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Air Care – Machine Learning Approach to Develop a Supportive and Monitoring System for an Elder

[1]Mathushan Shanmugathashan, [2]Sivagnanasundaram Naveen, [3]Mithusha Kamaleswaran, [4]Dasun Maduranga Weerasinghe, [5]K.B.A.B. Chathurika

[1,2,3,4,5]Department of Computer Science and Information Technology, Sri Lanka Institute of Information Technology, Malabe, Sri Lanka

***Abstract* - Elderly people are one of the greatest assets of our nation, and it suits all the countries. Due to the improper way of living, bad health habits, and because of many other factors, they need to be monitored. In these days of our lives, people are coming up with a lot of tools and technologies, but none of them suggested a good, sophisticated approach. Both human and technology has some downsides by themselves. This creates the need for an application that can fill all the downsides of the available approaches. Air Care is a cost-efficient, minimalistic, sophisticated approach to monitor elders by their activities. Mainly targets on loco-motions, high-level activities, restricting their motions, monitoring people who visit home and notify, and monitoring the attentiveness of caregivers like so. Accuracy rate of 89% gained through the process. The primary objective of our research project is to find a solution using Machine learning, and deep learning to overcome the monitoring issues. Therefore, this paper focuses on developing and deploying a monitoring application by clustering data and using algorithms (SVM & K-Means) and neural network in a minimalistic way.**

Keywords: machine learning, Clustering, algorithms, neural network, loco-motions, monitor, and deep learning.

I. INTRODUCTION

A) Background and Motivation

Over the ages, aged people get physically wane and getting weak is the norm. It causes many physical limitations, and serious health issues. Because of this elderly people need to be monitored by the guardians even if they are working, they have to find a way to monitor the elderly. Appointing a caretaker is a successful method theoretically. Nevertheless, there are some barriers to appointing a caretaker and practically over the years so many elderly abuses are placed and happened over the years.

Elderly people need to be physically active through studies and form the doctor's perspective. It is the best remedy and to keep them active, we need to take special care and special monitoring to keep them active. There is so much research that has been conducted over the years on elderly people's health relatedly and remedy related studies, but to monitor them with sophisticated technology is still a question mark and there is a gap in between these issues. This research proposes a method for monitoring elderly parents or the aged people at home with sophisticated technology and a few machine learning algorithms. This method is a minimalistic and affordable approach for the elderly people and to the guardians. This developed application will be able to monitor elderly people and in case of emergency it will send messages and notification to the guardian and to the caretaker.

B) Loco-motions of Elders

Figure 1: Capturing motions while the person is transitioning from one to another within a limited time period

With the RGB-D sensor and the system, elderly people's motions are monitored, and a new data set will be created on to the system. The data needs to be trained to specify it for a selected elder. Motion detection happens when the RGB-D sensor is placed in a constant and stable placement to avoid system errors.

C) Caretaker monitoring

Even if the elderly is monitored by a sophisticated tool, and technology some might need help when an emergency or elder might be physically wane. To help the elderly in these scenarios there should be a caretaker to take care of the elderly. Still caretakers need to be monitored as well, because of the records from the past. There are lot of abuses and neglects. To reduce the abuses or to monitor the elders from abuses and attentiveness of the caretaker's behaviors, it is a good way to monitor them too. Monitoring all the motions is

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practically impossible. To monitor a selected motion according to the need and to avoid the caretaker's inattentiveness, will lead to a secure environment for the elder or the aged person.

D) Visitor's alarm system

Many visitors will visit home and some new visitors also visit home in a typical scenario, most of the time there is no guarantee for the life of the elderly. There might be some cases where unknown or known persons will visit home with weapons with threatening ideas and it will end up with losing the life of the elder. By monitoring the visitors and giving notification will bring more confidence to the elderly and it will secure the life of innocent elderly aged people, even it can save the lives from robberies. And, if the visitors visit home with weapons, then it will notify the guardian to take special care.

E) Restrict the danger zones

Danger zones like wet-floor, electric shock, and places with external wire connections are dangerous to elderly people. It might be a reason for frailty, immobility, and acute and chronic health impairment. Prevention of elders from accessing or movements towards wet-floors or wires is very important. Specially, fractures are common and very serious injury resulting from fall in aged persons by the wet-floor and including other serious injuries like and it is resulting hematoma, severe laceration, joint dislocation, and other disabling soft tissues injury.

Zone Detection is the process of identifying wet-floors and places with chances for an electric shock and notify the elders when they are willing to visit or loitering around that place.

II. LITERATURE REVIEW

A) Data Classification

Machine learning algorithms are used to classify the motions and with the machine learning algorithms, clustering, data can be classified into different categories.

"Using Support Vector Machines to Classify Student Attentiveness for the Development of Personalized Learning System"; proves the novel approach for classifying the data of a selected motion. They use Support Vector Machines and K-Means algorithms to classify, and the accuracy of the proposed system is better than that of the machine learning approaches. And for this research they collected the data using the RGB-D camera such as the Kinect sensor. [1]

Each object that is going to be classified is pointed in a n-dimensional space. The coordinates of these points are called features. SVM performs the classification by drawing a hyperplane that is a line 2D or a plane in 3D, in such a way all points of one category are on one side of the hyperplane and all points of the other category are on the other side and there could be multiple such hyperplanes. SVM tries to find the one that best separates the two categories, in the sense that maximizes the distance to points in either category. Here the line is called margins and the points falls on the margin is called the support vectors.

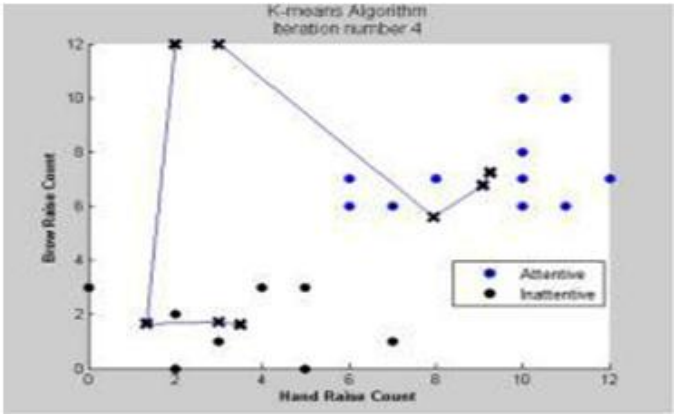

Figure 2: Results of K-means clustering

There is present-day research in 2018 examining Google's cloud vision technology that uses powerful machine learning approaches to caliber the contents. The whole framework is implemented by a basic and straight hardware implementation on a Raspberry PI running with python. And it was using Convolutional Neural Network (CNN). [2]

Another paper on Data Mining Classification Algorithms for Student Performance uses several methods, namely K-nearest neighbor, regression trees, classification, naïve bayes, extratree, adabboost, random forest. And with the technology of language Python programming to compare. Cross validation is done for the performance. Emny conducted a study and checked the performance of students with neural networks and data classification. [3] Corinna Cortes and Vladimir Vatnik focused on input vectors are mapped in a non-linear way to get a high dimension feature space. And we could make decision boundary using the Support Vector Machines algorithm for two groups of data.[4] K-means algorithm is used to classify the data into two groups that is stored in the database. [5]

B) Motion Detection

"Motion Detection and Analysis with Four Different Detectors" is research done by Malaysian students to find motion detection. They Enhanced motion detection technologies with globally recognized algorithms. [6] In one another research about "Communications on Spontaneous

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facial expressions". With 53 undergraduate receivers viewed the senders' facial expressions and they classified the expressions with algorithms and machine learning. The information that is gathered accurately showed seven affective stages, including six emotions and one neural expression. [6]

C) Face Detection

Convolutional Neural Network (CNN) is a deep learning algorithm used for face detection in machine learning. By Ashish Kumar and Shanmugavadivu "Rapid Face Detection and Annotation with Loosely Face Geometry" they addressed the Partially Occluded Face Detection (POFD) problem. Through this research they found that Nose is very hard to cover up without drawing suspension. It keeps nose components as a reference, and the algorithm searches the surrounding areas for main facial features. [7]

Review and Comparison of face detection algorithms by Kirti Dang and Shanu Sharma had a research and through the research they proposed that the Viola-Jones, SMQT features and Snow Classier Support Vector Machines Based Face detection, and Neural Network-based Face Detection methods are compared and based on the precision and recall value calculated using the DetEval application software and got the accurate results with the bonding boxes and the SVM algorithm comes with the maximum accuracy among other. [8]

Video Anomaly Search in Crowded Scenes via S-Temporal Motion Context describes the algorithm that is for the abnormal event detection in tempting video space by taking video anomaly detection as a retrieval problem. And they have developed two key-technologies for both event representation and anomaly measurement. And it was motivated by the "super pixel" methods. [9] [10]

III. SYSTEM ARCHITECTURE

We could implement an application which takes motions by RGB-D sensor and connects with the machine learning algorithms and libraries. Fig. 3.1 indicates the overall architecture of the system. Air Care application focuses on all aspects of the elder's care. The notification will be sent through the network to the guardian and to the caretaker. Here the dataset accuracy rate is kept above or more than ninety percent all the time to get the best results. Python language is used for all the processes of the application development and python related libraries are used.

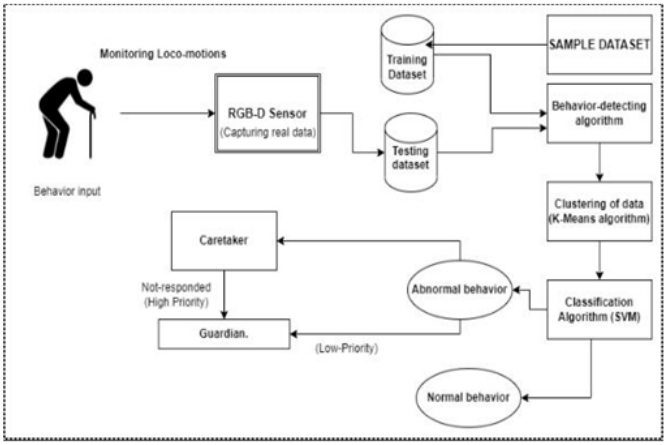

Figure 3: System overview diagram

IV. METHODOLOGY

Figure 3 describes the overall methodology that should be done along with the data-classification and data clustering processes in the application with the data captured with the RGB-D sensor.

The major goal of the above proposed project is to implement a reliable and secure application to monitor elderly parents or the aged people. Monitoring elderly people by their loco motions, monitoring the caretakers' motions and fall detection of the elder, Monitoring the danger zones loitering of the elderly people, and monitoring the visitors who visits the home and additionally the application will be monitor the visitor, whether they are bring any harmful equipment or not.

A) Motion detection using RGB-D Sensor

RGB-D camera is a brand-new model of optical sensor. It solved the depth information by simultaneously capturing the texture information and depth information. It consists of a color camera and depth sensor. These cameras have two fisheye or wide angle (extreme wide angle) cameras. Algorithm to perform a stereo that, in a way, detects an object for a feature point. By interpolating their relative differences or the angle between them, it will have some depth, and it is a tracking camera. To extract features on the face, we need to use the features vector. Once we get the sample stage, we can extend it to multiple stages.

RGB-D sensor helped to capture the dataset and with it the sample data set is created. Along with the development of deep learning techniques, artificial intelligence has remarkable success in computer success in the computer vision. A motion is considered as a type of motion performed by a special person over a short period of time, and it involves multiple body parts, in contrast with some body parts that are involved in gestures. Indeed, an activity is composed of sequence of actions. [11]

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The RGB-D data is the contribution of the depth information over clearly visual detection techniques. By considering these issues we considered Visual Haar-based Adaboost detector (HA) and visual HOG detector, it was initially proposed by the Jones and Viola [12] both detect people in the RGB images. These are because of the illumination issues. Here the environment is not optimally illuminated. Blurred images of moving people came because of the dark areas, and as the Kinect RGB-D camera by default extends its shutter time to produce brighter images. Saturated image areas and bad contrast because of the direct sunlight. AH methods, that is using the Haar-wavelets and it is illuminating to the changes contribute to the failure. According to these results demonstrate, the results shows that the people detection systems that work in ranges of conditions that are particularly widespread than the one for purely visual detection approaches and triggers the usage of depth information on this task. Image based techniques in contrast by geometric approaches is one of the importance equally.

Evaluation of the HOD11 method with BUTD, it is a 3D person detector for sparse 3D data such as point clouds by a Velodyne sensor. There the results are relatively favorable for the HOD11 with an EER of 72%. But this technique strongly relies on the shape information and is therefore compromised by the resolution lost for little, larger distances from the sensor. The special range image segmentation of BUTD is not work well with coarsely quantized depth data. But with close ranges both detectors perform similarly, and it was at an EER of around 86%. According to the results of the above it clearly shows the appropriateness of shape-based approaches given data of some of its quality. The computational performance is also evaluated for the HOD detector. Using the informed scale-space search versus the regular uninformed HOD method to compare the number of scales. With the pyramid scale of five percent increment regardless of the image consent by the HOD. In-depth information could provide a significant contribution. Such as notation of the object. Parsing the scene, estimation of the pose, tracking the visual, segmentation of the semantics, analyses the shape, rendering based on image, and reconstructions using 3D.

And the low-cost RGB-D cameras are realized by the 3D applications virtue. Here the second application automatically finds the kinetic energy consumed by it. It does this with the tracked Skelton, which may help the elders or the caretakers to find the know their motion effects and even the tiny movements of the body like eye-movements. These cameras also need to calibrate between the color and the depth of the cameras. To take the depth value, we need to systematically select it. SVM algorithm is reliable and very accurate on it, and it is stimulating the real-world examples. The point pair methodology helps with the cameras to achieve the check board pattern. We are used in computer vision.

B) Selection of activities of special interest

Concluding form, a set of motions, only a few motions were selected, and these motions were also deemed as most important by the doctors, those are explaining the following:

1) Sitting
2) Walking
3) Getting out of bed
4) Changing positions in bed
5) Waving hands
6) Changing the positions in the bed

Loco motions may end or lead to falls being a drastic issue problem for elders and it is a substantial healthcare burden. With the RGB-D sensor on several ranges at various partial occlusions and in different depth clutter and visual. And Note: this method neither relies on a ground plane nor background learning. [13] [14]

C) Face detection

Face detection is a computer vision task in which we detect the presence of human faces as well as its location within an image or video stream. Face detection is applied in multiple fields.

With the help of Python and OpenCV we developed a model for real-time human face detection. Face recognition is a technology in computer vision. And it is coming under the sub domain of object detection. By observing the instances of semantic objects. These objects should come under the particular class such as cars, humans, animals etc.

Create a Python file_detection.py and then need to import the CV2 and OS<div class = “open_grepper_editor” title = “Edit & Save To Grepper”> and then need to initialize the classifier and apply the faceCascade on Webcam Features Number equations consecutively. Here by removing irrelevant features results in a better performance model and in model that runs faster. For the feature selection we have used,

1) Percent missing values
2) Pairwise correlation
3) Multicollinearity
4) Cluster analysis
5) Correlation
6) Tree – based selection

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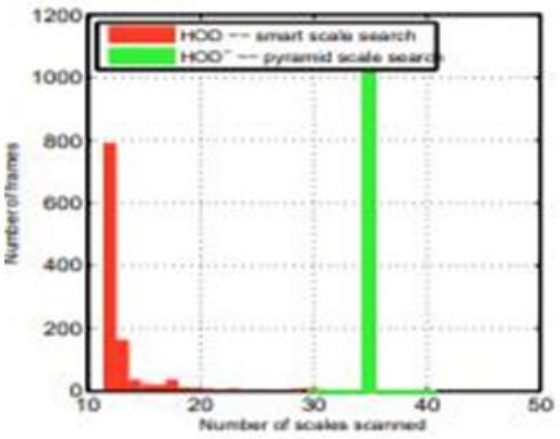

Figure 4: The no of scales tested with the image

Figure 5: Face image, rotated, translated, randomly mirrored and scaled by the small amounts

And label the faces that are in the dataset and name it comes under the known person. By using the existing dataset and create a neural network and in the neural network consists of convolutional classifications, and the input data will be classify using the matched and unmatched with the dataset and through the api connection using flask will send the notifications to the guardian and the caretaker on the application that is created using the Flutter mobile application creator. And the message priority will be set according to the message type. There are low-priority, medium Priority and high-priority.

D) Clustering data

1. Locomotion Clustering

By using this method, it is expected to cluster the loco motions of the elders. Users need to have a clear view of the room while the data is getting into the system as input. From the motions applications will cluster the main motions like walking, sitting and hand waving. By using the geocoders' library, the system will identify the main motions of the elder properly. Then the K-means algorithm is used to cluster the data of the elder. When using the silhouette score method, the accuracy rate of 85% is gained, while clustering coordinates into four clusters. And the data will not be vulnerable to others from the system. All the other data will be hidden and those could not identify using the cluster label.

2. Support vector clustering

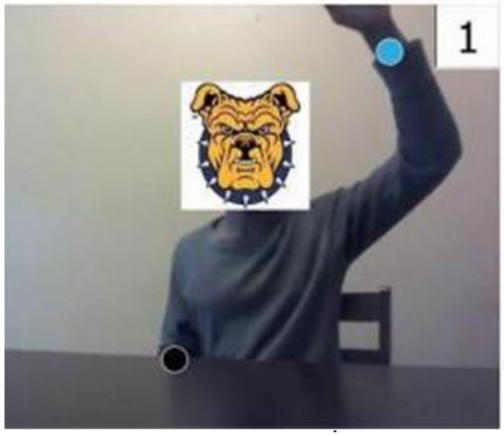

Figure 6: Hand Raise Counter Application

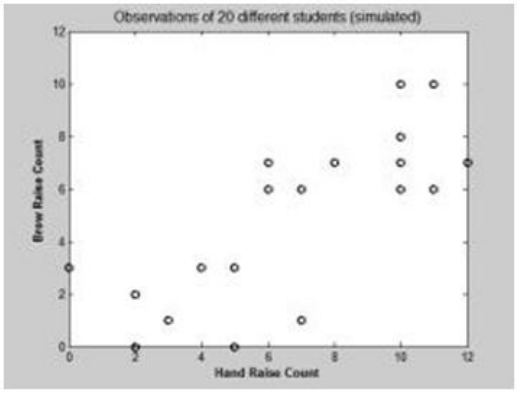

Figure 7: Plot of simulated elders' behavior

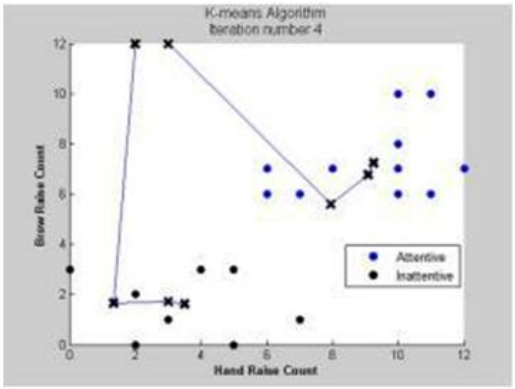

Figure 8: K-means algorithm clustering results

The generated set of data was then clustered into two categories and labeled as normal behavior and abnormal behaviors. These data sets were used to train + testing the data in the supervised learning algorithm to establish a decision

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boundary. This decision boundary can be used with automation to classify elders' normal motions and abnormal.

Once the data is clustered and labeled using the K-means algorithm, the next step will be classifying the data using the SVM algorithm. Algorithm 2 is a basic algorithm. The variable Θ is illustrating the parameters and the letter f is chooses based on the category of the kernel function use.

E) Fall detection

The 60 gigahertz millimeters wave sensors from TI are capable of sensing potential falls and detecting them by in-home monitoring systems. Home monitoring systems with fall detection can be of great assistance to elderly and disabled people. TI millimeter wave sensors provide range, velocity, and angle information for creating a rich 3D point cloud representing people in a scene. Notice how the point cloud can represent people without any contact or revealing any identifiable characteristics, making it suitable for installation in sensitive areas, such as bedrooms or any specific room. The point indicates when the figure changes shape and color. A person standing is typically shown as a long, thin cluster, while a person sitting is a round cluster. The color illustrates height by a person standing being represented as yellow, orange, and green points, and lying down as dark blue points. When a person falls, the cloud shape changes from long and thin to short and wide. Indicating analyzes the point cloud to determine if a person has fallen and then sends an alert to a caregiver. The latest fall detection technology uses millimeter wave sensors that do not require wearers to wear physical monitors. It relies instead on monitors. Instead, they monitor to detect falls. Rely on cameras to detect when someone falls. Multiple individuals within an area at once. Additionally, TI millimeter wave sensing enables high accuracy fall detection. In all lighting and environmental conditions. [15] [16] [17]

V. RESULTS AND ANALYSIS

The results that we got from the dataset clustering and classification using the SVM algorithm. It shows the final classification and decision boundary for the elderly parents.

From the test result, elders who need help or need to monitor will be monitored and the guardian will get a notification with the priority level of the notification. And meanwhile the caretaker is also going to get notification about the stage of the elder. The caretaker can monitor the elder and if the caretaker does not respond to the elder then the high-priority notification will be sent to the guardian. Guardian can take necessary steps to take care of the elder. Additionally, using the face detection system, visitors will be monitored and when the visitor is visiting the home. When a new neighbor visits the home guardian will get the update. This is taken care of the elderly's health.

VI. LIMITATIONS AND FUTURE WORK

So far, only Loco motions of the elder has been captured and monitored in the application. Other motions like eye-movements, hand-movements, and face emotions will be considered for the next phase of the investigation.

VII. CONCLUSION

As a result of this process, the application has monitoring features specially for elderly people or the aged people. That can monitor the elders' loco-motions and notify the guardian through the system. This is improved using dataset and machine learning algorithms. And this produces 92% of the accurate results. Identifying loco motions using RGB-D sensor and with the results the application classify the normal behavior and abnormal behavior and notify the caretaker or the guardian or both of them considering the priority level of the notification. Furthermore, the caretakers are also going to be monitored by the application and it will reduce the abuses of the caretaking process. And when using the support vector machine learning algorithms to cluster the motions clustering process happened with 98% accuracy.

The visitors' entrance visits will be monitored. And with that, the visitor will be checked whether he/she is carrying any harmful equipment. This enables the elderly to live a secure and healthy life, and which will be monitored and notified when there is any harm or help needed or in an emergency time. [18] [19] [20]

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