Project Proposal: CognisSAR

Project Category:

- Machine Learning and Deep Learning

Problem Statement:

Automatic change detection in Synthetic Aperture Radar (SAR) satellite images aims to identify changes in a geographical area over time by comparing different SAR images taken at various intervals. SAR images provide detailed information regardless of weather conditions and lighting, making them valuable for applications like environmental monitoring, disaster management, and urban growth analysis. However, the complex speckle noise inherent in SAR images and the varying image characteristics pose challenges for accurate change detection.

Current State: Existing methods for SAR image change detection often struggle with speckle noise, require extensive manual intervention, or use traditional algorithms that yield limited accuracy. Conventional techniques may also lack adaptability to different environments, leading to less reliable results.

Desired State: An ideal automatic change detection system would accurately and efficiently detect changes between SAR images with minimal human intervention, accounting for noise and providing high reliability across different terrains and environmental conditions. The system should be able to process large datasets autonomously, minimizing false detections and improving precision.

Context and Relevance: Given SAR's importance in applications such as disaster recovery, environmental management, and national security, enhancing change detection accuracy is crucial. Accurate detection of changes can help authorities respond more effectively to events such as deforestation, urbanization, or flood monitoring.

Project Aims:

1. Develop a deep learning model capable of robust automatic change detection in SAR satellite images.
2. Minimize the impact of speckle noise while maintaining high accuracy.
3. Optimize the model for real-time or near-real-time applications in critical monitoring scenarios.
4. Test and validate the model using datasets from reliable sources like ISRO.

SIH Problem Consideration:

- **Problem Number:** [SIH1563]
- **Problem Statement:** Background: Synthetic Aperture Radar satellite images have the capability for night time imaging as well as imaging without being affected by clouds.

Automatic change detection on such images have wider application for various use cases. Description: Change detection between two SAR (Synthetic Aperture Radar) satellite images are straight forward if they are co-registered as the difference or ratio of corresponding pixels of the two images itself will give the change map. But such change maps will invariably have many natural changes as well like water body extent, flood extent, snow cover and forest cover changes etc. Our interest is to detect only man made changes and avoid natural changes. The solution can make use of Sentinel 1 SAR Open source satellite images and Google Earth Engine platform to access them. These images are co-registered by default. The GRD (Ground Range Detected) intensity image version of the Sentinel 1 SAR is to be used. Please note that images with same viewing geometry are better suited for change detection purposes. The solution should give the option for the user to vary the thresholds if any used for filtering change results. The change output should be in the form of polygons in a geographically referenced vector file. The solution should be scalable, means should be able to run on huge areas of interest and generate change alerts. The criteria for winning solution would be minimum false alarms with regard to man made changes. Expected Solution: A software based solution is expected that has a GUI to specify the area of interest for change detection and threshold controls to filter changes and output changes in the form of shapefiles/geojson with geographical references. It shall run above Google Earth Engine.

- **Link:** https://www.sih.gov.in/sih2024PS

Scope:

The scope of this project includes developing a deep learning model for automatic change detection in SAR satellite images, focusing on enhancing accuracy and reducing noise. It encompasses data preprocessing, model training, and validation using SAR datasets from ISRO. The target audience includes space agencies, environmental monitoring organizations, disaster management authorities, and researchers in remote sensing. This solution aims to aid in timely detection of changes in urban areas, forests, and disaster zones, improving decision-making and response strategies across multiple sectors.

Specific Objectives:

• Objective 1: Develop a deep learning model for accurate change detection in SAR images, reducing noise and improving reliability. Impact: This will enhance the precision of monitoring land cover changes, urban expansion, and environmental shifts.

• Objective 2: Integrate an efficient data preprocessing pipeline to handle SAR image noise, including speckle reduction and normalization techniques. Impact: Improved data quality will lead to more accurate detection of changes over time, minimizing false positives.

• Objective 3: Validate the model using real-world SAR datasets, such as from ISRO, to ensure generalizability across different environments. Impact: This ensures the model's applicability to real-time monitoring in diverse scenarios like disaster management and environmental conservation.

Stakeholders:

- Space Agencies (e.g., ISRO): Beneficiaries of enhanced SAR image analysis for satellite-based earth observation and research.

- Environmental Monitoring Organizations: Users of the system to track deforestation, land degradation, and other ecological changes.

- Disaster Management Authorities: Clients who will benefit from real-time change detection to assess damage during natural disasters like floods or earthquakes.

- Urban Planning Departments: Users utilizing SAR-based change detection to monitor urbanization and infrastructure development.

- Researchers and Academicians in Remote Sensing: Beneficiaries of the improved methodology for studying geographical changes using SAR data.

Background:

This project is being undertaken to address the need for accurate and automated change detection in Synthetic Aperture Radar (SAR) satellite images. SAR images provide critical insights into Earth's surface, regardless of weather or lighting conditions, making them invaluable for monitoring environmental changes, urban expansion, and disaster impacts. However, the challenge lies in the complex noise (speckle) and variation in SAR image characteristics, which limits the effectiveness of traditional detection methods.

The opportunity to leverage deep learning models presents a solution to overcome these limitations, enabling more accurate, reliable, and timely detection of changes. This can lead to

significant improvements in areas such as disaster response, environmental conservation, and urban planning.

Review of Literature:

[Present a critical appraisal of previous work relevant to the project. Include a comparison chart to show previous work and how your project differs or adds value.]

Title	Reference	Date/Year	Features
Colorize Black and White Photos Automatically Online	https://www.cutout.pro/photo-colorizer-black-and-white	20/10/2024	Colorize Black and White Photos
AI Photo Colorizer	https://www.cutout.pro/photo-colorizer-black-and-white	20/10/2024	Photo Colorize
Colorize	https://imagecolorizer.com/	20/10/2024	Photo Colorize

Implementation and Deployment Considerations:

a) Social Benefits: Yes

Accurate change detection in SAR images can enhance disaster management, helping communities respond quickly to floods, earthquakes, and other events, thereby protecting lives and property.

b) Environmental Benefits: Yes

The project will aid in monitoring deforestation, land degradation, and climate change effects, contributing to environmental preservation and sustainable resource management.

c) Health, Safety, Legal, and Cultural Issues: Yes

While the project does not directly affect health or cultural practices, legal issues like data privacy in satellite imaging need to be considered to ensure compliance with global regulations.

d) Sustainable Development: Yes

The project promotes sustainable development by enabling more effective land-use planning, resource management, and environmental protection through accurate monitoring of land changes.

e) Ethical Principles: Yes

The project must ensure that data is used responsibly, respecting privacy, avoiding misuse of satellite imagery for unlawful purposes, and promoting transparency in its application.

f) Professional Ethics: Yes

Researchers and developers involved must adhere to high ethical standards in data handling, ensuring accuracy, fairness, and transparency in the development and deployment of the system.

g) Techniques and Tools: Yes

The project will employ deep learning models, image processing techniques, and tools like Python, TensorFlow, and OpenCV for model development, along with SAR datasets for training and validation.

h) Research and Analysis: Yes

Extensive research will be required to study SAR image characteristics, deep learning methodologies, and existing literature on change detection to optimize the model's performance and ensure its generalizability.

Technological Know-How Required:

• **Tools and Technologies:**

- HTML, CSS (for structuring and styling the website)
- JavaScript (for dynamic content and interactivity)
- React.js or Angular.js (for building responsive and scalable frontend interfaces)
- Node.js with Express.js (for backend development)
- MongoDB or MySQL (for database management)
- Git, GitHub (for version control and collaboration)
- RESTful APIs (for integrating services like data retrieval from the model)
- Web hosting platforms (e.g., AWS, Heroku)

• **Software Requirements:**

- Visual Studio Code or any IDE for web development
- Node.js and npm (Node Package Manager)
- MongoDB/MySQL client for database interaction
- Postman (for API testing)
- SSL/TLS for security (for HTTPS)
- Docker (optional, for containerization)

Key Personnel and Skills:

Name	Enrollment No.	Technical Skills	Contact Number
Chetna Sontaki	0827CI211051	Skills	7224006961
Dhruv Sharma	0827CI211061	Skills	7225925295
Divyanshu Aaliwal	0827CI211067	Skills	7489951720
[Guide]	Shruti Lashkari	[Expertise]	

Proposed Timetable:

Module	Description of Work	Expected Duration
Module One	[Description]	[Weeks]
Module Two	[Description]	[Weeks]
Module Three	[Description]	[Weeks]
[Additional Modules]	[Description]	[Weeks]

Project Benefits:

- Enhanced Decision-Making: Users and stakeholders will gain access to accurate, real-time detection of geographical changes, allowing for informed and timely decisions in urban planning, disaster management, and environmental monitoring.

- Improved Efficiency: Automating the change detection process reduces the need for manual analysis, saving time and resources for space agencies, environmental organizations, and government bodies.

- Greater Accuracy: The project's advanced deep learning model minimizes false detections and enhances precision, providing reliable data for critical applications like deforestation monitoring and flood assessment.

- Scalability and Adaptability: The model can be applied across various environments and use cases, offering flexibility to stakeholders like researchers, environmentalists, and urban planners.

- Cost Savings: The automation of SAR image analysis reduces labor costs, while improving the speed and quality of data analysis in large-scale projects, such as environmental assessments or disaster response efforts.

References:

- Chang, L., & Liu, C. (2020). "A deep learning-based approach for change detection in SAR images." Remote Sensing, 12(6), 945-960.
- https://doi.org/10.3390/rs12060945

- Shi, J., Zhang, L., & Xu, Y. (2018). "SAR image change detection using deep convolutional networks." IEEE Transactions on Geoscience and Remote Sensing, 56(8), 4565-4576.
- https://doi.org/10.1109/TGRS.2018.2806194

- Singh, S. (2021). "Applications of synthetic aperture radar in disaster management." International Journal of Remote Sensing, 42(7), 2437-2450.
- https://doi.org/10.1080/01431161.2020.1803645

- ISRO. (2022). "Synthetic aperture radar imaging: Technology and applications." Indian Space Research Organisation.
- https://www.isro.gov.in/SAR-imaging