A
Project Report
On
"Road Surface Quality Investigation"

(CE451 - Software Project Major)

Prepared at

ISO 9001:2008
ISO 27001:2013
CMMI LEVEL-5

Bhaskaracharya National Institute for Space Applications & Geo-informatics
Ministry of Electronics and Information Technology, Govt. of India.
Gandhinagar

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Under the Supervision of

Dr. Nikita Bhatt

Submitted to

Charotar University of Science & Technology (CHARUSAT)
for the Partial Fulfillment of the Requirements for the
Degree of Bachelor of Technology (B.Tech.)
in U & P U. Patel Department of Computer Engineering (CE)
for B.Tech Semester 8

Submitted at

CHARUSAT
CHAROTAR UNIVERSITY OF SCIENCE AND TECHNOLOGY

Accredited with Grade A+ by NAAC

U & P U. PATEL DEPARTMENT OF COMPUTER ENGINEERING
Chandubhai S. Patel Institute of Technology (CSPIT)
Faculty of Technology & Engineering (FTE), CHARUSAT
At: Changa, Dist: Anand, Pin: 388421.

April, 2023

DECLARATION BY THE CANDIDATES

We hereby declare that the project report entitled "**Road Surface Quality Investigation**" submitted by us to Chandubhai S. Patel Institute of Technology, Changa in partial fulfilment of the requirements for the award of the degree of **B.Tech Computer Engineering**, from U & P U. Patel Department of Computer Engineering, CSPIT, FTE, is a record of bonafide CE451 Software Project Major (project work) carried out by us under the guidance of **Dr. Nikita Bhatt**. We further declare that the work carried out and documented in this project report has not been submitted anywhere else either in part or in full and it is the original work, for the award of any other degree or diploma in this institute or any other institute or university.

(Karan Goswami (19CE036)) **(Jaydipsinh Padhiyar (19CE081))**

(Kushal Panchal (19CE083)) **(Jaydip Movaliya (19CE079))**

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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ISO 9001:2008
ISO 27001:2013
CMMI LEVEL-5

CERTIFICATE

This is to certify that the project report compiled by ***Mr. Karan Goswami, Mr. Jaydip Movaliya, Mr. Jaydipsinh Padhiyar and Mr. Kushal Panchal*** *students of 8th Semester* ***B.Tech-CE from Chandubhai S. Patel Institute of Technology, Charusat University, Changa*** *have completed their final Semester internship project satisfactorily. To the best of our knowledge this is an original and bonafide work done by them. They have worked on Web-based application for "****Road Surface Quality Investigation****", starting from January 02nd, 2023 to April 24th, 2023.*

During their tenure at this Institute, they were found to be sincere and meticulous in their work. We appreciate their enthusiasm & dedication towards the work assigned to them.

We wish them every success.

Harsh Kiratsata
External Co-Guide
BISAG- N, Gandhinagar

Punit Lalwani
CISO,
BISAG- N, Gandhinagar

CHARUSAT

CHAROTAR UNIVERSITY OF SCIENCE AND TECHNOLOGY

Accredited with Grade A+ by NAAC

CERTIFICATE

This is to certify that the report entitled "**Road Surface Quality Investigation**" is a bonafied work carried out by **Karan Goswami (19CE036), Jaydip Movaliya (19CE079), Jaydipsinh Padhiyar (19CE081), Kushal Panchal (19CE083)** under the guidance and supervision of **Dr. Nikita Bhatt** & **Mr. Harsh Kiratsata** for the subject **Software Project Major (CE451)** of 8th Semester of Bachelor of Technology in **Computer Engineering** at Chandubhai S. Patel Institute of Technology (CSPIT), Faculty of Technology & Engineering (FTE) – CHARUSAT, Gujarat.

To the best of my knowledge and belief, this work embodies the work of candidate themself, has duly been completed, and fulfills the requirement of the ordinance relating to the B.Tech. Degree of the University and is up to the standard in respect of content, presentation and language for being referred by the examiner(s).

Under the supervision of,

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About BISAG- N

ABOUT THE INSTITUTE

Modern day planning for inclusive development and growth calls for transparent, efficient, effective, responsive and low cost decision making systems involving multi-disciplinary information such that it not only encourages people's participation, ensuring equitable development but also takes into account the sustainability of natural resources. The applications of space technology and Geo–informatics have contributed significantly towards the socio-economic development. Taking cognizance of the need of geo-spatial information for developmental planning and management of resources, the department of Ministry of Electronics and Information Technology, Government of India, established "Bhaskaracharya National Institute for Space Applications and Geo-informatics" (BISAG- N). BISAG- N is an ISO 9001:2008, ISO 27001:2005 and CMMI: 5 certified institute. BISAG- N which was initially set up to carryout space technology applications, has evolved into a centre of excellence, where research and innovations are combined with the requirements of users and thus acts as a value added service provider, a technology developer and as a facilitator for providing direct benefits of space technologies to the grass root level functions/functionaries.

BISAG- N's Enduring Growth

Since its foundation, the Institute has experienced extensive growth in the sphere of Space technology and Geo-informatics. The objective with which BISAG- N was established is manifested in the extent of services it renders to almost all departments of the State. Year after year the institute has been endeavouring to increase its outreach to disseminate the use of geo-informatics up to grassroots level. In this span of nine years, BISAG- N has assumed multi-dimensional roles and achieved several milestones to become an integral part of the development process of the Gujarat State.

BISAG- N Journey

2003-04

Gujarat SATCOM Network

2007-08

Centre for Geo-informatics Applications

2010-11

Academy of Geo-informatics for Sustainable Development

2012-13

A full-fledged Campus

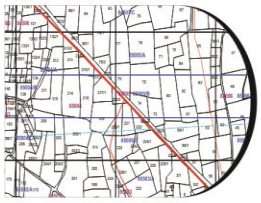
Activities

Satellite Communication..

for promotion and facilitation of the use of broadcast and teleconferencing networks for distant interactive training, education and extension.

Remote Sensing..

for Inventory, Mapping, Developmental planning and Monitoring of natural & man-made resources.

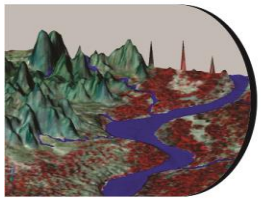


Geographic Information System..

for conceptualization, creation and organization of multi purpose common digital database for sectoral/integrated decision support systems.

Global Navigation Satellite System..

for Location based Services, Geo-referencing, Engineering Applications and Research.



Photogrammetry..

for Creation of Digital Elevation Model, Terrain Characteristic, Resource planning.

Cartography..

for thematic mapping, value added maps.

Software Development..

for wider usage of Geo-spatial applications, Decision Support Systems (desktop as well as web based), ERP solutions.

Education, Research and Training..

for providing Education, Research, Training & Technology Transfer to large number of students, end users & collaborators.

Applications of Geospatial Technology for Good Governance: Institutionalization

Through the geospatial technology, the actual situation on the ground can be accessed. The real life data collected through the technology forms the strong foundation for development of effective social welfare programs benefiting directly the grass root level people. The geospatial data collected by the space borne sensors along with powerful software support through Geographic Information System (GIS), the vital spatio-temporal maps, tables, and various statistics are being generated which feed into Decision Support System (DSS).

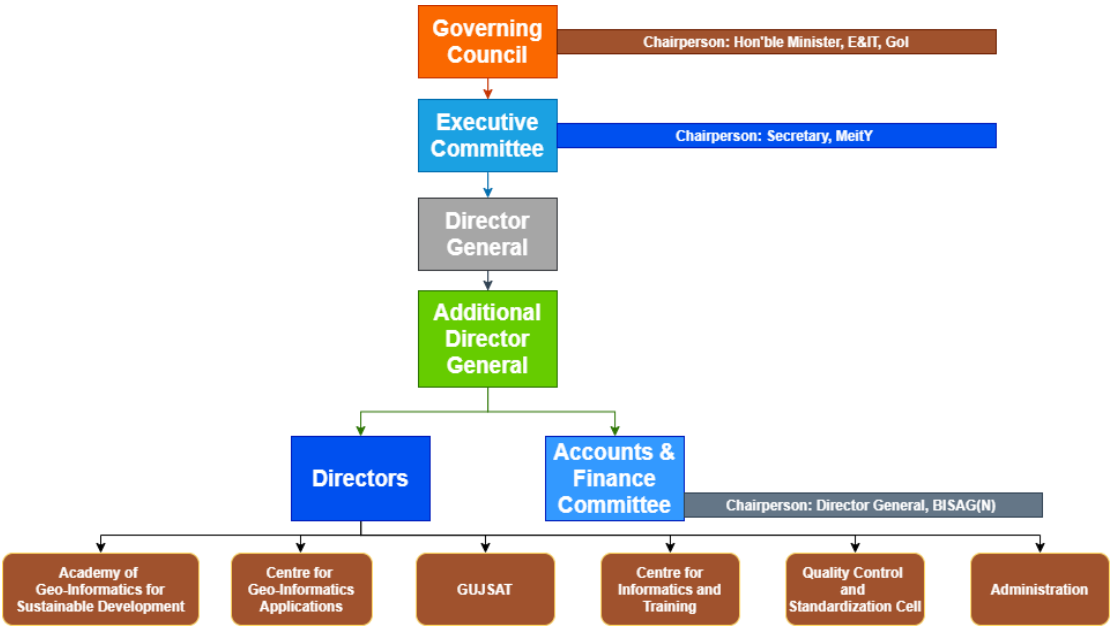
A multi-threaded approach is followed in the process of institutionalization of development of such applications. The 5 common threads which run through all the processes are: *Acceptability, Adaptability, Affordability, Availability and Assimilability*.
These are the "Watch Words" which any application developer has to meet. The "acceptability" addresses the issue that the application developed has met the wide acceptability among the users departments and the ultimate end beneficiary by way of providing all necessary data and statistics required. The "affordability" addresses the issue of the application product being cost effective. The "availability" aspect looks into aspect of easily accessible across any platform, anywhere and anytime. The applications should have inbuilt capability of easy adaptability to the changing spatio- and temporal resolutions of data, new aspects of requirements arising from time to time from users. The assimilability aspect ensures that the data from various sources / resolutions and technologies can be seamlessly integrated.

ACCEPTABILITY	▪ Problem definition by users • Proof of Concept development without financial liability on users ▪ Execution through collaboration under user's ownership
ADOPTABILITY	▪ Applications as per present systems & database ▪ Maximum Automation ▪ Minimum capacity building requirement at the user end
AFFORDABILITY :	▪ Multipurpose geo-spatial database, common, compatible, standardized (100s of layers) ▪ In house developed/open source software ▪ Full Utilization of available assets
AVAILABILITY:	▪ Departmental /Integrated DSS ▪ Desired Product delivery anytime, anywhere in the country
ASSIMILABILITY	▪ Integration of Various technologies like RS, GIS, GPS, Web MIS, Mobile etc.

Organizational Setup

The Institute is responsible for providing information and technical support to different Departments and Organizations. The Governing Body and the Empowered Executive Committee govern the functioning of BISAG- N. The Institute is registered under the Societies Registration Act 1860. Considering the scope and extent of activities of BISAG- N, its organizational structure has been charted out with defined functions.

Organizational Setup of BISAG- N



Governing Body

For smoother, easier and faster institutionalization of Remote Sensing and GIS technology, decision makers of the state were brought together to form the Governing Body. It is the supreme executive authority of the Institute. The Governing Body comprises of ex-officio members from various Government departments and Institutes.

- Hon'ble Minister of Electronics and Information Technology..... Chairperson (Ex-Officio)
- Hon'ble Minister of State Electronics and Information Technology.....……Deputy Chairperson (Ex-Officio)
- Secretary of Government of India: Ministry of Electronics and Information Technology..... .....Executive Vice Chairperson (Ex-Officio)
- Chief Executive Officer, Niti Aayog..... ……Member (Ex-Officio)
- Chairman, Indian Space Research Organization ..... ……Member (Ex-Officio)
- Secretary to Government of India: Department of Science and Technology .. ……Member (Ex-Officio)
- Additional Secretary to Government of India: Ministry of Electronics and Technology ……Member (Ex-Officio)
- Chief Secretary to Government of Gujarat..... ……Member (Ex-Officio)
- President & Chief Executive Officer, National e-Governance Division, Ministry of Electronics
- and Information Technology..... …… Member (Ex-Officio)
- Financial Advisor to Government of India: Ministry of Electronics and Information Technology ..... …Member (Ex-Officio)
- Distinguished Professionals from the GIS field-Three (3) (To be nominated by the Chairperson)

♦ Director-General, Bhaskaracharya National Institute for Space Application and Geo-Informatics {BISAG(N)} ..... Member Secretary (Ex-Officio)

Centre for Geo-informatics Applications

Introduction

The objective of this technology group is to provide decision support to the sectoral stake holders through scientifically organized, comprehensive, multi-purpose, compatible and large scale (village level) geo-spatial databases and supporting analytical tools. These activities of this unit are executed by a well-trained team of multi-disciplinary scientists. The government has provided a modern infrastructure along with the state-of-the-art hardware and software. To study the land transformation and development over the years, a satellite digital data library of multiple sensors of last twenty years has been established and conventional data sets of departments have been co-registered with satellite data. The geo-spatial databases have been created using conventional maps, high resolution satellite 2D and 3D imagery and official datasets (attributes).The geo-spatial databases include terrain characteristics, natural and administrative systems, agriculture, water resources, city survey maps, village maps with survey numbers, water harvesting structures, water supply, irrigation, power, communications, ports, land utilization pattern, infrastructure, urbanization, environment data, forests, sanctuaries, mining areas, industries. They also include social infrastructure like the locations of schools, health centres, institutions, aganwadies, local government infrastructure etc. The geospatial database of nagar-palikas includes properties and amenities captured on city and town planning maps with 1000 GIS layers. Similar work for villages has been initiated as a pilot project.

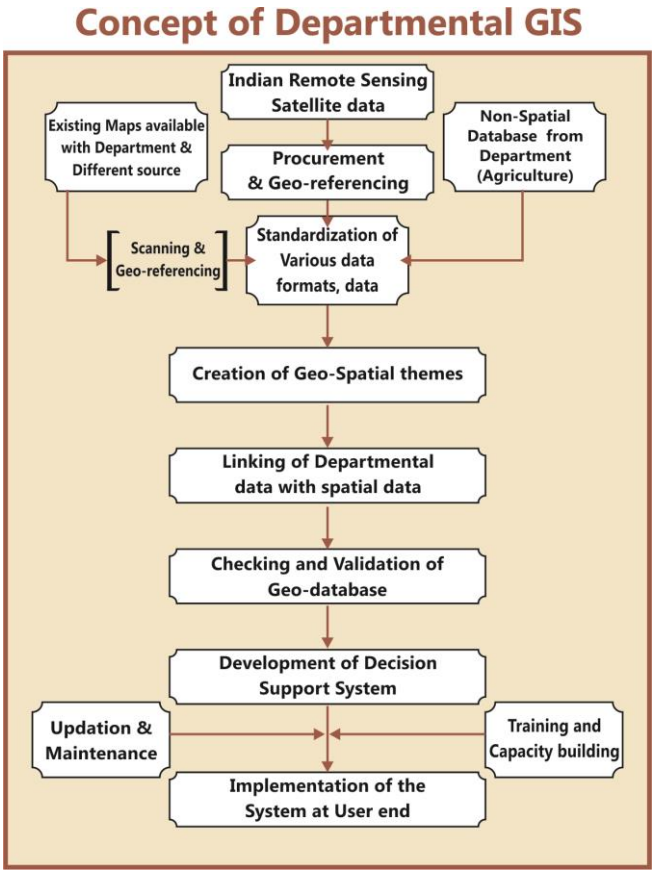
The applications of space technology and geo-informatics have been operational in almost all the development sectors of the state. Remote sensing and GIS applications have provided impetus to planning and developmental activities at grass root level as well as monitoring and management in various disciplines.

The GIS based Applications Development

The GIS software is a powerful tool to handle, manipulate and integrate both the spatial and non-spatial data. The GIS system operates on the powerful backend data base and Sequential Query Language (SQL) to inquiry the data bases. It has the capability to handle large volume of data and process to yield values of parameters which can be input to very important government activity as Decision Support System (DSS). Its mapping capabilities help the users and specialists in generating single and multi-theme wise maps.

The GIS based applications development has been institutionalized in BISAG- N. This process can be listed as (Refer Figure for Details)

- Making the users aware of the GIS capabilities through introductory training programme and by exposing to already developed projects as success stories.
- Helping the users in defining the GIS based projects.
- Digitizing the data available with the users and encouraging them to collect any additional data as may be required.
- Generating the appropriate data bases with the full involvement of the users following the data bases standards



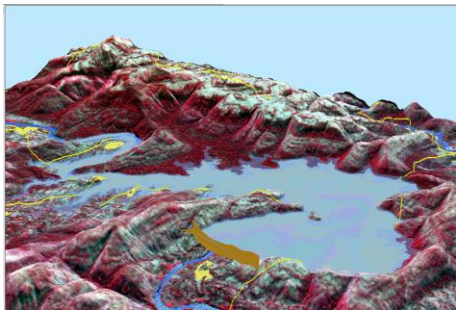
Remote Sensing and GIS Sectoral Applications:

Geo-informatics based Irrigation Management and Monitoring System

- The Geo-spatial information system for Irrigation water Management and Monitoring system for command areas in Sardar Sarovar Narmada Nigam Limited (SSNL) has been developed. Satellite image-based Irrigation monitoring system has been developed in GIS. From the multi-spectral Satellite images of every month, the irrigated areas were extracted.
- The irrigated area were overlaid on the geo-referenced cadastral maps and the statistics of area irrigated has been estimated.

- The user friendly Customized Decision Support System (DSS) has been developed.

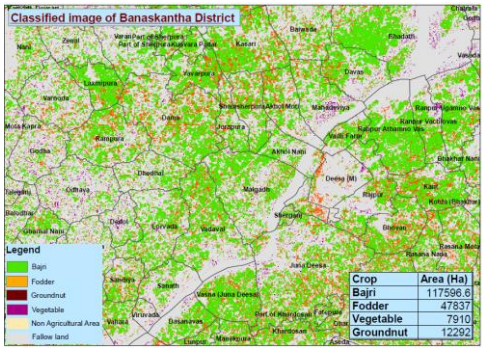
Preparation of DPR of Par–Tapi-Narmada Link using Geo-informatics for National Water development Agency (NWDA)



- The main objective of Par–Tapi-Narmada Link project is to divert surplus water available in west flowing rivers of south Gujarat and Maharashtra for utilization in the drought prone Saurashtra and Kachcha. On the request from NDWA, preparation of various maps for proposed DPR work was undertaken by the BISAG- N. Land use and submergence maps of proposed dams along with its statistics have been prepared by the BISAG- N. The detailed work consisted of generation of Digital Elevation Model (DEM), contour generation, Land use mapping, forest area generation of submergence extent at different levels etc.

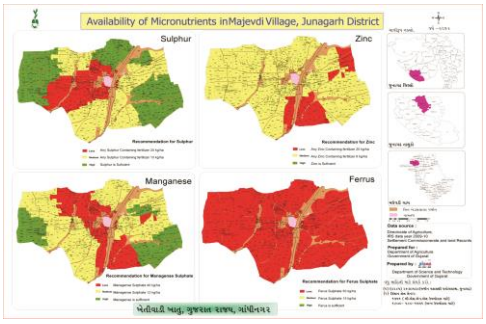
Agriculture

District and Village-level Crop Inventory



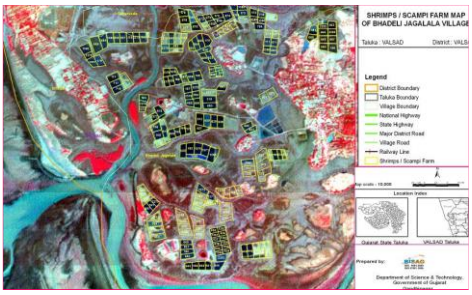
- Remote Sensing (RS) based Village-level Crop Acreage Estimation at was taken up in two villages of Anand and Mehsana districts of Gujarat state. The major objective of this study was to attempt village-level crop inventory during two crop seasons of Kharif (monsoon season) and Rabi (winter season) using single-date Indian Remote Sensing (IRS) LISS-III and LISS-IV digital data of maximum vegetative growth stage of major crops during each season.
- District-level crop acreage estimation during three cropping seasons namely Kharif, Rabi and Zaid (summer) seasons was also carried out in all the 26-districts of Gujarat State. Summer crop acreage estimation Gujarat State was carried out during 2012.

Spatial Variability Mapping of Soil Micro-Nutrients



- The spatial variability of soil micro-nutrients like Fe, Mn, Zn and Cu in various villages of different districts, Gujarat state was mapped using geo-informatics technology. The major objectives of this study were i) to quantify the variability of Mn, Fe, Cu and Zn concentration in soil; ii) to map the pattern of micro-nutrient variability in cadastral maps, iii) suggest proper application of micro-nutrients based on status of deficiency for proper crop management and iv) preparation of village-level atlases showing spatial variability of micro-nutrients.

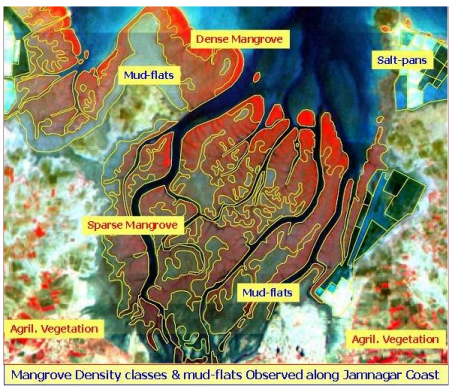
Geo-spatial Information System for Coastal Districts of Gujarat



- The project on development of Village-level Geo-spatial Information System for Shrimp Farms in Coastal Districts of Gujarat, was taken with major objective of development of Village-level Geo-spatial Information System for Shrimp/Scampi areas using Remote Sensing (RS) and GIS. This project was sponsored by the Marine Products Export Development Authority (MPEDA), Ministry of Commerce & Industry, Government of India for scientific management of Scampi farms in the coastal districts which can help fishermen to better their livelihood and increase the economic condition on sustainable basis. The customized query shell was developed using the open source software for sharing the information amongst the officers from MPEDA and potential users. This has helped the farmers to plan their processing and marketing operations so as to achieve better remunerations.

Environment and Forest

Mapping and Monitoring of Mangroves in the Coastal Districts of Gujarat State



Mangrove Density classes & mud-flats Observed along Jamnagar Coast

- Gujarat Ecology Commission, with technical inputs from the Bhaskaracharya National Institute for Space Applications and Geo-informatics - N (BISAG- N) made an attempt to publish Mangrove Atlas of the Gujarat state. Mangrove atlas for 13-coastal districts with 35-coastal talukas in Gujarat, have been prepared using Indian Remote sensing satellite images. The comparison of mangrove area estimates carried out by BISAG- N and Forest Survey of India (FSI) indicates a net increase in the area under mangrove cover. The present assessment by BISAG- N, has recorded 996.3 sq. km under mangrove cover, showing a steep rise to the tune of 88.03 sq. km. In addition to the existing Mangrove cover, the present assessment also gives the availability of potential area of 1153 sq. km, where mangrove regeneration program can be taken up.

Academy of Geo-informatics for Sustainable Development

Introduction

- Considering the requirement of high end research and development in the areas having relevance of geo-informatics technology for sustainable development, a separate infrastructure has been established. In collaboration with different institutes in the state as well as in the country, R&D activities are being carried out in the areas of climate change, environment, disaster management, natural resources management, infrastructure development, resources planning, coastal hazard and coastal zone management studies, etc. under the guidance of eminent scientists.

- Various innovative methodologies/models developed in this academy through the research process have helped in development of various applications. There are plans to enhance R&D activities manifold during coming years.
- This unit also provides training to more than 600 students every year in the field of Geo-informatics to the students from various backgrounds like water resources, urban planning, computer Engineering, IT, Agriculture in the areas of Remote sensing, GIS and their applications.
- This Academy has been established as a separate infrastructure for advanced research and development through following schools:
  - School of Geo-informatics
  - School of Climate & Environment
  - School of Integrated Coastal Zone Management

- School of Sustainable Development Studies
- School of Natural Resources and Bio-diversity
- School of Information Management of Disasters
- School of Communication and Society

During XIIth Five year Plan advance applied research through above schools shall be the main thrust area. Already M. Tech and Ph.D. students of other Universities/ Institutes are doing research in this academy in applied sciences under various collaborative programmes.

M. Tech. Students' Research Programme

The academy started M. Tech. students' research programme in a systematic way. It admitted 11 students from various colleges and universities in Gujarat, Rajasthan and Madhya Pradesh for period of 10 months from August 2011 to May 2012. All the students were paid stipend of Rs. 6000 per month during the tenure. The research covered the following areas:

- Cloud computing techniques
- Mobile communication
- Design of embedded systems
- Aquifer modelling
- Agricultural and Soils Remote Sensing
- Digital Image processing Techniques (Data Fusion and Image Classification).

The research resulted in various dissertations and publications in national and international journals.

• Now nine students, one from IIT, Kharagpur, three from GTU, one from M. S University, Vadodara and four from GU, are undergoing their Ph. D programme. Out of nine, two thesis have been submitted. Two students are from abroad. One each from Vietnam and Yemen. Since then (after approval of research programme from the Governing Body), 200+ papers have been published by the Academy.

ABSTRACT

We gained lots of experience from our internship at the Bhaskaracharya National Institute for Space Applications and Geo-informatics (BISAG), allowing us the chance to put our academic understanding into practice. Through this internship, we were able to close the knowledge gap between academia and industry while learning useful knowledge of the geo-informatics and space applications. The creation and deployment of a system for detecting road cracks using deep learning models and its integration with a full-fledged web-portal are the main highlights of this report. Road cracks pose a serious threat to the transport network and may elevate maintenance costs and shorten the lifespan of the road. For timely maintenance and ensuring road safety, a reliable crack detection system is therefore crucial.

The report then proceeds into particulars on the specific responsibilities and tasks that we performed during our internship, including our roles in the project and the work we did to deliver appropriate results. The report also sheds the light on development environment of the project whose leading component is ArcGIS bundled with web development tools. With the clear goal in mind, milestones were devised after each successful work which reaped benefits. Furthermore, discussions with the coordinators and professors paved the way for creating better and efficient road damage detection system which can be witnessed through the diagrams and testcases shown later in this report.

The report concludes with a broad evaluation of our development project, including a discussion of all the technologies we used and how the outcomes impacted the overall development of our project, as well as a summary of the company, including information on its background, organizational structure, and nature of operations. Furthermore, the internship we performed at the Bhaskaracharya National Institute for Space Applications and Geo-informatics (BISAG-N) presented us with a priceless chance to advance both personally and professionally

ACKNOWLEDGEMENT

I would like to convey my heartfelt gratitude to Bhaskaracharya National Institute for Space Applications and Geo-informatics for giving me the chance to complete my internship at your prestigious organisation. I've had a great experience, and I feel honoured to have been a member of your team.

I want to express my gratitude to Mr. Sidhdharth Patel, the project coordinator, and Mr. Harsh Kiratsata, my project guide, for their invaluable advice and assistance throughout my internship. They have greatly aided me in acquiring new knowledge and abilities thanks to their experience and expertise.

Additionally, I want to thank Dr. Nikita Bhatt, the college's internal faculty advisor, for her unwavering encouragement and suggestions throughout my internship. My comprehension of the field has really benefited from her direction and knowledge.

Finally, I would like to express my appreciation to the colleagues at the Bhaskaracharya National Institute for Space Applications and Geo-informatics for their kind hospitality and contribution to the success of my internship.

I want to thank you once more for giving me this opportunity. I'm looking forward to using the abilities and knowledge I gained from my internship in my future work.

Karan Goswami (19CE036)
Jaydip Movaliya (19CE079)
Jaydipsinh Padhiyar (19CE081)
Kushal Panchal (19CE083)

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1 INTRODUCTION

1.1 PROJECT SUMMARY

- The project involves collecting and processing large amounts of data, developing deep learning models to analyze the data by detecting road damage, and creating a user-friendly web portal for accessing the results of the analysis.
- The web portal provides better visual appeal so the user can navigate easily.
- Also the web portal provides information on road surface quality, allowing users to make informed decisions on their routes and providing valuable information for maintenance and improvement of road infrastructure.

1.2 PURPOSE

- This project's goal is to create a web site that uses machine learning models to locate and identify various kinds of road damage using satellite imagery and user-uploaded photographs and videos. Users can upload pictures of road surfaces to the portal, and it will automatically spot any damage, such as potholes, cracks, or uneven surfaces. The photos will be examined by the machine learning algorithms, which will then produce a report outlining the location, kind, and extent of the damage.
- Overall, by providing precise and timely information on the condition and degradation of the road surface, this initiative has the potential to contribute to safer and more effective transportation.

1.3 OBJECTIVE

- This project aims to analyse the quality of the road surface using ArcGIS and create a web-based model to forecast the state of the road surface. ArcGIS will be used for data gathering, analysis, and the creation of a prediction model
- A study including the analysis and visualisation of road surface data in order to pinpoint regions that need upkeep or repair is called "Road Surface Quality

investigation using ArcGIS and deep learning". To process the data gathered from multiple sources and forecast the quality of the road surface, deep learning techniques are used. These algorithms are capable of analysing vast volumes of data, finding patterns, and making precise predictions.

- Users can access the road surface data and maps using the project's web-based component from any location with an internet connection. Users can browse the data and maps, read specific information about the state of the road surface, and create reports using the web interface, which offers an interactive platform.

1.4 SCOPE

- This project aims to analyse the quality of the road surface using ArcGIS and create a web-based model to forecast the state of the road surface. ArcGIS will be used for data gathering, analysis, and the creation of a prediction model.
- The capacity to swiftly and reliably identify road damage and prioritise repairs would be helpful to road maintenance staff and municipal planners. Given that they might not have considerable technical knowledge, it is crucial to convey the information in a straightforward and understandable manner.
- Intended Audience and Reading Suggestions
  - Engineers and researchers: The technical specifics of your machine learning model and data processing techniques may be of interest to these experts. They would probably have more technical knowledge and be more interested in technical documentation.
  - Public: Access to information on local road damage could be advantageous for the general public. They may use your website to map out their routes or to report any road damage they come across.

1.5 TECHNOLOGY & LITERATURE REVIEW

- Geographic information system (GIS) software called ArcGIS was created by Esri. It offers resources and features for gathering, maintaining, processing, and displaying geographic data. The management of the environment, urban planning, and transportation

are just a few of the businesses that use ArcGIS extensively. ArcGIS will be utilised in this project for data gathering, analysis, and the creation of a web-based model.

- Location-based Services: Many IT applications today provide location-based services that rely on GIS data, such as mapping and navigation. Interactive maps that let users look up locations, receive directions, and see current traffic conditions can be made using GIS technology.
- Asset management: Using GIS technology, assets including buildings, machinery, and vehicles can be managed and tracked. Businesses and organisations are able to manage their resources more effectively by mapping the locations of these assets.
- Environmental Management: GIS technology is employed in the management and monitoring of the environment. GIS can be used, for instance, to track the movement of contaminants or keep an eye on alterations in land use.
- Urban planning: GIS technology is used to analyse and visualise traffic flow, land use patterns, and other elements that have an impact on city planning. GIS may be used to build 3D models of cities that assist planners in making better choices.
- Business intelligence: By analysing geographic data and spotting patterns and trends, GIS technology can be used in business intelligence. Understanding consumer behaviour, finding new markets, and supply chain management optimisation can all benefit from this.

- Web-based Model: Web development tools including HTML, CSS, JavaScript, and PHP will be used to create the web-based model. The model will be accessible through a website or mobile app and will be stored on a web server. Based on a number of variables, the model will give users precise forecasts of the quality of the road surface.

2 PROJECT MANAGEMENT

2.1 PROJECT PLANNING

2.1.1 Project Development Approach and Justification

- This project is being developed using Agile Development approach. Agile method is a well-liked development style that places a strong emphasis on adaptability, teamwork and iterative development.

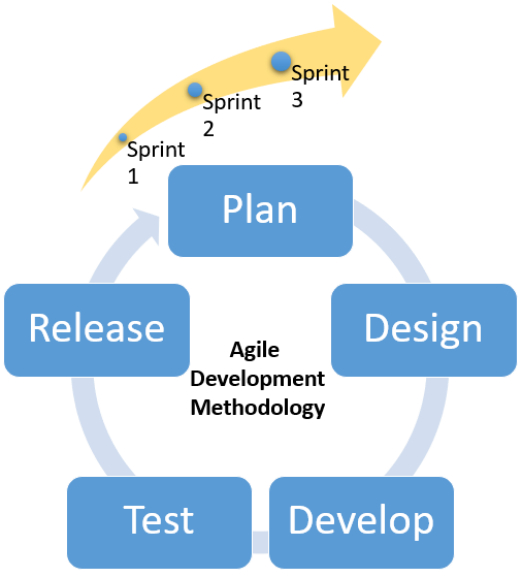


Fig 2.1 Agile Development Methodology

- Following are a few justifications for applying the agile methodology to this project:

  - **Rapid Adaptation**: This project demands knowledge from various fields and one can acknowledge that it is a complicated and dynamic project that necessitates regular feedback and change. The project's requirements and objectives would change as it moved along, therefore it required a development technique that could adapt.

- **Collaboration**: To ensure that the project team could successfully cooperate and remain aligned throughout the development process we used agile methodology which encourages regular communication and cooperation among team members, which aids in the establishment of a shared knowledge of the project's goals and needs.
- **Sprints**: The project is being developed with a small team of four people working on different parts of the project. Agile allowed us to break the project into small iteratives, or sprints, which provided us the power of quick development with the implementation of new ideas generated through brainstorming meetings.
- **Transparency**: Working in a group requires a high level of transparency, and by employing the agile technique, we were able to split the task in an excellent and transparent manner.

2.1.2 Project Effort and Time, Cost Estimation

Table 2.1 Calculation of Unadjusted Function Point

Functional Units		**Count**	**Weighting Factor**			**Count * (Average Weighting Factor)**
			Simple	**Average**	**Complex**	
External Inputs (EI)	User Login	5	3	4	6	5*4 = 20
	Admin Login					
	Add User					
	Add Road Coordinates					
	Add Road Data					
External Outputs (EO)	Login Confirmation	5	4	5	7	5*5 = 25
	Investigation Reports					

	Display Road Details					
	Display Users					
	Display Map					
External Inquiries (EQ)	Running DL Model	5	3	4	6	5*4 = 20
	Fetch User Details					
	Fetch Road Details					
	Fetch Reports					
	Fetch Map/ Coordinates					
Internal Logical Files (ILF)	User Documents	4	7	10	15	4*10 = 40
	Report Documents					
	Road Documents					
	Images Reference Documents					
External Interface File (EIF)	Application to server database	4	5	7	10	4*7 = 28
	User to application database					
	Main database to Media database					

	Application to Model Backend					
Total UFP						133

Table 2.2 Complexity Adjustment Factors

No.	Complexity Adjustment Factors	Degree of Influence (DI)
1	Data communication	5
2	Distributed data processing	4
3	Performance	5
4	Heavily used operational environment	3
5	Transaction rate	4
6	Online data entry	3
7	End user efficiency	4
8	Online updating	3
9	Complex processing	4
10	Code Reusability	2
11	Installation ease	0
12	Operational ease	0
13	Multiple sites	2
14	Ease of change	3
Total Degree of Influence (TDI)		42

Total UFP = 133

Total Degree of Influence (TDI) = 42

Complexity Adjustment Factor (CAF) = 0.65 + (0.01 * TDI)

= 0.65 + (0.01 * 42)

= 1.07

Adjustment Function Point (AFP) = UFP * CAF
= 133 * 1.07
= 142

Assuming that the 1 Function Point is equal to 50 lines of JavaScript code then,

Lines of Code (LOC) = (Lines of 1 FP) * (AFP)
= 50 *142
= 7100

Then KLOC = 7.1

Effort of the project is E = a1 * (KLOC) ^ a2

For the Organic project the value of a1 is 3.2 and the value of a2 is 1.05.

Therefore value of effort E = 3.2 * (7.1) ^ 1.05
= 25 person months (PM)

Duration of the project is M = b1 * (E) ^ b2
For the Organic project the value of b1 is 2.5 and the value of b2 is 0.38.

Therefore estimated Duration of the project M = 2.5 * (25) ^ 0.38
= 8.5 months

Suppose the average monthly salary of each software developer is Rs. 40,000.
Cost of the project = 30000 * E
= 30000 * 25
= 7,50,000.00 Rs

2.1.3 Roles and Responsibilities

Table 2.3 Roles and Responsibilities

Member Name	Responsibility	E-Mail
Karan Goswami	ML/DL Developer	19ce036@charusat.edu.in
Jaydip Movaliya	Full Stack Developer	19ce079@charusat.edu.in
Jaydipsinh Padhiyar	Full Stack Developer	19ce081@charusat.edu.in
Kushal Panchal	ML/DL Developer	19ce083@charusat.edu.in

2.1.4 Group Dependencies

- The system's front-end, the User Interface module, communicates with users. To authenticate and authorise users, it depends on the User Management module.
- The preprocessing module gets the input data ready for the deep learning module, which uses it to train on the data and forecast road damage. Data from different sources, such as satellite imagery and user-uploaded photographs and videos, are gathered and processed by the Data Ingestion module.
- Finally, the Report Generation module creates thorough investigative reports using the data that the system has gathered and processed. Overall, the modules are integrated and function together to give the user access to a thorough system for investigating the quality of the road surface.

2.2 PROJECT SCHEDULING

- Work Plan

	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names	Resource Initials	Resource Group	Add New Column
1		**Road Surface Quality Investigation**	**96 days**	**Mon 19-12-22**	**Sat 29-04-23**					
2	✓	**Research and Discovery**	**6 days**	**Mon 19-12-22**	**Sat 24-12-22**					
3	✓	Form Project Team	1 day	Mon 19-12-22	Mon 19-12-22		Project Manager	Jaydipsinh	Management	
4	✓	Kickoff Meeting	1 day	Tue 20-12-22	Tue 20-12-22	3	Fullstack Develo	Jaydip,Karan,Kushal,Ja	Web, Project Team,M	
5	✓	Determine Project Scope	4 days	Wed 21-12-22	Sat 24-12-22	4	Fullstack Developer 2	Jaydip,Kushal	Web, Project Team,ML/DL	
6	✓	Finalize Project Definition	4 days	Wed 21-12-22	Sat 24-12-22	4	Fullstack Developer 1	Jaydipsinh,Karan	Web, Project Team,ML/DL	
7	✓	**Software Requirement Gathering**	**6 days**	**Mon 26-12-22**	**Sat 31-12-22**	**2**				
8	✓	Sprint Meeting	1 day	Mon 26-12-22	Mon 26-12-22		Fullstack Develo	Jaydip,Karan,Kushal,Ja	Web, Project Team,M	
9	✓	Project Requirement Analysis	1 day	Mon 26-12-22	Mon 26-12-22					
10	✓	Functional Requirement	4 days	Mon 26-12-22	Thu 29-12-22	9	Fullstack Developer 2	Jaydip,Karan	Web, Project Team,ML/DL	
11	✓	Non Functional Requirement	4 days	Mon 26-12-22	Thu 29-12-22	9	Fullstack Developer 1	Jaydipsinh,Kushal	Web, Project Team,ML/DL	
12	✓	Brainstorming with External Coordinator	1 day	Fri 30-12-22	Fri 30-12-22		Fullstack Developer 2	Jaydip,Jaydipsinh,Kara	Web, Project Team,ML/DL	
13	✓	Finalize Technologies/Framework	1 day	Sat 31-12-22	Sat 31-12-22	10,11	Project Manager	Jaydipsinh	Management	
14	✓	**Project Planning**	**3 days**	**Mon 02-01-23**	**Wed 04-01-23**	**7**				
15	✓	Sprint Meeting	1 day	Mon 02-01-23	Mon 02-01-23		Fullstack Develo	Jaydip,Karan,Kushal,Ja	Web, Project Team,M	
16	✓	Assign Roles / Work Distribution	3 days	Mon 02-01-23	Wed 04-01-23		Project Manager	Jaydipsinh	Management	
17	✓	Create Project Timeline	3 days	Mon 02-01-23	Wed 04-01-23		Project Manager	Jaydipsinh	Management	

Fig 2.2 Work Plan

18	✓	**Development Sprint 1**	**21 days**	**Mon 02-01-23**	**Sat 28-01-23**	**14SS**				
19	✓	Meeting/ Brainstorming	2 days	Mon 02-01-23	Tue 03-01-23					
20	✓	**Web**	**21 days**	**Mon 02-01-23**	**Sat 28-01-23**	**19SS**				
21	✓	UI Design	6 days	Mon 02-01-23	Sat 07-01-23		Fullstack Develo	Jaydip,Jaydipsinh	Web, Project Team	
22	✓	Web: Database Design	6 days	Mon 09-01-23	Sat 14-01-23	21SS	Fullstack Developer 1	Jaydipsinh	Web, Project Team	
23	✓	Setting up Development Environment	6 days	Mon 16-01-23	Sat 21-01-23		Fullstack Developer 2	Jaydip	Web, Project Team	
24	✓	Code	11 days	Mon 16-01-23	Sat 28-01-23	23SS	Fullstack Develo	Jaydip,Jaydipsinh	Web, Project Team	
25	✓	**DL**	**21 days**	**Mon 02-01-23**	**Sat 28-01-23**	**19SS**				
26	✓	GIS/ML/DL Research	6 days	Mon 02-01-23	Sat 07-01-23		ML/DL Developer 1	Karan,Kushal	ML/DL, Project Team	
27	✓	Data Gathering	6 days	Mon 09-01-23	Sat 14-01-23	26SS	ML/DL Develope	Karan,Kushal	ML/DL, Project Team	
28	✓	Setting up Development Environment	6 days	Mon 16-01-23	Sat 21-01-23		ML/DL Developer 1	Karan	ML/DL, Project Team	
29	✓	Code	11 days	Mon 16-01-23	Sat 28-01-23	28SS	ML/DL Develope	Karan,Kushal	ML/DL, Project Team	
30	✓	Complete/Modify SRS	2 days	Fri 27-01-23	Sat 28-01-23		ML/DL Developer 2	Kushal	ML/DL, Project Team	

Fig 2.3 Development Sprint-1 Plan

31	✓	📌	**Development Sprint 2**	**21 days**	**Mon 30-01-23**	**Sat 25-02-23**	**18**			
32	✓	📌	Meeting/ Brainstorming	2 days	Mon 30-01-23	Tue 31-01-23		Fullstack Developer 2	Jaydip,Jaydipsinh,Kara	Web, Project Team,ML/DL
33	✓	📌	**Web**	**21 days**	**Mon 30-01-23**	**Sat 25-02-23**	**32SS**			
34	✓	📌	Review UI and Update	2 days	Mon 30-01-23	Tue 31-01-23		Fullstack Developer 1	Jaydipsinh	Web, Project Team
35	✓	📌	Full Authentication Module	9 days	Wed 01-02-23	Sat 11-02-23		Fullstack Developer 1 Fullstack	Jaydipsinh,Jaydip	Web, Project Team
36	✓	📌	Integration of Google Maps for Javascript	11 days	Mon 13-02-23	Sat 25-02-23		Fullstack Developer 1	Jaydipsinh	Web, Project Team
37	✓	📌	Backend API Generation	11 days	Mon 13-02-23	Sat 25-02-23		Fullstack Developer 2	Jaydip,Jaydipsinh	Web, Project Team
38	✓	📌	Research for Satellite Module	11 days	Mon 13-02-23	Sat 25-02-23		Fullstack Developer 2	Jaydip	Web, Project Team
39	✓	📌	**DL**	**21 days**	**Mon 30-01-23**	**Sat 25-02-23**	**32SS**			
40	✓	📌	Data Cleaning and Manipulation	11 days	Mon 30-01-23	Sat 11-02-23		ML/DL Developer 1	Karan,Kushal	ML/DL, Project Team
41	✓	📌	Preparing Data for Training	11 days	Mon 13-02-23	Sat 25-02-23		ML/DL Developer 1	Karan,Kushal	ML/DL, Project Team
42	✓	📌	Developer Testing/ Resolve Bugs	6 days	Mon 20-02-23	Sat 25-02-23		Fullstack Developer 1	Jaydipsinh,Karan	Web, Project Team,ML/DL
43	✓	📌	First Presentation	1 day	Sat 25-02-23	Sat 25-02-23		Fullstack Develo	Jaydip,Jaydipsinh,Kara	Web, Project Team,M

Fig 2.4 Development Sprint-2 Plan

44	✓	📌	**Development Sprint 3**	**21 days**	**Mon 27-02-23**	**Sat 25-03-23**	**31**			
45	✓	📌	Meeting/Brainstorming	2 days	Mon 27-02-23	Tue 28-02-23				
46	✓	📌	**Web**	**21 days**	**Mon 27-02-23**	**Sat 25-03-23**	**45SS**			
47	✓	📌	Image Investigation Module	11 days	Mon 27-02-23	Sat 11-03-23		Fullstack Developer 1 Fullstack	Jaydipsinh,Jaydip	Web, Project Team
48	✓	📌	Video Investigation Module	6 days	Mon 13-02-23	Sat 18-02-23		Fullstack Developer 1 Fullstack	Jaydipsinh,Jaydip	Web, Project Team
49	✓	📌	Backend of Image and Video Module	6 days	Mon 20-02-23	Sat 25-02-23		Fullstack Developer 1	Jaydipsinh	Web, Project Team
50	✓	📌	Image Processing Model For Satellite Image	26 days	Mon 20-02-23	Sat 25-03-23		Fullstack Developer 2	Jaydip	Web, Project Team
51	✓	📌	**DL**	**21 days**	**Mon 27-02-23**	**Sat 25-03-23**	**45SS**			
52	✓	📌	Training Deep Learning Models	16 days	Mon 27-02-23	Sat 18-03-23		ML/DL Developer 1	Karan,Kushal	ML/DL, Project Team
53	✓	📌	Learn/Research Different DL Models	6 days	Mon 20-02-23	Sat 25-02-23		ML/DL Developer 2	Kushal	ML/DL, Project Team
54	✓	📌	Improve Inference Time	6 days	Mon 20-02-23	Sat 25-02-23		ML/DL Developer 1	Karan	ML/DL, Project Team
55	✓	📌	Developer Testing/ Resolve Bugs	6 days	Mon 20-02-23	Sat 25-02-23		Fullstack Developer 2	Jaydip,Kushal	Web, Project Team,ML/DL

Fig 2.5 Development Sprint-3 Plan

56			**Development Sprint 4**	**24 days**	**Mon 27-03-23**	**Thu 27-04-23**	**44**			
57	✓		Meeting/Brainstorming	2 days	Mon 27-03-23	Tue 28-03-23		Fullstack Develo	Jaydipsinh,Jaydip,Kara	Web, Project Team,M
58	✓		Second Presentation	1 day	Thu 13-04-23	Thu 13-04-23		Fullstack Developer 1	Jaydipsinh,Jaydip,Kara	Web, Project Team,ML/DL
59			**Web**	**24 days**	**Mon 27-03-23**	**Thu 27-04-23**	**57SS**			
60	✓		Satellite Investigation Module	11 days	Mon 27-03-23	Sat 08-04-23		Fullstack Developer 1 Fullstack	Jaydipsinh,Jaydip	Web, Project Team
61	✓		Report Generation Module	6 days	Mon 10-04-23	Sat 15-04-23		Fullstack Developer 1 Fullstack	Jaydipsinh,Jaydip	Web, Project Team
62	✓		Geofencing and coordinates fetching	9 days	Mon 17-04-23	Thu 27-04-23		Fullstack Developer 2	Jaydip	Web, Project Team
63	✓		integrate DL Model with Website	9 days	Mon 17-04-23	Thu 27-04-23		Fullstack Developer 1	Jaydipsinh	Web, Project Team
64			Developer Testing/ Resolve Bugs	9 days	Mon 17-04-23	Thu 27-04-23		Fullstack Developer 2	Jaydip,Jaydipsinh	Web, Project Team
65			**DL**	**24 days**	**Mon 27-03-23**	**Thu 27-04-23**	**57SS**			
66	✓		Hyper-parameter tuning for better inference	16 days	Mon 27-03-23	Sat 15-04-23		ML/DL Developer 1	Karan	ML/DL, Project Team
67	✓		Compare Different DL Models	16 days	Mon 27-03-23	Sat 15-04-23		ML/DL Developer 2	Kushal	ML/DL, Project Team
68			Generate Model Comparision paper	9 days	Mon 17-04-23	Thu 27-04-23		ML/DL Developer 1 ML/DL	Karan,Kushal	ML/DL, Project Team
69			**Documentation**	**9 days**	**Mon 17-04-23**	**Thu 27-04-23**				
70	✓		Report Work Distribution	2 days	Mon 17-04-23	Tue 18-04-23		Project Manager	Jaydipsinh	Management
71			Complete Report Chapters	7 days	Wed 19-04-23	Thu 27-04-23		Fullstack Developer 1	Jaydipsinh,Jaydip,Kara	Web, Project Team,ML/DL
72			**Testing**	**10 days**	**Mon 17-04-23**	**Fri 28-04-23**				

Fig 2.6 Development Sprint-4 Plan

- Gantt Chart

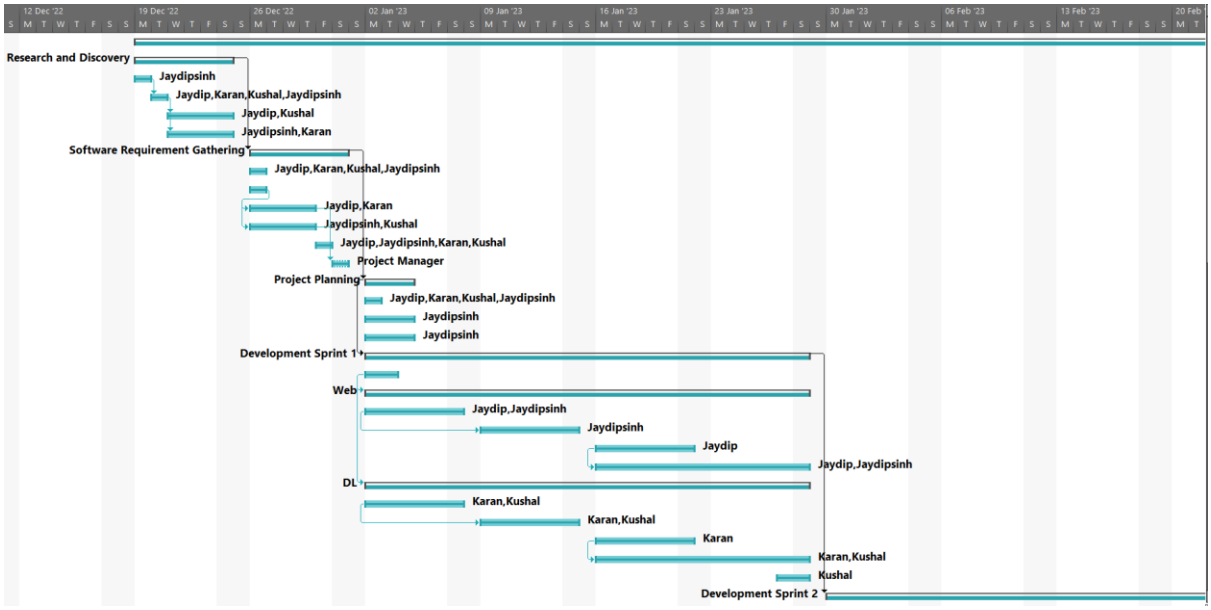


Fig 2.7 Gantt Chart 1

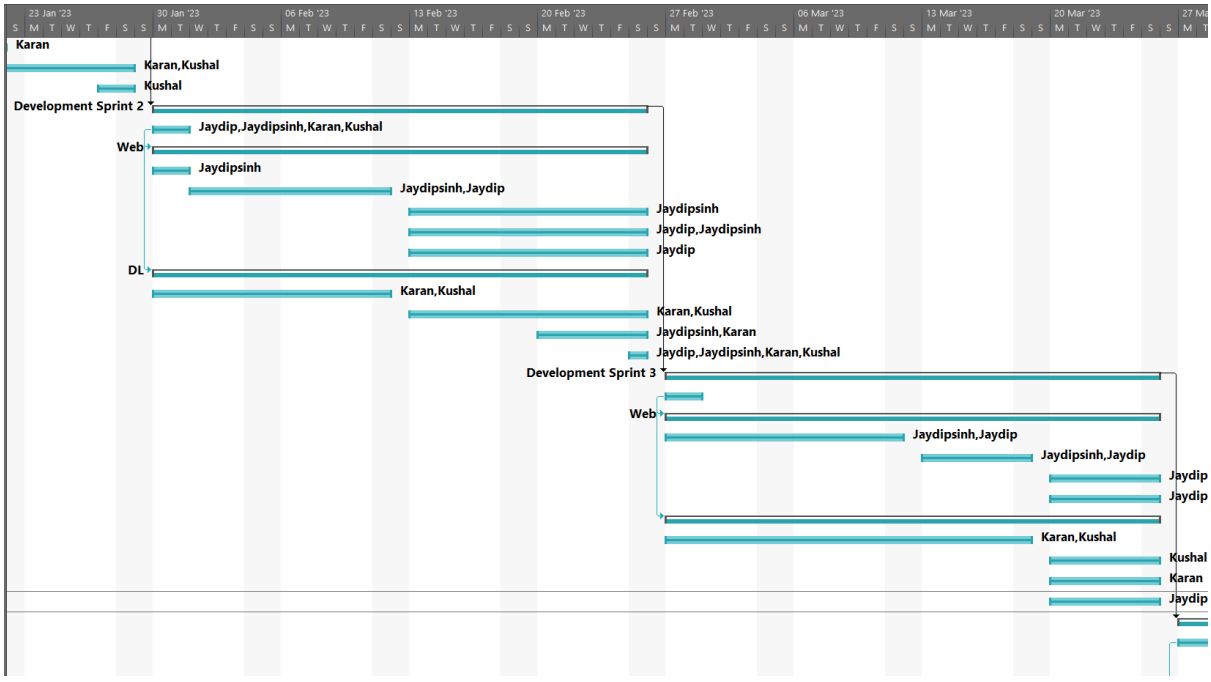


Fig 2.8 Gantt Chart 2

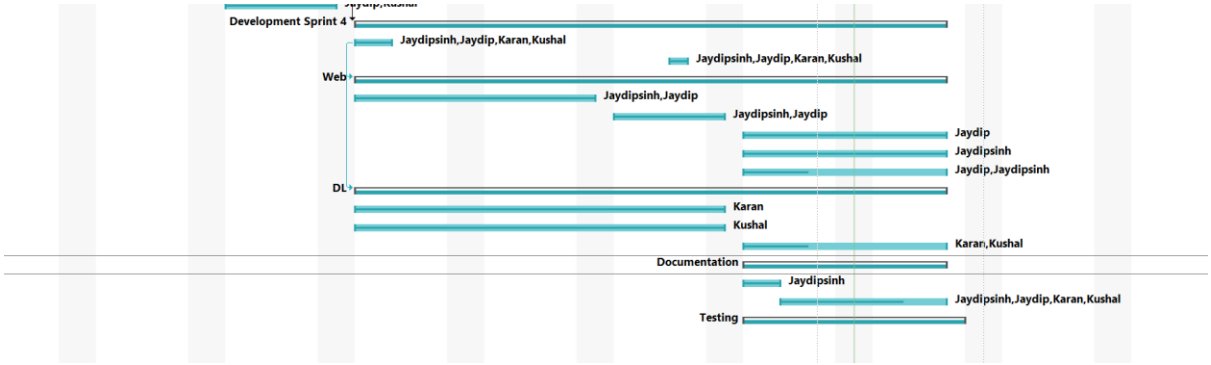


Fig 2.9 Gantt Chart 3

- Network Chart

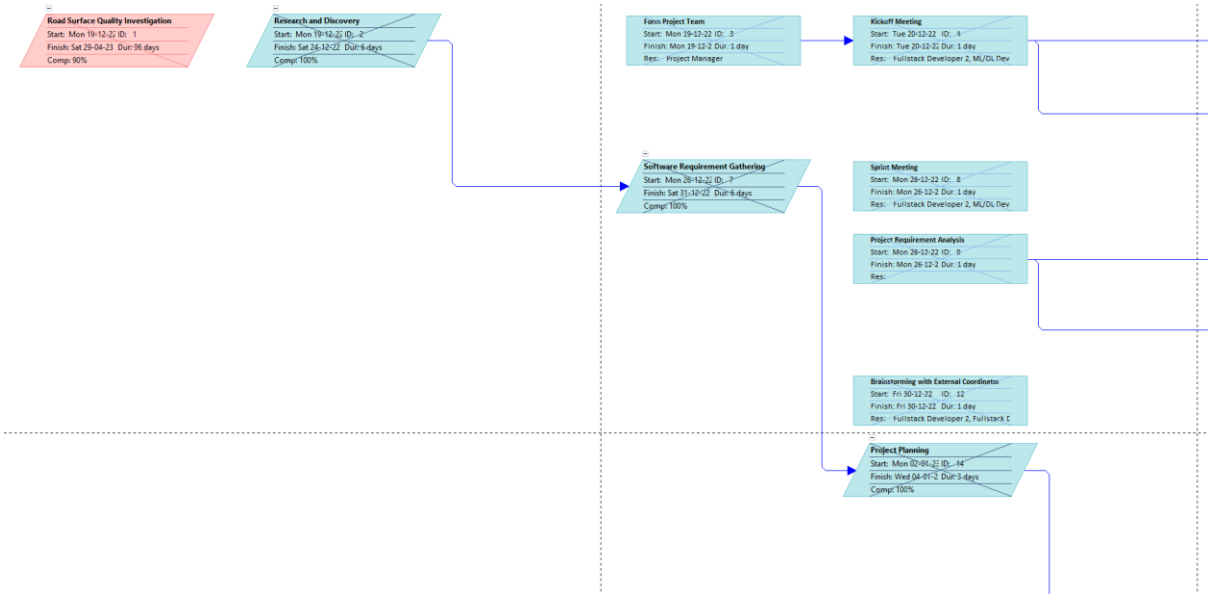


Fig 2.10 Network Chart

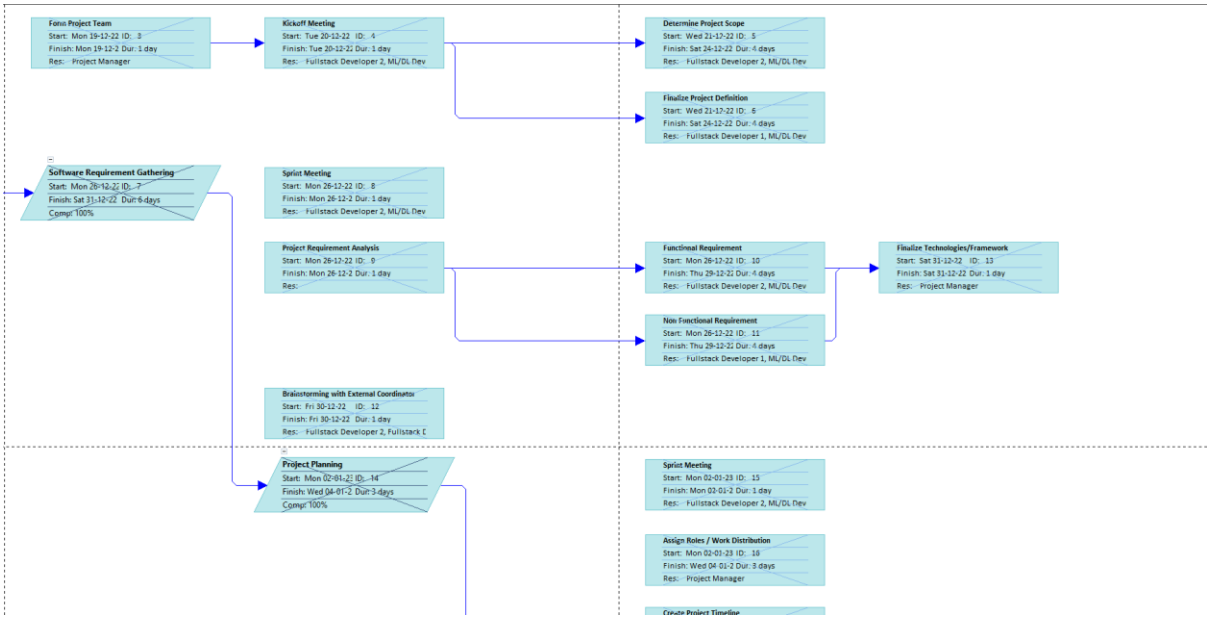


Fig 2.11 Requirement Gathering Network Chart

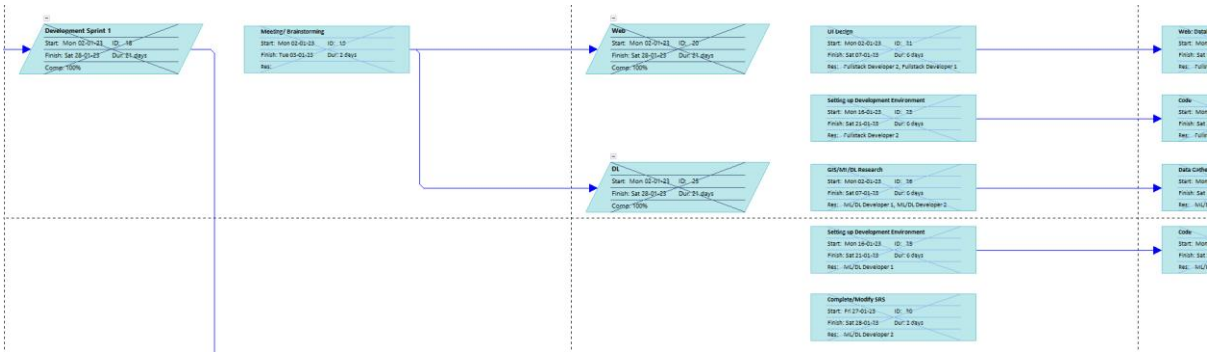


Fig 2.12 Sprint-1 Network Chart

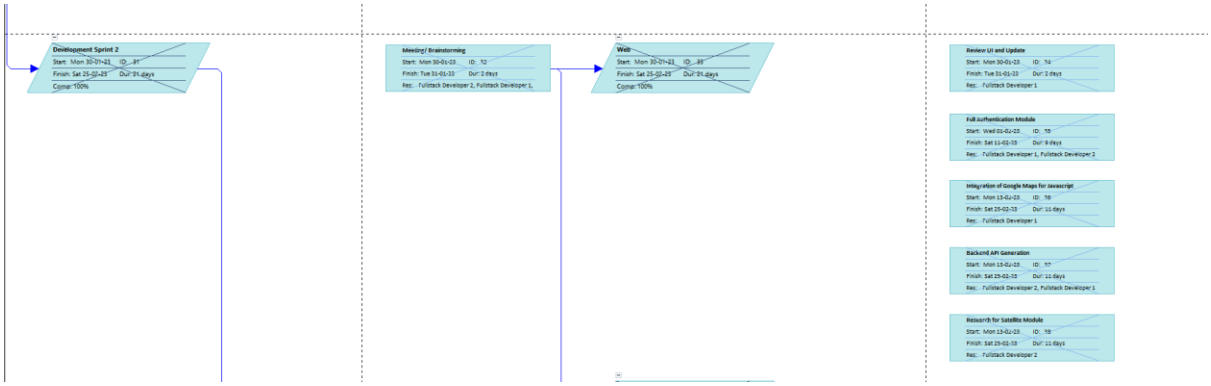


Fig 2.13 Sprint-2 Network Chart

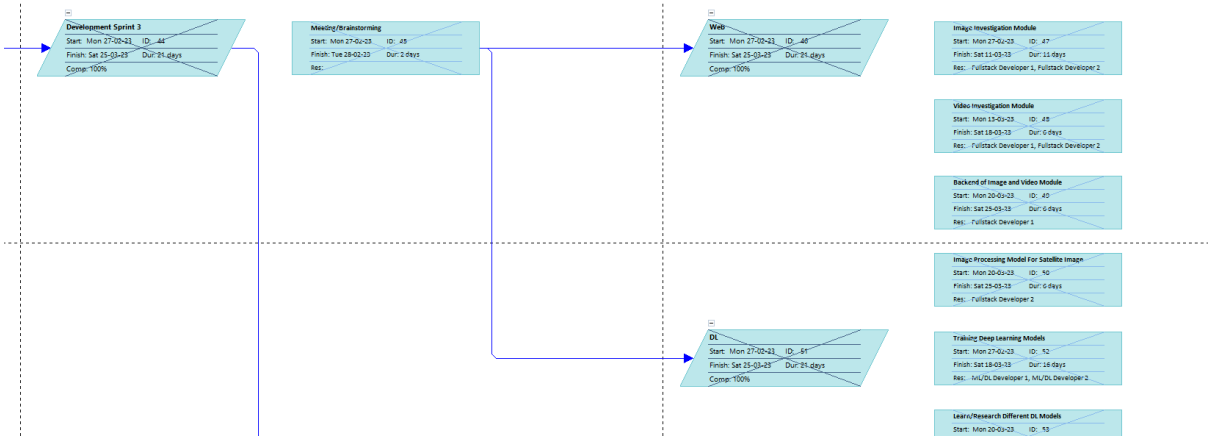


Fig 2.14 Sprint-3 Network Chart

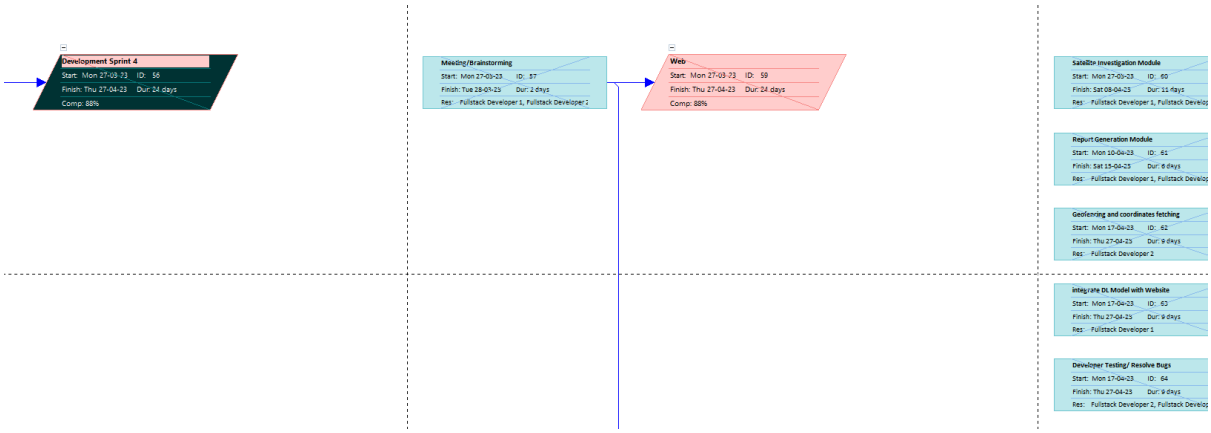


Fig 2.15 Sprint-4 Network Chart

3 SYSTEM REQUIREMENTS STUDY

3.1 USER CHARACTRISTICS

- GIS analysts : Professionals using GIS software and analyzing geospatial data. They will be in charge of gathering, processing, and visualizing the project's road surface data.
- Web developers : Professionals with experience in building web-based applications. They will be in charge of creating the project's web-based model.
- Roadway designers and maintainers: These are experts in the field of transportation engineering. They are in charge of using the information about the road surface to enhance maintenance and safety.
- Stakeholders: These are people or groups who are interested in the examination of the road surface quality. Government representatives, local residents, or advocacy organizations for transportation may be among them.

3.2 HARDWARE & SOFTWARE REQUIREMENTS

3.2.1 Hardware requirements:

- For Windows

  - Microsoft® Windows® 7/8/10 (32- or 64-bit)
  - The Android Emulator only supports 64-bit Windows (learn more).
  - 4 GB RAM minimum, 8 GB RAM recommended
  - 2 GB of available disk space minimum,
  - 4 GB Recommended (500 MB for IDE + 1.5 GB for Android SDK and emulator system image)
  - 1280 x 800 minimum screen resolution

- For Mac OS:

  - Mac® OS X® 10.10 (Yosemite) or higher, up to 10.14 (macOS Mojave)
  - 4 GB RAM minimum, 8 GB RAM recommended
  - 2 GB of available disk space minimum,
  - 4 GB Recommended (500 MB for IDE + 1.5 GB for Android SDK and emulator system image)
  - 1280 x 800 minimum screen resolution

- For Linux OS:

  - GNOME or KDE desktop
  - Tested on Ubuntu® 14.04 LTS, Trusty Tahr (64-bit distribution capable of running 32-bit applications)
  - 64-bit distribution capable of running 32-bit applications
  - GNU C Library (glibc) 2.19 or later
  - 4 GB RAM minimum, 8 GB RAM recommended
  - 2 GB of available disk space minimum,
  - 4 GB Recommended (500 MB for IDE + 1.5 GB for Android SDK and emulator system image)
  - 1280 x 800 minimum screen resolution

3.2.2 Software requirements

- Users should have a browser updated to its latest version such as Google Chrome, Microsoft Edge etc. having latest features.

3.2.3 Network requirements:

- User should have an active internet connection. Also, it needs to be consistent. The Federal Communications Commission (FCC) recommends at least 25 Mbps of download speed, which will allow one to surf the web.

3.3 ASSUMPTIONS & DEPENDENCIES

3.3.1 Assumptions:

- Data about road surfaces are available and can be gathered using the right techniques.
- The project team is equipped with the knowledge and abilities needed to gather, examine, and visualize geographical data.
- It won't be too tough to build and implement the web-based model.
- The gear and software required to operate the web-based model are available to users.
- The project's budget and schedule are adequate for its effective completion.

3.3.2 Dependencies:

- The reliability of the project's findings can be impacted by the quantity and quality of road surface data.
- Accessibility to and use of ArcGIS Online and the web-based model may be impacted by the stability and speed of the internet connection.
- The integration and utilization of hardware and software components might be impacted by their compatibility and interoperability.
- The ability to gather and analyses road surface data and create the web-based model might be impacted by the accessibility and availability of skilled employees.
- The ability to secure money, access data, and guarantee the project satisfies their needs can all be impacted by the participation and involvement of stakeholders.

3.3.3 Other Dependencies:

- Availability of Satellite Imagery
- Availability of Labeled Data
- Reliability of Satellite Imagery
- Web Portal Availability
- User Engagement
- Hardware and Software Dependencies
- Internet Connectivity:

4 SYSTEM ANALYSIS

4.1 STUDY OF CURRENT SYSTEM

- Road cracks are a frequent problem that affects the durability and safety of roadways. Early road crack detection may minimise maintenance costs and avoid accidents. The development of strategies to automate the identification of road cracks using machine learning algorithms has been the subject of recent investigations.

- Convolutional neural networks (CNNs) were put to use in one study by Indian Institute of Technology Madras (IITM) researchers to identify and categorise various kinds of road fractures. With 96.2% accuracy in identifying and categorising cracks, the CNN was trained using a dataset of more than 30,000 photographs of road cracks. Additionally, the researchers created a mobile application that allows road maintenance teams to swiftly find and fix fractures by using the trained CNN to do so in real time.

- Researchers from the University of Tokyo utilised an amalgam of deep learning and image processing methods in a different study to identify road fractures. The precision of the crack detection by the researchers, who employed a dataset of over 7,000 photographs of road fractures, was 94.6%. They have created a device that uses a camera installed on a car to instantly identify flaws. The technology is capable of automatically identifying and categorising various fracture types, including longitudinal, transverse, and alligator cracks.

- Using drones with high-resolution cameras to take aerial pictures of highways is another method for detecting road cracks. This method has the benefit of covering big areas fast and effectively, and it can also take pictures of difficult-to-reach places like bridges and overpasses. Drones were deployed by researchers at the University of Leeds to take pictures of UK roads, and machine learning algorithms were then used

to identify any flaws. With this method, the researchers were able to detect fractures with an accuracy of 98%.

- All in all, these investigations show the promise of automating the identification of road cracks using machine learning and image processing approaches. Early crack detection enables road maintenance teams to locate cracks immediately and fix them, enhancing the durability and safety of roadways. We may anticipate seeing increasingly advanced methods for spotting road cracks that can help avoid accidents and save money on repair expenditures as technology advances.

4.2 PROBLEM & WEAKNESS OF CURRENT SYSTEM

- Despite the advancements in road damage detection systems, there are still several problems and weaknesses that need to be addressed. Some of these include:

  - **Limited accuracy:** Road damage detection systems' accuracy varies, even when using machine learning algorithms and image processing methods. False positives and false negatives are still a possibility, which may lead to missing or pointless remedies.
  - **High cost:** Implementing some of the road damage detecting technology, including LiDAR and GPR, can be costly. This may reduce the accessibility of these systems, especially in low-income areas where funding for road repair may be scarce.
  - **Limited coverage:** Systems for detecting damage on particular kinds of roads, such urban or highway roads, are generally created. Systems that can accommodate a wider range of road types and circumstances are required.
  - **Limited data availability:** For machine learning algorithms to be trained and become more accurate, they need a lot of high-quality data. The effectiveness of these systems may be constrained in some regions due to the lack of data on road conditions.
  - **Maintenance requirements:** Systems for detecting road damage must undergo routine maintenance to keep working correctly. Budgets for road maintenance that are already limited, may incur extra expenses and maintenance requirements.

- **Limited adoption**: Despite the advantages of road damage detecting systems, several regions have yet to widely embrace these technologies. This can be because people are unaware of the advantages, have limited funds, or lack the technical expertise required to set up and oversee these systems.

- Road damage detection systems will need to continue to be researched and developed in order to address these issues and flaws. This might entail improving data gathering efforts, creating more precise and affordable technology, and raising knowledge of the advantages of these systems among decision-makers and organisations responsible for road maintenance.

4.3 REQUIREMENTS OF NEW SYSTEM

- Creating a new and better system to detect road cracks would require careful planning, research, and development. Here are some general requirements to consider:

  - **Data collection:** One would need a large and representative dataset of road crack photos to develop a reliable road damage detecting algorithm. The system will be trained and evaluated using this dataset. To make sure the system is reliable and can detect cracks effectively in diverse circumstances, high-quality photos of road cracks from a variety of roads, climates, and conditions must be collected.
  - **Image processing and analysis:** It would be essential to develop algorithms and methods for processing and analysing images. This can entail extracting information from the gathered photographs using computer vision techniques like feature extraction, image segmentation, and pattern recognition in order to automatically recognise and categorise road cracks. The effectiveness and efficiency of crack detection can be increased by using advanced image processing techniques, such as deep learning algorithms.
  - **Sensor technology:** For precise road damage identification, adequate sensor technologies must be taken into account. Road crack data may be collected using a variety of sensors, including optical cameras, infrared cameras, ground-penetrating radar (GPR), and LiDAR.

- **System integration:** It would be crucial to create a system that can easily connect with current road inspection and maintenance procedures. For data gathering, analysis, and visualisation, this may entail creating a user-friendly interface. It may also entail integrating the system with other databases or systems for reporting and decision-making.
- **Accuracy and reliability:** Road crack detection should be accomplished by the system with high accuracy and dependability. It would be important to validate and verify the system's performance, which involves field testing, benchmarking against other approaches, and ongoing development based on input from experts in road maintenance.
- **Cost-effectiveness:** The cost of installing the device for detecting road cracks should be affordable and justified. It would be vital to take into account aspects like initial setup costs, continuing maintenance expenses, and possible cost savings through better road maintenance practises.
- **Scalability and adaptability:** Scalability and adaptability to various road networks and weather should be highlights of the system. It should be able to process vast volumes of data and be flexible enough to respond to alterations in the lighting, weather, and surface of the road.
- **Legal and ethical considerations:** In order to create a road crack detecting system, compliance with legal and ethical factors, such as data protection, security, and ownership, is required. It is essential to make sure the system complies with all applicable rules and regulations and safeguards the security and privacy of the data gathered.
- **Documentation:** For openness, accountability, and future reference, documentation of the system's development process, methodology, and performance is vital.

4.3.1 Functional Requirements

- **User authentication:** To use the portal's functionality, users should be able to obtain login information from the super user and login successfully.
- **Upload and storage of images and videos**: In order to identify and categorise road damage, users should be able upload pictures and videos of road surfaces.
- **Image and video processing:** Deep learning models that can analyse pictures and videos to find and categorise road damage ought to be included in the site.
- **Localization of road damage:** The portal should be able to identify the location of road damage.
- **Map visualization:** The site ought to provide a map interface that enables visitors to view road maps for various regions.
- **Damage classification:** Based on the provided pictures and videos, the portal should be able to categorise various kinds of road damage, such as potholes, cracks, and bumps.
- **Investigation report generation:** Based on the information gathered from the user-uploaded photos and videos, the portal ought to produce a report on the general condition of a road.
- **Data management:** The site features a database for keeping track of all the photos and videos posted as well as the research papers produced.

4.3.2 Non-functional Requirements

- **Performance:** The web portal is able to handle a large volume of images and videos and can process quickly.
- **Reliability:** There is little to no downtime or faults, and the online portal is always accessible and responsive. The deep learning model is precise and trustworthy as well.
- **Security:** A secure online portal have the necessary safeguards in place to guard user information, prevent unauthorised access, and maintain data privacy.
- **Scalability:** The web portal is built with potential increases in data and user traffic in mind, without compromising dependability or performance.

- **Usability:** The online site is simple to use and navigate, with helpful feedback for users and clear instructions. The user interface is created with accessibility in mind and ought to function well across a range of gadgets and screen sizes.
- **Compatibility:** To maintain a consistent user experience for all users, the online portal is compatible with the latest versions of operating systems, devices, and browsers.

4.4 FEASIBILITY STUDY

4.4.1 Does the system contribute to the overall objectives of the organization?

- As BISAG-N works on satellite related tasks, our projects aligns with the overall objectives of organization.

4.4.2 Can the system be implemented using the current technology and within the given cost and schedule constraints?

- Yes, it can be done with today's technology, but the model's accuracy will suffer. Additionally, costs might differ based on the resources and software used.

4.4.3 Can the system be integrated with other systems which are already in place?

- Yes, it is compatible with the infrastructure of the road department, which enhances the project's usefulness by providing real-time road photos. The few systems that the project can integrate are listed below.
    - **Transportation Management Systems:** To track road conditions and schedule maintenance and repair tasks, the system might be connected with transportation management systems used by governmental organisations or transportation businesses.

- **Fleet Management Systems:** To track the status of their fleets and schedule maintenance tasks depending on traffic circumstances, fleet management systems are utilised by transportation businesses.
- **Traffic Management Systems:** The technology might be connected with traffic management systems used by government organisations to track traffic and schedule work on roads.
- **Navigation Systems:** To offer drivers with real-time information on road conditions and recommend detours to save road damage, the system might be connected with navigation systems.

- The efficiency and efficacy of the present methods might be increased by incorporating the proposed online site for Road Surface Quality Investigation, which could also reap other benefits.

4.5 FEATURE OF NEW SYSTEM

- The proposed web site for Road Surface Quality Investigation has the following features:

  - The system will use a deep learning model to identify and locate various kinds of road damage, such as potholes, cracks, and bumps. For maximum accuracy and dependability, the model will be trained on a sizable collection of road imagery.

  - Users can contribute pictures or videos of road damage to the system, and the deep learning model will analyse them and produce a report on the kind and extent of the damage found.

  - The system has access to satellite imagery of the road infrastructure, which it may use to identify and track road degradation over time.

  - The technology will enable users to quickly and simply identify the location and extent of road damage by providing real-time identification.

- Users have the option of creating investigation reports that include thorough details on the kind and extent of the harm. Prioritising repairs and better resource allocation can be done using this information.

- The system will be equipped with user management features that let administrators control user accounts.

- To guarantee information security and integrity, the system will securely store all data.

4.6 LIST MODULES OF NEW SYSTEM

- User Interface: The component in charge of offering a dynamic and intuitive user interface so that users can access the system.
- User Management: The component in charge of authenticating and granting users access to the system.
- Data Ingestion: The component in charge of gathering and processing information from a variety of sources, such as satellite imagery and user-uploaded pictures and videos.
- Preprocessing: The module in charge of cleaning, converting, and normalising the input data for the Deep Learning module.
- Deep Learning: The component in charge of developing and forecasting road damage using cutting-edge deep learning models.
- Report Generation: This module is in charge of producing thorough investigation reports using the data the system has gathered and examined.
- Real-time Identification: The Deep Learning module, along with user-uploaded pictures and videos, is used to identify road damage in real-time.

5 SYSTEM DESIGN

5.1 SYSTEM ARCHITECTURE DESIGN

5.1.1 Activity Diagram

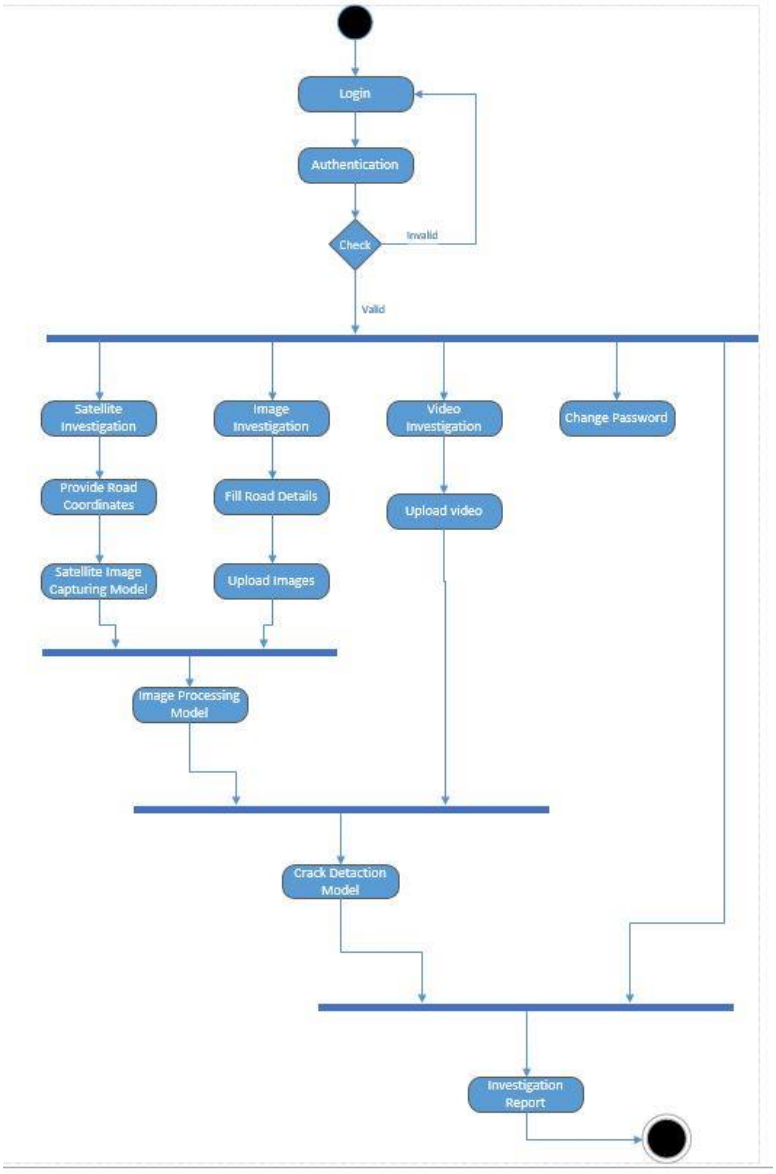


Fig 5.1 Activity Diagram

5.1.2 Context Diagram

Fig 5.2 Context Diagram

5.1.3 Data Flow Diagram

- Level-1

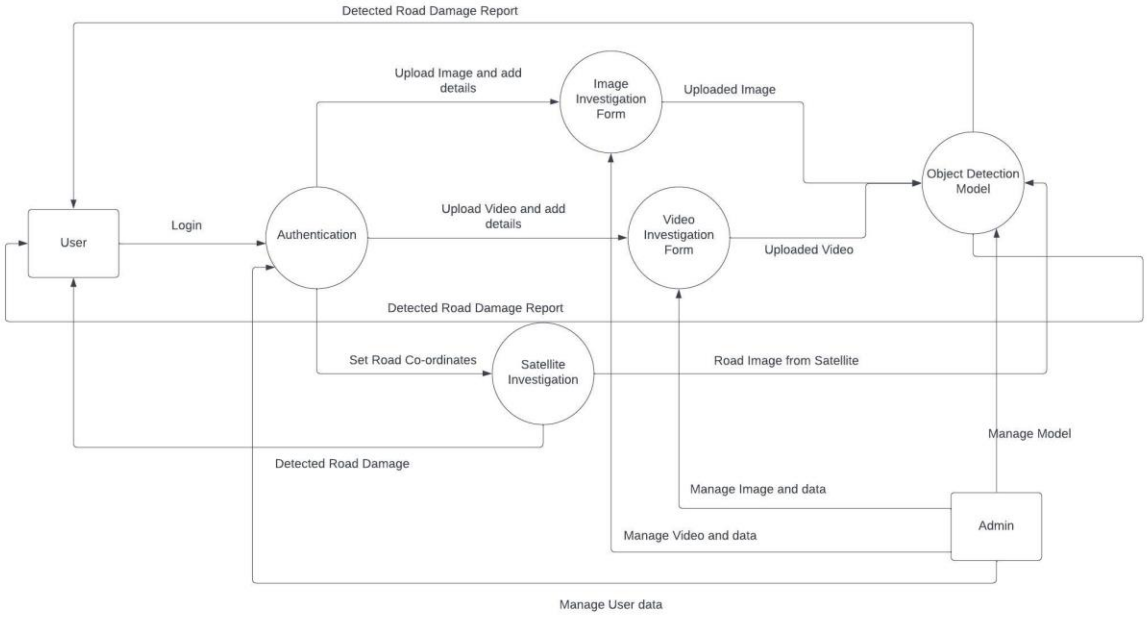


Fig 5.3 DFD Level-1

- Level-2

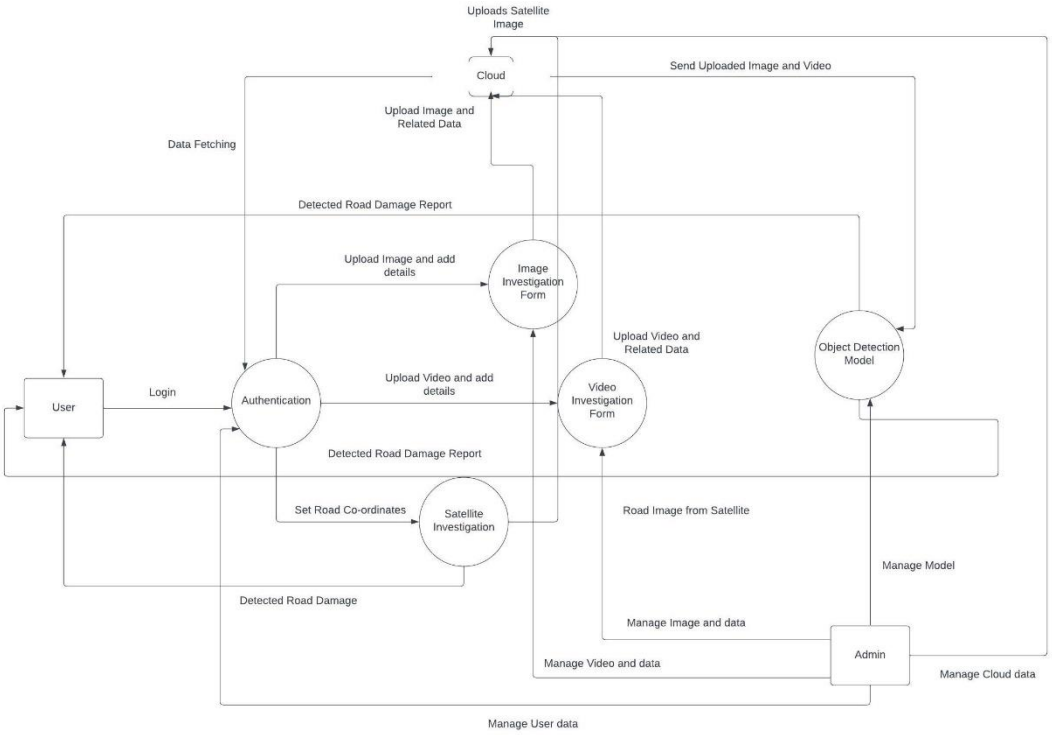


Fig 5.4 DFD Level-2

5.1.4 Structural Diagram

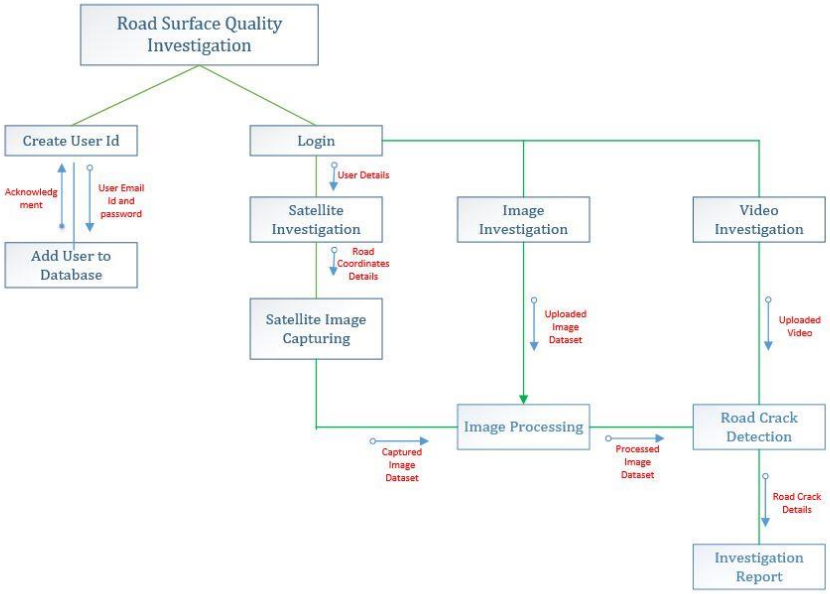


Fig 5.5 Structural Diagram

5.2 DATABASE DESIGN

5.2.1 ER Diagram

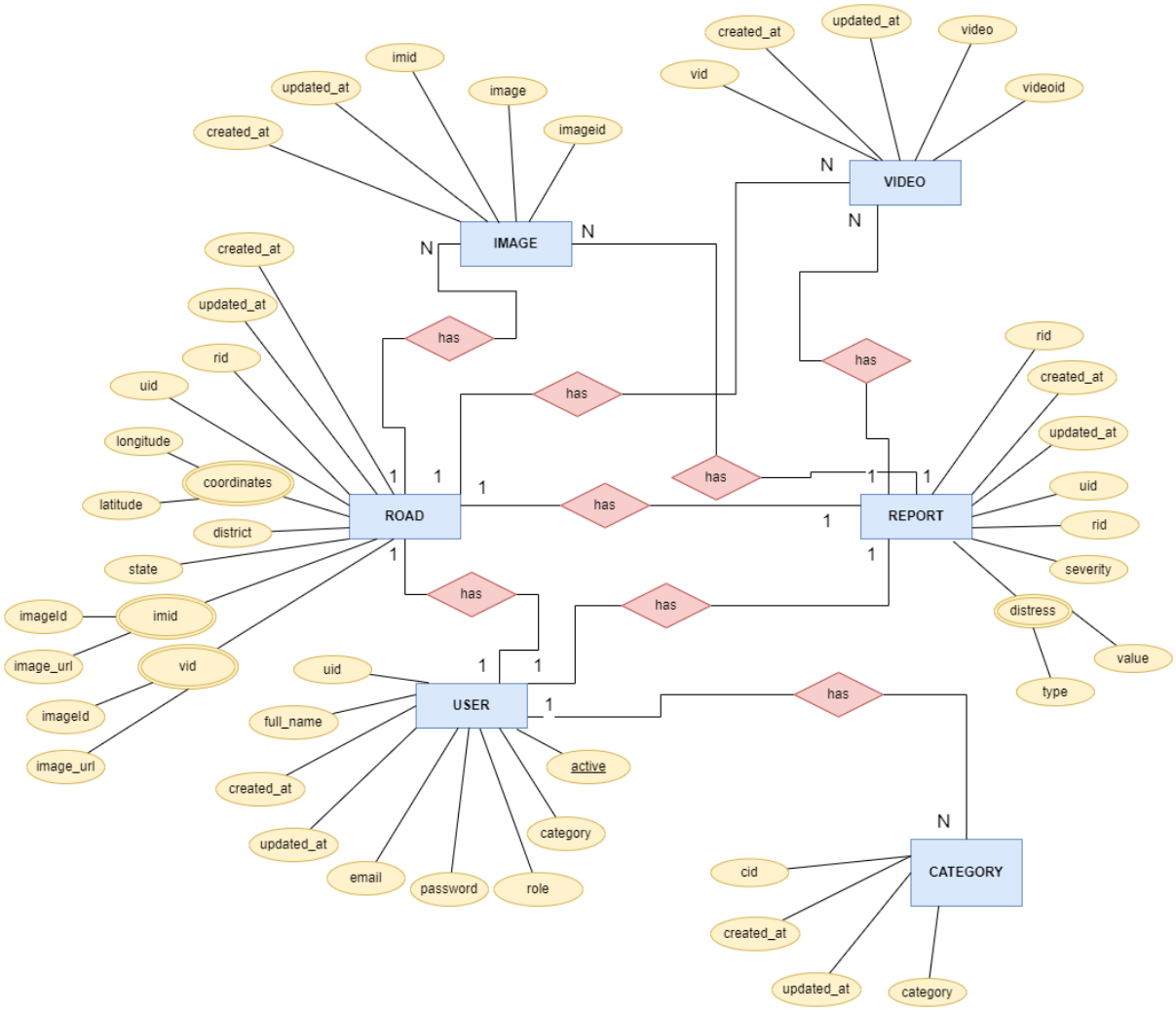


Fig 5.6 E-R Diagram

5.2.2 Data Dictionary

Table 5.1 User Data Table

Table name	Column Name	Type of Column	Other Info	Description
tblUser	Id	Object	Primary Key	Unique ID
	CreatedAt	Date	-	Date of creation
	UpdatedAt	Date	-	Date of last updated
	FullName	Varchar(100)	-	Name of the user
	Email	Varchar(255)	-	Registered email of user
	Password	String	-	Hashed password of the user
	Role	Boolean	-	Indicates whether account is admin (1) or simple user (0)
	Category	Object	Foreign Key	Unique ID of the category of the user
	Active	Boolean	-	Indicates whether account is active(1) or not (0)

Table 5.2 Category Data Table

Table name	Column Name	Type of Column	Other Info	Description
tblCategory	Id	Object	Primary Key	Unique ID
	CreatedAt	Date	-	Date of creation
	UpdatedAt	Date	-	Date of last updated
	Category	String	-	Category of the user

Table 5.3 Road Data Table

Table name	Column Name	Type of Column	Other Info	Description
tblRoad	Id	Object	Primary Key	Unique ID
	CreatedAt	Date	-	Date of creation
	UpdatedAt	Date	-	Date of last updated
	User	Object	Foreign Key	Unique ID of the user
	Name	Varchar(255)	-	Road's name or Nearby area name
	Coordinates	Object	-	Road's starting Longitude and Latitude values
	District	String	-	District name
	State	String	-	State name
	SampleImages	Object	Foreign Key	List of URLs of road sample images uploaded in cloudinary

	SampleVideo	Object	Foreign Key	List of URLs of road video uploaded in cloudinary

Table 5.4 Report Data Table

Table name	Column Name	Type of Column	Other Info	Description
tblReport	Id	Object	Primary Key	Unique ID
	CreatedAt	Date	-	Date of creation
	UpdatedAt	Date	-	Date of last updated
	User	Object	Foreign Key	Unique ID of the user
	Road	Object	Foreign Key	Unique ID of the road
	Distress	Object	-	Result of DL model which includes distress info.
	Severity	Enum	-	Road Damage Severity between Low, Medium, High

Table 5.5 Image Data Table

Table name	Column Name	Type of Column	Other Info	Description
tblImage	Id	Object	Primary Key	Unique ID
	CreatedAt	Date	-	Date of creation
	UpdatedAt	Date	-	Date of last updated
	User	Object	Foreign Key	Unique ID of the user
	Image	String	-	Uploaded Image’s URL in cloudinary
	ImageId	String	-	Image ID of uploaded image in cloudinary

Table 5.6 Video Data Table

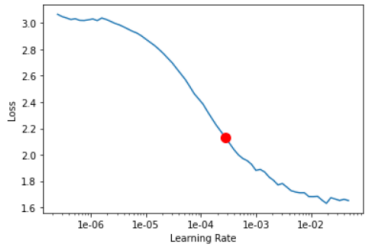
Table name	Column Name	Type of Column	Other Info	Description
tblVideo	Id	Object	Primary Key	Unique ID
	CreatedAt	Date	-	Date of creation
	UpdatedAt	Date	-	Date of last updated
	User	Object	Foreign Key	Unique ID of the user
	Video	String	-	Uploaded Video's URL in cloudinary
	VideoId	String	-	Video ID of uploaded Video in cloudinary

5.3 SNAPSHOTS

- Model Training
  - Algorithm: FasterRCNN, backbone: resnet101, epoch: 16

1. Another deep learning method used for object detection tasks, faster R-CNN (Region-based Convolutional Neural Network). A region proposal network (RPN) creates candidate object areas in the first step, which are subsequently improved upon and categorised in the second stage.
2. It is slower than SSD but provides better precision.
3. With the various backbones its mean average precision lies from 35% to 40%.
4. Following snapshot shows mean average precision to be 40%

```
In [20]: f_rcnn = arcgis.learn.FasterRCNN(data, backbone='resnet101')
In [21]: lr_f_rcnn = f_rcnn.lr_find(allow_plot=True)
```




```
In [22]: lr_f_rcnn
Out[22]: 0.0002754228703338166
In [23]: f_rcnn.fit(epochs=16, lr=lr_f_rcnn)
```

epoch	train_loss	valid_loss	average_precision	time
0	0.727198	0.498104	0.000000	03:27
1	0.393045	0.324830	0.131469	03:23
2	0.369195	0.358443	0.207054	03:24
3	0.377717	0.362132	0.262408	03:24
4	0.360871	0.371217	0.275049	03:24
5	0.348986	0.355165	0.313189	03:24
6	0.343075	0.379866	0.298712	03:25
7	0.330671	0.345722	0.326905	03:25
8	0.333126	0.333473	0.335712	03:26
9	0.316367	0.372183	0.329775	03:24
10	0.329123	0.340509	0.380475	03:24
11	0.312281	0.341510	0.369657	03:25
12	0.297411	0.336613	0.389799	03:24
13	0.302078	0.340506	0.381640	03:25
14	0.317442	0.338479	0.400570	03:25
15	0.280941	0.338274	0.401823	03:24

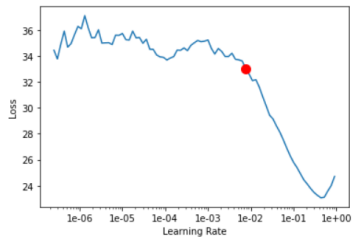
```
Created model files at D:\Work\BISAG\less_data\models\checkpoint_2023-04-05_17-40-22_epoch_0
Created model files at D:\Work\BISAG\less_data\models\checkpoint_2023-04-05_17-40-22_epoch_1
Created model files at D:\Work\BISAG\less_data\models\checkpoint_2023-04-05_17-40-22_epoch_1
```

Fig 5.7 Model With FasterRCNN Backbone

- Algorithm: Single Shot Detector (SSD), backbone: vgg16, epoch: 15

1. SSD can be used to identify and categorise road surface flaws, such as cracks or potholes, from high-resolution photographs of roads
2. Performs well on small objects.
3. However, it works well on large dataset but as we manipulated the dataset average precision lies between 3% to 6% on different backbones.
4. Following snapshot shows mean average precision to be 3%

```
In [16]: ssd = arcgis.learn.SingleShotDetector(data, backbone='vgg16',focal_loss=True)
In [17]: lr_ssd = ssd.lr_find(allow_plot=True)
```




```
In [18]: lr_ssd
Out[18]: 0.007585775750291836
In [19]: ssd.fit(epochs=15, lr=lr_ssd, early_stopping=True)
```

86.67% [13/15 18:47<02:53]

epoch	train_loss	valid_loss	average_precision	time
0	6.424531	3.279926	0.009469	01:27
1	2.416784	2.687859	0.017133	01:27
2	2.257239	2.868044	0.019872	01:25
3	2.279001	2.830596	0.013514	01:25
4	1.965959	2.270790	0.010079	01:24
5	1.736120	2.256324	0.038668	01:25
6	1.649121	13.646482	0.008888	01:25
7	1.546287	1.947929	0.036745	01:24
8	1.482832	173.147064	0.017207	01:25
9	1.389126	1789.587036	0.024468	01:26
10	1.382982	6082.510254	0.029161	01:28
11	1.323432	4674.886719	0.044715	01:29
12	1.304787	10585.598633	0.030874	01:30

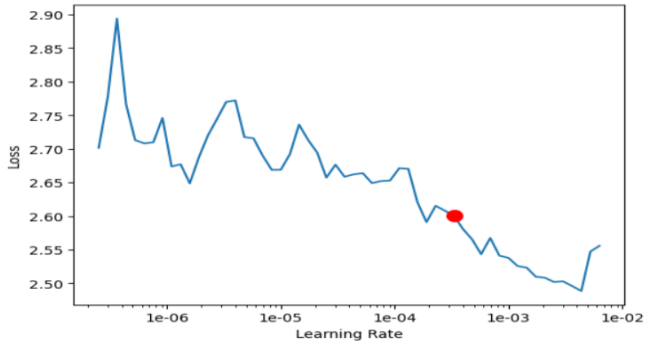
100.00% [19/19 00:06<00:00]

Fig 5.8 Model With SSD Backbone

- Algorithm: RetinaNet, backbone: vgg16, epoch: 15

1. RetinaNet resolves the class imbalance problem by providing a unique focus loss function that provides greater weight to difficult-to-detect objects which is a major problem in FasterRCNN.
2. RetinaNet works on One-Stage architecture.
3. It provides better mean average precision compared to SSD or FasterRCNN.
4. Following snapshot shows mean average precision to be 20%.

```
In [24]: retina = arcgis.learn.RetinaNet(data, backbone='timm:vgg16')
In [25]: lr_retina = retina.lr_find(allow_plot=True)
```




```
In [26]: lr_retina
Out[26]: 0.00033113112148259 11
In [27]: retina.fit(epochs=15, lr=lr_retina)
```

epoch	train_loss	valid_loss	average_precision	time
0	2.015223	2.426202	0.000000	01:26
1	1.476614	1.780295	0.036151	01:25
2	1.311044	1.504837	0.096881	01:24
3	1.262900	1.545929	0.161661	01:24
4	1.181202	1.525109	0.133685	01:24
5	1.068107	1.572743	0.070047	01:23
6	1.043384	1.672731	0.137061	01:24
7	0.914216	1.397924	0.178367	01:24
8	0.893072	1.327501	0.199308	01:24
9	0.788239	1.322499	0.203231	01:24
10	0.773610	1.420798	0.184336	01:24
11	0.656487	1.443125	0.186129	01:24
12	0.634210	1.462073	0.207555	01:24
13	0.603275	1.421915	0.190536	01:24
14	0.589020	1.418288	0.195008	01:25

Fig 5.9 Model With RetinaNet Backbone

- Types of Distress

  - D00: Liner, crack, longitudinal, wheel mark part
  - D01: Liner crack, longitudinal, construction joint part
  - D10: Liner crack, lateral, equal interval
  - D11: Liner crack, lateral, construction, joint part
  - D20: Alligator crack
  - D40: Rutting, bump, pothole, separation
  - D43: White line blur
  - D44: Cross walk blur

- Image and Video Prediction

  - Image Prediction: This is the snapshot of how image prediction is done using trained model it gives a tuple as output which includes coordinates of this bounded box, Distress type and Distress value.

Fig 5.10 Image Prediction

  - Video Prediction: This is the snapshot of output of trained model done on the input video. Which will be further stored and used for reporting purpose.

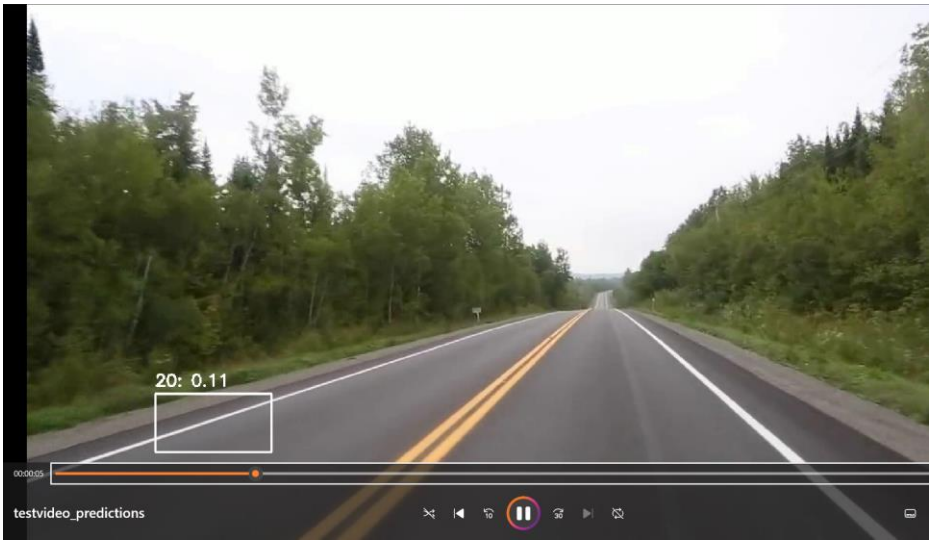


Fig 5.11 Video Prediction

- Web-portal

  - Login: This is the login page where user as well as admin can login. If it is a user it will be direct

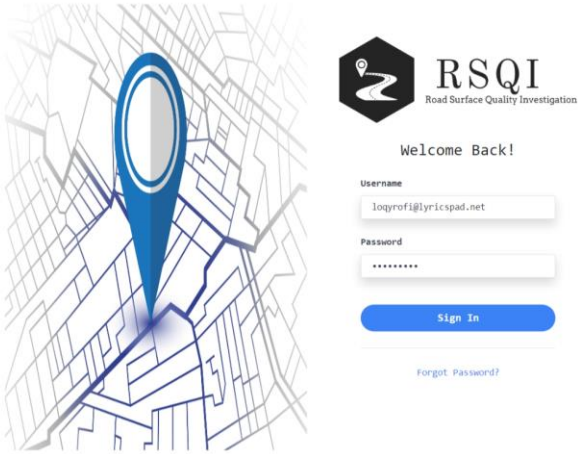


Fig 5.12 Website Login Page

- Admin Dashboard: If user is admin then it will redirect to admin dashboard which can mange the user details, add new user , remove user and show all user.

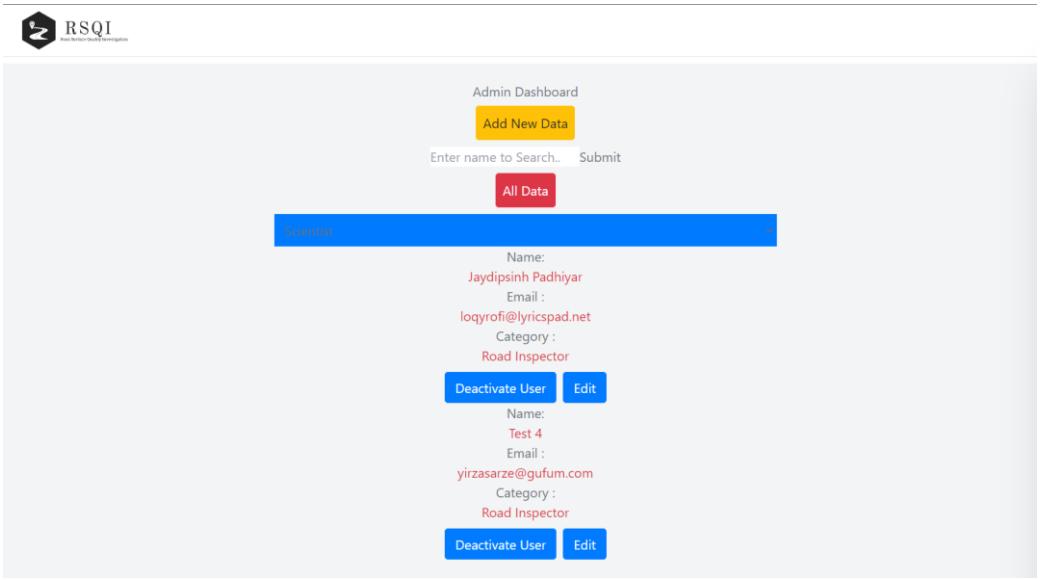
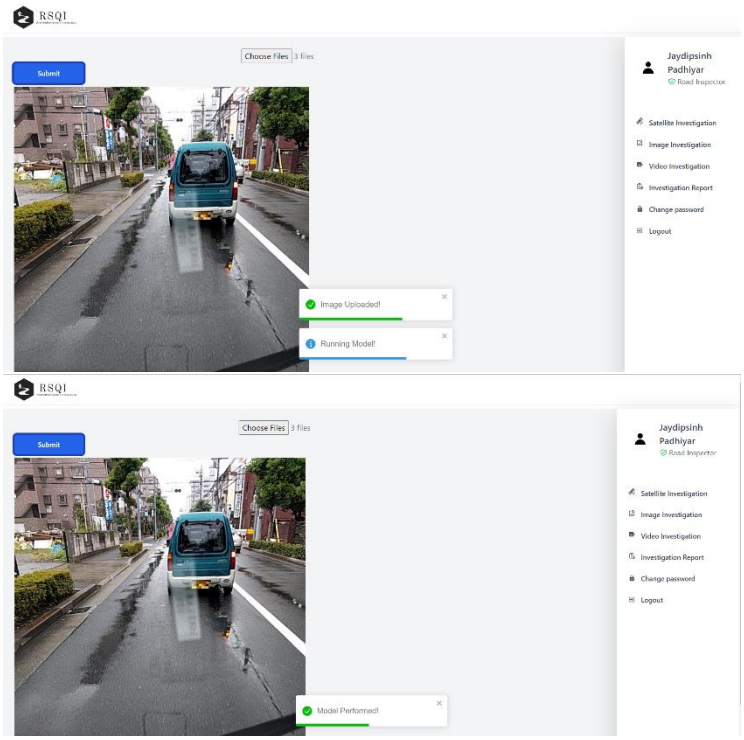


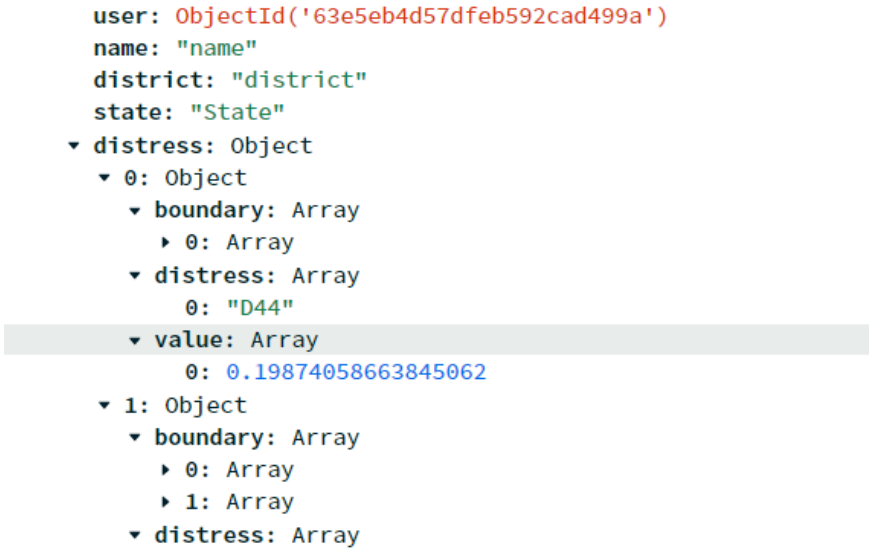
Fig 5.13 Admin Dashboard

- Satellite Investigation : This is the snapshot of Satellite investigation tab where user has to give starting and ending coordinates of a road. Now the road images will be automatically captured and further fed to Image Processing Model which will remove the unnecessary objects from image and will further fed to Trained model which identifies the distress.

Fig 5.14 Website Satellite Investigation

- Image Investigation: Image investigation tab is the site where website asks for the image inputs and will be stored in cloud and then fed to Trained model in the backend and as shown in the figure the model output will be stored in MongoDB.





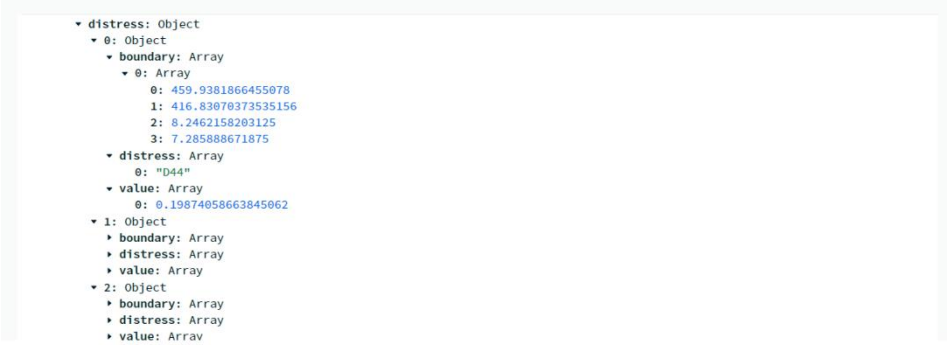


Fig 5.15 Website Image Investigation

- Video Investigation: Video Investigation tab asks user to input the video and it will further fed to trained model in backend which will generate processed video as shown further in figure 5.11

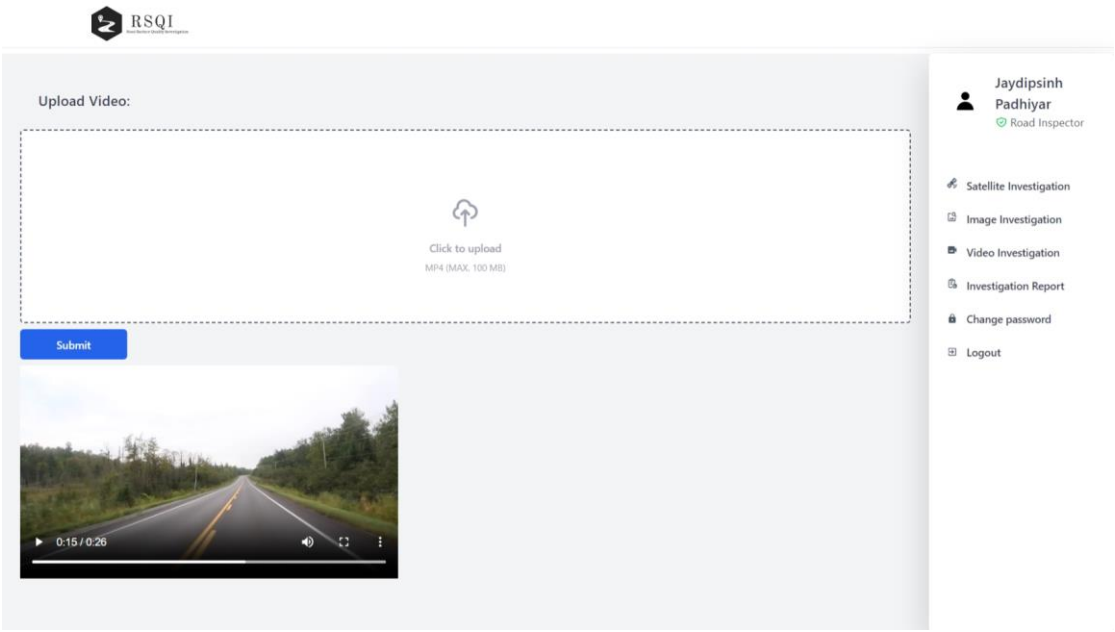


Fig 5.16 Website Video Investigation

- Database and Cloud

  - MongoDB: This snapshot shows database details where user, road sample image, road video and model output for the road is stored.

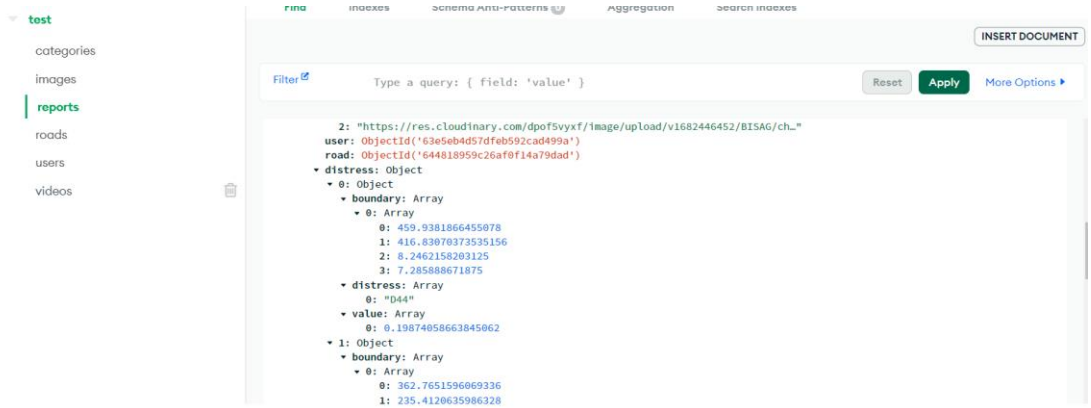


Fig 5.17 MongoDB Database

- Cloudinary: This snapshot shows the how the image and video from the Image Investigation and Video Investigation is stored for further usage and cloudinary gives back the URL details which is stored in MongoDB.

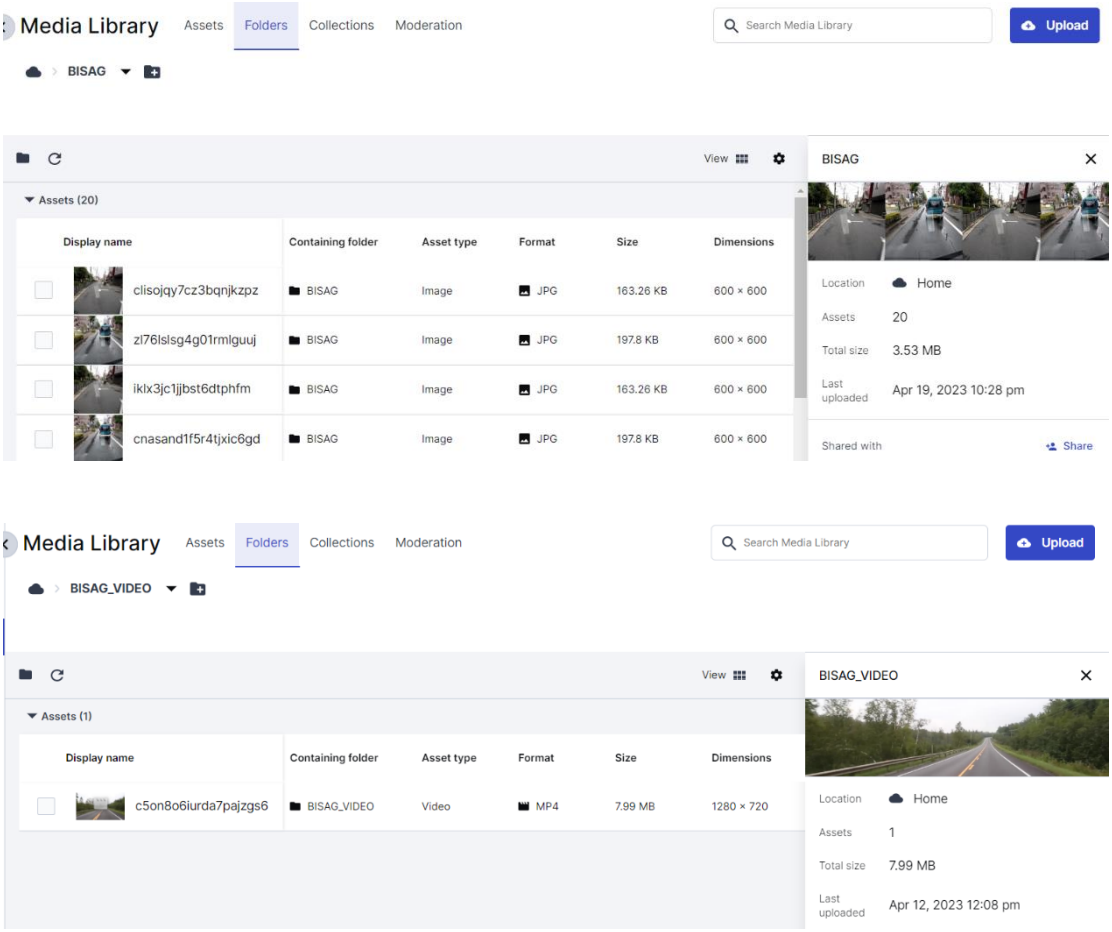


Fig 5.18 Cloudinary Media Storage

6 IMPLEMENTATION PLANNING

6.1 IMPLEMENTATION ENVIRONMENT

6.1.1 Hardware Requirements

- Processor (Core i5 or i7)
- Memory (RAM – 16 gb or more)
- Hard Disk Space (250 gb or more)
- Graphic Card (12 gb or more)
- Internet Connection

6.1.2 Software Requirements

- ArcGIS Desktop or ArcGIS Server
- HTML,CSS, Node.js environment
- Python and DL environment
- Google Cloud (Maps For JavaScript API)
- MongoDB Atlas
- Cloudinary (Media Storage)
- Windows OS

- **Scalability and resilience:** This section should provide details on the scalability and resilience of the application, including information on load balancing, failover mechanisms, and disaster recovery procedures. It should also include information on any monitoring or logging tools used to detect and diagnose application issues.
- **Single User or Multi user:** This web-application is currently multi user system, where more than one user can use and access the features provided parallelly.
- **GUI or Non-GUI:** Road Surface quality investigation has a full-fledged GUI which is simpler and convenient to use by any type of user.

6.2 SECURITY FEATURES

- Login Authentication: Super user or administrator of Road Surface Quality Investigation will provide unique credentials to the user who wants to access the web-application's features. Furthermore, the credentials will be stored in a MongoDB database which can only be accessed by super user in case of any dire needs.
- Cloud Service: Any image or video uploaded by user in any of the modules (image, video or satellite investigation) will be stored directly in a cloud service named Cloudinary. This data will only be visible to the administrator or cloud handler of the development team. In addition to this, the report generated by the user will not be saved in any of the database or cloud as it will be generated on the spot and user will be the sole owner of it.

6.3 CODING STANDARDS

- Following has been taken into account while working on python:

  - Used comments wherever required.
  - Followed PEP 8 style guide which states general guidelines for code layout, naming conventions. For example, using 4 spaces for indentation, limit lines to 79 characters, and use spaces around operators and after commas.
  - Used Markdown cells for better documentation and readability and makes the code more understandable.
  - Kept the cells concise i.e., each code cell is focused on a single task or purpose. This makes it easier to debug the code.
  - Provided validating inputs.
  - Included necessary imports which makes it easy to understand dependencies used in the code.

- Similarly, following has been taken into account while working on web module:

  - Used meaningful variable and function names that clearly convey the purpose and content of variables and functions.
  - Followed JavaScript coding conventions such as using camelCase for variables and functions, PascalCase for class and constructor names, and UPPER_CASE for constants.
  - Used meaningful comments wherever required to explain complex logic and to make code more understandable.
  - Use const and let at appropriate location to provide better scoping and error detection.
  - Modularized the code or broke the code into smaller, reusable function to maintain consistency and to enhance readability.
  - Handled errors gracefully by using try-catch blocks to handle errors and exception wherever required.
  - Provided proper indentation using extensions such as Prettier which beautifies the code and makes it more readable.

7 TESTING

7.1 TESTING PLAN

- This test plan's scope includes testing the system's operation, performance, security, usability, compatibility, and dependability.
- The Agile development technique is being used for this project. Agile sprints entail taking cyclic steps. 1) Plan, 2) Design, 3) Develop, 4) Test, and 5) Release.
- We performed Development Testing for each incremental job or module during each phase.

✓	📌	**Development Sprint 2**	**21 days**	**Mon 30-01-23**	**Sat 25-02-23**	**18**		
✓	📌	Meeting/ Brainstorming	2 days	Mon 30-01-23	Tue 31-01-23		Fullstack D	Jaydip,Jaydipsinh,Kara
✓	📌	**Web**	**21 days**	**Mon 30-01-23**	**Sat 25-02-23**	**32SS**		
✓	📌	**DL**	**21 days**	**Mon 30-01-23**	**Sat 25-02-23**	**32SS**		
✓	📌	Developer Testing/ Resolve Bugs	6 days	Mon 20-02-23	Sat 25-02-23		Fullstack Developer	Jaydipsinh,Karan
✓	📌	First Presentation	1 day	Sat 25-02-23	Sat 25-02-23		Fullstack D	Jaydip,Jaydipsinh,Kara
✓	📌	**Development Sprint 3**	**21 days**	**Mon 27-02-23**	**Sat 25-03-23**	**31**		
✓	📌	Meeting/Brainstorming	2 days	Mon 27-02-23	Tue 28-02-23			
✓	📌	**Web**	**21 days**	**Mon 27-02-23**	**Sat 25-03-23**	**45SS**		
✓	📌	**DL**	**21 days**	**Mon 27-02-23**	**Sat 25-03-23**	**45SS**		
✓	📌	Developer Testing/ Resolve Bug	6 days	Mon 20-03-23	Sat 25-03-23		Fullstack D	Jaydip,Kushal

Fig 7.1 Development Testing Plan

- Then, prior to integrating all of the modules, we did unit testing on the produced modules using test suites and API testing on the APIs.
- We did Integration Testing after doing unit testing and merging the modules.

	📌	**Testing**	**10 days**	**Mon 17-04-23**	**Fri 28-04-23**			
	📌	**Unit Testing**	**10 days**	**Mon 17-04-23**	**Fri 28-04-23**			
	📌	Test according to Test Suites	3 days	Mon 17-04-23	Wed 19-04-23		Fullstack D	Jaydip,Kushal
	📌	Modify Code / Resolve Bugs	3 days	Thu 20-04-23	Mon 24-04-23		Fullstack D	Jaydipsinh,Karan
	📌	Re-test Modified Code	4 days	Tue 25-04-23	Fri 28-04-23		Fullstack D	Jaydip,Kushal
	📌	**Integration Testing**	**10 days**	**Mon 17-04-23**	**Fri 28-04-23**			
	📌	Test Module Integration	3 days	Mon 17-04-23	Wed 19-04-23		Fullstack D	Jaydipsinh,Karan
	📌	Modify Code / Resolve Bugs	3 days	Thu 20-04-23	Mon 24-04-23		Fullstack D	Jaydip,Kushal
	📌	Re-test modified code	4 days	Tue 25-04-23	Fri 28-04-23		Fullstack D	Jaydipsinh,Karan

Fig 7.2 Testing Plan

7.2 TESTING STRATEGY

- Due to usage of Agile development methodology each sprint involves testing and the project modules were divided into small iteratives and each iterative had development level testing.

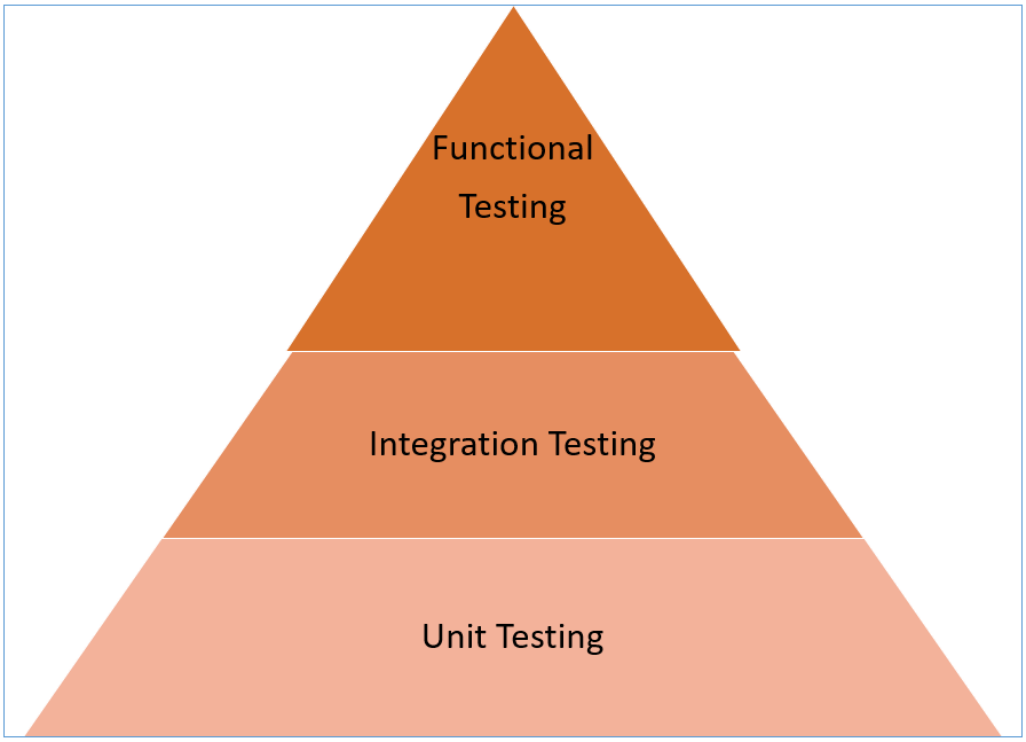


Fig 7.3 Testing Strategy

- Unit Testing : Because the project is divided into smaller modules, testing each individual unit is required, which is why unit testing was utilized to test distinct functional units.

- Integration Testing : Integrating all of the individual components is a major undertaking. While testing of this integrated large functional module is required to guarantee that the project runs effectively in all scenarios. After combining all of the components, we ran integration testing to ensure maximum realism.

7.3 TEST SUITES DESIGN

7.3.1 Test Cases

Table 7.1 Test Case L11

Test Scenario ID	Login-1	**Test Case ID**	L11
Test Case Description	User Login – Positive test case	**Test Priority**	High
Pre-Requisite	A valid user account	**Post-Requisite**	NA

Table 7.2 Test Case L11 Result

No.	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Result (Pass/ Fail)**
1	Launch application	Website site	Website Homepage	Website Homepage	Pass
2	Enter correct Email	Email id: test@test.com	-	-	-
3	Enter correct Password	Password: ********	-	-	-
4	Click Login	Click Login Button	User Dashboard	User Dashboard	Pass

Table 7.3 Test Case L12

Test Scenario ID	Login-1	**Test Case ID**	L12
Test Case Description	User Login – Negativ test case	**Test Priority**	High
Pre-Requisite	-	**Post-Requisite**	-

Table 7.4 Test Case L12 Result

No.	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Result (Pass/ Fail)**
1	Launch application	Website site	Website Homepage	Website Homepage	Pass
2	Enter incorrect Email	Email id: random@test.com	-	-	-
3	Enter incorrect Password	Password: ***	-	-	-
4	Click Login	Click Login Button	Authentication Error	Authentication Error	Pass

Table 7.5 Test Case L13

Test Scenario ID	Login-1	**Test Case ID**	L13
Test Case Description	Admin Login – Positive test case	**Test Priority**	High
Pre-Requisite	A valid admin account	**Post-Requisite**	NA

Table 7.6 Test Case L13 Result

No.	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Result (Pass/ Fail)**
1	Launch application	Website site	Website Homepage	Website Homepage	Pass
2	Enter correct Email	Email id: test@test.com	-	-	-
3	Enter correct Password	Password: ********	-	-	-
4	Click Login	Click Login Button	Admin Dashboard	User Dashboard	Fail

Table 7.7 Test Case L21

Test Scenario ID	Login-2	**Test Case ID**	L21
Test Case Description	Admin Login – Positive test case	**Test Priority**	High
Pre-Requisite	A valid admin account	**Post-Requisite**	NA

Table 7.8 Test Case L21 Result

No.	Action	Inputs	Expected Output	Actual Output	Test Result (Pass/ Fail)
1	Launch application	Website site	Website Homepage	Website Homepage	Pass
2	Enter correct Email	Email id: test@test.com	-	-	-
3	Enter correct Password	Password: ********	-	-	-
4	Click Login	Click Login Button	Admin Dashboard	Admin Dashboard	Pass

Table 7.9 Test Case L22

Test Scenario ID	Login-2	Test Case ID	L22
Test Case Description	Admin Login – Negative test case	Test Priority	High
Pre-Requisite	-	Post-Requisite	-

Table 7.10 Test Case L22 Result

No.	Action	Inputs	Expected Output	Actual Output	Test Result (Pass/ Fail)
1	Launch application	Website site	Website Homepage	Website Homepage	Pass
2	Enter correct Email	Email id: test@test.com	-	-	-
3	Enter correct	Password:	-	-	-

	Password	********			
4	Click Login	Click Login Button	Authentication Error	Authentication Error	Pass

Table 7.11 Test Case S11

Test Scenario ID	Satellite investigation -1	**Test Case ID**	S11
Test Case Description	Generate all coordinates that lies between start and end point of the road.	**Test Priority**	High
Pre-Requisite	User should be logged in and User should have selected start and end point of the road in the map	**Post-Requisite**	Generated Image dataset should give to the Image Processing Model.

Table 7.12 Test Case S11 Result

No.	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Result (Pass/ Fail)**
1	Open Satellite Investigation tab	Click on Satellite Investigation tab	Satellite Investigation page loaded	Satellite Investigation page loaded	Pass
2	Enter Star point	Start point latitude and	-	-	-

	Latitude and longitude	longitude			
3	Enter end point Latitude and longitude	End point latitude and longitude	-	-	-
4	Click Start	Click Start Button	Give a list of all the coordinate that lies in between the road	It Gives a list of all the coordinate that lies in between the road	Pass

Table 7.13 Test Case S21

Test Scenario ID	Satellite investigation -2	**Test Case ID**	S21
Test Case Description	Generate Satellite image dataset	**Test Priority**	High
Pre-Requisite	User should be logged in and User should have selected start and end point of the road in the map	**Post-Requisite**	Generated Image dataset should give to the Image Processing Model.

Table 7.14 Test Case S21 Result

No.	Action	Inputs	Expected Output	Actual Output	Test Result (Pass/ Fail)
1	Open Satellite Investigation tab	Click on Satellite Investigation tab	Satellite Investigation page loaded	Satellite Investigation page loaded	Pass
2	Enter Star point Latitude and longitude	Start point latitude and longitude	-	-	-
3	Enter end point Latitude and longitude	End point latitude and longitude	-	-	-
4	Click Start	Click Start Button	Gives the road image dataset at every 500 meter using coordinates that are lies in between the road points	Generates the road image dataset at every 500 meter of road.	Pass

Table 7.15 Test Case I11

Test Scenario ID	Image investigation - 1	**Test Case ID**	I11
Test Case Description	Upload Road Data with sample Images.	**Test Priority**	High
Pre-Requisite	User should be logged in and User should have Image dataset of road.	**Post-Requisite**	Deep learning Model should start to work

Table 7.16 Test Case I11 Result

No.	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Result (Pass/ Fail)**
1	Open Image Investigation tab	Click on Image Investigation tab	Image Investigation page loaded	Image Investigation page loaded	Pass
2	Enter road Details	Fill up all the required fields of form	Road Details given input as Investigation report	Investigation report takes input of road details	pass
2	Click on Start	Select Image Dataset from the local system	Image dataset is store and it generate notification of model running	It generates notification of model running.	Pass

Table 7.17 Test Case I12

Test Scenario ID	Image investigation - 1	**Test Case ID**	I12
Test Case Description	Upload Road Data with sample Images.	**Test Priority**	High
Pre-Requisite	User should be logged in and User should have Image dataset of road.	**Post-Requisite**	Deep learning Model should start to work

Table 7.18 Test Case I12 Result

No.	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Result (Pass/ Fail)**
1	Open Image Investigation tab	Click on Image Investigation tab	Image Investigation page loaded	Image Investigation page loaded	Pass
2	Enter road Details	Fill up all the required fields of form	Road Details given input as Investigation report	Investigation report takes input of road details	pass
2	Click on Start	Select Image Dataset that has more then 25 images from the local system	Image dataset is store and it generate notification of model running	Images not Uploaded.	Fail

Table 7.19 Test Case V11

Test Scenario ID	Video investigation - 1	**Test Case ID**	V11
Test Case Description	Upload video that is capturing the road.	**Test Priority**	High
Pre-Requisite	User should be logged in and User should have video of road.	**Post-Requisite**	Deep learning Model should start to work

Table 7.20 Test Case V11 Result

No.	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Result (Pass/ Fail)**
1	Open Video Investigation tab	Click on Video Investigation tab	Video Investigation page loaded	Video Investigation page loaded	Pass
2	Click on Start	Select video the capturing the road from the local system	Video is store and it generate notification of model running	It generates notification of model running.	Pass

Table 7.21 Test Case P11

Test Scenario ID	Image Processing - 1	**Test Case ID**	P11
Test Case Description	Enhancing Image pixels	**Test Priority**	High
Pre-Requisite	User should be logged in and input image is given to the image processing model	**Post-Requisite**	-

Table 7.22 Test Case P11 Result

No.	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Result (Pass/ Fail)**
1	Open Satellite Investigation tab	Enter start and end coordinates of road	-	-	-
2	Open Image Investigation tab	Select Image Dataset from the local system	-	-	-
3	Start Image Processing	Select Image based on user provided data	Image should be enhanced in terms of Gray level of pixels	Enhanced image is generated	Pass

Table 7.23 Test Case P21

Test Scenario ID	Image Processing - 2	**Test Case ID**	P21
Test Case Description	Road extracted from image	**Test Priority**	High
Pre-Requisite	User should be logged in and input image is given to the image processing model	**Post-Requisite**	Deep learning Model should start to work

Table 7.24 Test Case P21 Result

No.	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Result (Pass/ Fail)**
1	Open Satellite Investigation tab	Enter start and end coordinates of road	-	-	-
2	Open Image Investigation tab	Select Image Dataset from the local system	-	-	-
3	Start Image Processing	Select Image based on user provided data	Road edges should be detecting and extracted road image should give.	Extracted road image is given.	Pass

Table 7.25 Test Case R11

Test Scenario ID	Investigation report - 1	**Test Case ID**	R11
Test Case Description	Generation of Investigation report	**Test Priority**	High
Pre-Requisite	User should be logged in and input image is given to the image processing model	**Post-Requisite**	-

Table 7.26 Test Case R11 Result

No.	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Result (Pass/ Fail)**
1	Open Investigation report tab	Click on Investigation report tab	It should generate a report that contain road damage data	Report is generated with predicated data	Pass

Table 7.27 Test Case R12

Test Scenario ID	Investigation report - 1	**Test Case ID**	R12
Test Case Description	Generation of Investigation report	**Test Priority**	High
Pre-Requisite	User should be logged in and input image is given to the image processing model	**Post-Requisite**	-

Table 7.28 Test Case R12 Result

No.	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Result (Pass/ Fail)**
1	Open Investigation report tab	Click on Investigation report tab	It should generate a report that contain road damage data	Report is generated with half data not all the data.	Fail

8 CONCLUSION AND DISCUSSION

8.1 SELF ANALYSIS Of PROJECT VIABILITIES

- **Technical Feasibility:** One of the major software used in this project is ArcGIS API for Python.
  - Its capabilities are:
    1. Ease with ArcGIS's functions: The API allows developers to perform detection, segmentation, classification tasks etc. Furthermore, it provides easy implementation of these functions.
    2. Integration with ArcGIS Platform: Developers may use the whole functionality of the ArcGIS platform within their Python workflows thanks to the API's seamless interface with other ArcGIS platform elements including ArcGIS Online, ArcGIS Enterprise, and ArcGIS Desktop which can help expand one's project.
    3. Pytorch as base: The API is built over PyTorch which makes use of PyTorch's functionalities and also, has its own functions to work with.
    4. Deep Learning Module Availability: ArcGIS has hosted their deep learning modules installer on GitHub which installs all the necessary modules and dependencies required to perform model training.

  - Limitations of ArcGIS:

    1. Learning Curve: Geospatial data and GIS concepts are necessary for using the ArcGIS API for Python. There may be a learning curve for developers who are unfamiliar with GIS principles to comprehend the API and its functionality.
    2. Licensing and Data Access: To access specific ArcGIS services and data, you must have a working ArcGIS account and the necessary licencing. Some advanced functions and data may need additional licencing or permissions in order to be accessed.
    3. Platform Dependency: In order to function with the ArcGIS platform, the ArcGIS API for Python is dependent on ArcGIS services and data. It might not

be appropriate for developers searching for an open-source or platform-independent solution for their geospatial development requirements.

4. Performance: The performance of some geoprocessing and analysis tasks may be constrained by elements like the size and complexity of the data being processed, the performance of the underlying ArcGIS services, and the available system resources, even though the ArcGIS API for Python offers a wide range of geospatial capabilities.

- **Data Availability and Accuracy:** With the help of image, video and satellite imagery, data required for model to provide accurate prediction can grow overtime. It also depends on the quality of road image available. This model uses images from Japan's roads as Indian roads are blurry compared to other countries' images.

- **Market Demand and Potential Users:** In India, transport and traversal depends mainly on road. So, maintenance is crucial. This project can be extremely useful for road agencies (Government or private), maintenance contractors and so.

- **Financial Feasibility:** Currently the project has ben made with zero costs. However, for expansion of this project some finance will be required for using ArcGIS, Google cloud API's etc. for better integration and services.

- **Organizational Capabilities:** The co-ordination among the developers is exceptional as it has helped solve many unexpected errors. Developers have their domain's knowledge which has helped undertake integration seamlessly.

- **User Experience and Interface Design:** The visual appeal of the web-portal is easy to use and do provide user satisfaction. Furthermore, interface has been made with keeping in mind about the ease of access.

8.2 PROBLEM ENCOUNTERED & POSSIBLE SOLUTIONS

Table 8.1 Problems Encountered & Possible Solutions

Sr. No	Problem Encountered	Possible Solution
1.	Resource Constraint	With better resource capabilities, better precision scores can be achieved.
2.	Pay-to-use/trial software	Software which are free to use or open source can be used.
3.	Code Optimization	Code optimization in Image processing can be achieved using numpy vectorization and other modules may require multithreading.
4.	Uniformity in size of images	Sizes of images can be made uniform using export_training_function provided by ArcGIS.
5.	Deep learning Dependencies	Deep learning Dependencies can be downloaded by visiting ArcGIS Github page.
6.	Windows-focused software	ArcGIS enterprise edition provides server for linux which can be integrated with instance.
7.	Loading model into web	As deep learning model is implemented using python, writing backend in python may help.

8.3 SUMMARY OF PROJECT

- We knew that the project is comprised of deep learning and web development. So, the team was divided into 2 groups. One focuses on deep learning and another on web development.

- **Model Training:** Dataset was collected from ESRI website. The images in the dataset were then made uniform (size of images in dataset was made uniform). After this, algorithms such as SSD, FasterRCNN and RetinaNet were used to train the model with the specified dataset.

- **Image processing:** Roads were extracted from satellite imagery using concepts of image processing such as image thresholding and hoghline transformation. This also removed noise and interference, providing better picture.

- **Satellite Imagery:** By providing latitude and longitude of road, images from road can be captured. Images after every 500m are captured for further detection.

- **Model Integration with web:** Django was primarily used for model integration as it goes hand-to-hand because of python.

- **Cloud and database services:** MongoDB is used for storing user credentials and Cloudinary is used for storing images and videos for investigation. The generated report is stored in Cloudinary after user has uploaded image or video for detection, which is fetched afterwards.

- Overall, we have adopted agile methodology for software development. Also, decent amount of work has been done by the team members in given time limit.

9 LIMITATION & FUTURE ENHANCEMENT

9.1 LIMITATION

- Resource Constraints: As the project includes the utilization of a deep learning model, it is essential that the employed model should provide results with better precision. Due to the constraint, our model does provide results but with a reduced precision.
- Server Capability: The software used for the deep learning purpose (ArcGIS) has its own server named ArcGIS Server, compatible with Linux. Furthermore, server being costly, we could not provide server capability.
- Google Cloud API: Web-portal for RSQI uses API from Google cloud extending the functionality. However, it providing only a few free API's, it adds up being a disadvantage.
- Dependency on ArcGIS: This project utilizes a lot of functionalities from ArcGIS. It is efficient and easy to use ArcGIS. On the contrary, ArcGIS has its own ecosystem which makes it more difficult to use 3rd party or open-source dependencies and have to use it under ArcGIS only.
- ArcGIS API for python, which is used for model training, is built over PyTorch framework adding PyTorch's and its own functionality. But, some essential functions like to class imbalance and fetching accuracy, recall and related scores is not possible as it is calculated every epoch but in background.
- Scalablity: Cloudinary is the cloud service, this project has employed to store images and videos of road damage. Also, as the project gets expanded premium services has to be used offered by cloudinary.
- Similarly, MongoDB is also one of the services this project uses. It provides a free cluster for the initial utilization and, as the project gets expanded, pay-per-use services has to be adopted.
- Response Time: RSQI provides video and image investigation for detection road surface. However, detection from videos is taking too long to run (resource constraint) also, if multiple images have to be updated, web-portal may feel laggy at times.

9.2 FUTURE ENHANCEMENT

- Increase in the precision of the model: Due to resource constraints encountered on creation of object. Training the model on a PC having better specs may help in providing better results.
- Response Time: Response time can be significantly reduced when deep diving into certain domains however, currently, detection from videos takes ample amount of time to run (resource constraint) also, if multiple images have to be updated, web-portal
- Indian roads satellite availability: Images from Indian satellite providing images from Indian roads may be included as currently the dataset uses images from Japan roads due to restriction from Indian Government.
- Fixing minor and major bugs: Encountering bugs is a continuous problem any software uses. So, it is imperative that with overtime website will have only minor bugs.
- Enhancement of visual appeal: Overtime, we aim to improve our frontend for easy navigation for laymen users who want to use the web-portal.
- Upgrading satellite images: Currently, with the help of image processing we extract straight roads from satellite imagery by removing and reducing noise and interference and in the future, we hope to extract curved roads too.

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