Invention Disclosure Details

1. Please provide a suitable title for your invention.

"V-Belt"(Waist belt).Wearable sensor belt with IoT system for prevention of falls in elderly people

2. Please elaborate on the problem being solved by your invention. Please specify the actual problem in the existing product or process.

Disability is more common in elderly people, with falls being a major cause of disability. One-third of community-dwelling older adults experience a fall annually, leading to negative health outcomes and injury-related deaths [1], [2]. The psychological impact of falling can cause fear and limit physical activities, making individuals weaker and more susceptible to future falls. Many falls can be prevented, but fall prevention programs have faced barriers such as lack of resources, transportation issues, scheduling conflicts, and physical environmental factors [3], [4].

The objective of this project is to create a smart belt that will improve safety and lessen injuries for senior citizens who fall. Instead of avoiding falls, this belt's cutting-edge features aim to minimize injuries. In addition to being comfortable and made of lightweight materials, it has an emergency alarm system that, when a fall is detected, instantly notifies family members or caretakers via a GSM module. This capacity to respond quickly ensures that consumers get aid when they need it, improving their general safety and well-being.

3. Please detail the solution being provided by the invention to overcome the problem. Please provide a schematic diagram and its description if required.

The Waist belt wearable sensors with IoT systems may help elderly people prevent falls by giving feedback to users regarding the risks of falling. This software was developed with sensors that could able to sense whenever there is the risk of Line of Gravity (LOG) going outside the Base of Support (BOS) during day-to-day activities for elderly people as this is the most common reason for elderly people.

These technologies will help elderly people to prevent falling by which Disability may be prevented. This digital delivery of fall prevention may be feasible.

4. Please provide us with the already available solution to the problem. Please provide us any information with on the same.

The WaistonBelt X and similar wearable devices promote healthier lifestyles and support rehabilitation through accurate monitoring of activity recognition, and posture correction[3], [4]. However, some potential issues arise in the areas of

1. Privacy concerns: No continuous monitoring of an individual's activities and health data [5]
2. Comfort and wearability: It's not easy to incorporate into daily routines is crucial for long-term users [3]
3. Reliability and accuracy: While high accuracy rates are reported for waist measurement and activity recognition, real-world conditions may introduce variability [6], [17].

4. Integration with healthcare systems: No comprehensive health management and facilitate communication between users and their care teams[7].
5. Battery life and charging: Ensuring adequate battery life and convenient charging methods is important but getting interrupted in monitoring leads to user inconvenience[7].
6. Durability and water resistance: No proper design in the devices to withstand daily wear, including exposure to water and sweat[3], [8].

5. Please provide you with how your solution is unique and different as compared with other available/known solutions to the same/similar problems.

The belt can be worn around the waist, it's close to the body's center of mass, which is ideal for capturing overall motion, including falls, shifts in posture, or sudden movements. A belt is minimally invasive, easy to wear, and doesn't interfere with everyday activities like walking. Since it's not subject to constant foot impact (like a shoe), sensor accuracy remains high without the need for impact-proof designs. Protective Padding in the belt includes layers of high-density foam or materials like D3O (a smart material that stays soft but hardens on impact). This adds constant protection, particularly to the hips or lower back as shown in **Fig. 1**, areas most vulnerable to injury during a fall. While this method offers less dynamic protection compared to airbags, it’s easier to implement and can still significantly reduce the risk of fractures or bruising.
The ESP32 microcontroller serves as the central processing unit of the proposed system, which also includes an Inertial Measurement Unit (IMU) with accelerometer and gyroscope sensors as shown in **Fig. 1**. Together, these elements enable precise movement pattern detection and analysis, with an emphasis on fall event identification. The hardware architecture of the system is built to be small, familiar, and effective, guaranteeing constant monitoring without sacrificing user comfort. In addition to being comfortable and made of lightweight materials, it has an emergency alarm system that, when a fall is detected, instantly notifies family members or caretakers via a GSM module as illustrated in **Fig 3**. This capacity to respond quickly ensures that consumers get aid when they need it, improving their general safety and well-being.

The system's advanced data collecting and processing algorithms are what give it its intelligence. The ESP32 microcontroller processes the movement data that is continually collected by the IMU sensors in real time. An embedded GSM module with SIM functionality then sends this data to a cloud server, allowing for safe storage and sophisticated movement pattern analysis as shown in **Fig. 5**. Over time, the accuracy of the system's fall detection is increased because of this ongoing monitoring and data collecting.

Both automation and user control are considered in the design of the system's alert mechanism. The belt instantly sounds an audible warning when it detects a fall. Through a straightforward interface, the wearer may quickly deactivate the alarm if they are unhurt. Nevertheless, the system immediately starts its emergency procedure if the alarm is not answered as shown in the process in **Fig. 4**. This entails notifying emergency medical services if required after sending SMS notifications to pre-registered family members or caregivers via the cloud server as shown in **Fig. 2**.

Fall Detection System

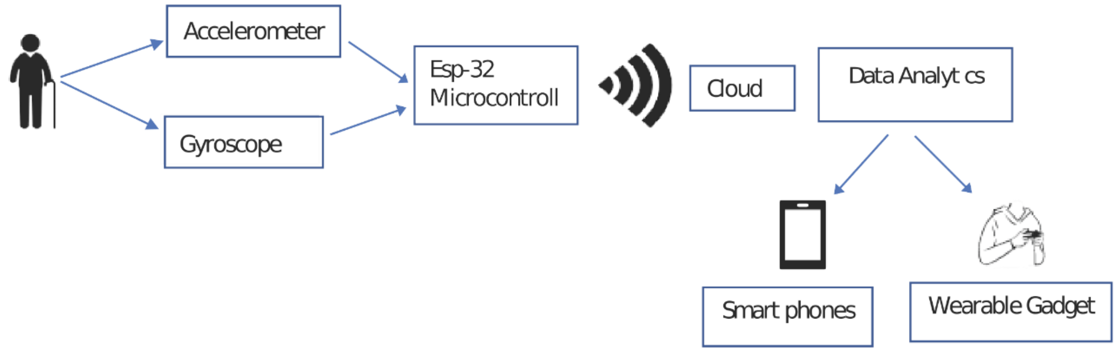

Fig 1: IMU sensor setup integrated into the belt for detecting movements and falls.

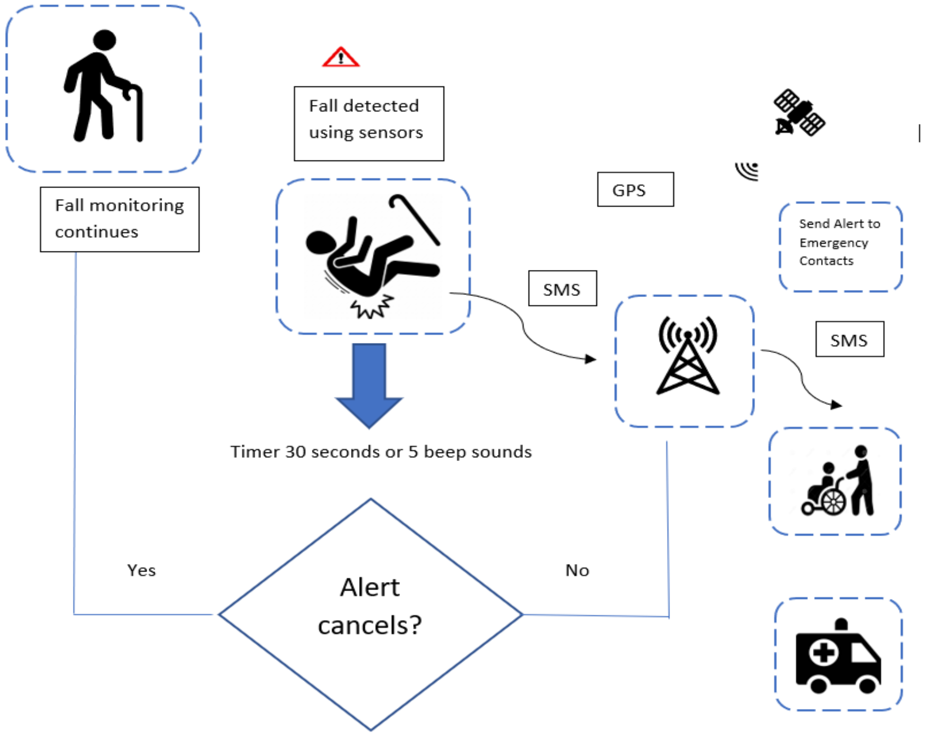

Fig-2: GSM Module used for sending alerts to caregivers upon fall detection.

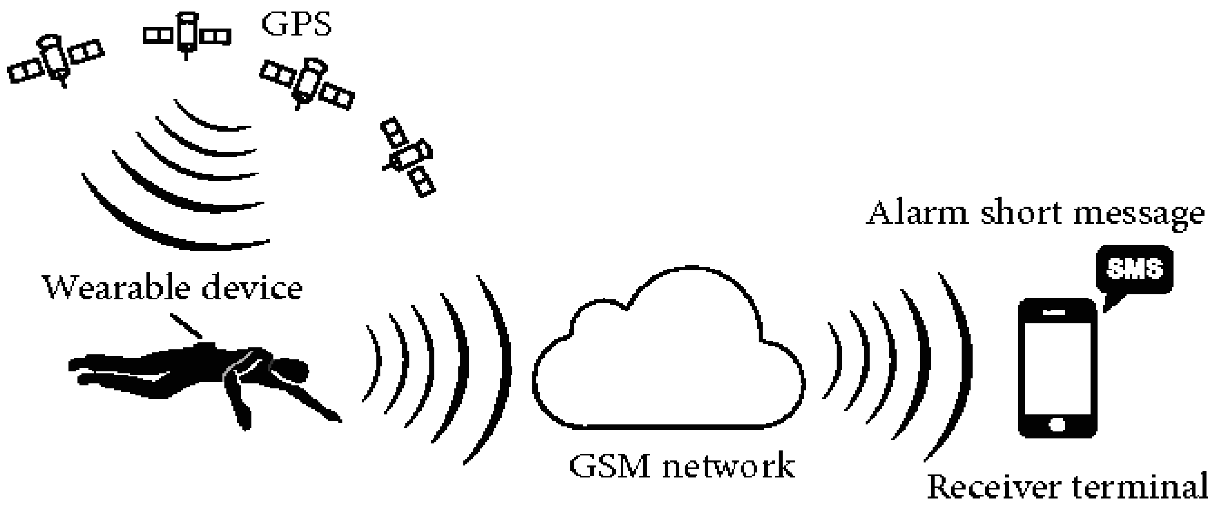

Fig-3: Emergency alert system embedded within the V-Belt for immediate notifications.

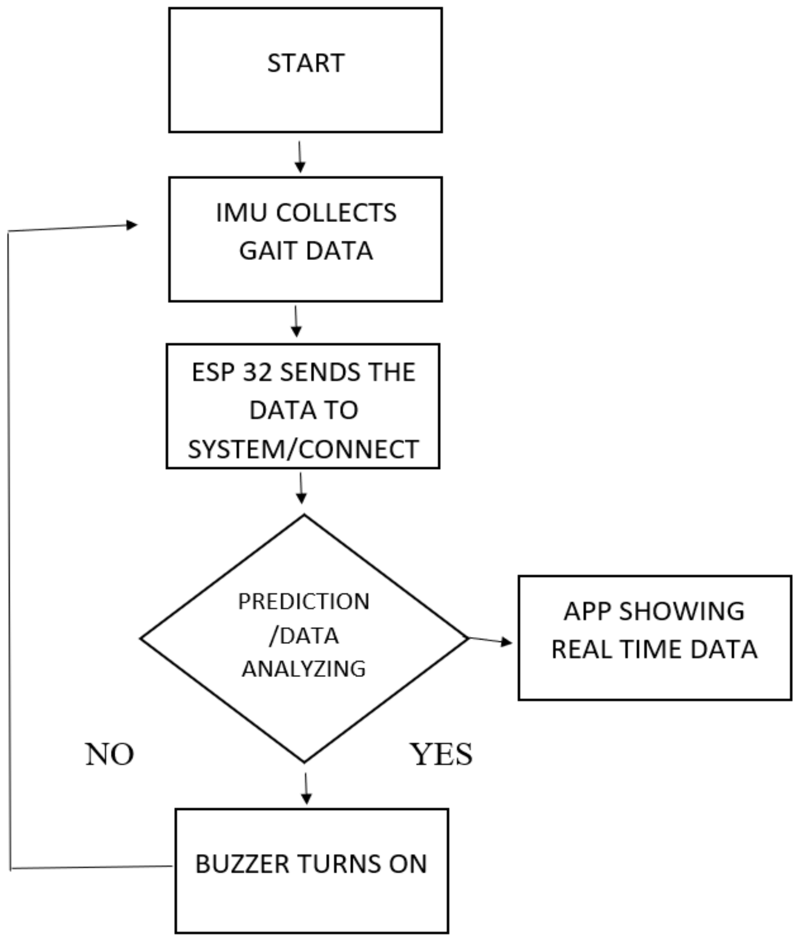

Fig-4: Process flow of the V-Belt system's fall detection and alert mechanism.

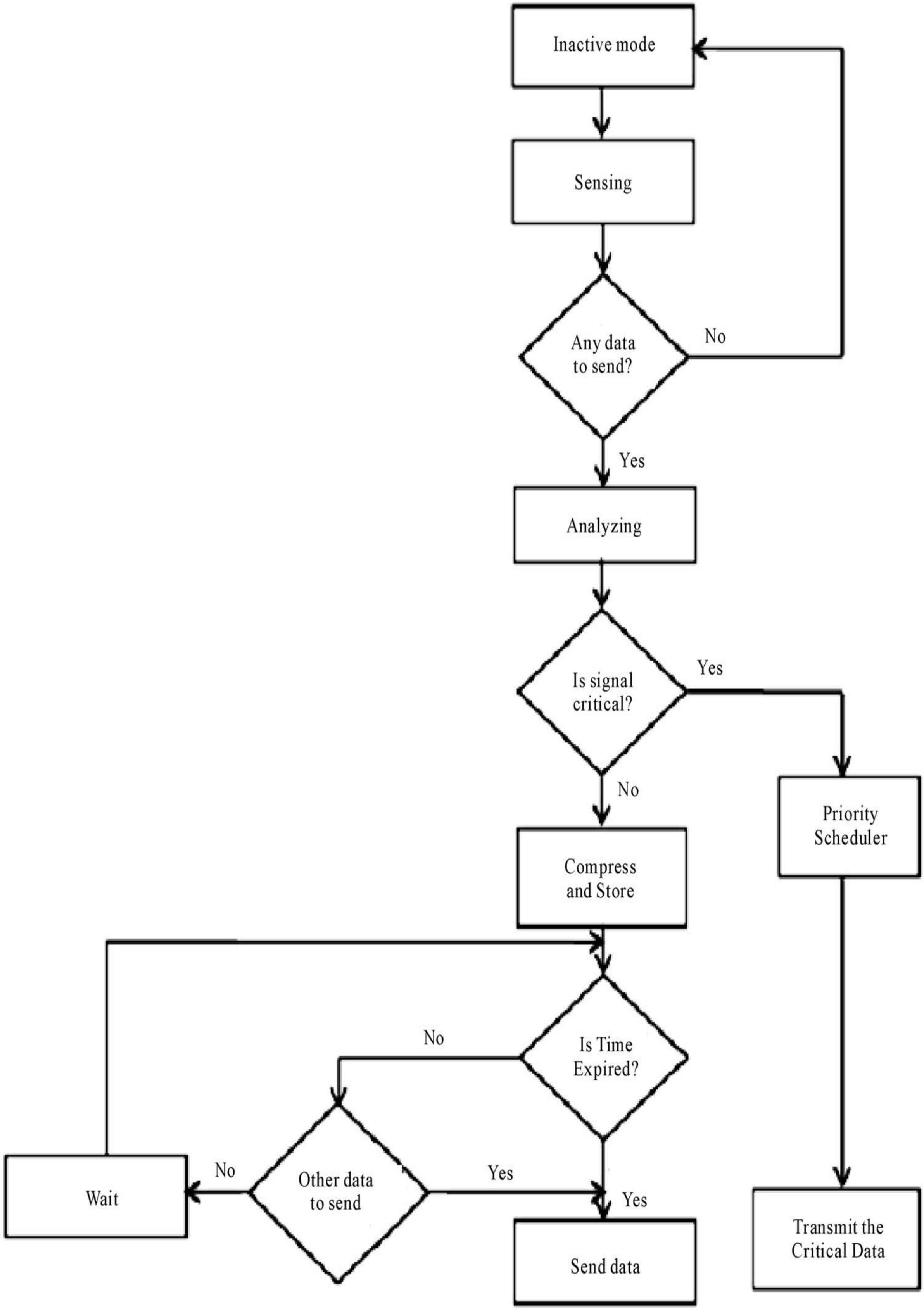

Fig-5: Data transmission process to cloud server for movement analysis.

6. **Please provide us with the advantages of your solution. Please Compare the advantages in view of the existing/conventional solutions uncovered during the search under point 5. You may make a table or figures. Further, you can provide us with the economic potential or commercial applications for the technology.**

Features	Existing Technologies	References I	References I I	Proposed Technologies
Fall Detection using a wearable device	Pendants, Watches, Or Belts[3], [9]	• Integrated Smartphone application • Intervention via belt vibration for high accuracy	• Smart Insole integrated with mobile application • Smart-cane device to detect fall • Sensor gives feedback and alerts users	Waist Belt
Fall Positions	Coming to rest on the floor, or other lower level, excluding the change in position to rest[5]	• Wireless smart shoe to detect falls using multi-sensors • Sensors pass to Machine learning • Posture detection		Coming to rest on the ground, floor, or lower level, including the position to rest
Power source	Batteries, Triboelectricity, Piezoelectricity, Solar batteries and supercapacitors[2]	• Recharging the device using triboelectricity		Batteries
Hardware materials	Polymers, Nylon, Carbon Nanotubes, Polyester and Metal Foils[4], [10]	• Using ML algorithm • To adjust with sensors like barometric, and to absorb shock		Viscoelastic, soft-density foam or materials like D3O or gel-based padding

		polymers are used.		integrated into the belt.
Detection method	AI, ML, IoT, Inertial Measurement Units (IMU), Deep learning, Insole-based, Matrix-based, threshold-based, Robotic analysis, and Camera-based[9], [10]	• Camera-based and 3D detection systems	• A 2D RGB camera is used to detect fall	IMU / IoT sensors integrated with ML
Monitoring and control	Limited to basic controls, some systems may include basic sensors[7]	• A systematic review of the sensor detection system to prevent falls in that less usage of gait analysis and false triggers due to poor tools used.		Arduino-based control for stepper motors; real-time monitoring via sensors
Portability	Varies; some systems are portable, while others are fixed			Adjustable
Alert Systems	Yes, but mostly false triggers and min 100 ms[7]	• False trigger or false alarm rate of 25 alarms per 59 hours of active		Yes, using buzzers and SMS to caretakers, 99% accuracy
Alert Trigger	Once the fall is confirmed, an alert is sent via: 1. Bluetooth + Mobile App (if using	• Send messages through telegram bots with triggered medical details		Bluetooth/ GSM Module

	a smartphone) 2. GSM Module (direct SMS) 3. Wi-Fi Module + Cloud [5], [11]	• Sensor feedback to prevent hazards		
Protection	It's based on the wearable body parts but particularly only saves from minor injury not focusing on comfort[7]	• low-power field-programmable gate arrays to implement a fixed neural network function • Using 3D accelerometer • combined with an ultra-low-power Lattice iCE40UP FPGA		Protect the lower back and hips from injury upon impact
Integrated with IoT	Limited with Arduino technologies[17]	• wearable-based fall-related recognition system (WFRS) which is limited to pressure and temperature detection		ESP -32 and Multi-Sensors
Sensors	Accelerometers, Gyroscopes, Pressure, Radar, Barometric and Triboelectric sensors[4]	• All various kinds of sensors are reviewed and how all these are detected is mentioned.		Accelerometers, Gyroscopes and Gait analysis
Pain relief	No [2], [3]	• An energy-efficient wearable device with high	• Require knowledge to handle it.	Reduce lower back pain, and muscle strain by promoting

		sensing parameters but heavy-weight		comfort and mobility.
Lightweight and Flexible Materials	Lightweight design that does not compromise flexibility or comfort[6]	• A wearable device that detects daily activities with less number of sensors leads to a lightweight		High-speed deployment while remaining soft against the skin, reducing abrasion risks.
Fixed Position	Limited coverage[17]	• Smart-cane and smart-insole devices to detect falls cover only particular parts of the body, not the head or other parts of the body.		Escapes with a minor injury
Use	Reusable[3]	• Waistonbelt x: rechargeable using triboelectricity		Reusable

Table 1: Comparison of features between existing and proposed fall detection technologies

7. Please intimate if can think of any alternative way/solution of achieving the same result as your invention. Please note that the alternative way/solution that you are thinking of may or may not have the same advantages as offered by the invention.

Smart Shoes or Insoles

- **Smart Insoles:** Embedded with sensors, these insoles can monitor pressure points, gait, and balance to predict fall risk. They can send alerts to the user or their caregivers if irregular movements or pressure shifts are detected[12].
- **Wearable Haptic Shoes:** Similar to belts, shoes with built-in haptic feedback mechanisms can guide users in adjusting their gait or posture when an imbalance is detected[13].

Smart Walking Aids (Canes, Walkers)

- **Smart Canes:** Equipped with sensors, smart canes can monitor the user's stability and balance. Some smart canes can detect uneven terrain and provide feedback to the user to avoid trips or falls. They can also send fall alerts if a sudden impact is detected[14].

- **Intelligent Walkers:** Advanced walkers with built-in sensors and AI can monitor the user's gait and walking speed, offering support or stopping in place when instability is detected.

AI-Enhanced Wearables

- **Camera-Based Fall Detection:** AI-powered cameras can be installed in homes to monitor the movements of elderly individuals. These systems analyze posture, gait, and other indicators of fall risk. When they detect signs of a potential fall, they can trigger alerts or preventive interventions[15], [16].
- **AI-Driven Gait Analysis:** AI techniques can identify patterns that indicate a higher risk of falling. This can be used for long-term fall risk assessment[9].

8. What are the novel aspects of your invention that need protection? Describe the technical difference between the conventional and available product/process and your solution.

Features	Conventional model	Waist-belt or Novel model
Deployment Speed	No detection to alert	High speeds (within milliseconds)
Lightweight and Flexible Materials	Lightweight design that does not compromise flexibility or comfort	High-speed deployment while remaining soft against the skin, reducing abrasion risks.
Fixed Position	Limited coverage	Escapes with a minor injury
Use	Single-use	Reusable
Smart sensors	Yes	Yes
Material	Nylon	Padding using viscoelastic
Battery	2000 mA (45 hrs)	
Mass	1.2 – 1.5 kg	Weightless
Alert/ Triggering	100 ms (false triggers or no alert system)	Yes
Pain relief	No	Reduce lower back pain, and muscle strain by promoting comfort and mobility.
Adjustable or flexible	No	Yes

Table -2: Technical differences between the conventional model and the novel V-Belt model

9. Are there any environmental issues confronted while developing or implementing the invention?

A) No.

10. Please enlist all innovative features of your invention that you think are making the invention more sophisticated.

1. Sensor Placement: The belt can comfortably house multiple sensors (accelerometer, gyroscope, etc.) without causing discomfort.
2. Wearable Microcontroller: Lightweight like Arduino Nano/ESP32 for the sensor and processing unit.
3. Battery: Lightweight, rechargeable Li-Po battery to power the device.
4. Alert Trigger: Once the fall is confirmed, an alert is sent via: the GSM module
5. Caregiver Notifications: If the belt continuously detects instability over time, it can also notify caregivers via a mobile app or SMS, warning them that the elderly person is at increased risk of falling.
6. Protective Padding Design: Since the padding is always integrated into the belt, it will provide constant protection even during light slips or sudden jerks that might not trigger the sensor-based systems.

11. What are the utilities/applications of the invention? Enlist them.

1. Prevention of falls in elderly and specially-abled people
2. Real-time alert system
3. Proactive monitoring of movement patterns using sensors
4. Integration with smart home technologies
5. Rehabilitation support

12. Has the invention already been implemented in any product or process?

A) No.

13. Has the invention been published or disclosed/discussed to anyone outside of your organization or any third party including abroad also (such as marketing meetings, conferences, tradeshows, trade fairs, websites, social media, newspapers etc)?

A) No.

14. Inventor details in the below format

Applicant:
School of Technology, Woxsen University
Inventors:
Mr. Kesava Datta G
Ms. Bharkavi P M
Dr. Bhanu Prakash S
Dr. Reddy Sekhar K
Ms. Kuppam Bhavya Sree
Ms. Charvi Ningala
Ms. Adlapally Chaitanya Jyothi

References

[1] T. Nguyen Gia *et al.*, 'Energy efficient wearable sensor node for IoT-based fall detection systems', *Microprocess Microsyst*, vol. 56, pp. 34–46, Feb. 2018, doi: 10.1016/j.micpro.2017.10.014.

[2] Q. Zhang *et al.*, 'Wearable Triboelectric Sensors Enabled Gait Analysis and Waist Motion Capture for IoT-Based Smart Healthcare Applications', *Advanced Science*, vol. 9, no. 4, Feb. 2022, doi: 10.1002/advs.202103694.

[3] Y. Nakamura, Y. Matsuda, Y. Arakawa, and K. Yasumoto, 'Waistonbelt x: A belt-type wearable device with sensing and intervention toward health behaviour change', *Sensors (Switzerland)*, vol. 19, no. 20, Oct. 2019, doi 10.3390/s19204600.

[4] A. S. Pillai, S. Badgujar, and S. Krishnamoorthy, 'Wearable Sensor and Machine Learning Model-Based Fall Detection System for Safety of Elders and Movement Disorders', 2022, pp. 47–60. doi: 10.1007/978-981-16-6887-6_5.

[5] A. Danilenka *et al.*, 'Real-Time AI-Driven Fall Detection Method for Occupational Health and Safety', *Electronics (Switzerland)*, vol. 12, no. 20, Oct. 2023, doi: 10.3390/electronics12204257.

[6] F. Wu, H. Zhao, Y. Zhao, and H. Zhong, 'Development of a wearable-sensor-based fall detection system', *Int J Telemed Appl*, vol. 2015, 2015, doi: 10.1155/2015/576364.

[7] J. Tian, P. Mercier, and C. Paolini, 'Ultra-low-power, wearable, accelerated shallow-learning fall detection for elderly at-risk persons', *Smart Health*, vol. 33, Sep. 2024, doi: 10.1016/j.smhl.2024.100498.

[8] L. M. Yee, L. C. Chin, C. Y. Fook, M. B. Dali, S. N. Basah, and L. S. Chee, 'Internet of Things (IoT) Fall Detection using Wearable Sensor', in *Journal of Physics: Conference Series*, Institute of Physics Publishing, Nov. 2019. doi: 10.1088/1742-6596/1372/1/012048.

[9] P. Kulurkar, C. Kumar Dixit, V. C. Bharathi, A. Monikavishnuvarthini, A. Dhakne, and P. Preethi, 'AI-based elderly fall prediction system using wearable sensors: A smart home-care technology with IOT', *Measurement: Sensors*, vol. 25, Feb. 2023, doi: 10.1016/j.measen.2022.100614.

[10] P. Pierleoni *et al.*, 'A Wearable Fall Detector for Elderly People Based on AHRS and Barometric Sensor', *IEEE Sens J*, vol. 16, no. 17, pp. 6733–6744, Sep. 2016, doi: 10.1109/JSEN.2016.2585667.

[11] A. Shahzad and K. Kim, 'FallDroid: An Automated Smart-Phone-Based Fall Detection System Using Multiple Kernel Learning', *IEEE Trans Industr Inform*, vol. 15, no. 1, pp. 35–44, Jan. 2019, doi: 10.1109/TII.2018.2839749.

[12] S. Saidani, R. Haddad, R. Bouallegue, and R. Shubair, 'Smart Insole Monitoring System for Fall Detection and Bad Plantar Pressure', in *Lecture Notes in Networks and Systems*, Springer Science and Business Media Deutschland GmbH, 2022, pp. 199–208. doi: 10.1007/978-3-030-99619-2_20.

[13] A. S. J, E. F. Sundarsingh, S. V, S. S, and S. S, 'Fall detection smart-shoe enabled with wireless IoT device', *Circuit World*, vol. 47, no. 4, pp. 325–334, Oct. 2021, doi: 10.1108/CW-08-2018-0067.

[14] S. Thanthoni, A. Kumaresan, and P. Suganthirababu, 'Effectiveness of Sensing and Feedback Alerting Smart Cane System: An Assisted Device for Geriatric Population to Prevent Falling', 2024.

[15] S. Nooruddin, M. M. Islam, F. A. Sharna, H. Alhetari, and M. N. Kabir, 'Sensor-based fall detection systems: a review', *J Ambient Intell Humaniz Comput*, vol. 13, no. 5, pp. 2735–2751, May 2022, doi: 10.1007/s12652-021-03248-z.

[16] F. Lezzar, 'Camera-Based Fall Detection System for the Elderly With Occlusion Recognition'. [Online]. Available: https://www.researchgate.net/publication/346582750

[17] Beckett, W.E.(2016).U.S.Patent No.9,392,826.Washington,DC:U.S.Patent and Trademark Office.