# Real-time Fall Detection System using Movenet Algorithm and ML Model

**Introduction:** The Real-time Fall Detection System is designed to monitor a live webcam feed and accurately detect falls using the Movenet algorithm for pose estimation. Falls are one of the leading causes of injury and accidental deaths among elderly people, making detection systems critical for timely intervention. This system integrates state-of-the-art technology to immediately notify a caregiver or healthcare assistant upon detecting a fall, thus minimizing injury-related risks. The system combines pose estimation and machine learning techniques, leveraging cloud services for scalability and real-time analysis.

**Tech Stack:**

- **Programming Language: Python**
  Python is a versatile language that is commonly used in machine learning and computer vision projects. It is also widely used in research studies for fall detection due to its rich ecosystem of libraries like TensorFlow and OpenCV.
- **Webcam Interface: OpenCV**
  OpenCV provides functions for accessing and processing video streams from webcams. It allows for efficient integration with Movenet for capturing live feed.
- **Pose Estimation Algorithm: Movenet**

Movenet is an advanced real-time pose estimation model developed by Google, leveraging deep learning techniques to accurately estimate human poses from video frames. The algorithm predicts 17 human key points and is robust in different lighting and motion conditions. It has been tuned for real-time performance and is suitable for detecting fast movement. Research indicates that systems combining wearable sensors and pose estimation are among the most reliable and accurate approaches for fall detection.

**Understanding Fall Risk Factors:** Understanding the risk factors responsible for falls in elderly persons is essential for developing an effective prevention system. Falls are often caused by a combination of biological, behavioral, and environmental factors. Common causes include physiological conditions and falls from beds. The detection and prevention of falls require a detailed classification and understanding of fall types, as well as the factors contributing to each type.

**Fall Detection/Prevention Approaches:** A variety of approaches have been developed by researchers to detect and prevent falls among the elderly. These approaches integrate **machine learning**, **IoT devices**, and **imaging techniques** to predict and detect falls, often using continuous monitoring. Fall detection systems typically fall into three categories:

1. **Wearable Devices**: These are worn by users and include accelerometers and gyroscopes to track body posture. However, users may find them intrusive or uncomfortable, and the device placement can affect accuracy.
2. **Camera-Based Devices**: These systems use cameras placed strategically to monitor movement, allowing for non-intrusive tracking. Unlike wearables, camera-based systems can analyze multiple features and store data for future reference.
3. **Ambient Sensors**: These are embedded in the environment, such as walls or floors, to detect falls based on activity patterns without requiring the user to wear a device.

The Movenet-based system falls under the **camera-based approach**, which is ideal for non-invasive, real-time monitoring. Such systems provide the advantage of tracking multiple people simultaneously and are well-suited for environments where elderly individuals are being monitored, such as assisted living facilities or homes.

**Important Considerations**:

- **Low Light Conditions**: The system's robustness in such environments can be enhanced by increasing the model's sensitivity or integrating infrared vision for better video analysis.
- **Internet Connectivity**: The system checks for internet availability before sending SMS alerts. If disconnected, it should queue messages to send when reconnected.
- **Real-Time Processing**: Both video and audio are processed in real-time, with a fall detection cooldown to avoid false positives.

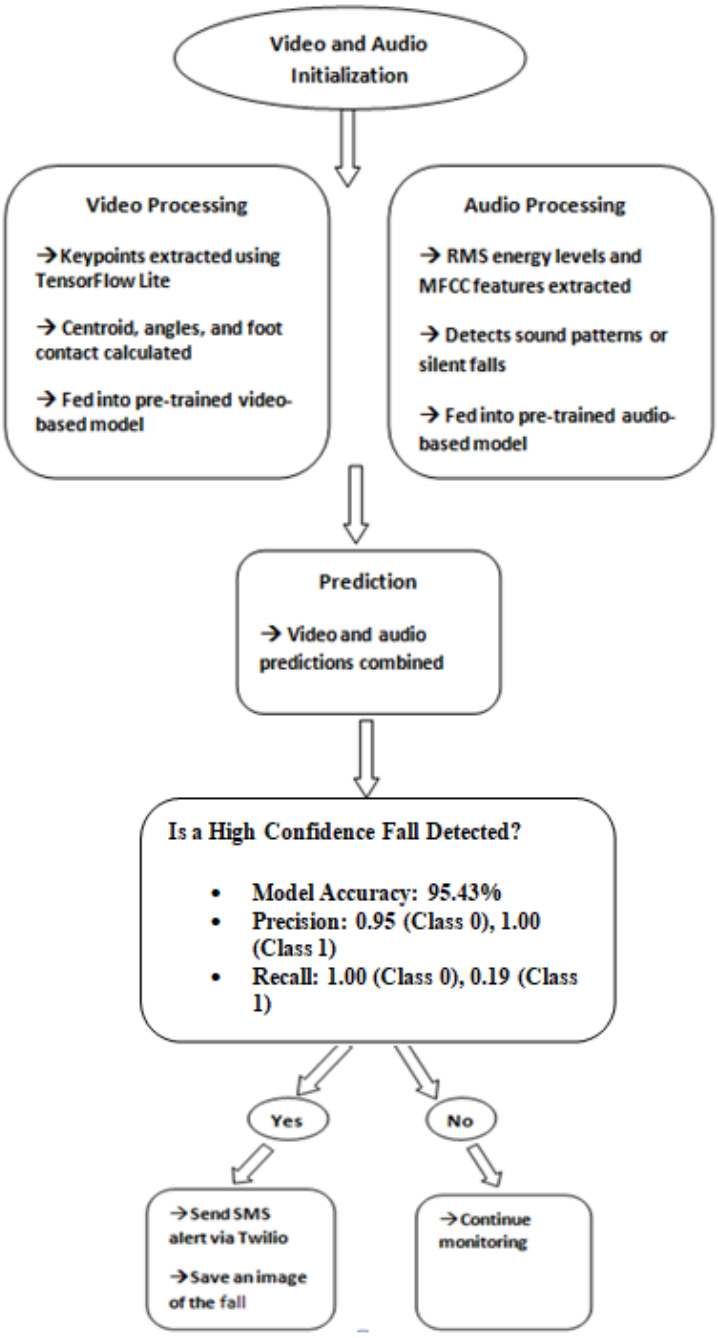
**Fall Detection Technology Trends**:

Research suggests that the adoption of fall detection technologies is growing rapidly, with a predicted 4% compound annual growth rate (CAGR) in the market from 2019 to 2029. Devices from companies like MobileHelp, LifeFone, and Apple Watch have entered the market, offering automatic fall detection features and real-time alerts. Governments are increasingly investing in these technologies to reduce the costs associated with treating after-fall injuries.

**Fall Prevention Approaches:** Fall prevention is not guaranteed but can be achieved by continuously monitoring and assessing fall risk factors. Simple strategies include:

- Checking if individuals are holding onto walls or objects while walking.
- Reviewing their medication.
- Performing safety assessments of their living environment.
- Encouraging regular health check-ups

**System Flow Diagram:**

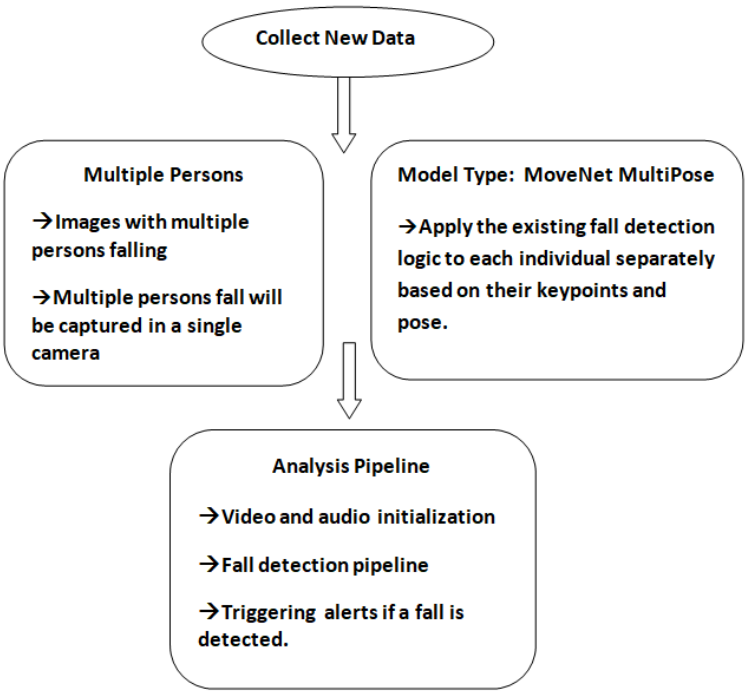



1. **Video and Audio Initialization**:

- Camera is initialized, and real-time audio is captured via PyAudio.
- Handles reconnections in case of camera standby.

2. **Fall Detection Pipeline**:
- Video: Keypoints are extracted using a TensorFlow Lite model (MoveNet). Additional features like centroid, angles, and foot contact are calculated.
- Audio: RMS energy levels and MFCC features are extracted to detect sound patterns or silent falls.
- Both audio and video data are fed into pre-trained models for fall prediction.
3. **Alert Mechanism**:
- If a fall is detected with high confidence, an SMS alert is triggered via Twilio, and an image of the fall is saved.

## Multi-Person Fall Detection




This approach can be visualized as a heading for the new pipeline that works in conjunction with the existing system.

**Machine Learning Framework: TensorFlow or PyTorch** TensorFlow is a powerful deep learning framework used widely for developing and training machine learning models. It plays a crucial role in building the fall detection classifier, which distinguishes between fall and non-fall poses.

**Fall Detection Model**

The fall detection model classifies fall and non-fall events using the pose data extracted from Movenet. The ML model can be trained on datasets like the SisFall and MobiFall, which have been widely used in the research community for validating fall detection systems.

**Model Deployment:** The deployment of the fall detection system can be achieved using web frameworks like FastAPI. These frameworks allow developers to build a custom deployment pipeline, making the model accessible via API endpoints.

**Alerting System**

For immediate response, the system integrates an alerting mechanism using services like Twilio to send SMS or text notifications to a caregiver when a fall is detected. According to the systematic review, timely alerts play a critical role in reducing the severity of injuries following a fall.

**Cloud Services:** AWS is recommended for handling object storage, computation, and deployment. Cloud services offer the flexibility and scalability required to ensure the system operates in real-time without latency issues.

**Version Control:** Git can be used to manage the codebase, ensuring seamless collaboration and version tracking throughout the development and deployment of the system.

**Conclusion:** This real-time fall detection system integrates cutting-edge pose estimation algorithms and machine learning models to monitor and detect falls. With a non-invasive camera-based setup, cloud scalability, and real-time alerts, the system addresses many of the key challenges faced in fall detection and prevention. The inclusion of camera-based, wearable, and ambient devices ensures comprehensive monitoring, helping reduce the risks and impacts of falls on the elderly.