SOFTWARE ENGINEERING CS 487
Homework – 4

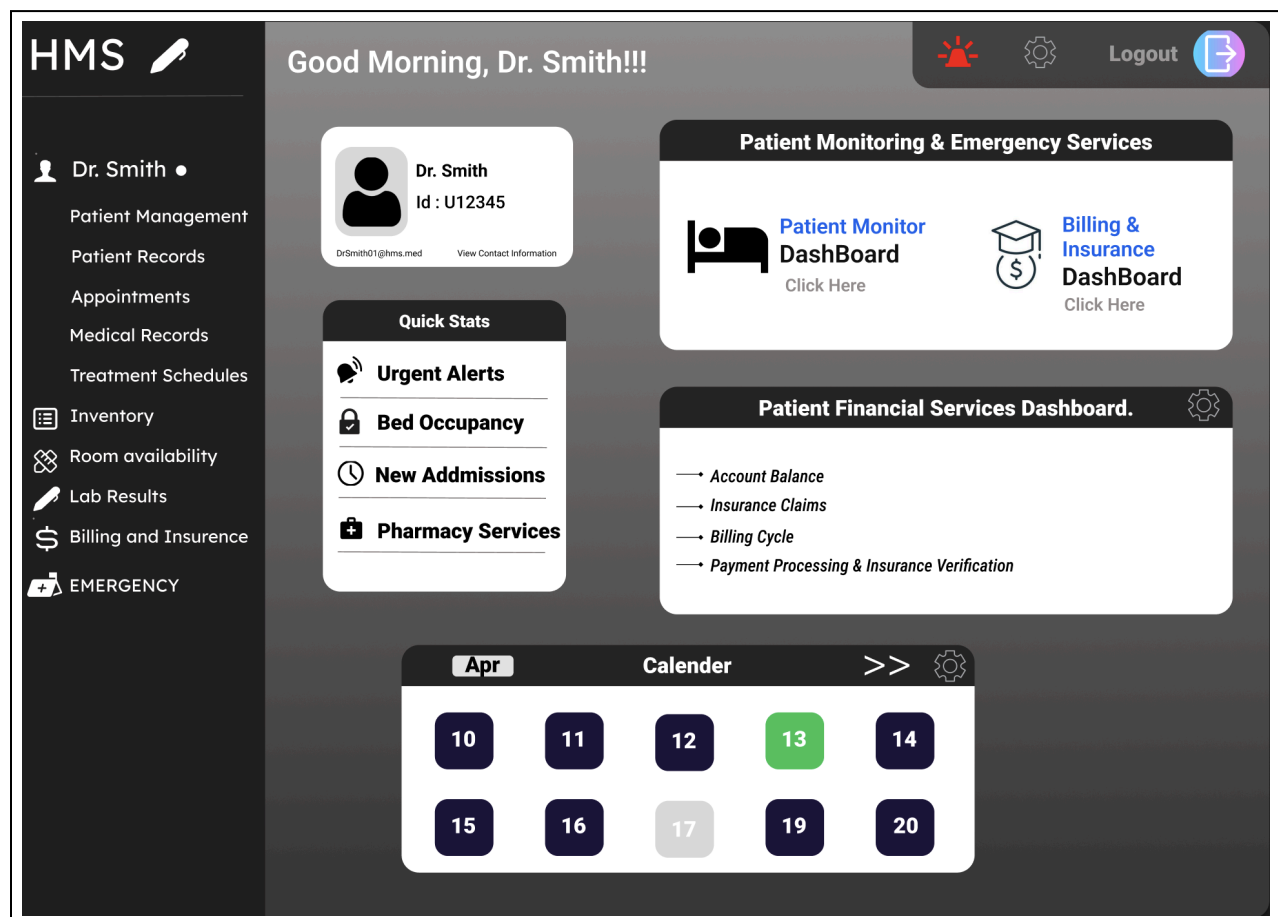Name : Satyam Rajput (A20537375)

srajput3@hawk.iit.edu

Homework - 4

Design a hospital management system (HMS) for a large hospital (1 patient and several sensors per room; many rooms across multiple floors)

UI Design Link for HMS :

https://www.figma.com/proto/vGtNvLRD4Lr2Ah79sLf5lf/Untitled?type=design&node-id=86-556&t=TAXLGmjH7liSIX3N-0&scaling=min-zoom&page-id=0%3A1

Considering the Concepts, Design Procces and Strategies of

- **Human Computer Interaction**
- **User-Centered Design** and
- **Situational Awareness** :

Designing a Hospital Management System (HMS) for a large hospital with complex requirements on the basis of the above Concepts, Design Procces and Strategies involves :

- **Real-Time Patient Monitoring:** Use sensors to track your health continuously.
  Involve users in the design and feedback process to increase user involvement.
  Concise, clear information delivery is essential for situational awareness.

- **Adaptive Interfaces:** Create user interfaces that anticipate problems and adjust to changing needs.

- **Clarity and Simplicity:** Give top priority to information that is logically organised and simple to use.

- **Security and Privacy:** Comply with laws such as HIPAA to safeguard personal information.

- **Continuous Evaluation:** Evaluate and improve the system on a regular basis in response to user input.

a) Caregivers must have real-time awareness of each patient's status

UI Design link :
https://www.figma.com/proto/vGtNvLRD4Lr2Ah79sLf5lf/Untitled?type=design&node-id=86-556&t=Sm90sTY8uU93yhEM-0&scaling=min-zoom&page-id=0%3A1

The following techniques can be utilised to ensure that caretakers in a hospital management system (HMS) have real-time awareness of each patient's status based on the concepts of Human-Computer Interaction (HCI) and User-Centered Design (UCD).

Considering all the Deliverables Mentioned in the Question following answer satisfies the requirement of them :

- **Integrated Sensor Systems:** Use room sensors to continuously check vital signs and notify caretakers through the HMS.

- **Adaptive Dashboards:** Provide vital patient data without overwhelming the user with a customised user interface.

- **Alert Mechanisms:** Use real-time alerts to notify carers in real time of major health changes so they can take appropriate action right away.

- **Mobile Accessibility:** Enable carers to be aware of patients' whereabouts at all times by providing mobile applications with access to patient data and alerts.

- **Security and Privacy:** Uphold adherence to healthcare regulations such as HIPAA in order to safeguard the confidentiality and integrity of patient data.
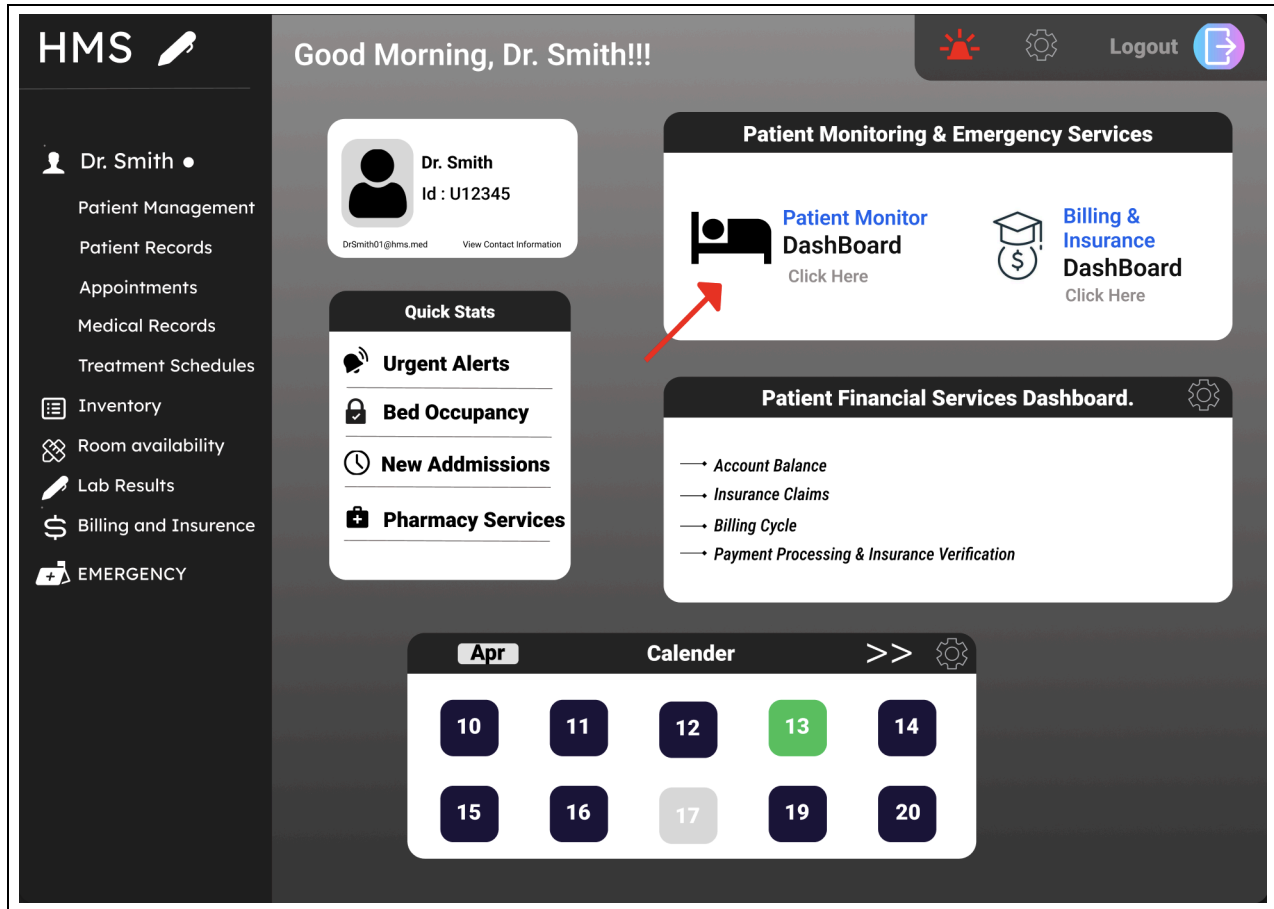
Deliverable 1

Requirement: Patients health updates must be continuously and instantly accessible to caretakers. Within seconds of data being collected by sensors in patient rooms, the system should update and present health data (heart rate, saturation of oxygen, and temperature) on caretakers interfaces.
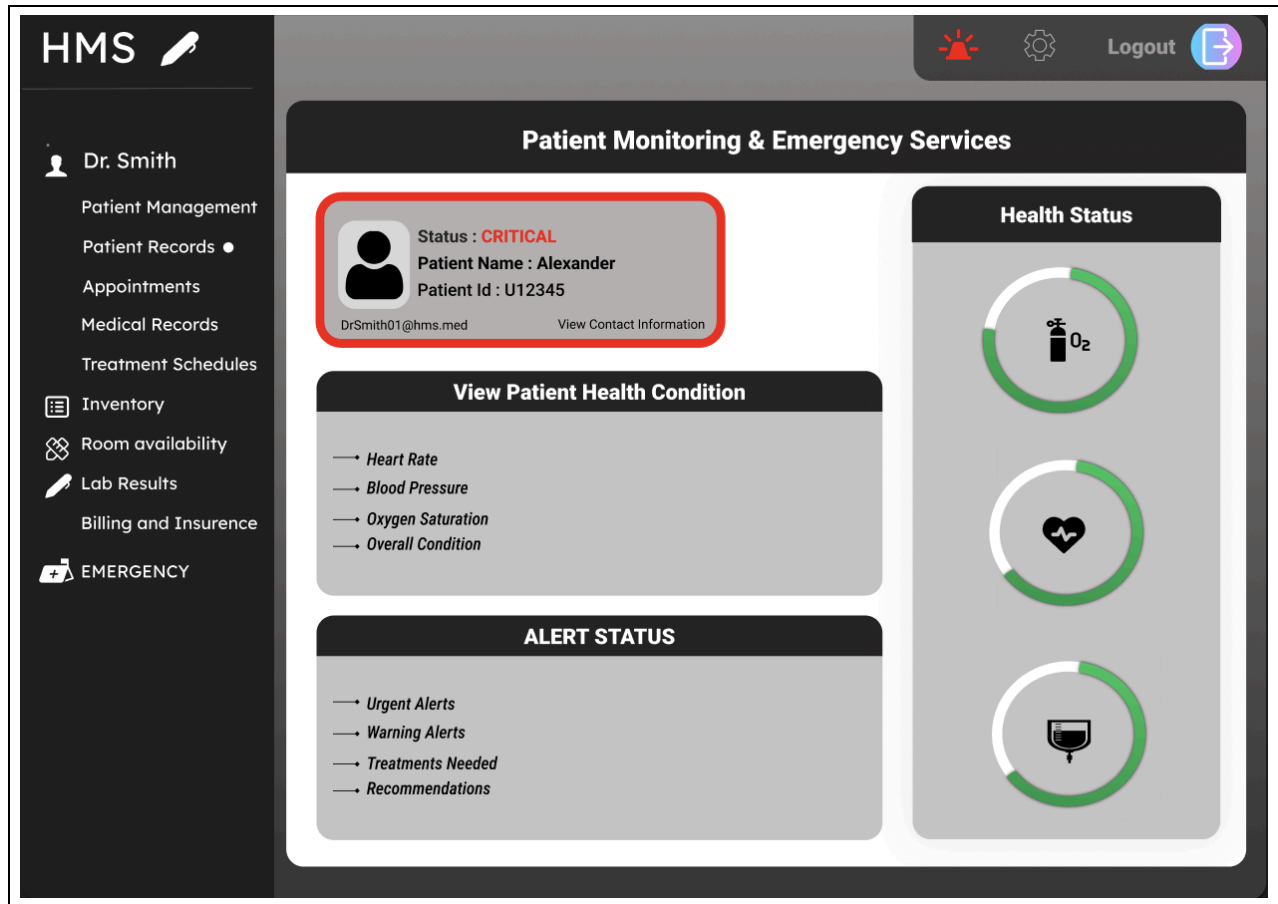
Deliverable 2

UI DESIGN LINK :
https://www.figma.com/proto/vGtNvLRD4Lr2Ah79sLf5lf/Untitled?type=design&node-id=86-556&t=Sm90sTY8uU93yhEM-0&scaling=min-zoom&page-id=0%3A1

UI which presents the status of each patient on a single screen
Link
https://www.figma.com/proto/vGtNvLRD4Lr2Ah79sLf5lf/Untitled?type=design&node-id=128-1040&t=kr6CQz2gb4NegI1X-0&scaling=min-zoom&page-id=0%3A1

Situational Awareness :

Visual Simplicity and Coding: Caretakers can rapidly interpret patient data by using colour coding and straightforward graphics, which lessen cognitive load.

Immediate Data Visibility: In a constantly changing healthcare setting, it is essential for carers to always be viewing the most recent information. This is made possible by displaying real-time data.

Consolidated Overview: The system improves situational awareness by enabling carers to monitor multiple patients at once, identify patterns, and act quickly in case of an emergency by displaying all patients on a single screen.

Deliverable 3 : Protocols used
- Automated Alert System
- Escalation Procedures
- Customised Alert Settings
- Integration with Mobile Devices

Deliverable 4

Quick Response Protocol

Immediate Notification: If a patient's vital signs deviate from normal, use an automated system to notify the emergency response team and the primary carer right away.
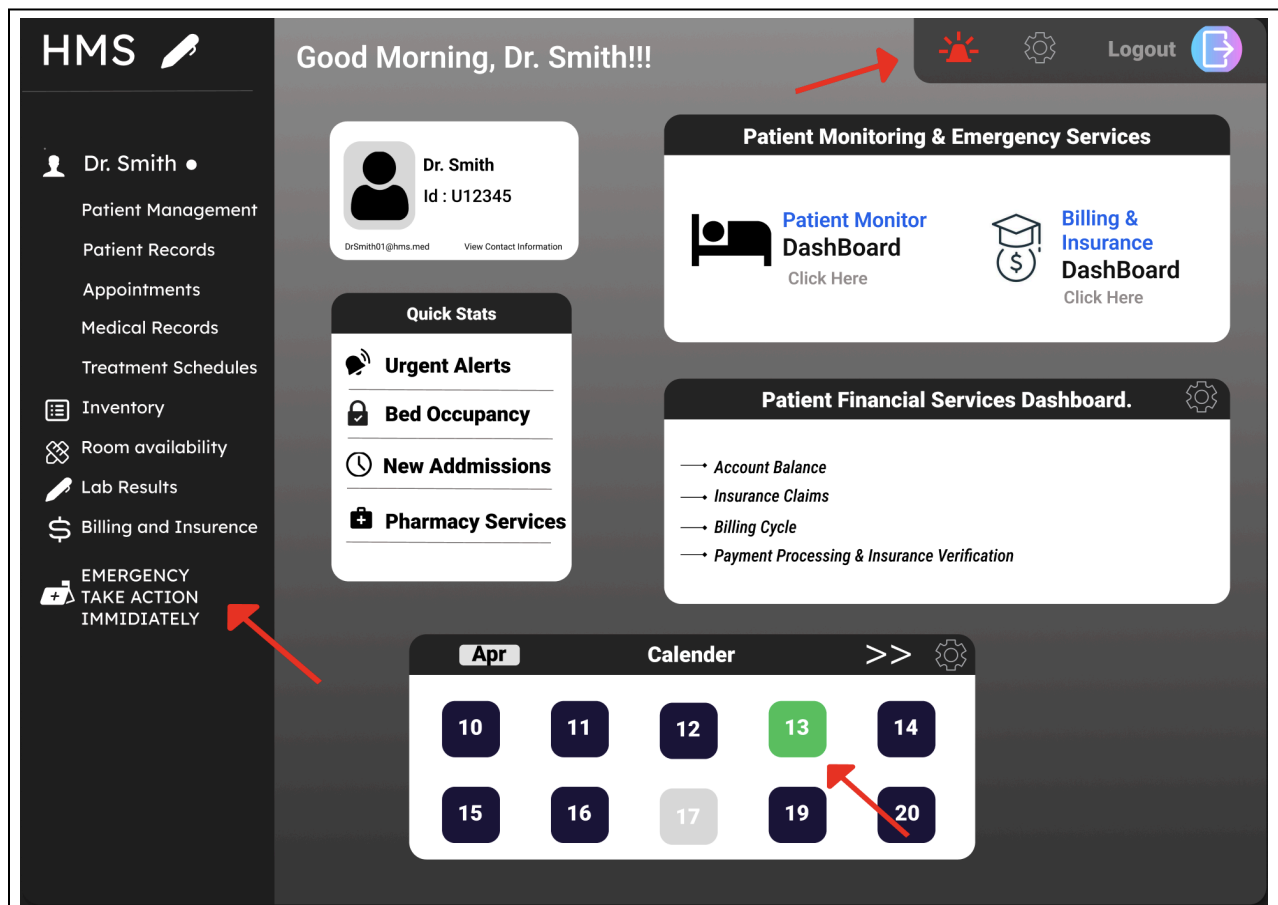
Prioritisation: Build an algorithm into the HMS to rank alerts according to their possible impact and degree of severity, making sure that urgent situations are taken care of first.

Mobile Integration: Make sure that notifications are sent to carers' mobile devices so they can respond right away even when they are not at their workstations

b) Caregivers must respond to patient emergencies quickly

UI Design :

https://www.figma.com/proto/vGtNvLRD4Lr2Ah79sLf5lf/Untitled?type=design&node-id=112-734&t=TAXLGmjH7liSIX3N-0&scaling=min-zoom&page-id=0%3A1

To enable quick caregiver responses to patient emergencies in a hospital management system, essential features include:

- **Automated Alert System:** Notifies caregivers of critical conditions instantly by using real-time processing.
- **Mobile Integration:** Provides caregivers with anywhere-in-the-hospital mobile device access to patient data and alerts.
- **Tools for Prioritisation and Assessment:** Uses AI to assist carers in rapidly ranking emergencies according to their severity.
- **GPS Services:** Assists emergency personnel in finding the hospital's emergency quickly by using indoor positioning.

- **Training and Simulation:** To improve preparation and efficiency in emergency responses, incorporates regular training using virtual or augmented reality.

Prioritising alerts
Decision trees and Bayesian inference are two techniques that can be used to prioritise alerts by estimating the likelihood of various patient outcomes based on past data and current vital signs.

Formula for **Bayesian Inference :**

$$P(D|S) \; = \; \frac{P(S|D) \times P(D)}{P(S)}$$

Here, P(D|S) is the probability of a diagnosis D given sympotom S, P(S|D) is the probabilty of observing symptom S given diagnosis D, P(D) is the prior proability of diagonsis, and P(S) is the probability of sympton.

Deliverable 1

- Upon detection of a patient emergency, the HMS shall automatically alert the designated caretakers within 10 seconds, providing them with the specific location and nature of the emergency.

Deliverable 2

UI Design Components:

- **Interface for Emergency Alerts:** High-priority alerts are kept separate on the carer dashboard. This consists of sounds and flashing icons that change according to how serious the emergency is.
- **Location Details:** Every alert shows the exact location details, so carers can act quickly and efficiently.
- **Critical Information Display:** When an alert is received, a clear display of the most important patient data is provided, along with advice on what to do right away.

Situational Awareness :

- **Prioritised Visual and Audio Cues:** To aid in rapid identification and prioritisation, use different colours and alert tones for varying levels of emergencies.
- **Quick Access to Useful Knowledge:** To facilitate quick decision-making, give patients immediate access to context-specific protocols and patient vital trends.
- **Real-Time Updates:** As the situation changes, alerts are updated dynamically to give carers the most recent information.

Deliverable 3

Protocols :

- Automated Detection
- Alert Prioritization:
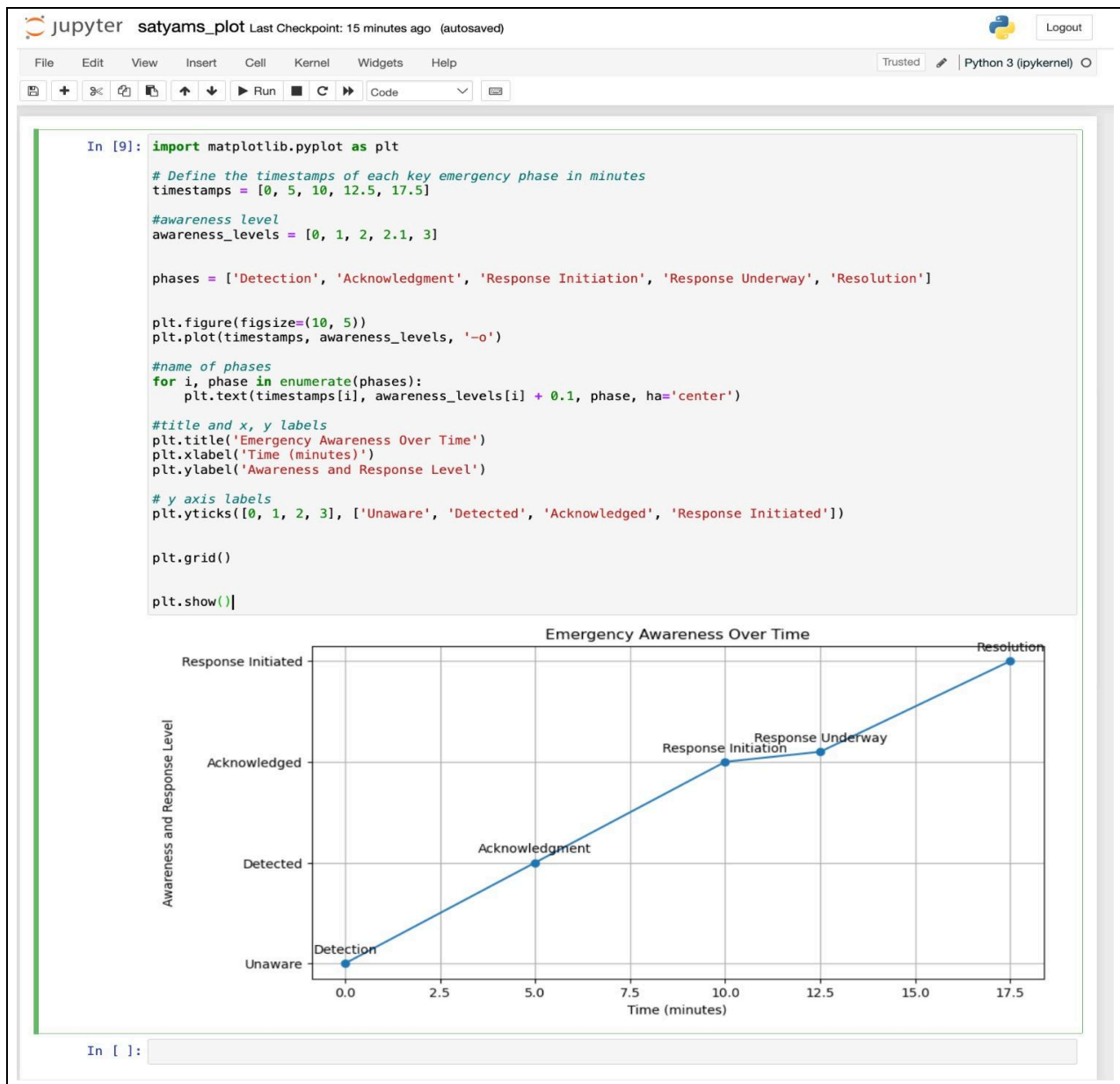- Immediate Notification:
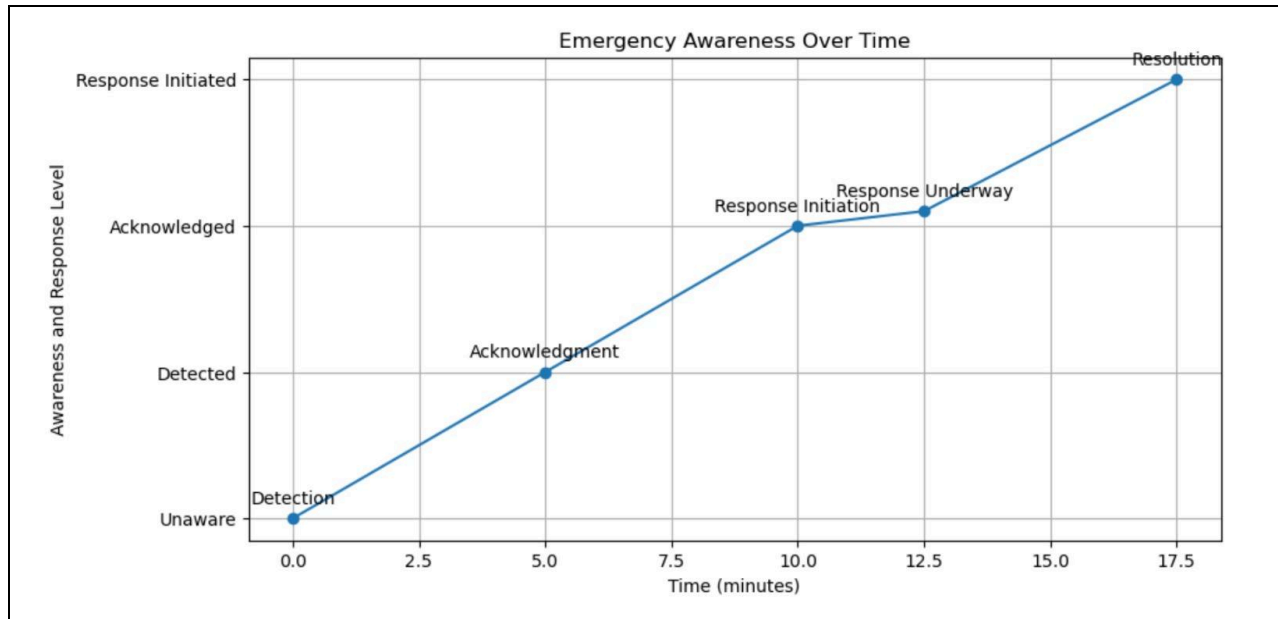- Streamlined Communication:

Deliverable 4

Protocols for Quick Response to Emergencies :
- Redundant Notification Systems
- GPS Integration
- Practice and Drill

Deliverable 5

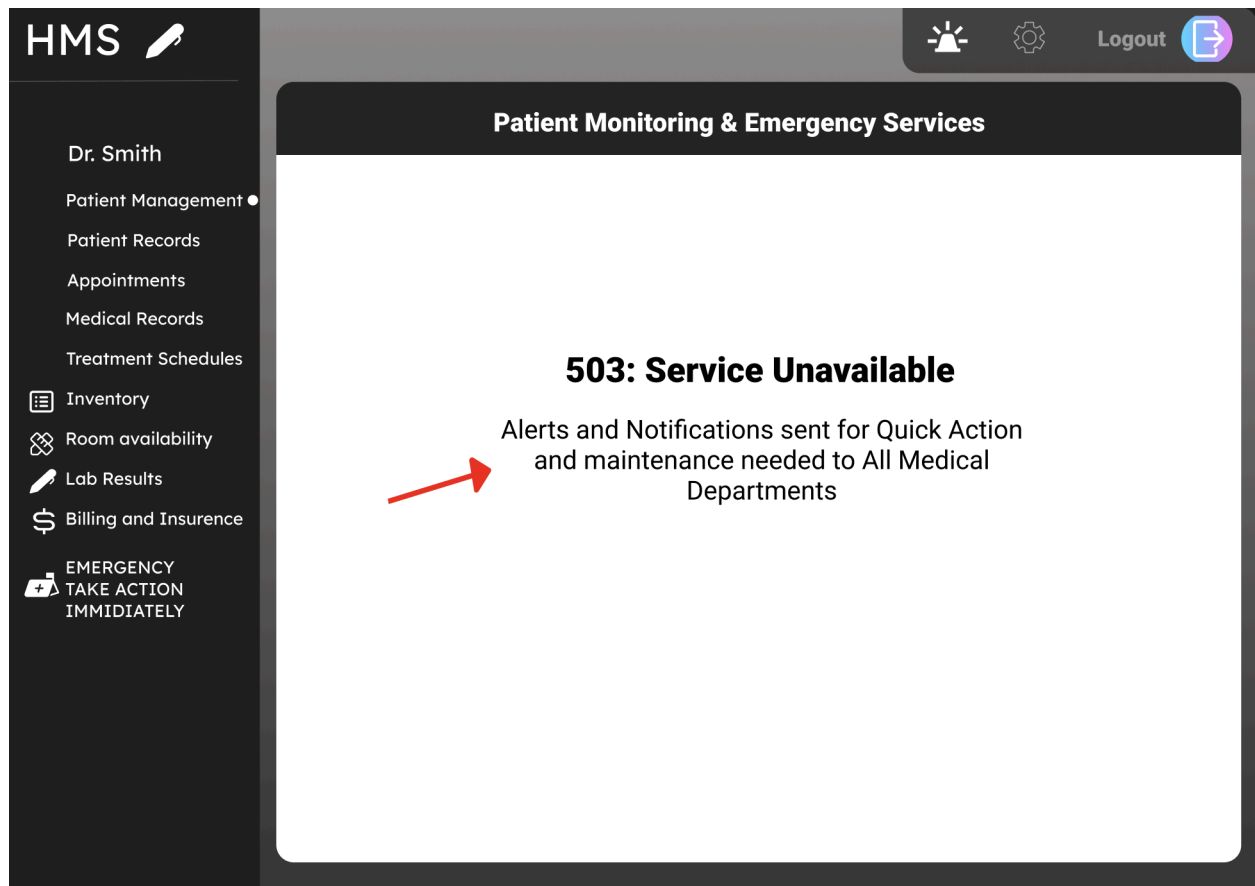In [9]:
```python
import matplotlib.pyplot as plt

# Define the timestamps of each key emergency phase in minutes
timestamps = [0, 5, 10, 12.5, 17.5]

#awareness level
awareness_levels = [0, 1, 2, 2.1, 3]


phases = ['Detection', 'Acknowledgment', 'Response Initiation', 'Response Underway', 'Resolution']


plt.figure(figsize=(10, 5))
plt.plot(timestamps, awareness_levels, '-o')

#name of phases
for i, phase in enumerate(phases):
    plt.text(timestamps[i], awareness_levels[i] + 0.1, phase, ha='center')

#title and x, y labels
plt.title('Emergency Awareness Over Time')
plt.xlabel('Time (minutes)')
plt.ylabel('Awareness and Response Level')

# y axis labels
plt.yticks([0, 1, 2, 3], ['Unaware', 'Detected', 'Acknowledged', 'Response Initiated'])


plt.grid()

plt.show()
```


In [ ]:

Emergency Awareness Over Time

c) Maintenance workers must respond to sensor failures quickly

UI Design :
https://www.figma.com/proto/vGtNvLRD4Lr2Ah79sLf5lf/Untitled?type=design&node-id=118-885&t=TAXLGmjH7liSIX3N-0&scaling=min-zoom&page-id=0%3A1

To ensure maintenance workers quickly respond to sensor failures in a hospital management system, key strategies include:

- Automated Detection: To reduce downtime, install a system for automatically identifying and notifying users of sensor malfunctions or failures.
- Prioritisation System: Sort alerts according to their level of severity to make sure that urgent problems are fixed right away.
- Mobile Notifications: Regardless of the maintenance staff's location, use mobile apps to instantly notify them and enable prompt action.
- Geolocation Tracking: To maximise response times, use sensor and staff geolocation to direct workers to the broken unit.
- Training and Resources: Give maintenance employees mobile device access to digital manuals and troubleshooting guides for instant access.
- Feedback Loop: To enhance communication and system dependability, implement a mechanism that allows maintenance personnel to report on the status of repairs.

Prioritization System Logic
Alert Prioritization: Differentiate alerts by urgency and potential impact on patient care. Critical failures trigger immediate high-priority alerts.

Priority Score = Risk Factor x Impact Level

Deliverable 1

Requirements : Upon detection of a sensor failure, the HMS shall automatically notify the designated maintenance staff within 60 seconds, providing them with the specific location of the failure and a detailed description of the issue.

Deliverable 2

UI Design Components for Maintenance Dashboard:
- Interface for Sensor Alerts: Separate high-priority alerts are displayed on the maintenance dashboard. These alerts include visual signals such as flashing icons and auditory cues that escalate in urgency based on the severity of the sensor failure.
- Location Details: Each alert specifies the exact location of the sensor, facilitating quick navigation and efficient repair work.

- Critical Information Display: Alerts come with a detailed display of the sensor's critical data and preliminary diagnostic information to assist maintenance staff in preparing appropriate tools and components before arrival.

Situational Awareness:

- Prioritized Visual and Audio Cues
- Quick Access to Useful Knowledge
- Real-Time Updates

Deliverable 3

Protocols for Sensor Failure
- Automated Detection: Set up mechanisms to automatically identify malfunctions in sensors and continuously monitor their performance.
- Prioritise alerts: Sort sensor failures according to urgency and effect on hospital operations to make sure that the most important problems are taken care of first.
- Ensuring prompt notification of alerts to the mobile devices or handheld communicators of the maintenance staff is crucial.
- Streamlined Communication: Provide quick coordination and status updates by enabling direct channels of communication within the HMS between the hospital administration and the maintenance team.

Deliverable 4

Protocols for Quick Sensor Repair:
- Redundant Notification Systems: To guarantee that maintenance workers always receive alerts, use a variety of notification channels (such as SMS, email, and app notifications).
- GPS Integration: To improve route planning and speed up response times, install GPS tracking for hospital sensors as well as maintenance personnel.
- Practice and Drill: Hold drills and practice sessions on a regular basis to acquaint maintenance personnel with emergency protocols and the configuration of the hospital's sensor network.