FALL DETECTION IN ALZHEIMER'S DISEASE PATIENTS USING MACHINE LEARNING, INTEGRATED WITH A WRIST-WRAP DESIGN AND MOBILE APP

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ABSTRACT

Based on information collected from various research papers [1] about the blood pressure values and daily check-up details of patients suffering from Alzheimer's disease (AD), a machine learning algorithm is applied to predict the fall of the patients. A wrist wrap is designed to detect the fluctuations in blood pressure, pulse rate and muscle activity of the patient and will help in predicting the fall of the patient with precise location [2]. The logistic regression model is trained using the dataset on two different platforms, i.e., Peltarion and Weka. Finally, the fluctuation in blood pressure and fall detection was verified using Arduino based tool and appropriate C# coding. The accuracy of the test was nearly 66%.

Key words: fall detection, Alzheimer's disease, machine learning, blood pressure, logistic regression, IoT

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1. INTRODUCTION

In the modern society, the quality of life has improved greatly thanks to scientific advancements [3]. People are ageing healthily and stay active even in their 60s and 70s. However, individuals suffering from Alzheimer's Disease (AD) are still facing challenges because of the abnormal lifestyle and health issues that come with AD. Health problems for elderly people with AD is an increasing concern in our society [4].

AD is a common neurological disorder in elderly people in which a person is not able to perform day-to-day routine activities. There needs to be a caregiver around the patient to assist the patient in all tasks including behavioural tasks. Thus, it is difficult for a family to give the proper and persistent care required for a person suffering from AD.

In the last decade, many scientific advancements have been made to improve the lifestyle of patients with AD, including research that uses artificial intelligence and machine learning (AI/ML). Moreover, IoT tools have made data collection from patients much easier.

This paper focuses on the problem of regular falls faced by patients with AD. Fall detection can be done using posture analysis and machine learning algorithm like artificial neural network. In this paper, we focus on physiological indicators such as blood pressure and pulse pressure conditions and the gender and age at which the AD was detected in the patients to detect falls in patients.

A wrist wrap has been designed to constantly monitor the blood pressure, pulse rate, and muscle activity of the patient. Falling is a concern for AD patients because if a caregiver is not nearby, then the patients is stuck lying down on the site where the fall occurred and may not be able to seek medical attention to treat their injuries. The lifestyle of AD patients can be improved by minimising falls and ensuring proper help is received in case of a fall, using a wrist wrap with sensors and coding on Arduino. Arduino is platform where C# coding can be applied to use sensors for different purposes. Arduino can be used to track muscle activity. The wrist wrap has a pulse meter or heart rate measuring device which can measure systolic and diastolic blood pressure regularly. This can be useful to predict falls using the logistic regression or random forest algorithm and for the caregiver to understand the conditions of patients in real time using a mobile app, ILAD (Improving the Lifestyle of patients with Alzheimer's Disease), which will also notify the caregiver in case of a fall.

In this paper, I will first explain how the data is collected and analysed using machine learning algorithm. Then the symptoms of patients with AD will be analysed. Then in the third section, the design of wrist wrap will be explained. In the following section, I will explain the algorithms used in machine learning. Finally, I will explain the conclusion based on results obtained. In this paper, the API generation for the app has been done on Peltarion platform. Further analysis of the data using Machine learning algorithm "Random Forest" has been done on Weka.

2. DATA COLLECTION

Data for different parameters for patients suffering from AD was collected from various resources. A few rehabilitation centres conduct routine check-ups for patients which includes tracking their body temperature, age, sex, blood pressure, memory check, behaviour and muscle activity. However, these parameters are not often analysed to understand different problems faced by patients suffering from AD. These parameters are related to the physiological processes of the patients and can affect the brain conditions as well.

The data is shown below. The unprocessed data was collected from Kaggle [8].

Data

Table 1 Sample processed data collected from Kaggle.

MMSE	age at Entry	CDR	memory	BP code	code for gender	code for AD fall
16	79.14579	1	1	1	1	1
21	79.14579	0.5	0.5	0	1	1
20	68.07666	1	1	1	1	1
28	68.07666	1	1	1	1	1
29	68.07666	0.5	0.5	0	1	1
29	68.07666	0.5	1	1	1	1
24	73.69746	2	2	1	1	1

28	73.69746	0.5	1	1	1	1
30	63.92608	0.5	0.5	0	0	1
30	63.92608	1	0.5	0	0	1
30	63.92608	0.5	0.5	0	0	1
30	63.92608	0.5	0.5	0	0	1
23	64.81314	0.5	0.5	0	1	1
25	62.98426	0.5	0.5	0	1	0
27	67.48254	0.5	0.5	0	0	0
17	67.48254	1	1	1	0	1
27	67.48254	0.5	0.5	0	0	0
29	72.29295	0.5	0.5	0	1	0
28	67.54278	0.5	0.5	0	1	1
27	67.54278	0.5	0.5	0	1	1

MMSE: The mini mental state exam (MMSE) gives a score from 0 to 30. A score ranging from 20 to 24 shows mild dementia, less than 20 but more than 13 shows moderate and less than 13 shows severe dementia condition.

CDR (clinical dementia rating): This is another tool to understand the dementia condition in patients with AD. This is score from 0 to 5. Above 3 is severe dementia, 1 is mild and 2 is moderate dementia, a score of 0 to 0.5 is considered normal.

Memory:

This test scores patients from 0 to 2, similar to CDR, with a score of 2 showing mild dementia and lower than 2 showing more normal conditions.

BP code: Systolic and diastolic blood pressure explain the heart conditions in the patients. Below 110 of systolic blood pressure is considered low blood pressure, which is shown as 0 in the above table. Higher than 130 mm of Hg for systolic blood pressure is considered high blood pressure, which is shown as 1 in the above table. Thus the binary code represents only high and low blood pressure conditions. Normal blood pressure conditions have been eliminated from the table as elderly people with AD hardly have normal blood pressure level of 120/80.

Code for gender: Male is represented with 0 and female with 1 as binary code system in above table.

Code for AD fall: Individuals with AD and for whom a fall is detected are represented with a 1 and when no fall is detected, it is shown with a 0.

The first 20 entries of data are shown in the above table for reference. The entire data can be seen in CSV file associated above.

These data were analysed using Weka and Peltarion tools.

Weka tool is a set of artificial intelligence and machine learning algorithms which is used for data analysis. This includes regression, clustering, classification, and visualization of data.

Peltarion platform is an open source for Artificial intelligence-based app development which includes training the model with right algorithms and right parameters.

The “Weka” analysis and “Peltarion” experiment is shown as follows:

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Figure 1 Weka Analysis of the data collected. Random forest algorithm to show factors that can predict the fall in patients with AD.

Above is the “Weka” analysis for the dataset collected which helps in understanding that on application of Random Forest machine learning algorithm, the results analysed were having high correlation coefficient of 0.9175 which shows that there is good relationship between the independent variables chosen and the output variable of fall prediction.

Following are the details of API (application programming interface) which has been used for making the ILAD app for predicting falls. These codes are obtained after running the model on Peltarion platform with appropriate algorithm and other parameters.

URL for the experiment on “Peltarion”

<https://a.azure-eu-west.platform.peltarion.com/deployment/fcb3f877-06c2-47a8-bcb4-f58bfe2afc33/forward>

Token generated for API:

0f169248-f041-44a3-9744-2e828e5b1310

Input for the experiment (independent variables):

```
curl -X POST
-F "code for gender=VALUE"
-F "cdr=VALUE"
-F "BP code=VALUE"
-F "memory=VALUE"
-F "mmse=VALUE"
```

```
-F "ageAtEntry=VALUE"
```

```
-u "0f169248-f041-44a3-9744-2e828e5b1310:"
```

```
https://a.azure-eu-west.platform.peltarion.com/deployment/fcb3f877-06c2-47a8-bcb4-f58bfe2afc33/forward
```

Output for the experiment:

```
{
"code for AD": "{<Data based on output type>}"
}
```

3. STEPS ON PELTARION PLATFORM

Collection of Datasets

Figure 2 Data collection and processing on Peltarion platform.

Evaluation of Trained Machine Learning Model with the Data

Figure 3 Evaluation of the data after running the training of model.

Deployment of the Machine Learning Model and API Development

Figure 4 API generation on Peltarion for the app predicting fall in patients with AD.

This API is decoded to make an app which will be connected to the wrist wrap and will help in predicting whether there is a fall or not a fall as binary output to the caregiver for patients suffering from AD.

4. ALZHEIMER'S DISEASE AND SYMPTOMS

This is a neurological disorder which starts at elderly age and worsens over time. This affects the brain progressively over time. More than 7% people globally with in age group of 65-80 years are suffering from this disease and the worst part is that there is no cure to this disease. The reason is known but that can not be controlled. However, if detected at early age, it can be treated. This occurs because of the damage to neurons and neuroglial cells which are irreparable. This leads to dementia, memory loss and loss of control on the regular activities. Common symptoms of AD are loss of memory, increased sleepiness, confusion, problems in planning and decision making, repetition of same task or sentences or activity, difficulty in understanding simple things like image, audio, words, etc., altered mood and behaviour.

Medical practitioners perform some simple tests with patients to understand whether the patient is suffering from AD. This includes MMSE, CDR and other cardiovascular tests.

Cardiovascular factors have great significance in AD. The heart supplies blood to brain to provide the nutrients and oxygen. Any issue with this supply may lead to the poor activity and physiology of the brain. And ultimately this may lead to the memory-based problems like AD [9].

5. DESIGN OF THE WRIST WRAP

Key Features

- Sensors tracking the movement: using the Arduino sensor, the Blood pressure, temperature, nerve and muscle movements can be tracked.
- Touchscreen display utilizing solar power.
- Velcro strap for various hand size.
- Breathable, stretchable material for comfort and ease.

Sketches displaying design and features:

Figure 5

Improving the Lifestyle of Alzheimer's Disease Patients (ILAD) app: following images explain the user environment and user interface for the app that can be designed using above API.

Figure 6

Coding for Muscle Activity Sensor on Arduino

```
void setup()
{
  Serial.begin(9600);
}

void loop()
{
  float sensorValue = analogRead(A1);
  float millivolt = (sensorValue/1023)*5;
```



```

Serial.print("Sensor Value: ");
Serial.println(sensorValue);
Serial.print("Voltage: ");
Serial.print(millivolt*1000);
Serial.println(" mV");
Serial.println("");
delay(1);
}

```

Coding for pressure sensor on Arduino:

```

int fsrPin = 0; // the FSR and 10K pulldown are connected to A0
int fsrReading; // the analog reading from the FSR resistor divider
void setup(void){
  Serial.begin(9600);
}
void loop(void){
  fsrReading = analogRead(fsrPin);
  Serial.print("Analog reading = ");
  Serial.print(fsrReading); //print the raw analog reading
  if (fsrReading < 10) {
    Serial.println(" - No pressure");
  } else if (fsrReading < 200) {
    Serial.println(" - Light touch");
  } else if (fsrReading < 300) {
    Serial.println(" - Light squeeze");
  } else if (fsrReading < 350) {
    Serial.println(" - Medium squeeze");
  } else {
    Serial.println(" - Big squeeze");
  }
  delay(1000);
}

```

6. APPLICATIONS OF THE WRIST WRAP

The wrist wrap can measure the pressure that a patient can apply on regular objects. If the person is applying less than the threshold pressure, this shows that person is having slight instability. Same is applied with the muscle sensor and its output.

The data collected from wrist wrap from patients can be used by the caregiver using the ILAD app for their own tracking of the patient's progress. The algorithm developed on Peltarion is implanted in the app to detect whether the patient may suffer fall, allowing the caregiver can take appropriate action.

7. ALGORITHM FOR MACHINE LEARNING

As the data is numeric, algorithms like logistic regression and Random Forest can be used to get the binary output from the data collected from patients.

Logistic regression can do good prediction using the several independent variables at once and can give a binary output, similarly Random Forest is the result of many Decision Tree algorithms which are used not only for binary output but for the classification or clustering also. These algorithms are widely used in machine learning apps.

Both these algorithms used the data of MMSE, CDR, Memory test, gender and age as the independent variables and gave a prediction of fall or not as output. This was tested on the Weka and Peltarion platform.

8. CONCLUSION

The problem with AD is that the caregiver can not continuously keep an eye on the patients suffering from AD [10]. The wrist wrap and the app can help notify the caretaker of in case of a fall or sudden change in physiological indicators of the patient. These signals can minimise the events of falling and ensure the AD patient receives appropriate and immediate care in case of a fall. This will lead to an improvement in the safety and quality of life of patients. This does not require continuous monitoring as the caregiver can be alerted in case of fall-detection. Such devices are effective and popular as they not only help people suffering from AD and their family but any family with an elderly person [11].

The device was tested on normal and elderly individuals with AD and without AD and it gives results close to 90% accuracy in the identification of problems associated with AD. However, the relationship between cardiovascular imbalance and prediction of fall was having an accuracy of 66%. This low accuracy is probably because of limited number of data or limited type of data. This can be rectified with proper augmentation of data. This can be done by increasing the volume and velocity of the data.

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DECLARATION OF CONFLICTING INTERESTS

The author declares that there are no conflicting interests.

The author declares that there is no relationship with patients involved in the data collection.

The author declares that there is no known competing financial interest in this paper affecting the work done by the author.