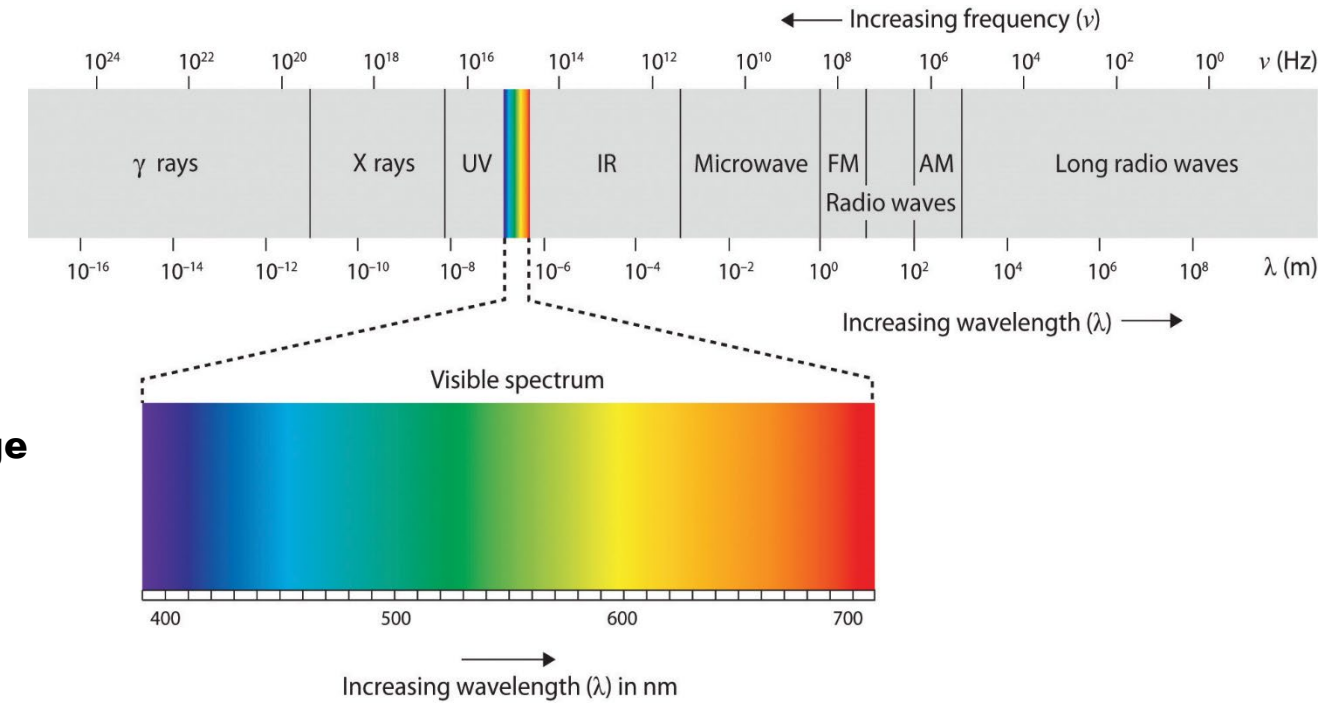
Lets Make Eyes from the SKY (Drones) SMART Enough

- Key infrastructure objects recognition without the use of GPS
- Analysing the extent of damage
- Searching for survivors
- Creating BEFORE/AFTER Maps
- Rapid situational awareness
- Path planning

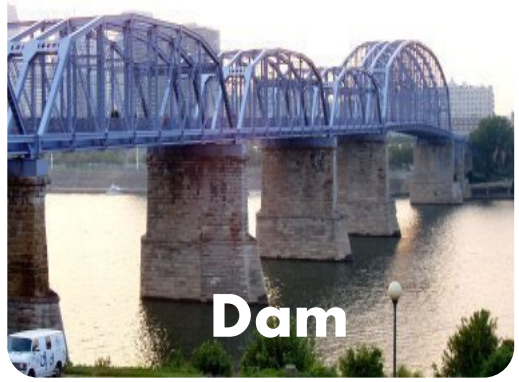
MULTISPECTRAL Aerial Images

- Visible
- Thermal
- Infrared
- Satellite
- SAR (Synthetic Aperture Radar Image



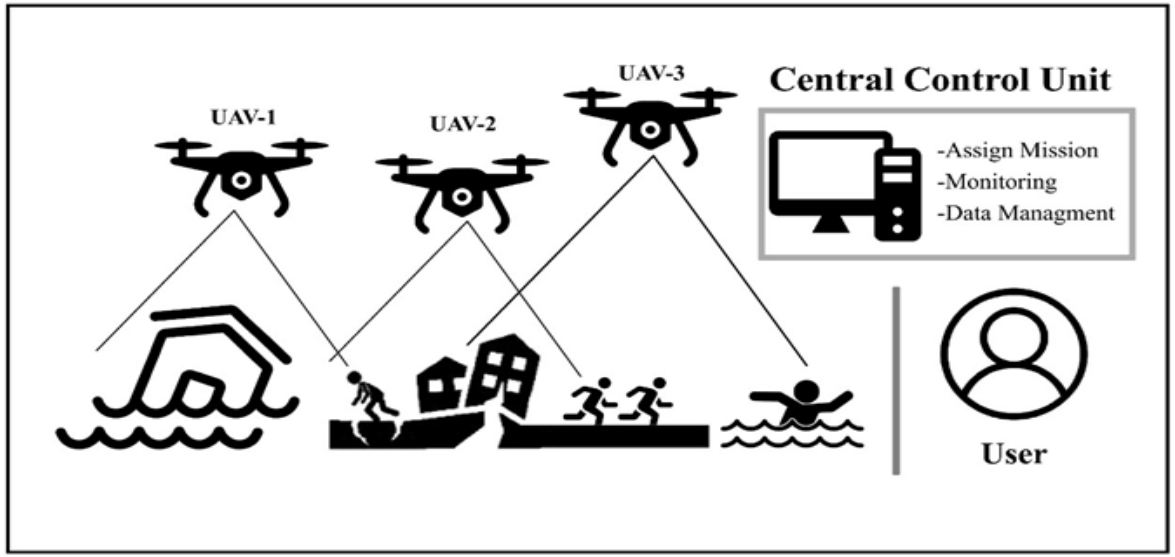


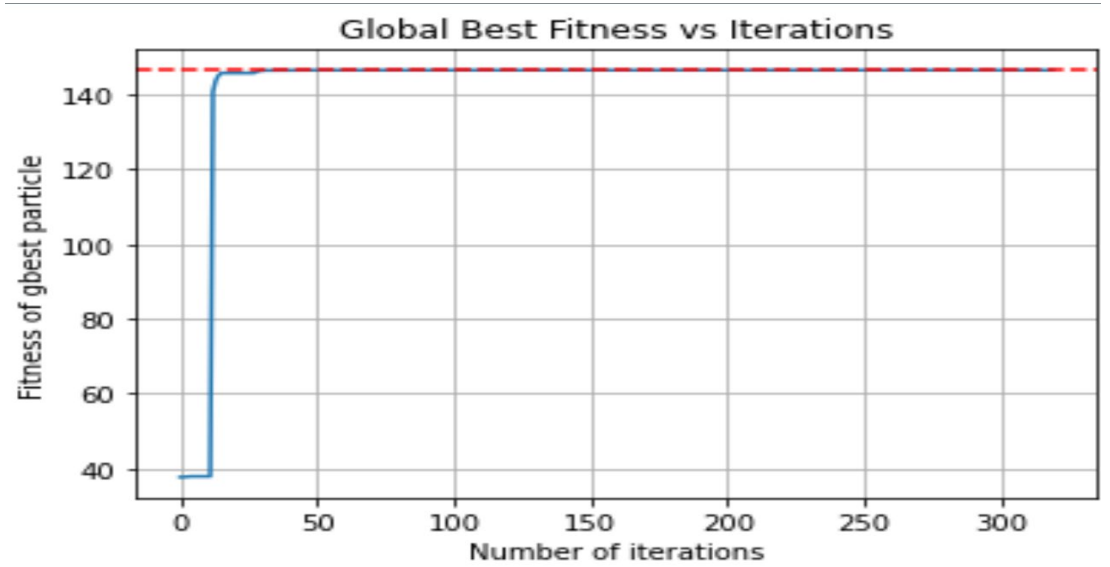
Key infrastructure….



Maximizing Area Coverage with minimum UAVs

- Particle Swarm Optimization algorithm used for maximizing the area coverage of the disaster affected area
- The UAV parameters used for the simulation
  - Height of the UAV
  - Focal length
  - UAV field of view
- The PSO parameters used for the simulation
  - Inertia weight
  - Velocity
  - Fixed area dimensions
  - Cognitive weight
  - Social weight
- The simulation was performed using 4 UAVs performing at a certain inertia and height to achieve the results



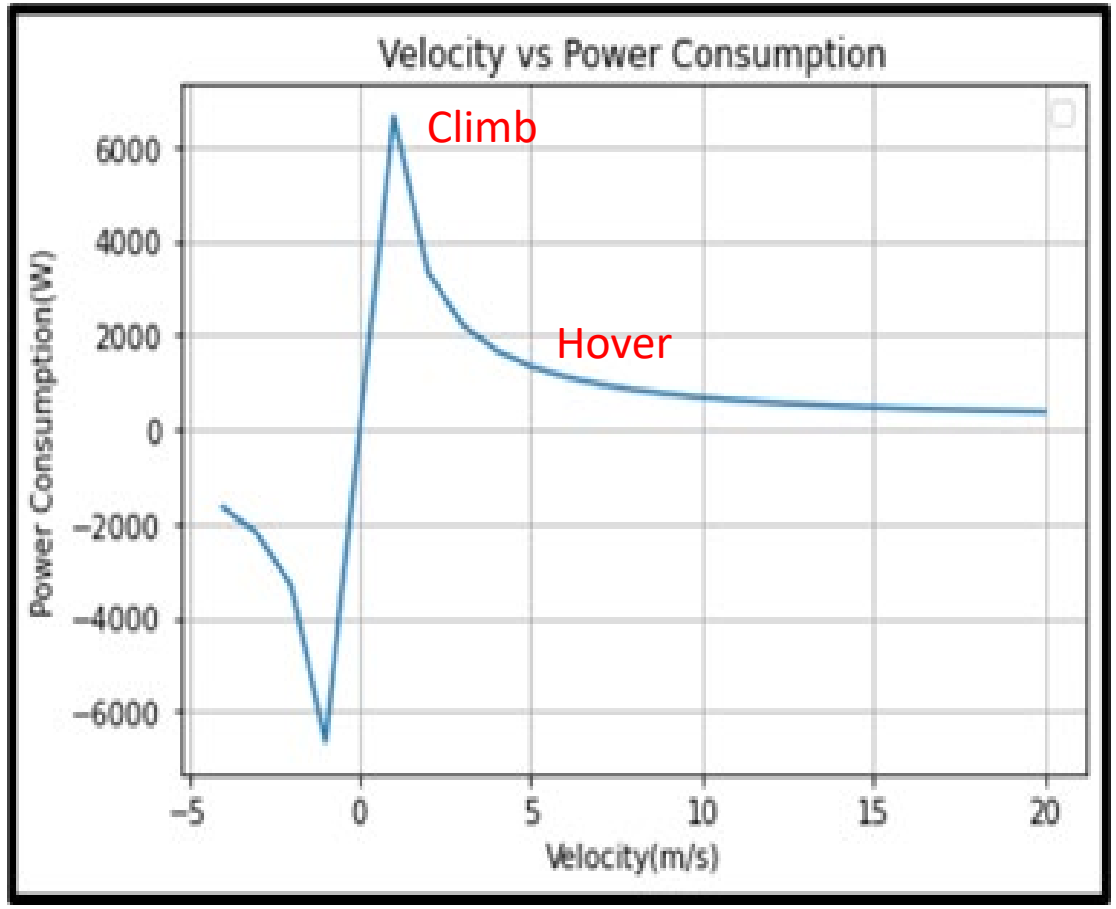


Optimizing Battery Performance

- Battery performance of UAVs impacts the mission success
- Battery parameters considered for simulation

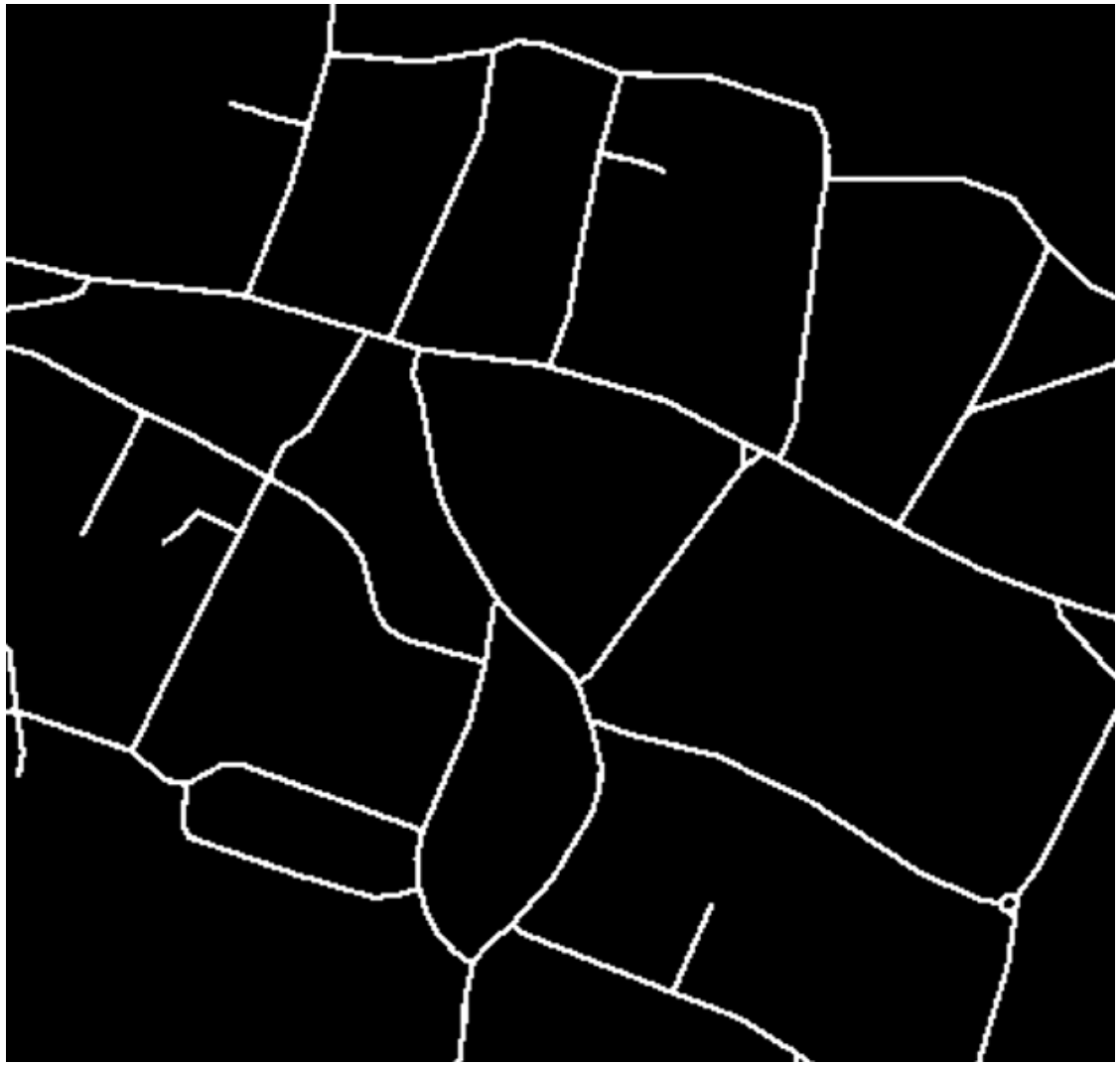
  - Total weight of the UAV
  - Density of the air
  - Projected Frontal Area of the UAV
  - Width of the UAV
  - Drag coefficient

- The battery performance was simulated in 3 phases of the UAV - climb, hover and descent
- The maximum and minimum power consumption against the velocity of the UAVs were calculated.



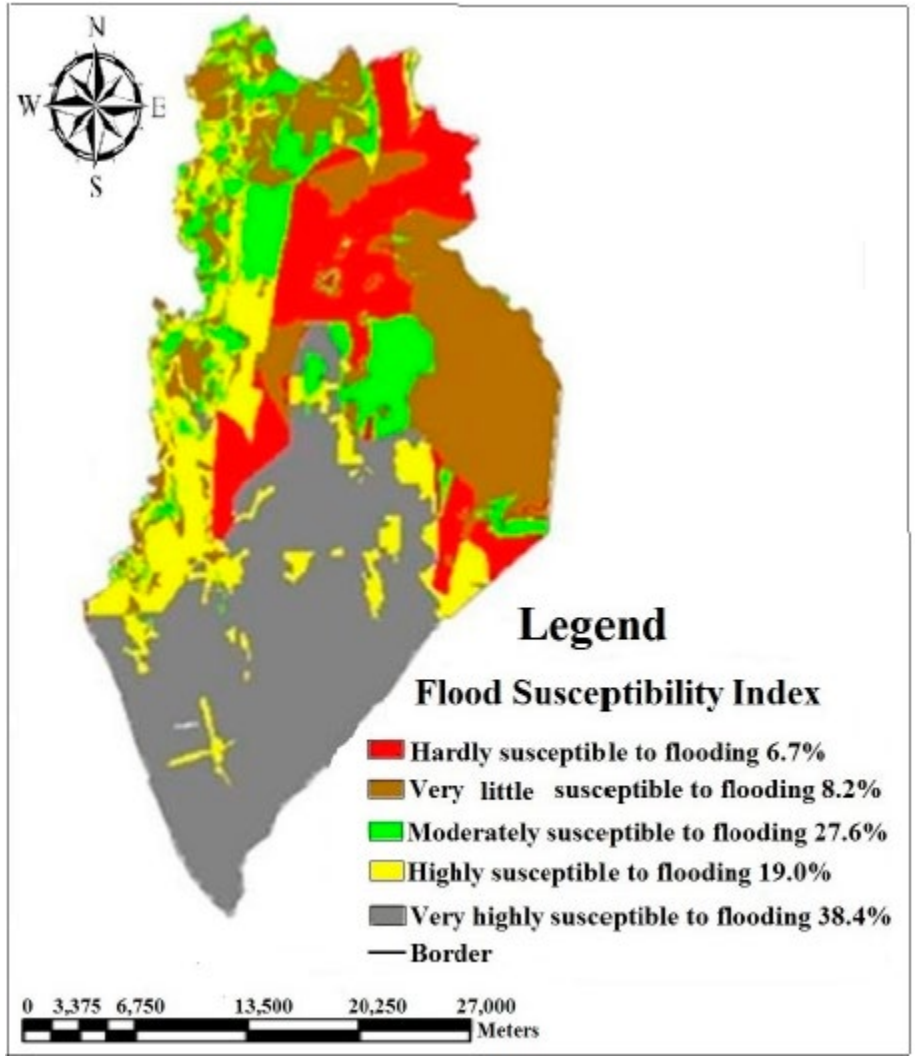
Extraction of Road Network/ Damaged Links

Original Aerial Image



Road Network

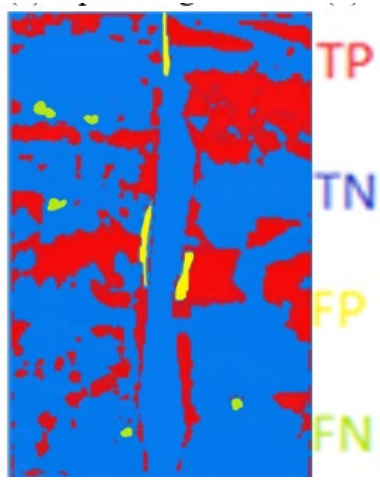
Generation of Flood Map/ DEM



(a) Input Image

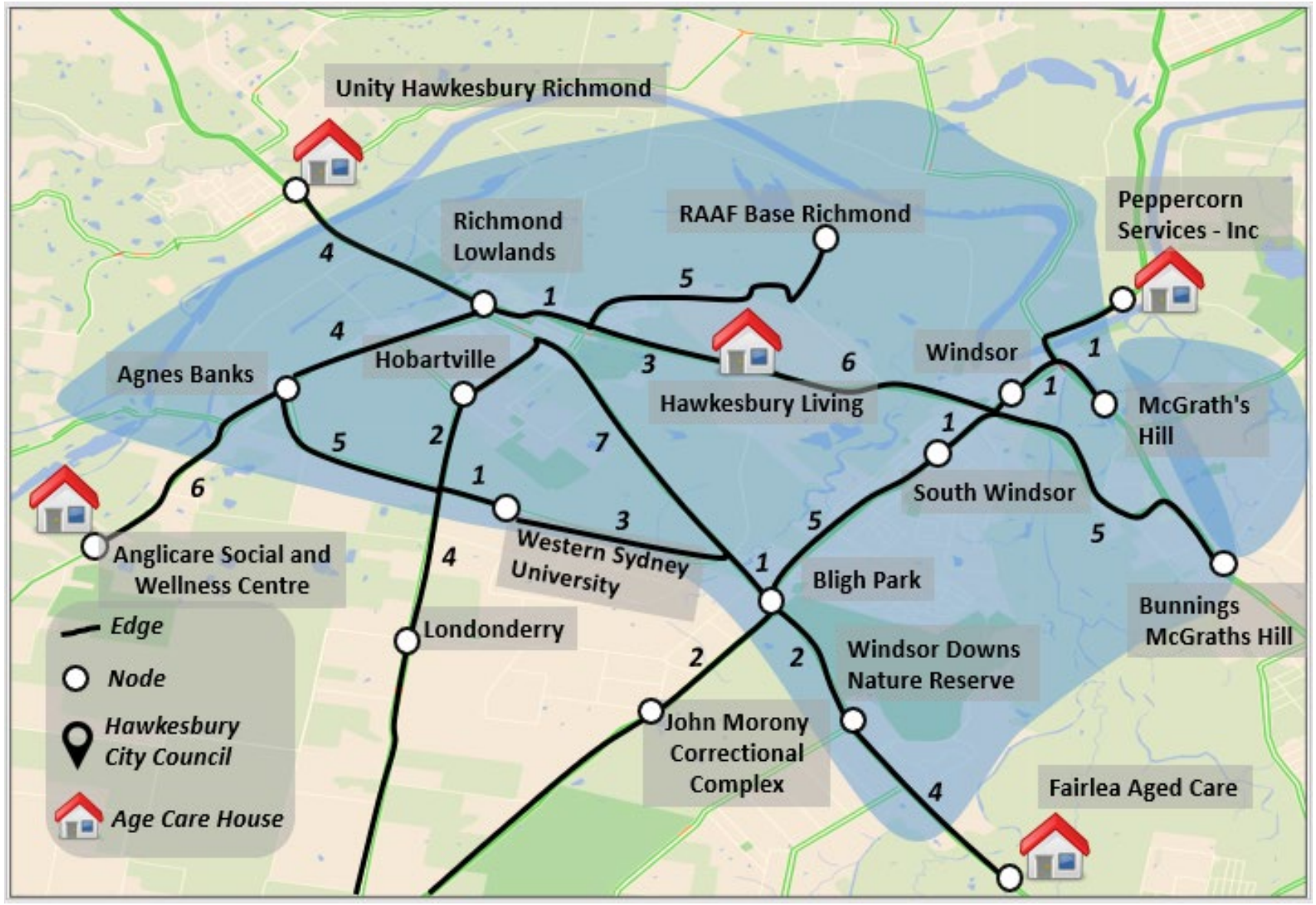
(b) Ground Truth

(c) Segmented Areas



(d) Result

Solving Evacuation Problem for Disasters Victims



Solving Evacuation Problem

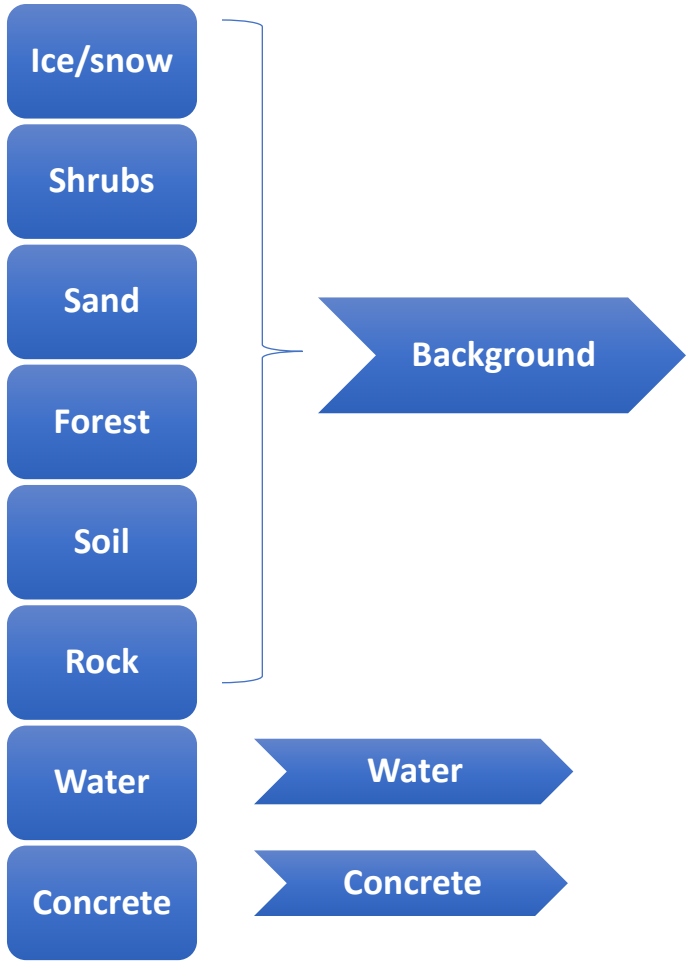
- Travel time matrix between the shelter and pick up points calculated using the BPR - Bureau of public roads function.
- Vehicle Routing problem was solved between the location points to simulate the maximum relief provided within a minimum amount of time.
- Simulation was attempted to cover the route using minimum number of vehicles and the shortest route available.

Why Bridges/Roads..?

It is useful to extract objects such as bridges/Roads automatically in many important applications, such as navigating the unmanned aerial vehicle (UAV), maintaining geographical databases, disaster response, path planning, damage detection and so on.

Two basic observations.

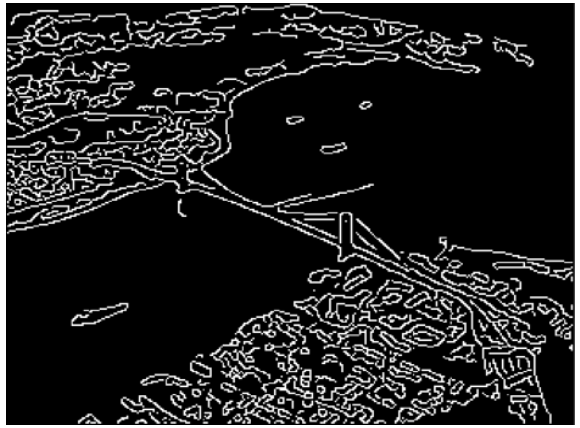
1) **The bridge on a water body is linear.**
2) **The width of bridges is relatively small.**



The classified image is then categorized into a tri-level image: water, concrete, and background

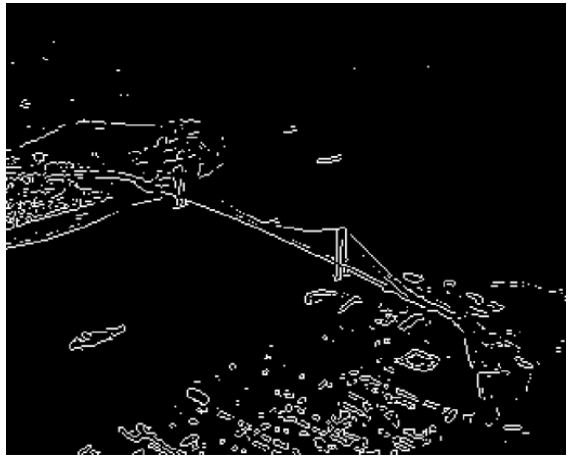
Results of Edge Detectors

(a) Original Image

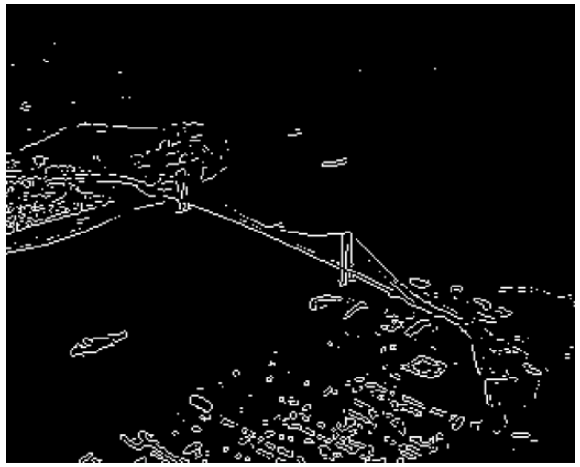


(b) Canny Edge

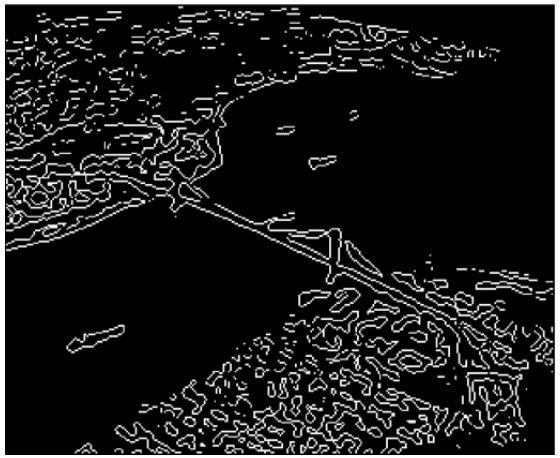
(c) Sobel Edge



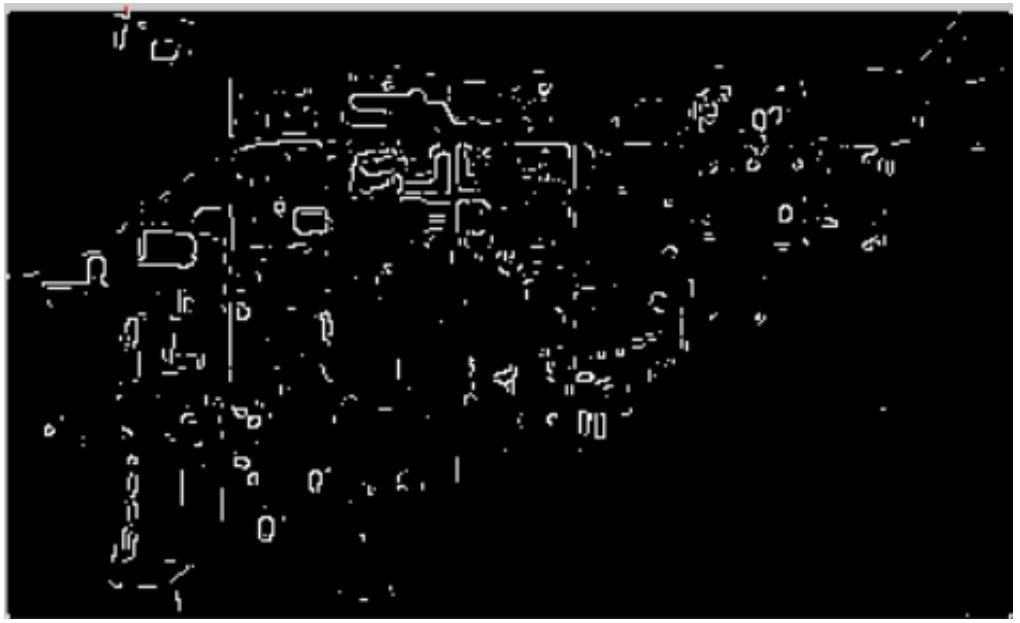
(d) Prewitt Edge Edge



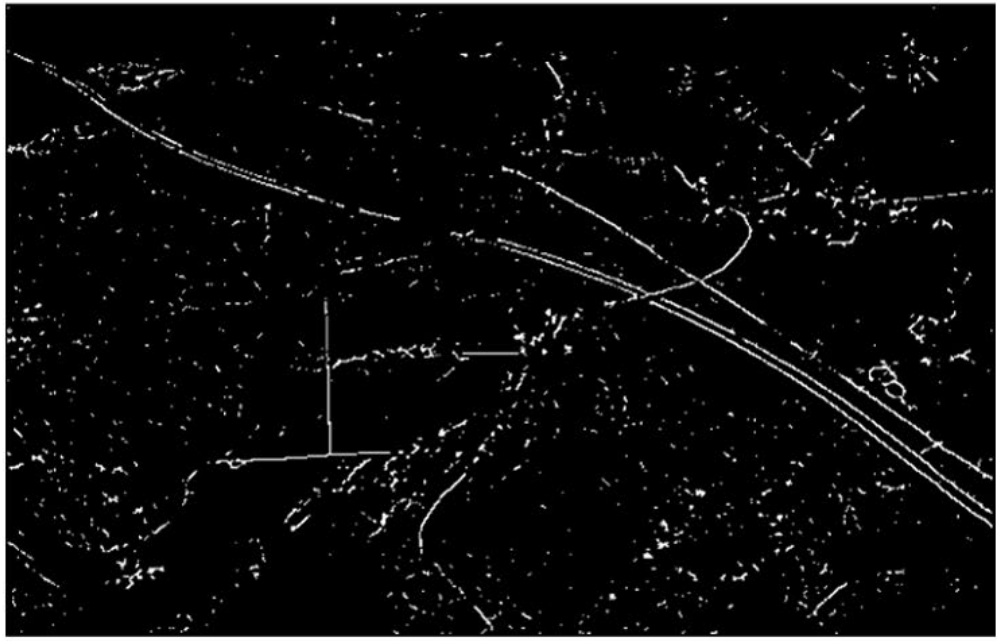
(e) Roberts Edge



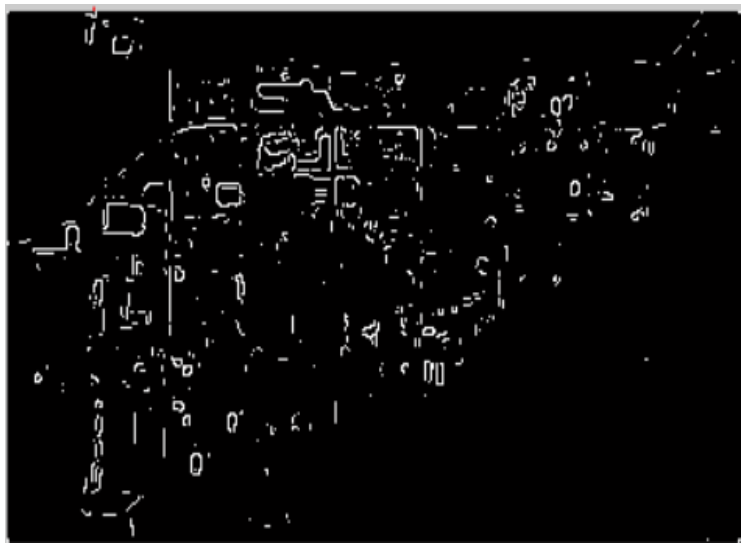
(f) Zero cross Edge



Edge Detection



Edge Detection

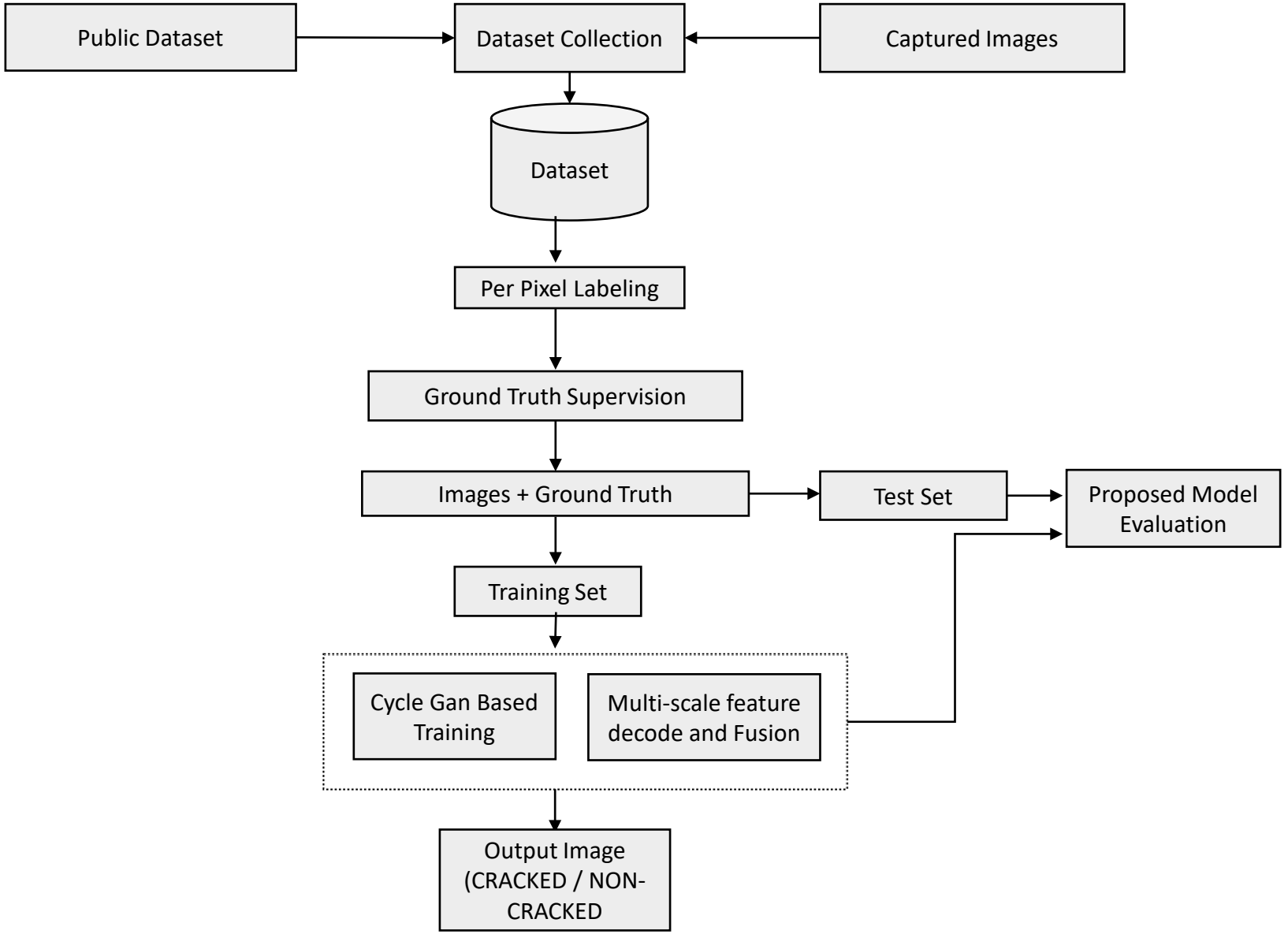

HOUSES Recognition RESULTS

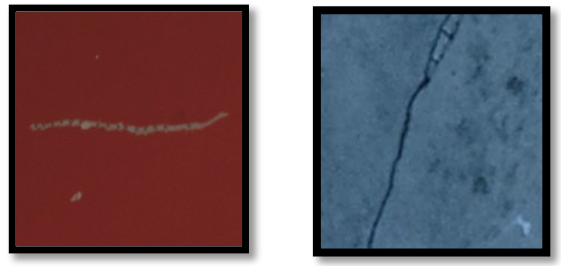
Damaged Infrastructure

- Roads
- Bridges
- Buildings

Infrastructure Damage Detection (Roads, Bridges)

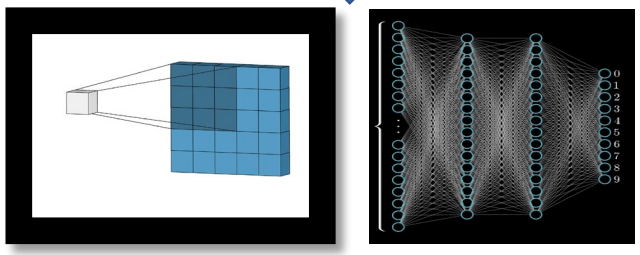
Methodology





Dataset

Labeling

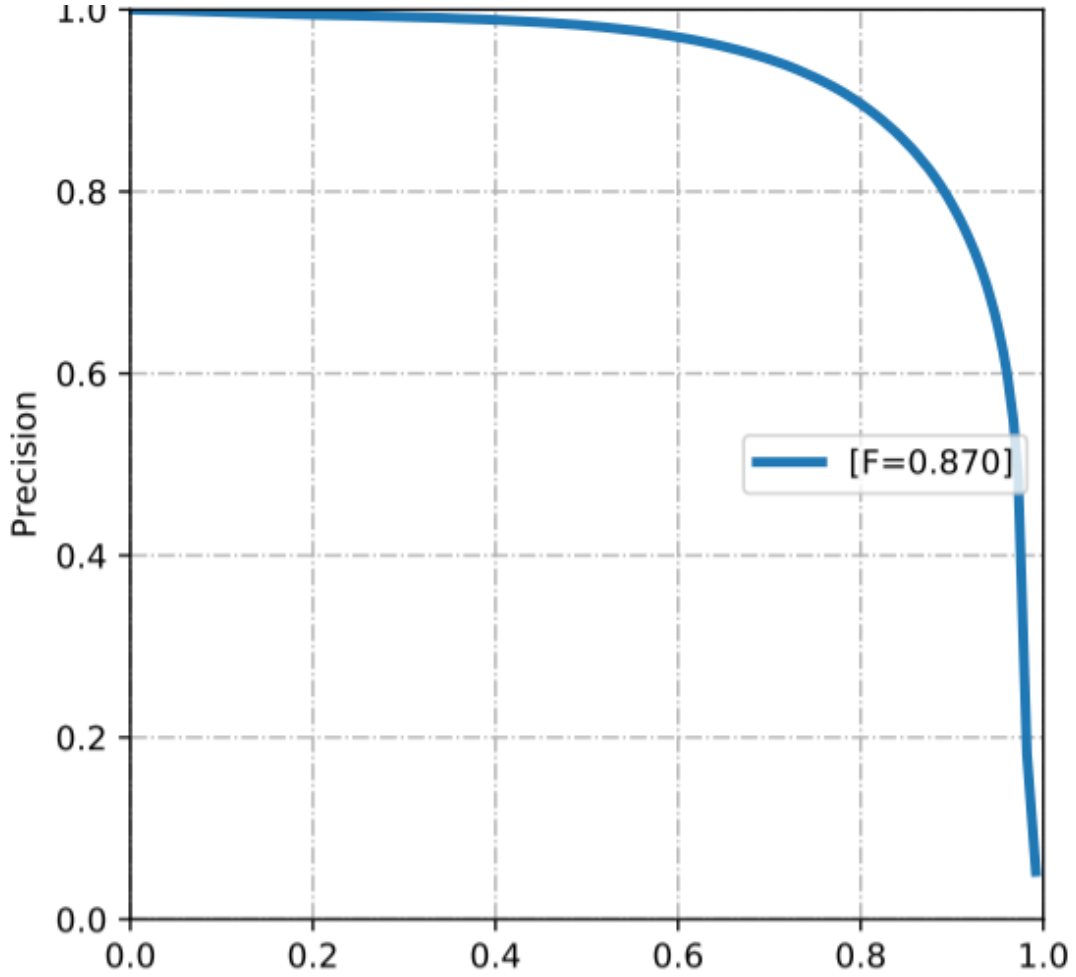


Training

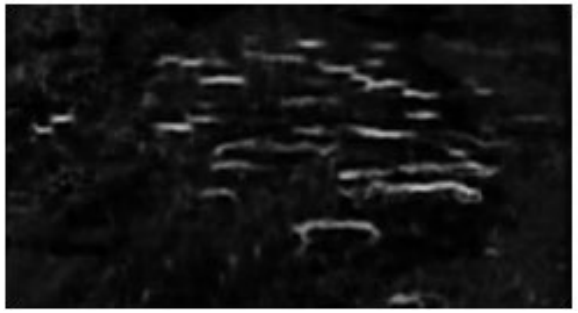
Output – Cracked Regions

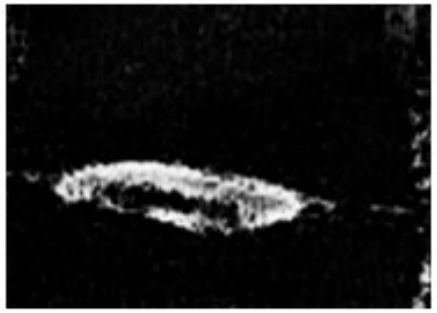
Summary of Results

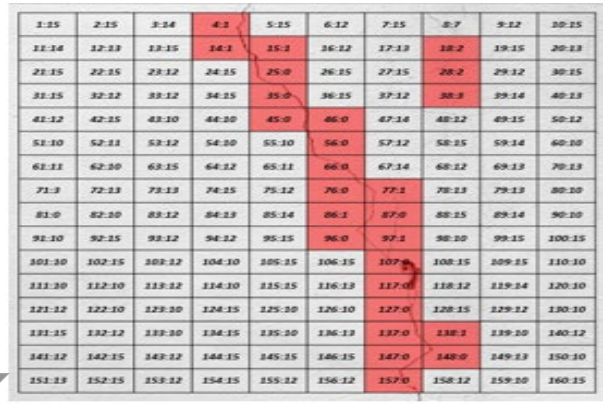
- **Imaging System:** Unmanned Aerial Vehicle (UAV)
- **Total Captured Images:** **2097+**
- **Material:** Concrete Images from Bridge
- **Image Dimensions:** 4864x3648 || Image Size: 7MB || Image Type: JPEG
- Training images **1300**
- Image with significant crack **78%**
- image with weak crack **13%**
- Without crack (used only in test) **9%**



Infrastructure Damage Detection (Roads, Bridges)





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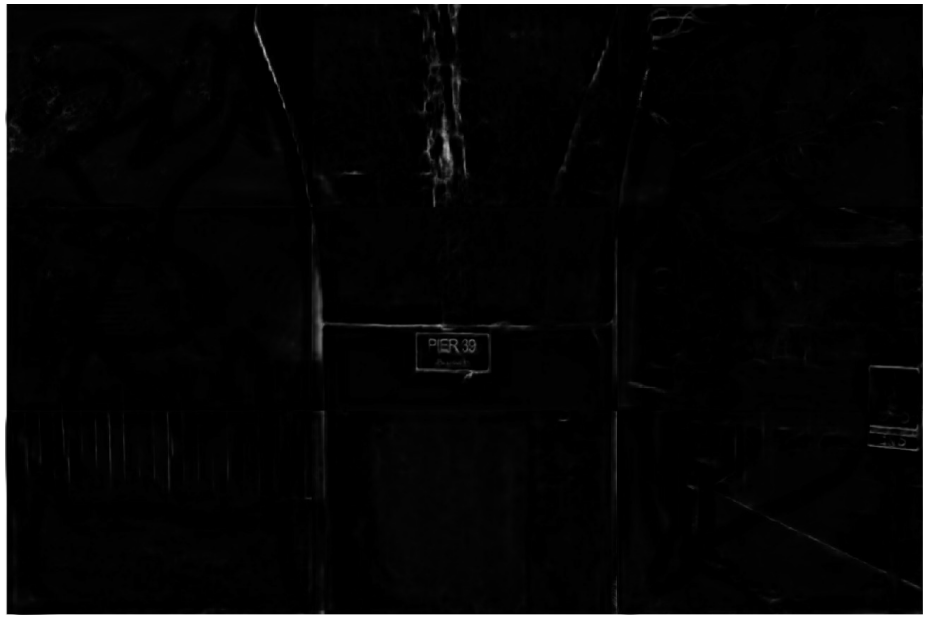
END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Implications

- This project has significant potential to contribute practical solutions to facilitate people stuck in flood related crisis.
- It aims towards improving the efficiency of disaster operation management not only in Australia but also in other countries, especially the countries frequently struck by disasters.
- The outcomes of this research directly align with the United Nations International Strategy for Disaster Reduction and Sendai Framework for Disaster Risk Reduction 2015-2030 (UNISDR, 2015).
- The proposed research can be significant for State Emergency Services (SES), FIRE Department, Emergency Management Departments across globe AAND National Disaster Management Authority (NDMA) for carrying out post flood rescue services.

Natural Hazards Research Australia

CDRI
Coalition for Disaster Resilient Infrastructure

Australian Government
Attorney-General's Department
Australian Emergency Management Institute

SES
STATE EMERGENCY SERVICE

UNISDR
The United Nations Office for Disaster Risk Reduction

Aim of Sendai Framework

"The substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries."

- It focuses on enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction.

- The target is to use state-of-the-art technology and to carrying out the actions identified by this framework.

THANK YOU very much for your Attention.

Any Question ?