IMAGE SIMULATION AND VISUALIZATION

INTERNSHIP PROJECT REPORT

Submitted by

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In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY in

Computer Science and Engineering

Parul Institute of Engineering and Technology, Limbda

VADODARA February - 2025

**Parul Institute of Engineering & Technology Internship Report**

**Parul University, Limbda February-2025**

Date: 12/11/2024

**To,**

**Indian Space Research Organisation Ahmedabad**

Subject: NOC of the selected student for the internship

Dear Sir / Madam,

This is to inform that **Enrollment No 210303124014,Harshalkumar Sunilkumar Patel** from division **8B3** from our institute is allowed to join the internship from date **09-12-2024** up to **12-04-2025**. This student can join your organisation on full time basis but at the same time, he/she will be required to appear for all Weekly Tests, Mid-Sem Exams, External Semester Exams, vivas, submission and practical exams and must perform satisfactorily in order to become eligible to get degree certificate.

We would request you to kindly consider the same and approve leaves accordingly as per the exam schedule as & when gets finalised.

**Yours Faithfully,**

**Dr.Sanjay Agal**

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Declaration

We here by declare that the Project report submitted along with the Project entitled Image simulation and

Visualization submitted in partial fulfillment for the degree of Bachelor of Engineering in Computer Science

Engineering to Parul University, Vadodara, is a bonafide record of original project work carried out by me

at Indian Space Research Organisation under the supervision of Krishna Raulji and that no part of this

report has been directly copied from any students’ reports or taken from any other source, without providing

due reference.

Harshalkumar Sunilkumar Patel

Name of the Student Sign of Student

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CERTIFICATE

This is to certify that the project report submitted along with the project entitled Image simulation and Visualization has been carried out by Harshalkumar Sunilkumar Patel under my guidance in partial fulfillment for the degree of Bachelor of Engineering in Computer Science and Engineering, 8th Semester of Parul University, Vadodara during the AY 2024-25.

Krishna Raulji,

Project Guide

Dr. Sanjay Agal,

Head of Department,

AI and AIDS, PIET,

Parul University.

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I am also immensely grateful to my institute mentor, Ms. Krishna Rauji, for her unwavering support, valuable feedback, and constructive suggestions throughout the project. her mentorship played a crucial role in refining my approach and ensuring the project’s successful completion.

Lastly, I would like to thank my colleagues, peers, and everyone who supported and motivated me throughout this journey. This project would not have been possible without their constant encouragement and collaboration.

Harshalkumar SunilKumar Patel AI and AIDS, PIET

Parul University, Vadodara

Abstract

The Image Simulation and Visualization project aims to assist in designing and evaluating satellite imaging systems by simulating how a camera would capture images in a lunar environment. By allowing users to define various camera parameters such as position, altitude, roll, yaw, pitch, and lens settings, this system generates simulated images that closely represent the expected results from actual lunar missions.

The project is developed using PyQt5 and Qt Designer for the graphical user interface, while NumPy, PyQtGraph, and GDAL handle image processing and spatial data operations. The iterative waterfall model is followed to ensure systematic development and refinement based on feedback at each stage.

This system plays a crucial role in optimizing camera settings before deployment on lunar satellites, reducing experimental costs and improving mission accuracy. The feasibility and effectiveness of the simulation ensure that future moon exploration missions can be planned with greater precision and confidence.

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1 OVERVIEW OF THE COMPANY

1.1 HISTORY OF SAC ISRO

Figure 1.1: SPACE APPLICATION CENTER ISRO

The Space Applications Centre (SAC), located in Ahmedabad, is a premier unit of the Indian Space

Research Organisation (ISRO), established in 1973. SAC plays a pivotal role in the development of

space-based applications and technologies for communication, broadcasting, meteorology, Earth

observation, and satellite payloads.

SAC is involved in designing and developing payloads and space systems for Indian satellites,

contributing to various national and international missions.

SAC’s primary focus has been on developing payloads that enable the delivery of services like

telecommunication, television, remote sensing, meteorology, and satellite navigation.

SAC’s efforts have been integral to the success of ISRO’s commercial and scientific satellite

programs.

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1.2 SCOPE OF WORK

SAC is responsible for the design and development of advanced payloads, satellite communication

systems, and other critical components used in Earth observation and communication satellites. The

major products and scope of work include:

• Satellite Payloads – Development of sensors, transponders, and communication equipment.

• Spacecraft Bus Systems – Design and development of the satellite structure, thermal

management, and power systems.

• Ground Systems – Establishment of ground stations and communication infrastructure.

• Earth Observation Systems – Development of systems like remote sensing payloads for

applications in agriculture, forestry, and disaster management.

• Satellite Launch and Mission Support – Assisting in mission planning and execution for

satellite launches and operation of payloads.

1.3 ORGANIZATION STRUCTURE

The organization structure of SAC ISRO consists of multiple divisions and departments focusing on

different aspects of space research, design, and development. The key departments include:

• Payload Design and Development

• Communication Payload Systems

• Spacecraft Integration and Testing

• Ground Segment Operations

• Satellite Data Processing

• Applications Development

A detailed organization chart will display the hierarchical structure from the Director down to

the specialized teams responsible for various tasks in the development, integration, and testing of

space systems.

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1.4 CAPACITY OF PLANT

SAC is equipped with state-of-the-art facilities that cater to the design, integration, and testing of

satellite payloads and communication systems. These facilities include:

• Clean Room Facilities – SAC’s clean rooms ensure a contamination-free environment for

sensitive satellite payload assembly.

• Antenna Testing and Simulation Lab – Used for the testing and simulation of communication

systems and payloads.

• Satellite Payload Integration Facility – Where satellite payloads are integrated, tested, and

validated.

• Thermal and Vibration Testing – Specialized testing facilities that simulate space conditions

like temperature extremes and vibration during launch.

• High-Performance Computing Systems – Support the simulation, data analysis, and image

processing for mission planning and satellite operation.

Capacity: SAC can handle the development and integration of multiple satellites simultaneously,

supporting both Indian and international missions.

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2 OPERATIONAL DETAILS

2.1 OVERVIEW OF DIFFERENT UNITS AND DEPARTMENTS

SAC ISRO is divided into various specialized departments that focus on the research, design,

development, testing, and integration of space systems. The key departments involved in the

development of satellite payloads and communication systems are:

2.1.1 Payload Design and Development

Scope: This department is responsible for designing the payloads used in communication satellites,

remote sensing satellites, and other space applications.

Work Carried Out:

• Design and development of payload systems like communication transponders, sensor

payloads, and optical instruments for Earth observation.

• Development of payload integration strategies and testing procedures.

2.1.2 Satellite Systems Integration and Testing

Scope: Focuses on integrating various subsystems of satellites (payloads, bus systems, etc.) and

ensuring they function as a cohesive unit.

Work Carried Out:

• Integration of communication systems, electrical power systems, thermal management

systems, and payload systems.

• Conducting rigorous testing (thermal, vibration, EMI, etc.) to ensure that the satellite meets

the performance standards required for space missions.

2.1.3 Earth Observation and Remote Sensing

Scope: Development of remote sensing payloads for Earth observation and monitoring.

Work Carried Out:

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• Design and testing of imaging sensors, radar systems, and hyperspectral sensors for

applications like agriculture, disaster management, weather monitoring, and environmental

monitoring.

• Development of data processing and analysis systems to handle large volumes of satellite

imagery.

2.1.4 Communication Systems

Scope: Responsible for the development of space-based communication systems including

telecommunication transponders, broadcasting systems, and satellite networks.

Work Carried Out:

• Designing transponders, antennas, and communication protocols to enable satellite

communication services.

• Implementation of ground communication infrastructure to support satellite data transmission.

2.1.5 Ground Systems and Control

Scope: Design and implementation of ground stations to track, communicate with, and control

satellites during their mission life cycle.

Work Carried Out:

• Setting up ground stations equipped with tracking and data receiving equipment.

• Managing satellite health and performing routine control functions for satellites.

2.1.6 Applications Development

Scope: Develop innovative space-based applications using the data provided by the satellites, such

as satellite navigation, telemedicine, and e-learning.

Work Carried Out:

• Implementation of space technology for practical solutions in areas like disaster management,

telemedicine, and education.

• Develop user interfaces and systems for end-users to access satellite-based services.

2.2 TECHNICAL SPECIFICATIONS OF MAJOR EQUIPMENT USED

IN EACH DEPARTMENT

Each department at SAC ISRO employs specialized equipment and technology to carry out their

tasks effectively. Below are the major technical specifications of some of the equipment used:

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2.2.1 Payload Design and Development Department

Imaging Sensors:

• Resolution: Up to 1-meter resolution for Earth observation.

• Spectral Range: Multi-spectral (visible, infrared, thermal).

Communication Transponders:

• Frequency Range: C-band, Ku-band, S-band.

• Power Output: Up to 100 watts for high-efficiency communication.

2.2.2 Satellite Integration and Testing Department

Thermal Vacuum Chamber:

• Temperature Range: From -150°C to 150°C.

• Size: Can accommodate satellites of up to 6 meters in diameter.

Vibration Testing Equipment:

• Frequency Range: Can simulate vibration from 1 Hz to 10,000 Hz for satellite testing.

2.2.3 Ground Systems Department

Tracking and Data Reception Antennas:

• Size: 10m to 30m parabolic dish antennas.

• Frequency Range: Covers L-band, S-band, C-band, and Ku-band.

2.3 2.3 SCHEMATIC LAYOUT SHOWING SEQUENCE OF

OPERATIONS FOR MANUFACTURING END PRODUCT

The manufacturing process at SAC ISRO follows a structured sequence for designing, developing,

integrating, and testing space systems. The schematic layout of the workflow includes the following

steps:

1. Design Phase:

• Conceptual design of payloads, subsystems, and satellite bus systems.

• Detailed system architecture design and simulations.

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2. Development Phase:

• Procurement of components.

• Fabrication and assembly of satellite payloads and systems.

3. Integration Phase:

• Assembly of satellite components.

• Integration of payloads with satellite bus systems.

4. Testing Phase:

• Thermal, vibration, and electromagnetic interference (EMI) tests.

• Performance verification through ground-based simulations.

5. Launch and Deployment Phase:

• Satellite launch via ISRO’s launch vehicles.

• Monitoring and control through ground stations post-launch.

2.4 2.4 EXPLANATION OF EACH STAGE OF PRODUCTION

1. Design: In the design stage, concepts for payloads, spacecraft systems, and ground

infrastructure are developed. The design is based on mission objectives and space conditions.

2. Development: Components such as payloads, sensors, and communication equipment are

designed, fabricated, and tested for functionality.

3. Integration: In this phase, the various subsystems such as payloads, power systems, and

thermal systems are integrated into the spacecraft.

4. Testing: The integrated system undergoes rigorous performance testing, which includes

thermal vacuum tests, vibration tests, and power system validation.

5. Launch and Deployment: The final satellite is launched, and real-time data transmission and

satellite health checks are conducted from the ground.

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3 INTRODUCTION TO PROJECT

3.1 PROJECT SUMMARY

This project focuses on Moon Surface Image Simulation using satellite imaging technologies to

simulate and visualize images of the moon’s surface. The goal is to understand how a camera will

capture an image in an unknown environment, such as the moon’s surface, and help in designing

and setting up camera parameters for such simulations. The project aims to provide an effective

system for simulating images by adjusting parameters like camera position, altitude, roll, yaw, and

pitch, which can be used in designing cameras for future lunar missions.

By simulating the moon’s surface images based on user input, the system can assist in camera

parameter optimization for space missions. It provides an interface where users can input pre-

captured images and define specific parameters, and in return, they will get a simulated moon

surface image.

3.2 PURPOSE

The primary purpose of this project is to simulate and visualize how the moon’s surface will appear

based on different camera parameters such as position, altitude, and orientation. The system will

serve as a tool for space scientists and engineers involved in the design and calibration of lunar

imaging systems.

By offering an interactive platform, the project aims to:

• Provide a realistic simulation of moon surface images based on camera position and settings.

• Aid in studying how camera will capture the images.

3.3 OBJECTIVE

The main objectives of this project are:

• To design a system that can take user input images (pre-captured) and simulate the appearance

of the moon’s surface under different camera parameters.

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• To help in studying for lunar missions by visualizing how the camera would capture images

of the moon from different perspectives.

• To develop an intuitive user interface using PyQt5 that allows users to interact with the

simulation and adjust parameters like latitude, longitude, altitude, and camera orientation.

3.4 SCOPE (WHAT IT CAN AND CAN’T DO)

Scope of the Project:

• The system can simulate images of the moon’s surface, enabling users to visualize how

different camera parameters impact the final image.

• The tool will allow users to input camera settings, such as camera position, altitude, and

orientation parameters, and generate simulated images of the lunar surface.

What the Project Can’t Do:

• It cannot provide real-time image capturing or real-world data from lunar surface cameras.

• It cannot generate new images of the moon based on raw data but will only work with

pre-captured input images.

• The simulation is limited to a static model and does not include dynamic changes (e.g.,

changing lunar phases or real-time environmental variations on the moon’s surface).

3.5 TECHNOLOGY

The project uses the following technologies:

• PyQt5: For creating the graphical user interface (GUI) that allows users to input and

manipulate parameters.

• PyQtGraph: Used for visualization, it provides a fast and efficient way to display simulated

images and graphical representations of camera settings.

• GDAL: A library used to handle geographic data and transform spatial data for accurate

simulation of images.

• NumPy: Essential for performing mathematical operations and data transformations involved

in the image simulation.

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3.6 PROJECT PLANNING

3.6.1 Project Development Approach and Justification

Figure 3.1: Iterative Waterfall Model

This project follows the Iterative Waterfall Model, allowing for incremental development and

continuous feedback after each phase. The iterative model provides flexibility to refine the design

after each cycle, ensuring that user needs are met and issues are addressed promptly.

Phase 1: Requirements Gathering and Initial Design: In this phase, project requirements

were gathered from experts in space imaging.

Phase 2: Prototype Development and User Interface Design: Based on the requirements,

an initial prototype of the GUI was developed using PyQt5. Early simulations with predefined

parameters were conducted to verify the system’s functionality.

Phase 3: Iteration and Refinement: After initial feedback from users, the system was

iteratively refined. New features like parameter adjustments and image enhancement tools were

added based on user input.

3.6.2 Project Effort and Time, Cost Estimation

The project is expected to take 3-4 months for completion. This includes time for prototype

development, testing, and refinement of the system.

Time Estimation:

• Prototype development: 1 month

• Testing and refinement: 2 months

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• Final adjustments and presentation: 1 month

Cost Estimation: The project will require already available hardware for testing.

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4 SYSTEM ANALYSIS

4.1 STUDY OF CURRENT SYSTEM

Currently, there is no integrated system that allows users to simulate the appearance of the moon’s

surface based on varying camera parameters in a user-friendly way. Various image processing and

satellite simulation tools exist but often focus on post-processing images or limited camera settings.

Therefore, a need exists for a customizable, efficient tool that can provide simulations of lunar

surface images with the flexibility to adjust camera positions, orientations, and other parameters.

Existing systems for space imaging simulations may lack features like interactive user inputs

or adjustments for environmental factors such as altitude, yaw, and pitch. They also tend to be

rigid in their design, focusing mainly on theoretical models rather than offering detailed user-driven

simulations.

4.2 REQUIREMENTS OF NEW SYSTEM

The new system must fulfill the following requirements:

1. Customizable Parameters: The system should allow users to input and modify camera

parameters, such as altitude, latitude, longitude, pitch, yaw, and roll.

2. User-Friendly Interface: The system must have an intuitive graphical user interface (GUI)

developed using PyQt5, enabling easy input of parameters and viewing of simulated results.

3. Realistic Simulations: It should simulate realistic moon surface images using pre-captured

satellite images.

4. Support for Lunar Mission Data: The system must allow integration with data from lunar

missions such as Chandrayaan, enabling the simulation of different lunar regions and testing

of different camera configurations.

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4.3 SYSTEM FEASIBILITY

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

Yes, the system contributes to the overall objectives of ISRO, especially in the area of satellite

imaging and space exploration. By helping engineers design and set up optimal camera parameters

for lunar missions, the tool supports space mission readiness and camera configuration optimization.

It aligns with the vision of advancing space technology and enhancing satellite-based remote sensing

for lunar exploration.

4.3.2 Can the system be implemented using the current technology and schedule constraints?

Yes, the system can be implemented using current technologies such as PyQt5, NumPy, PyQtGraph,

and GDAL. These tools are highly capable for developing the GUI, performing mathematical

computations, and processing satellite image data. Additionally, the iterative waterfall model allows

for efficient development within the time constraints, as each phase will build upon feedback from

the previous iteration.

4.3.3 Can the system be integrated with other systems already in place?

Yes, the system is designed to integrate with existing simulation modules

4.4 PROCESS IN PROPOSED SYSTEM

The proposed system will include the following activities:

• Input Data: Users will provide pre-captured lunar images and set parameters such as latitude,

longitude, altitude, camera orientation, etc.

• Image Simulation: Based on the input parameters, the system will simulate a new image

of the moon’s surface, reflecting how the camera would capture the scene in those specific

parameters.

• Visualization: Simulated images will be visualized on a graphical interface, and users can

interact with the interface to adjust parameters.

• Export: After running the simulation, users can export the generated images or data for

further analysis.

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4.5 FEATURES OF PROPOSED SYSTEM

• Interactive User Interface: Developed using PyQt5, allowing users to easily input and

modify camera parameters and view simulated images.

• Simulation: Based on pre-defined camera parameters and the moon’s surface data.

• Parameter Control: Includes controls for various camera settings (e.g., latitude, longitude,

altitude, pitch, yaw, roll).

• Export and Report Generation: Users can save simulated images and generate detailed

reports for mission planning.

4.6 LIST OF MAIN MODULES / COMPONENTS / PROCESSES /

TECHNIQUES OF NEW SYSTEM / PROPOSED SYSTEM

The main modules/components of the system will include:

• User Interface Module: Developed with PyQt5 for user input and interaction.

• Simulation: Handles image processing and simulation based on camera parameters using

NumPy and GDAL.

• Visualization Module: Uses PyQtGraph to display the simulated image and allow interactive

viewing.

• Data Integration Module: Interfaces with satellite data for real-time simulation.

• Export/Reporting Module: Allows users to export simulated images for analysis.

4.7 SELECTION OF HARDWARE / SOFTWARE / ALGORITHMS /

METHODOLOGY / TECHNIQUES

4.7.1 Hardware:

The project will be developed on standard computers with sufficient computational power to handle

image processing. Systems should have good graphic processing capabilities for efficient simulation

and rendering.

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4.7.2 Software:

• PyQt5 for GUI development

• NumPy for mathematical operations

• PyQtGraph for image visualization

• GDAL for handling geospatial data

4.7.3 Algorithms:

Parallel processing algorithms were implemented for fast processing.

4.7.4 Methodology:

The project will follow the Iterative Waterfall Model, ensuring that each phase undergoes continuous

refinement through feedback loops.

4.7.5 Techniques:

The system will employ camera parameter optimization and image simulation techniques to provide

users with a realistic simulation of lunar surface imagery.

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5 SYSTEM DESIGN

5.1 SYSTEM DESIGN & METHODOLOGY

The image simulation system is designed to take a GeoTIFF image as input and simulate how

a camera would capture it in an unknown environment. The methodology follows a structured

pipeline consisting of image loading, parameter configuration, marker placement, and simulation

output. it’s made through Iterative Waterfall Model.

The key components of the system design are:

5.1.1 Graphical User Interface (GUI)

Built using PyQt and PyQtGraph, providing an interactive environment for parameter adjustments

and image visualization.

5.1.2 Camera Parameters Handling

Users can set parameters such as detector height, width, FOV, focal length, and altitude to define

the camera specifications.

5.1.3 Marker-Based Simulation

Users can place markers using latitude-longitude coordinates to define the simulation area. Single-

point mode allows one marker, while multi-point mode enables simulation between two points.

5.1.4 Footprint Preview

The system provides a footprint visualization before actual simulation to help users understand the

expected output coverage.

5.1.5 Image Processing

The core simulation logic processes the input GeoTIFF based on selected camera parameters,

generating the simulated image.

This structured approach ensures that the system effectively meets the objective of simulating

camera behavior for testing and design purposes.

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5.2 DATA STRUCTURE / PROCESS / STRUCTURE DESIGN

5.2.1 Data Structure Design

The system primarily works with the following data structures:

• Camera Parameter Dictionary: Stores values such as detector size, FOV, focal length, and

altitude.

• GeoTIFF Image Data: Handled as multi-dimensional arrays for processing.

• Marker Data: Stores latitude-longitude pairs for single and multi-point modes.

5.2.2 Process Design

The image simulation follows these steps:

1. Load Image: User selects a GeoTIFF image.

2. Set Camera Parameters: Parameters are either manually entered or selected from the

preloaded camera types via a combo box.

3. Mark Position(s): User marks a single or two-point location using the mouse or by entering

coordinates.

4. Preview Footprint: The system calculates and displays the expected coverage.

5. Simulate Image: The system processes the image according to camera parameters and outputs

the simulated image.

6. Save or Clear: Users can save results or reset parameters and markers.

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Figure 5.1: User Flow Chart

5.3 INPUT / OUTPUT AND INTERFACE DESIGN

5.3.1 State Transition Diagram (Optional)

If required, a state transition diagram can be included to depict the various states of the system,

such as:

Idle ® Image Loaded ® Parameters Set ® Simulation Performed ® Output Displayed

5.3.2 Samples of Forms, Reports, and Interface

• Forms & Inputs: The GUI provides QLineEdit fields for numerical input and a QComboBox

for selecting preloaded camera types.

• Interactive Controls: Buttons for loading, saving, and clearing data, along with QDials for

adjusting roll, pitch, yaw, and tilt angles.

• Visualization: The PyQtGraph canvas displays the input and output images with an interactive

histogram.

5.3.3 Access Control / Security (If Applicable)

Since this is a local simulation tool, access control is minimal. However, basic safeguards such as

input validation and error handling are implemented to prevent incorrect data entry.

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6 IMPLEMENTATION

6.1 IMPLEMENTATION PLATFORM / ENVIRONMENT

The image simulation system is developed using Python and implemented on a Windows/Linux

environment. The key components of the implementation platform are:

• Programming Language: Python

• GUI Framework: PyQt5 (for creating an interactive graphical interface)

• Image Processing Library: GDAL (for handling GeoTIFF images)

• Visualization Library: PyQtGraph (for displaying images and histograms)

• Mathematical Computation: NumPy (for handling array-based image transformations)

• Development Environment: Spyder

• Hardware Requirements: A system with a minimum of 8GB RAM, multi-core CPU, and

GPU acceleration

The system runs efficiently on standard computing hardware, with optimizations to handle large

GeoTIFF files.

6.2 PROCESS / PROGRAM / TECHNOLOGY / MODULES

SPECIFICATION(S)

6.2.1 Process Flow

The image simulation follows these steps:

1. Loading the Input Image:

• Users load a GeoTIFF file using a file selection dialog.

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• The image data is read using the GDAL library and processed into an array for simulation.

2. Setting Camera Parameters:

• Users manually enter or select a predefined camera type from a QComboBox.

• Parameters such as detector size, focal length, field of view, and altitude are applied.

3. Marking Positions (Single or Multi-Point Mode):

• Users click on the image or enter latitude-longitude coordinates to set markers.

• The system converts these to pixel coordinates for processing.

4. Footprint Visualization:

• A footprint button calculates and overlays the expected simulated area on the original

image.

5. Simulating the Image:

• The system applies geometric transformations based on camera parameters.

• The modified image is displayed on the PyQtGraph canvas.

6. Saving / Resetting Data:

• Users can save results, reset inputs, or clear markers as needed.

6.2.2 Technologies & Modules Used

The following technologies and modules are used in the implementation:

• PyQt5: GUI framework for interactive controls.

• PyQtGraph: Efficient image rendering and histogram display.

• GDAL: Reads and processes GeoTIFF images.

• NumPy: Handles mathematical transformations for image simulation.

6.2.3 Findings / Results / Outcomes

The implementation of the system resulted in the following outcomes:

• Accurate Image Simulation: The system successfully simulates how a camera would capture

an image in an unknown environment.

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• Parameter Adjustment: Users can modify camera parameters and observe changes

dynamically.

• Footprint Visualization: The footprint feature helps users understand how the final image

will appear before simulation.

• Multi-Mode Simulation: Both single-point and multi-point simulation modes function as

expected.

• Efficient Processing: The use of NumPy and GDAL ensures that large GeoTIFF images are

processed efficiently.

6.2.4 Result Analysis / Comparison / Deliberations

The system was tested with various input images and camera parameters to evaluate its performance.

The key observations include:

• Comparison with Theoretical Expectations: The simulated images align with expected

outputs based on camera equations.

• Performance Metrics: Processing time varies based on image resolution and selected

parameters. Higher-resolution images take longer to process.

• User Interaction: The GUI provides an intuitive interface for parameter adjustments, making

the system user-friendly.

• Challenges: Some minor challenges were faced in marker precision, which were mitigated

using coordinate transformations.

6.2.5 Implementation :

• Screenshots :

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Figure 6.1: screenshot 1

Figure 6.2: screenshot 2

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Figure 6.3: screenshot 3

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7 TESTING

7.1 TESTING PLAN / STRATEGY

The testing phase ensures that the image simulation system functions correctly and meets the

intended objectives. The strategy involves:

7.1.1 Testing Types Used

• Unit Testing – Individual components (e.g., image loading, parameter inputs, footprint

preview) are tested separately.

• Integration Testing – Ensures that different modules (e.g., GUI, parameter selection,

simulation engine) work together correctly.

• Functional Testing – Verifies that all features (e.g., single/multi-point simulation, marker

placement) perform as expected.

• Performance Testing – Checks system efficiency with different image sizes and parameter

variations.

• User Acceptance Testing (UAT) – Ensures the system meets user requirements for camera

testing and design.

7.1.2 Testing Environment

• Platform: Linux

• Software Dependencies: Python, PyQt5, PyQtGraph, GDAL, NumPy

• Hardware: System with at least 8GB RAM and multi-core processor

7.2 TEST RESULTS AND ANALYSIS

Multiple test cases were executed to verify the system’s performance and accuracy. The following

table summarizes key test cases:

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7.2.1 Test Cases

Test ID Test Condition Expected Output Actual Output Remarks

TC-01 Load GeoTIFF image Image loads Image loads correctly Pass successfully

TC-02 Enter valid camera parameters

Parameters accepted and applied

Parameters stored and Pass used

TC-03 Enter invalid camera parameters

Error displayed

message Error handled Pass correctly

TC-04 Single-point marker placement

Marker appears at correct lat-long

Marker placed Pass accurately

TC-05 Multi-point marker placement

Two markers placed correctly

Markers appear as Pass expected

TC-06 Footprint preview Correct displayed

footprint Footprint aligns with Pass expected region

TC-07 Run image simulation Simulated image is generated

Image output is Pass accurate

TC-08 Save simulated image

TC-09 Clear parameters

Image saved directory

All fields reset

in File successfully

Fields properly

saved Pass

cleared Pass

TC-10 Performance with high-res image

Processing within reasonable time

Acceptable Pass (minor delay) performance

Table 7.1: Test Cases for Image Simulation System

7.3 ANALYSIS OF TEST RESULTS

• Functionality: All core features performed as expected, with accurate image simulation.

• Usability: The GUI is intuitive, with smooth user interactions.

• Performance: The system handles various image resolutions well, but higher-resolution

images slightly increase processing time.

• Error Handling: Proper validation prevents invalid inputs, improving system robustness.

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8 CONCLUSION AND SUMMARY

8.1 CONCLUSION AND SUMMARY

The image simulation system was developed to evaluate how a camera would capture images in an

unknown environment. By incorporating camera-specific parameters such as detector height, width,

field of view (FOV), focal length, and altitude, the system provides an effective way to analyze and

design cameras before actual deployment.

The system meets its objectives by providing a useful tool for Image simulation and being

helpful for studying images.

8.2 LIMITATIONS

• Processing Time for High-Resolution Images: When working with very large GeoTIFF

images, processing can take longer than expected. Optimizations in computation can help

reduce delays.

• Limited Camera Parameter Customization: The system currently supports predefined

parameters and manual input. Future versions could allow users to import real-world camera

calibration data.

• No Real-Time 3D Visualization: The system operates in a 2D simulation environment.

Adding a 3D rendering option could improve visualization and understanding of camera

perspectives.

• Georeferencing Accuracy: While the system accurately places markers based on latitude-

longitude coordinates, minor discrepancies may arise due to projection transformations.

• No External Data Integration: Currently, the system processes only user-provided images.

Future enhancements could support integration with external satellite data sources.

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