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CENG 407

PROJECT REPORT

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Contents

Introduction

This document encompasses a literature review, Software Requirements Specification (SRS), and Software Design Document (SDD) for the Insightio platform. The literature review provides a summary of existing information about the advanced features and use cases of the platform. Subsequently, the SRS section elucidates the purpose, scope, and general requirements of Insightio. Following the SRS, the SDD intricately presents the architecture, functionality, and design details of the platform from a user perspective. By step-by-step narration of the project's overall structure and content, this document provides a comprehensive overview of the Insightio platform.

Project Plan

LITERATURE REVIEW

Özet

Bu araştırma, perakende sektöründen acil tahliye senaryolarına kadar farklı alanlarda, insan varlığını etkili bir şekilde kontrol etmek amacıyla kullanılan insan sayım sistemlerinin giderek artan önemini ele almaktadır. Bu makale, kalabalık alanlarda bireyleri doğru bir şekilde belirlemenin ve nicelendirmenin zorluklarına odaklanmakta ve bunun için aydınlatma, hava koşulları ve görüntü kalitesi gibi faktörleri dikkate almaktadır. Ayrıca, daha geleneksel yoğunluk regresyon tekniklerini yerine koyan daha sofistike bilgisayar görüsü tabanlı stratejilerin gelişimini göstermektedir. Farklı çalışma hedeflerinde homojen değerlendirmeler sağlamak için standartlaştırılmış değerlendirme yöntemlerinin önemini vurgulamaktadır. Bu analiz, kalabalık sayımın çağdaş operasyonel ve güvenlik önlemlerinde oynadığı hayati rolü vurgulayarak, bu alandaki başarıları ve zorlukları kapsamlı bir şekilde sunmaktadır.

Abstract

This study of research investigates the expanding importance of people counting systems in efficiently controlling human presence in a variety of contexts, from retail to emergency evacuation situations. The paper discusses the challenges of precisely identifying and quantifying individuals in crowded locations, taking into account elements like lighting, weather, and image quality. It also illustrates the development of computer vision-based strategies, showing how more sophisticated approaches replaced more conventional density regression techniques. In order to provide uniform assessments across various study objectives, the analysis underlines the need for standardized evaluation techniques. In summary, this analysis highlights the critical role that crowd counting plays in contemporary operational and safety measures by offering a comprehensive overview of the field's accomplishments and obstacles.

1. Introduction

In today's global landscape, grappling with the complexities of managing human presence has become increasingly challenging due to the ever-expanding population. Businesses, public spaces, and communities seeking to efficiently navigate and analyze crowded environments require robust tools for data acquisition and manipulation. The global market for people counting systems reached a valuation of 969.9 million USD in 2021, with a projected annual growth rate of 12.2% from 2022 to 2030 (People Counting System Market Size, Share & Trends Analysis Report by End-use (BFSI, Corporate), by Offering (Hardware, Software), by Mounting Platform (Ceiling, Wall), by Type, by Technology, and Segment Forecasts, 2022 - 2030, n.d.).

Importantly, people counting methods are essential in many industries, retail being one of the best examples. The transition from manual counting to sophisticated computer solutions has been crucial for retail organizations seeking to modernize operations and improve consumer experiences. According to Chakraborty (2023), these systems provide real-time analysis, identify high-traffic areas, optimize staffing, examine consumer behavior, and facilitate forecasting.

Real-time tracking also extends its reach to emergency evacuations, where human-centered sensing proves invaluable for monitoring crowd behavior in real-time, ultimately bolstering incident management strategies (Crowd Models for Emergency Evacuation: A Review Targeting Human-Centered Sensing, 2013).

These statistics underscore the profound impact of people counting technology across diverse industries. Evidently, businesses and organizations are increasingly embracing this technology to enhance operational efficiency, elevate security measures, and foster data-informed decision-making processes.

2. Main Findings

The literature review findings are bifurcated into two distinct parts. The first part scrutinizes the challenges entailed in accurately discerning individuals within crowded spaces. This encompasses considerations such as variations in lighting, weather, and image quality, in addition to complexities arising from overlapping individuals and occluded areas.

The following section then explores the development of computer vision-based approaches. The noteworthy advancements in computational approaches and their usefulness in crowd counting are emphasized. This includes talking about methods such as density regression and dense detection and how they can be used to improve the accuracy and efficiency of this field. All of these studies provide an extensive understanding of the basic concepts and recent developmentsin crowd counting.

2.1. Challenges and Difficulties in Human Detection and Counting

Accurately identifying and counting people in congested spaces is a complex task with many moving parts. External factors that introduce unpredictability and can have a major impact on the accuracy of human detection include variations in lighting, weather, and image quality (Raghavachari et al., 2015). Accurate counting is made more difficult by overlapping people and occluded areas, necessitating complex discerning techniques (Sam et al., 2020).

Public spaces, characterized by dynamic crowd densities, pose another layer of complexity. Maintaining consistent accuracy becomes a formidable challenge as these spaces transition from peak to off-peak crowd conditions (Raghavachari et al., 2015). Additionally, the choice of camera orientation is critical in determining detection efficacy, with different angles yielding distinct perspectives on human objects, each presenting unique challenges (Sam et al., 2020).

Unfavorable circumstances, such as poor lighting and camera glare, can cause problems like visual blurriness, which makes it harder for people to perceive objects of interest (Bhangale et al., 2020). The already difficult task of precise counting is made more problematic by these environmental influences. Researchers use sophisticated computer vision techniques and machine learning algorithms in response. For example, deep learning models have the potentialto improve human detection accuracy in a variety of circumstances (Bhangale et al., 2020). To handle particular issues like occlusion and different crowd sizes, complementary techniques arealso suggested. These include trajectory clustering, feature-based regression, and individual pedestrian detection (Huang & Chung, 2004). These group efforts serve as an example of the continuous struggle to overcome the difficulties associated with human identification and counting in various dynamic environments.

2.2. Computer Vision Based Approaches to Crowd Counting

Crowd counting has witnessed a notable evolution in computer vision algorithms. Initially, density regression techniques were employed, estimating crowd density maps to infer counts (Raghavachari et al., 2015). However, this approach faced limitations, particularly in scenarios with dense crowds (Sam et al., 2020). To address this, recent advancements have shifted towards dense detection methods, which present more practical and accurate solutions (Sam et al., 2020). Notably, deep learning models, including Convolutional Neural Networks (CNNs) like VGG andResNet, have played a crucial role in this transition.

According to Bhangale et al. (2020), these models excel in feature extraction and pattern recognition, rendering them well-suited for crowd counting tasks. Moreover, they have been adeptly adapted to handle the intricacies of crowd analysis, effectively capturing complex spatial arrangements and density variations (Sam et al., 2020; Sjöberg & Hyberg, 2023; Hussain, 2023).This adaptability showcases the versatility of CNNs in addressing the challenges posed by dynamic crowd environments.

In addition to CNNs, YOLO (You Only Look Once) models have emerged as powerful tools in object detection, including humans, and have been particularly effective in crowd counting tasks (Hussain, 2023). These models utilize a single neural network to simultaneously predict bounding boxes and class probabilities for multiple objects in a single pass. This makes them well-suited for real-time processing and applications like object detection and tracking in video streams. YOLO models, including the latest YOLO-v8 release, have demonstrated high- classification performance and fast detection capabilities, making them increasingly relevant in industrial settings (Hussain, 2023).

Additionally, techniques like multi-scale analysis have proved indispensable, given that crowd images often encompass individuals of varying sizes (Huang & Chung, 2004; Hussain, 2023). Methods such as image pyramid decomposition and feature pyramids facilitate the analysis of images at different resolutions. This approach ensures that individuals are detected and counted irrespective of their scale, thereby bolstering the overall robustness of the counting system (Huang & Chung, 2004; Hussain, 2023). This emphasis on multi-scale analysis underscores its pivotal role in accurately estimating crowd counts, especially in scenarios with diverse crowd compositions.

Furthermore, the integration of detection and tracking systems has demonstrated remarkable efficacy in dynamic environments. As suggested by Huang and Chung (2004) and Sjöberg and Hyberg (2023), detection algorithms identify individuals, while tracking algorithms ensure object continuity across frames. This synergistic approach significantly enhances crowd counting reliability, particularly in situations characterized by occlusions and dynamic movement (Sjöberg & Hyberg, 2023; Hussain, 2023). The fusion of detection and tracking mechanisms addresses challenges associated with the inherent movement and occlusions within crowd scenes.

Some other methods have also significantly contributed to the evolution of crowd counting algorithms. For instance, CSRNet, a CNN tailored for congested scene recognition, has emergedas a prominent tool in crowd counting applications (Bhangale et al., 2020). This model employs a multi-column architecture in conjunction with top-down modulation, allowing for the precise detection and localization of individuals within densely populated scenes. Notably, CSRNet's proficiency in generating accurate crowd density maps from point annotations underscores its robustness in crowd counting scenarios.

In addition to CSRNet, the integration of advanced image descriptors like Perspective Invariant Histograms of Oriented Gradients (HOGp) has revolutionized crowd counting, eliminating the need for camera calibration (Reis, 2014). This innovative technique not only addresses privacy concerns but also proves particularly adept in systems with limited resources. Consequently, it stands as a valuable tool in urban planning and crowd control applications. By emphasizing these image descriptors, this approach offers an alternative avenue to achieve accurate crowd counting.

Furthermore, the application of Hidden Markov Models (HMM) shows promise in recognizing various human dynamics, including walking and sitting (Huang & Chung, 2004). HMMs provide a robust framework for understanding temporal dependencies within crowd behavior, introducing an additional layer of sophistication to crowd counting algorithms (Huang & Chung, 2004). The fusion of HMMs with other detection and tracking methodologies presents a holistic approach to crowd analysis.

In summary, the landscape of crowd counting has witnessed a transition from traditional density regression techniques to the adoption of dense detection strategies. While deep learning models like VGG, ResNet, and YOLO have played pivotal roles, it is imperative to recognize the substantial contributions of other noteworthy models like CSRNet, innovative techniques like HOGp descriptors, and the integration of HMMs. These diverse methods collectively underscore the versatility and adaptability of computer vision in achieving accurate crowd estimates across various domains, ranging from smart building management to urban planning and public safety.

3. Evaluating Model Accuracies

Precisely evaluating crowd counting models' performance is a complex process that depends on a number of variables and methodological techniques. The assessment procedure depends on the particular approach taken. When it comes to urban areas that use the HOGp approach (Reis, 2014), comparing models that integrate HOGp with those that do not provide a solid framework for measuring accuracy when it comes to counting disparities. This method clearly illustrates the usefulness and effectiveness of the idea by reducing counting errors without requiring camera calibration.

For evaluating the accuracy of YOLOv8 in pedestrian detection (Sjöberg & Hyberg, 2023), mean Average Precision at 50 (mAP50) scores serve as a pivotal metric, illuminating the nuanced interplay between accuracy and model performance across diverse lighting conditions. This assessment provides critical insights into the model's viability for applications such as self- driving vehicles, while also highlighting areas for refinement, particularly under varying illumination scenarios.

The contour-based matching method for human detection (Rahman, 2017) relies on metrics like average accuracy and precision in still images to gauge accuracy. This approach acknowledges the trade-offs inherent to still-image analysis, especially in scenarios with overlapping human entities, emphasizing the method's efficacy within these constraints.

In the context of agricultural pest and disease detection (Zhang, Ding, Li, & Li, 2023), the focus of accuracy evaluation lies in model performance metrics encompassing detection accuracy and recognition. This assessment highlights improvements in model precision, indicating concrete strides in the field of agricultural pest and disease detection.

Metrics such as mean absolute error (MAE) and mean square error (MSE) are used by real-time crowd counting systems (Bhangale et al., 2020) to evaluate accuracy. This approach highlights the model's higher accuracy compared to traditional methods, confirming its usefulness for crowd counting applications in various real-time settings.

For YOLO models (Mokayed et al., 2022), accuracy percentages stand as critical metrics in the evaluation process, drawing attention to the intricate balance between processing speed and model accuracy. This assessment paradigm highlights the trade-offs that must be considered when deploying YOLO models in applications where both speed and accuracy are paramount.

3.1. Unified Evaluation Protocol

To guarantee consistent model assessment across various situations, datasets, and research goals, a unified evaluation protocol is necessary. But its foundation is hindered by differences in datasets, contextual differences, and the quick development of approaches. Because of these elements, developing uniform evaluation frameworks is both necessary and challenging. The scientific community is working to create more standardized standards in response to this need.

The lack of a single, universally applicable evaluation process results from the many different uses of computer vision and machine learning, each with its own set of objectives for research. The creation of a uniform evaluation framework is further complicated by differences in datasetquantity, quality, and annotations. Because of these differences, developing an assessment process that stays up to date in the face of deep learning and computer vision techniques' rapid advancement is difficult.

Despite these challenges, there is a growing recognition within the research community of the necessity for unified evaluation protocols. This collective effort signifies a commitment to enhancing the rigor and comparability of evaluations in the field. As the field continues to advance, establishing standardized evaluation protocols remains a crucial area of focus to ensureimpartial and consistent assessments across various research endeavors.

4. Conclusion

The culmination of our research and literature review unequivocally underscores the substantial potential of pre-trained networks, particularly YOLO-based models, in pivotal domains of visual processing such as object detection, head counting, and human counting. These studies shed light on the instrumental role such technologies can play in real-world applications. Real-time object detection and counting stand out as paramount in domains like security, surveillance, and crowd management, where the algorithms driving object tracking and detection form the cornerstone of effectiveness.

Beyond mere head counting, density estimation presents an opportunity for a more nuanced analysis of visual data. However, for research in this domain to progress, reliance on larger, high-resolution datasets and standardized evaluation protocols is imperative to ensure both accuracy and practicality. The imperative for faster and more precise real-time counting methods in various applications remains a critical requirement. Studies comparing different algorithms illuminate the robustness and adaptability of methods like HoG in diverse scenarios. While these methods demonstrate promise, it is essential to address challenges, such as varying lighting conditions, through further research.

In summary, our reviews and research studies unveil numerous opportunities and potential for advancement in the fields of object detection, human counting, and density estimation. The application of standardized evaluation protocols and specialized algorithms serves as a catalyst for further progress in these domains. It is clear that these research contributions wield a significant impact on crucial areas like real-time applications, security, and crowd management. The ongoing collaborative efforts in the research community to establish unified evaluation protocols signal a commitment to enhance the rigor and comparability of evaluations in the field. As the field continues its forward momentum, the establishment of standardized evaluation protocols remains a pivotal area of focus, ensuring impartial and consistent assessments across diverse research endeavors.

SOFTWARE REQUIREMENT SPECIFICATION

1 Introduction

The Insightio platform provides crowd/object counting and tracking solutions for businesses. Users have the capability to establish an account, acquire a commercial license, set up cameras, and define the classes of tracked objects. In this section, Insightio is described in broad strokes.

1.1. Purpose

This SRS is about the Insightio platform, which provides solutions for crowd/object counting and tracking to businesses. In 1. Introduction section, we aimed to give a brief information about the purpose and scope of our system. The 2. General Description section splits into four parts: 2.1 Glossary, include any specialized jargon and terminology used by the system, 2.2 User Characteristics, explains the features of the users, 2.3 Overview of Functional Requirements, describes the functions briefly which are used in the system, 2.4 General Constraints and Assumptions, the system's limits and expectations are defined. The following section, 3. Specific Requirements, comprises three units:

3.1 Interface Requirements, which delineates features for the user interface, such as account setup, camera configuration, and access to statistical data. 3.2 Detailed Function Requirement describes functions with specifications designed based on test-ability principles. 3.3 Non-Functional Requirements elucidate performance and hardware type requirements. The 4. Analysis UML section is composed of two parts: 4.1 Use Cases : This section elaborates in detail on how users will interact with the system and carry out tasks. 4.2 Functional Modeling (DFD): This section, demonstrating the system's boundaries through data flow diagrams, assists us in comprehending the functioning of the system. Additionally, it clarifies the relationships between objects through a data dictionary. The 5. References section encompasses the resources used in the document, including literature, documents, and source materials referenced during analysis and design.

1.2. Scope

The Insightio platform offers crowd/object counting and tracking solutions for businesses. When businesses need periodic statistics on specific object counts, they can utilize the Insightio platform.

A business looking to use the platform must first create an account and purchase a suitable license for commercial use. Once the business has an account on the platform, they can begin their operations by adding cameras and specifying the object classes they want to track. Optionally, they can limit counting in certain areas on camera images.

Once a customer defines and configures cameras on the platform, they can access statistics related to the previously determined object counts. When camera configurations are complete, Insightio performs the real counting and tracking of objects. The data on the number of objects captured by the platform is processed to create visualizations, such as graphs and drawings, presenting statistics based on the preferred time frame (day, week, month, year, etc.) for the user.

2 General Description

This section provides a foundational overview of Insightio, starting with a glossary to define essential terms. It then outlines the characteristics of users before delving into the system's functional requirements, emphasizing user interface design. The subsequent exploration encompasses general constraints and assumptions that shape Insightio's operational context.

2.1. Glossary

User	Individuals who use and interact with the application for various purposes.
Actor	Any entity, including users or other software systems, that interacts with the primary system.
Object Detection	A computer vision technique that enables systems to identify objects in digital images, videos, and visual inputs.
Computer Vision	A subfield of Artificial Intelligence focused on making systems see and recognize objects using visual inputs.
YOLO Models	YOLO Models are a type of object detection algorithm used in computer vision.
Javascript	A scripting language commonly used to enhance the interactivity and functionality of web pages.
SvelteJS	A JavaScript framework used to build user interfaces.
Kotlin	A programming language often used for developing Android applications.
Python	A versatile programming language widely used for various applications.

2.2. User Characteristics

Understanding the diverse characteristics of the intended user groups for the Insightio platform is paramount for designing an interface and functionalities that align with their needs and capabilities. The following user categories are suggested to represent a varied user base:

- Business Owners and Administrators: Business owners and administrators exhibit diverse educational backgrounds, ranging from business management to technical expertise. With substantial industry experience, their focus is on strategic decision-making. Their moderate to high technical proficiency enables them to comprehend the business implications of technical features.
- Operations Managers: Operations managers bring varied educational backgrounds, including operations management and technology. With substantial experience in day-to-day operations management, they possess moderate technical proficiency and are comfortable with the operational aspects of the platform.

- Security Personnel: Security personnel encompass diverse educational backgrounds, emphasizing security and emergency management. With substantial experience in security operations, they exhibit moderate to high technical proficiency, particularly in using real-time tracking features.

- Data Analysts: Data analysts typically hold degrees in data science, statistics, or related fields. With a strong analytical background and experience in interpreting statistical visualizations, they demonstrate high technical proficiency for in-depth data analysis.

- General Users: General users have varied educational backgrounds, including non-technical fields. With limited to moderate experience in data analysis tools, they exhibit limited technical proficiency and prefer user-friendly interfaces.

- Technical Support Staff: Technical support staff possess technical degrees or certifications related to IT support. With extensive experience in providing technical support, they have high technical proficiency and are capable of troubleshooting and resolving technical issues.

2.3. Overview of Functional Requirements

With solutions for crowd and object monitoring, Insightio is a strong platform that meets the counting and tracking needs of businesses. The technical backbone of the platform is composed of a server with that directly communicates with an object tracking software.

2.3.1. Designing User Interfaces:

- Account Creation: Simplified procedure for opening an account.
- License Procurement: Secure and efficient commercial license acquisition.
- Camera Setup: Tracking zones and object classes are intuitively configured.
- Statistics Access: User-friendly presentation of statistical data through charts.

2.3.2. Overview of Functional Requirements:

- User authentication: Strong security to allow users to log in.
- Email Verification: Safely validate user accounts' emails.
- License management is the effective administration of business licenses.
- Camera Configuration: An easy-to-use configuration for both object tracking and cameras.
- Zone Definition: Creating polygonal zones for accurate tracking.
- Object Counting and Tracking: Reliable tracking is achieved with server-side scripts.
- Data processing: Optimized server-side operations to ensure effective data transfer.
- Object count statistics are visualized statistically using dynamic charts.
- User Password Reset: Safe methods for changing passwords.
- Error handling and logging: all-inclusive troubleshooting systems.

2.4. General Constraints and Assumptions

Insightio operates within a framework of constraints and assumptions that influence its functionality and user interactions. Understanding these factors is crucial for a comprehensive perspective on the platform's capabilities.

2.4.1. Constraints

- Technology Compatibility: Supervision and YOLO models are integrated with Javascript, SvelteJS, Kotlin, and Python to form the foundation of Insightio. The compatibility of these technologies may impose limitations or restrictions that could affect the platform's functionality.

- Network Dependency: In order to ensure smooth data transfer between the server and frontend, the platform relies on a dependable network connection. The processing and visualization of data in real time may be impacted by any network connectivity issues or disruptions.

- User Compliance: It is anticipated that users will abide by license agreements and system guidelines. Access to specific features or services may be restricted in the event of non- compliance.

- Security Regulations: User authentication, data transmission, and system integrity all depend on adherence to security measures. Violating security protocols may compromise user data integrity and confidentiality.

2.4.2. Assumptions

- User Environment: It is anticipated that users will use common web browsers with JavaScript enabled to access Insightio. Any modifications to this assumed user environment could have an effect on the platform's usability and functionality.

- Email Reliability: Users' access to a dependable email service is assumed by the email verification process. Email delivery issues or delays might cause problems with the registration and verification procedures.

- Camera Functionality: Insightio makes the assumption that the platform's cameras are operational and able to take the desired pictures. Accurate object counting and tracking may be impacted by any hardware issues or camera capacity restrictions.

- Server Reliability: The platform counts on the client-side scripts that track and count objects to run consistently and dependably. Real-time tracking and data processing may be momentarily hampered by server outages or performance problems.

- Data Integrity: The accuracy and integrity of the data depends on the cameras being configured correctly and the object counting algorithms operating as meant. Inconsistencies in statistical visualization can result from deviations.

- Legal Compliance: It is expected of users to follow the laws governing the use of recording devices and the privacy of personal information. Legal violations and illegal use of the platform might be outside of Insightio's responsibility.

3 Specific Requirements

Insightio is a comprehensive platform designed to address the counting and tracking needs of businesses, offering solutions for both crowd and object monitoring. This section outlines the specific requirements that govern the functionality and user interface of the Insightio platform. The following subsections detail the interface requirements and provide a comprehensive description of the functional and non-functional requirements, each formulated to be precise, testable, and directly aligned with the project's objectives.

3.1. Interface Requirements

The interface of Insightio is designed to provide an intuitive and user-friendly experience for businesses seeking crowd and object counting solutions. The specifications for the user interface, such as account setup, camera configuration, and statistical data access, are described in this section.

3.1.1. Account Creation

- The system shall provide a user registration page with fields for username, email, and password.
- System must allow passwords to be at least 8 characters long and to include at least one uppercase, one lowercase, one special character and one number.
- Upon successful registration, the system shall send a confirmation email to the provided email address for account verification.
- The user interface shall include a login page with fields for username and password.
- Users shall have the option to reset their password via a 'Forgot Password' link on the login page.

3.1.2. License Procurement

- After successful login, users shall be able to access a section for procuring a commercial license.

- The license procurement process shall guide users through selecting the appropriate licensing options and making the necessary payments securely.

3.1.3. Camera Setup

- The system shall provide a dashboard for users to add and configure cameras.
- Users shall be able to specify the class of objects they intend to track for each camera.
- Optionally, users may define polygonal zones on camera images to restrict counting to specific areas.

3.1.4. Statistics Access

- Upon successful camera configuration, users shall have access to statistical information related to the tracked subject such as average population, rush and non-peek hours.
- The platform shall offer an intuitive interface for users to view and interact with the generated charts and plots.

3.2. Detailed Description of Functional Requirements

The particular functional requirements that specify how the Insightio platform behaves are described in this section. Each functional requirement listed here is designed with the ideas of precision and testability in mind.

3.2.1. User Authentication

- The system shall authenticate users based on their provided username and password.
- System must log every login attempt for observability and reliability.
- Failed login attempts shall trigger appropriate error messages for incorrect credentials.
- Successful authentication shall grant users access to their personalized dashboard.

3.2.2. Email Verification

- Upon successful registration, the system shall send a verification email to the provided address.
- Users must confirm their registration by clicking the verification link within the email.

3.2.3. License Management

- Users shall be able to select and purchase a suitable commercial license from the available options.
- The system shall generate and associate a unique license key with each purchased license.

3.2.4. Camera Configuration

- Users shall be able to add new cameras to their account, providing necessary details such as camera name and IP address.
- For each camera, users shall be able to specify the class of objects they wish to track.

3.2.5. Zone Definition

- Optionally, users may define polygonal zones on camera images to restrict counting to particular areas of interest.
- The system shall provide an intuitive interface for users to draw and modify these zones.

3.2.6. Object Counting and Tracking

- Once cameras are configured, a server-side script shall execute to perform object counting and tracking.
- The script shall run concurrently for each active camera, relaying gathered information to the server.

3.2.7. Data Processing

- The server shall process the received data from active cameras for transmission to the platform's frontend.
- Data processing shall include aggregation and formatting of object count information.

3.2.8. Statistical Visualization

- The platform shall generate charts and plots based on the received object count data.
- Users shall have the ability to select specific time periods (day, week, month, year, etc.) for visualization.

3.2.9. User Password Reset

- The system shall allow users to reset their password by providing their registered email address.
- A password reset link shall be sent to the user's email for security verification.

3.2.10. Error Handling and Logging

- The platform shall implement robust error handling mechanisms to gracefully manage unexpected events.
- Detailed logs shall be maintained to track system behavior and aid in debugging processes.

3.3. Detailed Description of Non-Functional Requirements

This section outlines the non-functional requirements essential for the effective implementation and performance of Insightio. Non-functional requirements encompass aspects such as system reliability, performance, security, and user experience. The specifications in this section provide a foundation for evaluating and ensuring the overall quality and effectiveness of the Insightio platform.

3.3.1. Security

- The system must guarantee data transmission that is both secure and protected from threats.
- The system must protect user data privacy and forbid unauthorized access.
- The platform should have multi-factored authentication such as email verification to improve security.
- Logs should be used to monitor actions of users, system events and modifications, ensuring auditing.

3.3.2. Performance

- The system must operate efficiently with little lag time at 30 ms maximum.
- Response times for tracking should not vary by more than 20% during peak and off-peak hours.

3.3.3. Fault Tolerance

- The system should include redundancy planning to make sure backup systems to take over in cases where core components break down.
- Services must be designed to be isolated from each other, preventing the spread of faults and impacting functionality of other components.

3.3.4. Maintainability

- The system should evolve to meet the changing needs such as the subject being tracked.
- The system should be able to scale horizontally to work with an increasing number of cameras and users.
- Software should be designed such that it optimizes utilization of resources such as CPU load and memory consumption to ensure efficient performance.
- Software should be able to integrate with other components such as third party tools.

3.3.5. Internationalization and Localization

- The system should be easily adaptable to different languages and cultural preferences in cases where in the future, users of different regions can benefit from the usage of the application.

3.3.6. Server System Capacity

- The server infrastructure, including CPU, GPU and storage, must be capable of handling the computational load generated by real-time tracking and data processing.

3.3.7. Connection

- Connection must remain continuous with cameras to ensure real-time tracking, it should automatically attempt to reconnect in cases where connection is lost.

3.3.8. Usability

- User interfaces must be designed such that it's easy to use, accessible and consistent by users. Software should be tested thoroughly in order to ensure user experience is seamless and useful.

3.3.9. Documentation

- Documentation should be provided to end users demonstrating the usage and the benefits of the system.
- Technical documentation should also be included for developers such as API documentation.

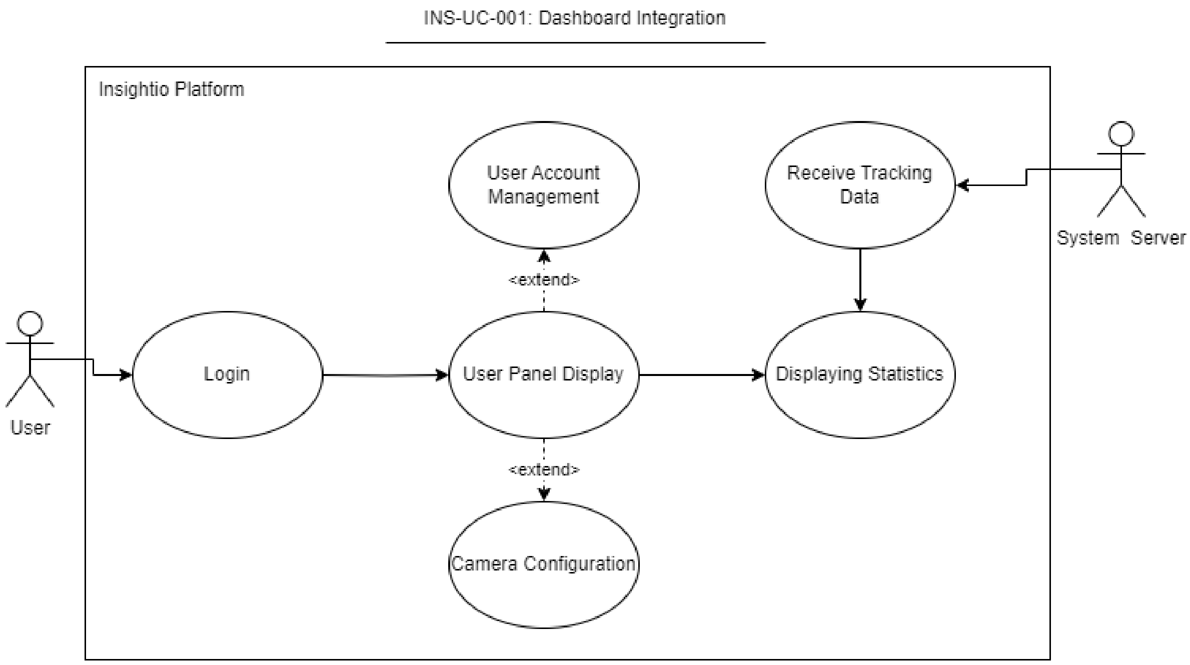
3.3.10. Data Accuracy

- The tracking algorithm must have an accuracy rate of at least 90%, and statistical reports created by the system should include precise and up-to-date information.

4 UML - Use Cases

Use cases in Insightio represent essential functionalities that cater to the diverse needs of its users. Each use case encapsulates a specific interaction scenario within the platform, contributing to its overall functionality.

4.1. INS-UC-001: Dashboard Integration



Use Case Name: INS-UC-001

Related Use Cases: INS-UC-005

Actors: User

Description: Utilizing the Insightio platform enables seamless crowd and object counting, providing businesses with valuable statistics and insights. The process begins with creating an account and obtaining a commercial license. After registration, businesses configure cameras and optionally define restricted counting areas. Insightio then takes control of real-time counting and tracking.

The platform offers a user-friendly interface, providing access to comprehensive statistics and presenting graphs and drawings based on the user-defined time intervals. This allows businesses to make data-driven decisions, optimize operations, and gain effective insights into object counts within their operational environments.

Preconditions:

- User must have internet connection
- User must have an account and must login

Postconditions: -

Main Flow for INS-UC-001:

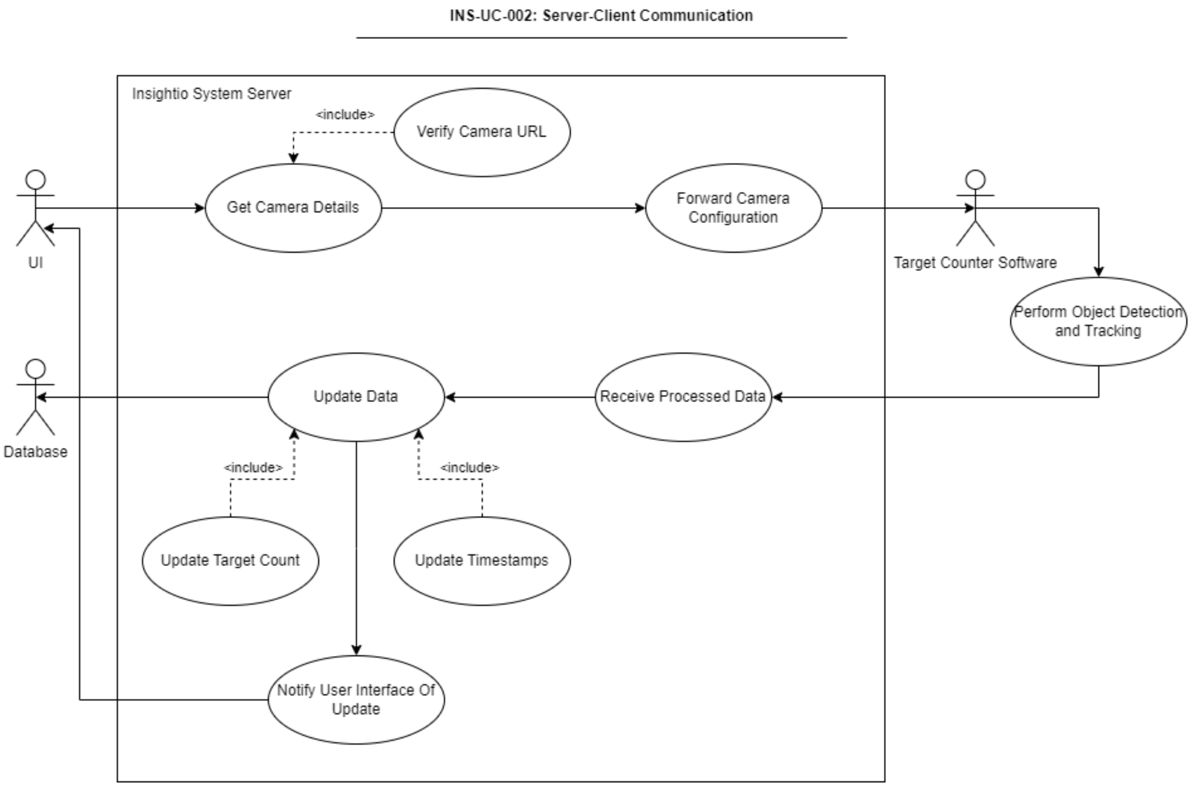
1. The user logs into the Insightio platform with valid credentials.
2. The system authenticates the user successfully.
3. After successful authentication, the system displays the user dashboard.
4. The user navigates to the statistics section through user interface.
5. The system retrieves statistical data based on the configured cameras and tracking settings.
6. The retrieved data is presented to the user through visualizations such as charts and plots.

Alternate Flow for INS-UC-001:

2.a. If the user fails to authenticate, an error message is displayed, and feedback is provided to try logging in again.

4.a. If the user encounters issues executing functions in the user panel due to internet or system problems, they receive an error message.

4.2. INS-UC-002: Server-Client Communication



Use Case Name: INS-UC-002

Related Use Cases: INS-UC-003

Actors: Target Counter Software, Database, UI

Description In this use case, the process begins with the user configuring the camera through the interface, followed by the verification of the camera device URL, which is then sent to the tracker software for object detection and tracking. The tracker software reports the total target count within the designated time frame, and this data is subsequently inserted or updated in the database for continuous monitoring. In the event of potential errors, the system is equipped to handle them effectively. If the camera device URL cannot be verified, an error is promptly returned to the user interface, ensuring transparency about the issue. Similarly, if the tracker software fails to send data, the server patiently waits until new data is received, preventing data loss. Additionally, in cases where data transmission encounters errors, the system ensures proper error handling by returning an error message to the user interface. These error-handling mechanisms contribute to the overall reliability and resilience of the target counting system, ensuring a smooth user experience.

Preconditions:

- Stable connection to a valid camera device.
- Stable connection to database service.

Postconditions:

- Tracking target counts in the database are updated.
- Alternatively, if update/insertion fails, the server waits until tracker software sends new data in the next time frame.

Main Flow for INS-UC-002:

1. Camera configuration is received from the user interface.
2. Camera device URL is verified and sent to the tracker software.
3. Tracker software performs object detection and tracking.
4. In a given time frame, tracker software sends total target count at the end of that time frame.
5. Data is received from the tracker software and is inserted or updated in the database.
6. The same is done for the following time frame(s).
7. When the user asks to see target count data, count data is transmitted to the user interface.

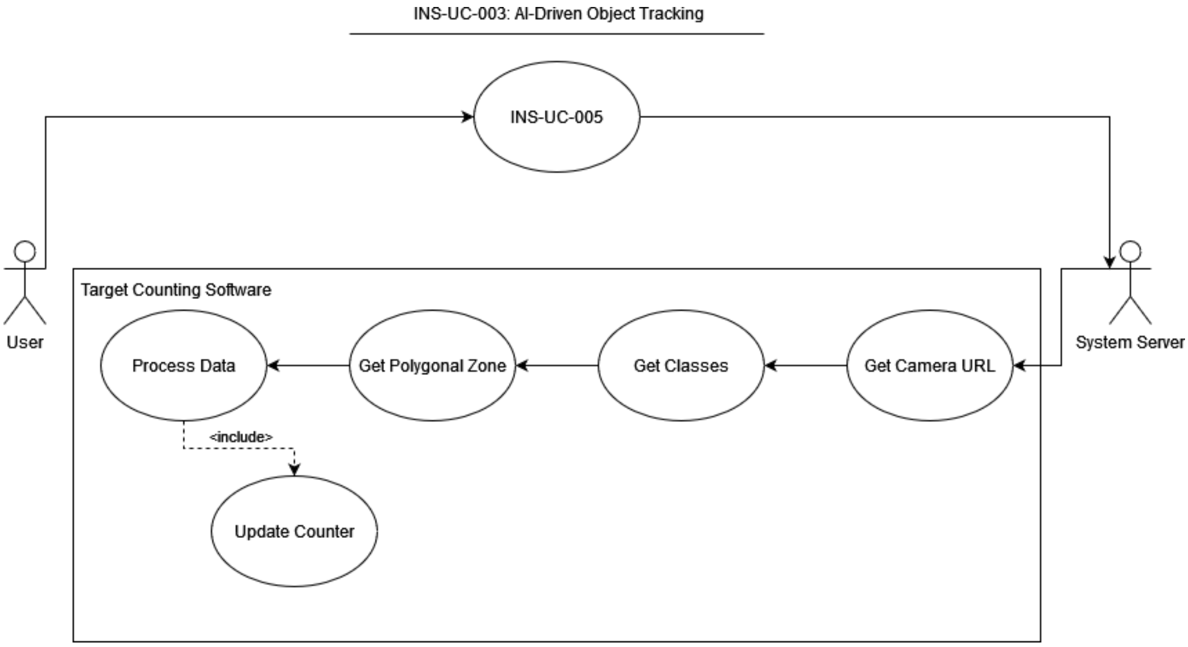
Alternative Flow for INS-UC-002:

2.a. If camera device cannot be verified with the provided URL, an error is returned to the user interface.

4.a. If the tracker software fails to send the data, the server waits until new data is received.

7.a. Should data transmission fail, an error is returned to the user interface.

4.3. INS-UC-003: AI-Driven Object Tracking



Use Case Name: INS-UC-003

Related Use Cases: INS-UC-005

Actors: User, System Server

Description: In the Insightio platform workflow, users initiate the process by retrieving essential information, such as the camera URL, and ensuring system connectivity to the video source. They then acquire knowledge about available object classes to customize tracking capabilities. Users can define polygonal zones on camera images, focusing counting efforts on specific regions. With these configurations in place, the system proceeds to process data, establishing connections and employing advanced AI algorithms for object recognition and tracking. This seamless workflow enables comprehensive data processing and analysis within the Insightio platform.Periodic updates of counters occur when trackers are identified. This structured sequence ensures that the Insightio platform is optimally configured to efficiently count, and track objects based on user-specified criteria.

Preconditions:

- The user is logged into the Insightio platform.
- The user has navigated to the camera setup and configuration section.

Postconditions:

- The camera is successfully configured with the provided settings.
- The system is connected to the specified video source.
- Object classes are identified and available for tracking.
- Polygonal zones, if defined, are established on the camera images.
- The system is ready for data processing and analysis.

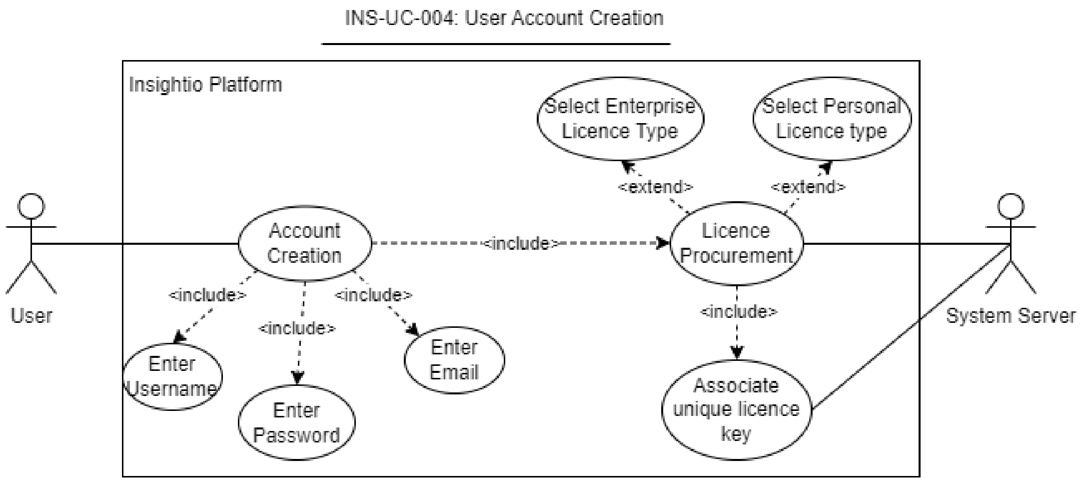
Main Flow for INS-UC-003:

1. User provides the camera URL to ensure system connectivity.
2. User acquires information about available object classes.
3. User defines polygonal zones on camera images for concentrated counting efforts.
4. User reviews and confirms the preliminary configurations.
5. The system processes data by establishing connections, applying AI algorithms, and initiating the periodic update of counters when trackers are identified.

Alternative Flow for INS-UC-003:

5.a. If there is an issue establishing connections or applying AI algorithms, the system returns an error message, and the user interface displays the error to the user.

4.4. INS-UC-004: User Account Creation



Use Case Name: INS-UC-004

Related Use Cases: -

Actors: User, System Server

Description: The procedure through which a user creates an account on the Insightio platform is represented by this use case. It includes necessary actions like supplying an email address, generating a username, and establishing a strong password. Furthermore, users can extend this process by obtaining a license during account creation, for personal or enterprise use. A distinct license key produced by the system server is associated with the license procurement process.

Preconditions:

- The user has access to the Insightio website.
- The user has a stable internet connection.
- The user has not created an account on Insightio with the provided email address.

Postconditions:

- The user has successfully created an account on Insightio.
- If selected, the user has procured a license during the account creation process.
- If a license was procured, the system has associated a unique license key with the user's account.

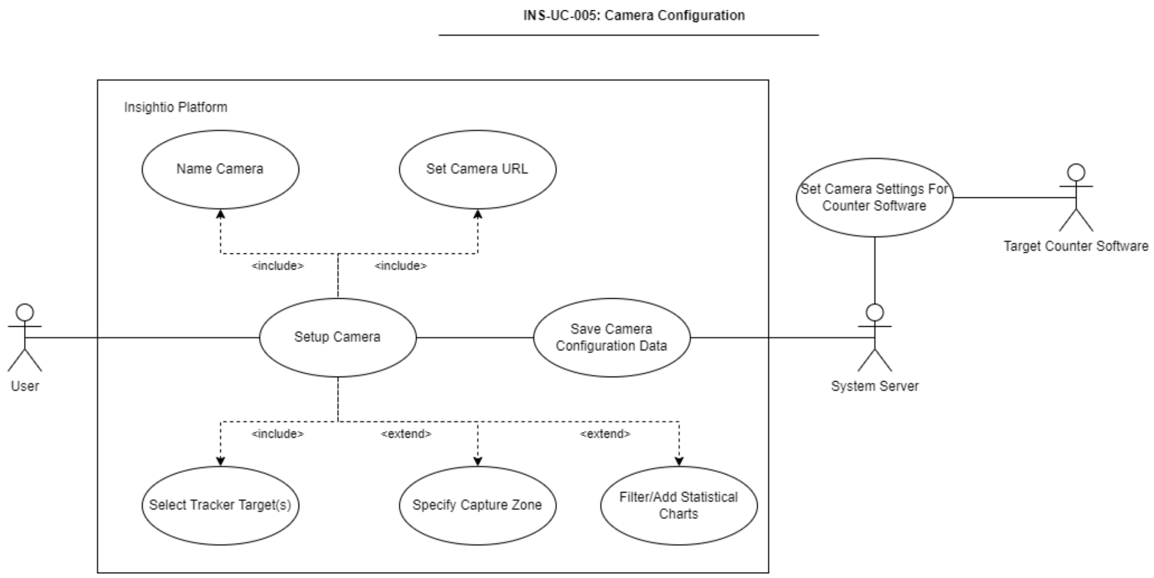
Main Flow for INS-UC-004:

1. The user initiates the account creation process by visiting the Insightio website.
2. The system prompts the user to enter their email address, desired username, and a secure password.
3. Upon successful submission, the system verifies the provided information and creates a new user account.
4. Optionally, the user may choose to extend the account creation process by selecting either an enterprise or personal license procurement.
5. If the user selects a license, the system guides them through the license procurement process, associating a unique license key generated by the system server with the user's account.

Alternative Flow for INS-UC-005:

4.a. If there is an issue during the license procurement process (e.g., payment failure), the system provides appropriate error messages.

4.5. INS-UC-005: Camera Configuration



Use Case Name: INS-UC-005

Related Use Cases: -

Actors: User, System Server, Target Counter Software

Description: To initiate the recording of target counts, users must configure a camera through the platform interface. This setup involves assigning a name to the camera, specifying the URL of the camera device, and choosing target class(es) to inform the counting software about what to track. Optionally, at this stage, users can also establish capture zones known as polygon zones, concentrating counting efforts on specific regions within the camera feed. Users also have the option to choose or exclude statistical charts displaying the desired data from the captured camera feed. After completing the configuration, the camera settings are transmitted to the server for distribution to the counting software.

Preconditions:

- User logged into the system.
- User navigated to the camera configuration page.

Postconditions:

- A new camera is accepted as a data source or a an existing camera is given new targets.
- Alternatively, if provided device URL is invalid, camera configuration insertion or update fails.

Main Flow for INS-UC-005:

1. User specifies a camera name and provides the device URL.
2. User chooses target class(es) for tracking.
3. User optionally configures capture zones within the camera feed.
4. User optionally customizes statistical charts for desired data display.
5. User reviews and confirms the camera settings.
6. User transmits the configured settings to the server.
7. The server distributes the settings to the counting software.
8. Server confirms validity of device URL.
9. Counting software initiates recording based on the configured settings.

Alternative Flow for INS-UC-005:

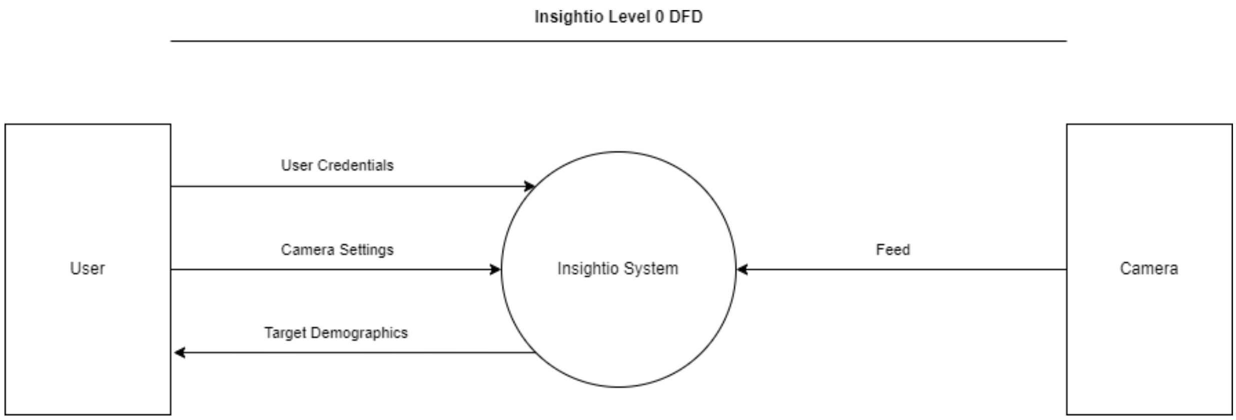
8.a. If the server cannot confirm the provided device URL belongs to a valid camera device, server does not forward the settings to the tracking software and returns an error to the user interface which the interface then displays to the user.

5 DFDs Overview

The Data Flow Diagrams (DFDs) for Insightio offer a concise portrayal of the system's data interactions. At Level 0, key components of the ecosystem are highlighted. These entities form the foundational structure, showcasing the primary data flows between users, cameras, and the Insightio System. The DFDs collectively illustrate the initial data pathways and entities that shape the broader Insightio data ecosystem.

5.1. Level 0

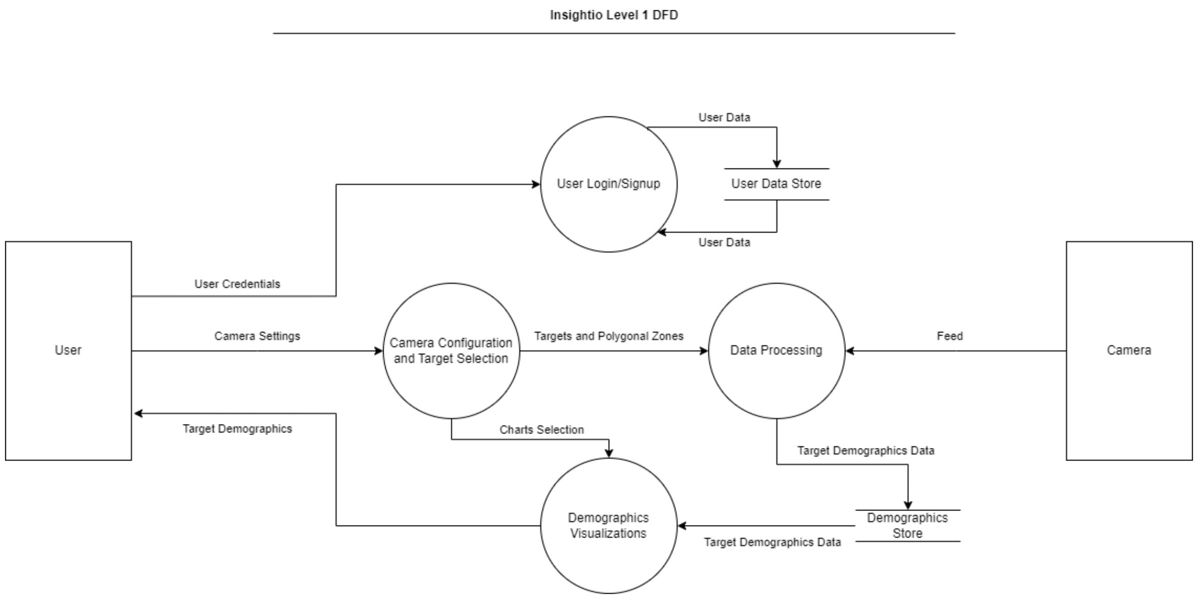
In Level 0, the Data Flow Diagram (DFD) accentuates pivotal external factors and entities integral to the initial data exchanges. This delineation encapsulates the data transactions between the Insightio System and users, incorporating the camera devices they utilize. As illustrated in the diagram, Insightio assumes the role of an intermediary, managing and interpreting camera feeds to enhance user convenience.



5.2. Level 1

Transitioning to Level 1, a more comprehensive exploration unveils specific processes and data stores, offering a detailed insight into the operations performed by the Insightio System. The diagram categorizes these operations into four main components: User Login/Signup, encompassing processes related to user account management; Camera Configuration and Target Selection, involving procedures for establishing camera connections and specifying demographic data targets; Data Processing, representing all processes related to extracting target demographics from camera feed frames; and Demographics Visualizations, consolidating processes designed to present demographic data to users through charts and plots.

This meticulous breakdown enriches understanding of the intricate data movements and processes within the Insightio platform, providing clarity from user interactions to data processing and visualization.



6 Conclusion

In summary, Insightio is a platform designed to meet businesses' crowd and object counting and tracking needs. This Software Requirements Specification (SRS) document provides an objective overview of the system's purpose, scope, and functional details.

The platform streamlines critical operations such user account creation, commercial license acquisition, camera setting, and statistical data access. It caters to a variety of user roles, including business owners, operations managers, security personnel, data analysts, general users, and technical support staff, with features tailored to their specific needs and technical competence.

The functional requirements emphasize clear and testable specifications and cover critical areas such as user authentication, license administration, camera setup, real-time tracking, and data processing. Security, performance, fault tolerance, maintainability, internationalization, server system capacity, connectivity, usability, documentation, and data accuracy are examples of non-functional requirements.

The use cases present practical situations exhibiting user interactions with the platform, hence assisting in a thorough knowledge of system functionality

In conclusion, Insightio is a comprehensive solution, and the requirements mentioned serve as a guide for the development process, ensuring the delivery of a secure, stable, and user-friendly platform.

SOFTWARE DESIGN DOCUMENT

1. Introduction

The Insightio platform provides crowd/object counting and tracking solutions for businesses. Users have the capability to create an account, obtain a commercial license, set up cameras, and define classes for monitored objects. This section explains the system designand user perspective of Insightio.

1.1. Purpose

Software Design Document provides a comprehensive overview of the architecture and system design of the Insightio application. In this document, functionality and systemdesign are explained from the user's perspective. Its purpose is to offer users a holistic view.

1.2. Definitions

Name	Definitions
User	Individuals who use and interact with the application for various purposes.
Actor	Any entity, including users or other software systems, that interacts with the primary system.
Object Detection	A computer vision technique that enables systems to identify objects in digital images, videos, and visual inputs.
Computer Vision	A subfield of Artificial Intelligence focused on making systems see and recognize objects using visual inputs.
YOLO Models	YOLO Models are a type of object detection algorithm used in computer vision.
Javascript	A scripting language commonly used to enhance the interactivity and functionality of web pages.
SvelteJS	A JavaScript framework used to build user interfaces.

Kotlin	A programming language often used for developing Android applications.
Python	A versatile programming language widely used for various applications.
Database	Organized collection of structured data, storing user settings, camera configurations, and statistical data for local processing in Insightio.
System Server	Component managing licenses in the current Insightio design, with potential future integration for enhanced license control and cloud-based solutions.
IP	Internet protocol
Id	Unique Identifier
UI	Interface between the user and the application

2. System Overview

The system is designed as a comprehensive platform offering users crowd and object counting capabilities, providing valuable statistical insights to businesses. Operating under the brand name "Insightio," the platform is accessible through a user-friendly web interface and offers simplicity from account creation to data analysis with the business-specific account.

Users engage with Insightio by creating accounts, a straightforward process involving the provision of basic details such as email addresses, usernames, and secure passwords. Users must extend their accounts by procuring licenses during the registration process, each associated with a unique license key.

The core functionality of Insightio revolves around real-time counting and tracking. Upon successful account creation and license procurement, users can configure cameras, define tracking settings, and initiate the counting process. The platform seamlessly communicates with cameras, retrieves data, and employs advanced AI algorithms for object recognition and tracking.

Users have the flexibility to configure cameras, provide device URLs, choose target classes, and define capture zones for concentrated counting efforts. The server manages the distribution of camera settings to the counting software, ensuring accurate and reliablerecording based on user-configured parameters.

In summary, Insightio is a versatile platform that caters to the needs of businesses seeking to leverage crowd and object counting for informed decision-making. With its user- centric design, robust functionality, and emphasis on real-time data analysis, Insightio stands as a valuable tool for businesses across various industries.

3. System Design

Insightio's system architecture is designed to support desktop applications, with the main purpose of providing businesses object counting and tracking solutions. Along with its 3 layered architecture, this design choice allows the application to be deployed locally on clients, offering centralized enhanced control, reduced dependency and direct management ofdata processing.

3.1. Architectural Design

Insightio's system architecture is conceived to empower a desktop application aimed at providing businesses with crowd and object counting and tracking solutions. Thisdesign choice allows the application to run locally on a client's machine, offering enhancedcontrol and direct management of data processing.

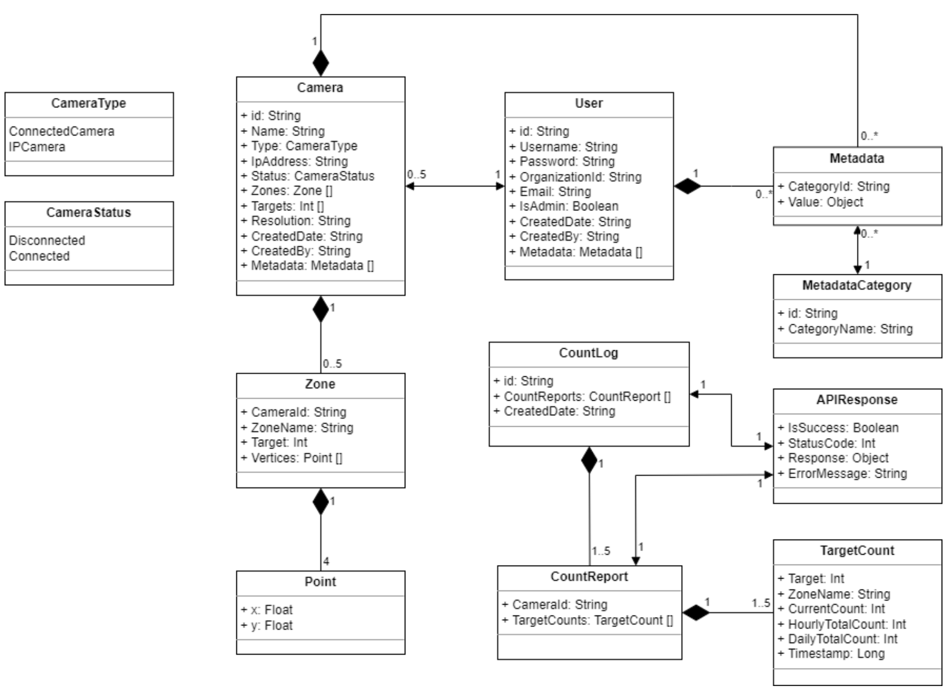
The architecture is segmented into three primary layers. The User Interface Layer, also called presentation layer, is tailored for simplicity and ease of use, enabling clients to seamlessly add cameras, configure object classifications, and define specific zones for counting within camera feeds. This layer is developed using desktop application technologies, ensuring a user-friendly experience.

In the Application Logic Layer, the core functionalities of Insightio are housed. This includes the execution of counting and tracking algorithms. It processes the configurations set by the user, managing the intricate interaction between the user interfaceand the data storage. By handling camera feed processing and object tracking tasks locally, the system ensures prompt response times and reduces dependency on continuous internetconnectivity or external servers.

The Data Storage Layer is integral for the secure storage and management of user data, also responsible for interaction with the application layer. This includes client- specific settings such as camera configurations and the statistical data derived from object counting and tracking. The emphasis is on data integrity and security within the local operational environment of the client's desktop application. Insightio mainly stores tracking data, user data, camera configuration, zone definitions and logs.

While the current architecture primarily focuses on local data handling and processing, Insightio envisions the future integration of a central server. This server would primarily be responsible for controlling the licenses of each desktop application. Additionally, while not currently implemented, there's potential for incorporating cloud- based solutions in the future, particularly for data backups and enhanced data accessibility,catering to the evolving needs of the business.

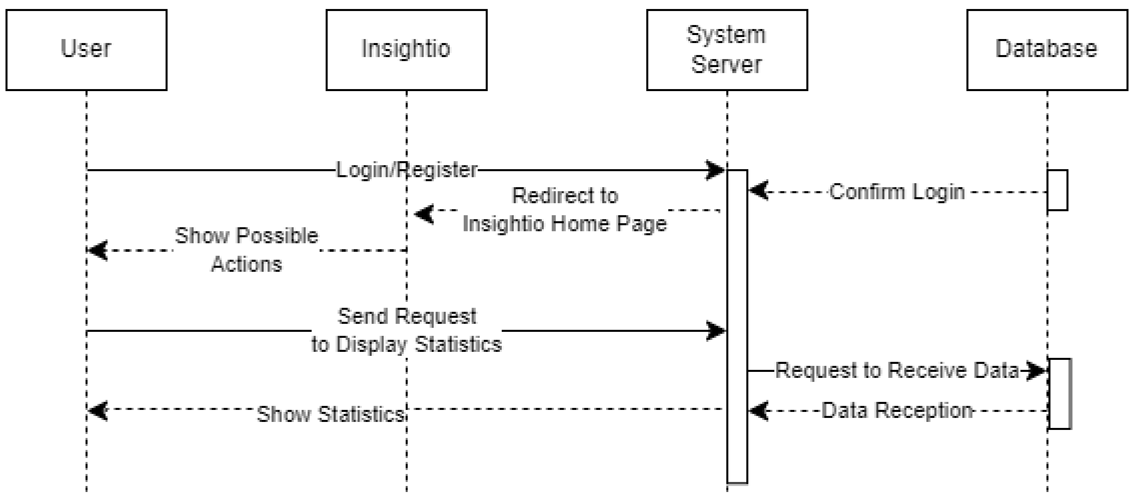
3.2. Decomposition Description



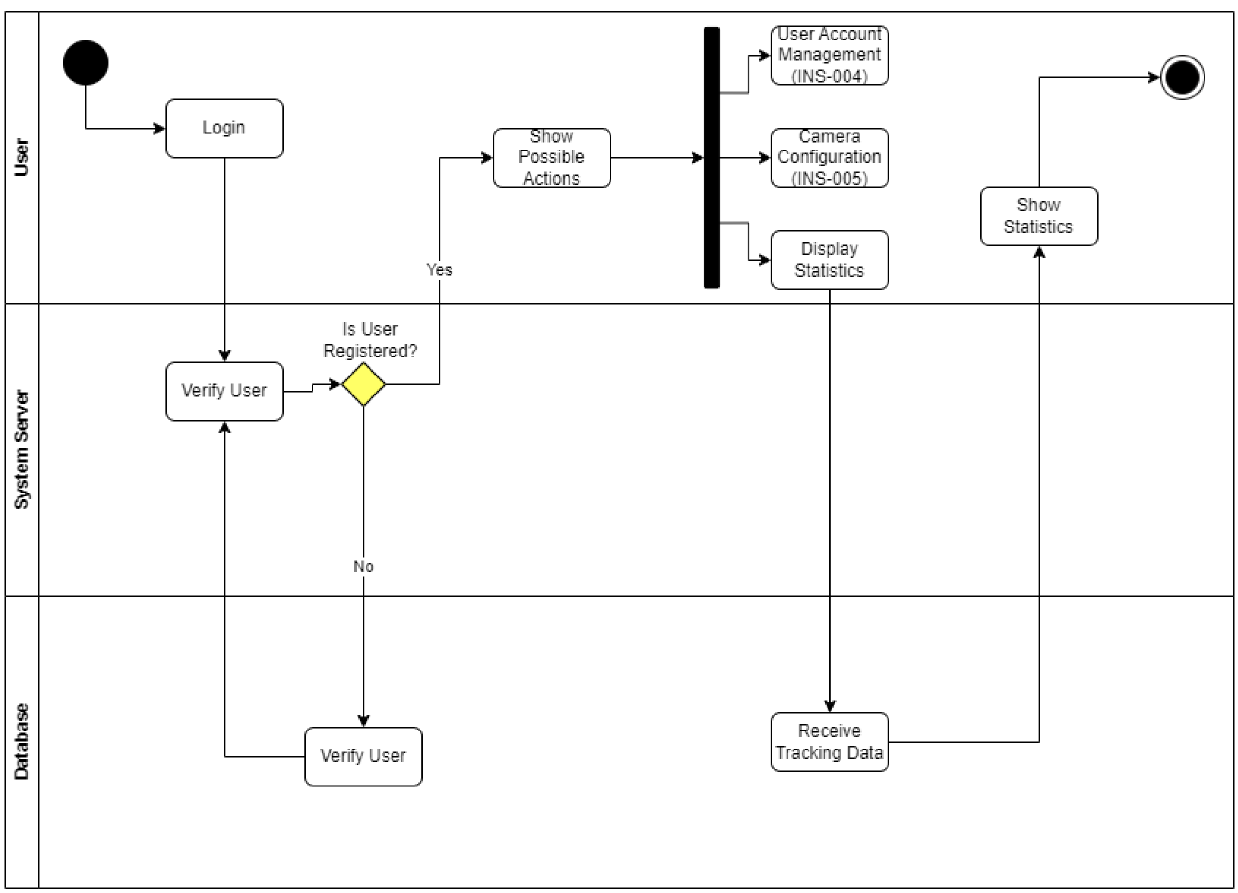
4. System Modeling (Activity & Sequence Diagrams)

INS-UC-001: Dashboard Integration

Sequence Diagram

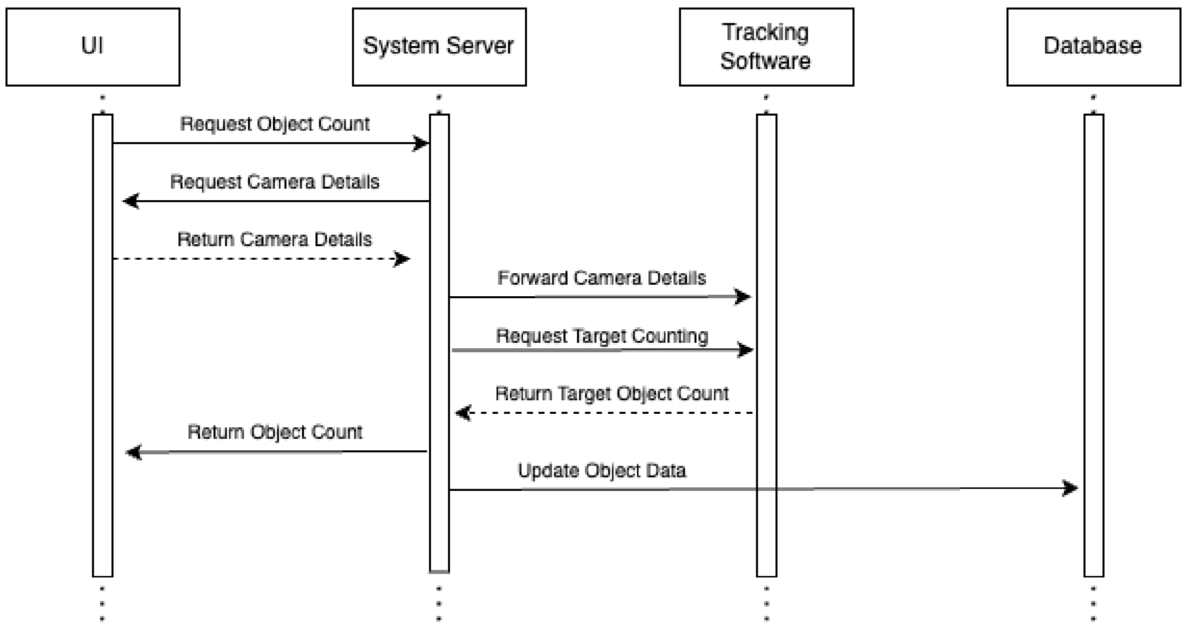


Activity Diagram

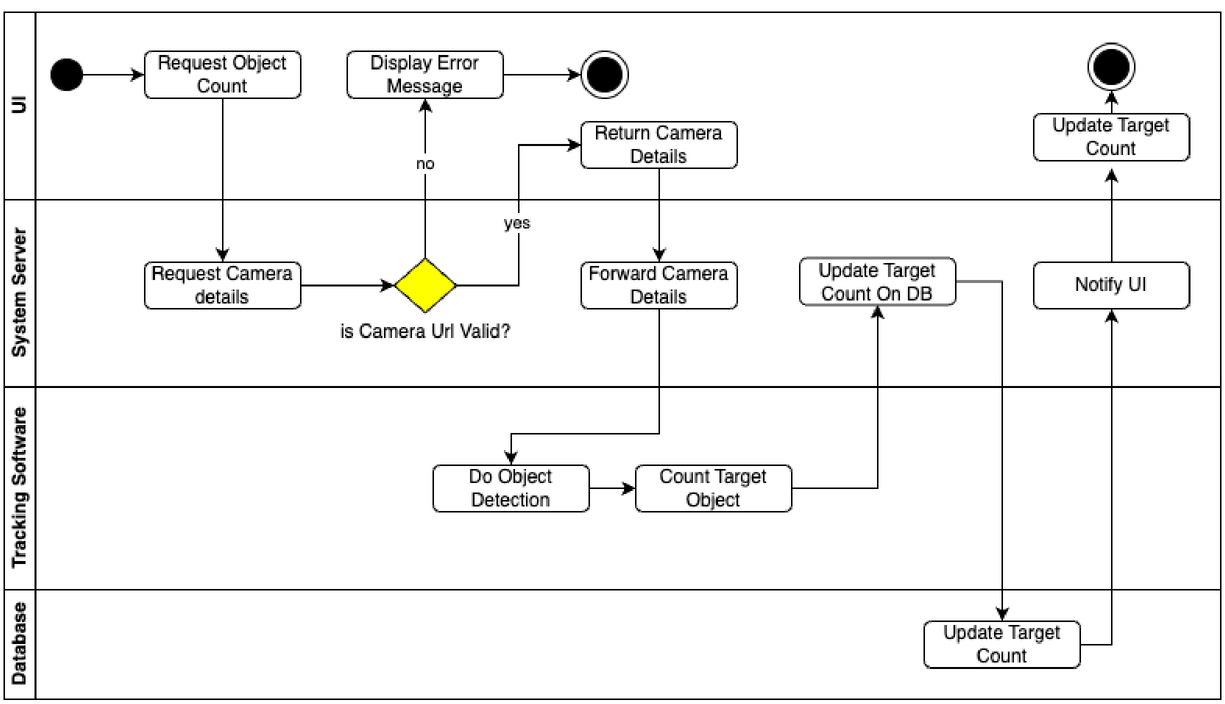


INS-UC-002: Client-Server Communication

Sequence Diagram

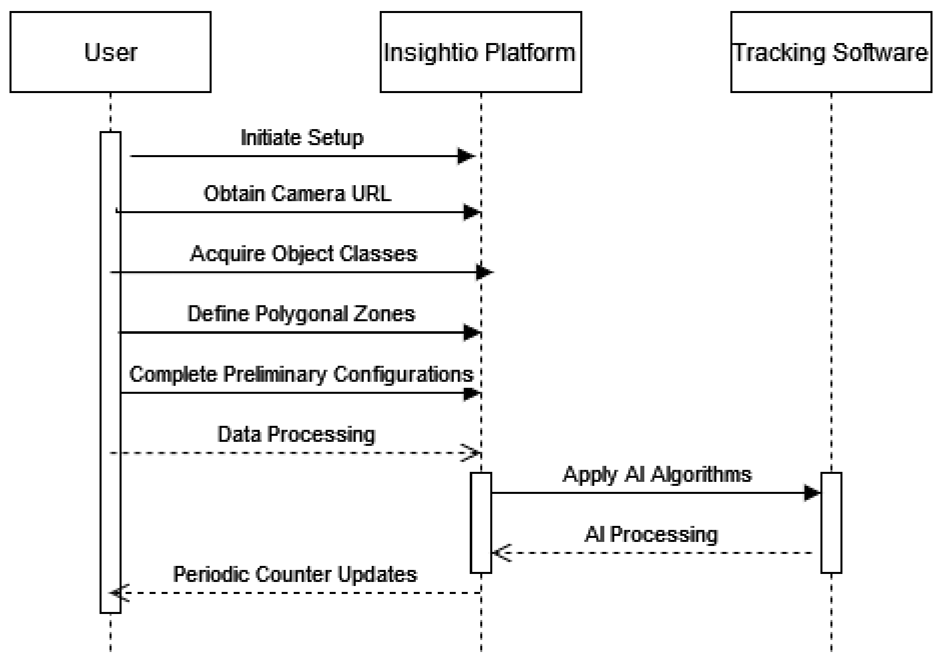


Activity Diagram

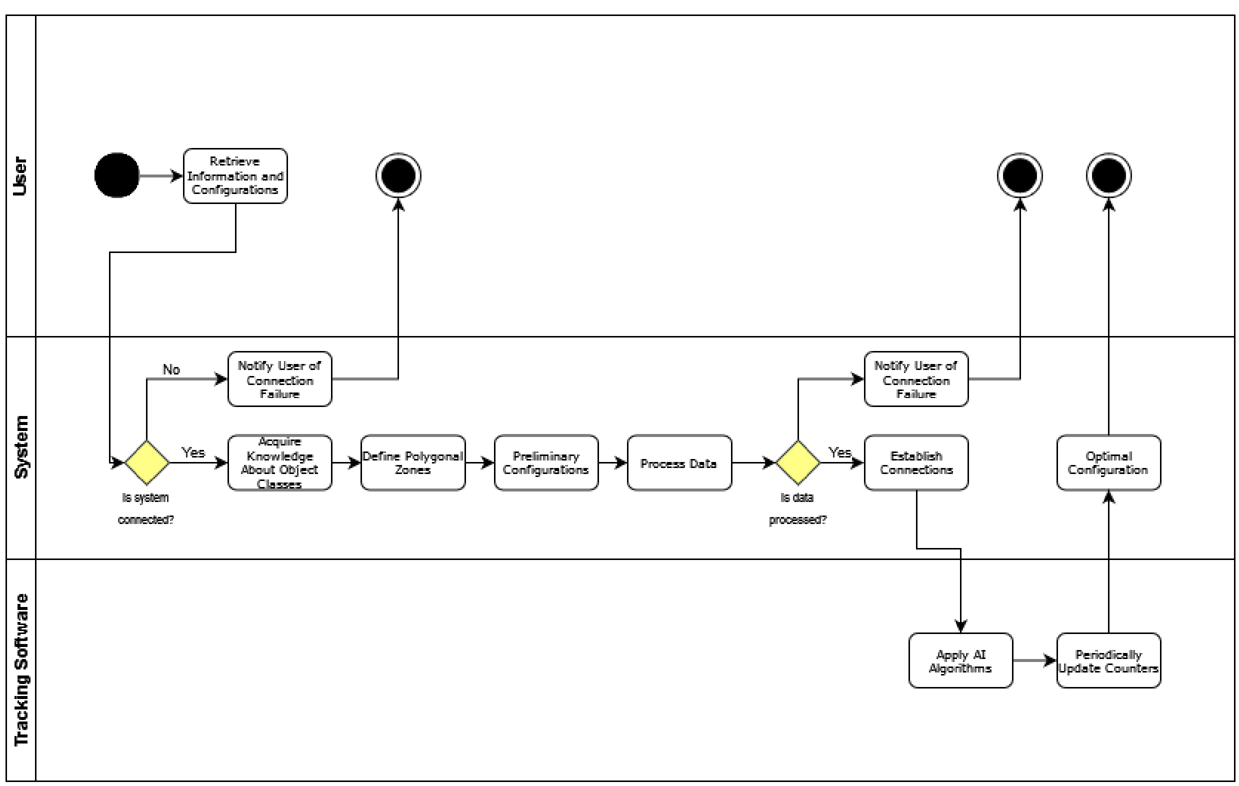


INS-UC-003: AI Driven Object Tracking

Sequence Diagram

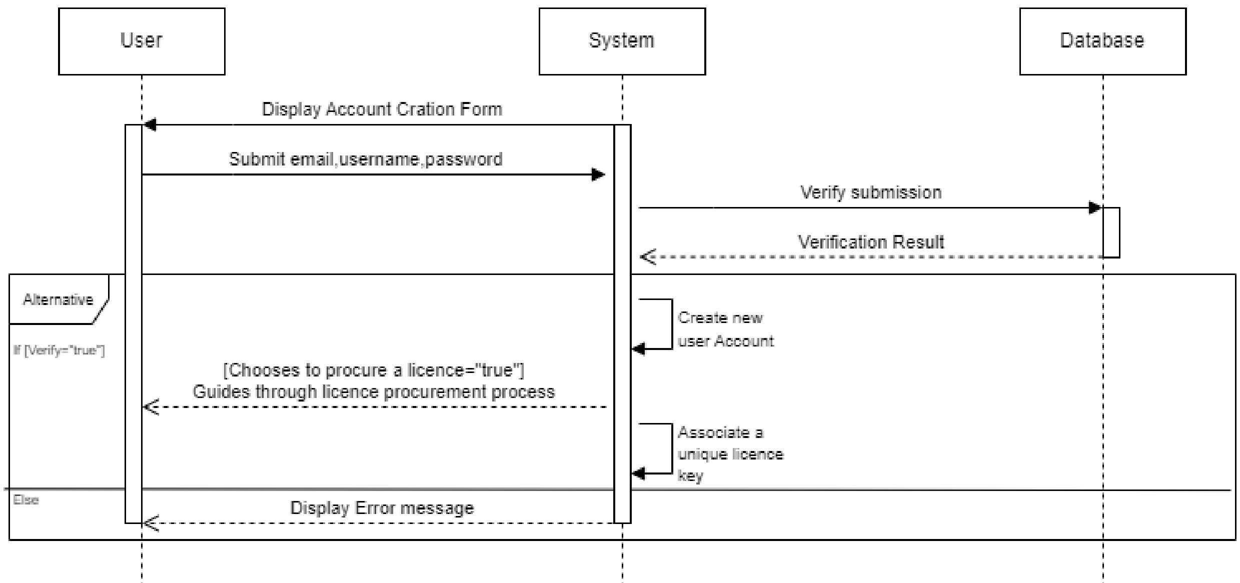


Activity Diagram

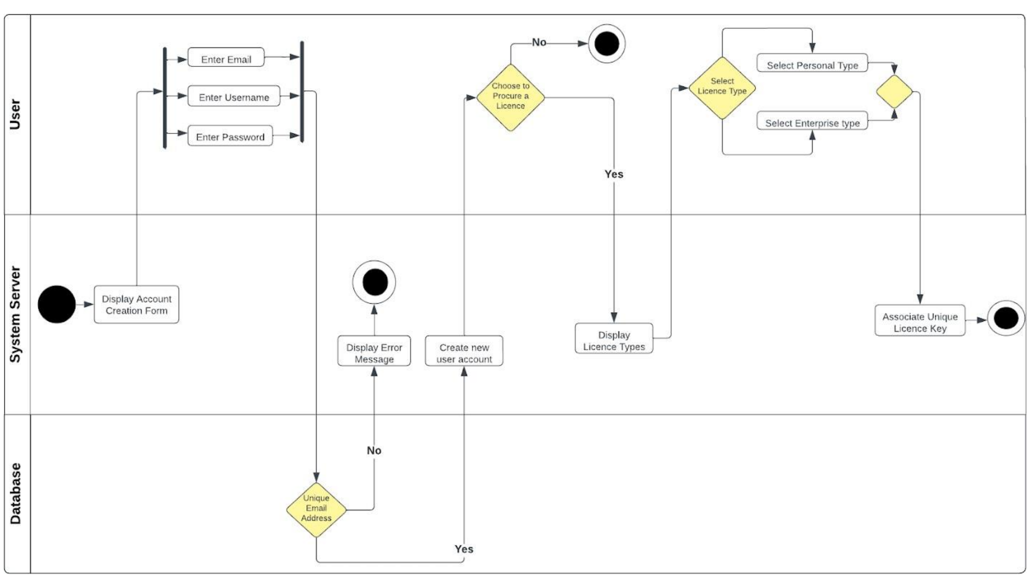


INS-UC-004: User Account Creation

Sequence Diagram

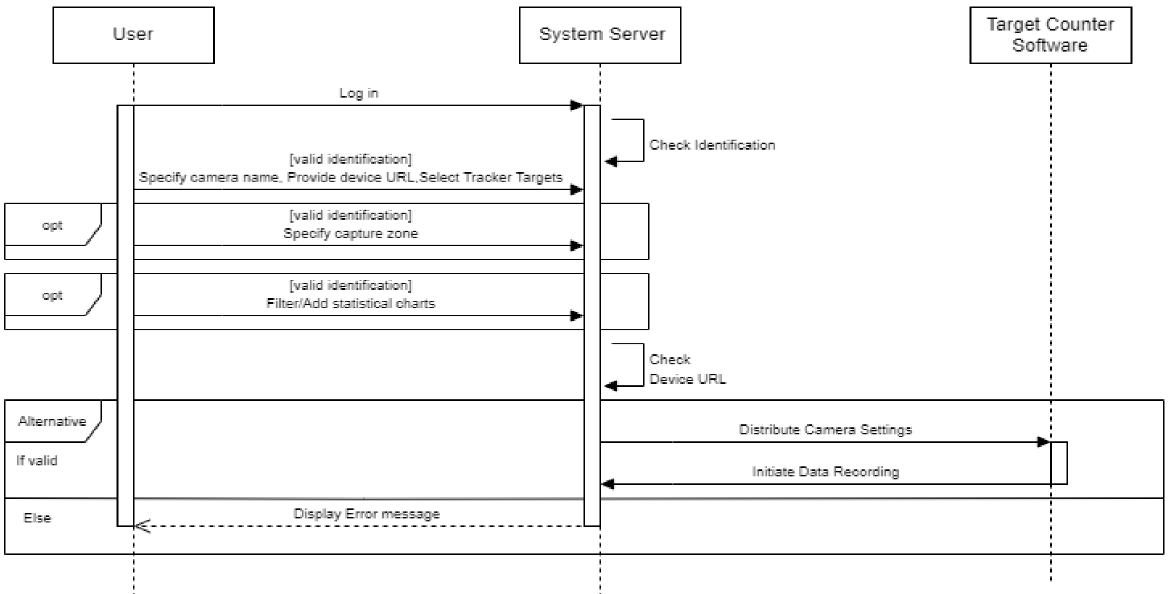


Activity Diagram

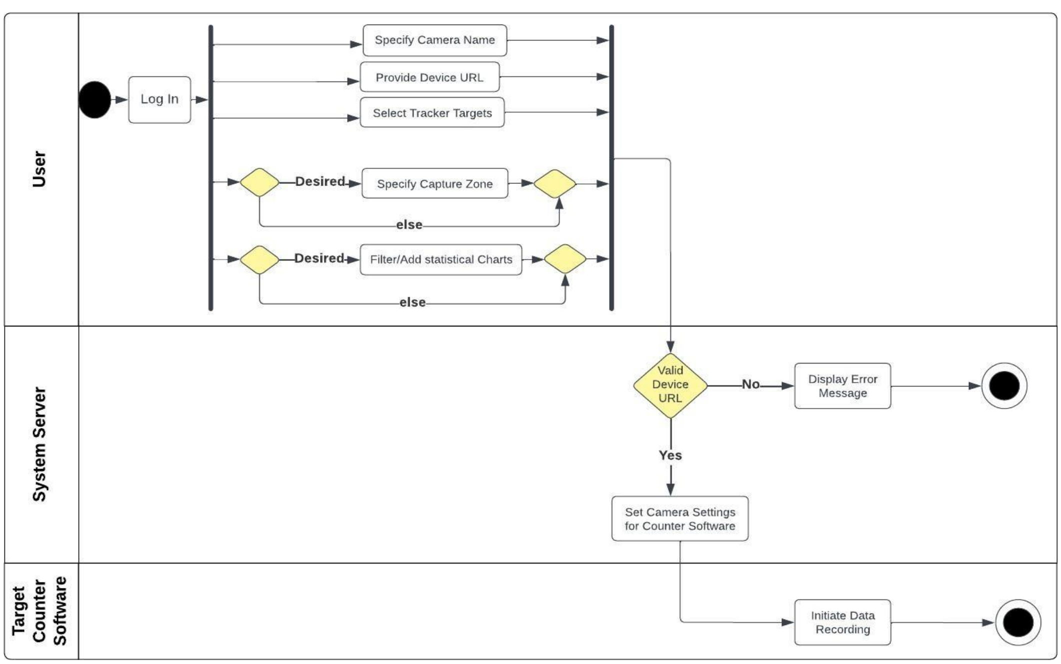


INS-UC-005: Camera Configuration

Sequence Diagram

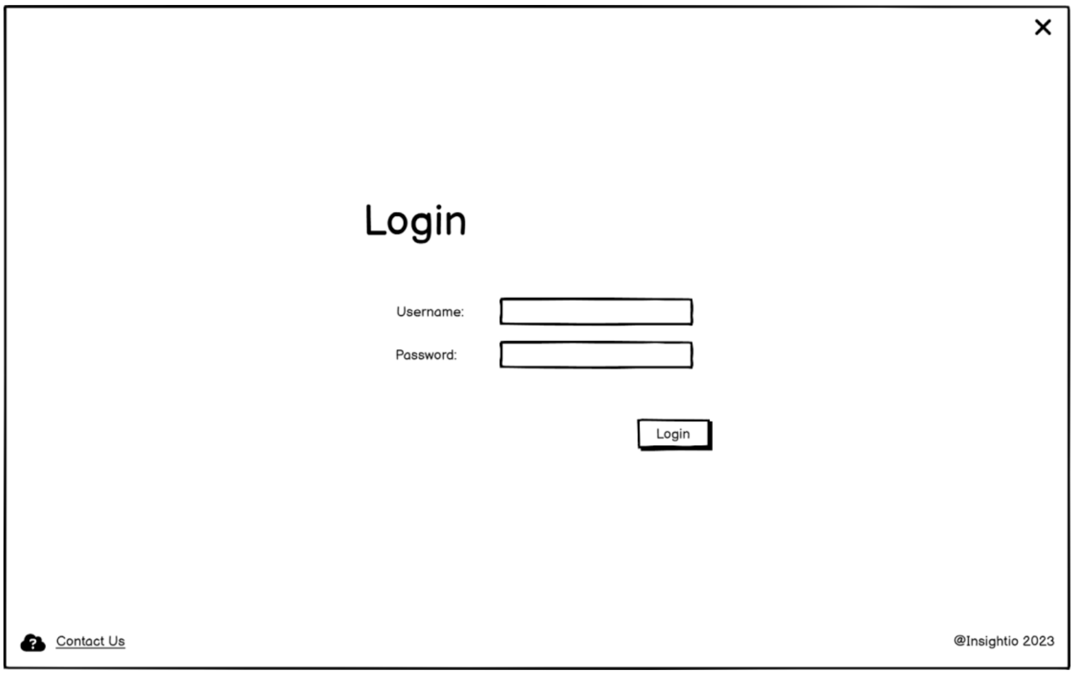


Activity Diagram



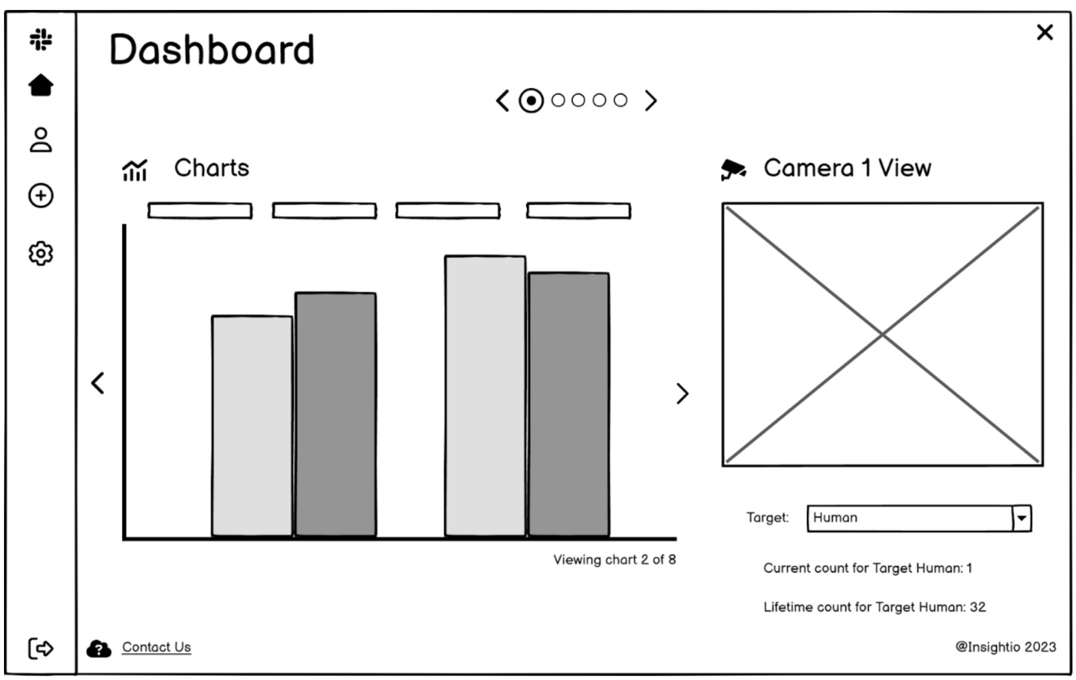
5. Interface Design

5.1. Login

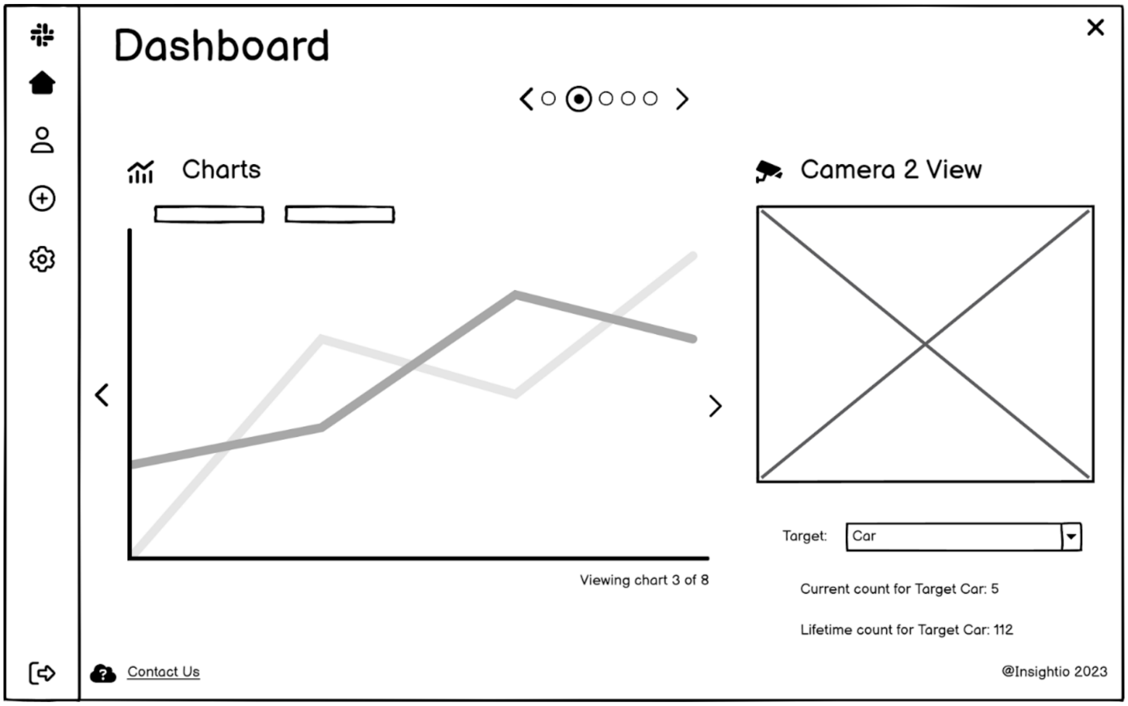


5.2. Dashboard

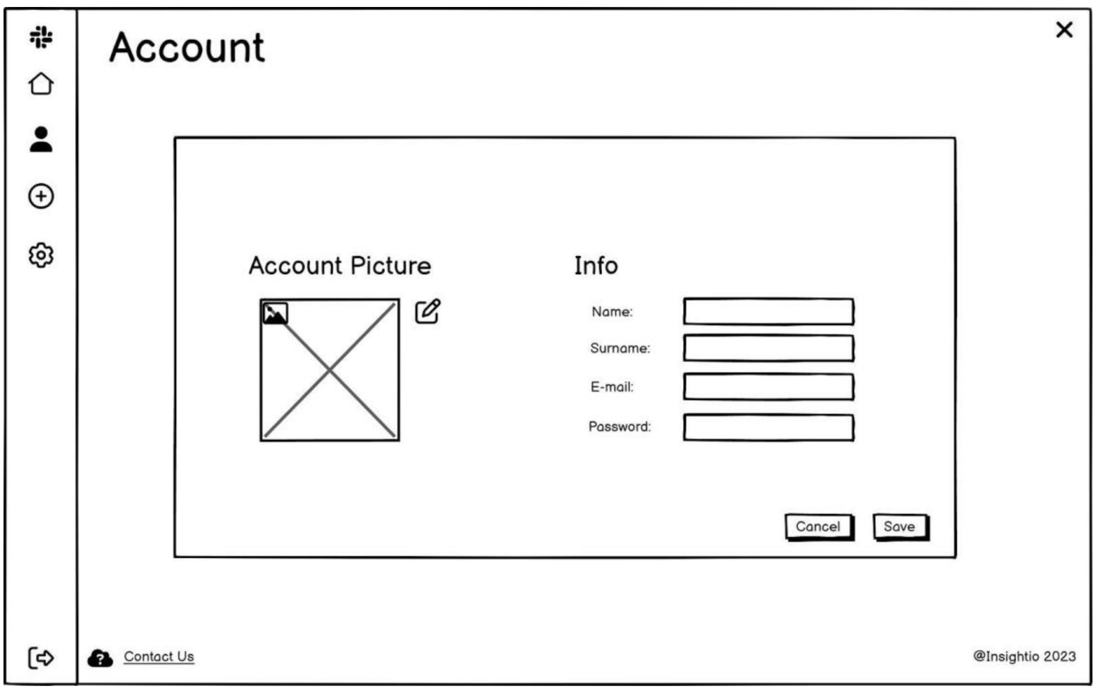
5.2.1. Example 1



5.2.2. Example 2

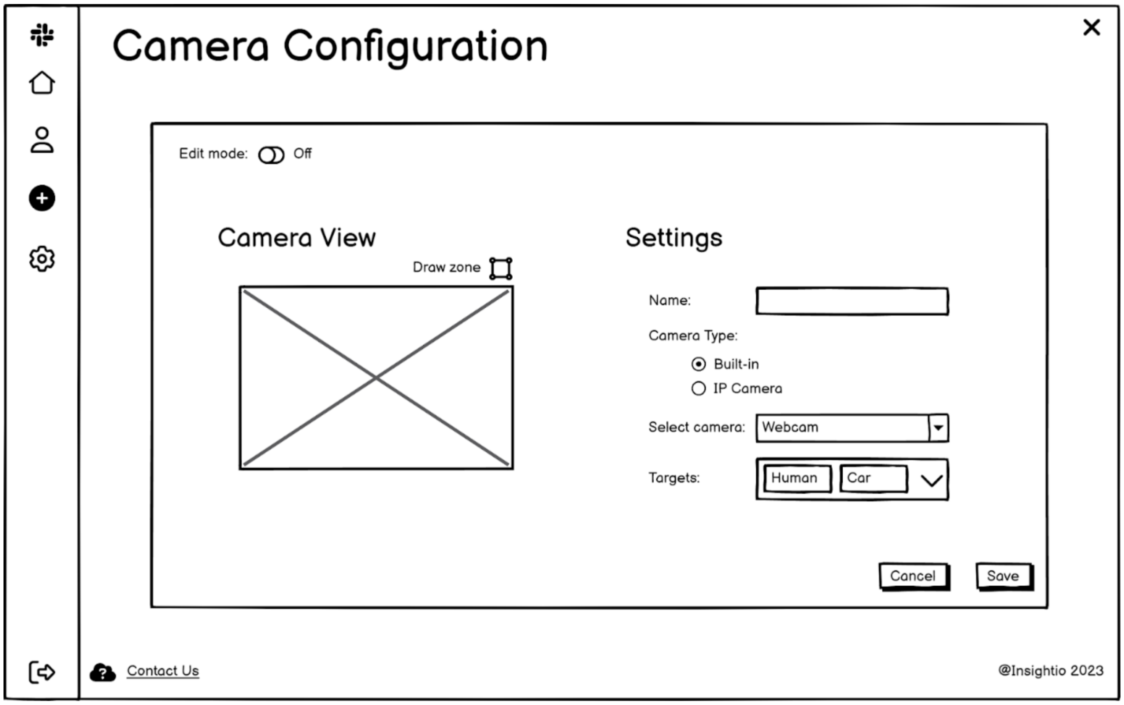


5.3. Account

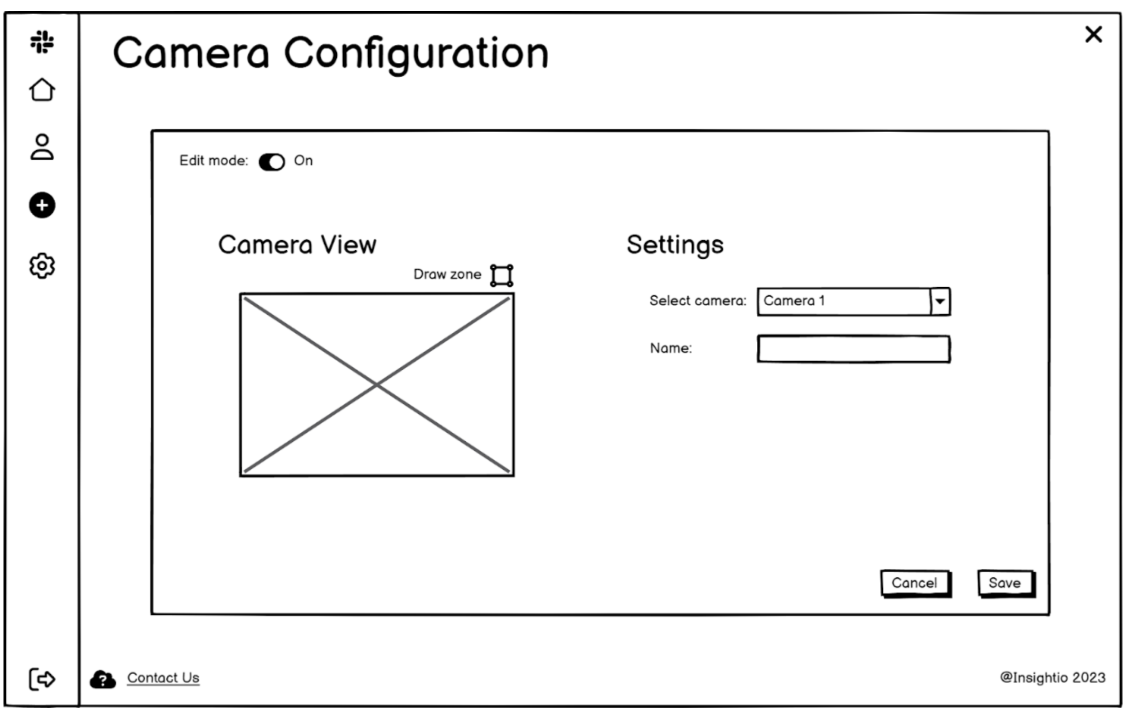


5.4. Camera Configuration

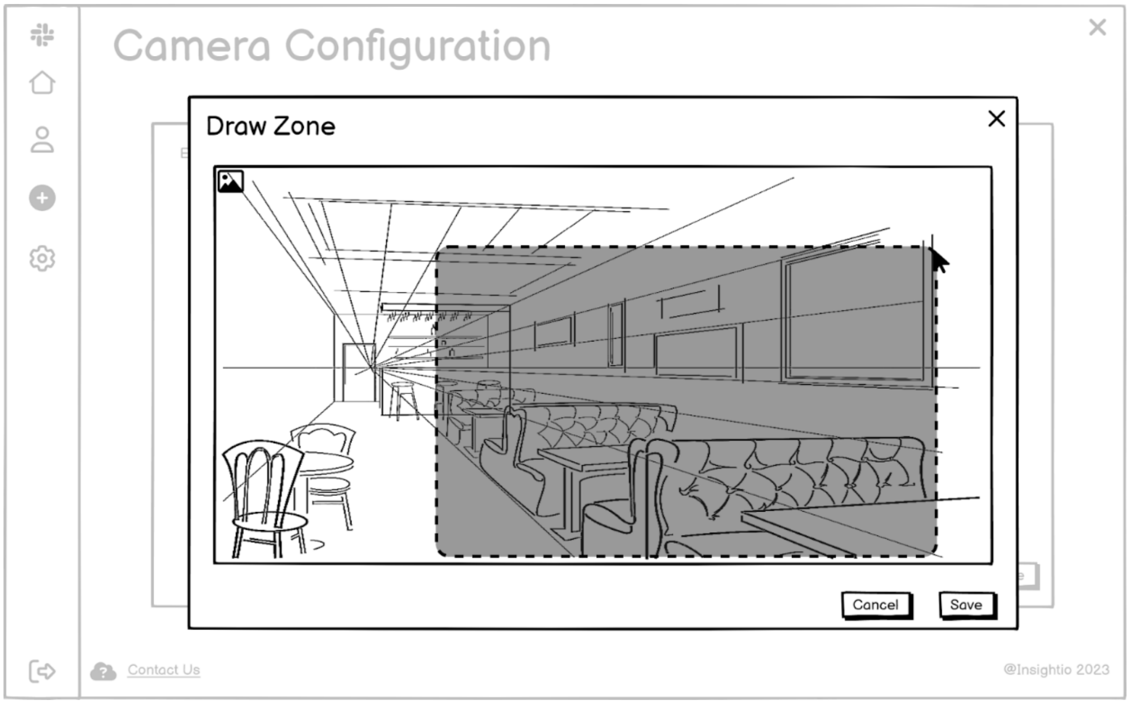
5.4.1. Edit mode off



5.4.2. Edit mode on

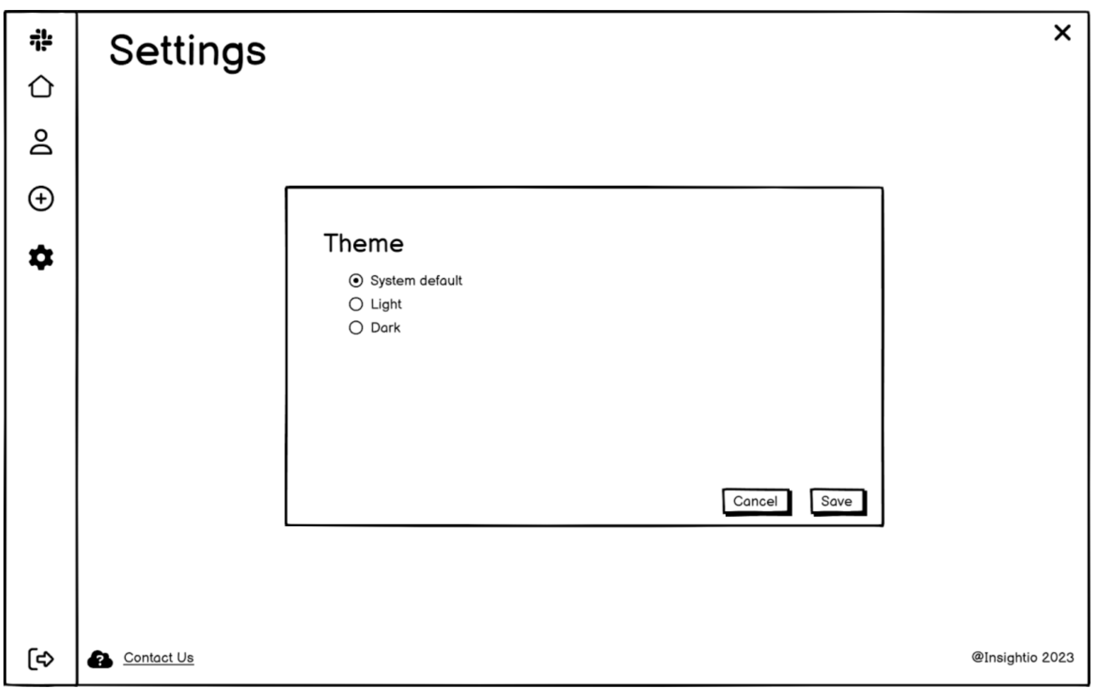


5.4.3. "Draw Zone" modal

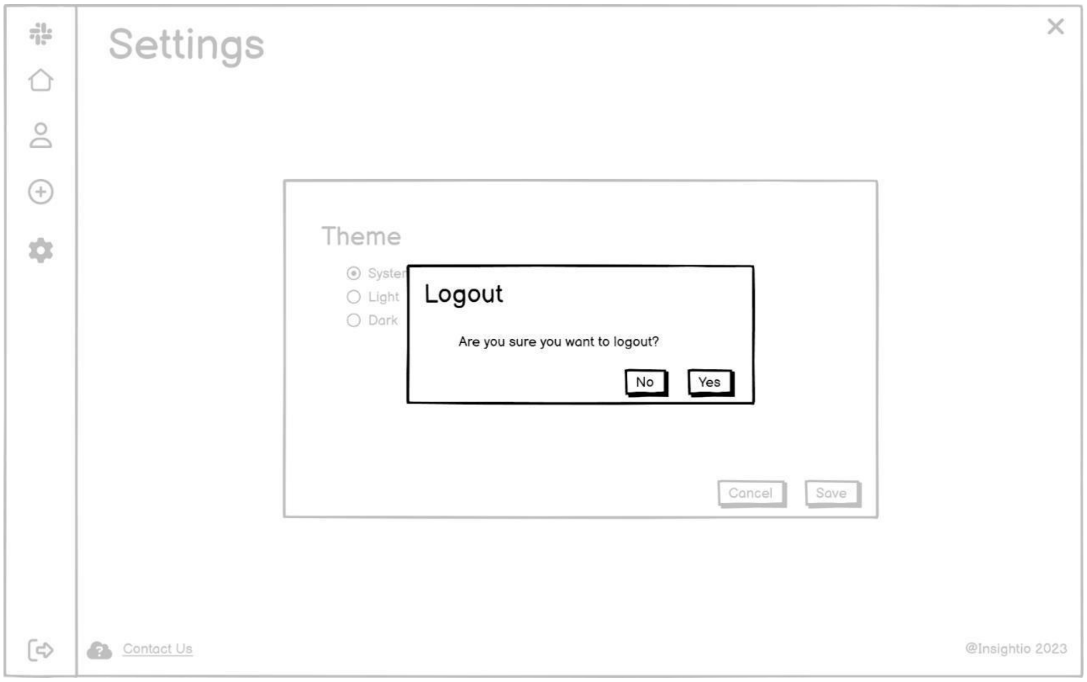


5.5. Settings and Logout Modal

5.5.1. Settings



5.5.2. Logout Modal



Conclusion

This document provides a step-by-step overview of the overall structure of the Insightio project, offering a comprehensive insight into the platform. The literature review highlights the prominent features of the platform based on current information. The Software Requirements Specification (SRS) clearly defines the purpose and requirements of the project, while the Software Design Document (SDD) elaborates on the technical details of the platform based on these requirements.

In conclusion, the Insightio document serves as a comprehensive resource for the project team, developers, and stakeholders to understand the general design and functionality of the platform. The literature review goes beyond existing information, emphasizing the innovative features of the platform. The SRS and SDD sections establish a clear foundation for successful project management by defining the project's goals and technical requirements.

This document guides the development of the Insightio platform, providing the project team with both a functional and technical perspective, contributing to a successful implementation process.

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