

Development of an Assistance Robot for Fall Detection and Reporting in Healthcare

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Abstract. Falls pose a substantial risk to elderly individuals, especially those over 65, often leading to severe consequences. This project investigates the potential of the tēmi robot for fall detection in care facilities and its integration into a simulated clinical workplace system. The prototype employs the YOLOv8 image recognition model to detect fallen individuals during patrols, transmitting incident data to a simulated clinical system via Fast Healthcare Interoperability Resources (FHIR). While initial tests delivered promising results, enhancements in image recognition accuracy are required for effective real-world deployment.

Keywords. Social robotics, fall detection, FHIR integration

1. Introduction

Robots are increasingly being explored in nursing for applications such as mobility aids, transport tasks, and patient monitoring [1,2]. Additionally, social robots can support emotional and cognitive care [3]. Despite promising developments, the widespread use of robots in the Swiss healthcare system remains limited. The Institute for Medical Informatics at Bern University of Applied Sciences has integrated robots into student education [4,5] and actively examines the potential of robots in medical environments. Among these, patient falls are a critical area of focus, as they are one of the leading causes of injuries among elderly individuals. Early detection of falls is vital to improving outcomes and ensuring timely interventions [6].

In collaboration with LEP AG, the provider of the LEP Nursing 3 interventions catalog, this project investigated the use of an assistance robot for fall detection in healthcare environments. A key focus was on integrating the robot with clinical information systems (CIS) to streamline communication and documentation processes.

The project aimed to reduce the workload of healthcare staff by enabling the robot to conduct ward rounds, detect fallen patients, and promptly notify or call a nurse to the scene. This objective led to the following research question:

"How can an assistance robot perform a LEP nursing-3 intervention such as a ward round or night watch, transmit the activity record to the clinical information system (CIS), and notify or call healthcare staff in the event of a detected patient fall?"

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2. Methods

A literature review was conducted to identify appropriate communication standards for the interaction between the robot and the clinical information system (CIS). Practical requirements were refined through discussions with CIS providers, such as Nexus.

The prototype was developed on a Tēmi robot (version 3) running Android, with the robot's application programmed in Kotlin. Additionally, the simulated clinical information system (CIS) was implemented using Python. Communication between the Tēmi robot and the simulated CIS was established using the standardized FHIR format, with JSON files transmitting intervention tasks.

YOLOv8 model (You Only Look Once) was used, a real-time object detection algorithm for Fall detection. The dataset, originally adapted from the study "Fallen People Detection Capabilities Using Assistive Robot"[7], consisted of 6,982 images, including 5,023 images of falls and 2,275 non-fall images. To enhance recognition accuracy, an additional 1,906 images were captured under varying lighting conditions. The YOLOv8 model was trained over 200 epochs to optimize detection performance.

The prototype was tested in the Medical Informatics Laboratory at Bern University of Applied Sciences, which simulated a clinical environment featuring corridors, patient rooms, and a nursing station to replicate real-world conditions. These scenarios were designed to mimic practical care settings and assess the robot's functionality.

The testing phase evaluated the functionality of the prototype through two scenarios. In the first, routine patrols were conducted, during which the robot followed predefined routes to monitor the environment and detect fallen individuals. The second scenario simulated fall events, with test participants acting as patients by deliberately falling or lying on the ground. These situations were used to assess the system's ability to accurately identify and respond to falls.

3. Results

The prototype consisted of two primary components: communication simulation and fall detection. Communication between the Tēmi robot and the simulated clinical information system (CIS) was successfully implemented using a WebSocket connection, enabling real-time data exchange. Fall detection alerts were transmitted as standardized FHIR JSON files, containing key details such as timestamp, fall location, and the detected individual's position. These alerts were seamlessly integrated into the CIS using FHIR resources like "Observation" and "Task", ensuring compatibility with electronic health record (EHR) systems.

Additionally, the Tēmi robot's tablet interface displayed real-time alerts for detected falls, providing immediate feedback to healthcare staff (Fig. 1).

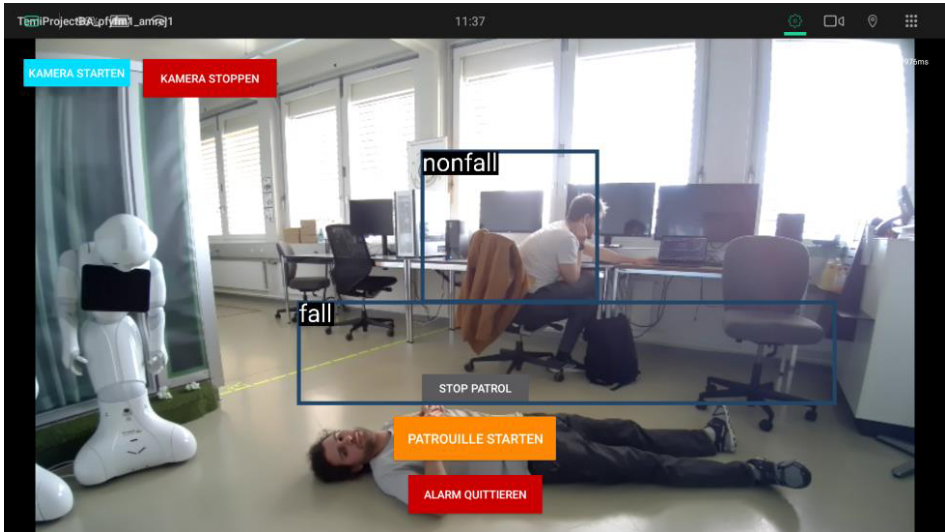


Figure 1 Tēmi detects a fall and shows this with an alarm on the tablet interface. Fallen and not fallen individuals are distinguished

Fall detection relied on the YOLOv8 image recognition model, which distinguished between routine rounds and incidents involving falls. When a fall was detected, the system triggered an alarm and transmitted the incident details directly to the simulated CIS or care staff. Performance evaluation of the YOLOv8 model revealed that the F1-score across all classes peaked at 0.81 at a confidence threshold of 0.182, demonstrating a balanced trade-off between precision and recall.

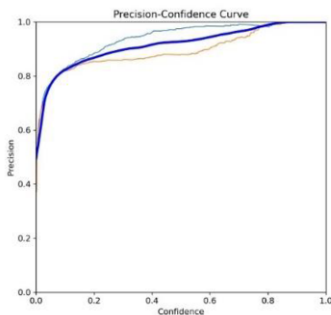


Figure 2 Precision-Confidence Curve

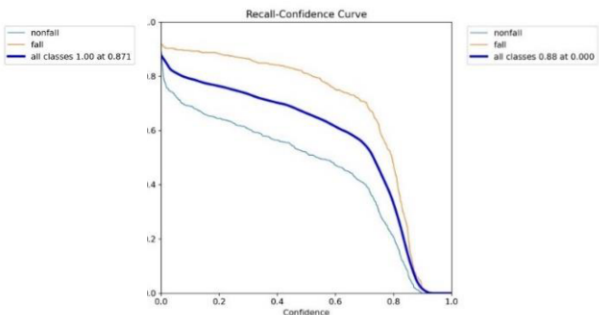


Figure 3 Recall-Confidence Curve

4. Discussion

The integration of assistive robots in healthcare can reduce nursing workload by automating fall detection and documentation. In hospitals, where nurses manage multiple floors during night shifts, robots could improve patient monitoring and response times. Standardized protocols like FHIR ensure compatibility with clinical IT systems and enhance interoperability.

Alternative fall detection methods, such as wearable sensors (e.g., Apple Watch), belt sensors, or inflatable hip airbags, are increasingly used but rely on patient compliance and are designed for home settings. In contrast, robot-based systems provide continuous, non-intrusive monitoring, making them more suitable for hospitals where caregivers need automated surveillance tools.

While an F1-score of 0.81 is promising for an experimental setup, it falls below the threshold required for clinical use, where high sensitivity and specificity are essential. Studies suggest that AI models in healthcare often need F1-scores above 0.90 to minimize false positives and negatives, ensuring reliable decision-making in patient care [8]. Similarly, research highlights that such high accuracy is critical to maintaining diagnostic integrity and reducing misclassification rates [9]

Initially, a system may generate false alarms, but preventing real falls from being missed is the priority. Further refinements in training datasets and model optimization are needed to reach clinically acceptable performance levels.

5. Conclusion

This project demonstrated the feasibility of integrating assistive robots into healthcare workflows for fall detection and documentation. The Tēmi robot, which uses a YOLOv8-based detection system, delivered promising results with high detection accuracy and seamless integration into clinical information systems via FHIR standards.

Further refinements are needed to improve accuracy under varying conditions and reduce false alarms. Future work should address real-world testing and ethical considerations. With continued development, assistive robots like Tēmi could play a crucial role in supporting healthcare staff and enhancing patient safety.

References

- [1] Maalouf N, Sidaoui A, Elhadj IH, Asmar D. Robotics in Nursing: A Scoping Review. *J Nurs Scholarsh*. 2018 Nov;50(6):590–600. doi: 10.1111/jnu.12424.
- [2] Adami I, Antona M, Stephanidis C. Home Trials of Robotic Systems: Challenges and Considerations for Evaluation Teams. In: Antona M, Stephanidis C, editors. *Universal Access in Human-Computer Interaction Users and Context Diversity*. Cham: Springer International Publishing; 2016. p. 291–301.
- [3] Figliano G, Manzi F, Tacci AL, Marchetti A, Massaro D. Ageing society and the challenge for social robotics: A systematic review of Socially Assistive Robotics for MCI patients. *PLoS One*. 2023;18(11):e0293324. doi: 10.1371/journal.pone.0293324.
- [4] Bürkle T, Bender M, Glauser R. Using Robots in Medical Informatics Education. *Stud Health Technol Inform*. 2022 May 25;294:765–9. doi: 10.3233/SHTI220580.
- [5] Glauser R, Holm J, Bender M, Bürkle T. How can social robot use cases in healthcare be pushed - with an interoperable programming interface. *BMC Med Inform Decis Mak*. 2023 Jul 11;23(1):118. doi: 10.1186/s12911-023-02210-7.
- [6] BFU [Internet]. [cited 2025 Jan 16]. Stürze bei älteren Erwachsenen. Available from: <https://www.bfu.ch/de/die-bfu/medien/stuerze-bei-aelteren-erwachsenen>
- [7] (PDF) Fallen People Detection Capabilities Using Assistive Robot. ResearchGate [Internet]. 2024 Oct 22 [cited 2025 Jan 16]; Available from: https://www.researchgate.net/publication/335318179_Fallen_People_Detection_Capabilities_Using_Assistive_Robot
- [8] Calster BV, Collins GS, Vickers AJ, Wynants L, Kerr KF, Barreñada L, et al. Performance evaluation of predictive AI models to support medical decisions: Overview and guidance [Internet]. arXiv; 2024 [cited 2025 Mar 11]. Available from: <http://arxiv.org/abs/2412.10288>
- [9] F1 Score in Machine Learning: Intro & Calculation [Internet]. [cited 2025 Mar 11]. Available from: <https://www.v7labs.com/blog/f1-score-guide>