iJRASET
International Journal For Research in Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 9 **Issue:** XII **Month of publication:** December 2021

**DOI:** https://doi.org/10.22214/ijraset.2021.39635

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 9 Issue XII Dec 2021- Available at www.ijraset.com

# Detecting Real-Time Fall of Elderly People Using Machine Learning

Prathima P[1], Dr. Ravindra S[2]
[1, 2]Department of Computer Science, Jawaharlal Nehru National College of Engineering

***Abstract: Fall is a significant national health issue for the elderly people, generally resulting in severe injuries when the person lies down on the floor over an extended period without any aid after experiencing a great fall. Thus, elders need to be cared very attentively. A supervised-machine learning based fall detection approach with accelerometer, gyroscope is devised. The system can detect falls by grouping different actions as fall or non-fall events and the care taker is alerted immediately as soon as the person falls. The public dataset SisFall with efficient class of features is used to identify fall. The Random Forest (RF) and Support Vector Machine (SVM) machine learning algorithms are employed to detect falls with lesser false alarms. The SVM algorithm obtain a highest accuracy of 99.23% than RF algorithm.***
***Keywords: Fall detection, Machine learning, Supervised classification, Sisfall, Activities of daily living, Wearable sensors, Random Forest, Support Vector Machine***

## I. INTRODUCTION

Health status is one of the most prominent indicators of perfection in physical, psychological and societal well-being. In order to maintain good health, proper health care need to be taken. Ageing is the process of becoming older. Only for a certain group of age people, health care can be taken by themselves i.e., self-care taker. After getting old they need to depend on others. Caring for older adults require a certain amount of co-ordination between healthcare staff, caretakers and family members. Some of the common factors that affect old age people are cataract, hearing impairment, urinary problems, hypertension, falls and so on. Fall is a primary health difficulty for old folks. As stated in World Health Organization (WHO) report [1], the secondary root cause of accidental death of a person is fall. Fall of a person is influenced by physical factors such as weak muscles, improper vision, hip fractures etc. and psychological conditions such as depression, fear of falling, anxiety etc. and finally it may lead to death of elder people. With the intention of determining and preventing real-time fall of elder person, Fall Detection System (FDS) is designed.

FDS is devised based on machine learning and wearable sensor-based approach, which detects falls by categorizing various day-to-day life activities as plain-fall or not and alert the guardian of the old man in emergency situations. Falls are detected with the help of supervised Machine Learning (ML) algorithm on classification. SisFall dataset is freely accessible, wherein composed of both activities of daily living (ADLs) and fall gained by wearable device of Tri-axial accelerometer. On comparison of accuracy among Random Forest (RF) and Support Vector Machine (SVM) algorithms. The RF algorithm for fall detection obtain an accuracy of 99.23%.

## II. LITERATURE SURVEY

In this section, relevant survey from literature on fall detection-based algorithms, is described. The most relevant studies uncover different methods employed in fall detection. The most common pipeline followed by any machine learning algorithm is data collection, preprocessing, feature extraction, classification and validation. In literature, data is derived from SisFall [2], is a publicly available fall and movement dataset which is used to differentiate fall or non-fall activities.

Numerous fall monitoring systems founded on accelerometer and gyroscope for the detection of fall. However, almost all erroneously recognize the daily-life activity as fall and vice versa. To avoid this, Faisal Hussain et al. introduced an effective ML based fall classification algorithm [3]. There exist four major stages in the proposed approach i.e., data acquisition, pre-processing, feature extraction, and fall identification. Fall detection problem come under the category of binary classification problem. Therefore, the entire dataset is divided as category-1 for fall movement and category-2 for nonfall movement. A 10-fold cross validation strategy is applied during training and testing phase with the purpose of building a better machine learning predictive model and thereby reducing bias. The performance of the proposed system is estimated by four machine learning classification algorithms i.e., Decision Tree (DT), Logistic Regression (LR), KNearest Neighbour (KNN) and Support Vector Machine (SVM) classifier. The operation of these classification algorithms is analyzed on the grounds of frequently used performance-measures, i.e., sensitivity, specificity and accuracy. Among all classifiers, SVM reports a highest accuracy of 99.98%.

 

Daniele De Martini et al. [4] proposed wearable sensors and ML based fall determining system aimed to detect fall occurrence in real-time such that a remote notification is triggered automatically prompting the request for necessary assistance. It is based on supervised training on SVM algorithm for fall detection. The system extracts a number of features and rank them as fall or non-fall. The phases involved in the proposed Automatic Fall Detection (AFD) are signal acquisition integrated with slicing, feature-extraction, feature-scaling, classification and filtering. Feature scaling is an important and most common processing phase honestly applicable for the features in many ML algorithms. In this paper, Standard Scaler is the scaling method adopted for selecting features. Recursive Feature Elimination (RFE) algorithm is employed to select smaller set of features [5]. The classification method introduced in this literature is evaluated based on the parameters: recall and precision. The proposed technique procure an F1 score greater than 97% and a highest recall of 99.7% for SisFall dataset.

Paper titled "A Comparison of Machine Learning Algorithms for Fall Detect-ion using Wearable Sensors" [6] is based on developing a system for capturing fall movements of a person with accelerometer, gyroscope using various Machine Learning (ML) algorithms and their main objective is to determine falls and inform guardians of oldsters. The general format of Fall detection system includes data-acquisition, data-preprocessing, feature extraction, processing and evaluation. The proposed algorithm execution was evaluated by using k-folds cross-validation. Along with the accuracy, the Area Under the Receiver Operating Characteristics Curve (AUROC) is calculated. They are implemented with five distinct ML classifiers. Ensemble learning algorithms such as Random Forest and Gradient Boosting have the outperforming results, with sensitivity and specificity nearer to 99%. Generally, ensemble-learning algorithms achieve better performance than lazy or eager learning ones.

In 2014, Aguiar et al. explored benefits of employing neural networks with feedforward, recurrent and convolutional neural networks in fall detection [7]. In the current literature, along with neural networks, four popular fall detection machine learning methods were also examined. Conventional machine learning methods such as K-nearest neighbors (KNN), Gradient boosting technique (XGBoost) and so on. The outcomes of the experiment show that performance of neural networks is substantially better than conventional methods. CNN achieves 99.05% and 99.68% accuracy in terms of both sensitivity and specificity.

Thiago B. Rodrigues et al. [8] introduced inexpensive, inactive sensor and supervised learning-based fall classification system. This work concern about Brazilian public health to fulfill the need of all the citizens problem related to medical-care system, minimize expenditures and finally to improve the living conditions of the elderly people. A classification algorithm is applied on training dataset acquired from sensor and produces alarm for detecting fall as output. The MATLAB platform provides classification algorithms from the ML framework. In this experiment, each of those algorithms in the framework were investigated and selected one resulting in best accuracy. After testing against other models, k-Nearest Neighbor algorithm (kNN) records a highest precision of 99.4% with training time of 13.6 sec.

In this paper, a framework of deep belief network (DBN) based classification method for intelligent detection, recognition and warning of aged person falls was presented by Anice Jahanjooa et al. [9]. The acceleration data of the person's movements from tri-axial accelerometer is measured by using a personal smartphone. In this work two public datasets i.e., TFall, MobiFall over nine varieties of fall and only a type of routine activities was considered. The proposed methodology has four phases: preprocessing, data-segmentation, feature extraction, and classification. For detecting fall, deep belief network (DBN) which is a new deep-learning algorithm implemented for categorization on both datasets. The results exhibit those various kinds of falls are identified with 100% precision. Cross-validation is applied to assess the designed approach counting more pragmatic samples where the system is trained and tested with dissimilar datasets. Due to this, the deep network learns wide spectrum of data upon diverse population with distinct kinds of fall and anthropometric characteristics. Simulation results demonstrate sensitivity of 97.56% and specificity of 97.03%.

Falls are distinguished from ADL's by using six ML classifiers in a self-regulatory FDS with wearable, movability sensor segments fitted at six distinct positions of human body [10]. Machine learning classifiers were employed for distinguishing between fall and ADLs using standardized experimental procedures. Among these classifiers neural network requires more training period and lesser testing period than others. The performances of the six machine learning techniques were analyzed in accordance with accuracy and computational complexity. The k-NN algorithm achieves greatest accuracy of 99.91%. The k-NN and least square method are considered to be reliable classifiers since they do not miss any falls.

A wearable gadget is designed for data aggregation and an efficacious fall detection system based on neural network developed with the intention of differentiating fall activities from other [11]. The proposed methodology consists of mainly four steps and they include data acquisition, data processing, event classification and alert. To make a distinction between a fall and other events during the learning process, the network is trained with datasets which involves inputs and the required output. On comparing the desired output with the output obtained from neural network determines their accurate level and the variance is so-called as error.

To minimize this, weights must be altered as much as possible. The system is embedded with a sensor having both accelerometer and gyroscope in a separate section. I2C protocol is utilized for connecting Arduino Uno microcontroller board and sensor. A Bluetooth unit is made in contact with Arduino board which allow transferring of the accumulated signals. Since there is a built-in Bluetooth facility in RaspberryPi-3 therefore, acquired data is sent to RaspberryPi-3 by using sensor through enabling Bluetooth. The designed wearable device was successfully capable to assemble and transfer indications to RaspberryPi. From the result it is clearly known that, if the prediction value to an event almost equal to 1 then it is considered as a fall otherwise it is not a fall event having a prediction around 0.

A typical fall detection system is presented by Abbas Shah Syed et al. [12], aimed to differentiate between everyday activities and falls as well the fall direction and severity. The proposed method follows a typical ML pipeline. Recursive Feature Elimination (RFE) is used for feature selection thereafter features are reduced to sustain or enhance operation of an algorithm by iteratively eliminating excess features. Four different classifiers are tested and tested. A 5-fold cross-validation method is used for training all classifiers. Experiments were split into two parts where first part distinguishes only fall-direction and the second part differentiates severity along with fall-direction. Among these classifiers, SVM was considered to be the best performing model with a F1 score of 90.4%. On the basis of labelling for direction and severity SVM classifier achieves the greatest weighted F1 record of 78.44%. For best performing classifier in each case the particular scores, precision and recall were presented. In both cases the SVM classifier is found to be the best performing classifier.

Fall is a main health warning to the elderly people. Kai-Chun Liu et al. [13] developed a wearable-sensor-based systems which detect fall based on machine learning for the sake of improving safety-measures of older ones. The consequences of declining sampling rates range from 200/128 Hz to 3 Hz on detection devices were studied attributed to four ML models. The evaluation results demonstrate that SVM modelled FDS with radial base task able to achieve minimum of accuracy 98% and 97% for a sampling rate of 11.6 Hz and 5.8 Hz respectively. The observational results proved that 22 Hz sampling rate is acceptable by almost all models to promote reliable-fall-detection method.

After reviewing these literatures, Ensemble learning algorithm such as Random Forest and Support Vector Machine supervised machine learning algorithms are considered for developing fall detection system.

## III.METHODOLOGY

The Fig. 1 shows the flow of a fall detection system. Each step involved in them are briefly explained.

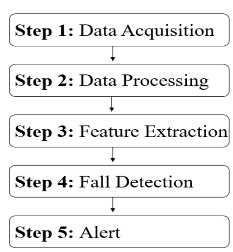


Fig. 1 System flow

### *A. Data Acquisition*

Data is collected from the SisFall dataset recorded with accelerometer. Acceleration data taken from six young adults of code "SA02, SA05, SA10, SA15, SA20, SA23" and two elders of code "SE06, SE10" is considered.

### *B. Data Processing*

Data processing stage is performed to eliminate noise and unwanted signals from the acquired sensor data by using "4th Order Butterworth filter with a threshold of 5Hz".

### *C. Feature Extraction*

Features are extracted for better classification. The features considered in this work are "amplitude, angle of orientation, area under the curve, crucial phase-time and statistical moments".

### *D. Fall Detection*

The algorithms like Random Forest and Support vector machine are used for implementation.

1) *Random Forest:* Random forest is "*ensemble-learning*" technique for classification, regression which uses multiple decision tree in parallel during training period and as an output the combined result of individual trees of either classification or regression is produced. They apply the common method of bootstrap aggregating or bagging. Random forest is constructed with unrelated trees using a CART algorithm. Random forests defeat the problem of decision trees i.e., overfitting to training set of data because of low bias and very high variance. Random forest algorithm was first described by Leo Breiman [14] and Adele Cutler [15]. Breiman's "bagging" idea is combined with random feature selection introduced by Ho [16][17] and Amit and Geman [18].

**Algorithm 1** Random Forest for Classification (RFC)

1: **for** $b \leftarrow 1, B$ **do**
2: (a) Draw a bootstrap sample $\mathbb{Z}^*$ of size $N$ from the training data.
3: (b) Grow a random forest tree $T_b$ to the bootstrapped data, by recursively repeating the following steps for each terminal node of the tree, until the minimum node size $n_{\min}$ is reached.
4: (I) Select $m$ variables at random from the $p$ variables.
5: (II) Pick the best variable/split-point among the $m$.
6: (III) Split the node into two daughter nodes.
7: **end for**
8: Output the ensemble of trees $\{T_b\}_1^B$
9: Make prediction at new point $x$:
10: Let $\hat{C}_b(x)$ be the class prediction be the class prediction of the $b$th random forest tree. Then $\hat{C}_r f^B(x) =$ majority vote $\{\hat{C}_b(x)_1^B\}$.

2) *Support Vector Machine:* Support vector machine is a superintended learning model correlated with training algorithms for analyzing data and recognizing patterns by classifying, regression and ranking data. They are also known as "support vector networks"[19]. They develop a model, where "a hyperplane or set of hyperplanes in a large or infinite dimensional space" is represented, which are useful in performing classification, regression on training data.

**Algorithm 2: Support Vector Machine algorithm**

**Require:** **X** and **y** loaded with training labeled data, $\alpha \Longleftarrow 0$ or $\alpha \Longleftarrow$ partially trained SVM
1. $C \Longleftarrow$ some value (10 for example)
2. **repeat**
3. **for all** $(x_i, y_i)$ $(x_j, y_j)$ **do**
4. Optimize $\alpha_i$ and $\alpha_j$
5. **end for**
6. **until** no changes in $\alpha$ or other resource constraint criteria met
**Ensure:** Retain only the support vectors ($\alpha_i > 0$)

## E. Alert

The concerned person of elder people is informed whenever fall occurs.

## IV. ALGORITHM IMPLEMENTATION

The Fig. 2 shows the flowchart of the algorithm implementation. It is implemented in Python 3.7 and sklearn. The fall detection system consists of the following steps:

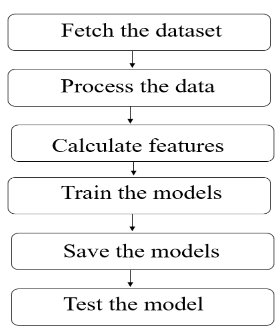


Fig. 2 System Implementation

The first phase of the project focuses on data collection. Sisfall dataset is considered because of its high quality. After data acquisition, they are preprocessed to eradicate unwanted noise from data. Features are extracted to obtain meaningful information. The model is trained with the dataset and saved using pickle. Finally, they are tested to evaluate performance.

## V. RESULT-ANALYSIS

The random forest and support vector machine algorithms were analyzed by varying test size of samples. In table 6.1, accuracy varies as on dividing training and testing data.

Table I: Analysis of test size on algorithms

| Accuracy | | |
|---|---|---|
| Test size | Random Forest | Support Vector Machine |
| 0.20 | 99.2% | 99.3% |
| 0.25 | 99.2% | 99.22% |
| 0.30 | 99.3% | 99.18% |
| 0.35 | 99.1% | 99.25% |
| 0.40 | 99.2% | 99.22% |

Feature importance is important characteristic of Random Forest algorithm where features are selected on the basis of their influence in target variable by the model in the training. The Fig. 3 & Fig. 4 shows the most significant features before and after applying feature reduction.

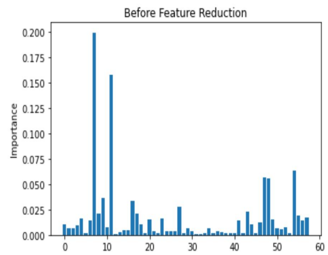


Fig. 3 Importance of feature before feature reduction

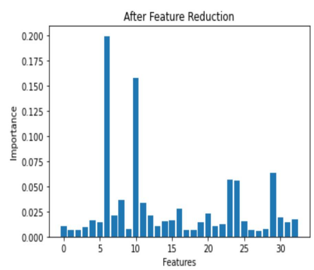


Fig. 4 Importance of feature after feature reduction

## VI. CONCLUSION AND FUTURE ENHANCEMENT

Fall is a life-threatening problem for people in old age groups. As the people becomes older, fear of falling is huge. To improve the standard of living of older ones and guarantee living assurance to them, an automatic real-time fall recognition method come into existence. Most of the studies are only concerned with lowering false alerts. The main objective of this wearable sensor-based approach is to find out fall in the everyday routine activities with highest accuracy and lesser fake alerts. The model is evaluated with efficiency parameters. SVM algorithm obtain a highest accuracy of 99.23% than RF algorithm.

Further enhancement of precision could be achieved through training the model with huge dataset by identifying maximum number of features. Deep Learning models can be implemented for this work for even better accuracy.

## REFERENCES

[1] World Health Organization, World Report on Ageing and Health, World Health Organization, Geneva, 2015.
[2] Angela Sucerquia, José David López ,Jesús Francisco Vargas-Bonilla, “SisFall: A Fall and Movement Dataset”, Sensors, 17, 3390/s17010198, 2017.
[3] Hussain, F., Umair, M. B., Ehatisham-ul-Haq, M., Pires, I. M., Valente, T., Garcia, N. M., & Pombo, N. (2019). An efficient machine learning-based elderly fall detection algorithm. arXiv preprint arXiv:1911.11976.
[4] Giuffrida, D., Benetti, G., De Martini, D., & Facchinetti, T. (2019, July). Fall detection with supervised machine learning using wearable sensors. In 2019 IEEE 17th International Conference on Industrial Informatics (INDIN) (Vol. 1, pp. 253-259). IEEE
[5] I. Guyon and A. Elisseeff, “An introduction to variable and feature selection,” J. Mach. Learn. Res., vol. 3, pp. 1157–1182, Mar. 2003.

[6] Zurbuchen, N., Bruegger, P., & Wilde, A. (2020, February). A comparison of machine learning algorithms for fall detection using wearable sensors. In 2020 International Conference on Artificial Intelligence in Information and Communication (ICAIIC) (pp. 427-431). IEEE.
[7] Wang, G., Liu, Z., and Li, Q. (2019). Fall Detection with Neural Networks. In IEEE International Flexible Electronics Technology Conference (IFETC).
[8] Rodrigues, T. B., Salgado, D. P., Cordeiro, M. C., Osterwald, K. M., Teodiano Filho, F. B., de Lucena Jr, V. F., .. & Murray, N. (2018). Fall detection system by machine learning framework for public health. Procedia Computer Science, 141, 358-365.
[9] Jahanjoo, A., Naderan, M., & Rashti, M. J. (2020). Detection and multi-class classification of falling in elderly people by deep belief network algorithms. Journal of Ambient Intelligence and Humanized Computing, 1-21.
[10] Özdemir, A. T., & Barshan, B. (2014). Detecting falls with wearable sensors using machine learning techniques. Sensors, 14(6), 10691-10708.
[11] Purushothaman, A., Vineetha, K. V., & Kurup, D. G. (2018, April). Fall detection system using artificial neural network. In 2018 Second International Conference on Inventive Communication and Computational Technologies (ICICCT) (pp. 1146-1149). IEEE.
[12] Syed, A. S., Kumar, A., Sierra-Sosa, D., & Elmaghraby, A. S. (2020, December). Determining Fall direction and severity using SVMs. In 2020 IEEE International Symposium on Signal Processing and Information Technology (ISSPIT) (pp. 1-7). IEEE.
[13] Liu, K. C., Hsieh, C. Y., Hsu, S. J. P., & Chan, C. T. (2018). Impact of sampling rate on wearable-based fall detection systems based on machine learning models. IEEE Sensors Journal, 18(23), 9882-9890.
[14] Breiman, Leo (2001). Random Forests". Machine Learning 45 (1): 5-32. doi:10.1023/A:1010933404324.
[15] Liaw, Andy (16 October 2012). Documentation for R package Random Forest" (PDF). Retrieved 15 March 2013.
[16] Ho, Tin Kam (1995). Random Decision Forest (PDF). Proceedings of the 3rd International Conference on Document Analysis and Recognition, Montreal, QC, 14{16 August 1995. pp. 278-282.
[17] Ho, Tin Kam (1998). The Random Subspace Method for Constructing Decision Forests" (PDF). IEEE Transactions on Pattern Analysis and Machine Intelligence 20 (8): 832-844. doi:10.1109/34.709601.
[18] Amit, Yali; Geman, Donald (1997). Shape quantization and recognition with randomized trees" (PDF). Neural Computation 9 (7): 1545{1588. doi:10.1162/neco.1997.9.7.1545.
[19] Cortes, C.; Vapnik, V. (1995). Support-vector networks". Machine Learning 20 (3): 273. doi:10.1007/BF00994018.