A-Eye

Multi-Angle Fall Detection for Nursing Homes

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Use case/Problem

Elderly healthcare is a substantial part of the healthcare industry, providing services in nursing homes, assisted living, end-of-life care, and various other forms of healthcare. However, this industry suffers from systemic elderly neglect, including but not limited to: Inconsistent diaper changes, failure to provide food and water, carelessness in providing requested aid, etc. This negligence occurs for 2 main reasons: procedure neglect and patient neglect.

Procedure neglect is defined as the healthcare staff's failure to provide standard care, while patient neglect refers to the staff's attitude about care. While both forms of neglect can result in the same form of elderly abuse, the reason why negligence exists is different. In the case of procedure neglect, it originates from staff inexperience, limited staff resources, administrative pressures, and team communications [1]. While these are not the only reasons elderly neglect occurs, regardless of whether the neglect leads to elderly patients suffering, including the elderly patients falling.

According to the CDC, 1 in 4 of the 14 million older adults reports falling every year. Of these reported fallings, 37% percent of them required some medical attention and/or restricted the older person's movement for the day [2]. These problems are preventable when medical staff are given proper resources to administer proper care. The A-Eye provides medical staff with the procedural tools healthcare providers need to provide such care.

Solution:

To solve the issue of procedural neglect, A-Eye aims to solve this problem by providing A-Eye a privacy-centric monitoring ecosystem built on edge computing. A-Eye has several camera nodes, which observe patients and provide the feed to the A-Eye device, which can analyze and alert on patient status. A-Eye device provides on-board analysis and is able to report on patient conditions. The device's scope includes whether they detect the patient has fallen, is experiencing seizures, or is sickly based on their paleness/flush, etc. A-Eye uses the Edge-Fog-Cloud architecture, which is able to provide a local and private solution to patient neglect.

The Edge device layer is the cameras, which provide a feed that can contain patient medical events, such as seizures and falls. The Fog layer, being the local computational unit, analyzes the footage and, by using pose estimation and other AI technologies, can determine if the cameras are indeed recording some medical incident. The Fog device will also compare camera feeds to determine if a false positive occurs or to confirm the medical emergency. When such an event is confirmed, the device reports to the staff via SMS/email regarding the medical incident. Finally, the cloud layer is where these reports on medical incidents are kept, so when incidents are investigated or the data is needed, it can be retrieved from there.

A-Eye provides solutions to the challenges of procedural neglect by providing accountability, privacy, and optimized resource distribution. A-Eye can provide a transparent view of patient care by providing receipts of when medical emergencies occurred and why care may not have been provided. The technology also provides patient privacy since all the analysis is done on the device, and all patient recordings from the device aren't saved to maintain their privacy. Finally, the device being able to act like a resource distributor will only alert staff if the device is confident that the medical emergency is not a false positive. A-Eye is a powerful tool that will improve elderly care and reduce elderly neglect.

Demo:

The proof-of-concept demo will showcase a functional three-tier architecture using a simulated nursing home environment. In terms of the scope of our device, we will only be checking whether an elderly patient has fallen to the ground or not. We will use 1-2 edge devices, depending on how we set up the camera system.

The cameras will be set up in a way that has different angles of our mock patient. The edge device(s) will run a Python script using the MediaPipe Pose library to track the resident's center of gravity

relative to the floor. This will perform real-time recordings, and the camera nodes will interact with the fog Node (some central computing device) over the local wifi network.

The fog confirms that both edge devices have detected that a patient has fallen to ground level for over 5 seconds. This is to prevent false positives and only distribute medical resources if a fall has actually occurred. Once the Fog confirms a fall has taken place, it will trigger a Cloud-based API in order to send out to medical staff that a fall has taken place and where, such as "Emergency: Fall Detected in Room 101" . In terms of the API, services like Twilio or other free SMS/email API services should suffice for the demo.

Task Distribution:

- Edge Layer (2 Nodes): They are responsible for real-time video capture, AI inference (MediaPipe), and coordinate extraction. They make the initial local decision: "Does it look like a fall from my specific angle?" If yes, they send a JSON-formatted alert to the Fog.
- Fog Layer (1 Node): It handles the interaction between devices. It maintains a state machine that listens for alerts from both Edge nodes. It is responsible for "voting" logic (to reduce false positives) and time-window filtering. It acts as the bridge between the local network and the internet.
- Cloud Layer: It provides the long-term storage and external communication gateway. It hosts the API that sends the SMS/Email notification and logs the event for later review by a doctor or administrator.

Citations:

[1] Reader TW, Gillespie A. Patient neglect in healthcare institutions: a systematic review and conceptual model. BMC Health Serv Res. 2013 Apr 30;13:156. doi: 10.1186/1472-6963-13-156. PMID: 23631468; PMCID: PMC3660245.

[2] Centers for Disease Control and Prevention. "Older Adult Falls Data." CDC, 28 Oct. 2024, www.cdc.gov/falls/data-research/index.html