Wearables and IoT to Predict and Prevent FALL During Daily Activities

AK 47 (Minor)

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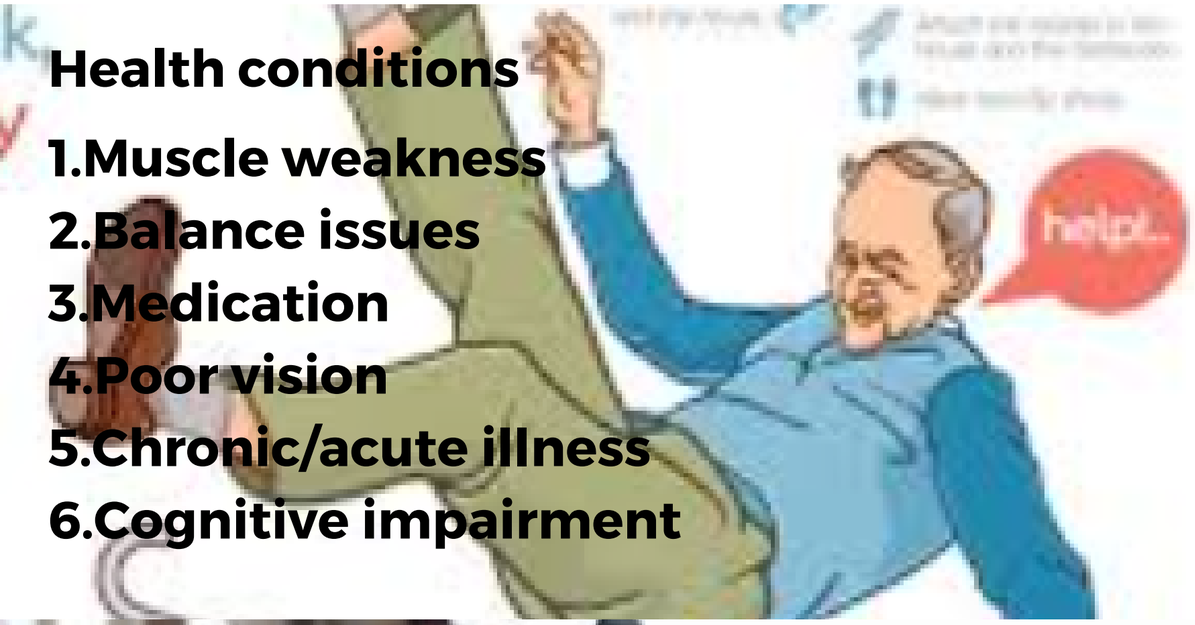
When can a person fall?



Health conditions

1.Muscle weakness
2.Balance issues
3.Medication
4.Poor vision
5.Chronic/acute illness
6.Cognitive impairment

Environment al Factors

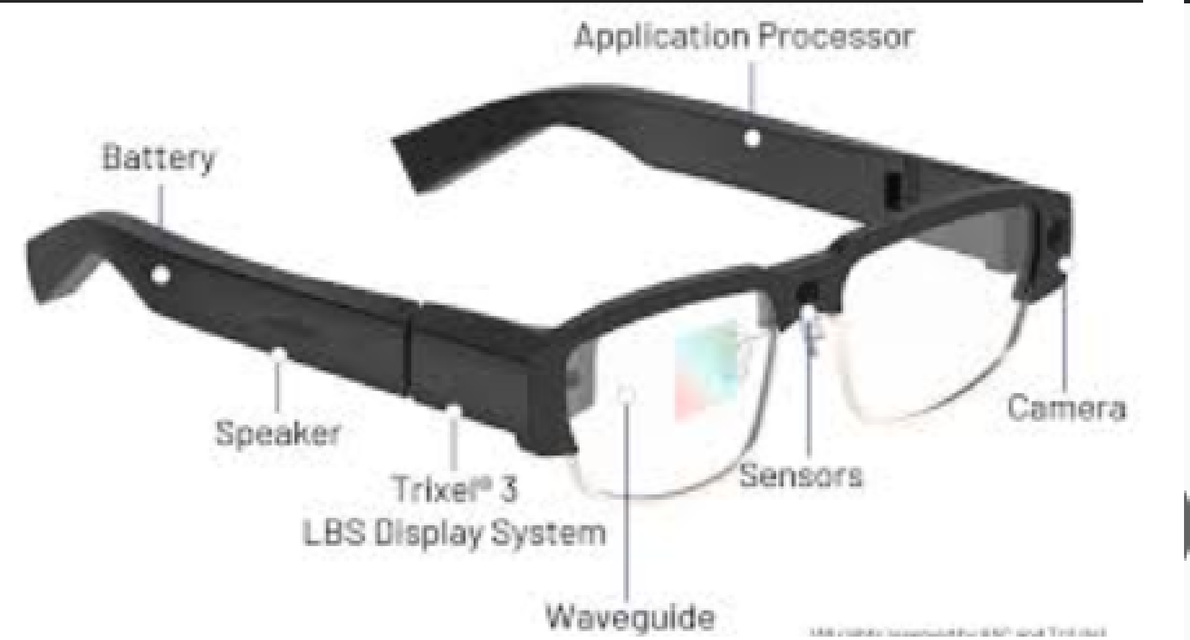
1.Cluttered Spaces
2.Slippery Surfaces
3.Poor Lighting
4.Uneven Surfaces

Behavioral Factors

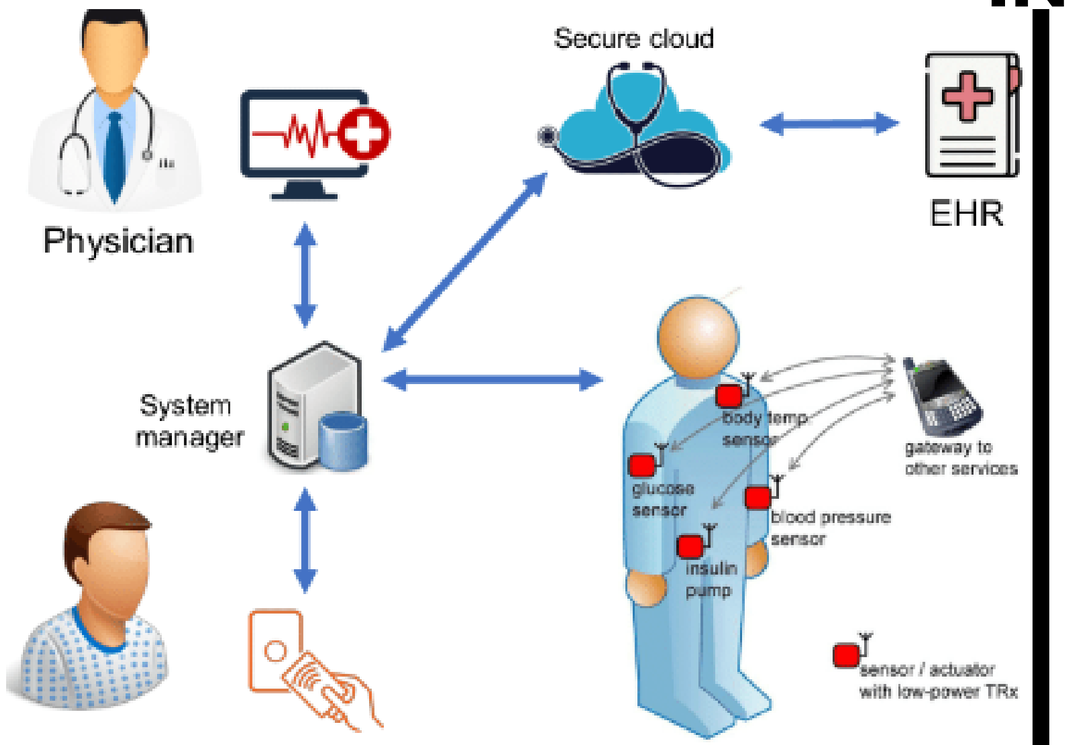
1. Rushing:
2. Multitasking
3. Inattention

Situational factor

When cops after you



INTRODUCTION



MATERIALS AND METHODS

CONTEXT-AWARE SYSTEMS WITH AMBIENT SENSORS

- **Camera-Based Sensors**
- **Proximity and Pressure Sensors**
- **Motion Detection with Gaming Devices**

BEHAVIOURAL MODELLING FROM SENSOR DATA IN SMART HOMES (Forbes et al.)

Sensor Deployment

Passive sensors like infrared motion detectors & door sensors are installed to track location, movement, and activity transitions.

Behavioral Modeling

ML algorithms, including Hidden Markov Models and Conditional Random Fields, recognize activities of daily living and detect deviations from established patterns.

Data Analysis

Comparison between normal activity and observed changes helps identify subtle shifts in behavior, such as reduced gait speed which are early indicators of potential falls.

WEARABLE SENSOR-BASED SYSTEMS

- **Accelerometers and Gyroscopes**
- **Pressure Sensors**
- **Multi-Sensor Integration**

PATIENT-SPECIFIC SINGLE SENSOR IoT BASED SYSTEM (Saadeh et al.)

Sensing and Data Acquisition

Tri-axial accelerometer on the patient's thigh, collect data at 256 samples/sec and transmit via Bluetooth to an FPGA.

Fall Prediction (FMFP)

Employs a Nonlinear SVM algorithm with seven extracted features from acceleration data.

Fall Detection (SMFD)

Utilizes a threshold-based algorithm with a 1-sec sliding frame to classify fall or non-fall instances.

AI-BASED ELDERLY FALL PREDICTION SYSTEM WITH IoT INTEGRATION (Kulurkar et al.)

Wearable Sensors

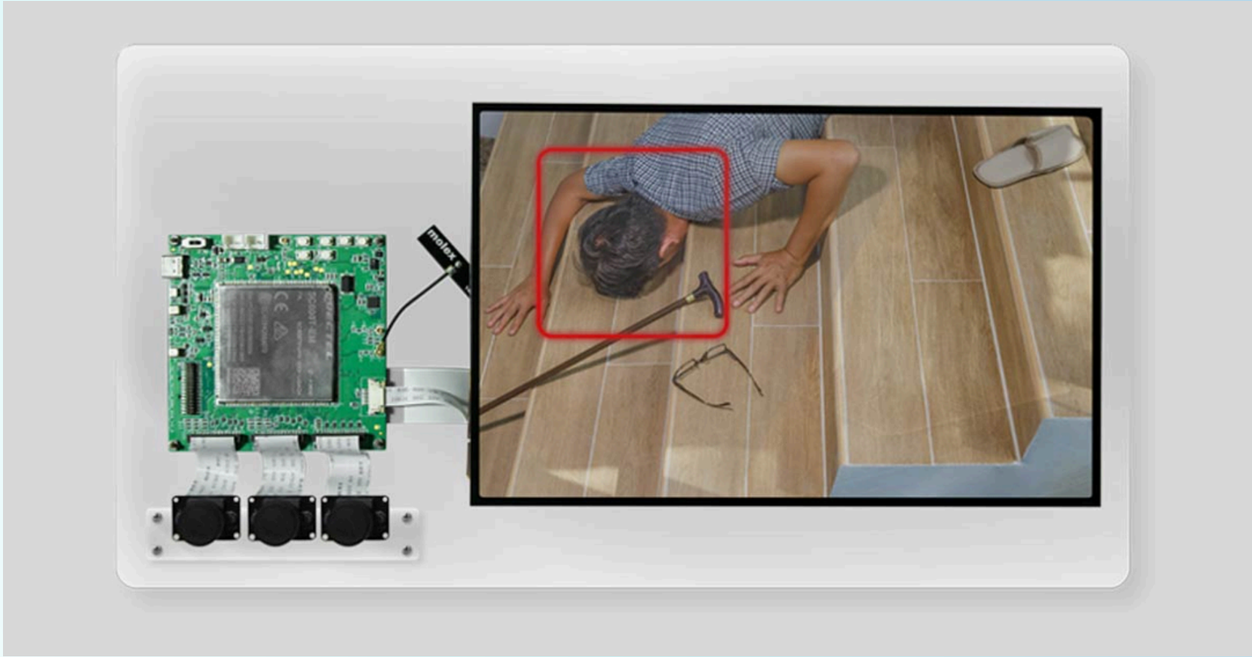
Low-power wearable sensor with 3 axis accelerometer (LSM6DS0) for motion data collection.

Wireless Communication

IPv6-enabled 6LowPAN protocol for IoT network communication, transferring data to cloud via IoT gateway.

Machine Learning Models

LSTM deep learning models for fall detection and prediction, with ensemble approach for reliable results.



RESULTS

- **BEHAVIOURAL MODELLING FROM SENSOR DATA IN SMART HOMES**- Detects anomalies like reduced movement and prolonged sedentary behavior. Long-term monitoring enables predicting falls weeks in advance for timely intervention.

- **PATIENT-SPECIFIC SINGLE SENSOR IoT BASED SYSTEM** - 97.8% sensitivity and 99.1% specificity in fall prediction, and 98.6% sensitivity and 99.3% specificity in fall detection.

- **AI-BASED ELDERLY FALL PREDICTION SYSTEM WITH IoT INTEGRATION**- Achieved 99% accuracy in fall detection with high precision of 96%, especially with wrist and waist sensor placement.

SUMMARY

- IoT and AI-based fall prediction and detection systems offer a significant advancement in elderly care, combining real-time data analysis, behavioral monitoring for proactive fall prevention.

- Patient-specific designs and optimized sensor placements ensure unobtrusive, continuous monitoring that adapts to various environments, seamlessly integrating into daily life.

- With high accuracy and reliability, these systems enhance safety and independence in elderly care and hold potential for broader applications in smart home and assisted living environments.

LIMITATIONS

Challenges Identified:

- **Energy Efficiency:** High energy consumption in wearable devices limits continuous monitoring capabilities, leading to potential data gaps and lower reliability.
- **False Positives/Negatives:** Existing detection algorithms may incorrectly classify daily activities as falls, resulting in user frustration and system inefficiency.
- **User Comfort:** Wearable devices often cause discomfort over long-term use, leading to reduced adherence, especially among older adults.
- **Data Integration Issues:** Combining data from multiple sensors for comprehensive fall prediction is complex and often lacks user-friendly interfaces.

PERSPECTIVES

Alternative Methods to Overcome Limitations:

- Improved Energy Solutions:

- Low-Power Designs: Implement ultra-low-power sensors or energy-harvesting technology to extend battery life.

- Edge Computing: Shift computational tasks to local IoT gateways to minimize power usage on wearables.

- Enhanced Detection Algorithms:

- Hybrid AI Models: Integrate machine learning models like SVMs with deep learning (e.g., LSTMs) to reduce false positives and enhance accuracy.

- Patient-Specific Calibration: Customize algorithms to individual user profiles for more accurate fall predictions.

Comfort-Oriented Wearable Designs:

- Flexible and Lightweight Materials: Develop wearables with soft, breathable materials to encourage continuous use.
- Minimalistic Sensors: Focus on single-sensor solutions with high precision to reduce the device size and increase user comfort.

- Data Fusion for Comprehensive Monitoring:

- Integrated Sensor Networks: Use a combination of wearable and ambient sensors to capture contextual data and improve prediction accuracy.
- User-Friendly Interfaces: Develop smartphone apps with intuitive dashboards for real-time monitoring and feedback.

TAKE HOME MESSAGE

Fall Prediction Technology: Wearables and IoT enable real-time fall monitoring for at-risk individuals.

Current Limitations: Challenges include high energy use, false detections, and discomfort in wearables.

Improvement Strategies: Solutions like low-power designs, hybrid AI, and comfortable wearables can boost effectiveness.

User-Centered Focus: User-friendly, personalized systems are essential for accessibility and reliability.

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