Amelio-rater

Detection and Classification of Driving Abnormal Behavior for Automated Ratings and Real-time Monitoring

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Introduction 1/2

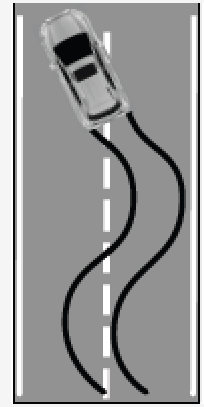
- Road traffic injuries are a leading cause of preventable deaths.[1]

- In Egypt:
  - More than 12,000 fatalities each year from road traffic crashes.[2]

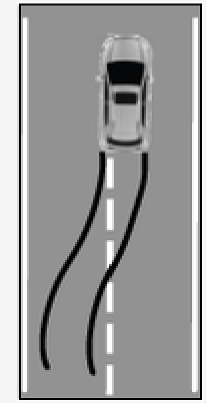
[1] Global Status Report on Road Safety by who 2015
[2] ROAD SAFETY IN TEN COUNTRIES by who 2013

Introduction 2/2

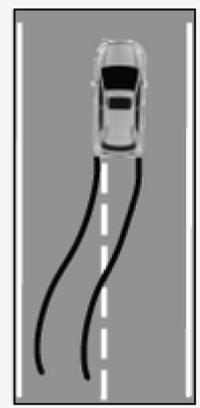
Biased user ratings



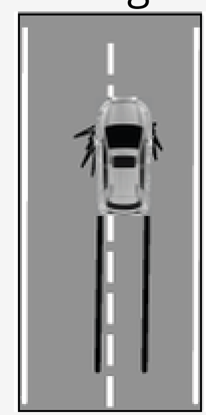
Weaving



Sudden lane change



Single weave



Speeding

Abnormal driving behaviors

Driving Abnormal Behaviours Illustration

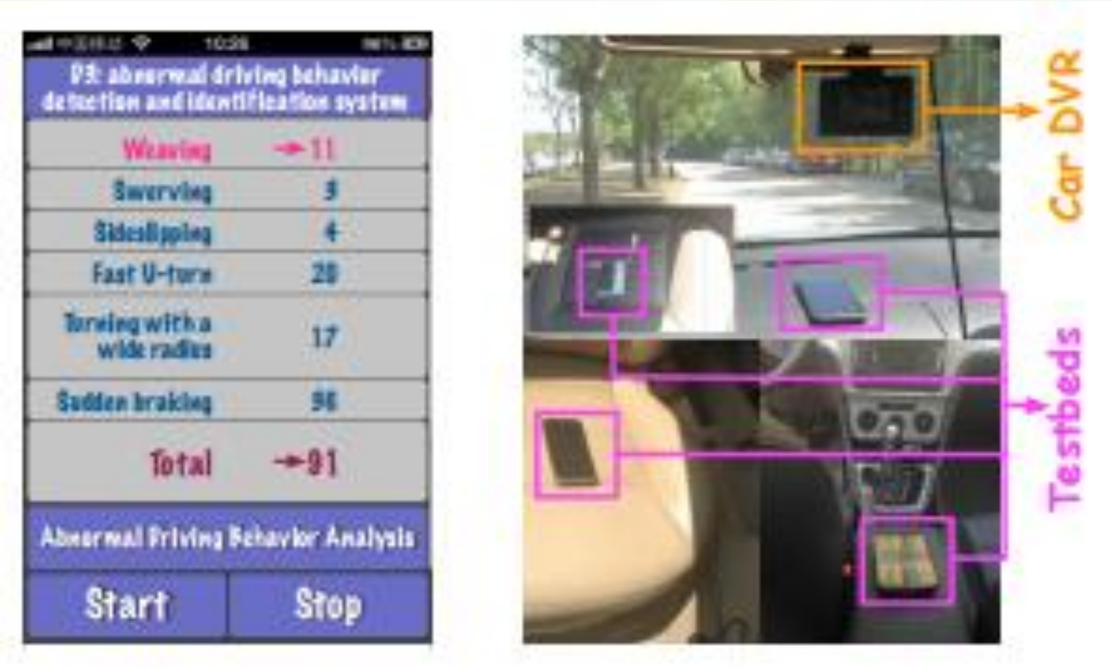
Related Work 1: MyDrive

- Proposed and used the algorithm SAQ
- Worked on Acceleration and Deceleration

Tanushree Banerjee, Arijit Chowdhury, and Tapas Chakravarty. \My-Drive: Drive Behavior Analytics Method And Platform". In: Proceedings of the 3rd International on Workshop on Physical Analytics. ACM. 2016,pp. 7-12.

Related Work 2: D3

- Detection using smartphones sensors to analyze patterns of driving abnormal behavior.
- D3 used SVM algorithm.

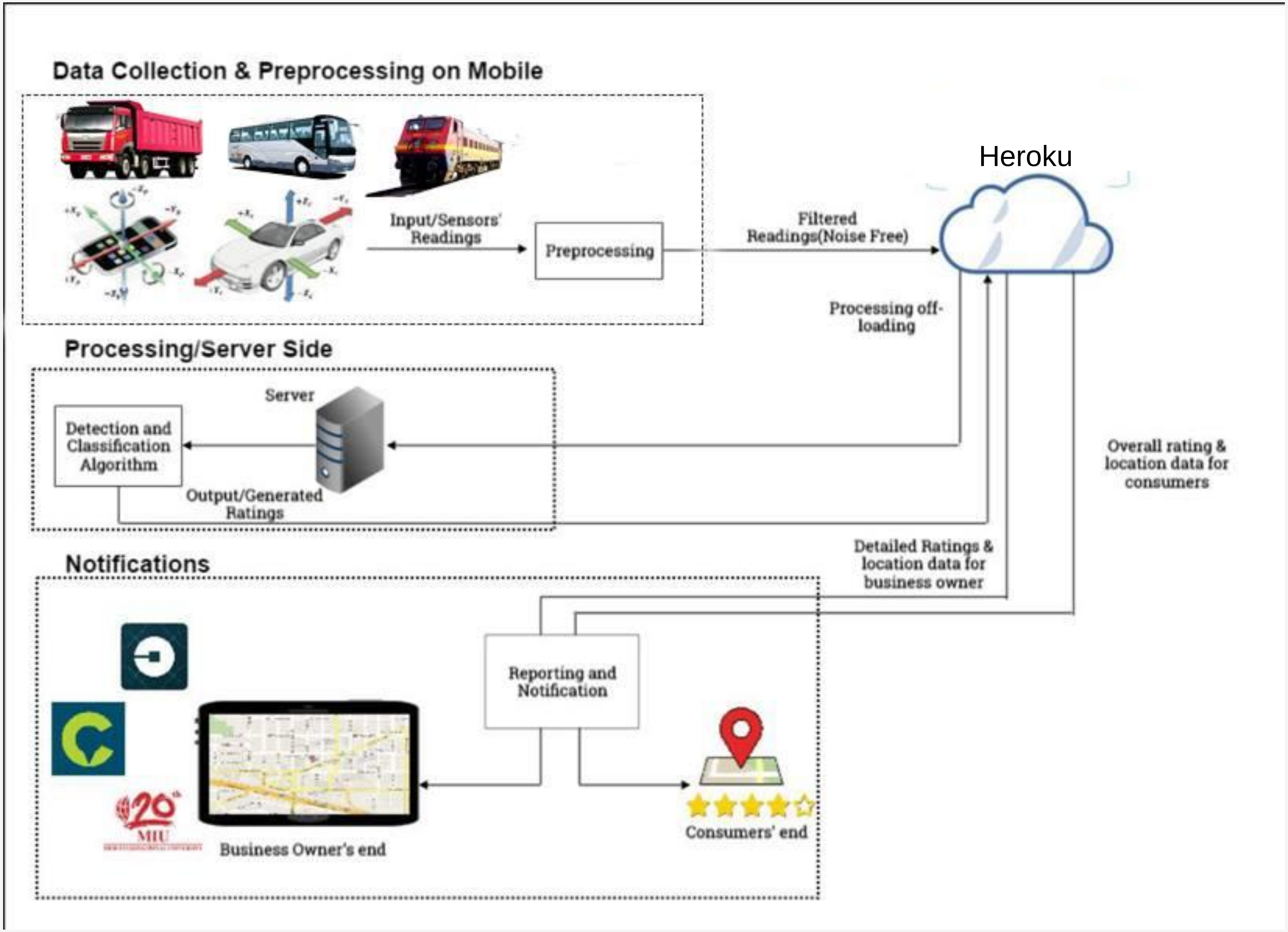


Zhongyang Chen et al. “D 3: Abnormal driving behaviors detection and identification using smartphone sensors”. In: Sensing, Communication, and Networking (SECON), 2015 12th Annual IEEE International Conference on. IEEE. 2015, pp. 524–532.

Problem Definition

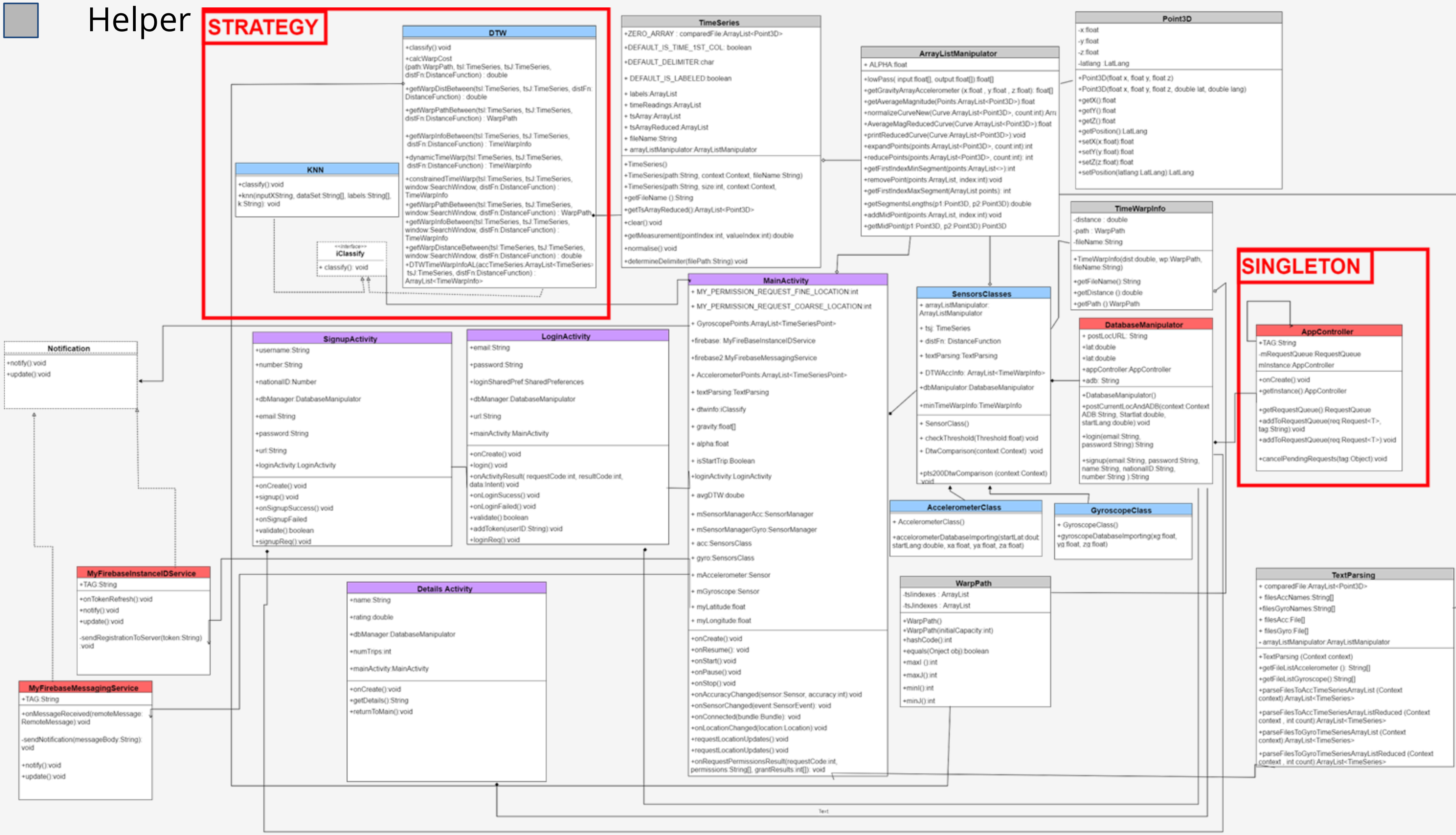
Detection and IMPROVEMENT OF CLASSIFICATION ACCURACY of Driving Abnormal Behaviors and Road Conditions to AUTOMATICALLY Generate RATINGS in REAL-TIME

System Overview



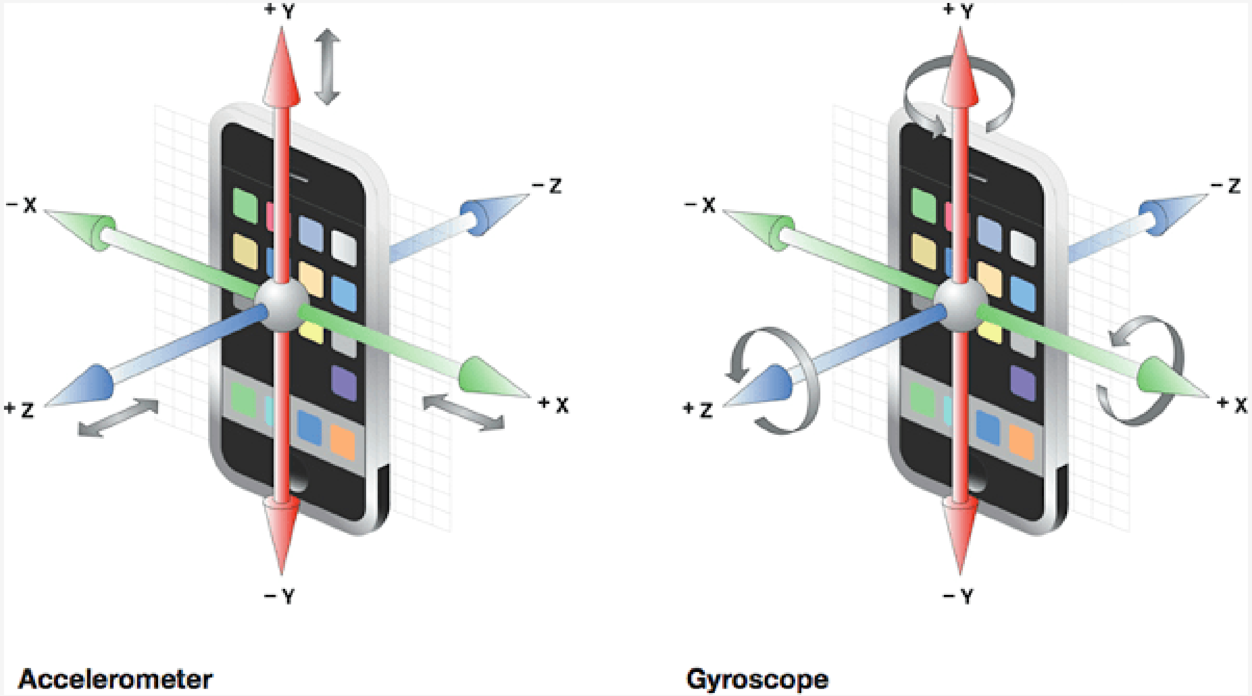
Class Diagram

- Model
- View
- Control
- Helper



System Details-Hardware

- Smartphone
- Smartphone that has GPS sensor.
- Smartphone that has Accelerometer and Gyroscope Sensors



System Details-Mobile Positioning

Overview:

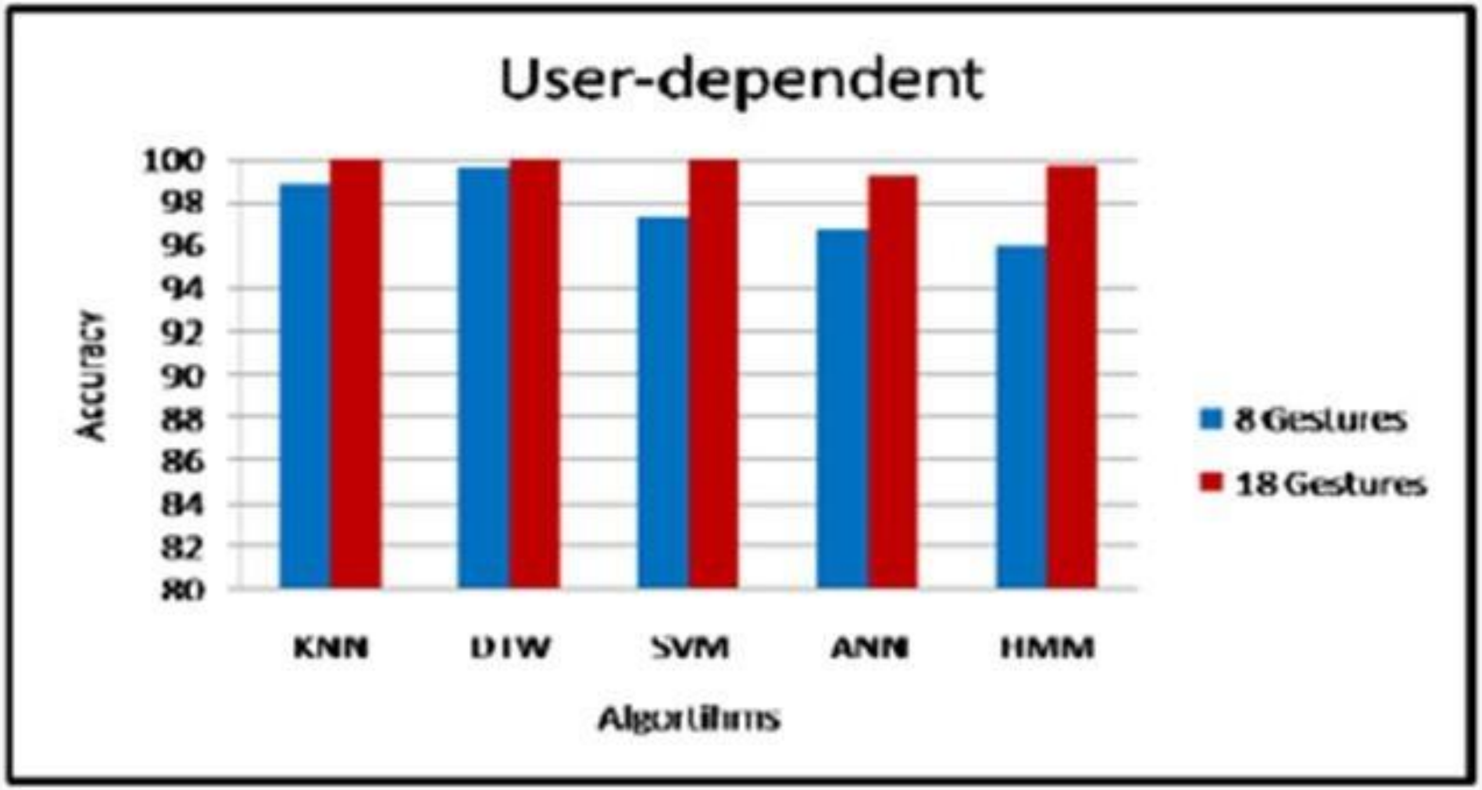
The mobile device is placed in the car in order for the built in sensors to detect the car movements sequence.

Challenges:

- Unifying the x,y,z co-ordinates of the car and mobile device.
- Ensuring the mobile device is in a horizontal plane in a fixed position.

System Details - Algorithm 1/2

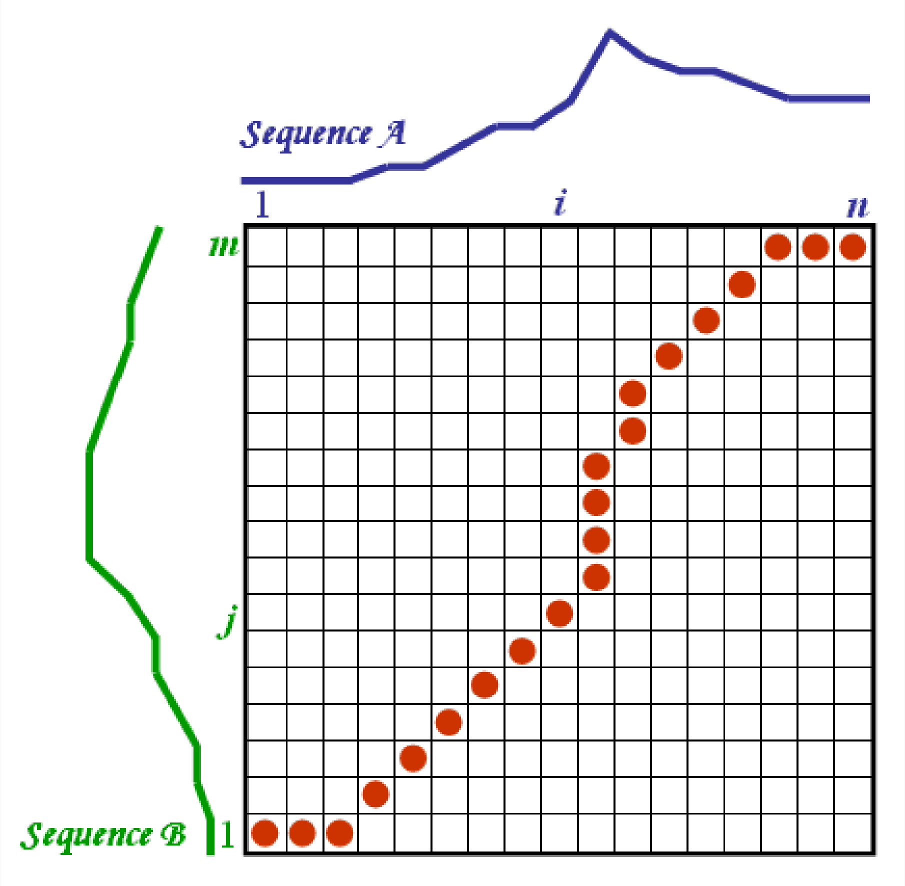
- A comparative study showing that the DTW algorithm showed best accuracies.



Aya Hamdy Ali, Ayman Atia, and Mostafa Sami. “A comparative study of user dependent and independent accelerometer-based gesture recognition algorithms”. In: International Conference on Distributed, Ambient, and Pervasive Interactions. Springer. 2014, pp. 119–129

System Details - Algorithm 2/2

- Dynamic Time Warping
- Measure the distance between the two time series (testing and training) Euclidean distance calculation.



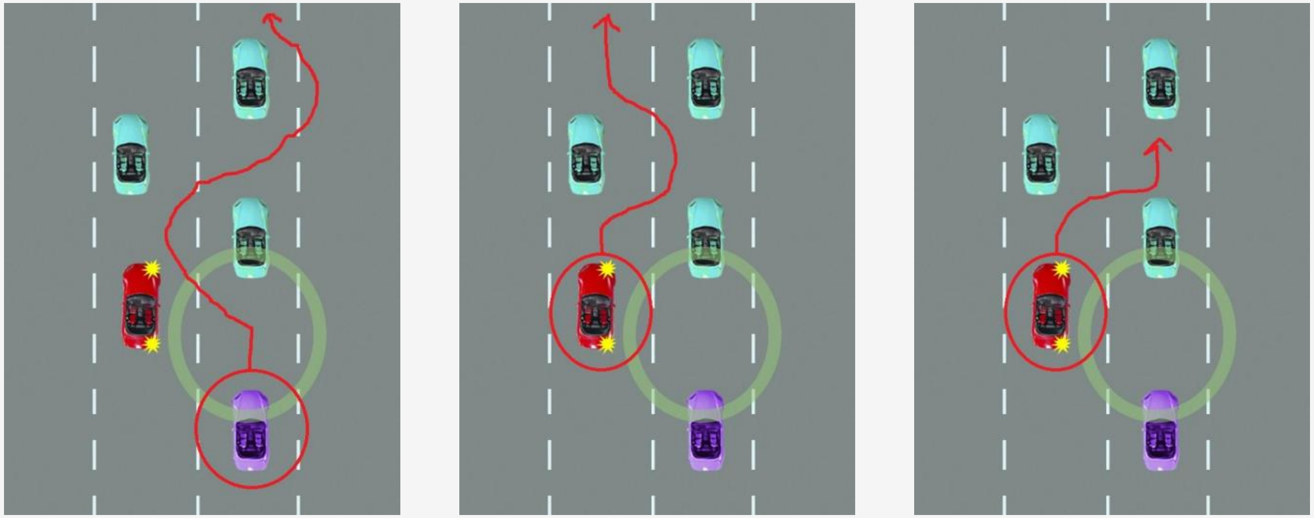
System Details - Rating

- Get the ratio of ADB in all trips.
- There are 2 types of rating.
  1. Rate out of 5
  2. Categorization (Cautious, novice, intermediate, reckless)

Evaluation 1
Pre-experiment for Sensor Selection

Goal:

Measure Accuracy for using each sensor - accelerometer and gyroscope.

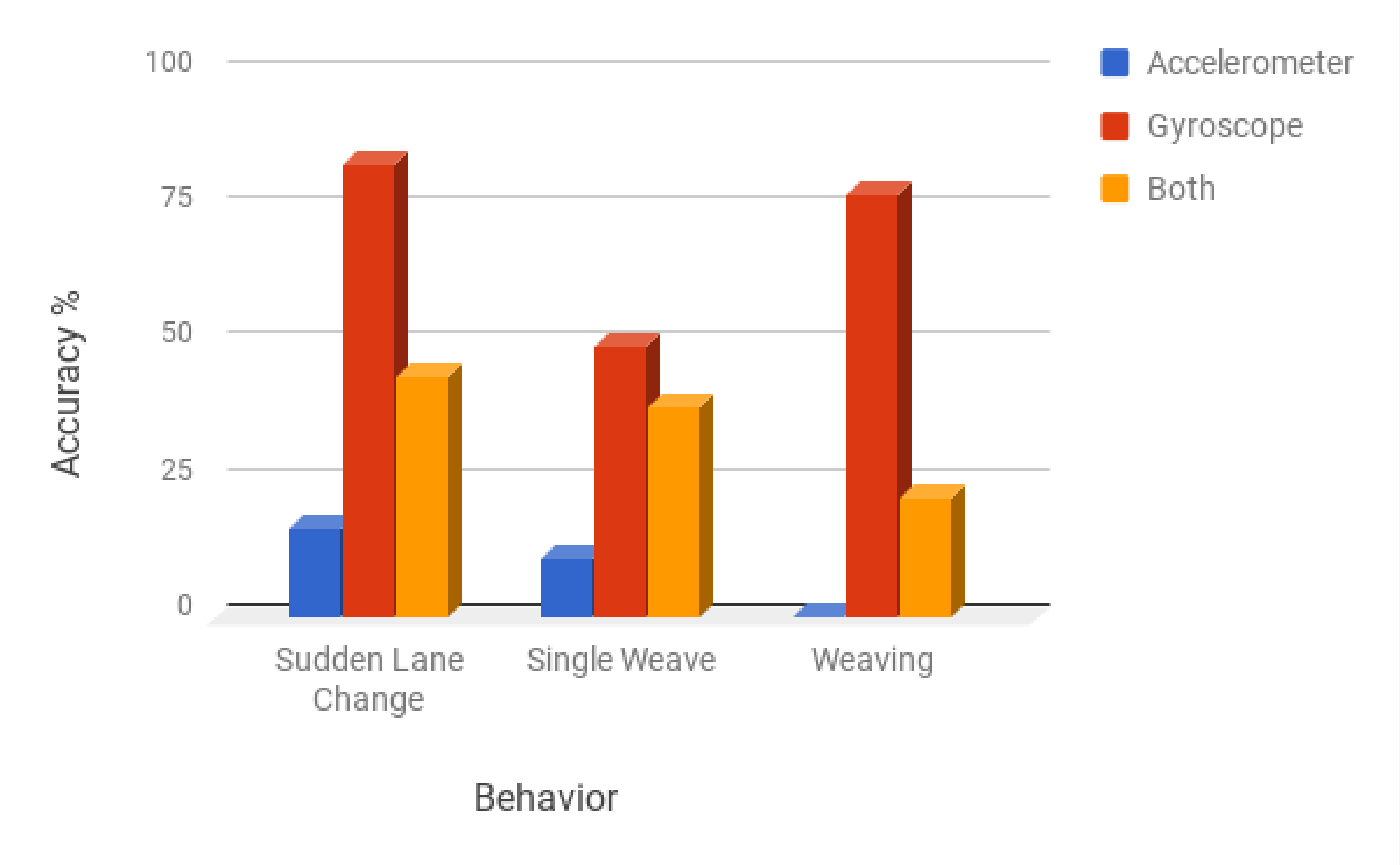


Setup:

- Mobile attached to object with 4 wheels; a simulated car for example.

Evaluation 1
Pre-experiment for Sensor Selection

Results:



Evaluation 2
Single Behaviours File Testing

Goal:

1. Window size selection in DTW.
2. Selection between SVM and DTW classifiers.

Setup:

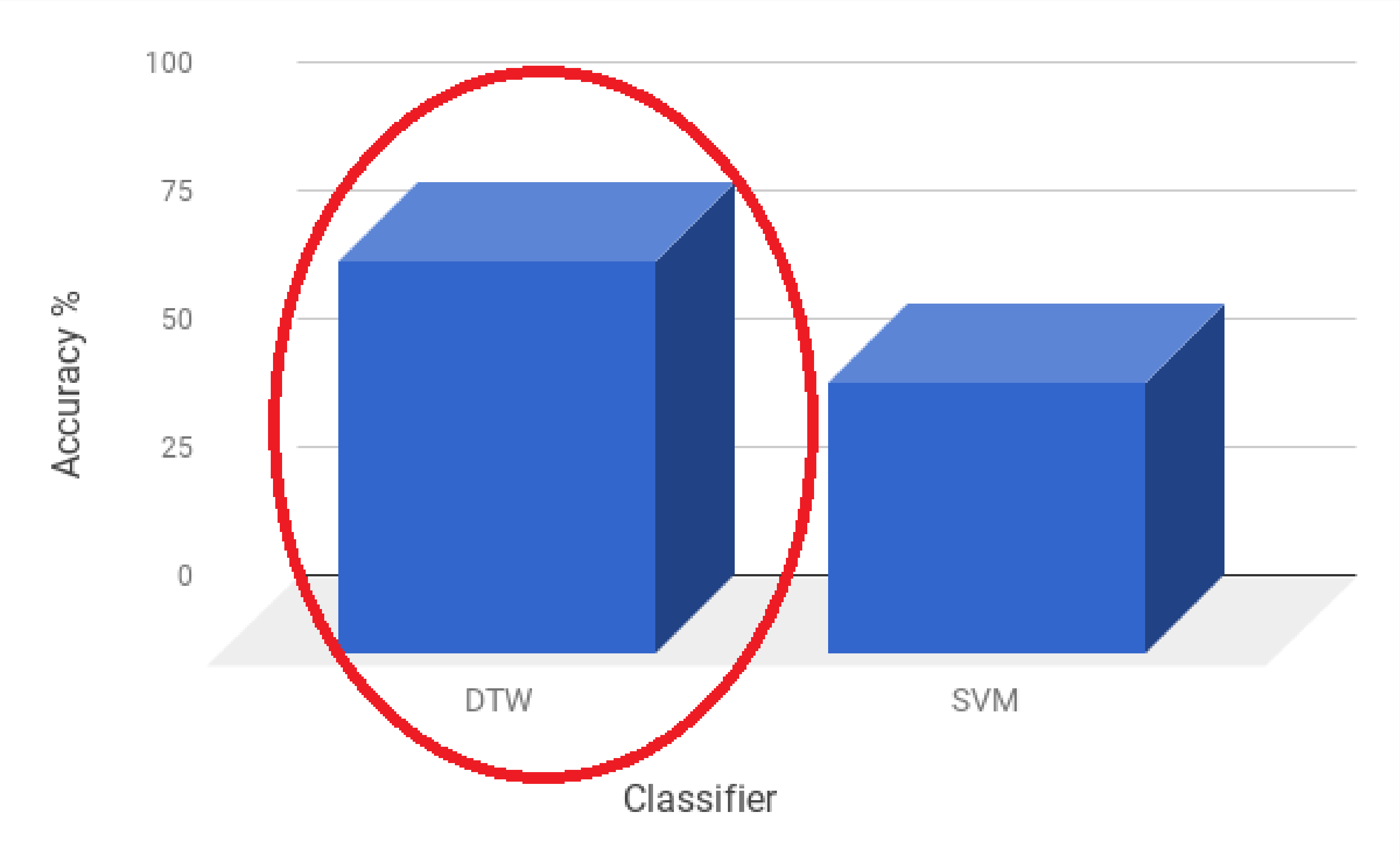
- Mobile device placed in horizontal flat plane inside car.
- Single behaviour is tested at a time.
- Manual car used.

Evaluation 2
Single Behaviours File Testing

Results 1/2 - Window size(Weaving):

Evaluation 2
Single Behaviours File Testing

Results 2/2 - DTW vs SVM:



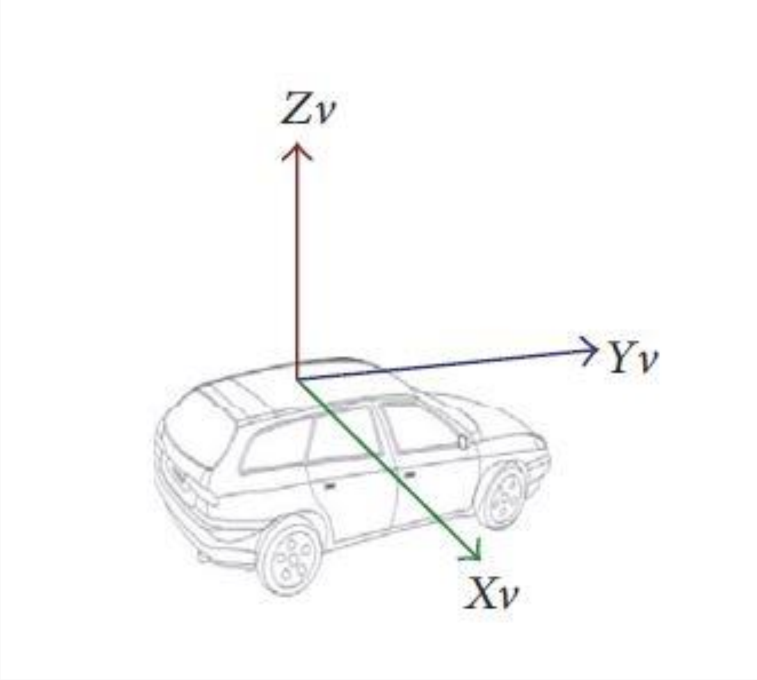
Evaluation 3
User Study, Feedback and Rating

Goal:

1. Check DTW's accuracy of classifying behaviours in a trip.
2. Get user feedback.

Setup:

- Mobile device placed in horizontal flat plane inside car.
- Multiple Behaviours tested in a stream of readings.
- Manual and automatic cars used.



Evaluation 3
User Study, Feedback and Rating

Results 1/2 - User Feedback:

ADB classified as Normal	
Participant	No. of Confusions
1	2
2	0
3	1

ADB detection with high speed	
Participant	Status
1	Detected
2	Detected
3	Not Detected

- 9 out of 10 abnormal behaviours are *correctly* classified.

Evaluation 3
User Study, Feedback and Rating

Results 2/2 - Rating:

	Total Driver Rate	Current User Rate	Amelio-rater Rater
Participant 1	4.5	3	3.2
Participant 2	5	3.6	3.7
Participant 3	4.6	4	3.8

- Manual Rate:
  - Current User Rate
  - Total Driver Rate
- Automatic Rate:
  - Amelio-rater Rate

Demo

Questions?

Real-time Monitoring

Rate Generation

Similar Systems

Biased Ratings

DTW psuedocode

DTW details

Class Diagram

Dataset

SVM Results

Distance Equations

Future Work

Competitions

Appendix

Real-time Monitoring

Socket.io: real-time bidirectional event-based communication.

1. Retrieve data from the ADB collection based on the update date.
2. View the retrieved data on web Google maps showing different colors for different ADBs

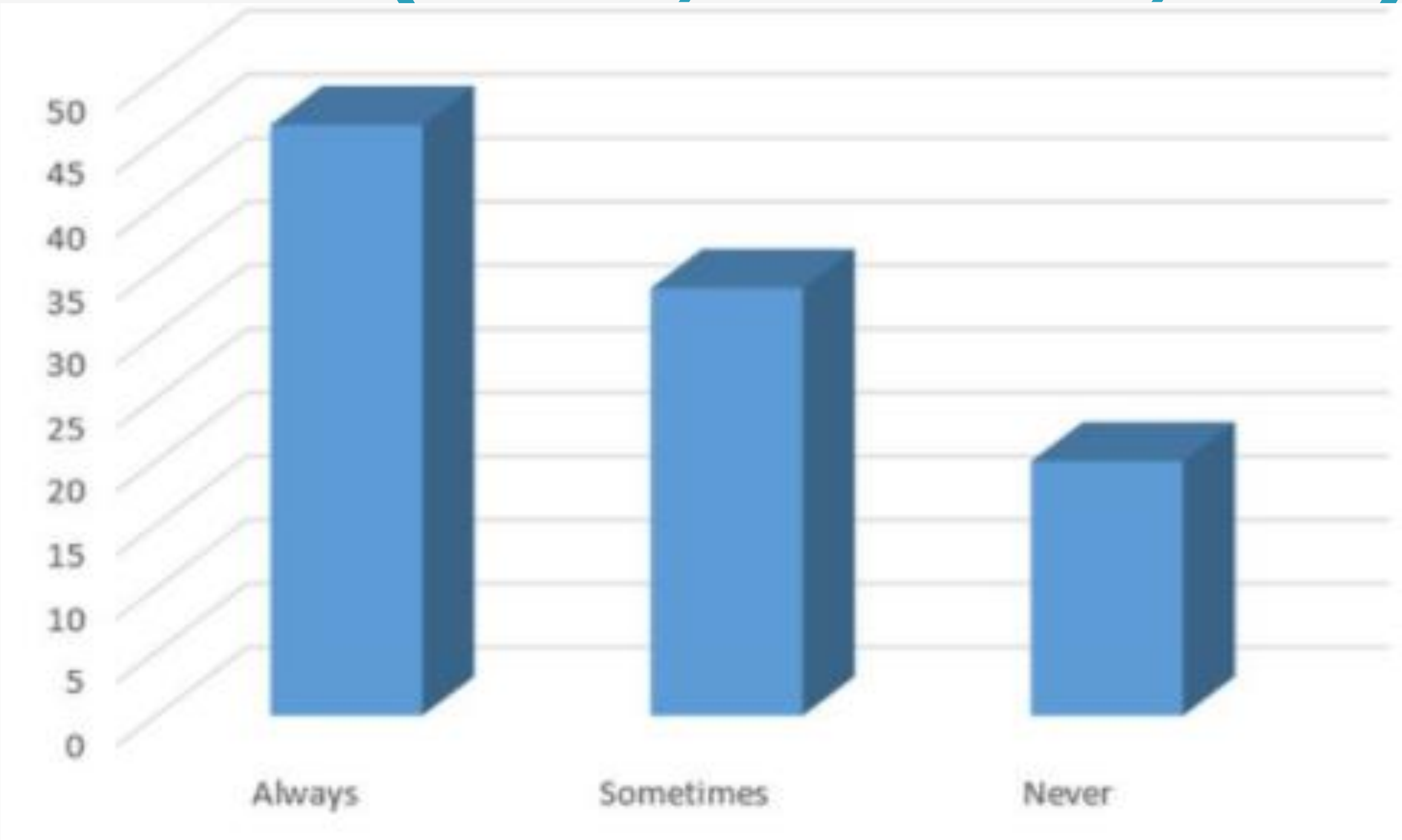
Automated Rate Generation

1. Counter for each behavior.
2. Counters are used in calculating the ratio of ADB in all trips performed by a specific driver.
3. The calculated ratio is then used to categorise the driver and to get his/her rate out of 5.

Comparison with Similar Systems

Points of Comparison	Algorithm Used	Accuracy Acheived(%)	Gesture Types	Smartphone Orientation	Real Time	Training Samples
D3	SVM	95.36	6 driving patterns	Horizontal	Offline	Up to 4019
MyDrive	SAQ(Skill Aggression Quantifier)	Not Mentioned	Velocity only	Not Mentioned	Offline	-
A Comparative Study for Accelerometer Based Gesture Recognition Algorithm	KNN, DTW	99.7,99.8	Human Gestures	Horizontal	Offline	At least 1
Amelio-rater	DTW	76.31	Driving Behaviours with 4 driving patterns	Horizontal	Online	At least 1

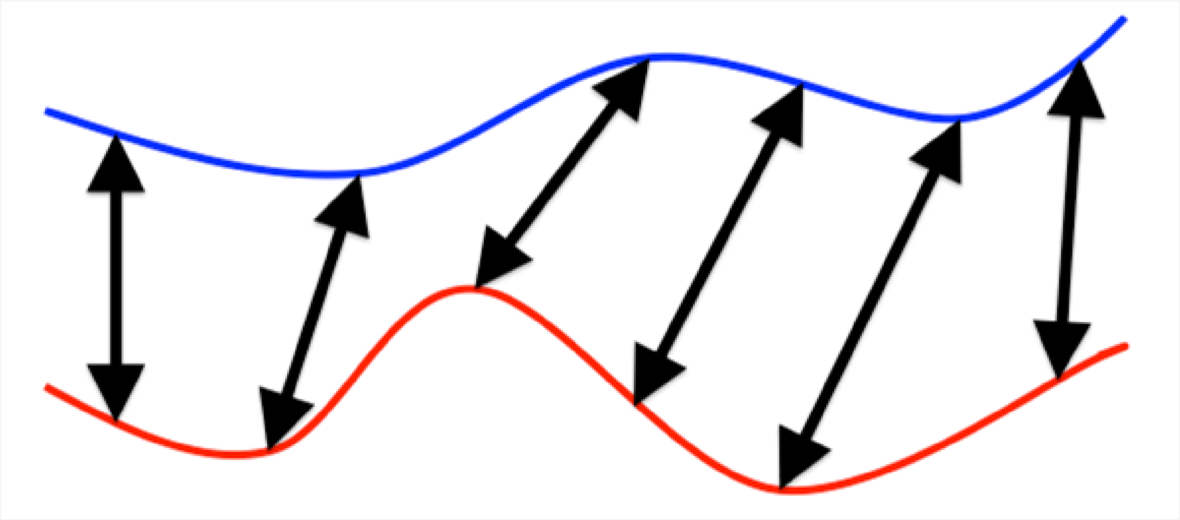
Survey Question
Do you rate the drivers after a ride?(uber, careem,etc.)



System Details-DTW pseudocode

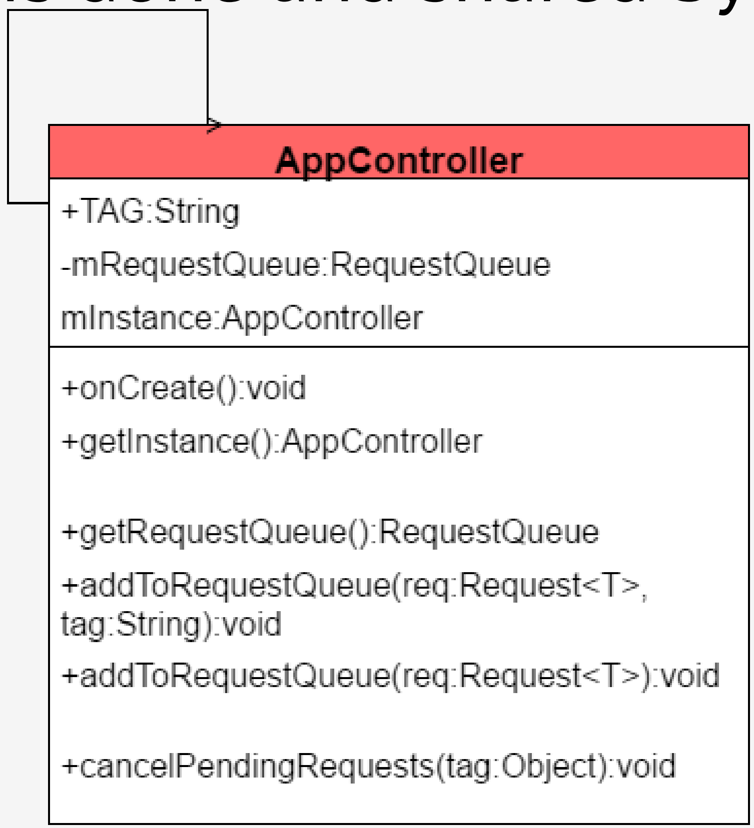
```
DTW(v1, v2)  {
//where the vectors v1=(a1,...,an), v2=(b1,...,bm) are the time series with n and m
time points
    Let a two dimensional data matrix S be the store of similarity measures
such that S[0,...,n, 0,...,m], and i, j, are loop index, cost is an integer.
    // initialize the data matrix
    S[0, 0] := 0
    FOR i := 1 to m DO LOOP
        S[0, i] := ∞
    END
    FOR i := 1 to n DO LOOP
            S[i, 0] := ∞
    END
    // Using pairwise method, incrementally fill in the similarity matrix
    with the differences of the two time series
    FOR i := 1 to n DO LOOP
        FOR j := 1 to m DO LOOP
        // function to measure the distance between the two points
            cost := d(v1[i], v2[j])
            S[i, j] := cost + MIN(S[i-1, j],            // increment
                                  S[i, j-1],     // decrement
                                  S[i-1, j-1])  // match
        END
    END
    Return S[n, m]
}
```

System Details-DTW Details



Singleton Design Pattern

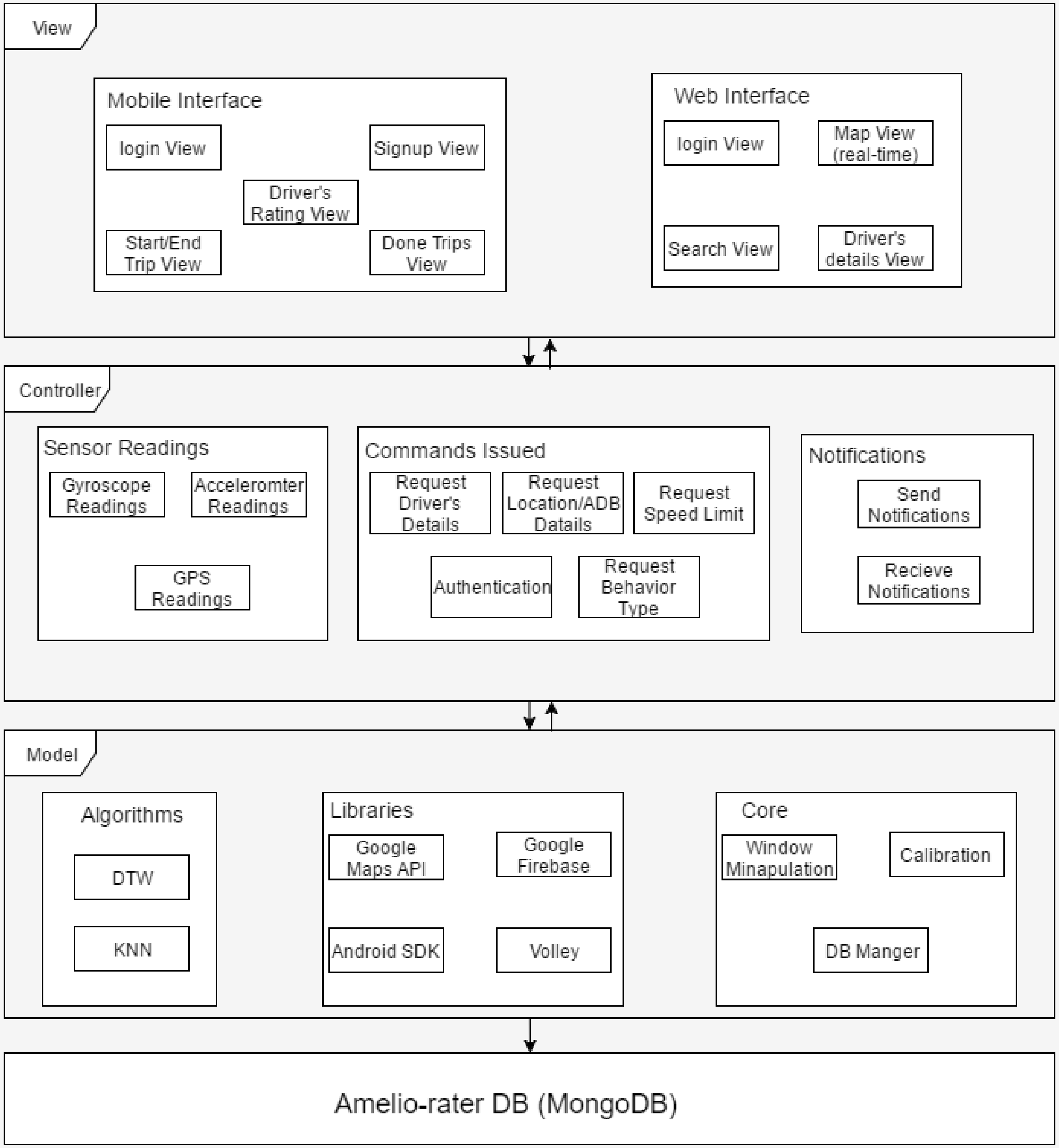
- A design pattern restricting the instantiation of a class to *one* object.
- Database connections are costly, thus a single connection is done and shared by multiple objects.



Strategy Design Pattern

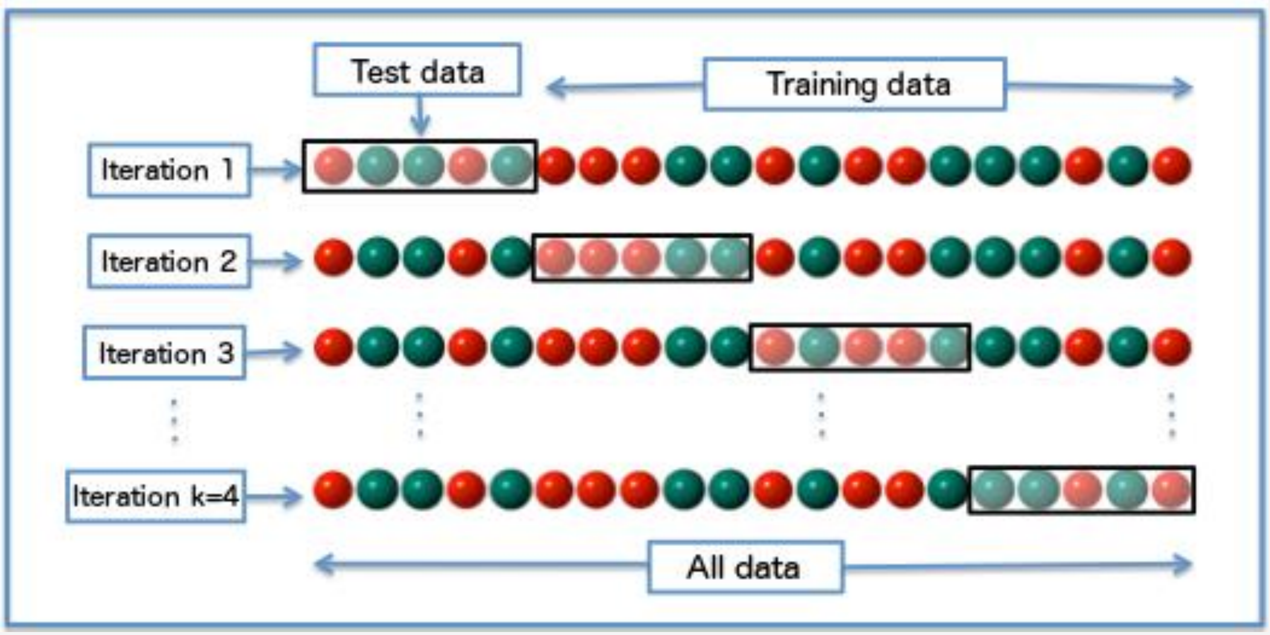
- A design pattern where a class behaviour or its *algorithm* can be changed at run time.
- Good to use when implementing multiple algorithms.

Architecture Diagram



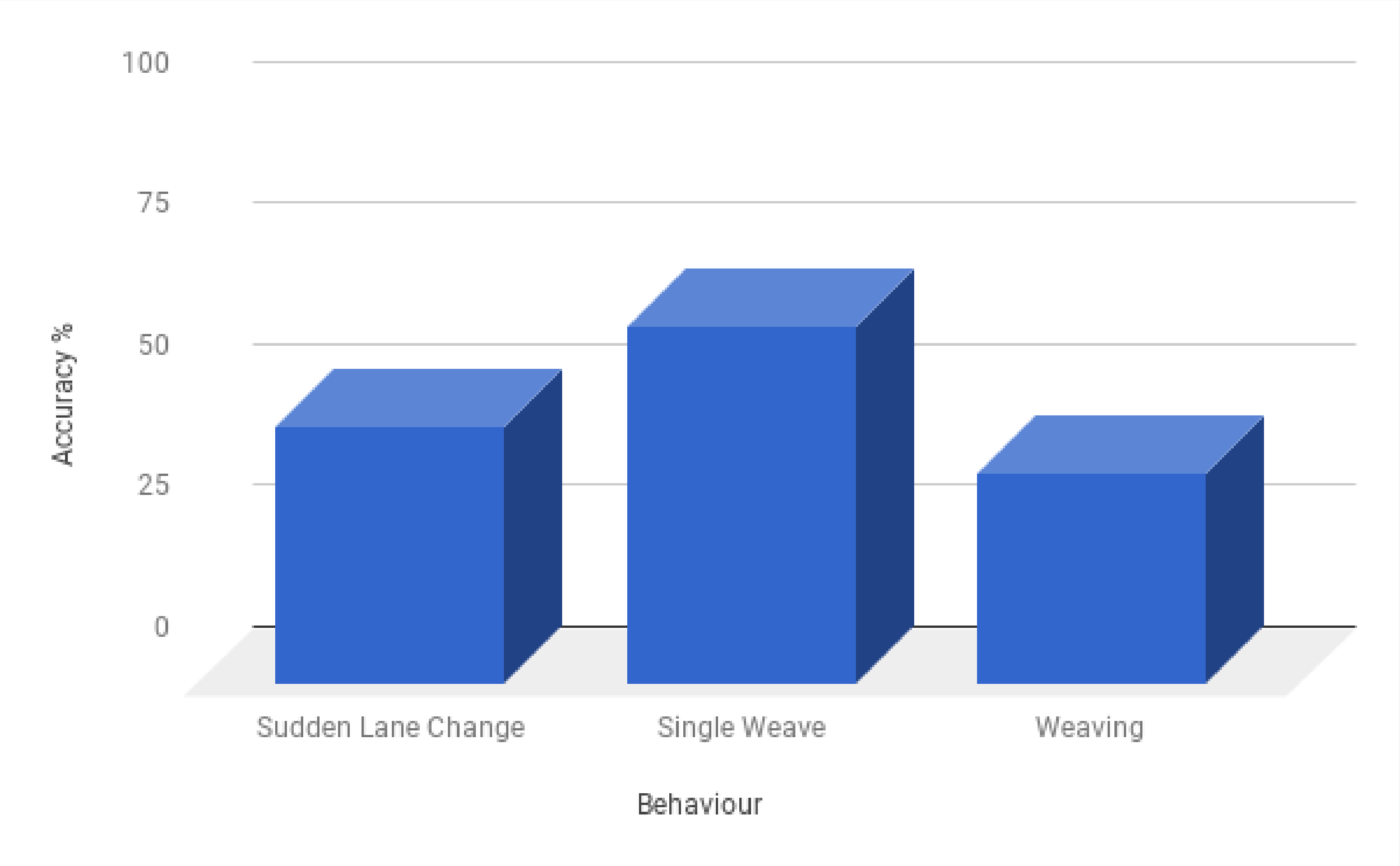
Dataset

- Dataset was collected by us.
- 11 samples for each behaviour.
- 3 training samples selected via ***cross validation***.

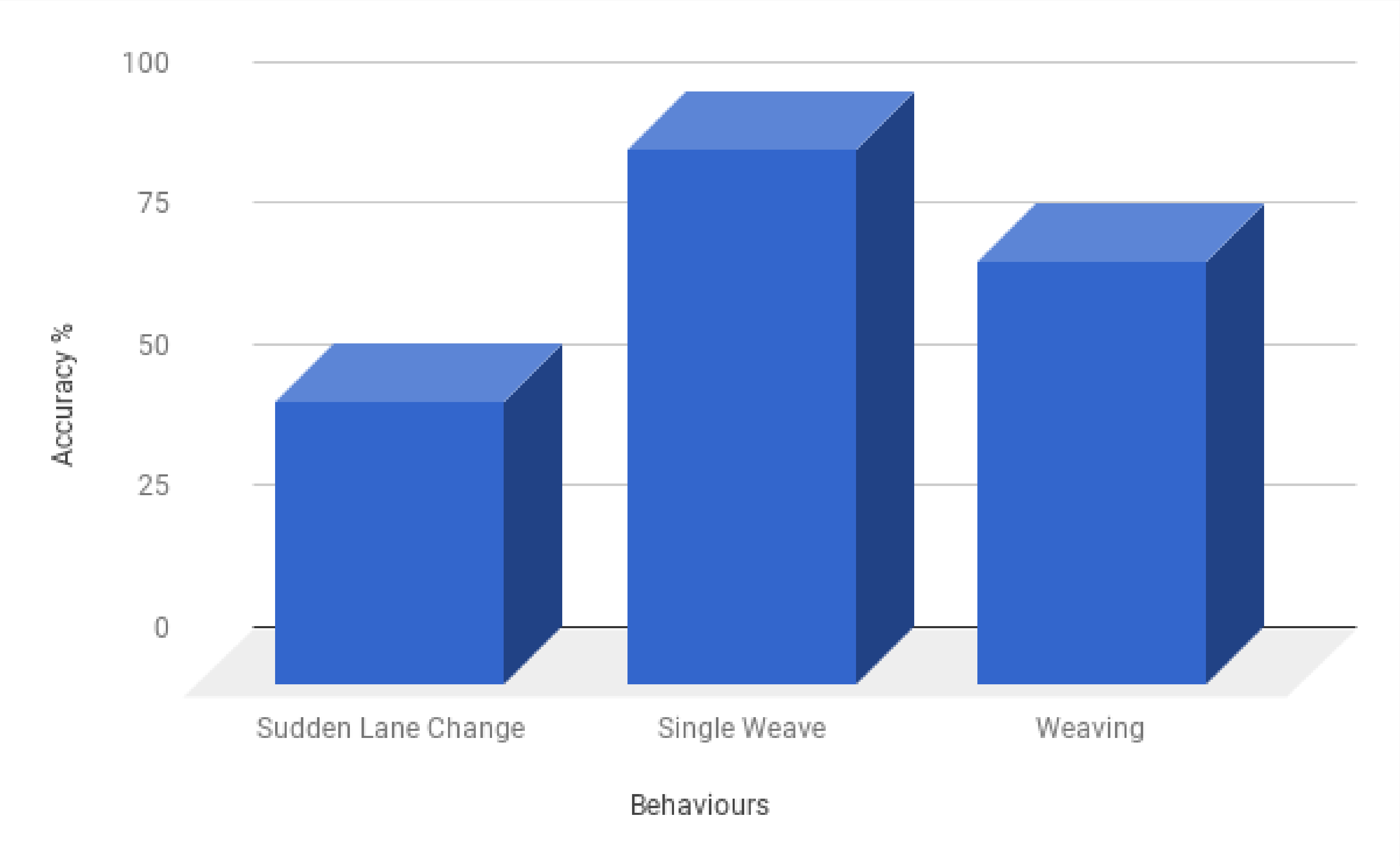


SVM Overall Results

- Used Linear Kernel.

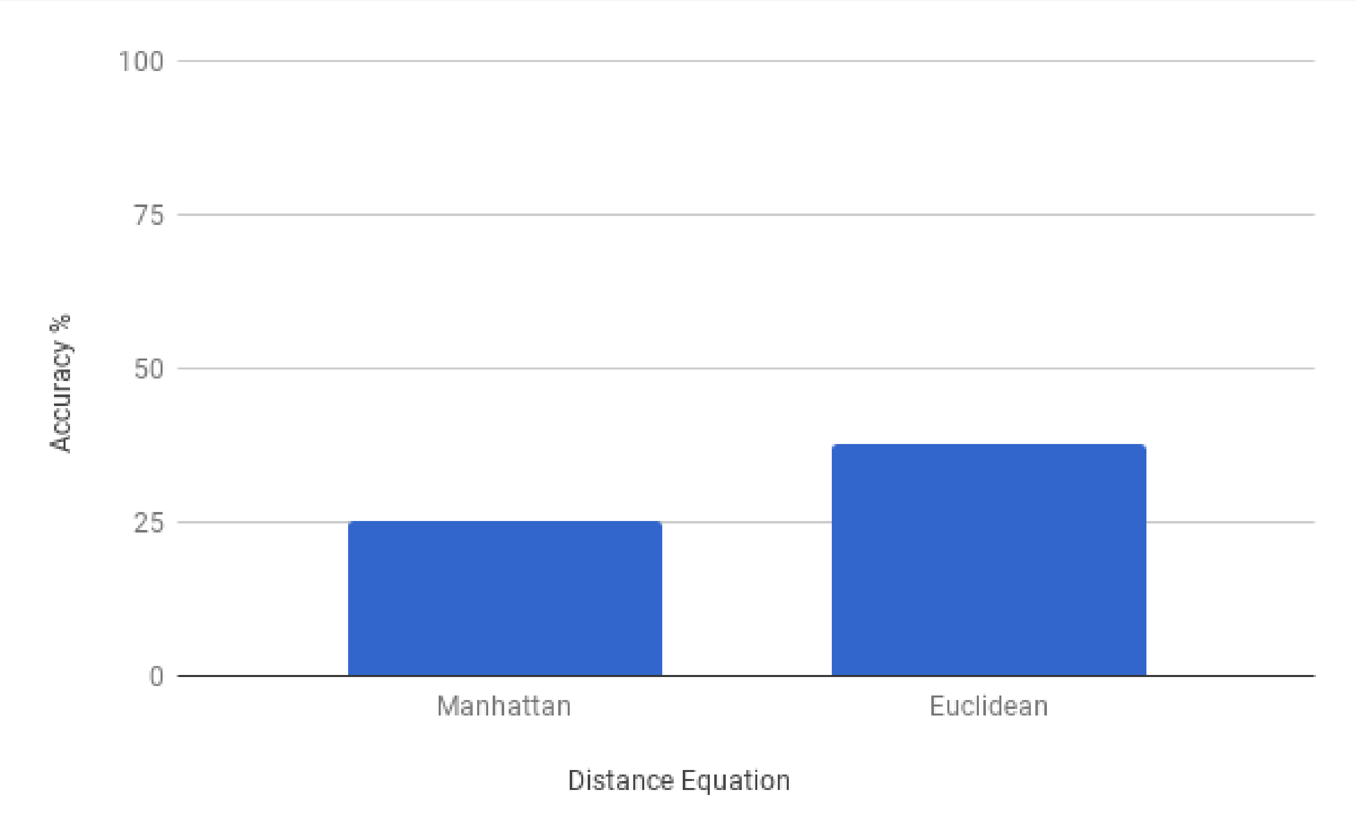


DTW Overall Results



Euclidean Vs. Manhattan

- Difference in accuracy of classifying weaving behaviour only in window size 150.



Future Work

- Interpolate for GPS readings.
- Introduce more behaviours.
- Use GPS and gyroscope readings to create road analysis.

Competitions Trials

We have applied to some competitions but haven’t participated in any.