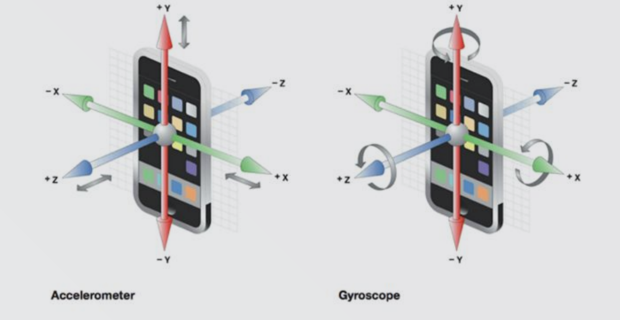
Machine Learning Project Falling Detection : kNN + Python + Colab



Shoumya Singh

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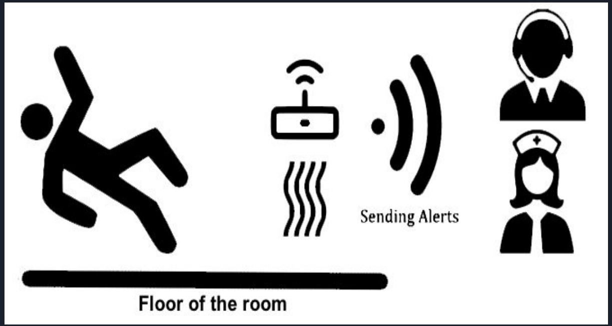
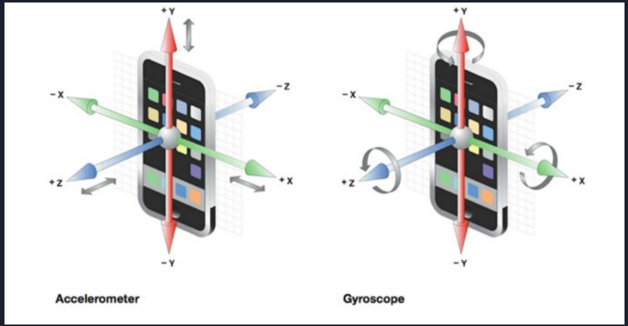
Introduction

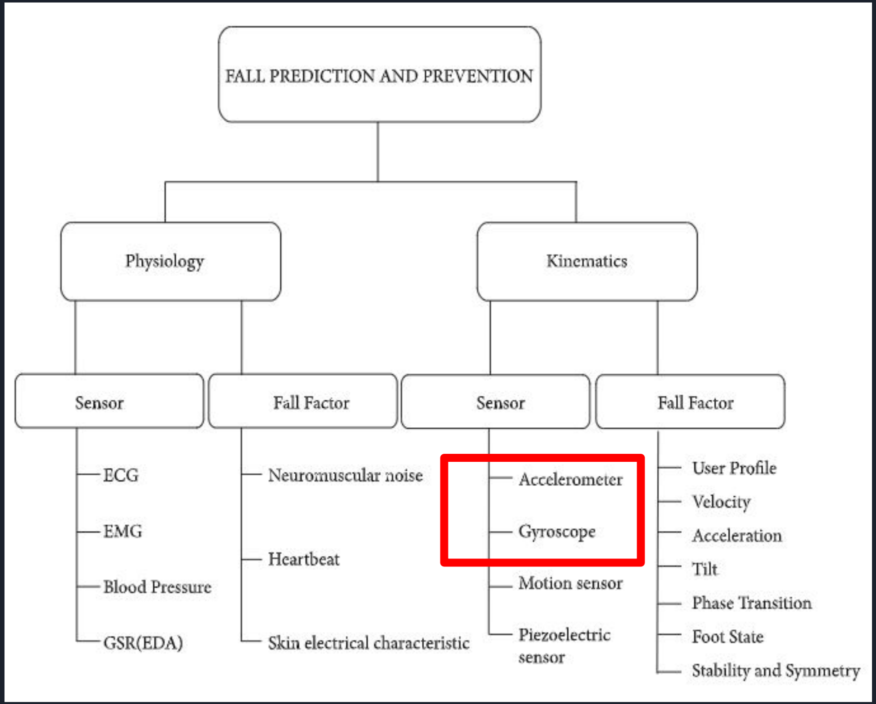




- This project is an evaluation on the fall prediction and prevention system from personal devices.
- Injuries due to unintentional falls cause high social cost in which several systems have been developed to reduce them. Recently, two trends can be recognized.
- Firstly, the market is dominated by fall detection systems, which activate an alarm after a fall occurrence, but the focus is moving towards predicting and preventing a fall, as it is the most promising approach to avoid a fall injury.
- Secondly, personal devices, such as smartphones, are being exploited for implementing fall systems, because they are commonly carried by the user most of the day.
- This project reviews various fall prediction and prevention systems, with a particular interest to the ones that can rely on the sensors embedded in a smartphone, i.e., **accelerometer and gyroscope.**

Classification of Fall Factors

- Fall prediction and prevention is a multifaceted problem that can be broadly categorized into two different domains: physiology and kinematics.
- In this project we are focusing on the kinematics which includes sensors.
- Accelerometer - An accelerometer is a device that measures acceleration, i.e, the rate of change of the velocity of an object.
- Gyroscope - A gyroscope gives the angular rate around one or more axes of the space. Angular measurement around lateral, longitudinal and vertical plane are referred to as pitch, roll and yaw, respectively.



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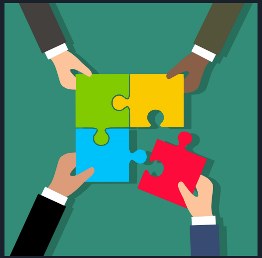
Project Description



- Most mobile devices are equipped with different kind of sensors.
- In this project we have the training data and test data from the accelerometer and gyroscope from a smartphone, we will apply the kNN (k-Nearest Neighbors) algorithm in two ways.
    - To manually calculate the distance using kNN and predict the results .
    - Use Python to implement the application of using kNN to predict falling.
    - Then compare both the results.

- We will be using Colab by Google as a tool to write and execute python code through the browser, which is especially well suited for machine learning.

- We have the data sent from Gyroscope sensor and Accelerometer sensor to categorize any motion:
    - 3 numbers from Accelerometer sensor.
    - 3 numbers from Gyroscope sensor.
    - Total 6 numbers of sensor data.

Desired Result

Accelerometer Data			Gyroscope Data			Fall (+), Not Fall (-)
X1	Y1	Z1	X2	Y2	Z2	+/-
1	2	3	2	1	3	-
2	1	3	3	1	2	-
1	1	2	3	2	2	-
2	2	3	3	2	1	-
6	5	7	5	6	7	+
5	6	6	6	5	7	+
5	6	7	5	7	6	+
7	6	7	6	5	6	+
7	6	5	5	6	7	???

Prediction

In case of Python code , we will use Fall (1) /Not Fall (0)

```
dataset = [[1,2,3,2,1,3,0],
           [2,1,3,3,1,2,0],
           [1,1,2,3,2,2,0],
           [2,2,3,3,2,1,0],
           [6,5,7,5,6,7,1],
           [5,6,6,6,5,7,1],
           [5,6,7,6,5,6,1],
           [7,6,7,6,5,6,1]]

#for predicting fall
testdata = [[7,6,5,5,6,7,1]]
```

kNN - k Nearest Neighbors Algorithm

- The k-nearest neighbors (**KNN**) **algorithm** is a simple, supervised machine learning **algorithm** that can be used to solve both classification and regression problems.
- In this project we have we determine K = 8 (given in the table 8 nearest neighbors) as parameter of this algorithm.
  - Then we calculate the distance between the query-instance and all the training samples.
  - Because we use only quantitative Xi, we can use Euclidean distance.
  - Suppose the query instance have coordinates (X1 q, X2 q) and the coordinate of training sample is (X1 t , X2 t) then square Euclidean distance is dtq 2 = (X1 t - X1 q) ^2 + (X2 t - X2 q)^ 2

- **K = Number of nearest neighbors**
  = sqrt (number of neighbors)
  = sqrt (number of data samples)
  = sqrt (8)
  = 3

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Implementation (1)-Manually calculate the distance and predict the result using kNN.

Accelerometer Data			Gyroscope Data			Fall (+), Not Fall (-)
X1	Y1	Z1	X2	Y2	Z2	+/-
1	2	3	2	1	3	-
2	1	3	3	1	2	-
1	1	2	3	2	2	-
2	2	3	3	2	1	-
6	5	7	5	6	7	+
5	6	6	6	5	7	+
5	6	7	5	7	6	+
7	6	7	6	5	6	+
7	6	5	5	6	7	???

Distance to each neighbor = (Target X1-Data X1) ^2 +(Target Y1-DataY1) ^2 + (Target Z1-Data Z1) ^2 +(Target X2-DataX2) ^2 + (Target Y2-Data Y2) ^2 + (Target Z2-Data Z2) ^2

= (7-1) ^2+(6-2) ^2+(5-3) ^2+(5-2) ^2+(6-1) ^2+(7-3) ^2
= 36 + 16 + 4 + 9 + 25 + 16
= 106

= (7-2) ^2+(6-1) ^2+(5-3) ^2+(5-3) ^2+(6-1) ^2+(7-2) ^2
= 108

= (7-1) ^2+(6-1) ^2+(5-2) ^2+(5-3) ^2+(6-2) ^2+(7-2) ^2
= 115

= (7-2) ^2+(6-2) ^2+(5-3) ^2+(5-3) ^2+(6-2) ^2+(7-1) ^2
= 101

= (7-6) ^2+(6-5) ^2+(5-7) ^2+(5-5) ^2+(6-6) ^2+(7-7) ^2
= 6

= (7-5) ^2+(6-6) ^2+(5-6) ^2+(5-6) ^2+(6-5) ^2+(7-7) ^2
= 7

= (7-5) ^2+(6-6) ^2+(5-7) ^2+(5-5) ^2+(6-7) ^2+(7-6) ^2
= 10

= (7-7) ^2+(6-6) ^2+(5-7) ^2+(5-6) ^2+(6-5) ^2+(7-6) ^2
= 7

Modified table with complete data in in the next slide.

Accelerometer Data			Gyroscope Data			Fall (+), Not Fall (-)	Distance to each neighbor = (Target X1-Data X1) ^2 +(Target Y1-DataY1) ^2 + (Target Z1-Data Z1) ^2 +(Target X2-DataX2) ^2 + (Target Y2-Data Y2) ^2 + (Target Z2-Data Z2) ^2	K = Number of nearest neighbors = sqrt (number of neighbors) = sqrt (number of data samples) = sqrt (8) = 3
X1	Y1	Z1	X2	Y2	Z2	+/-	= (7-X1) ^2+(6-Y1) ^2+(5-Z1) ^2+(5-X2) ^2+(6-Y2) ^2+(7-Z2) ^2	
1	2	3	2	1	3	-	106	
2	1	3	3	1	2	-	108	
1	1	2	3	2	2	-	115	
2	2	3	3	2	1	-	101	
6	5	7	5	6	7	+	6	+
5	6	6	6	5	7	+	7	+
5	6	7	5	7	6	+	10	
7	6	7	6	5	6	+	7	+
7	6	5	5	6	7	???		+

Implementation (1)-Manually calculate the distance and predict the result using kNN.

- So, we check the distance to each neighbor, and select K=3 minimum values from the distance to each neighbor column.
- Then the corresponding sign in **Fall (+), Not (-)** column is checked, and the majority sign is the predicted result.
- In this case , 6,7 and 7 are selected and the corresponding to '+' sign in the **Fall (+), Not (-)** column so the prediction result will also be **'+'**.
- This indicates a Fall with '+' sign.
- Now let check Using Python to implement the application of using kNN to predict falling then compare them.

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Implementation (2)- Using Python to implement the application of using kNN to predict falling.

1. **Using Python code to find the Euclidean distance**

```
# Example of making predictions
from math import sqrt
# calculate the Euclidean distance between two vectors
# Euclidean Distance = sqrt(sum i to N (x1_i – x2_i)^2)

def euclidean_distance(row1, row2):
  distance = 0.0
  for i in range(len(row1)-1):
    distance += (row1[i] - row2[i])**2

  return sqrt(distance)
```

Implementation (2)- Using Python to implement the application of using kNN to predict falling.

2. Using Python code to find the nearest neighbors

```
# Locate the most similar neighbors
# Result
# [6, 5, 7, 5, 6, 7, 1]
# [7, 6, 7, 6, 5, 6, 1]
# [5, 6, 6, 6, 5, 7, 1]
def get_neighbors(train, test_row, num_neighbors):
  distances = list()
  for train_row in train:
    dist = euclidean_distance(test_row, train_row)
    distances.append((train_row, dist))
  distances.sort(key=lambda tup: tup[1])
  neighbors = list()
  for i in range(num_neighbors):
    neighbors.append(distances[i][0])
  return neighbors
```

Implementation (2)- Using Python to implement the application of using kNN to predict falling.

3. **Using Python code to make the prediction.**

```
# Make a classification prediction with neighbors
# - test_row is [7,6,5,5,6,7]
# - num_neighbors is 3
def predict_classification(train, test_row, num_neighbors):
  neighbors = get_neighbors(train, test_row, num_neighbors)
  output_values = [row[-1] for row in neighbors]
  prediction = max(set(output_values), key=output_values.count)
  return prediction
```

Implementation (2)- Using Python to implement the application of using kNN to predict falling.

4. **Using Python code to find the result by adding the real and target data in the code**

```
# Test distance function
# 0 means Not Fall (-), 1 means Fall (+)
dataset = [[1,2,3,2,1,3,0],
  [2,1,3,3,1,2,0],
  [1,1,2,3,2,2,0],
  [2,2,3,3,2,1,0],
  [6,5,7,5,6,7,1],
  [5,6,6,6,5,7,1],
  [5,6,7,6,5,6,1],
  [7,6,7,6,5,6,1]]
```

```
prediction = predict_classification(dataset, [7,6,5,5,6,7], 3)
# - Display
# Expected 1, Got 1.
print('Expected %d, Got %d.' % ([7,6,5,5,6,7,1][-1], prediction))
```

```
Expected 1, Got 1.
```

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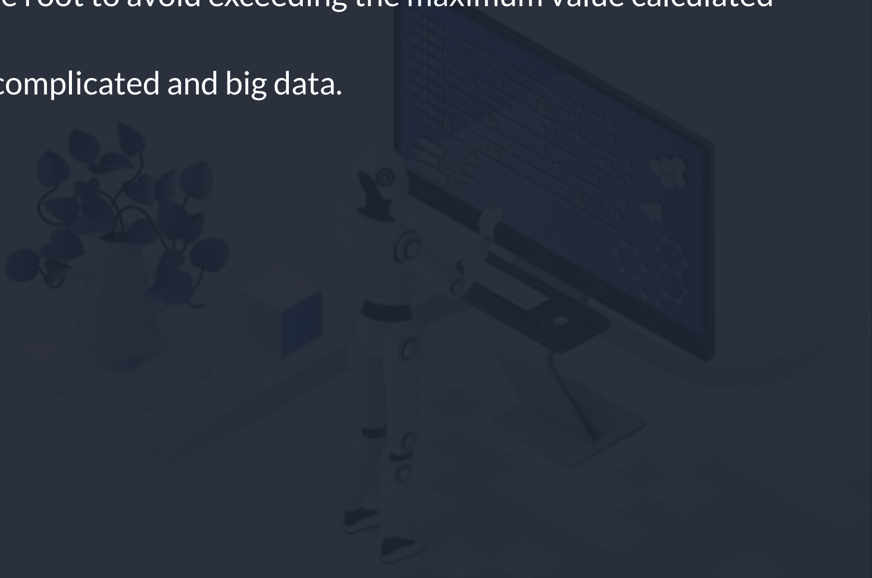
Test Result

- **Manually**
  - Distance to each neighbor
  - Number of nearest neighbors
  - Compare the majority sign (-/+)
  - **It is a Fall**
- **Python**
  - Find the Distance
  - Get the nearest neighbors
  - Make a Prediction
  - Add the real data and target data in the code.
  - **It is a Fall**

Conclusion

- ➔ In the manual method of kNN algorithm , we do not need to square root the distance.
- ➔ In case of Python coding, we need to use square root to avoid exceeding the maximum value calculated by the computer.
- ➔ Python method could be easier and faster for complicated and big data.



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