WHO AM I?

Tamanna Grover. Pre-final year CSE. SRMIST. A tech geek. Nerd :)

WHAT'S SPECIAL ABOUT ME?

1

Lot of experience! Loves tech! Worked with institutions like Reliance Jio, NIT Rourkela, MEITY (govt. of India), Several startups

2

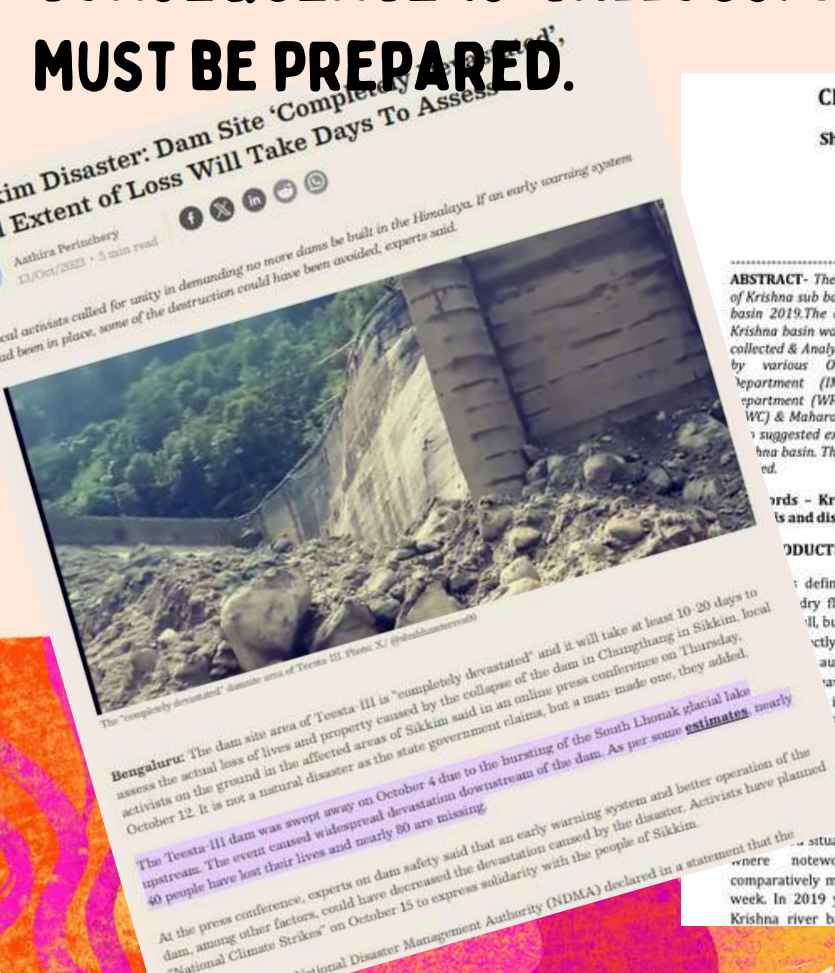
Currently researching in IIT Madras on SHAKTI microprocessor (I've inculcated that experience with my idea :))

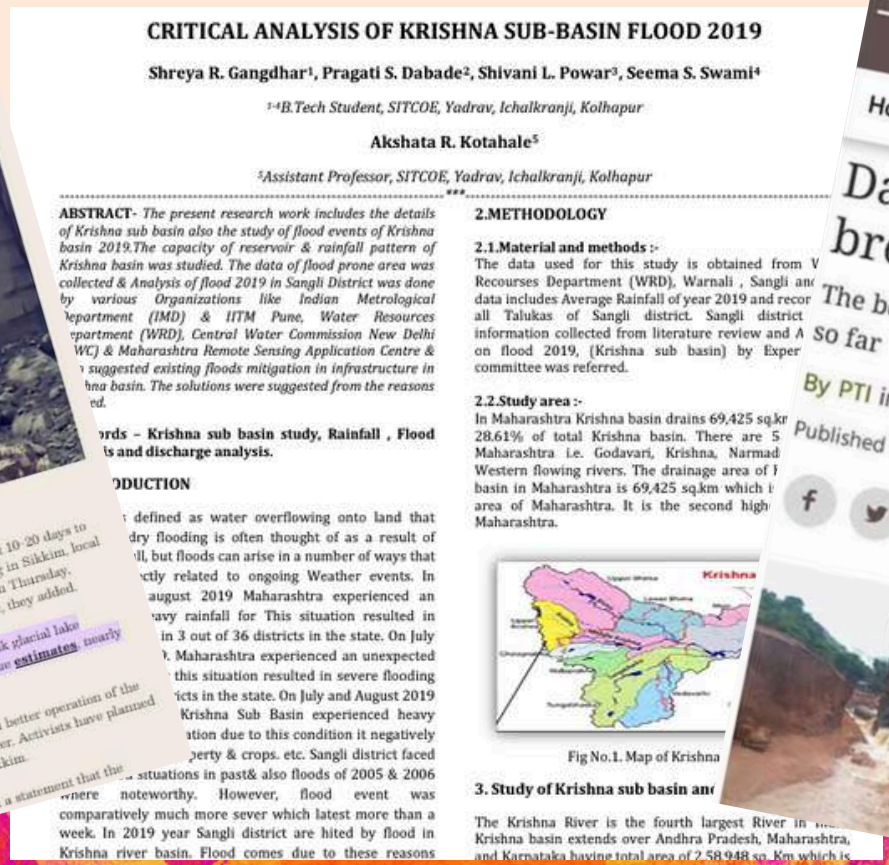
3

The best part? Very dedicated, creative, and a perfect amalgamation of Hard and Smart work!

QUESTION (RHETORIC)

HOW DISRUPTED IS URBAN WATER-BODY INFRASTRUCTURE?
CAN WE LEAVE IT AT IT'S FATE? MUSN'T WE ANALYZE IT?
DUE TO DEVELOPING CRACKS, WEAKENING STRUCTURES, THE CONSEQUENCE IS CALLOUS! FLOODS CANNOT BE CONTROLLED, BUT WE MUST BE PREPARED.





WHAT DO I PROPOSE?

An UNDERWATER ROV!

(Remotely Operated Underwater Vehicle) is a submersible craft that allows exploration of the ocean depths without the operator physically being underwater.

This is a perfect blend of a solution involving Hardware (Chassis), AI-ML (crack detection using CV), IOT (receiving data through channels) and analytics (analyzing the IOT- based data using ML to predict values).

I have prototyped a basic architecture of the whole machine, inculcating most sustainable resources at each step. For now, I'm working on Crack-detection as it is most important.

Earlier, this inspection was carried out manually. Even so, we cannot go beyond 10000 meters! (35,856 feet record was set by James Cameron).

We cannot afford any more human-life threats due to negligence gathering at the bottom of our beds, right?

Even my sustained, non-industry-equipment based prototype is relevant for smaller targets like expanding it's use case to explore marine life in local bodies (Let's check for crocodiles, IIT M campus has dangerous marshes 🐊); Analyse for algae growth or prevention of eutrification!

My project can be multi-purpose, but a smart city deals with more utility-based product which caters to solving a problem such as dam-crack-detection.

YOU MUST HAVE GOTTEN SOLUTIONS FOR WATER BASED ARCHITURECTURE MANAGEMENT BEFORE. HOW IS THIS DIFFERENT?

An UNDERWATER ROV stands out.

A sonar system is not accurate! UROV captures images with real-time detection and extended analysis. (One aspect is inculcating sonar feature of depth of crack)

Pre-engraved sensors are prone to damage. They do not have visual facility, no mobility and no real-time aspect.

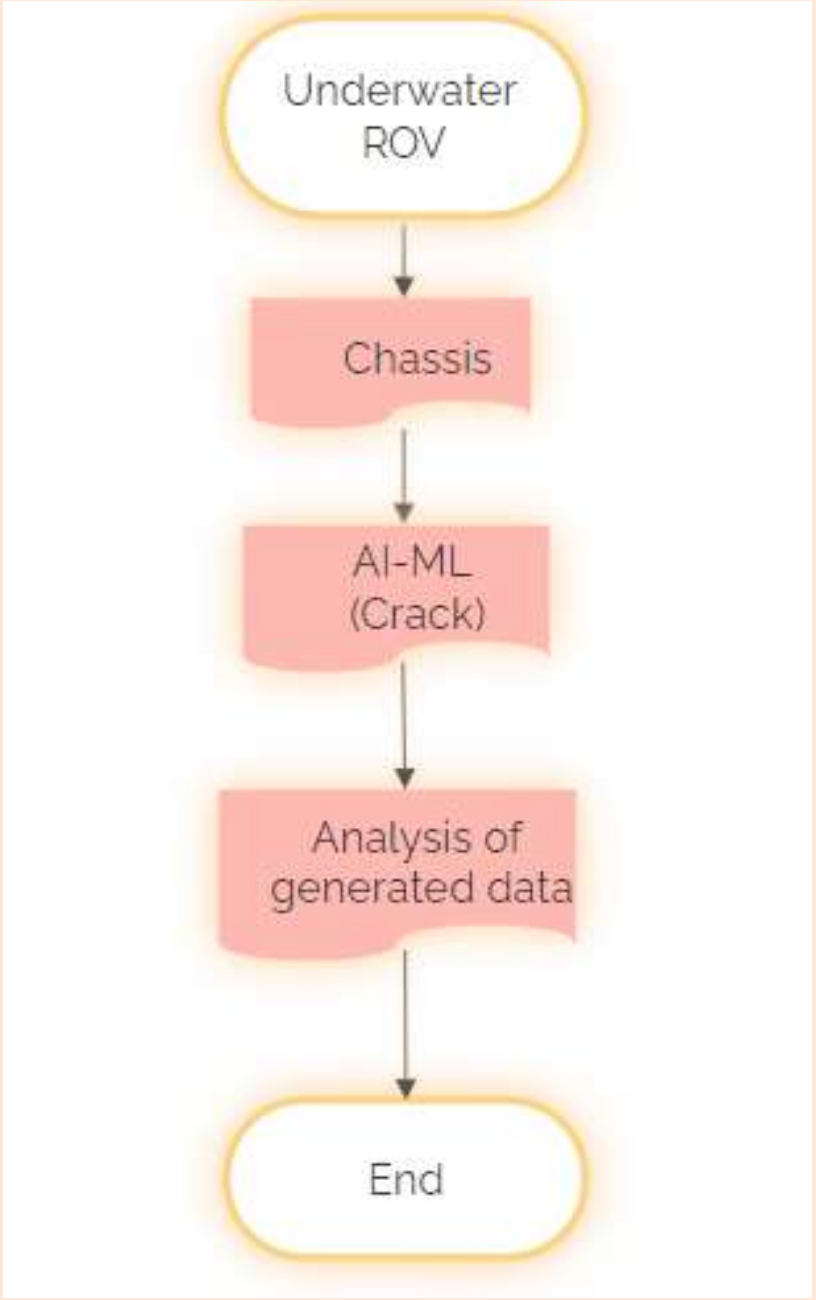
AUVs' vs ROV? ROV establishes control for real-time management, which is more relevant to crack detection than an AUV, which surveys a specific purpose. Precision not guaranteed.

Moreover, as an independent product, my project employs real-time visuals, IOT(sending signals) and data-analysis.

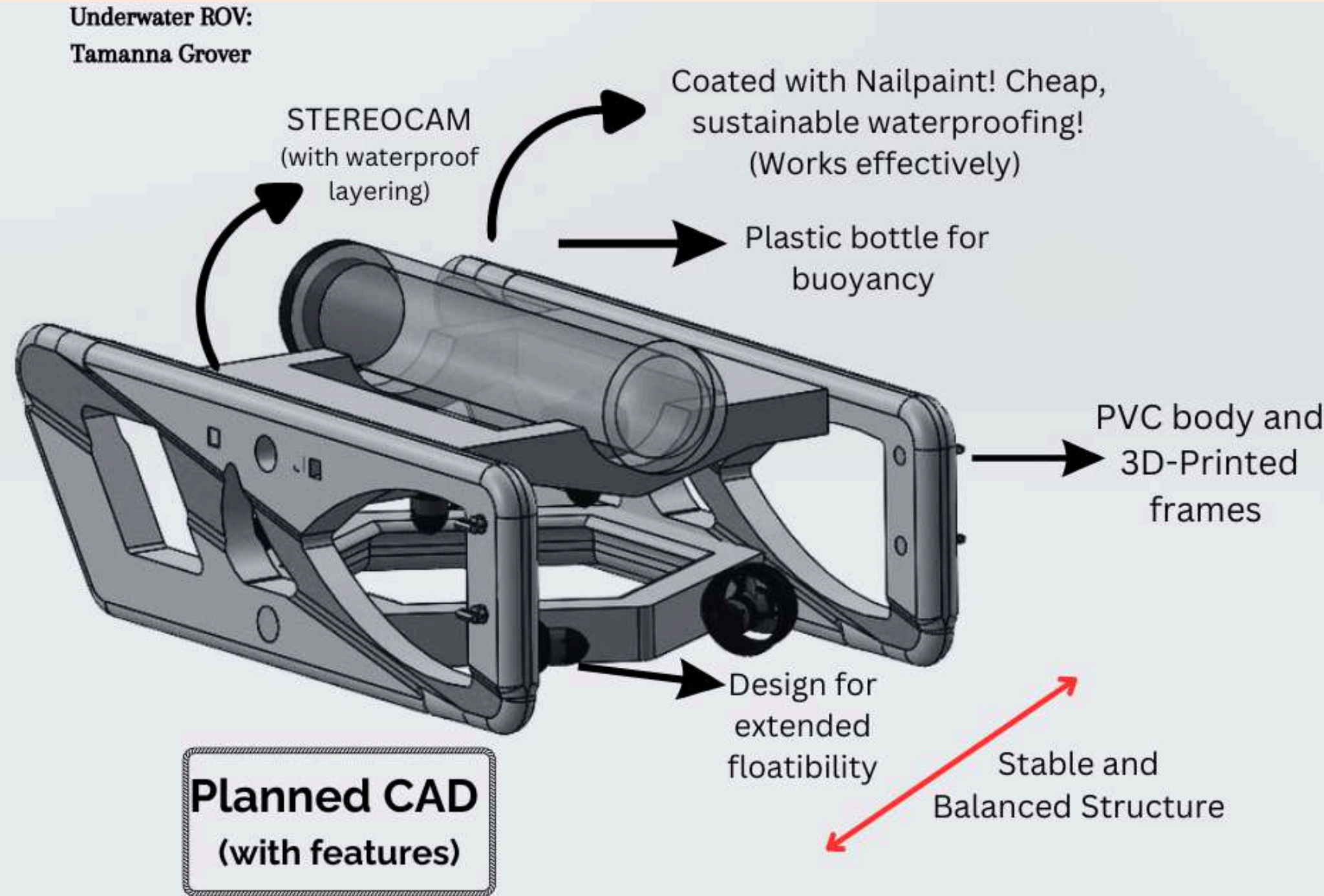
Smart cities and IOT?

How can we somehow make our underwater ROV smart, sustainable, utilize AI and IOT technology to automate this process?

Here's how it would look in general:



HERE'S WHAT I PROPOSE FOR THE DESIGN:



I CAN EXPLAIN!

The chassis can be explained as 3 significant parts:

-The main body

- Core structure built using PVC pipes and 3D-printed frames. It provides a framework for attachment.

-The Buoyancy Control System

- Easily fitted changeable plastic bottles+correctly architectured gaps/design
- By adjusting buoyancy, you can achieve neutral buoyancy (hovers in place) or slightly negative buoyancy (sinks slowly) for better maneuverability.

-Payload Section

- The stereocam, the processing unit-Pi 5, battery
- Waterproof enclosure using 3D printing (PETG)

+ desiccant packs(keeps it sustainable, cheap, effective!)

- Properly architected heat sink
- Or we can consider off-board analysis depending on usecase and real-time necessity!

HOW DOES THE CRACK DETECTION WORK

The best way to implement crack detection using machine learning is find a LARGE dataset for cracks, train it with a detailed CNN model, and further work on precise location tracking of the cracks using U-net. Why not, further derive data using Sonar sensors to detect the depth of the crack (yet to be implemented)

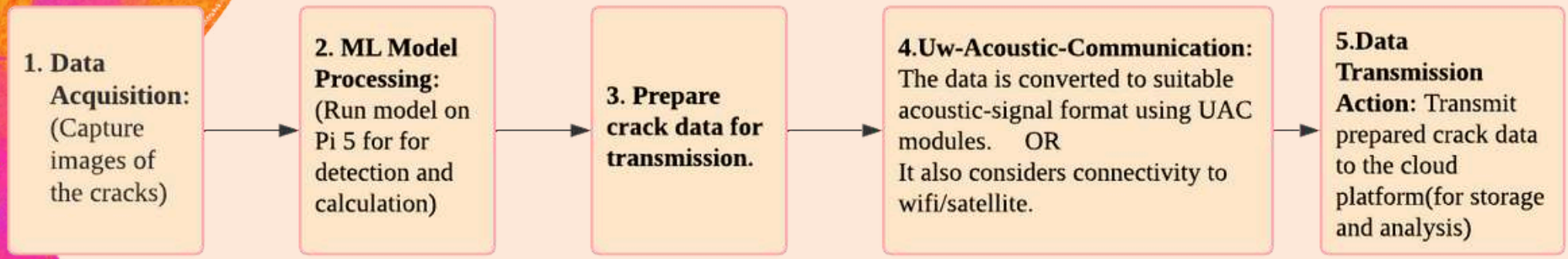
That's exactly what I did. Currently, I worked on a crack dataset with 20k+ images, classify them, and also undergo ensembling to enhance crack specification-detection.

With enhanced computational capacity, I seek to achieve beyond 90% accuracy, a good f1-score and probability determination for surety of the cracks.

My model is not just a classifier. It bases its roots to segment(U-net) and study the cracks, compare it with other images to read an in-depth analysis. It collaborates with sonar-based data to interpret depth.

HOW DO THE SIGNALS GET CONVEYED

NOTE: (This is in-case of on-site processing. It depends on the usecase. If the analysis is of high importance where data-loss may be possible, it is necessary to obtain results there itself.
Otherwise for local usage, we can employ small eeprom or flash devices to store, and later perform processing.)



1. Data Acquisition

- **Through the images captured by our camera.**
- **Specifications: Image resolution (e.g., 640x480 pixels)**
- **Image format (e.g., JPEG)**
- **Capture rate (e.g., 1 image per second)**

2. ML Model:

- The raspberry pi processes the pre-trained model to bring the following outputs: Crack location (bounding box coordinates), length, depth(through sonar sensors).
- Now, analysis is done and data to be sent, is ready for transmission.

3. and 4. Prepare Crack data for transmission using Uw-Acoustic-Communication:

- In case of absence of Cellular/Wi-fi network/satellite (not feasible for infrequent checks) networks.
- Convert data from pi through UAC modules from available formats (like json) to electrical signals as deemed necessary. Eg. {"LocationX": 100, "LocationY": 50, "Length": 20, "Depth": 5}

#Why Uw-Acoustic-Communication?: Provides a reasonable signal penetration and also allows a range of frequencies depending on use. In comparison to satellite, it is cheaper (data processing plays a crucial role here; even for data compression to reduce cost).

5. Data transmission to Cloud platforms for analytics:

- Not necessary but a good step, that after UAC decrypter analysis the message on-shore, it is saved on cloud platforms for storage purposes (fast data incoming, big amount every second).
- The platform may also provide analytics' tools for ease.

{"LocationX": 100, "LocationY": 50, "Length": 20, "Depth": 5}

ANALYSIS OF THE DATA

Analysis of the data would certainly involve the following steps:

- **Decrypting the UAC-based data**
- **Uploading it on cloud**
- **Cleaning the data for outliers-erroneous_values-missing_sections**
- **Data calibration might be necessary based on environmental conditions, such as- Lens distortion error (due to water, image capturing might lead to hazy/non-straight images); or sound wave propogation affected by nature of water/salinity/temp. etc.**

Now to analyze the clean data for the cracks:

- **Extract the data with better useability, like de-crypting key-value pairs in json file.**
- **Use visualization tools for heatmaps(3D generation of the cracks for better analysis) and scatter plots for length against other parameters like depth.**
- **Calculate mean/median/std. dev. for crack length data and classify the various cracks as emergency/non-harmful etc.**
- **Trend analysis and future prediction (Again, AI is employable)**

WHY IS MY SOLUTION ECONOMIC, SUSTAINABLE, AND EFFICIENT ?

My UAC based Underwater-crack-detection-ROV is economic, sustainable and efficient.
It utilizes/intends to reuse material (Plastic bottle/pvc). It attempts to reduce cost with signals as well.

It is sustainable with the chassis design and outlay. It enables a long term study of a specific place and provides real-time analysis.

In comparison to other methods or even manual-checks as exists, it is indeed reducing physical efforts, and overall brings out, an excellent solution for the crack-detection problem.

,Moreover, it can be put to multi-use. This makes is unique and independent an idea!


THANK YOU!