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A study of fall detection monitoring system for elderly people through IOT and mobile based application devices in indoor environment

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Abstract: **This research presents the structure and framework for identifying falls by remote observing of old individuals in indoor environments by taking advantages of the Internet of things as well as mobile-based applications. This smart framework identifies fall occurred to older individuals who are living alone or living in residential nursing homes. To monitor the fall it uses real-time monitoring by use of open source camera and wearable devices. The system is carried out by pose recognition and object detection method for identifying the object taken by an open-source camera.**

A systematic review was performed using the Primo Search tool for finding eBooks, articles, and journals from the CSU library database. To provide a high efficiency using this information all inclusion criteria were meet by choosing the journal article which was closely related to the topic. The proposed study of fall detection monitoring system for older people living in geriatric residents allows data for caregivers and clinicians to provide better control in monitoring the health status of older patients and allows closer communication with the patients' family members and relatives. This study can be used as an approach for improving the cost of care in elderly population.

Keywords— Elderly people, Nursing intervention, Fall detection, Object detection, Real-time monitoring, Smartphones, wearable devices

I. INTRODUCTION

Since on the rise in the quantity of the older living alone and several health issues caused by physical accidents, the interest for a monitoring framework equipped for supporting quick reaction if there should arise an occurrence of an emergency circumstance by observing their regular daily existence in their private spaces has been expanding [1]. The ability to move has limitations in elderly people that is due to adults are associated with improper clinical outcomes including high death rate and injury rates [2]. Falls among elderly people is a significant general wellbeing concern, particularly in nations with an immense measure of aging people [3]. The impacts of a fall on an elderly individual can be annihilating, perhaps bringing about incessant agony, loss of autonomy, and reduced personal satisfaction. Taking care of elderly people and preventing injurious falls should be one of the key issues to be handled in a society with an aging population [3]. An injury that is caused by Falls in older people can lead to death around the world. [4].

IoT advances have entered several fields of human services, from the follow-up to restoration treatments, individual monitoring of the day by day exercises, tokens of clinical arrangements, and prescription admissions, to the remote checking of crucial indications of patients [5]. The innovations that are made in the technological field might improve care for elder people that have mental illness and neural disorders which are taken by measurement and evaluation of sensual motion [6]. The advancement in technology has transformed the outlook of treatment for seniors with mental illness. This study gives a brief technological transformation that may upgrade care for seniors with anxiety and mental disorders by the quantification and evaluation of physical motion. This research study had used wearable sensors like smart watches and activity trackers like Fitbit [6]. Open source camera like Raspberry pi can be used to monitor and track older people living in an indoor environment. pose recognition and emergency are characterized utilizing object detection and Also, pose recognition was made using the Tensor Flow Object Detection using google API [1]. This study depicts the model for checking the mobility and stability of old individuals and works as support tools to the personnel responsible for the care of old individuals in nursing homes. this assists with knowing the real-time, the health status of patients, and keep in steady correspondence with family members, through the IoT and wearable devices.

II. LITERATURE REVIEW

A. Fall Detection

Fall recognition calculation was built dependent on the way that the breakdown speed is quick when an emergency happens and falls. The fall discovery utilizes the adjustment in the slope of the object, amount of change in slope, and time variation in slope [7]. The framework is intended to recognize falls by gathering and examining video data through an open-source camera and send an instant message when falls are taken place [7]. Youm[1] developed a framework for detecting emergencies in elderly people's life. This system was carried out by utilizing the Tensor flow object detection API of google. This system search pictures from the web and the picture are kept in Pose Image Database and the Images are preprocessed for preparation of object detection API capable of identifying the persons and model generating will take place that determines the highest accuracy model for the process. After finding the highest accuracy model, pose detecting and speed tracking is executed for each frame of pictures. After tracking speed for the pictures and it eventually executes emergency situations and sends alert in an emergency. The speed between the outlines was determined by tracking the change in pose from standing to lying down and from sitting to lying down [1]. For the three poses of sitting, standing, and resting, a total of 350 images per pose were learned using Fast-RCNN, and a deep-learning model capable of distinguishing more than 90% of the poses was created.

A study done by Yacchirema [8] has used four AI algorithms for determining high efficiency in fall detection, which are Logistic regression, ensemble, decision trees, and Deepnets which were evaluated according to training time

and testing time. The sliding-windows techniques along with normalised Signal magnitude Area (SMA) strategies are also utilized to remove the highlights that portray the crude sign of the older individual's developments from a freely open dataset. The determination of appropriate classifier (logistic regression, decision trees, ensemble (random) comprised of assessing the presence of fall and activities of daily living (ADL). Ensemble- RF was the most reasonable classifier. IoTE-Fall framework utilizes a 3D-pivot accelerometer installed into a 6LowPAN wearable devices fit for tracking progressively the information of the movements of elderly peoples [8]. The IoTE-Fall framework takes the information the speeding up estimated in the x, y, and z-axis originating from the progress of older adults continuously.

The framework' execution was assessed for perceiving three sorts of falls: fall forward, fall in reverse and sidelong fall, and three kinds of ADLs: Walking, steps climbing, and sitting. The normal parameters accuracy (98.72%), precision (96.22%), sensitivity (94.60%), and explicitness (99.48%) show that the proposed framework has a high achievement rate, both in falls and ADL recognition [8]. IoT technologies that are used in medical sectors helps caregivers and clinicians to know the physical condition of patients remotely in real-time [5].

B. Wearable Devices

The advancement in smart devices and sensors have prompted the innovation of wearable devices that can link with smart devices to integrate the information collected from individuals who use them to check and observe their health and provides advice to cure it and even find out any diseases through machine learning algorithms from the data that is sensed from the wearable devices that are implanted in the bodies of individuals [9]. Wearable and mobile devices incorporate smartphones, smart watches, smart clothing [10]. The components of motion estimated by these devices are categorized into three things: positioning, human activity recognition (HAR), and vital sign monitoring [11]. Positioning devices give exact localization of people and can be utilized both inside and outside the environment. Global Positioning System(GPS) is used as a preferred technique of monitoring physical activity in the outside environment by evaluating the location based on smartphones and wearable devices. There is a newer form of a technology called Indoor Positioning System(IPS), the system gives persistent and multivariate constant information, which can be utilized to track activity and provide support during emergency circumstances. IPS uses the arrangement technologies that include Wi-Fi, Camera, Bluetooth, radio frequency, and infrared (IR. Loc) for monitoring. The activity recognition system is another component of determining a motion for constant checking of the older population to reduce the risk of acute circumstances like falls[12]. This helps elderly people to manage their day to day activities.

C. Smartphone based Applications and Nursing care needs for elderly individuals

Mobile devices like smartphones and tablets work as a major role in our day to day activities. The advancement in mobile technology has taken in such a way that in recent years they are used in greater potential than a desktop computer. Serious video games like Fall sensei can provide an engaging way to study domestic falls dangers and can make an essential contribution to aging [4]. According to Tsai[13] smartphone-based videoconferencing application helps to reduce the feelings of loneliness in older people living in nursing homes and by enhancing communication with their family members as well as caregivers. In Beijing, the proportion of older people using Emergency Medical Services due to injurious falls extended with age and was once positively correlated with the percentage of the older population. Taking care of elderly human beings and preventing injurious falls must be one of the key problems to be treated in a society with an aging population [3].

A scientific report by Goes[14] has proposed a conceptual framework to evaluate nursing interventions according to self- care deficits, where the participants were classified by sex (male and female) and age group (65 to 74 years, 75 to 84 years and 85 years or old) and ordinal regression model was used to distinguish health issues of the participants and to access nursing care as indicated by self consideration deficits. Krick[15] outline the field of advanced technologies for casual and formal consideration that has just been investigated regarding acknowledgment, viability, and productivity (AEE), and to show the extent of the pre-owned techniques, target settings, target gatherings and fields of help. The Quality Indicators(QIs) were developed or applied to assess the quality of care in the community (e.g. home care, primary care, community care, and ambulatory care [16].

Segercrantz & Forss[17] in their study that took place in two public sector organizations in Finland, the first one is called wecare, and second is senior strength. The organization provides a variety of services to older adults ranging from service in elderly people home to residential care. In this study, the data are taken residential care in the form of observation, and interviews were analyzed. The proposed strategy for transformation in residential care provides beneficial for expanding the number of care factors in organizations.

D. System Components

The component aspects of the framework are the core mechanics that enables the framework to work. A conceptual framework was created dependent on the vigilant analysis and study of emerging and past research works in the area of IoT and multimedia for falls and emergency detection system in elderly people living in indoor environment. Research on various strategies that were reviewed from the related works done in past had helped to gain high accuracy to propose the process. Figure.1 shows the diagram of the proposed system with the components. The overall system describes emergency detection of elderly people in indoor environment and by the help of wearable IoT devices and open source camera. the video captured from the camera are further passed to computer devices for Object detection and pose recognition techniques from open source camera. The first part of this system uses open source camera in an indoor environment where the object is detected by using tensorFlow machine learning library. The object is detected by binarization techniques. For the detected object to be considered as fall, by identifying Objects' change in slope from vertical length (y2-y1) and horizontal length(x2-x1), and time for variation in slope. And Similarly, IoT fall detection is carried out by using wearable devices that measures the acceleration of the body movements of elderly people and the signal is calculated by IoT gateway in a wireless network and then the data are analyzed and processed to detect fall.

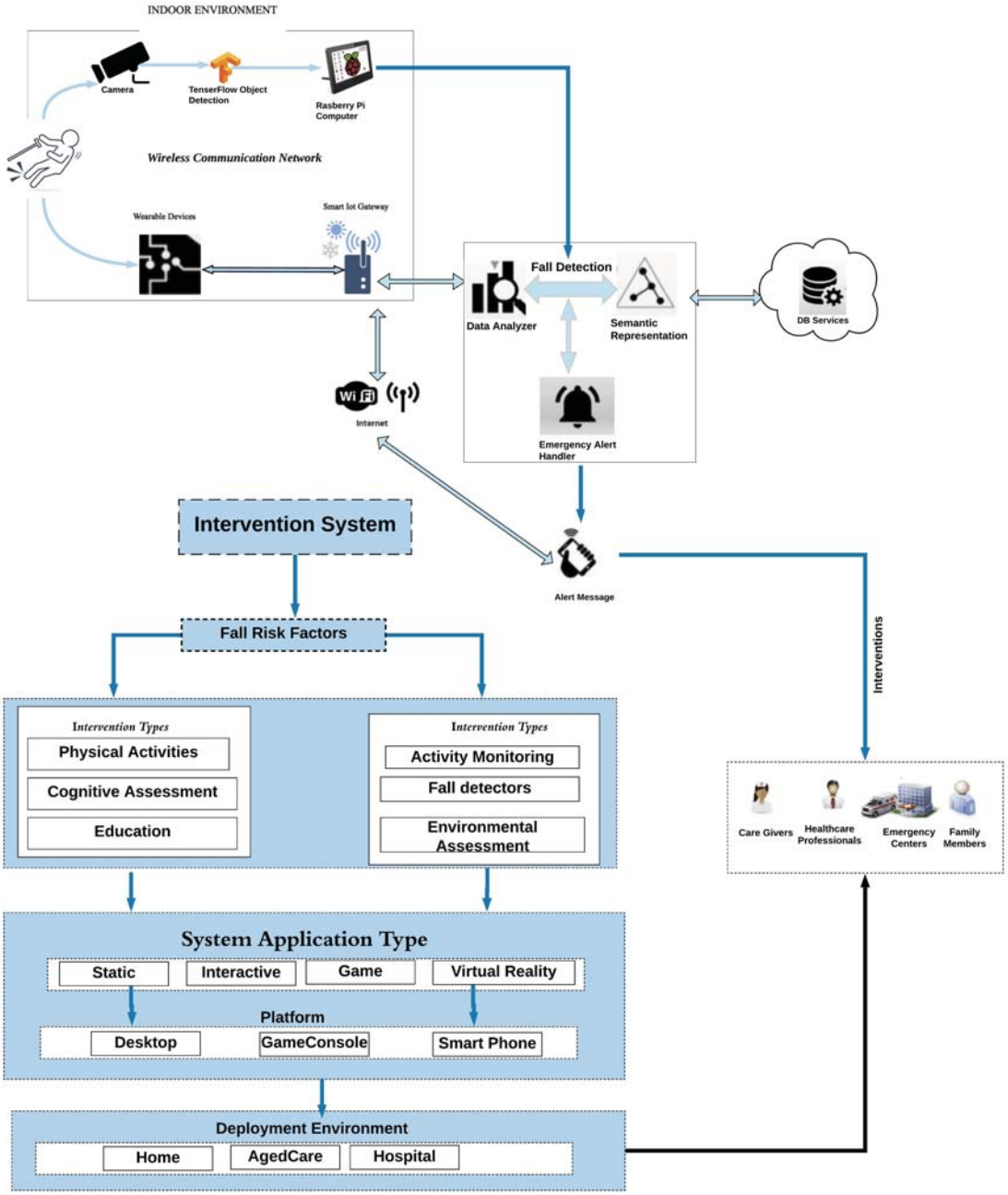

Fig. 1. System Architecture.

E. System Architecture

The review paper was classified according to various characteristics of the research. Some of the properties of the research which are found on all the research papers includes survey, case study, survey, reports, experiments etc. Table 2 and table 3 illustrates the classification table of top 15 relevant selected journal papers. This are categorized according to the input raw data, algorithms, techniques, methods, hardware and software tools being used for the evaluation of the research papers. The data in the table were categorized into the different attributes of the research which are presented in the form of input, data analysis and process, evaluation and output, which are further classified in different heading in more details. This classification provides the field of overall study of the journal paper.

TABLE I. CLASSIFICATION OF JOURNAL PAPERS USED IN THE RESEARCH

Main attributes & Authors	Input(Raw Data)	Smart Devices & Sensors	Health condition	Population type / Gender	Techniques	Algorithm	Frameworks	Mobile multimedia apps/ IoT	Interventions & Interviews	Evaluation Criteria	Tools being used(Hardware/ Softwar	Devices for Display	Medical Response
[2]	WS, Ageing, SP, GPS data	IS, magnetometer, gyroscope,accelerator	Older patients,	Older adults.	IMT	GNSS,	N/S	MOBITEC-GP	GPS/ IMU-based measurements,	SA, validity/ reliability, applicability	mobile Apps, GPS device	Smartphones	GP
[4]	3D exploration games	Virtual games	N/S	Older people	HHDT	N/S	N/S	Fall Sensei-System	SUS questionnaire, Interviews, IG	UE, DSA, one-sampled t-tests	Unity3D engine	mobile phones, computes, tablets	FM
[13]	Video from camera, Loneliness scale,	N/S	DSA, loneliness, physiological health	Older nursing home residents.	MBV	RM, GEE	N/S	LINE application	QERD, VI, SF-36, GDS	SA	Self-report	Smartphones, Computers	N/S
[6]	RSR	SW, FMSC, PMS, IS, Wifi Signals	depression, dementia, anxiety, and schizophrenia,	Older adults	GPS, IPSs, HAR	N/S	N/S	The Smart Home Model	Focus groups and Interviews	Motion measurement, actigraphy	GPS device, Bluetooth, Google Glass Application,	Hands-free Video and audio recording	Clinicians, caregivers
[21]	Falls rate	N/S	Podiatry	Older People.	SR	N/S	TiDIER reporting guidelines	N/S	(RCTs/ quasiRCTs, MFPI	Statistical Analysis(SA)	PRISMA guidance Tool, (CRB)	N/S	Caregivers, FM
[3]	Ageing and Injurious falls	N/S	Harmful falls	Elderly People(60–79yrs 80–100yrs)	EMS, cORs and aORs,	Univariable and multivariable (LRM), Linear trend $\chi 2$ test	MCRM	N/S	Study Sample	SA**,** Sociodemographic factors	IBM SPSS Statistics V.22, Beijing Statistical Yearboo	N/S.	Caregivers.
[7]	Video from camera, TD	Raspberry Pi Camera V2 model, wifi signals	N/S	Elderly people	ORS or PRS	Binarization, FDA	N/S	Fall detection system	Fall detection Experiment,	N/S	Galileo board, and Raspberry Pi, smartphones	Raspberry Pi computer	caregivers
[16]	Quality of care	N/S	Cognition/ Mental health	Older Individual	QI, AIRE	Database search	N/S	N/S	study sample, QI sets	MQ	PRISMA guidelines for SR, ERD, Excel	computer	Clinicians, caregivers
[1]	Video from Camera,	N/S	Emergency situation	Elderly Individual	TensorFlow, OD API of Google, ODS/ PRS	Univariable and multivariable (LRM),	(Fast-RCNN) Model	EBEDS	EDE	Behaviour Analysis, Image Analysis.	Web Camera, Website, Database	Computer	Clinicians, caregivers

[14]	nursing care needs	N/S	N/S	Elderly Individual aged 65 and Older	EFA, CFA	regression model	N/S	N/S	Interview, Diagonisis phase and	DA, SDV	ULSBA database, Webpage,	Computer, bar graph	Clinicians, caregivers
[15]	Informal and formalNursing care	ICT, robots PMR, HER/ EMR	N/S	Informal caregivers and children rare.	AEE, E-Learning	N/S	Ark-sey and O'Malley's, SRF	N/S	Review, systematic literature search,	Meta-analysis	Medline, Scopus, ACM,DL IEEE Xplore	N/S	Caregivers
[8]	Fall detection	Accelerometer, wearable devices, WiFi	N/S	Elderly people	SWT 6LowPAN, Ensemble-RF model	LR, ELA, Decision trees,	Fall Framework, sisFall	IoTE-fall system	Experiment, Control trials	IOT Gateway, CS, PT & TT	Wifi, ROC curve	N/S	Caregivers, HP
[5]	geriatric residences	WD, Smartphones, biometric bracelet, sensors	N/S	older adults	WC, RM	N/S	IoT paradigm	Abueló metro application system	semi-structured interviews, (SUS)	Remote Servers,	Mobile application, database	Smart phones	caregivers and FM
[22]	Personal care	Mobile Phones,	N/S	Aged care workers (PCs/ AIN),	Picture Care Plan (PCP), mobile technology	N/S	N/S	point-of-care information systems	anonymous questionnaire, Study design	accuracy and efficiency	Mobile devices, OS, Leecare Solutions	Smart phones, tablets	caregivers
[17]	Care practices	Mobile Phones,	N/S	Elderly care	Past, Present, and Future SP	N/S	N/S	WeCare, SeniorStrength	Observations, case study	Critical evaluation	EDS, organizational documents	Computer tablets, game consoles	Care workers

F. Evaluation and Validation

Evaluation of the system is the way of delivering the functionality and value of the system where validation decides the appropriate system was implemented with the evidence of accuracy and performance. The table no.4 illustrates the analysis of the technologies that were based on the best 15 journal articles chosen for review. For measuring the daily activities status IoT smart devices were used and for monitoring mobility different sensor were worn by elderly people. When fall occurs the alert message is sent to the caregivers and family members.

The journal papers selected were deliberately analysed in terms of datasets of older adults. Also random dataset of research was conducted and used in various steps of analysis process. Here from the 15 journal papers most common classifier were categorized to determine the suitable techniques being used in the recent studies. using this techniques helps to automate the process and improve to get best accuracy of the suitable techniques that are implemented and which are efficient to monitor the falls and make elderly people safe and comfortable.

TABLE II. EVALUATION AND VALIDATION OF SYSTEM COMPONENTS

Study	Applied Area	Participant	Medical Response	Context	Fall detection Source					Secure	Cost efficient	Time efficient	Result
					Smartphone	Camera	Wearable sensors	Intervention/Interviews	Traditional source				

[2]	Healthcare, GP	Older people	General Practicioner	MOBITEC-GP:MOBIlity assessment in older patients' real-life by the GP	✔	-	-	✔	-	✔	✔	✔	accuracy is high. less personnel consuming cutoffs workload give better performance.
[4]	Home environment	Older peoples	Family members	Fall sensei:3D exploration game	✔	-	-	✔	✔	✔	✔	✔	SUS score = 77.5/100 which indicates 'Good' levels of usability. Higher the participant age the more is the Usability of game. Usability of the game ($p <= 0.05$ for 9/10 items).
[13]	Nursing home	Elderly residents feeling of loneiness and depressive	-	Smartphone based video conferencing	✔	✔	-	✔	-	✔	✔	✔	Effective performance for improving residents' feelings of loneliness, and physiological health, liveliness and pain.
[6]	Smart home models	Older adults with mental illness and neurocognitive disorders	Clinicians, caregivers	Psychiatric Care of Older Adults	✔	-	✔	-	-	✔	✔	✔	assist doctors in diagnosing dementia prior using the judgement of walk, stability, and position dynamics.
[21]	Community and care homes	Older people(aged 60+)	Caregivers and family members	Podiatry interventions to prevent falls	✔	✔	-	✔	-	✔	✔	✔	multifaceted podiatry interventions(falls rate ratio 0.77 [95% CI 0.61, 0.99]). multifactorial interventions (falls rate ratio: 0.73 [95% CI 0.54, 0.98]).
[3]	EMS(2010 to 2017) in China.	residents aged 60 or above	Caregivers	The proportion of elderly people using EMS due to detrimental falls	✔	-	-	✔	✔	✔	-	-	The amount of fall incremented from 7.12% in 2010 to 9.45% in 2017, and urban regions (8.62%) >suburban regions(7.80%).
[7]	Fall detection in indoor environment	Elderly Population	Caregivers	Fall detection monitoring system	✔	✔	-	✔	-	✔	✔	✔	The fall discovery utilizes the adjustment in the slant of the object $m = tan\theta = \frac{y_2 - y_1}{x_2 - x_1}$ Difference in the slope can be done by using $\Delta m = M_k / M_{k-1}$ Where, Δm= amount of change in slope M_k = slope of fall recognition methods in current edge
[16]	Community care	Older individuals	Clinicians, Caregivers	Quality Indicator for community care	-	-	-	-	✔	✔	-	✔	Standarized domain score= (total score-min possible score)/(max score-min possible score)*100%. Higher score =Higher methodological quality
[1]	Emergency situations.	Elderly people, people with disabilities	Clinicians , caregivers	Emergency situation recognition	✔	✔	✔	✔	-	-	✔	✔	accuracy % of more than 90

[14]	Nursing care	Elderly people,	Caregivers	Nursing care intervention model	-	-	-	✔	✔	✔	-	✔	Less performance, self care interventions for people aged 85 years and above.
[15]	Nursing care and Digital technologies	-	Formal and informal caregivers	Informal and formal care in terms of Acceptance, Effectiveness, and Efficiency (AEE)	-	-	-	✔	✔	✔	-	✔	Higher Effectiveness and Acceptance for ICT, robots and EHR/EMR. Efficiency studies were very less.
[8]	Indoor environment, Nursing homes	Older Individuals	Healcare professionals	IoTE Fall detection system	✔	-	✔	-	-	✔	✔	✔	system accuracy, precision, sensitivity, and specificity is above 94% which is High.
[5]	Nursing homes	Older adults	Family members and caregivers	Abuelómetro application system	✔	-	✔	✔	-	-	✔	✔	High accuracy and performance. Improve the quality of life.
[22]	Personal care in aged care	Aged care workers(PCs/AIN)	Caregivers	Point-of-care information system	✔	-	-	✔	✔	-	-	✔	Results from the questionnaire shows 60 % of participants use mobile device when providing care, with a further 15 % sometimes used the device. In all, 75 % of participants find the device was helpful most of the time.
[17]	Private care home in Finland	Elderly people, care workers	Caregivers	WeCare, SeniorStrength	-	-	-	✔	✔	-	-	✔	Productivity and performance oriented. created important new opportunities and relations in care

III. Discussion

In this session of the research, we evaluate the literature review, system components and overall architecture that were reviewed. By congregate all the selected articles. I have analysed and and compared the components for improving performance and accuracy in IoT and smartphone based elderly monitoring system. The main aim of this research is to conduct remote monitoring of the elderly people living in nursing care home or living alone in indoor environment. Only 30 papers were retained having met the requirement of the present study. Among them five studies have discussed different dimensions of IoT and mobile based monitoring of elderly people. IoT allows the connection of the different appliances and system to the internet.

A. Comparison Study

The development of the model that shows the real time tracking of the general condition of elderly patients allows interaction between caregiver and family [5]. The condition of the elderly patients can be identified and accessible easily and help to improve the quality of elderly healthcare. As stated in literature review, Since few years now the number of research have been done to address and monitor fall detection caused in older population. Yacchirema [8]leverages the effectiveness of ensemble algorithm machine learning for obtaining fall detection results in terms of accuracy(98.72%), sensitivity(96.22%) and specificity(94.60%). Tong [18] in his study characterized the algorithm used has an ideal sensitivity(100%) and specificity(100%), although it has an ideal sensitivity and specificity the data used used for system test doesn't correlate with the targeted results applied to elderly people. Also system proposed by Tong [18] does not provide alert incase of fall which is an essential requirement for improving the elderly people quality of life. Similar to the proposed system by Yacchirema[8], the MLP- based system by Nguyen[19] used sisfall dataset for the detection of falls. This system shows the specificity of 99.62% and the accuracy is equal to the approach by Yacchirema[8] in response to fall detection. However the dataset which are used in all stages of the system will result to fail to fit additional data and also fall detection does not send notification when fall takes place.

Further studies that were reviewed during the research. A study by Youm [1] have discussed the system capable of detecting emergency situations of elderly living alone or living in indoor environment using a low-cost device and open source software. In his experiment accuracy was determined on the basis of object detection and pose detection. The image of three different poses of sitting, standing and lying down was measured using Fast–RCNN algorithm of Tensorflow objection API. Pose detection accuracy was determined by identifying the distance between elderly and camera. This system was capable of more than 90% detection success rate. So, analysis shows that some studies for managing safety of elderly and preventing serious injuries fall can require considerable expenses because of the use of many sensors and wireless

devices. This proposed system by Youm[1] requires less cost by using low cost camera and open-source software.

A System Usability Scale(SUS) provides a reliable tool for measuring usability. In a study by Duran [5] the SUS evaluation score is 83.0. This states that according to Sauro [20] the evaluated SUS score is considered as a very good usability. This suggests that IoT system for remote health monitoring in elderly people is more likely recommendable to users. Also a similar study by Money[4] 'Fall sensei' 3D exploration game which provides an information to older adults regarding external falls risk within home environment. In his study The SUS score = 77.5 out of 100. This indicates 'Good' usability level. Usability of the game increased with participant age.

B. Limitations

A robust fall detection system should present high sensitivity and specificity. At the time of experiment the sensitivity and specificity can reach foremost but when applied to real-life conditions the performance decreases. This devices are normally tested under the controlled conditions which may not be accurate when aimed to elderly people so it should be developed involving them. Most of the studies shows the approach of capturing images of the elderly people living in indoor environment and he detection of fall based on object detection and image processing techniques. However this system techniques comes with shortcoming and challenge in general detection affordability and acceptability. This is because of many reasons such as limited area is taken for detection in monitoring environment which can be in costly to develop and implement. Other reasons like people's privacy will be undermined. Also visual fall detection system are unable to distinguish 100% movement patterns between real fall and event when person movement of sitting or lying. Accuracy of the system also depends on the device used for the required process in the study raspberry pi camera is considered slower that webcam.

IV. Conclusion and Future Work

The Internet of Things is a cutting-edge model improving the quality of life of elderly population by equipping a widespread and more personalized form of care. This study has presented a systematic review on IoT system for fall detection monitoring system of elderly people in indoor environments. The overall studies show that there is a demand for a fall identification system for elderly people in nursing homes and aged care centers. The key findings from the above literature review describe the methods for interfacing with wearable sensors and assemble a user-friendly fall identification framework. This will enable the strategy to minimize the expenses for social and health issues in the older population. Also, studies provide structure and framework to monitor the critical situation of elderly people living alone by the use of wearable devices and open-source applications and hardware. In the study the framework performance was assessed for perceiving three sets of falls: fall forward, fall in reverse and sidelong fall, and three kinds of ADLs: Walking, steps climbing, and sitting. Moreover, the comparative analysis carried out in this study exhibit the benefit of fall detection result over other research study of the similar nature. The benefit includes high levels of average accuracy, precision, sensitivity, and specificity. Also the emergency alert messaging system service allows effectual and timely action on making decision to caregivers and health care professionals by advising about the nature of fall and location of the elderly person's residence.

My research is based on a system that is capable of detecting emergencies of older residents living in an indoor environment by using a low-cost device and providing nursing intervention according to self-care deficiency. The proposed real-time health monitoring system for older adults living in geriatric residents will provide data for caregivers to decide the health status of older patients. The fall identification framework in this research provides a stage to interface with wearable sensors and assemble a brilliant home framework. Besides, it is believed to be helpful to set up an observing framework that can be utilized in an outside space rather than only living space. Also in future the study aims to utilize profound running to recognize different emergencies just as falls. The future related works are mainly focused on monitoring health situations of elderly people by focusing on more IoT sensors and multimedia devices. Also It is important to enhance the proposed framework through preparing on both the postures of individuals and family unit objects, for example, furniture and home machines, so different activities, for example, eating, sitting in front of the TV, cooking, and working out, can be distinguished.

REFERENCES

[1] Youm, S., Kim, C., Choi, S., & Kang, Y. S. (2019). Development of a methodology to predict and monitor emergency situations of the elderly based on object detection. *Multimedia Tools and Applications*, 78(5), 5427-5444. https://doi.org/10.1007/s11042-018-6660-7

[2] Münch, M., Weibel, R., Sofios, A., Huang, H., Infanger, D., Portegijs, E., ... & Schmidt Trucksäss, A. (2019). MOBIlity assessment with modern TEChnology in older patients' real-life by the General Practitioner: the MOBITEC-GP study protocol. *BMC Public Health*, 19(1), 1-10. https://doi.org/10.1186/s12889-019-8069-2

[3] Zhao, S., Cao, Y., Lei, Y., Liu, F., Shao, S., Liu, J., Nie, D., Yang, N., & Liu, M. (2019). Population ageing and injurious falls among one million elderly people who used emergency medical services from 2010 to 2017 in Beijing, China: a longitudinal observational study. *BMJ open*, *9*(6), e028292. https://doi.org/10.1136/bmjopen-2018-028292

[4] Money, A. G., Atwal, A., Boyce, E., Gaber, S., Windeatt, S., & Alexandrou, K. (2019). Falls Sensei: a serious 3D exploration game to enable the detection of extrinsic home fall hazards for older adults. *BMC medical informatics and decision making*, 19(1), 85. https://doi.org/10.1186/s12911-019-0808-x

[5] Durán-Vega, L. A., Santana-Mancilla, P. C., Buenrostro-Mariscal, R., Contreras-Castillo, J., Anido-Rifón, L. E., García-Ruiz, M. A., ... & Estrada-González, F. (2019). An iot system for remote health monitoring in elderly adults through a wearable device and mobile application. Geriatrics, 4(2), 34. http://journals.sagepub.com/doi/suppl/10.1177/1460458217704251

[6] Collier, S., Monette, P., Hobbs, K., Tabasky, E., Forester, B. P., & Vahia, I. V. (2018). Mapping movement: applying motion measurement technologies to the psychiatric care of older adults. *Current psychiatry reports*, 20(8), 64. https://doi.org/10.1007/s11920-018-0921-z

[7] Choi, S., & Youm, S. (2017). A study on a fall detection monitoring system for falling elderly using open source hardware. *Multimedia Tools and Applications*, 1-12. https://link.springer.com/article/10.1007/s11042-017-5452-9

[8] Yacchirema, D., de Puga, J. S., Palau, C., & Esteve, M. (2019). Fall detection system for elderly people using IoT and ensemble machine learning algorithm. *Personal and Ubiquitous Computing*, 23(5-6), 801-817. https://doi.org/10.1007/s00779-018-01196-8

[9] Pasluosta, C.F., Gassner, H.; Winkler, J.; Klucken, J.; Eskofier, B.M. (2015) An Emerging Era in the Management of Parkinson's Disease:

Wearable Technologies and the Internet of Things. *IEEE J. Biomed. Health Inform*, 19, 1873–1881 https://doi.org/10.1109/JBHI.2015.2461555.

[10] Wang, Z., Yang, Z., Dong, T.(2017). A review of wearable technologies for elderly care that can accurately track indoor position, recognize physical activities and monitor vital signs in real time. *Sensors* (Basel), 17(2) https://doi.org/10.3390/s17020341

[11] Schrack JA, Cooper R, Koster A, Shiroma EJ, Murabito JM, Rejeski WJ, (2016). Assessing daily physical activity in older adults: unraveling the complexity of monitors, measures, and methods. *J Gerontol A Biol Sci Med Sci.* 71(8):1039–48. https://doi.org/10.1093/gerona/glw026.

[12] Godfrey, A. (2017). Wearables for independent living in older adults: Gait and falls. *Maturitas*, *100*, 16-26. https://doi.org/10.1016/j.maturitas.2017.03.317

[13] Tsai, H. H., Cheng, C. Y., Shieh, W. Y., & Chang, Y. C. (2020). Effects of a smartphone-based videoconferencing program for older nursing home residents on depression, loneliness, and quality of life: a quasi-experimental study. *BMC geriatrics*, 20(1), 27. https://link.springer.com/article/10.1186/s12877-020-1426-2

[14] Goes, M., Lopes, M., Oliveira, H., Fonseca, C., & Marôco, J. (2020). A Nursing Care Intervention Model for Elderly People to Ascertain General Profiles of Functionality and Self Care Needs. *Scientific Reports*, *10*(1). https://doi.org/10.1038/s41598-020-58596-1

[15] Krick, T., Huter, K., Domhoff, D., Schmidt, A., Rothgang, H., & Wolf-Ostermann, K. (2019). Digital technology and nursing care: a scoping review on acceptance, effectiveness and efficiency studies of informal and formal care technologies. *BMC health services research*, 19(1), 400. https://doi.org/10.1186/s12913-019-4238-3

[16] Joling, K. J., Van Eenoo, L., Vetrano, D. L., Smaardijk, V. R., Declercq, A., Onder, G., ... & van der Roest, H. G. (2018). Quality indicators for community care for older people: A systematic review. *PloS one*, 13(1). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5760020/

[17] Segercrantz, B., & Forss, M. (2019). Technology Implementation in Elderly Care: Subject Positioning in Times of Transformation. *Journal Of Language And Social Psychology*, *38*(5-6), 628-649.https://doi.org/10.1177/0261927x19830445

[18] Tong, L., Song, Q., Ge, Y., & Liu, M.(2013). HMM-Based Human Fall Detection and Prediction Method Using Tri-Axial Accelerometer. *IEEE Sensors Journal*, *13*(5), 1849-1856. https://doi.org/10.1109/jsen.2013.2245231

[19] Nguyen, L., Saleh, M., & Le Bouquin Jeannès, R. (2020). An Efficient Design of a Machine Learning-Based Elderly Fall Detector. Retrieved 31 May 2020, from: https://doi.org/10.1007/978-3-319-76213-5_5

[20] Sauro, S. (2011). SCMC for SLA: A Research Synthesis. *CALICO Journal*, *28*(2), 369-391. https://doi.org/10.11139/cj.28.2.369-391

[21] Wylie, G., Torrens, C., Campbell, P., Frost, H., Gordon, A. L., Menz, H. B., ... & Morris, J. (2019). Podiatry interventions to prevent falls in older people: a systematic review and meta-analysis. *Age and ageing*, 48(3), 327-336. https://academic.oup.com/ageing/article/48/3/327/5274645

[22] Brimelow, R. E., Gibney, A., Meakin, S., & Wollin, J. A. (2019). Accessing care summaries at point-of-care: Implementation of mobile devices for personal carers in aged care. Health informatics journal, 25(1), 126-138. https://journals.sagepub.com/doi/full10.1177/1460458217704251

[23] Zhang, J., Xu, L., Li, J., Sun, L., Ding, G., Qin, W., … Xie, S. (2018). Loneliness and Health Service Utilization among the Rural Elderly in Shandong, China: A Cross-Sectional Study. *International Journal of Environmental Research and Public Health*, *15*(7), 1468. https://doi.org/10.3390/ijerph15071468

[24] Peretz, D., Arnaert, A., & Ponzoni, N. N. (2018). Determining the cost of implementing and operating a remote patient monitoring programme for the elderly with chronic conditions: A systematic review of economic evaluations. *Journal of Telemedicine and Telecare,* 24(1), 13–21. https://doi.org/10.1177/1357633X16669239

[25] Calvaresi, D., Cesarini, D., Sernani, P. (2017). Exploring the ambient assisted living domain: a systematic review. *J Ambient Intell Human Comput* **8,** 239–257. https://doi.org/10.1007/s12652-016-0374-3

APPENDIX

ERD:	Electronic reference databases
RCNN:	Region-based Convolution Network Model
EBEDS:	Elderly behavior emergency detection system
EDE:	Emergency detection experiment
ERD:	Electronic reference databases
RCNN:	Region-based Convolution Network Model
EBEDS:	Elderly behavior emergency detection system
EDE:	Emergency detection experiment
EFA:	Exploratory factor analysis
CFA:	Confirmatory factor analysis
EHR:	Electronic Health Records
EMR:	Electronic Medical Records
AEE:	Acceptance, Effectiveness and Efficiency
SRF:	Scoping Review Framework
SWT:	Sliding Windows Techniques
ELA:	Ensemble Learning Algorithm
SUS:	Systems Usability Scale
EDS:	Electronic Documentation Systems
RCTs:	Randomization Controlled Trials
MFPI:	Multi facet podiatry intervention
CRB:	Cochrane Risk of Bias tool
EMR:	Electronic Medical Records
AEE:	Acceptance, Effectiveness and Efficiency
SRF:	Scoping Review Framework
SWT:	Sliding Windows Techniques
HP:	Health care professionals
FM:	Family Members
SDV:	sociodemographic variables
DA:	descriptive analysis
DL:	Digital Library
CS:	Cloud services
PT:	Performing time
TT:	Testing time
WC:	wearable computing
RM:	Remote monitoring,
OD:	Object detection
WD:	Wearable Devices
SMA:	Signal magnitude Area
ADL:	Activities of Daily Living
MLP:	Machine Learning Programming