Problem Statement and Goals
Software Engineering

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Table 1: Revision History

Date	Developer(s)	Change
9/24/2024	Oleg, Kartik, Kyle, Mathew	First Revision

1 Problem Statement

1.1 Problem

There is currently a lack of high-quality, labeled satellite imagery datasets tailored for specific use cases. Many industries require specialized data for tasks like disaster response, environmental monitoring, urban planning, or defense, but building these datasets manually is time-consuming, costly, inefficient and may require expert data analysis. This hinders the development and deployment of accurate computer vision models for critical use cases across these various industries.

Our team at OKKM Insights aims to solve this problem by creating an online platform that accelerates this process and brings transparency to satellite imagery data analysis. Using an AI-powered crowd-sourcing model, our platform will allow users to label commercially available satellite images, helping us to build datasets. These datasets will then be used to train custom computer vision models for various use cases. At its core, the platform will offer a paid service for identifying objects within satellite images, and in turn, distribute the earnings to the users who contribute to the labeling effort.

1.2   Inputs and Outputs

Inputs:

- Satellite imagery: Raw, unlabeled (satellite) images that form the foundational data for analysis.

- Financial resources: Monetary resources for user compensations.

- Human effort: Time and expertise contributed by users who label the images.

Outputs:

- Labeled datasets: high-quality, specialized datasets tailored to specific industry needs.

- Actionable insights: Industry specific information derived from the data as part of the labeling process

- Trained models: Trained CV models capable of automating or simplifying image analysis tasks for different use cases.

- User satisfaction: Users satisfaction stemming from platform use and monetary rewards.

- Revenue generation: Income derived from providing paid services to clients needing specialized datasets and models.

2   Stakeholders

1. Air Rescue Services: These organizations rely on satellite imagery to assist in critical missions like search and rescue. High-quality datasets can enhance their ability to assess disaster zones or monitor large areas efficiently, making response times quicker and saving lives. Satellite images tailored to disaster management, including flood zones or forest fires, are of particular importance to them.

2. Alternative Financial Data Companies: These companies use satellite data to analyze economic activities and trends. For example, satellite imagery of crop growth can be used to predict agricultural yields, or images of traffic patterns near malls can provide insights into retail performance. High-quality datasets enable these companies to develop more accurate financial models and market predictions.

3. Farmers and Agricultural Enterprises: Farmers benefit from satellite imagery for precision farming, monitoring crop health, soil conditions, and weather

patterns. Access to customized datasets allows them to optimize planting schedules, monitor water usage, and make informed decisions about fertilizer application, improving yield and reducing costs.

4. Users: These are individuals or entities responsible for labeling the data on the platform. In return for their efforts, they receive compensation. Their primary role is to ensure that the datasets are correctly annotated according to specified requirements, which forms the basis of the models developed. Their work directly impacts the quality and usability of the final product.

5. End Clients/Customers: These stakeholders include governments, NGOs, private companies, and environmental organizations that pay for access to the labeled datasets and models. They rely on these datasets to make informed decisions in areas like environmental monitoring, urban planning, or defense-related tasks. Their satisfaction depends on the accuracy and reliability of both the data and the models provided.

Other Stakeholders: Beyond the primary stakeholders, other key groups that benefit from high-quality satellite imagery datasets include defense agencies, which rely on tailored data for surveillance, intelligence, and threat detection to enhance national security. Environmental agencies use satellite data to monitor ecosystems, track deforestation, and respond to climate change. Similarly, urban planners leverage this data to manage land use, plan infrastructure development, and promote sustainable growth in cities. Additionally, disaster relief organizations depend on satellite imagery to assess damage in real-time and prioritize aid during crisis situations, making these datasets crucial for effective disaster response. Another important group includes the image labeling teams, who manually classify and annotate satellite images. Their work is crucial for building accurate datasets, and they benefit from improved tools and clearer guidelines to make the labeling process more efficient.

3 Environment

The primary environment for this project will be a web-based application, ensuring accessibility across a wide range of devices, including laptops, desktops, and potentially mobile devices. The web app will be accessible via any modern browser, making it cross-platform compatible and usable on Windows, Linux, and macOS.

The development and deployment will prioritize portability to maximize usability across different platforms. Key points regarding the environment include:

- Web-Based: The software will be a web app, meaning it will run within web browsers, such as Google Chrome, Mozilla Firefox, and Safari. This will allow users to access the application regardless of their operating system, making it highly portable.

- Cross-Platform Compatibility: While primarily targeted for laptops and desktops, the web app will also be responsive to work on mobile devices. The development will aim to make the app usable across all major operating systems (Windows, Linux, macOS).

- Hosting and Backend: The backend services and APIs will be hosted on AWS/Azure, ensuring high scalability, performance, and availability. Users will not need to install any specific software or dependencies, as all services will be accessible through the web.

- Development Environment: The development will be done primarily on Linux for server-side services, but the tools and frameworks used (Node.js, Flask, Python) are cross-compatible, meaning that development and testing can also occur on Windows and macOS environments.

- Portability: Due to its web-based nature, the application will not be tied to any specific hardware and can be accessed from any device with internet connectivity, further enhancing its portability and ease of use.

4 Goals

4.1 High Data Accuracy

Description: The system should have high classification accuracy for objects reported in the images.

Rationale: The core problem this system must solve is extracting useful information from the provided images. One key metric to determine the utility of the information found, is the classification accuracy of objects identified in the images. If the system is not able to determine what is contained in an image, it will not be useful to stakeholders.

4.2 Ease of use

Description: The system should be very easy for stakeholders to use. There should be very low friction for users to classify images and objects found within images, with minimal training. It should also be simple for users to upload images to be analyzed.

Rationale: To maximize the information gained from users who are contributing to classification efforts, the system must ensure it is simple for users to get started with, and continue using the system. This is necessary to build a large

enough user base, which will make it more likely to get insights in an acceptable amount of time.

4.3 Minimizing Cost to Analyze Images

Description: The system should minimize the cost for users request insights from images. This could be implemented through intelligent algorithms for task delegation.

Rationale: Users of the system who upload images are interested in getting an appropriate return for their investment. If the cost to analyze is too high, the platform will not retain a sufficiently large user base of purchasers.

4.4 Results Returned Within Appropriate Timeframe

Description: The system should ensure the time it takes to obtain information from images is within a specified limit, as determined by users who upload images.

Rationale: Purchasers will have some time limit they require the system to process images within. To ensure timing needs are met, the system should provide realistic timelines and stick to them.

4.5 High System Reliability and Accessibility

Description: The system should be useable remotely for purchasers and labellers, and have minimal downtime.

Rationale: The system should allow purchasers to upload images without being physically located where the system is hosted to ensure flexibility of use. The same should also be true for labellers, as they should be able to perform their tasks remotely. In both cases, the system should have low down time as to not introduce additional friction into the completion of tasks.

5 Stretch Goals

5.1 Automatic Data Labelling

Description: The system should be able to use our extensive data set to automatically label new images.

Rationale: The introduction of automatic data labelling will improve the speed and reduce the cost to label images. This will allow the system to provide more value to purchasers, and allow the labellers to focus on harder to label images.

5.2 Multi-Source Integration

Description: The system should combine additional geo-spatial datasets, such as weather or census data, to obtain additional information from satelite imagery.

Rationale: Additional data sources will improve the value of data collected for purchasers. This is especially true for those interested in predicting future trends from the data found in their satelite images.

6 Challenge Level and Extras

6.1 Challenge Level

We anticipate this project to be advanced due to our limited domain knowledge of satellite imagery and the complexity of the implementation. To begin, we will be developing a web application from scratch, which poses a challenge as most team members lack experience in front-end development. Additionally, we need to figure out how to seamlessly and automatically acquire paid satellite images for labeling from third-party providers upon customer request. We also need to consider how to break down and distribute image-labeling tasks. This may involve algorithms for splitting larger images into smaller pieces for analysis, identifying images with relevant objects, and determining which users are best suited to label specific images. Complicating matters further, our aim is for users to be able to label the same images in parallel, which will require designing systems to manage simultaneous contributions and prevent conflicts or inconsistencies. We will also need to design a consensus algorithm to ensure accurate labeling, likely incorporating a user accuracy system and a statistical model—both of which will require research to understand and implement effectively. Once a dataset is validated, we will face additional challenges in the realm of computer vision models. Our team has minimal experience in this area, so selecting, tweaking, training, and testing the appropriate model for optimal accuracy across diverse datasets will require significant effort. Moreover, we aim to automate the training of the model once a labeled dataset is complete, which will add to the complexity. The application will also need to handle secure payments from customers and distribute payments to users and third parties. Since we have no experience with online monetary transactions, this will involve additional research and effort to ensure security and reliability. Finally, we must integrate all these components seamlessly and deploy the system in a way that ensures efficiency and an excellent user experience.

Overall, with the complexity of the implementation and our current knowledge gaps, we believe that the extra research and level of development will make this an advanced project.

6.2   Extras

- Usability Testing: Conducted by allowing users to test the application interface and provide feedback to us through a questionnaire

- Demonstration Video: Create a video demonstrating how to use the product and its various features

- Formal Proof: Come up with a proof of convergence for labeled images to show that they have a certain level of consistency and accuracy

Appendix — Reflection

The purpose of reflection questions is to give you a chance to assess your own learning and that of your group as a whole, and to find ways to improve in the future. Reflection is an important part of the learning process. Reflection is also an essential component of a successful software development process.

Reflections are most interesting and useful when they're honest, even if the stories they tell are imperfect. You will be marked based on your depth of thought and analysis, and not based on the content of the reflections themselves. Thus, for full marks we encourage you to answer openly and honestly and to avoid simply writing "what you think the evaluator wants to hear."

Please answer the following questions. Some questions can be answered on the team level, but where appropriate, each team member should write their own response:

1. What went well while writing this deliverable?

   This deliverable was relatively straightforward for our team to complete. We had decided on a project early in the process and made sure that all team members were genuinely interested in the proposal before moving forward. We regularly discussed the progress of the deliverable, both in our team meetings and following our capstone classes. The workload was distributed evenly, and team members cross-checked each other's work to ensure consistency in our understanding of the project's objectives. This collaborative approach helped us stay aligned and on track throughout the process.

2. What pain points did you experience during this deliverable, and how did you resolve them?

   The primary challenge was establishing the project's workflow, specifically configuring the GitHub-LaTeX pipeline to automatically compile files upon upload. We addressed this by organizing a team-wide meeting to align everyone on the process and identify best practices. Additionally, we consulted with the professor, both in-person and through a discussion post on Teams, to ensure we were following the correct approach.

3. How did you and your team adjust the scope of your goals to ensure they are suitable for a Capstone project (not overly ambitious but also of appropriate complexity for a senior design project)?

   Our project's flexible nature allows us to adjust its complexity by adding or removing features around the core idea. While the core concept itself is not entirely new, our focus is on applying it to a new domain, which will require research to determine the best approach. The core functionality will be supplemented with more advanced features and techniques to allow our project to be classified as "advanced". However, should we encounter time constraints or technical challenges, these additional features can be omitted without compromising the project's core functionality.