PROJECT 4.0

TEAM C1 - CARING MINDS

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Introduction

In an era where the aging population is on the rise, addressing the well-being and safety of elderly individuals has become a critical concern. Our project, Visi-Age, seeks to navigate this challenge by leveraging computer vision and data analysis. Designed to ensure the independence of elderly individuals, Visi-Age detects critical events, such as falls and emergencies, without constant supervision.

Imagine an elderly woman named Sarah, who, like many others, wishes to continue living independently in the comfort of her own home. However, as time progresses, concerns about her safety become paramount, especially after experiencing distressing incidents like sudden episodes of dementia that lead to wandering off alone. Visi-Age is born out of the recognition that technology, specifically computer vision and data analysis, can play a pivotal role in ensuring the well-being of elderly individuals in the face of such challenges.

At the core of our initiative is the vision to redefine elderly care through technology. By implementing advanced computer vision algorithms, Visi-Age not only responds rapidly to emergencies but also monitors overall well-being through facial expressions, audio analysis, and movement tracking. This comprehensive system aims to enrich the lives of the elderly, providing timely support and redefining the narrative of aging gracefully at home.

This report encapsulates the journey of Visi-Age, showcasing the development of a web application with a robust data model. From incident detection to caregiver insights and optional modules, our system is tailored to empower both caregivers and elderly residents. Join us in exploring a future where technology becomes a compassionate companion, ensuring the safety and dignity of the elderly population.

1. Market Research

This market research section explores systems dedicated to caring for the elderly by detecting incidents like falls and loud coughing. We will investigate current trends and technology in this field, focusing on how these systems enhance the well-being of seniors. As the elderly population grows, innovative solutions that quickly detect and respond to incidents become increasingly important. Our goal is to understand the market landscape, key players, and the preferences of users seeking elderly care systems that prioritize early incident detection.

Upon research we found 7 existing monitoring systems for elderly patients. These systems have some of the services we wish to offer in our solution, so looking at the way they implemented their solutions helped us gain further insight into different possibilities. To put things into perspective, we're only going to be doing fall and cough detection as well as monitoring coughing patterns. The existing systems all have fall detection, but none have cough detection. They do, however, have other services that could be potential ideas for expanding our solution in the future. For now, cough detection makes ours stand out amongst our competitors.

The existing systems we found are:

1. Mintt Mintt | The most reliable fall detection and prevention solution
2. Skyresponse Fall Detection and Prevention Systems in Elderly Care (skyresponse.com)
3. Altus Protect Your Loved Ones: The Revolutionary AI-Powered Fall Detection System - Altus Digital (altusdigitalservices.com)
4. Fall Detect by KamiCare Kami (kamihome.com)
5. Hikvision Fall Detection - AI Analytics - Hikvision
6. Viso.ai Fall Detection - viso.ai
7. AUO AI-based smart fall detection - AUO

We will analyze them by providing a description of each system's services, the functionalities they offer, and the costs of them.

1.1. Description of Existing Monitoring Systems

To get a better understanding of each system we will look at the background of it in terms of who's behind it, as well as their key offerings and solutions.

1.1.1. Mintt:

Mintt, headquartered in Brussels, is a collaborative effort between medical professionals and AI specialists dedicated to offering advanced solutions for fall prevention in elderly care. Leveraging a unique blend of expertise, Mintt aims to enhance the safety and well-being of seniors through a comprehensive suite of services. Their commitment to proactive care is reflected in the meticulous design of their system, which encompasses a range of features to address various aspects of fall prevention and incident management.

1.1.2. Skyresponse:

Skyresponse, a distinguished Swedish technology company, stands at the forefront of alarm and event handling management, specializing in Personal Care, including Elderly Care, and Personal Safety. The company's cloud-based platform reflects a commitment to security, leveraging modern and innovative technology to ensure top-tier quality and scalability. Positioned as a future-proof solution, Skyresponse facilitates seamless integration of new and upcoming fall detection devices and alarms into an existing system, establishing a robust ecosystem that adapts to evolving needs.

1.1.3. Altus – The Nobi Fall Detection system:

Altus introduces the Nobi Fall Detection system, a groundbreaking solution harnessing AI-powered sensors to address the increased risk of falls among aging individuals. Recognizing the severe consequences of falls, especially for seniors living alone, Altus developed a device that revolutionizes fall prevention without the need for wearables or intrusive equipment. Integrated into the ceiling, the Nobi system uses a combination of visual and thermal sensors to monitor movement and temperature changes in a room, instantly detecting falls. This unobtrusive design allows for seamless integration into the existing home environment, ensuring minimal disruption. The Nobi system provides a sense of security by sending alerts to designated caregivers, family members, or emergency services when a fall is detected, promoting swift response and potentially reducing the impact of falls on seniors' well-being.

1.1.4. Fall Detect by KamiCare:

KamiCare specializes in cutting-edge in-home care solutions, leveraging advanced Artificial Intelligence technology. At the forefront of their offerings is the Fall Detection System, designed to provide unparalleled safety and support for individuals living independently at home. This comprehensive system combines 24/7 fall detection capabilities with real-time alerts, two-way communication, live view features, and forthcoming emergency response functionalities. KamiCare emphasizes user convenience with hassle-free setup via WiFi and standard electrical outlets. With a focus on user privacy, all video data is fully encrypted, ensuring restricted access only to approved family or caregivers. Notably, the system targets seniors living alone, individuals with dementia, and those with a high risk of falls due to various health factors. Boasting a claimed accuracy of 99%, KamiCare's Fall Detection System stands out as a non-intrusive, efficient, and technologically advanced solution to address the unique needs of its diverse user base.

1.1.5. Hikvision:

Hikvision, founded in 2001, is a leading global provider of innovative video surveillance products and solutions. As a pioneer in the field, they specialize in developing cutting-edge technologies for security, safety, and intelligent analytics. Their extensive product range includes IP cameras, network video recorders (NVRs), access control systems, and video management software. These solutions cater to various industries, such as retail, transportation, healthcare, and smart cities. Hikvision’s commitment to research and development is evident through their work in artificial intelligence (AI), deep learning, and video analytics. One of their notable innovations is the Fall Detection system, which combines video analytics with real-time alerts. This system enhances safety and security in environments where falls can

have serious consequences. Operating globally with offices and partners in over 150 countries, Hikvision prioritizes quality, reliability, and customer satisfaction. Their ethical approach ensures compliance with legal and regulatory requirements, emphasizing privacy protection.

1.1.6. Viso.ai

The Viso.ai Fall Detection System is an automated vision-based solution designed to recognize human falls in real-time. Leveraging deep learning algorithms, this system analyzes video feeds from cameras to accurately detect falls without any need for subject interaction. By processing visual data locally (edge AI), it ensures privacy and eliminates the use of invasive wearables. The system is valuable for enhancing elderly safety, improving quality of life, and optimizing resource allocation. Viso.ai, the company behind this innovation, is trusted by leading Fortune Global companies and provides a no-code architecture for real-world computer vision applications.

1.1.7. AUO

AUO, a technology-driven company, has developed an advanced AI-based smart fall detection system to address the critical issue of falls among seniors. Their system offers active notification and alerts, behavior analysis, an electronic fence, reduced false alarms, and unnoticed notifications prevention. By integrating AI, AUO ensures timely rescue during emergencies and provides caregivers with valuable insights into seniors' daily routines. Their commitment to precision and cutting-edge solutions makes them a trusted partner for global companies and organizations.

1.2. Functionalities and Costs

To get a better understanding of a system, we look at the functionalities/services/solutions they offer. Each system provides its services for a certain price, that price can be a dealbreaker for many people when it comes to choosing a system. We will dive deeper into the functionalities and costs of each system from our market research.

1.2.1. Mintt

- **Functionalities:**
    - Fall Detection: Mintt's system is equipped to detect all categories of falls promptly. It triggers a real-time alert to notify medical personnel, ensuring swift response and assistance.
    - Bed Exit Detection: The system issues an alert when an at-risk patient attempts to leave their bed. This feature serves as a preventative measure, minimizing the risk of potential falls during bed exits.
    - Absence Detection: For areas outside the sensor's field of vision, a timer activates when a patient is absent. If the timer exceeds a set duration, an alarm is sent to the caregiver, serving as a preventive measure for out-of-sight incidents.

- Close Follow-up: Mintt provides a feature that allows remote check-ins on patients without physical presence, respecting their privacy and minimizing disruptions to their sleep.
- Activity Monitoring: The system includes a comprehensive dashboard for real-time monitoring of various parameters, such as the patient's movement, agitation in bed, room-specific incidents, exits from bed, and detected absences.
- Fall Analysis: Post-fall, the system conducts a thorough analysis of the circumstances to understand the incident better. This analysis is instrumental in formulating strategies to prevent the recurrence of falls.
- Fall Register: The fall detection solution generates detailed reports, including images before and after each fall. Automated updates to the falls register provide precise statistical analysis, aiding in the assessment of intervention effectiveness and contributing to the improvement of patients' quality of life.

- **Costs:** Mintt offers multiple plans based on the number and type of services the customer wants, as well as the types of sensors/cameras that will be used. They don't specify a certain price on their website but they do offer to book a free demo for whichever plan the customer would like. Upon testing things out during the demo, they can come to a conclusion on the price.

1.2.2. Skyresponse

- **Functionalities:**
  - Fall Detectors: Provides reliable detection and emergency alerts for falls, contributing to the prevention of dangerous situations.
  - Tracking Alarms: Enables dependable tracking of care receivers, striking a balance between independence and safety.
  - Phone-integrated Alarms: Equipped with mobile apps, facilitating seamless alarm management through phones or computers for enhanced accessibility.
  - Monitored Alarms: Integrated with a 24-hour monitoring service, ensuring continuous attention and prompt responses to critical situations.
  - Proactive Care Emphasis: This includes integration of Artificial Intelligence to identify unusual behavior for early issue detection, medical robots that assists patients in adhering to medication regimens, advanced fall Detection Radars that actively prevent them through secure data collection.

- **Costs:** Upon researching, there doesn't seem to be a set price, one can download the application on their mobile device. There might be additional costs depending on the solution.

1.2.3. Altus – The Nobi Fall Detection system

- **Functionalities:**
    - AI-powered Sensors: The system employs advanced sensors to monitor movement in a room, utilizing AI for precise fall detection.
    - Wearable-Free Design: Unlike traditional fall detection solutions, Nobi does not require wearables, enhancing user comfort and ease of use.
    - Visual and Thermal Sensors: Visual sensors akin to security cameras detect changes in movement, while thermal sensors identify alterations in temperature, collectively providing a comprehensive monitoring solution.
    - Automated Alerts: In the event of a fall, the system sends immediate alerts to designated recipients, enabling quick response and assistance.
    - Integration into Existing Lighting System: The system seamlessly integrates into a room's existing lighting system, streamlining the installation process and maintaining the aesthetic of the home.
    - Customizable Alerts: Users can customize the system to send alerts for specific scenarios, such as detecting a fall or if someone remains motionless for a predetermined period.
    - Enhanced Quality of Life Features: Nobi goes beyond fall detection, offering features such as automatic lighting activation when entering a room, contributing to fall prevention, and facilitating easier control of other devices like TVs or thermostats for an improved living environment.
    - Ease of Installation and Use: Designed for user convenience, the Nobi system can be easily integrated into a room's existing setup, requiring only a few hours for installation. Once set up, it provides a user-friendly interface for customization and use.

- **Costs:** To purchase the smart lamps with sensors for detecting falling you can pay £1499 plus Value Added Tax (VAT). You can also pay over the span of 36 months, the cost per month is stated as £51.19 plus VAT.

1.2.4. Fall Detect by KamiCare

- **Functionalities:**
    - Monitoring and Alerts: 24/7 Fall Detection even in low-light conditions, real-Time Alerts, and 30-Day Fall Recording History.
    - Communication: Allows users to view live room video on their mobile devices and facilitates instant communication with the monitored person.
    - Features (Coming Soon): Incorporates human verification, emergency help button, and professionally monitored emergency services. It also authorizes others to receive real-time alerts and communicate directly for assistance.

- **Costs:** $49.99, includes 2 months free service.

1.2.5. Hikvision Fall Detection system

- **Functionalities:**
    - Video Analytics and Machine Perception: The system utilizes video analytics and machine perception to continuously monitor camera feeds. It intelligently detects instances of people falling within its field of view.
    - Real-Time Alerts: When a fall event is detected, the system triggers instant alerts to authorized personnel. These alerts allow caregivers or security personnel to take immediate action.
    - Height Thresholds: Hikvision's Fall Detection system uses pre-programmed height thresholds to determine if a person is upright or not. This ensures accurate fall detection even in varying scenarios.
    - Safety Enhancement: By promptly identifying falls, the system enhances safety in environments where falls can have serious consequences. It is particularly valuable in healthcare facilities, assisted living centers, and private homes.

- **Costs:** Costs aren't explicitly mentioned, they do however outline on their website that fall detection is available in a selection of Hikvision's products, specifically a Behavior Analysis Sever DS-IE1016-03U/BA(07) and DeepinMind NVS iDS-6704NXI-I/BA. So presumably, these would add up to the costs.

1.2.6. Viso.ai

- **Functionalities:**
    - Fall Detection: The system accurately identifies human falls in real-time, ensuring timely assistance and safety for vulnerable individuals.
    - Activity Monitoring: It tracks daily activities, providing insights into routines, deviations, and potential health issues.
    - Emergency Alerts: In case of emergencies (falls, sudden health deterioration), the system sends immediate alerts to caregivers or emergency services.
    - Privacy-Preserving: By processing data locally (edge AI), it maintains privacy and confidentiality.
    - No-Code Development: Viso.ai's no-code architecture simplifies solution deployment and customization.
    - Integration with Existing Infrastructure: The system seamlessly integrates with existing cameras and infrastructure.
    - Scalability: It can be deployed across multiple locations, making it suitable for large-scale implementations.

- **Costs:** They don't mention explicit numbers for their prices, but they do offer multiple solutions to suit various needs:
    - Viso Suite Standard: An all-in-one solution for building, deploying, and operating computer vision applications. It includes unlimited user seats, camera streams, data collection, image annotation, ML model training, and a no-code application development environment. It's Ideal for organizations seeking a comprehensive solution.

- Viso Suite Production: An advanced solution that secures and scales multiple computer vision applications. It offers unlimited applications, deployments, custom module SDK, advanced team management, and a security center. It also includes on-demand expert services and a technical account manager.
- Viso Suite Enterprise: A customized package aligned with enterprise-specific computer vision needs. It provides service-level agreements (SLAs), multiple workspaces, custom integrations, and full solution services. It also supports on-premises deployment and 24/7 priority support.

1.2.7. AUO

- **Functionalities:**
  - Active Notification and Alerts: The system ensures timely rescue during emergencies by sending real-time alerts to caregivers or emergency responders when a fall occurs.
  - Behavior Analysis: By integrating AI, the system collects and analyzes the behaviors of seniors. It detects unusual lingering patterns, monitors daily routines, and assesses activity levels.
  - Electronic Fence: An electronic fence is established around seniors. If they enter a dangerous area, caretakers receive alerts, allowing them to ensure seniors' physical and mental well-being and safety.
  - Reduced False Alarms: The system employs AI-optimized fall detection algorithms, minimizing false alarms. It provides in-depth analysis of senior behaviors, enhancing accuracy.
  - Unnoticed Notifications Prevention: Through the Caretaker group online, the system sends push notifications when a fall occurs, ensuring timely rescue and minimizing unnoticed incidents.

- **Costs:** Explicit pricing isn't mentioned on their website.

1.3. Conclusions for our Monitoring System

Upon looking at all these different systems, we managed to gather a lot of information on the types of services that could be beneficial to elderly patients. There's a wide range of possibilities but as stated before, our system would be focusing not only on fall detection, but also on cough detection. This will be unique to our monitoring system and help us stand out in the market. Elderly people are very prone to diseases and early prevention can be life-saving. And in cases where the coughing is extreme, urgent care is vital.

The other systems seem to be using not only cameras, but also IOT devices like sensors along with AI models. In our case, we will only be deploying an AI system that monitors the patients using a camera and microphone with respect to their privacy of course. We won't have any wearable devices as that might not be the most practical or comfortable for the patients.

2. Application Design

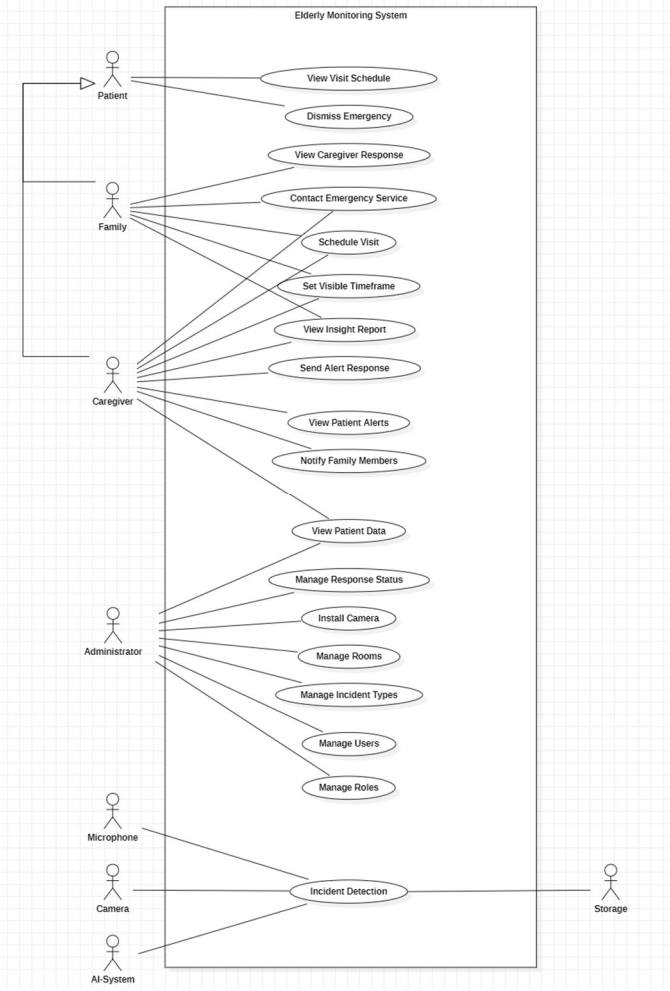
In this section, we delve into the intricacies of the application design, outlining key functional requirements and providing a comprehensive use case model. Additionally, we explore the underlying data model that forms the foundation for the seamless operation of the proposed system.

2.1. Functional Requirements

The functional requirements serve as the cornerstone of our application design, delineating the system's expected behavior and interactions. These requirements are articulated through a detailed use case model, offering a structured representation of various user interactions and system responses.

2.1.1. Use Case Model

The use case model encapsulates the essential functionalities of the system, illustrating the dynamic interactions between actors and the proposed solution. Each use case is meticulously described, encompassing preconditions, postconditions, and potential alternate flows, providing a comprehensive understanding of the system's behavior.



2.1.2. Use Case Descriptions

Actor: Patient

- **Use Case: View Visit Schedule**
  - Description: The patient can access their upcoming visit schedule through the system, allowing them to stay informed about planned caregiver or family visits.
  - Preconditions: The patient is logged into the system.
  - Postconditions: The patient has successfully viewed their visit schedule.

- **Use Case: Dismiss Emergency**
  - Description: In the event of a perceived emergency alert, the patient has the ability to dismiss the emergency if it is a false alarm or if no assistance is required.
  - Preconditions: An emergency alert has been triggered.
  - Postconditions: The emergency alert is dismissed by the patient.
  - Alternate Flows:
    - If the patient dismisses the alert, but the system determines the incident is genuine, the alert remains active until acknowledged by a caregiver.

Actor: Family (Inherits Patient's Use Cases)

- **Use Case: View Caregiver Response**
  - Description: Family members can access and review caregiver responses to incidents and emergencies through the system.
  - Preconditions: The family member is logged into the system.
  - Postconditions: The family member has successfully viewed caregiver response.

- **Use Case: Contact Emergency Service**
  - Description: Family members can initiate contact with emergency services through the system in case of a critical event.
  - Preconditions: A situation requiring emergency services has occurred and no other caregiver is available.
  - Postconditions: Emergency services have been contacted.

- **Use Case: Schedule Visit**
  - Description: Family members can schedule visits through the system.
  - Preconditions: The family member is logged into the system.
  - Postconditions: A visit is successfully scheduled.

- **Use Case: Set Visible Timeframe**
  - Description: Family members can set visible timeframes for when the patient is not visible on camera, so incident detection is aligned with the resident's routine and preferences.
  - Preconditions: The family member is logged into the system.
  - Postconditions: The visible timeframe is successfully set.

- **Use Case: View Insight Report**
    - Description: Family members can access insight reports for specific elderly residents, providing a comprehensive overview of recent detections and well-being.
    - Preconditions: The family member is logged into the system.
    - Postconditions: The family member has successfully viewed the insight report.

Actor: Caregiver (Inherits Patient's Use Cases)

- **Use Case: Contact Emergency Service**
    - Description: Caregivers can initiate contact with emergency services through the system in case of a critical event.
    - Preconditions: A situation requiring emergency services has occurred.
    - Postconditions: Emergency services have been contacted.

- **Use Case: Schedule Visit**
    - Description: Caregivers can schedule routine visits through the system.
    - Preconditions: The caregiver is logged into the system.
    - Postconditions: A visit is successfully scheduled.

- **Use Case: Set Visible Timeframe**
    - Description: Caregivers can set visible timeframes for when the patient is not visible on camera, aligning incident detection with the resident's routine and preferences.
    - Preconditions: The caregiver is logged into the system.
    - Postconditions: The visible timeframe is successfully set.

- **Use Case: View Insight Report**
    - Description: Caregivers can access insight reports for specific elderly residents, providing a comprehensive overview of recent detections and well-being.
    - Preconditions: The caregiver is logged into the system.
    - Postconditions: The caregiver has successfully viewed the insight report.

- **Use Case: Send Alert Response**
    - Description: Caregivers can send responses to alerts generated by the system, confirming the need for intervention or categorizing incidents appropriately.
    - Preconditions: An alert has been triggered.
    - Postconditions: The caregiver's response is successfully recorded.

- **Use Case: Notify Family Members**
    - Description: Caregivers can notify family members of incidents and emergencies through the system, ensuring open communication.
    - Preconditions: An incident has occurred.
    - Postconditions: Family members are successfully notified.

- **Use Case: View Patient Alerts**
    - Description: Caregivers can access a log of alerts related to a specific patient, providing a history of incidents and responses.
    - Preconditions: The caregiver is logged into the system.
    - Postconditions: The caregiver has successfully viewed patient alerts.

Actor: Administrator

- **Use Case: Manage Response Status**
    - Description: Administrators can manage the status of caregiver responses, ensuring appropriate follow-up and resolution of incidents.
    - Preconditions: The administrator is logged into the system.
    - Postconditions: The response status is successfully managed.

- **Use Case: Install Camera**
    - Description: Administrators can install cameras in designated locations to enhance incident detection and monitoring capabilities.
    - Preconditions: The administrator is logged into the system.
    - Postconditions: Cameras are successfully installed.

- **Use Case: Manage Rooms**
    - Description: Administrators can manage the allocation of rooms within the system, ensuring accurate spatial representation for incident detection.
    - Preconditions: The administrator is logged into the system.
    - Postconditions: Room management is successfully performed.

- **Use Case: Manage Incident Types**
    - Description: Administrators can manage the types of incidents tracked by the system, customizing the system to specific caregiving needs.
    - Preconditions: The administrator is logged into the system.
    - Postconditions: Incident types are successfully managed.

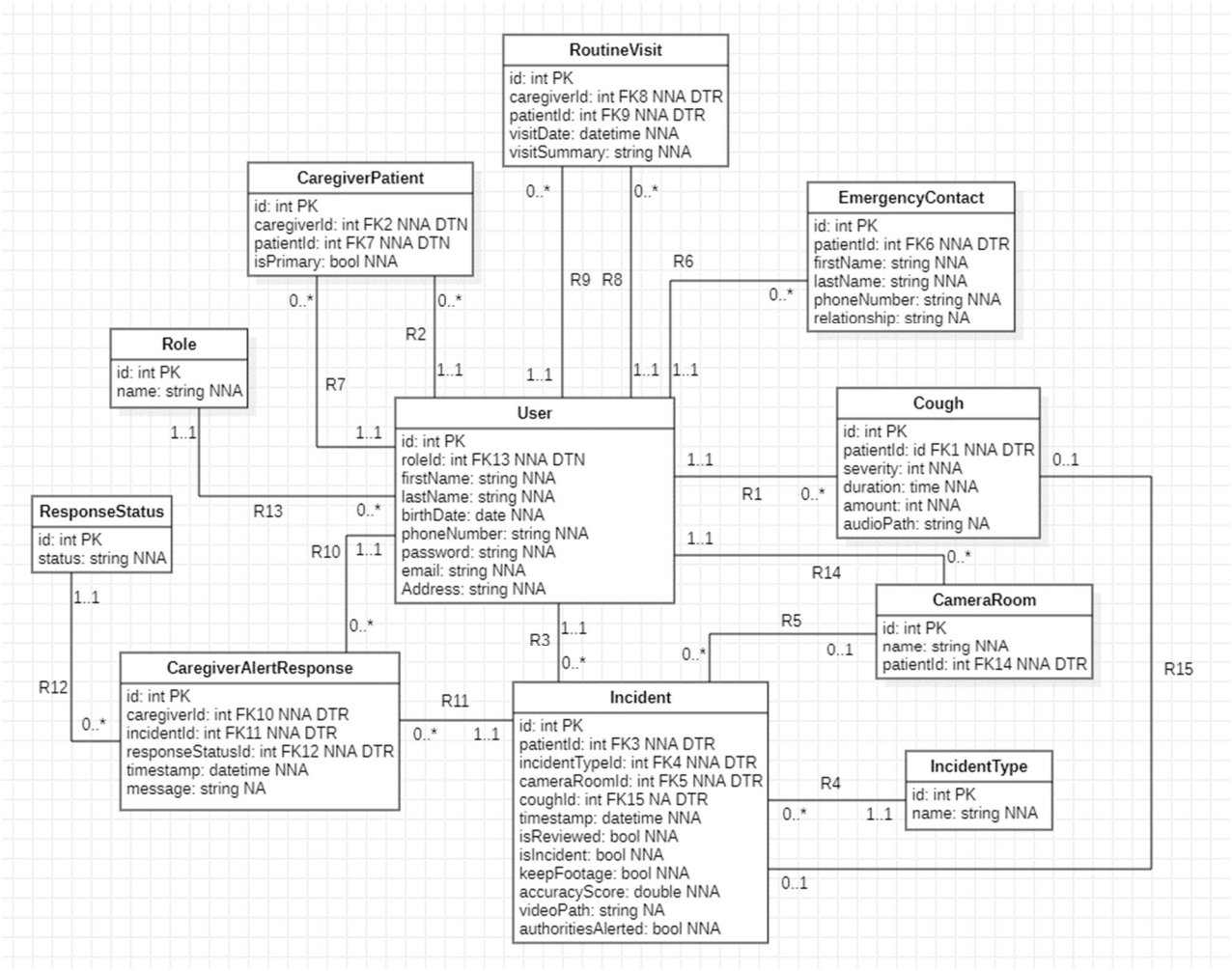
- **Use Case: Manage Users**
    - Description: Administrators can manage user accounts within the system, ensuring secure access and permissions.
    - Preconditions: The administrator is logged into the system.
    - Postconditions: User accounts are successfully managed.

- **Use Case: Incident Detection**
    - Description: The system employs various sensors and algorithms to detect potential incidents, enhancing the overall safety and well-being monitoring capabilities. All the data will be written to the storage system.
    - Preconditions: The system is actively monitoring audio and visual inputs, and it is in a state ready for incident detection.

- Postconditions: The system successfully detects potential incidents based on the analysis of audio and visual data. And the data is correctly stored in the storage system.
- Alternate Flows:
  - Abnormal Audio Patterns:
    - Condition: The microphone detects abnormal audio patterns.
    - Action: The system triggers an additional analysis or alert to caregivers for further investigation.
  - Disputed Camera Incident:
    - Condition: A camera captures an incident, but the resident disputes its occurrence.
    - Action: Caregivers review the captured footage to clarify the situation.
  - Urgent Incident Detected by AI:
    - Condition: The AI system detects a potential incident that requires urgent attention.
    - Action: The system triggers an immediate alert to caregivers for a rapid response.

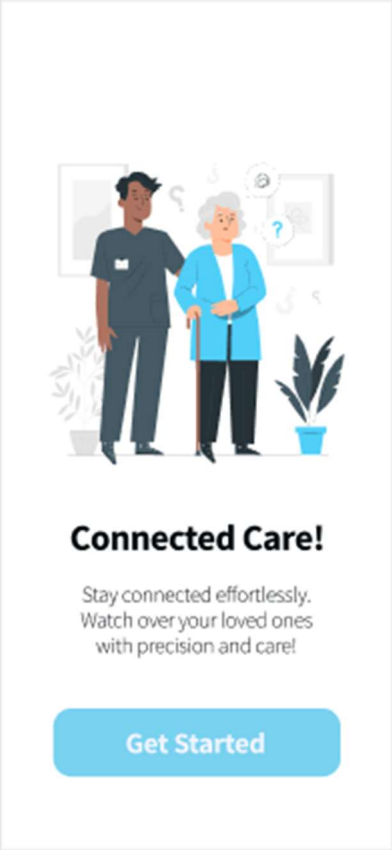
2.2. Data Model

This is the data model that will be used to create the mobile app. Our relational database model features tables for RoutineVisit, EmergencyContact, User, Cough, CameraRoom, IncidentType, CaregiverAlertResponse, CaregiverPatient, Role, ResponseStatus, and Incident. These tables are interconnected to streamline the tracking of patient information, incidents, alerts, and caregiver responses. The model is designed for insight reports, efficient data management, and supporting real-time alerts in healthcare operations.

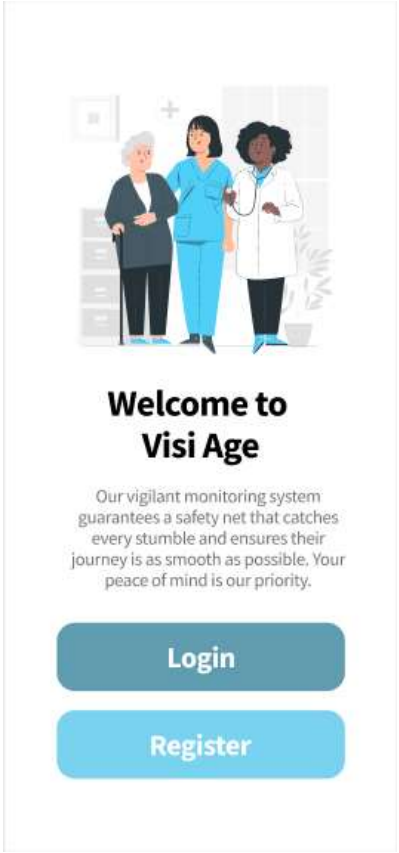


2.3. Wireframes

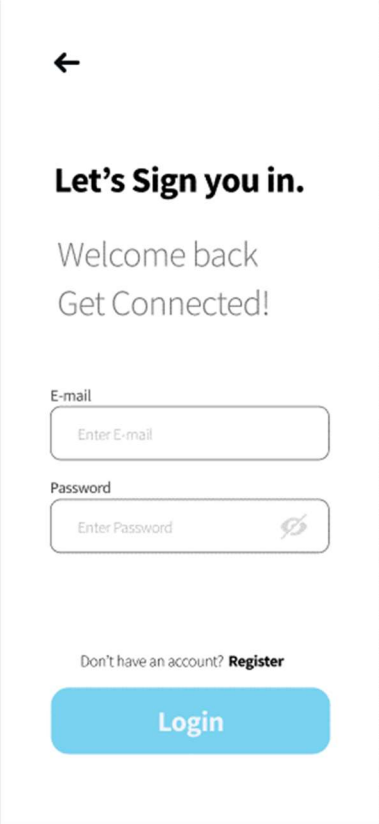
Embarking on the design journey for Visi-Age, the wireframes serve as the visual blueprint for our AI-powered system. This section offers a concise preview of the user interface, highlighting the seamless integration of advanced Artificial Intelligence. These wireframes encapsulate the user journey, illustrating the intuitive design that empowers caregivers, family members, and administrators in redefining elderly care.



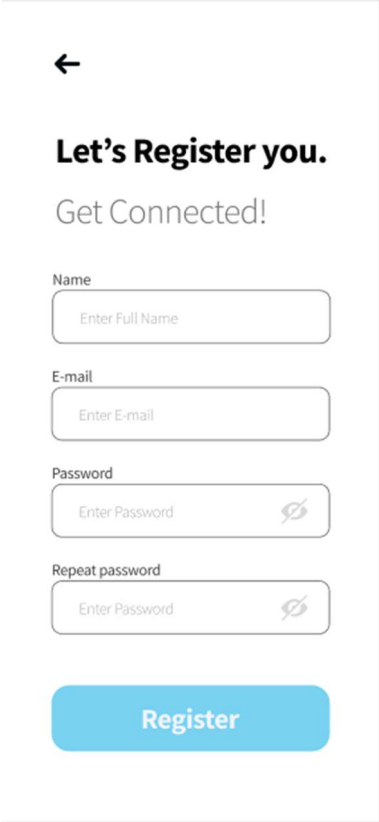
The first wireframe introduces a user-friendly homepage featuring a captivating image and a prominent "Get Started" button, inviting users to initiate their Visi-Age journey effortlessly.



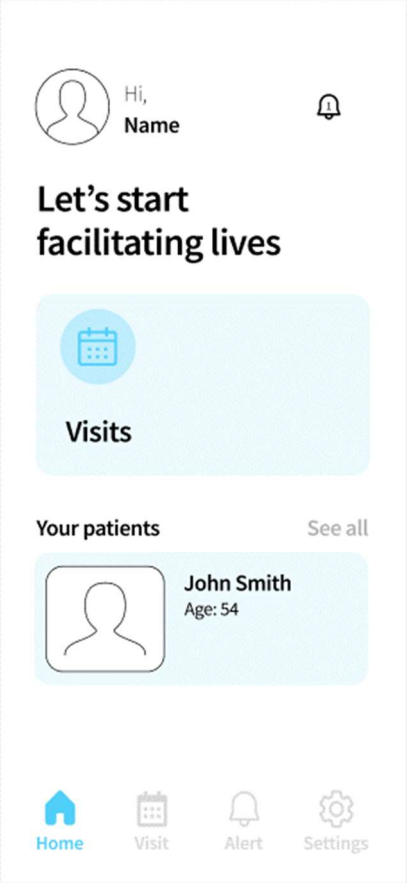
The second wireframe streamlines user access, providing clear options to log in or register. Its design prioritizes simplicity, ensuring swift entry into the transformative capabilities of Visi-Age.



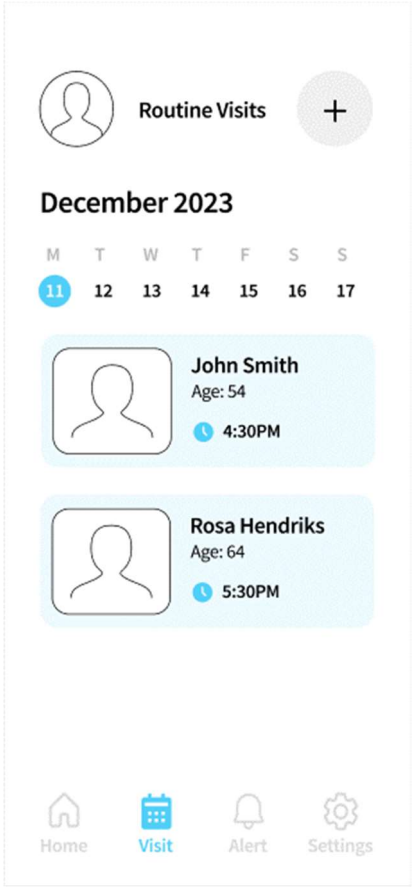
In Wireframe 3, users encounter the Login Page where they can securely access their Visi-Age account. The layout prioritizes user convenience, offering straightforward fields for username and password entry. The design focuses on a seamless login experience, ensuring quick and secure access to the personalized features of the system.



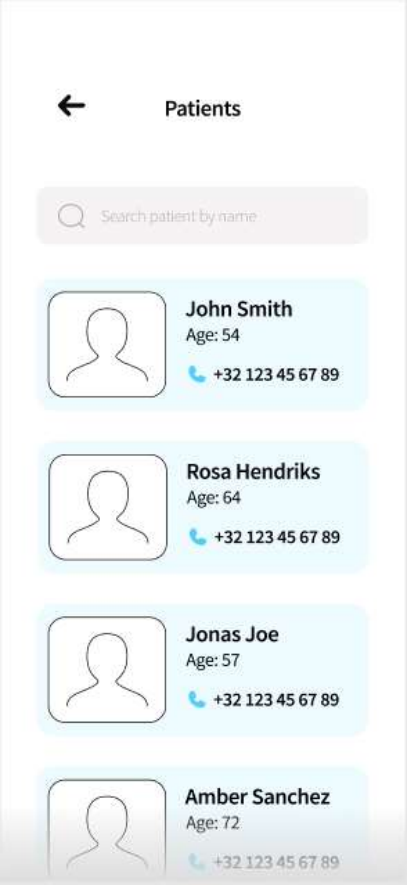
Wireframe 4 guides users through the Register Page, facilitating the creation of a new Visi-Age account. Intuitive form fields prompt users to input essential information for a personalized experience. This wireframe emphasizes clarity and ease of use, streamlining the registration process to welcome new users efficiently.



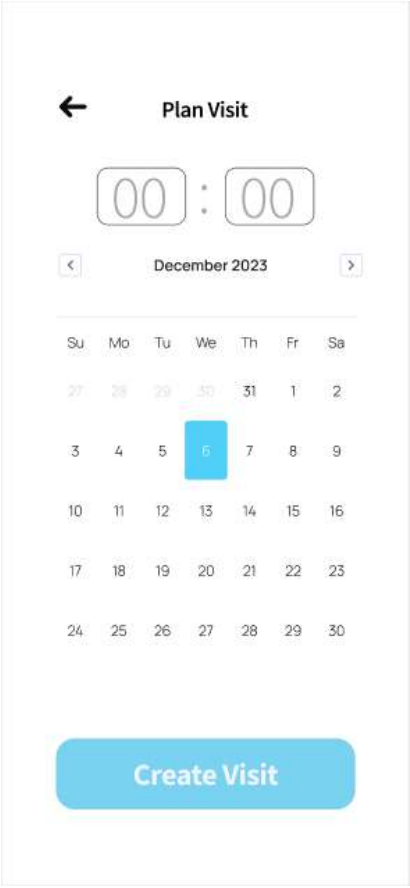
Upon successful login, users encounter a dynamic homepage (Wireframe 5) tailored to their individual needs. A user-centric menu positioned at the bottom of the screen ensures easy navigation. Two prominent buttons invite users to seamlessly access vital features: "Visits" to view the upcoming visits and "View Patients" for a comprehensive overview of their assigned patients.



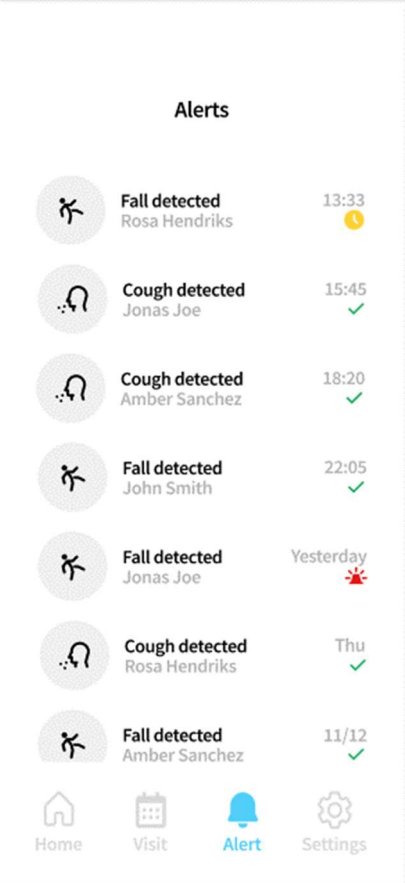
This wireframe reveals the Routine Visits Page, presenting caregivers with a concise weekly calendar displaying their scheduled visits. The user-friendly interface allows quick identification of daily appointments, while an accessible "Create New Routine Visit" button streamlines the process of adding new engagements.



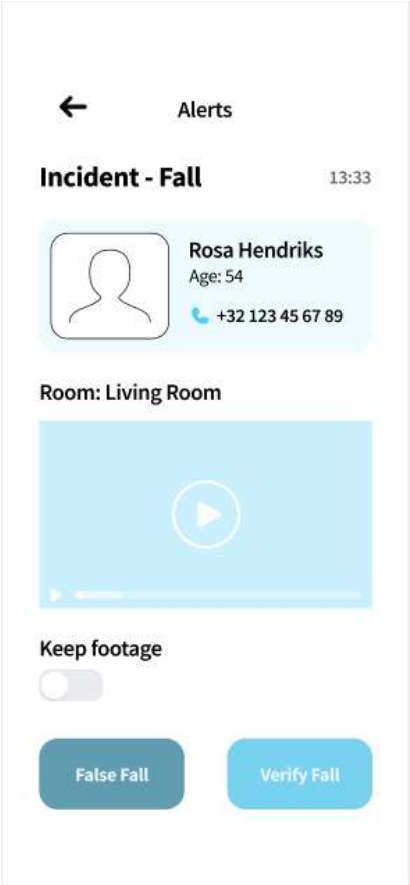
In Wireframe 7, caregivers encounter a streamlined list of all assigned patients. The intuitive design incorporates a search feature for quick and efficient patient retrieval based on names. Clicking on a patient's name seamlessly transitions users to the next page.



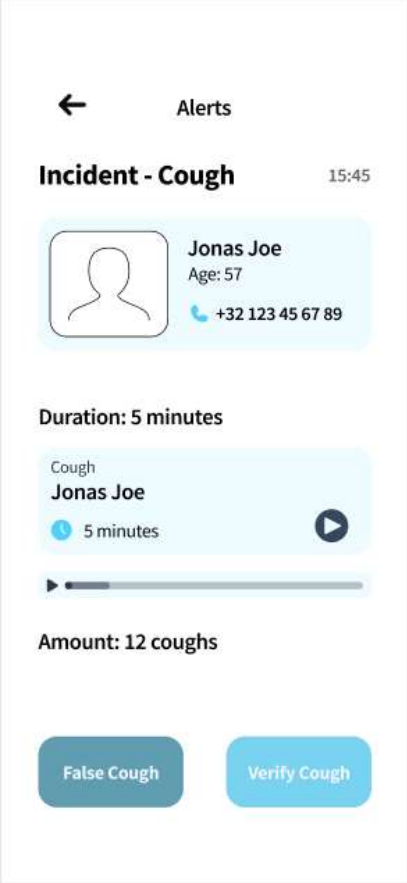
Wireframe 8 presents the Plan Visit Page, empowering caregivers to select a specific date and time for appointments with the chosen patient. This user-friendly interface optimizes the scheduling process, ensuring precision and ease in planning patient visits.



Wireframe 9 unveils the Alert Page, accessible through the bottom menu, providing caregivers with an organized list of detected incidents. The interface distinguishes between falls and coughs, displaying details such as the time and alert status. The status indicates whether the alert has been reviewed, remains unreviewed, or if authorities have been alerted. This page ensures caregivers can efficiently monitor and respond to critical incidents in real-time.

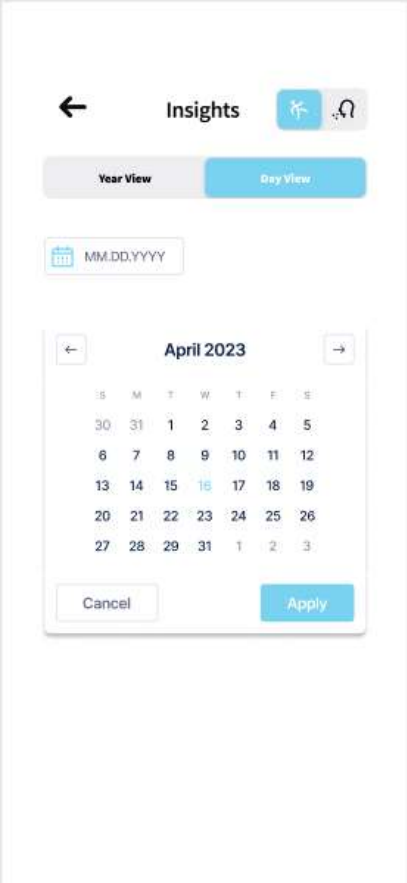


Upon selecting a detected fall, Wireframe 10 provides vital information: incident type, patient, room, and brief camera footage. Caregivers can decide to keep or discard the footage and swiftly verify if the incident was a genuine fall or a false alarm.



Wireframe 11 mirrors the previous page but focuses on coughing incidents. The interface displays incident details, including type, patient, cough duration, and the number of coughs. A playback feature allows caregivers to review the incident. Like fall incidents, caregivers can efficiently verify whether the coughing incident is genuine or a false alarm, facilitating quick and informed decision-making.

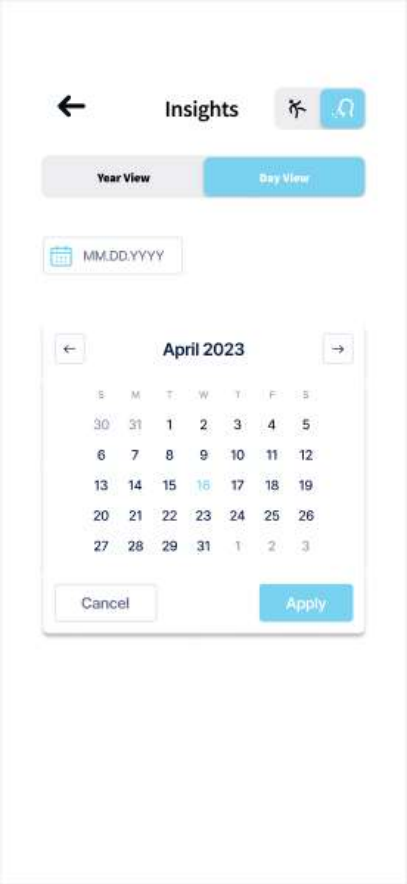
Users can seamlessly explore fall-related insights for various years by selecting different options. The graph, organized by months, remains a dynamic visual tool for caregivers to assess fall patterns over chosen years. This flexibility ensures caregivers can adapt their understanding of patient behavior based on historical data, fostering a proactive and adaptable approach to care.



Wireframe 13 introduces a simplified interface, featuring a date picker for selecting the specific day of interest. Streamlining the user experience, caregivers can effortlessly navigate to the desired date, ensuring efficient access to detailed fall-related insights organized by hours for the chosen day.

As an outcome of the previous selection, Wireframe 14 shows a detailed chart showing the hours of the day when falls occurred most frequently. This focused visualization empowers caregivers with insights into specific timeframes, facilitating targeted interventions and heightened situational awareness.

Offering dynamic exploration, Wireframe 15 allows caregivers to adapt their understanding of cough-related insights across various years. The organized graph by months provides a quick overview, facilitating trend identification and informed decision-making.



Wireframe 16, in the day view for cough-related insights, initiates with a prompt for caregivers to specify the exact day for detailed data. This interactive feature ensures precision in accessing granular cough-related insights organized by hours for the chosen day.

As a result of the date selection in the previous step, Wireframe 17 displays a detailed chart focused on cough-related incidents. The visualization highlights the hours of the day when coughs occurred most frequently, providing caregivers with targeted insights for informed decision-making and timely interventions.

The wireframes serve as a visual blueprint for Visi-Age's AI-powered system. From the captivating homepage to the detailed insights pages, the wireframes showcase an intuitive design that empowers caregivers, family members, and administrators. The interface seamlessly integrates advanced AI, offering a transformative experience in elderly care.

2.4. Application design conclusion

In conclusion, Visi-Age's application design is a blend of functionality, user experience, and data management. The tailored use cases go over different user roles, presenting a holistic approach to elderly care that prioritizes individual needs. The robust data model and intuitive wireframes lay the groundwork for a system that not only adeptly detects incidents but also places a premium on user accessibility and empowerment. Visi-Age emerges not just as a solution for incident detection but as a pivotal force in redefining elderly care, seamlessly fusing advanced technology with compassionate caregiving practices. It stands to revolutionize the caregiving landscape by providing a comprehensive, proactive, and empathetic platform for the well-being of our elderly.

3. Edge & Cloud Application network

In this section, we will detail the decisions made regarding both edge and cloud environments.

3.1. Edge Hardware Configuration

This section will have the edge environment choices.

3.1.1. Weighted Decision Matrix for Camera Selection

Criteria	Weight (1-5)	AXIS P3719-PLE	Hikvision DS-2CD2385G1-I	Dahua IPC-HDBW5831R-ZE
Resolution	4	4	5	4
Frame Rate	4	4	4	4
Sensor Type	3	4	4	4
Low-Light Performance	4	5	4	4
Field of View (FOV)	3	5	4	4
Lens Quality	4	4	4	4
Connectivity	3	4	5	4
Durability	3	4	4	4
Power Consumption	2	3	3	3
Integration with AI Platforms	4	4	4	4
Onboard Processing	3	4	4	4
Cost	2	1	5	3
USB microphone that connects directly to the edge hardware				
https://www.amazon.nl/gp/product/B001TGTDFM/ref=ewc_pr_img_1?smid=A356OU9ZCGW24B&psc=1				

We utilized a weighted decision matrix to evaluate potential camera options. After considering three different cameras, the chosen camera is the Axis P3719-PLE: Axis P3719-PLE

3.1.2. Data Stream Pipeline from Camera to Edge Configuration

The selected camera is an IP camera, ensuring its availability on the local network. This enables the retrieval of videos through an HTTP connection, facilitating processing on the edge hardware.

3.1.3. Audio Recording

Implementation for Cough Detection.

Selected audio recording device: MXL AC404 USB Conference Microphone Amazon Link.

3.2. Cloud Architecture and Components

This section contains all the cloud architecture choices and the software stack that will be used.

3.2.1. Cloud Architecture

Our cloud architecture is designed to provide a robust and scalable foundation for deploying and managing cloud components. It encompasses a strategic blend of cutting-edge technologies to ensure optimal performance, reliability, and cost-effectiveness. By leveraging the principles of Infrastructure as Code (IaC) through Terraform, we gain the benefits of version control, collaboration, and repeatability, streamlining the deployment and management of our cloud infrastructure.

This section introduces the fundamental concepts and guiding principles that shape our cloud architecture, setting the stage for the detailed exploration of our technology stack in the subsequent sections.

3.2.2. Cloud Technology stack

- **Terraform:**

  We will use Terraform to be able to deploy our cloud components. We have chosen to do this because we would gain version control, collaboration, and repeatability benefits. Terraform allows us to define our infrastructure as code, enabling us to manage and version our infrastructure configurations efficiently.

- **Container Instance:**

  Using containers will allow us to reduce the cost of hosting the project on a cloud platform. This approach provides scalability and flexibility, allowing us to encapsulate our application and its dependencies. We can leverage container orchestration tools, such as Kubernetes, for efficient deployment, scaling, and management of containerized applications. This also enables us to delve into specific specifications and ensures consistency across different environments.

- **Cosmos DB for API data:**

  Cosmos DB provides a globally distributed, multi-model database service that supports document, key-value, graph, and column-family data models. By choosing Cosmos DB for API data storage, we ensure high availability, low-latency access, and seamless scaling. The multi-model support caters to diverse data storage requirements, and the globally distributed nature of Cosmos DB enhances the performance and resilience of our application.

- **MS Eventhubs:**

  Microsoft Azure Event Hubs is a scalable event streaming platform that can ingest and process large volumes of events in real-time. By integrating Event Hubs into our architecture, we can handle high-throughput, real-time data streaming. This is particularly beneficial for scenarios involving event-driven architectures, telemetry processing, and real-time analytics.

Publishing Events: The camera publishes events to an Azure Event Hub. These events could include video frames, sensor readings, or any other relevant data.

- **Blob Storage for Video:**

  Azure Blob Storage provides scalable, secure object storage for large amounts of unstructured data, making it an ideal choice for storing video files. Leveraging Blob Storage allows us to efficiently manage and serve video content, and it provides features like tiered storage for cost optimization based on access patterns. This is where all of the video's that get sent from the edge hardware will be stored.

- **NAT Gateway:**

  A Network Address Translation (NAT) Gateway is crucial for providing outbound internet connectivity to resources within a private network. By incorporating a NAT Gateway into our architecture, we ensure that components within our network can communicate with external services while maintaining a secure and controlled environment.

3.2.3. Conclusion for Cloud Technology stack

This comprehensive technology stack leverages Terraform for infrastructure as code, containerization for cost-effective hosting, and specific Azure services for data storage, event streaming, and video content management. It creates a robust foundation for building scalable, reliable, and efficient cloud-based applications.

3.3. Application

Explore the core technologies driving our application – MongoDB, React Native, and Docker. Uncover the rationale behind these choices, each playing a pivotal role in shaping our app's functionality and user experience. Join us on a concise journey through our technology stack.

3.3.1. Software stack

MongoDB for Database:

MongoDB was chosen as the database solution for our app for several reasons:

- Scalability and Flexibility: MongoDB's NoSQL nature allows for flexible schema design and seamless scalability, ensuring adaptability to evolving data needs.
- Document-Oriented Storage: The document-oriented storage model aligns well with the varied and hierarchical nature of our data, providing efficient storage and retrieval.
- Real-time Data Access: MongoDB's support for real-time data access and indexing suits the dynamic nature of our application, ensuring quick and efficient retrieval of information.

React Native for Development: (Skuza, Janiec, & Bartosińska, 2023)

The decision to use React Native for app development was driven by the following considerations:

- Cross-Platform Compatibility: React Native enables us to build a single codebase for both iOS and Android platforms, reducing development effort and time-to-market.
- Native Performance: React Native achieves native performance by using native components, resulting in an app that feels and performs like a native application.
- Developer Productivity: The ability to use JavaScript and React, along with features like Hot Reload, enhances developer productivity, facilitating faster development cycles.

Docker:

Docker was incorporated into our technology stack for the following reasons:

- Containerization: Docker provides a containerized environment, ensuring consistent deployment across various stages of development and production.
- Isolation and Security: Containers in Docker offer isolation, enhancing security by encapsulating the application and its dependencies in a controlled environment.
- Portability: Docker's containerized approach ensures that the application runs consistently across different environments, simplifying deployment and reducing compatibility issues.

3.3.2. Conclusion for Software stack

In conclusion, the chosen technologies—MongoDB, React Native, and Docker—were strategically selected to address specific requirements related to data management, cross-platform development, and deployment consistency, respectively. These choices collectively contribute to the efficiency, scalability, and robustness of our application.

4. AI Design

The core of our system is Artificial Intelligence (AI) which will be used to detect falling and coughing. We will delve into the details of the AI components which will be deployed in our system. The tasks we have at hand are, first, accurately detecting falls and alerting the caregivers. And second, detecting coughs while differentiating between severe coughs that require attention and immediate care, and normal mild coughs that can be early signs of disease (no alerting necessary, but useful for insights). We will be using pre-trained models, but we will still look for sample videos and audios that will serve as a validation dataset. Since we will be saving some videos (pre & post falling/coughing), we need to define the data structure in which these will be saved.

4.1. Collection of Test Video's/Audios

For each detection system we managed to collect the following:

- **Fall detection video dataset for validation:**
  - 24 different falling incidents from 8 different angles.
  - Link to website with the dataset: https://www.iro.umontreal.ca/~labimage/Dataset/
- **Cough detection audio dataset for validation:**
  - 115 different types of cough recordings both mild and aggressive for male and female.
  - Link to website with the dataset: https://pixabay.com/sound-effects/search/cough/

4.2. Research of Existing AI-Algorithms/Models

For each detection system we decided to use the following models:

- **Fall Detection:** There were several options online, but our target was to find a pre-trained model that works directly with a video stream rather than static images. Upon consulting experts and doing research, we found that detecting falling using pose estimation is the best. We would apply key-point detection on the person and check the coordinates as they change to detect falling. Several models were tried but the ones we decided on were:

  - **Key-Point Detection Model from YOLO.** YOLO (You Only Look Once) is an object detection algorithm that is used in the field of computer vision. It is fast and efficient, thus a great choice for real-time object detection tasks. We will be using one of YOLOv8 pretrained pose models (specifically either, YOLOv8n-pose or YOLOv8m-pose, yet to be decided in realization phase but so far both work). These models come with an AGPL-3.0 License for all users by default. These models are pretrained on the COCO (Common Objects in Context) dataset which is a large-scale image recognition dataset. The models have been downloaded from Ultralytics HUB and tested on one of our pcs with a sample video from our validation set. We will get the key-point coordinates for each point and do some calculations on them (if the top (head) and bottom (feet) points are close) then send out

an alert when necessary. This will of course require that the camera be positioned in a place that is on the same level as the person, so for example, not on the ceiling.
Link: https://docs.ultralytics.com/tasks/pose/

- **OpenPifPaf model (second option).** According to the official website, OpenPifPaf is "we present a general framework that jointly detects and forms spatio-temporal key-point associations in a single stage, making this the first real-time pose detection and tracking algorithm". We first found out about it through a GitHub repository where they used it for fall detection: https://github.com/cwlroda/falldetection_openpifpaf
  It is made of models, software and code (Python, C++) for Human Pose Estimation, and published under the AGPL license.
  Their website: https://openpifpaf.github.io/intro.html
  Official GitHub: https://github.com/openpifpaf/openpifpaf

- **Cough Detection:**
  - There are useful uses for cough detection in the medical field, especially in the monitoring and early diagnosis of respiratory disorders. Conventional techniques for identifying coughs frequently depend on physical examinations or specialized tools. The incorporation of machine learning, specifically XGBoost, presents the possibility of enhanced precision and automated cough identification.
  - It will help in the early identification of potential health issues since both mild and aggressive will be detected. Caregivers will be able to catch respiratory diseases early.
  - Chosen model: pre-trained model XGBoost able to detect both mild and aggressive cough.
  - Link to GitHub repository of the model: https://github.com/bagustris/detect-segment-cough

4.3. Data Structure for Data Transfer to Cloud Application

Since our application will be on the cloud, we need to define how the data will be transferred from our AI models to the mobile application whenever a fall/cough is detected. The data is only transferred when an incident happens. Using JSON format ensures clarity and efficiency in data representation, facilitating rapid response and analysis.

- **Fall Detection Data Structure:**
  - Json Format:
    - Fall timestamp
    - The camera ID that captured the falling incident
    - Probability (Accuracy score) of whether it's a fall or not
- **Cough Detection Data Structure:**
  - Json Format:
    - Cough timestamp
    - Microphone ID
    - Intensity (moderate or High)
    - Frequency (frequent or occasional)

4.4. Conclusion for AI Design

In essence, our AI design strives to offer real-time incident detection, early health issue identification, and streamlined communication with caregivers. The chosen pre-trained models for our system align with our goal of having real-time video stream analysis and machine learning precision. The selected models, open-source and compliant with AGPL licenses, also align with our commitment to transparency and accessibility. Our data structure for seamless transfer to the cloud application prioritizes key information such as timestamps, incident details, camera and microphone IDs (to identify location), and accuracy scores. As we move forward into the realization phase, the groundwork laid in this section forms the base of an intelligent, responsive, and user-centric caregiving system.

Conclusion

In conclusion, our comprehensive monitoring system, Visi-Age, has been meticulously designed to address the diverse needs of elderly patients, offering a unique blend of functionality, user experience, and data management. By focusing not only on fall detection but also on cough detection, we distinguish ourselves in the market, recognizing the significance of early prevention and urgent care for the elderly, who are particularly susceptible to diseases. This was realized after conducting research on existing monitoring systems for elderly patients with dementia, where we found that fall detection is quite common for elderly and, of course, a crucial one as well. While cough detection isn't as explored as fall detection but it is also vital for elderly people so the caregivers can check up on their health and be able to help them when necessary, in cases like extreme coughing.

The monitoring system employs an AI system using cameras and microphones, prioritizing patient privacy and eliminating the need for wearable devices, which may be impractical or uncomfortable. The core of our application is AI, and we managed to find the best pre-trained models to use for both detection models. A key-point detection model is the best when it comes to falling, and an XGBoost one for cough detection. These two will help provide real-time alerts with high accuracy. The data structure for transferring any alerts to the cloud application emphasizes key information and establishes the basis for an intelligent, responsive, and user-centric caregiving system.

The chosen cloud technology stack, including Terraform, containerization, and specific Azure services, forms a robust foundation for building scalable, reliable, and efficient cloud-based applications. The software stack, comprising MongoDB, React Native, and Docker, strategically addresses data management, cross-platform development, and deployment consistency, contributing to the overall efficiency, scalability, and robustness of our application.

In essence, our holistic approach, combining innovative monitoring features, a thoughtfully designed application, a robust cloud technology stack, and strategic software choices, positions Visi-Age as a revolutionary force in elderly care. The system provides a comprehensive, proactive, and empathetic platform that fulfills the diverse needs of elderly individuals while setting new standards in the caregiving landscape.

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