Background

We built a detection and monitoring system that works to detect both the risk of a fall and a fall event through edge detection and video monitoring.

Designed to reduce the time patients are unattended in the event of a fall.

Key Features

- Bed with an array of force sensors capable of edge detection
- Sensors are mapped to a GUI and display the location of the patient with RGB color
- Visual alarm displayed on GUI when patient is near the edge or off the bed – Fall Risk
- Video stream of the patient viewable on the GUI

The System

Use Cases

Bed Occupancy

- Patient’s absence is noticed by bed sensors
- System sends push notifications to all active web sessions
- User is alerted that a patient needs checking
- User clears patient or snoozes alert

Status Check

- Caregiver wishes to remotely monitor/check patient
- User screens UI through URL
- User logs in using credentials
- User can view patient location in bed, as well as video feed of the room

System Overview

Camera Module:
- Raspberry Pi Cam V2 streams through Pi 3 Model B to server
Pressure Sensing Module:
- A301 Force Sensors sends data to server through Pi Zero
Server Module:
- Data from other modules is processed and displayed in GUI

Pressure Sensing Mat

The fall detection system is fueled by several existing hardware packages. Along the mattress, sixteen Flexiforce A301 force sensors are employed in an array across the surface of the mattress.

This is to detect where the patient is at any given time.

NodeRED Flow Management

NodeRED acts as the back-end software. It creates sockets and holds code modules. It also allows us to host our front-end web GUI to allow for a single deployable package.

Allows for easy build on new servers by cross OS compatibility and the ability to import/export flows.

Summary of Results

Table 1

<table>
<thead>
<tr>
<th>Test Case</th>
<th>Description</th>
<th>Test Details</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed Sensor Data</td>
<td>Serial sensor data reaches the processor at the application level, as in a typical system</td>
<td>Different weight distributions were applied to the bed and pressure was measured.</td>
<td>Given 300 pounds (max), display was stuck at 90% since the given weight is below the cut off value.</td>
</tr>
<tr>
<td>Seizure Detection</td>
<td>Sensors are protected from external force and fluid</td>
<td>Serial sensor data was passed over the housing and the internal sensor was checked for damage.</td>
<td>Raw data was read by a sensor and housing was checked afterward.</td>
</tr>
<tr>
<td>Video Camera Data</td>
<td>Images can be displayed accurately</td>
<td>Serial images were passed and handled properly as expected.</td>
<td>Video stream was handled accurately.</td>
</tr>
<tr>
<td>ECG Data Visualization</td>
<td>Test data will be displayed properly from the sensor system to the GUI</td>
<td>All test data was obtained as expected.</td>
<td>ECG data was displayed properly and in proper position - no drift.</td>
</tr>
<tr>
<td>Movement Data</td>
<td>Movement trigger on appropriate GUI event</td>
<td>All movement was initiated and stop was observed.</td>
<td>Pop up window and sound alert was displayed off when the trigger of a fall.</td>
</tr>
<tr>
<td>Sensitivity Test</td>
<td>Sensors to allow safe alarm and allow for visual check within a monitored time</td>
<td>All tests were initiated and stop was observed.</td>
<td>Pop up window and sound alert were triggered within a second of software.</td>
</tr>
</tbody>
</table>

Web-Based GUI

- The user interface is entirely web-based, meaning:
  - The system is platform independent
  - The system can be integrated into existing systems.

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References: