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[Google Scholar]Hsieh, S.L.; Su, M.H.; Liu, L.F.; Jiang, W.W. A finite state machine-based fall detection mechanism on smartphones. Telecare 2005, 11, 194–198. Although the last option is the least costly solution, phone manufacturers would not lean towards it, since it requires changing the main processor. Then, feature selection algorithms are employed to determine the most discriminative features. ACM SIGKDD Explor. An acoustic alarm is emitted continuously for 20 s after a fall-like event is reported by the FDE. machine learning) using waist-mounted tri-axial accelerometer signals from a comprehensive set of falls and non-fall trials. In context-aware systems, visual and audio information was gathered from sensor networks deployed in the environment, especially indoors, whereas accelerometers and gyroscopes were used on the human body and they were introduced as wearable sensors. 1–4. In addition to this energy saving, the hybrid method has a 93% of accuracy, which is superior to thresholding methods and better than machine learning only solutions. Since thresholding is capable of making a decision by employing a single comparison of raw accelerometer data and 96% of data are evaluated by PE and DT tiers, very close low energy consumption values of only thresholding and hybrid method, as shown in Figure 8, are observed in conducted 24 h tests. Although the end of summer sales don't get as much attention as holiday sales, these discounts should be on your radar, particularly if enjoy spending time outdoors. In Proceedings of the 2016 IEEE Sensors, Orlando, FL, USA, 30 October–3 November 2016. Since misclassified falls are much more costly than misclassified daily activities, we compared F-measure values of models generated by the combination of classification algorithms and feature selection methods in order to determine the final configuration of our hybrid model. Let x 1 , y 1 , z 1 and x 2 , y 2 , z 2 be two successive accelerometer readings at times t 1 and t 2 , which are equally spaced in time, corresponding to the system sampling rate. [60]. Figure 10. Sensors 2014, 14, 10691–10708. Number of FeaturesF-Measure ValuesNaive BayesK-StarJ48430.7580.790.875200.8090.8540.899150.80.8660.892100.7870.8960.90450.8270.9020.889 Table 3. 2013, 13, 1849–1856. The weights of the subjects ranged from 50 to 95 kg while their heights varied between 155 and 185 cm. [Google Scholar]Shmueli, G.; Patel, N.R.; Bruce, P.C. Data Mining for Business Intelligence: Concepts, Techniques, and Applications in Microsoft Office Excel with XLMiner, 2nd ed.; Wiley: Hoboken, NJ, USA, 2010. [Google Scholar] [CrossRef]Vavoulas, G.; Pediaditis, M.; Spanakis, E.G. The mobifall dataset: An initial evaluation of fall detection algorithms using smartphones. The next day should be just as impressive as the first but Friday the 12th turned out to be the last!She is given seven days (more like she relives these previous days) to determine the mystery surrounding her death and to value what she lost on that day, was it worth living? Since from time-to-time we leave our phones on the table, desk, couch, bed, car, bag, etc., smartwatches are the perhaps the most appropriate candidates for analyzing daily activities of people. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (. 4628–4631. 338–345. "Graphical View" button provides a graphical representation of the buffered data. Finally, the last tier of the fall detection engine utilizes machine learning algorithms to recognize slow falls and fall-like events like sitting, which are difficult to distinguish from actual falls.People either exhibit a low degree of activity or remain motionless most of the time in their daily lives. In order to calculate the Binned Distribution feature, we first determined the range along each axis by finding out the respective maximum and minimum values and divided the range into 10 bins of equal size.Since a representation that uses too many features increases the computational complexity of machine learning algorithms and may lead to poor prediction accuracy due to the high signal to noise ratio, we exploited feature selection methods to minimize the number of extracted features. Average: Average acceleration along each axis (3).Standard Deviation: Standard deviation along each axis (3).Maximum Value: Maximum value along each axis (3).Average Consecutive Differences: Average difference of consecutive values along each axis (3).Average Resultant Acceleration: Average of the square roots of the sum of the values along each axis squared over the frame (1).Binned Distribution: Fractal distribution along each axis into equal sized bins (30).Average and Standard Deviation groups contain six basic features, which are also quite discriminative for fall detection. Advanced features of smartphones make them indispensable to people at any moment. The design of a practical and reliable fall detector for community and institutional telecare. Figure 10. Thus, a fair number of falls of subjects with larger body sizes are classified successfully more than fall events of low-to-average weight people. In order to make a fair comparison and have a different test dataset, a new set of 175 fall events were first recorded by 15 subjects and then analyzed with three different approaches, only thresholding approach, machine learning only approach and the proposed hybrid method. The "Cancel" button needs to be pressed by the victim to deactivate the alarm and prevent the message from being sent. In the following paragraph, we briefly address these existing surveys.A comprehensive literature review was completed and published in 2013 [1]. This is to be attributed to the fact that some subjects did not stay motionless after falling down, although they were specifically instructed to do so. Procedia Comput. The proposed method is implemented on a mobile application, called uSurvive, for Android smartphones. Double thresholding mechanism evaluates both actual and post events performed by the user. [Google Scholar]Hsu, Y.-W.; Chen, K.-H.; Yang, J.-J. [Google Scholar] [CrossRef]Vallabh, P.; Malekian, R.; Ye, N.; Bogatinoska, D.C. Fall detection using machine learning algorithms. Even weirder than that was the fact that we'd all just been talking about it--how it would be just before you died, I mean. One of the most comprehensive databases that include accelerometer, gyroscope and orientation measurements of fall events and daily activities is the MobiFall dataset [58]. [Google Scholar] [CrossRef] [PubMed]Hijaz, F.; Afzal, N.; Ahmad, T.; Hasan, O. Table 11. 120–125. Indian J. For this reason, preferring a lightweight machine learning approach then the proposed hybrid model is considered. Figure 4. To the best of our knowledge, there are only a few studies which compare the thresholding and machine learning methods [20,23]. Lindsay picked finding out that she got into Princeton, obviously, and Ally--who was complaining of the cold, as usual, and threatening to drop dead right there of pneumonia--participated long enough to say she wished she could relive her first hook-up with Matt Wilde forever, which surprised no one. Oguz Kansiz and N. The McNemar test for binary matched-pairs data: Mid-p and asymptotic are better than exact conditional. In Proceedings of the 1st Transdisciplinary Conference on Distributed Diagnosis and Home Healthcare D2H2, Arlington, VA, USA, 2–4 April 2006; pp. In this study, the authors exploit a magnetic sensor attached on either chest or waist or placed in a trouser pocket of a person, besides the built-in accelerometer of the smartphone. OneRAtrributeEval selects the feature that gives the minimum error. Survey and evaluation of real-time fall detection approaches. Neurocomputing 2013, 107, 87–96. Number of FeaturesF-measure ValuesNaive BayesK-StarJ48430.7580.7900.875200.7720.8990.896150.7790.8930.906100.7950.8920.87750.8260.9090.902 Table 4. Since the system is trained by only five features, the depth of the produced tree offers a reasonable test complexity for a mobile application. ACM SIGARCH Comput. Telemed. 2014. [Google Scholar]Rougier, C.; Meunier, J. The truth is, though, I wouldn't have minded reliving my greatest hits: when Rob Cokran and I first hooked up in the middle of the dance floor at homecoming, so everyone saw and knew we were together; when Lindsay, Elody, Ally and I got drunk and tried to make snow angels in May, leaving person-sized imprints in Ally's lawn; my sweet sixteenth party, when we set out a hundred tea lights and we all danced on the table in the backyard; the time Lindsay and I pranked Clara Seuse on Halloween, got chased down by the cops, and laughed so hard we almost threw up. What would you do? OneRAttributeEval, RelieFAttributeEval and SVMAttributeEval algorithms were employed and their results were evaluated [37]. In order to reduce the number of false positives, like several other apps, iFall emits a prompt to cancel an alert before it is automatically sent. Constraints on power consumption and CPU utilization made us to choose K-Star [41,42], Naive Bayes [40,43,44] and J48 [45] algorithms which have low computational cost. 323–326. F-measure value was obtained according to Equation (4) where true positive (TP), false positive (FP) and false negative (FN) indicate the number of true positive samples, false positive samples and false negative samples respectively: Weka software was used for performing the tests. In Proceedings of the Biomedical Engineering International Conference (BMEiCON), Ubon Ratchathani, Thailand, 5–7 December 2012; pp. In Proceedings of the Ninth International Workshop on Machine Learning, Aberdeen, UK, 1–3 July 1992; pp. Therefore, the aforementioned savings of 25% by our proposed hybrid method is crucial in extending the usage time of the smartphone.In this study, a novel hybrid model, which reduces power consumption of the system by combining thresholding with machine learning methods, is introduced. But before I died I didn't think of Rob, or any other guy. This book is intended for young adults.Before I Fall Quotes"So many things become beautiful when you really look." — Lauren Oliver, Before I Fall"A good friend keeps your secrets for you. MORE FROM CONSUMERSEARCH.COM A popular Internet search engine developed by Open Text Corporation. The average accuracy rates of fall events and daily activities are calculated as 92% and 90% respectively. Predicted Hybrid MethodMachine Learning OnlyOnly ThresholdingActual FallADLsFallADLsFallADLsFall126241212911436ADLs6894368644896 Table 11. The tires skidded a little on the wet road and the car was full of cigarette smoke, little wisps rising like phantoms in the air.Then all of a sudden there was a flash of white in front of the car. The impact of feature reduction on energy consumption values. For events that do not meet the Equation (1), the DT tier, as shown in Figure 1, is employed. It evaluates the worth of a feature by repeatedly sampling an instance from the data and then locating its nearest neighbors from the same and opposite classes. On the other hand, for the verification of energy consumption results, corresponding tests were also run on a Samsung Galaxy S3 device, which runs Android 4.3.Thresholding parameters of the DT tier are crucial in the success of the proposed 3-tier hybrid architecture. Hence, floating a smartphone's main processor between those states in order to achieve energy efficient sampling would not produce eligible sensor data. 1–6. Hence the very appropriate name "Before I Fall". Reducing the number of features improved the fall detection accuracy while reducing the energy consumption up to 50%.Thanks to the proposed hybrid approach, we achieved substantial energy savings. Confusion matrixes for three approaches: the proposed hybrid method, only thresholding approach and machine learning only approach. J48 is the java implementation of the C4.5 algorithm in the Weka [37].In order to compare the performances of the classification algorithms, 43 time domain features were reduced to 20, 15, 10 and 5 dimensions by using OneRAttributeEval, ReliefAttributeEval and SVMAttributeEval algorithms. The authors in [23] proposed a multiphase architecture but did not take energy consumption into consideration, whereas [35] exploit machine learning algorithms for classifying daily activities (ADLs). Estimating continuous distributions in Bayesian classifiers. SV t values lower than T h l o w correspond to daily activities such as walking, wiggling or stooping, which correspond to regions I and VI in Figure 2. 2006. Amac Guvensan; M. Then, we present the results in the following subsections.uSurvive was run on a Samsung Galaxy S3 Mini smartphone [46], running Android 4.1 Jelly Bean [47]. All text copies of Before I Fall PDF acquired through Reading Sanctuary require you to leave a review on the book's Amazon page to help authors (which can be found below). divide fall detectors into two main categories: context-aware systems and wearable devices [1]. Then, it determines the rule with the smallest error rate as its 'one rule' [38]. In order to compare the classification accuracy of the proposed hybrid approach with the studies that use MobiFall dataset, a total of 200 events from MobiFall dataset (100 fall events and 100 daily activities) are classified by the proposed hybrid approach. [Google Scholar]Sucerquia, A.; Lopez, J.D.; Vargas-Bonilla, J.F. SisFall: A fall and movement dataset. In Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Orlando, FL, USA, 31 October–3 November 1991; pp. Lindsay complained that someone was elbowing her in the neck. Thus, we succeeded in minimizing the complexity of ML tier by removing 38 features.uSurvive is composed of three parts: (i) sensor data acquisition (SDA); (ii) fall detection engine (FDE); and (iii) emergency alert mechanism (EAM) as shown in Figure 3. On the other hand, [23] has introduced a similar multiphase architecture using wearable sensors to our proposed multi-tier architecture designed for smartphones. In Proceedings of the 21st International Conference on Neural Information Processing Systems (NIPS), Vancouver, BC, Canada, 8–10 December 2008. These results show that the effect of the computational cost of machine learning algorithm selected for ML tier to the total power consumption of the system is negligible. In Proceedings of the Eleventh conference on Uncertainty in Artificial Intelligence, Montreal, QC, Canada, 18–20 August 1995; pp. On the other hand, one of the first apps published on the Android market, iFall [28], introduces an adaptive thresholding mechanism for fall monitoring and response. The test results, given in Figure 8, show that almost 25% of energy could be saved via the hybrid method against the ML only approach. Both reasons lead us to present a system that utilizes the proven success of fully featured machine learning approaches in fall detection task while eliminating their disadvantage in terms of energy consumption by employing PE and DT tiers.Studies that propose multiphase [23,51,56] approaches in order to detect fall events use wearable sensors for data acquisition. When a fall event is detected by uSurvive, an acoustic alarm is emitted and a notification message appears on the smartphone's screen. 2013, 2, 3118–3124. iFall evaluates both the root-sum-of-squares of the readings from the accelerometer's three axes and the position of the human body, since people tend to stay motionless for a while after an accident. According to this study, there are two main approaches. An acoustic fall detector system that uses sound height information to reduce the false alarm rate. The things I wanted to remember; the things I wanted to be remembered for. Open Text Corporation licenses its search engine software as a product called LiveLink. mUX J. Our proposed hybrid approach would also contribute to more energy efficient operation even with specialized hardware.The proposed hybrid architecture, that combines simple thresholding methods with machine learning algorithms, allows for energy-efficient operation, which is essential for mobile applications without compromising the performance of fall detection. Sensitivity values seem slightly less than expected. Add in all of the boring family vacations, pointless algebra classes, period cramps and bad kisses I barely lived through the first time around... [Google Scholar] [CrossRef]Dai, J.; Bai, X.; Yang, Z.; Shen, Z.; Xuan, D. Region II in Figure 2 corresponds to events, which cannot be classified directly by DT tier using SV t and SV t + 1 values. As high sensitivity may result in lower specificity ratios, a fall alert handling mechanism has been added to the application to avoid calls caused by misclassified daily activities.The key contributions of this study could be summarized as follows:A new hybrid fall detection approach is introduced in which we take advantages of both thresholding and machine learning algorithms. Table 5. It was one of those memories I didn't even know I remembered, if you know what I mean. Comparing two classification techniques, Neural Network provides an overall classification accuracy of 96%, whereas Support Vector Machine results in a classification accuracy of 91.7%. [Google Scholar] [CrossRef]Özdemir, A.T.; Barshan, B. Corresponding confusion matrixes for each carrying type are given in Table 8. We then explain the modules of our mobile application and discuss its advantages in Section 4. A Real-time Low-complexity Fall Detection System on The Smartphone. OneR learns a one-level decision tree by creating one rule for each feature in the training data. Specificity values of the three different approaches. In Proceedings of the International Workshop on Robotic and Sensors Environments (ROSE 2008), Ottawa, ON, Canada, 17–18 October 2008; pp. As most smartphones incorporate accelerometers and gyroscopes, the kinematic sensor-based approach [19] could be implemented on them due to their cost effectiveness, portability, robustness, and reliability.There are also some surveys, which cover existing fall detectors [2,3]. [Google Scholar]Galaxy S3 Mini. Subjects repeated each daily activity for five times. Available online: (accessed on 23 June 2017).Kira, K.; Rendell, L.A. A practical approach to feature selection. 2000, 33, 1497–1500. In Proceedings of the 2016 IEEE International Conference on Electro Information Technology (EIT), Grand Forks, ND, USA, 19–21 May 2016. Whenever a whole buffer of data becomes available for FDE processing, the thread is released via its locking semaphore and the thread locks itself upon its completion.EAM is responsible for alerting the caregivers and the authorities whenever a fall event is detected. The OneRAtrributeEval algorithm evaluates the significance of a feature by using the OneR classifier. However, the authors did not give any success rate for their threshold-based method.In [30], the authors model the fall activities with a finite state machine and propose a mechanism which utilizes the accelerometer readings of a smartphone. F-measure values using features obtained via ReliefAttributeEval algorithm. [Google Scholar] [CrossRef]Rojas, R. Accuracy is computed by Equation (5) in order to overcome class imbalance:We also analyzed the impact of the tiers to show its contribution to the proposed architecture. We also analyzed the battery remaining power running the system with/without hybrid approach. The test results, given in Table 11, show that the energy consumption is a linear function of time and feature reduction provided up to 32 and 50% energy savings on the S3 Mini and S3, respectively.Next, all the three modes were tested on both smartphones for a duration of 24 h each by a 23-year old computer engineer affiliated with our lab. The remaining 4% of the samples are sent to the ML tier and classification is made in this tier. Instead, I thought of Vicky Hallinan. They also recorded three different daily activities: walking, running, and standing. Fall detection using smartphone audio features. Lindsay yelled something--words I couldn't make out, something like Sit, or Shit, or Sight--and suddenly the car was flipping off of the road and into the black mouth of the woods. In Proceedings of the 2016 24th International Conference on Software, Telecommunications and Computer Networks (SoftCOM), Split, Croatia, 22–24 September 2016; pp. Another Android application for fall detection was introduced in [29]. [Google Scholar] [CrossRef] [PubMed]Cheffena, M. The values of the nearest neighbors are then compared to the sampled instance and used to update the relevance scores for each feature [40]. 1663–1666. Since only five features almost achieve the most successful recognition performance of fall events, we implemented J48 with five features selected by the OneRAttributeEval algorithm. Table 2. 108–114. CPU time of the three approaches. IEEE Pervasive Comput. [Google Scholar]Nait-Charif, H.; McKenna, S.J. Activity summarisation and fall detection in a supportive home environment. 2017, 55, 45–55. Since accurate detection of fall events is crucial, the parameters of this hybrid system have been adjusted accordingly to increase the sensitivity, specificity and accuracy. This application is based on the principle that accelerometer values indicate zero at the time of a fall. In [2], fall detectors are divided into three groups, including wearable device-based, ambiance sensor-based and camera- based. IEEE J. Fall detection using ultra-wideband positioning. [Google Scholar] [CrossRef] [PubMed]Miaou, S.G.; Sung, P.H.; Huang, C.Y. A customized human fall detection system using omni-camera images and personal information. [Google Scholar] [CrossRef] [PubMed]Juneja, D.; Sharma, S.; Jain, A.; Sharma, S. 2011, 10, 12–15. Elody put on "With or Without You" to piss Ally off, maybe because she was sick of her whining. Perry et al. In the literature, there are two main data processing techniques to discriminate fall events and fall-like events/daily activities [1,2,3,4,5]: thresholding techniques and machine learning algorithms. 3-axis accelerometer data obtained via SDA is stored in a double buffer. If not cancelled within 20 s, a text message is sent to the predefined contacts.We evaluated the performance of the proposed method in terms of fall/non-fall events detection accuracy and energy consumption. [Google Scholar]Panhwar, M.; Shah, S.M.S.; Shah, S.M.Z.S.; Shah, S.M.A.; Chowdhry, B.S. Smart Phone Based Fall Detection using Auto Regression Modeling in a Non-Restrictive Setting. 23–25. [Google Scholar]Yi, W.-J.; Sarkar, O.; Gonnot, T.; Monsef, E.; Saniie, J. The thresholding method decreases the computational time, thus saving energy, whereas decision-making based on machine learning algorithms ensures high rates of true positives.A novel pre-elimination phase is introduced to save energy, especially in cases where the smartphone retains motionless for extended periods of time, such as when left lying on a desk.A mobile application, uSurvive, based on our hybrid fall detection approach has been introduced in this paper. 2009, 11, 10–18. The purpose of pre-elimination is to detect such cases and eliminate them before further processing is applied on sensor data. [Google Scholar]Naik, B.A.; Chavan, R.K. Optimization in power usage of smartphones. Average Resultant Acceleration, i.e., signal vector magnitude is calculated using Equation (3): where N corresponds to the number of accelerometer readings within a frame, which is equal to 60 in our case.Binned Distribution involves determining what percentage of all values fell within each of the bins. [Google Scholar]Chetima, M.M.; Payeur, P. However, until smartphones with such specialized hardware for sensing became more customary, we believe that there is still room for more energy efficient operation by engaging hybrid-like solutions as proposed in [23,35] and a hybrid approach with double-thresholding mechanism in this study. This difference can be explained by greater impact values produced while the large-size bodies are hitting the ground.Comparisons of the proposed hybrid method with only thresholding approach and with machine learning only approach are also performed using asymptotic McNemar's test in order to assess statistical significance of the results [48]. The highest accuracy, calculated as 87.5% is achieved by k-NN algorithm. Predicted Fp of the TrouserRp of the TrouserIp of JacketActual FallADLsFallADLsFallADLsFall4284010446ADLs229822982298 Table 9. "She's too fat," Lindsay blurted out. A fast decision tree learning algorithm. In Proceedings of the 2016 24th International Conference on Software, Telecommunications and Computer Networks, Split, Croatia, 22–24 September 2016. In Proceedings of the 2012 ACM Conference on Ubiquitous Computing, Pittsburgh, PA, USA, 5–8 September 2012; pp. Figure 7. We observe that carrying smartphone in the upper part of a body has a positive effect on the detection rate, as the fall event takes longer time than with the lower part of a body. The daily tests show that pre-elimination tier has eliminated almost 90% of the sampled data while 6% of the sampled data have been eliminated by double thresholding tier. I'd be happy to forget all of fifth grade, for example (the glasses-and-pink-braces period), and does anybody want to relive the first day of middle school? And Vicky's face. Thresholding techniques are advantageous due to their low computational complexity. [Google Scholar]Figueiredo, I.N.; Leal, C.; Pinto, L.; Bolito, J.; Lemos, A. Newsl. The sensitivity of the system when the smartphone is carried in the front pocket of the subject's trousers, in the rear pocket of the subject's trousers and in an inner pocket of the subject's jacket are calculated as 84, 80 and 88% respectively, while the specificities of all three modes are calculated as 99.3%. The results indicate that how the smartphone is carried does not affect the specificity of the system, whereas carrying the smartphone in the inner pocket of jacket positively affects the success of fall detection as it enables more acceleration due to the higher position of the smartphone on the body.In order to analyze the effect of body sizes of the subjects to the performance of the hybrid method, subjects were separated into three groups according to their weights: Subjects within a range of 50–60, 61–70 and 71–95 kg. Comparing the proposed hybrid method with only the thresholding approach by using McNemar's test results in rejecting the null hypothesis that suggests only thresholding approach performs better than proposed hybrid method at the 5% significance level where p-Value of the test is calculated as 6.2 × 10−3.Power consumption is one of the most important criteria for mobile application evaluation. Especially, the very slow falls of low-weight people might be missed. 1–10. Relief feature selector was proposed by Kira and Rendell [39]. Thank you! Before I Fall Book PDF.pdfDownload PDFPurchase Book or Audiobook Department of Computer Engineering, Yildiz Technical University, 34220 Istanbul, Turkey IT Department, Garanti Technology, 34212 Istanbul, Turkey Centre for Vision, Speech and Signal Processing (CVSSP), University of Surrey, GU2 7XH Guildford, UK Author to whom correspondence should be addressed. Regions IV and V in Figure 2 correspond to this classification. Besides, a notification message appears on the screen of smartphone. [Google Scholar] [CrossRef]Kansiz, A.O.; Guvensan, M.A.; Turkmen, H.I. Selection of time-domain features for fall detection based on supervised learning. [Google Scholar]John, G.H.; Langley, P. [Google Scholar]Lee, T.; Mihailidis, A. 2010, 14, 633–643. 2015, 119, 18. F-measure values using features obtained via SvmAttributeEval algorithm. Our test results show that the position of the mobile phone on the user body slightly affects the detection of fall events. In the first approach, the researchers exploit accelerometer values at the time of impact created by hitting the ground, whereas studies based on the second approach also take the postfall phase into account. In Proceedings of the International Congress on Image and Signal Processing, BioMedical Engineering and Informatics (CISP-BMEI), Datong, China, 15–17 October 2016. Thus, several optimization techniques could be introduced regarding the most energy consuming components of smartphones [49,50]. [Google Scholar]Hsieh, C.-Y.; Liu, K.C.; Huang, C.N.; Chu, W.C.; Chan, C.T. Novel hierarchical fall detection algorithm using a multiphase fall model. [Google Scholar] [CrossRef] [PubMed]Qu, W.; Lin, F.; Xu, W. This contemporary study discusses available fall detection systems in terms of the dataset, fall types, performance, sensors and features used for fall detection. [Google Scholar] [CrossRef]Perry, J.T.; Kellog, S.; Vaidya, S.M.; Youn, J.H.; Ali, H.; Sharif, H. Another study was presented by Vallabh et al. Due to its experimental success and low test complexity the C4.5 algorithm is exploited in the ML tier of the proposed method. Commun. iFall: An Android application for fall monitoring and response. A smart and passive floor-vibration based fall detector for elderly. Figure 6. (a) The startup screen of uSurvive and (b) The setup UI for run-time options. System ConfigurationSpecificityOnly Thresholding99.8%Machine Learning98%Hybrid Method99.5% Table 7. Archit. Med. Lindsay and Elody were smoking, and freezing rain was coming in through the cracked windows. Figure 5. In Proceedings of the 2009 Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Minneapolis, MN, USA, 3–6 September 2009; pp. Amac Guvensan, H. Confusion matrixes of three approaches are given in Table 10.The null hypothesis (H0) for the first test suggests that machine learning only approach performs better than the proposed hybrid method whereas the alternative hypothesis (H1) claims the contrary. As stated in [23], in this study, we implemented an out of lab environment and refined our fall detection system for continuous monitoring. Hence, further computations of sampled data have been prevented and it resulted in energy-savings.In the former tests, we have trained our system with the samples which are acquired while carrying smartphone in the front pocket of the subject's trousers. In Proceedings of the 2007 29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Lyon, France, 22–26 August 2007; pp. Feature Reduction Time (min)Energy Consumption w/5 Features (J)Energy Consumption w/43 Features (J)Energy Saving (%)Galaxy S3 Mini51.11.631.25102.23.231.253079.425.5Galaxy S351.42.441.66103.15.947.463091850 © 2017 by the authors. 1151–1154. Figure 5. [Google Scholar] [CrossRef]Hakim, A.; Huq, M.S.; Shanta, S.; Ibrahim, B.S.K.K. Smartphone Based Data Mining for Fall Detection: Analysis and Design. [Google Scholar] [CrossRef]Tong, L.; Song, Q.; Ge, Y.; Liu, M. In Proceedings of the 2006 2nd International Conference on Information & Communication Technologies, Damascus, Syria, 24–28 April 2006; Volume 1, pp. [Google Scholar]Tasoulis, S.K.; Doukas, C.N.; Plagianakos, V.P.; Maglogiannis, I. 6LoWPAN-enabled fall detection and health monitoring system with Android smartphone. This significantly shortens the battery life of a phone because of the associated energy overhead. The first tier is designed as a filter, which blocks the cases, where the smartphone retains immobile. Math. Different fall detection approaches reported so far, are thoroughly examined in different surveys [1,2,3,4,5]. 158–164. However, regarding total experiments, our test results show that body sizes do not significantly change the fall detection rates of the proposed hybrid approach. In order to overcome this problem and increase the accuracy, we believe that deep learning solutions could give a superior fall detection rates without any need to subject-specific parameters.In our tests, we also realized that the way of falling could affect the fall detection rates. Thus, a lightweight machine learning algorithm such as Online Perceptron or a fully featured classification algorithm with high-test complexity such as k-Nearest Neighborhood (k-NN) would barely change the energy consumption of the proposed hybrid model.Fully featured machine learning methods such as SVM, Multi Layer Perceptron and k-NN are proven methods for fall detection [20]. [Google Scholar]Noury, N.; Fleury, A.; Rumeau, P.; Bourke, A.K.; Laighin, G.O.; Rialle, V.; Lundy, J.E. Fall detection-principles and methods. Comparative analysis of bayes and lazy classification algorithms. They underline three different solutions. Therefore, we used PowerTutor for the energy measurement tests and to be confident about the obtained results we conducted all the corresponding tests on two separate phones with different models, namely the Galaxy S3 Mini and Galaxy S3.Before comparing and evaluating the energy consumption of the three approaches—only thresholding approach, machine learning only approach and hybrid method—we investigated the impact of feature reduction on the energy consumption of ML only approach. [Google Scholar] [CrossRef] [PubMed]Zhang, L.; Tiwana, B.; Qian, Z.; Wang, Z.; Dick, R.P.; Mao, Z.M.; Yang, L. The results show that running uSurvive with the hybrid approach adds only 2% additional burden to the battery consumption in a daily usage of smartphone.The PE and DT tiers perform thresholding on the difference of accelerometer readings (Equation (1)) and signal vector magnitude of all three axes (Equations (2) and (3)), respectively. 2010, 3, 305–310. With the ML only approach, only three other components besides the fall detector come into consideration, kernel, system, and PowerTutor, as given in Figure 10. Confusion matrixes of each group are given in Table 9.Sensitivity of the system for three different weight groups 50–60, 61–70 and 71–95 kg are calculated as 81.6, 80 and 91.1%, respectively, while specificity values are calculated as 100, 99.2 and 98.5%. I don't remember exactly how it came up except that Elody was complaining that I always get shotgun and refusing to wear her seatbelt and kept leaning forward into the front seat to scroll through Lindsay's iPod, even though I was supposed to have deejay privileges. Res. The first smartphone app, PerFallID [27], running on Android G1 was developed in 2010. Figure 9. Amac Guvensan and H. Researchers have exploited several types of sensors, such as accelerometers, cameras, microphones, infrared, floors and pressure sensors to detect fall events. F-measure values using features obtained via OneRAttributeEval algorithm. 39–42. Figure 9. Neural Networks: A Systematic Introduction; Springer: Berlin, Germany, 2013. Oguz Kansiz, N. 2017, 10. The DT tier runs relatively more complex instructions in contrast to the PE tier.In uSurvive, the detection of harsh falls and physical activities at a slow pace relies on a double thresholding mechanism, which is illustrated in Figure 2. To validate the final feature set, we analyzed their variations for 100 fall events and 150 non-fall events, which were acquired by 15 subjects, using three different classification algorithms explained in the following subsection.Classification of fall and non-fall events with high accuracy plays a crucial role in ML tier to build a robust model. [Google Scholar]Williams, G.; Doughty, K.; Cameron, K.; Bradley, D.A. A smart fall and activity monitor for telecare applications. Irem Turkmen performed the experiments; M. I was trying to explain my "greatest hits" theory of death and we were all picking out what those would be. The experimental results show that, the accuracy of the detection via smartphone accelerometer is 90%, whereas the magnetic accessory improves the success rate by 3%. Another improvement could be made for position/orientation problem. Several drawbacks of video and audio processing, including their limited area of usage and their high CPU/RAM requirement [9,10,11,12,13,14,15], led the researchers to make more use of wearable sensors [16,17,18]. I had time to wonder whether Lindsay had put her cigarette out. I didn't think of all the outrageous things I'd done with my friends. The computational time results of the 100 fall events were averaged for each approach respectively and presented in Figure 9. Analyzing the results shows us that, reducing the number of features do not significantly affect the success rate of J48 and K-Star. Nevertheless, the cancellation option of the generated alerts were adequate to countermeasure this misclassification. Feature ranking is produced by using the square of the weights assigned by the SVM.The 43 features were ranked using the aforementioned algorithms. This tier is very lightweight and includes only two additions, three subtractions and one comparison. Figure 8. Although there is no standard way of monitoring the energy consumption of a mobile application running on a smartphone, there are applications which enable the monitoring of the energy consumption of both system components and applications. [Google Scholar]Hall, M.; Frank, E.; Holmes, G.; Pfahringer, B.; Reutemann, P.; Witten, I.H. The WEKA data mining software: An update. Classification results using features obtained via ReliefAttributeEval, SVMAttributeEval and OneRAttributeEval algorithms are summarized in Table 1, Table 2 and Table 3, respectively.All models especially the ones generated by using K-Star and J48 algorithms resulted in high F-measure values of around 90%. This app runs as a background service and is capable of detecting fall events, and informing the authorities and/or possible caregivers.The rest of this paper is organized as follows: in Section 2, we briefly discuss the pros and cons of fall detection approaches and elaborate the fall detectors running on smartphones. [Google Scholar]Popescu, M.; Li, Y.; Skubic, M.; Rantz, M. We also plan to extend our database by including subjects with ages older than 50 to improve the sensitivity. Thus, unnecessary further processing of sensor data is prevented in this tier. In Proceedings of the World Congress on Engineering and Computer Science, San Francisco, CA, USA, 23–25 October 2013; pp. A recent study [33], clearly shows that the main processors of customary smartphones require more than 1 s to transition between sleep and idle states and vice versa. [Google Scholar] [CrossRef] [PubMed]Mubashir, M.; Shao, L.; Seed, L. From the best parking spot to the best food at Thomas Jefferson High School. After FDE finishes its processing, the active buffer pointer is switched accordingly. During real-life tests mobile phones were carried in front/rear pocket of subject's trousers and a jacket pocket of the subject. Amac Guvensan, A. Most of the available studies [25,26] propose thresholding methods. [Google Scholar] [CrossRef]Lin, F.X.; Wang, Z.; LiKamWa, R.; Zhong, L. Moreover, high accuracy rates for fall detection and usability both indoors and outdoors made accelerometer as well as the gyroscope sensors more attractive for fall detection systems.Several surveys [1,2,3,4,5] about fall detection, published so far, discuss the pros and cons of the proposed approaches from different angles. If you're looking to score some deals, here are 30 things you should be buying this fall while they're cheaper. In Artificial Intelligence: Concepts, Methodologies, Tools, and Applications; IGI Global: Hershey, PA, USA, 2017; pp. Accelerometer data was sampled at 20 Hz for 3 s intervals. They played field hockey together and said hi in the halls. Each fold included the same total number of fall and non-fall events from each subject so that a fair comparison has been carried out. The purpose of the DT tier is to detect harsh falls and physical activities occurring at a slow pace like wiggling and stooping. The ROC Curve of Low Threshold values. Statistical data mining of streaming motion data for activity and fall recognition in assistive environments. Consequently, a smartphone would either be exposed to motions of varying low magnitude or retain motionless as well. As we use 3-s windows for the determination of the event type, approximately 30,000 events are analyzed within a regular working day, i.e., 24 h. On the other hand, the event occurring at time t + 1 is the post event and exploited to detect the inactivity state of the victim. It is evident that on both of the phones, the ML only fall detector consumes nearly as much energy as the Android system itself. You can stash some of these items away for holiday gifts and store others until you need them yourself. The second option is to add a dedicated low-power microcontroller to the smartphone. One of the lightweight algorithms with the lowest query complexity is Online Single Layer Perceptron. The result of McNemar's test indicates rejection of the null hypothesis at the 5% significance level where the p-Value of the test is calculated as 2.3 × 108. [Google Scholar]Priyantha, B.; Lymberopoulos, D.; Liu, J. The goal of this tier is to enable fast and accurate decisions for cases involving either a harsh fall or a slow activity without the need for employing machine learning algorithms.In Figure 2, the actual event is represented by the y-axis, whereas the x-axis represents the post event. Fifteen subjects were involved in the collection of these events. [Google Scholar] [CrossRef] [PubMed]Vallabh, P.; Malekian, R.; Ye, N.; Bogatinoska, D.C. Fall detection using machine learning algorithms. They implemented a filter rank based system for feature extraction. This is followed by a bias correction and a comparison. In 1991 Lord and Colvin first proposed to exploit the accelerometer sensor for fall detection [6]. [Google Scholar] [CrossRef]Sposaro, F.; Tyson, G. Biol. Regarding these success rates we can safely claim that our hybrid method outperforms the latest studies using the MobiFall dataset in an energy efficient manner.Our next goal is to publish the collected datasets totally consisting of 425 fall events including five different fall types, three different ways of carrying the mobile phone and 1200 daily activities collected from 25 subjects with a reasonable range of age and body sizes. [Google Scholar]Ra, M.R.; Priyantha, B.; Kansal, A.; Liu, J. I didn't even think of my family, or the way the morning light turns the walls in my bedroom the color of cream, or the way the azaleas outside of my window smell in July, a mixture of honey and cinnamon. System ConfigurationSensitivityOnly Thresholding77%Machine Learning82%Hybrid Method86% Table 6. However, apart from using accelerometers, there are several different approaches, such as video processing, audio processing, exploitation of gyroscope sensor and processing Wi-Fi signals [7,8] to detect fall events. Afterwards, Williams introduced an autonomous belt device, which could detect the impact of the shock on the ground, and a mercury tilt switch to detect the lying position of a human body [5]. Some things are better left buried and forgotten, as my mom would say. It's not like Vicky was traumatized or anything. Thus, in [33], the authors propose the use of a dedicated low-power processor for mobile sensing applications. Gokhan Yavuz wrote the paper.The authors declare no conflict of interest.Igual, R.; Medrano, C.; Plaza, I. The performance of the proposed method was evaluated in terms of fall detection performance and energy consumption. The main goal of this study is to discriminate fall events from daily activities with high accuracy in an energy-efficient way. Irem Turkmen conceived and designed the experiments; A. The sum vector (SV t), i.e., signal vector magnitude, of all three axes is calculated using Equation (2), where x t , y t , z t correspond to the accelerations along the three axes of the smartphone at a given time t: SV t is a common feature also used in other studies to determine a fall event, since a harsh fall always results in a large sum vector. In this study, Igual et al. Each survey has its own categorization and group the available studies based on such as the type of sensors, the applied methods, and/or the intrusiveness of the proposed approach. [Google Scholar]Su, J.; Zhang, H. Predicted 50–60 kg (4 Person)61–70 kg (3 Person)71–95 kg (3 Person)Actual FallADLsFallADLsFallADLsFall4911369414ADLs036022684266 Table 10. She started cursing and trying to brush the embers out from the seat cushion and Elody and Ally were still fighting and I was trying to talk over them, reminding them all of the time we'd made snow angels in May. Vicky wasn't very fat to begin with--just some baby weight on her face and stomach--and before high school she'd lost that and grown three inches. In Proceedings of the 20th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 1998, Hong Kong, China, 1 November 1998; Volume 3, pp. Appl. If the victim does not deactivate the alarm within 20 s,

front pocket of their trousers. To be honest, I'd always thought the whole final-moment, mental life-scan-thing sounded pretty awful. The action is labeled as motionless if the following equation is satisfied: where T h P E refers to a threshold value which is determined based on the analysis of daily activities. Both approaches started to lose popularity with the widespread use of smartphones [1]. [3] group the existing studies into three categories based on the measurement techniques used: methods that process acceleration data, methods that measure acceleration combined with other methods, and methods that do not use acceleration. In Proceedings of the 12th International Conference on Machine learning, Tahoe City, CA, USA, 9–12 July 1995; Volume 5, pp. The results in [20] support our proposed approach and show that machine-learning approaches are indispensible for high fall detection rates. In Proceedings of the National Conference on Artificial Intelligence, Boston, MA, USA, 16–20 July 2006. Its energy efficient architecture would possibly increase the demand to our mobile application. Developing a successful mobile fall detection system is based on two key factors: energy efficiency and high fall detection accuracy. It is expected that configuring the thresholding and machine learning tiers with subject-specific parameters will increase the success rates. Similar to most of the former studies, this app is able to inform social contacts, such as relatives and emergency units, when a fall is detected if not deliberately disabled by the user. Eng. Cihan Camgoz and H. We considered three different supervised learning approaches for classification: instance-based learning, probabilistic learning and decision tree learning. Fall detection part of the application cycles through PE, DT and ML tiers as necessary. Survey of fall detection and daily activity monitoring techniques. The size of the buffers and the sampling interval are parametric and could be changed during code generation.To be able to collect and evaluate accelerometer data concurrently, Fall Detection Engine was implemented as a Runnable (Thread). However, calling for help could be impossible, especially when the injury results in unconsciousness and injured person is alone in the scene. System ConfigurationAccuracyOnly Thresholding88.4%Machine Learning90%Hybrid Method92.75% Table 8. Our proposed 3-tier architecture could overcome the energy efficiency problem in fall detection systems designed for smartphones without sacrificing the performance of detection of fall events. 249–256. 1938–1939. Comput. In Proceedings of the 2012 9th International Conference on Ubiquitous Intelligence & Computing and 9th International Conference on Autonomic & Trusted Computing (UIC/ATC), Fukuoka, Japan, 4–7 September 2012; pp. Our 3-tier architecture, composed of pre-elimination (PE), double thresholding (DT) and machine learning (ML) tiers, shown in Figure 1, accomplishes this goal. The thresholding phase of the proposed approach, not only eliminates several daily activities, which do not show fall patterns, it also detects severe fall events. On the other hand, Noury et al. We believe that increasing the number of these types of falls in training set would help to the recognition of these fall events.Another important point is that there are only a few public available datasets [51,57]. She even became friends with Lindsay. In daily life, people could unwillingly be part of some dangerous events resulting in a fall, which may be fatal due to a head injury and/or bleeding. Although the sensor itself uses very little power, the problem lies in the need to keep the phone’s main processor and associated high-power components active to achieve sensor sampling at periodical intervals. Table 6. That's what I remembered in that before-death instant, when I was supposed to be having some big revelation about my past: the smell of varnish and the squeak of our sneakers on the polished floor; the tightness of my polyester shorts; the laughter echoing around the big empty space like there were way more than twenty-five people in the gym. During the test scenarios, the subjects were asked to carry the Galaxy S3 Mini in front pocket of their trousers.Figure 5, Figure 6 and Figure 7 show the Receiver operating characteristic (ROC) curves of T h l o w and T h h i g h , T h i n a c t i v i t y respectively. Improving energy efficiency of personal sensing applications with heterogeneous multi-processors. Machine learning methods, on the other hand are applied to the remaining ambiguous activities to distinguish fall events from fall-like events. In Proceedings of the 2016 IEEE First International Conference on Connected Health: Applications, Systems and Engineering Technologies (CHASE), Washington, DC, USA, 27–29 June 2016. Sensors 2017, 17, 198. Five classification methods including Naive Bayes, k-NN, Neural Network, Support Vector Machine, and Least Squares Method were compared to each other. Table 3. To this end, we also take the post event at time t + 1 into account and calculate the corresponding a SV t + 1 value. On the other hand, machine learning methods lead to accurate detection of fall events among the various movement types [1,2]. 735–739. In [34], researchers present Reflex, a suite of compiler and runtime techniques that significantly lower the barrier for developers to leverage such low-processors. It is observed that while there is no significant difference between the success rates of 50–60 kg group and 61–70 kg group, there is a fair amount of increase in sensitivity and specificity values of 71–95 kg group. Finally, we discuss the results and conclude our paper in Section 6 and Section 7.The fall detection problem has been investigated since the beginning of 1990s. examined available studies based on their detection approaches [4].

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