DRIVING BEHAVIOR ANALYSIS BY USING SMARTPHONE'S SENSORS AND ITS APPLICATIONS

HA-NAM NGUYEN

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OUR OBJECTIVES

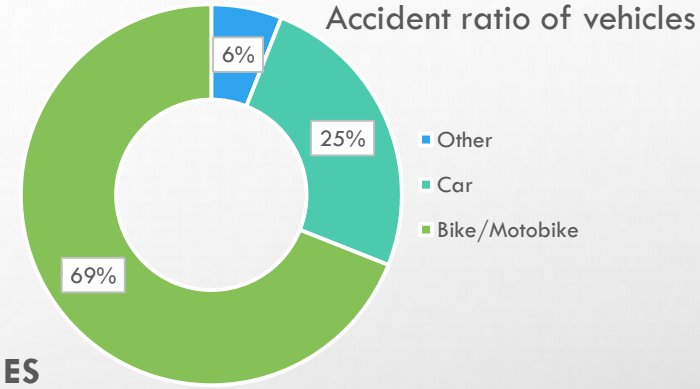
1. DEVELOP A DRIVING ASSISTANT APPLICATION FOR THE POPULAR PRIVATE VEHICLES IN VIETNAM LIKE MOTORBIKES OR BICYCLES BASED ON SMARTPHONE SENSORS.

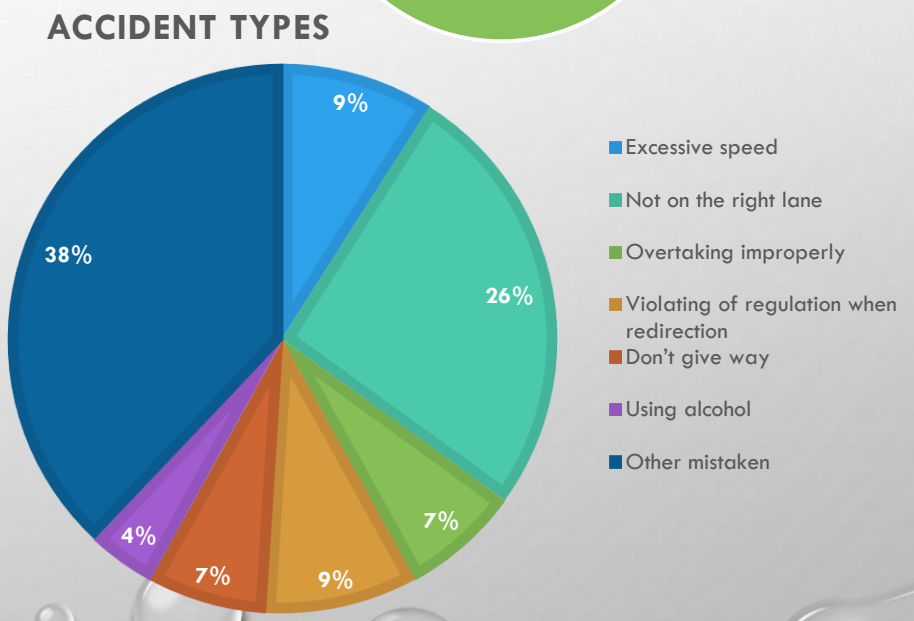
2. CONGESTION REDUCTION

CURRENT STATUS OF TRAFFIC IN VIETNAM

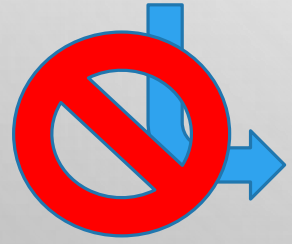
CURRENT STATUS OF TRAFFIC IN VIETNAM

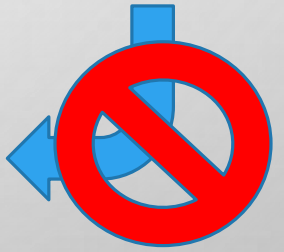
	Bus	Car	Motobike/ bike
Hanoi	9%	5%	84%
Hochimin	11%	6%	85%



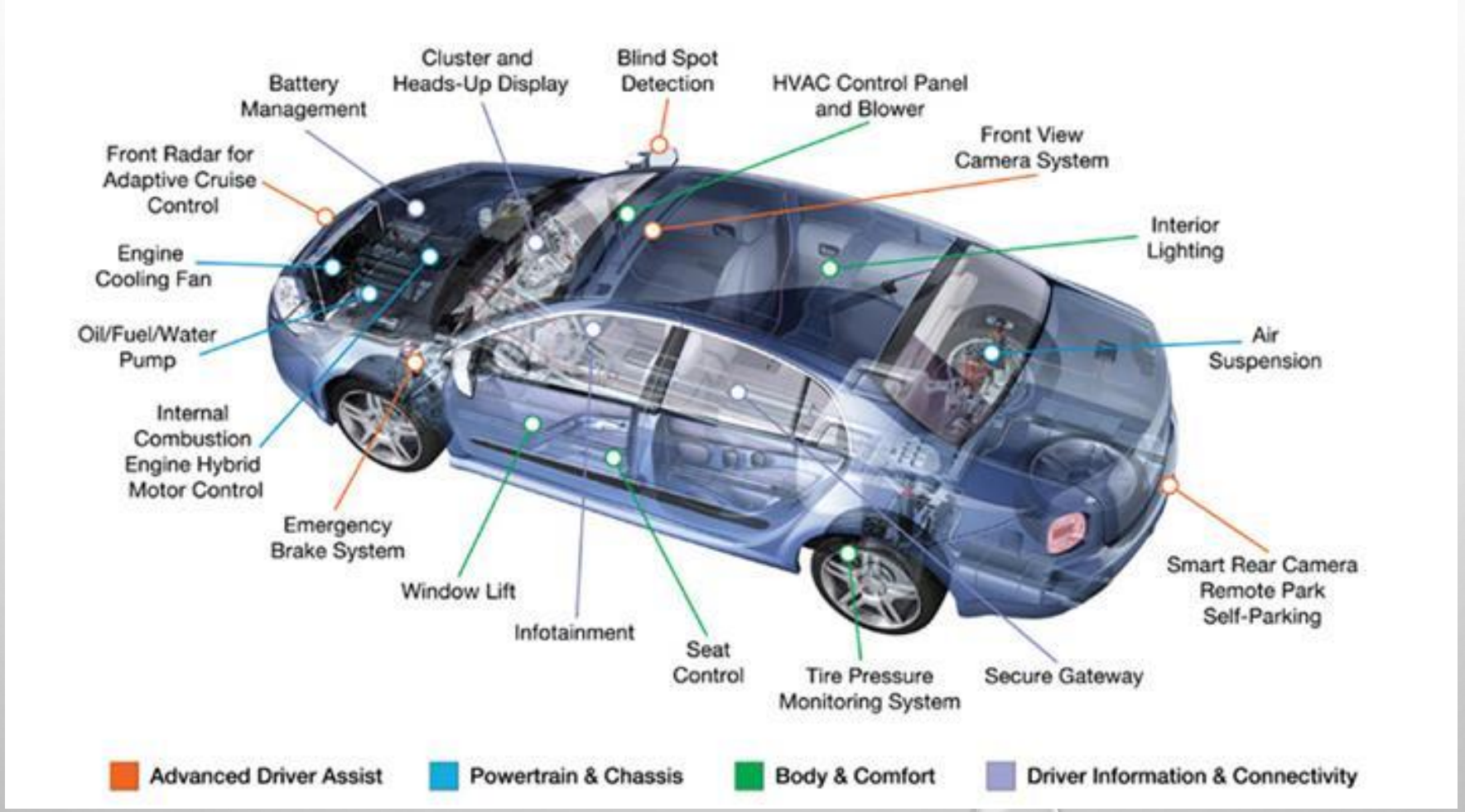


LIMITED OF CONVENTION APPROACHES



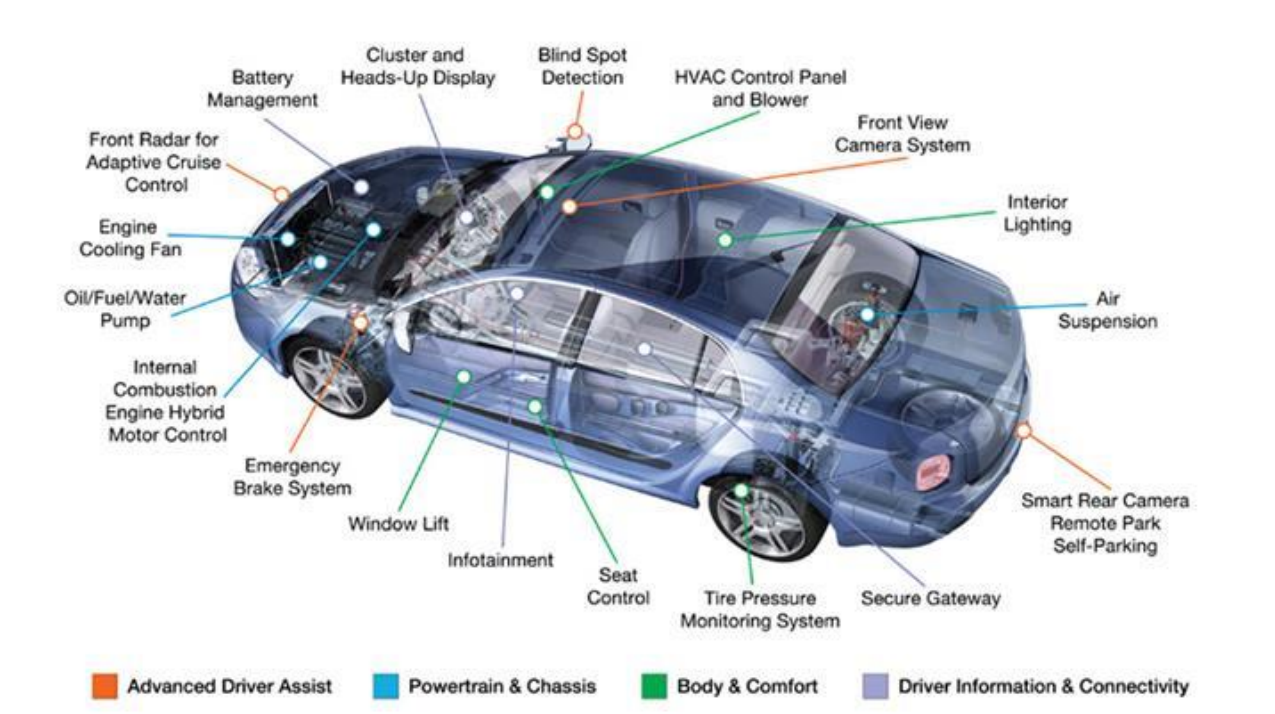


EXISTING TRANSPORT SUPPORTING DEVICES



Source: https://www.embitel.com

EXISTING TRANSPORT SUPPORTING DEVICES



- MUST BE CHEAP
- EASY TO USE AND TO REPLACE

A REASONABLE SOLUTION ?

- SMARTPHONES:
  - LOWER PRICE
  - LIGHTWEIGHT AND EASY TO USE
  - SET OF SENSORS: ACCELEROMETER, GYROSCOPE, GPS, MAGNETOMETER, CAMERA…
- COMPUTATION: POWERFUL
- COMMUNICATION: GPS, WIFI

93M

Population

50M+

Internet Users

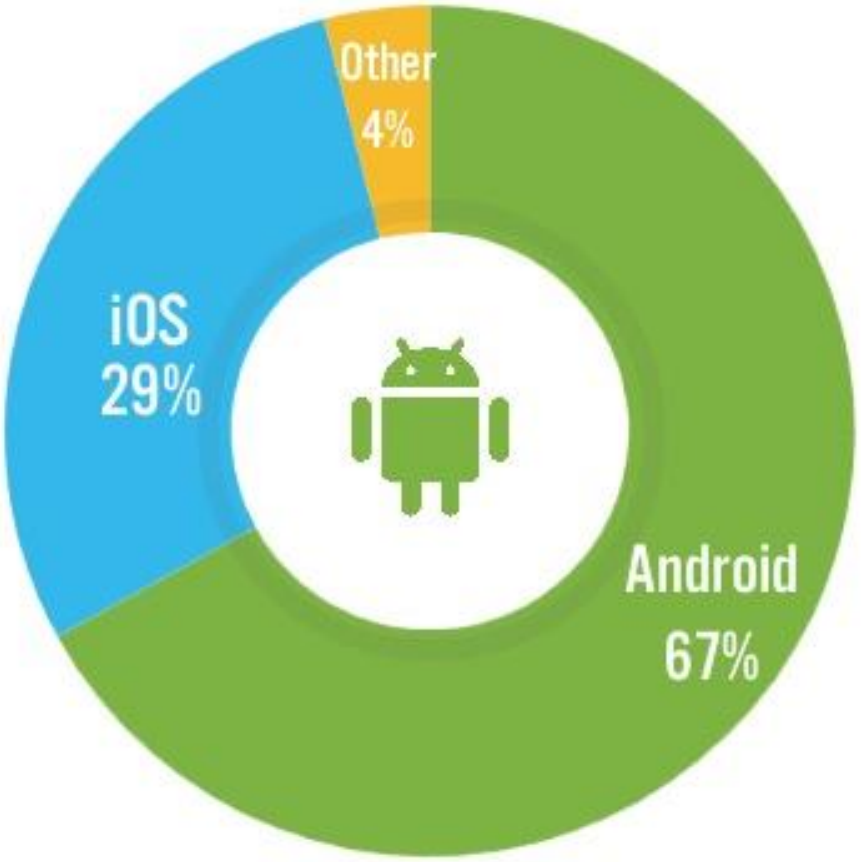
130M

Mobile Subscription

55% (~48M devices)

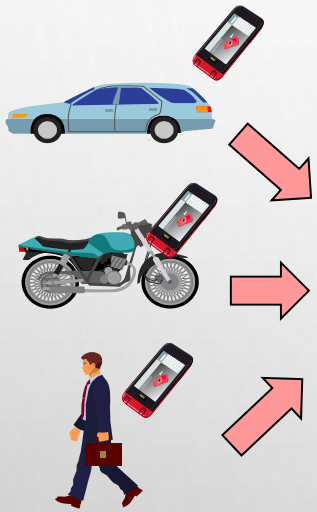
Smartphone Penetration

Mobile OS Market Share in Vietnam



Source: MIC, VNPT, internetworldstats

GENERAL FRAMEWORK



Data preprocessing
(smoothing/ normalization/ transformation/ feature extraction)

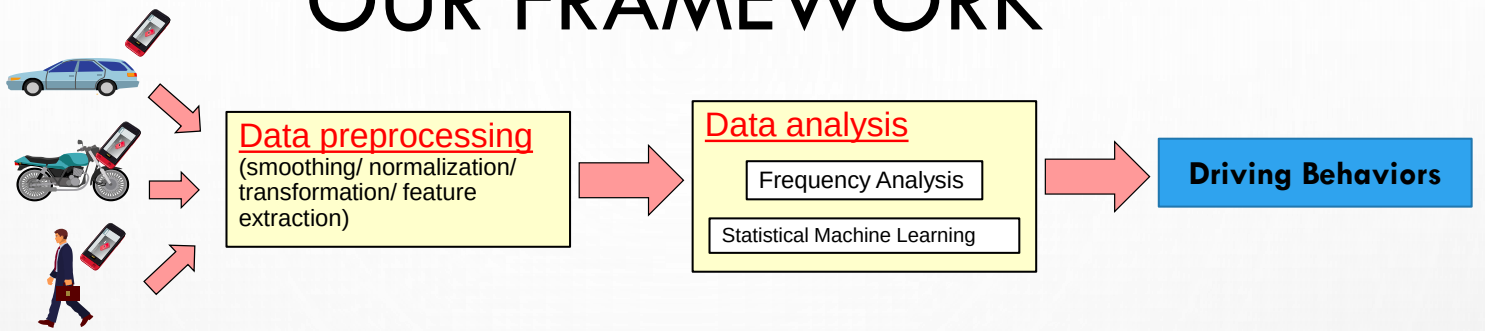
Data analysis

Frequency Analysis

Statistical Machine Learning

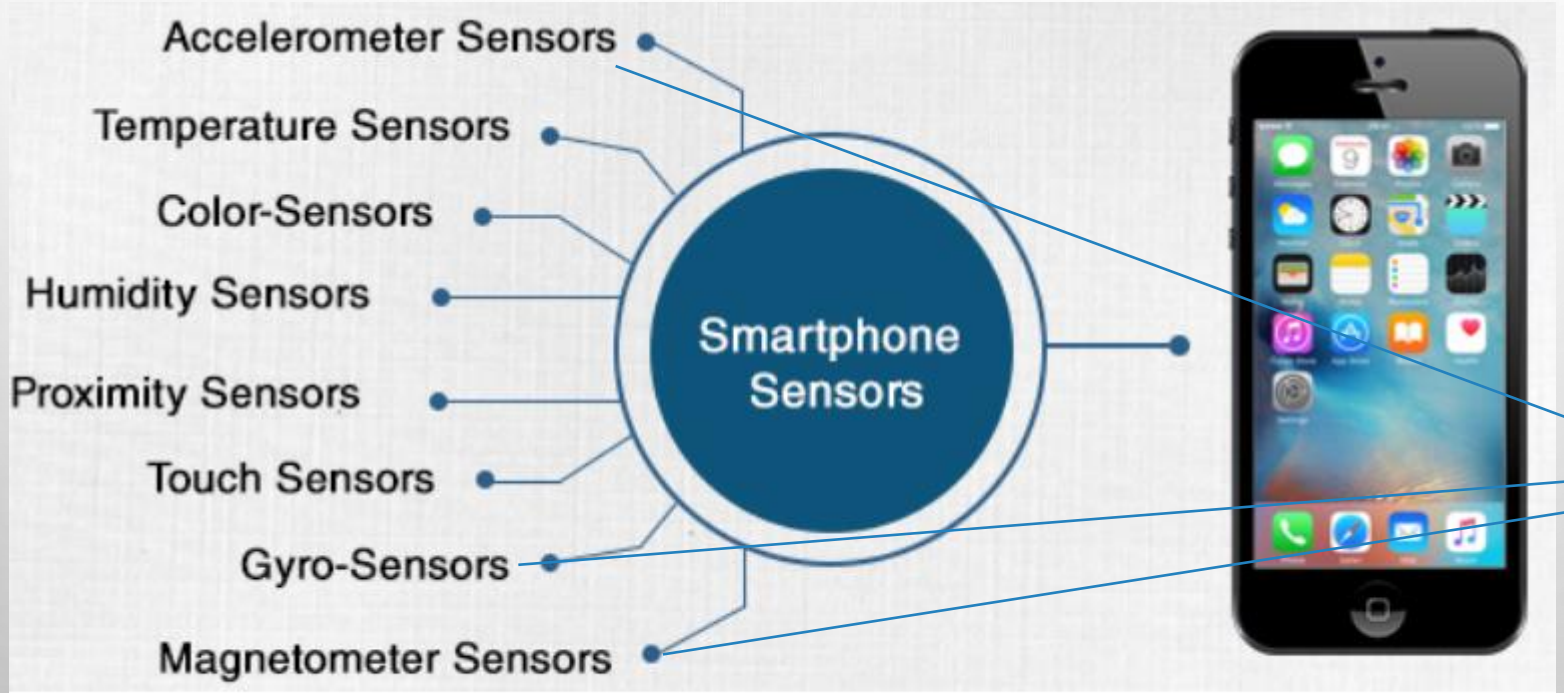
Driving Behaviors

OUR FRAMEWORK



Ob1: Data preprocessing	• Collecting data from smartphone/ transform and extract relevant information
Ob 2: Vehicle classification	• detect the modality of vehicles (i.e: working, bike, motorbike, car…)
Ob 3: Activities detection	• Sub Objdetect the status of drivers on the road (i.e: Stop, Driving, turn left, turn right)
Ob 4: Behavior analysis	• Detect the driving behavior (i.e: normal and abnormal behavior)

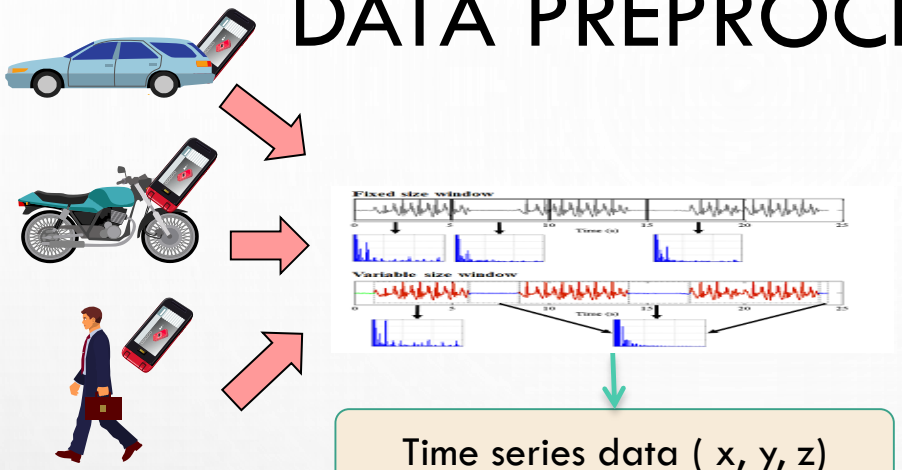
SENSORS SELECTION?



Sensors in smartphones (source: http://myphonefactor.in/)

- ALWAYS AVAILABLE
- BATTERY CONSUMPTION

DATA PREPROCESSING



Time series data (x, y, z)

Frequency-based Data Extraction

Time-based Data Extraction

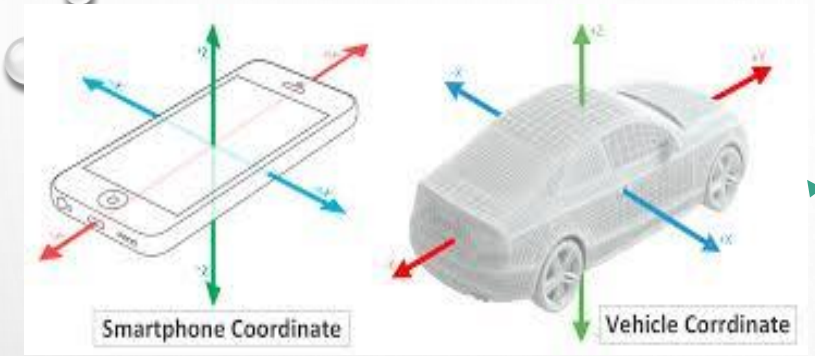
Hjorth parameters - based Data Extraction

Feature extraction

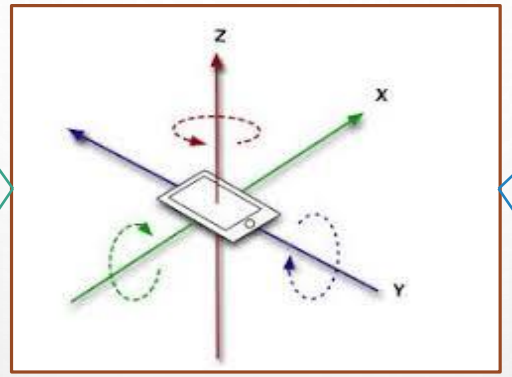
1. Vehicle detection
2. Activity Detection

DATA PREPROCESSING

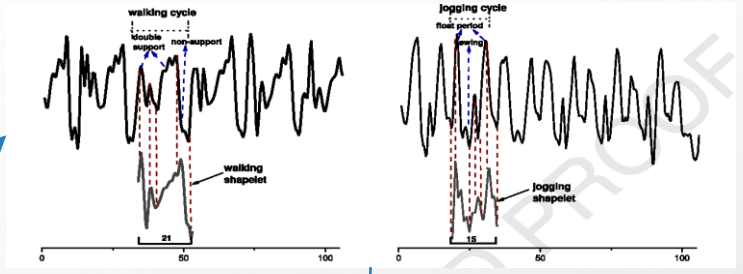
Fixed position



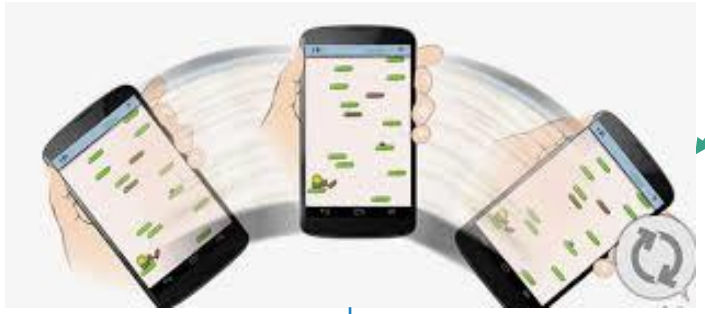
Accelerometers data



Raw data

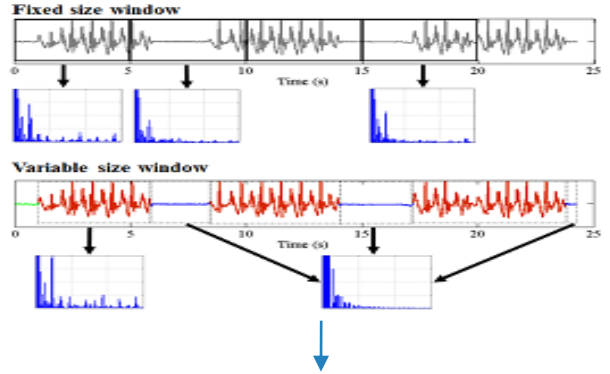


Changeable position

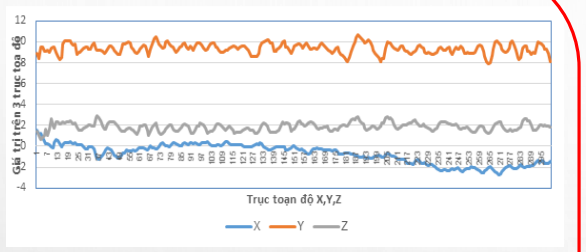


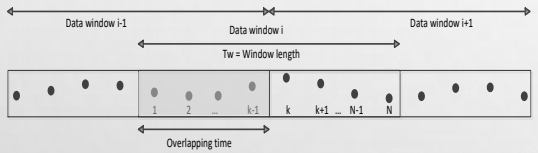
transfer axes coordinates

window technique

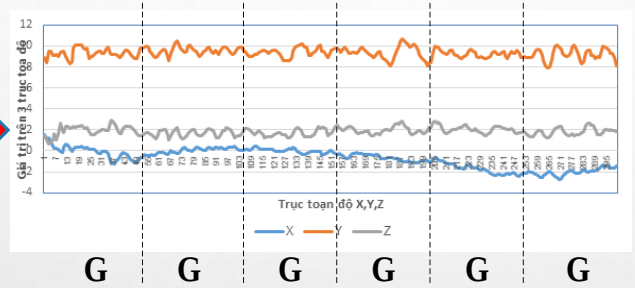


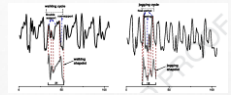
APPLICATION 1 -VEHICLES CLASSIFICATION



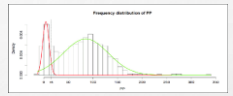


Ground trust





Frequency-based



Time-based

Hjorth parameters

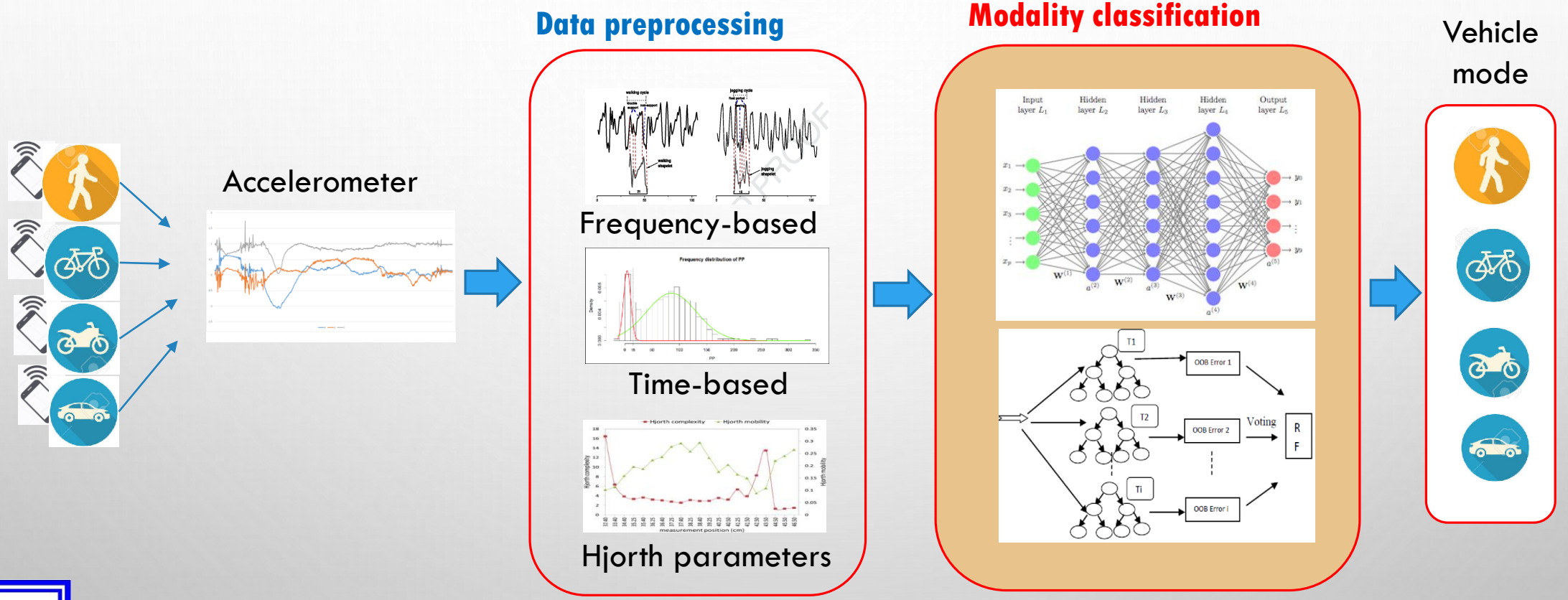
Data Preprocessing

Training data

DATA PREPROCESSING

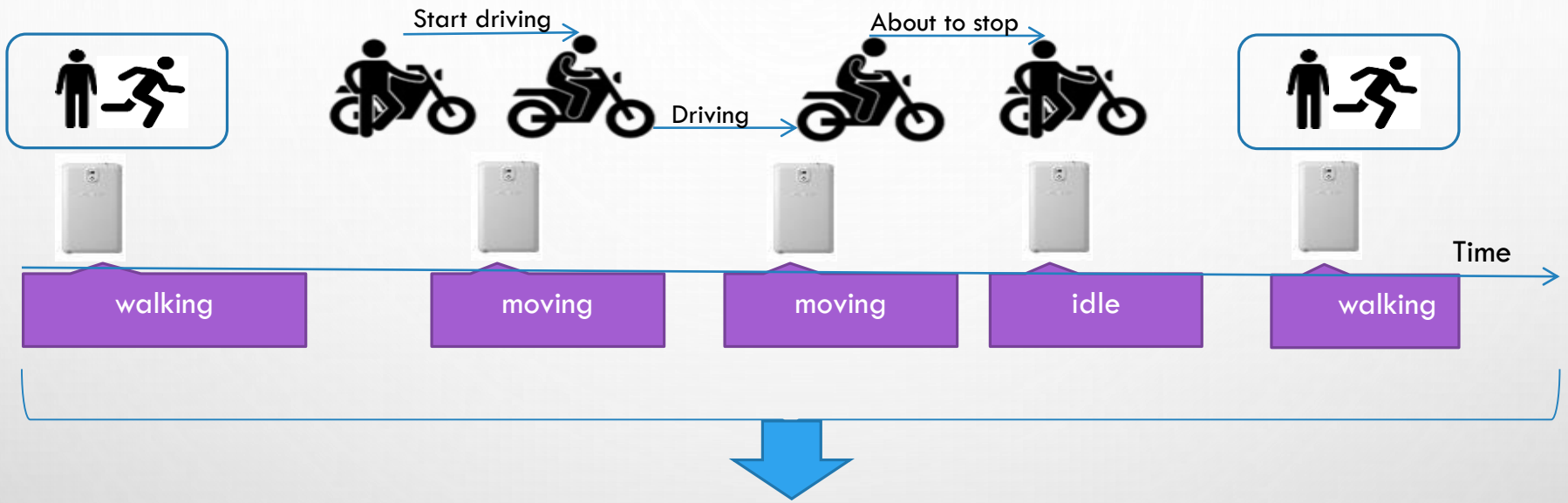
Domains	Set of Features	Number of Features
Time (T)	T1	20
Frequency (F)	F1	04
Hjorth (H)	H1	03
T+F+H	TFH1	27

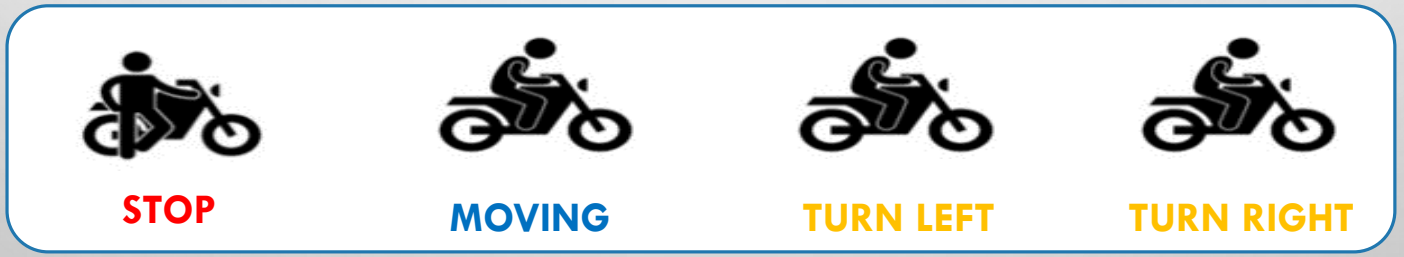
APPLICATION 1 -VEHICLES CLASSIFICATION



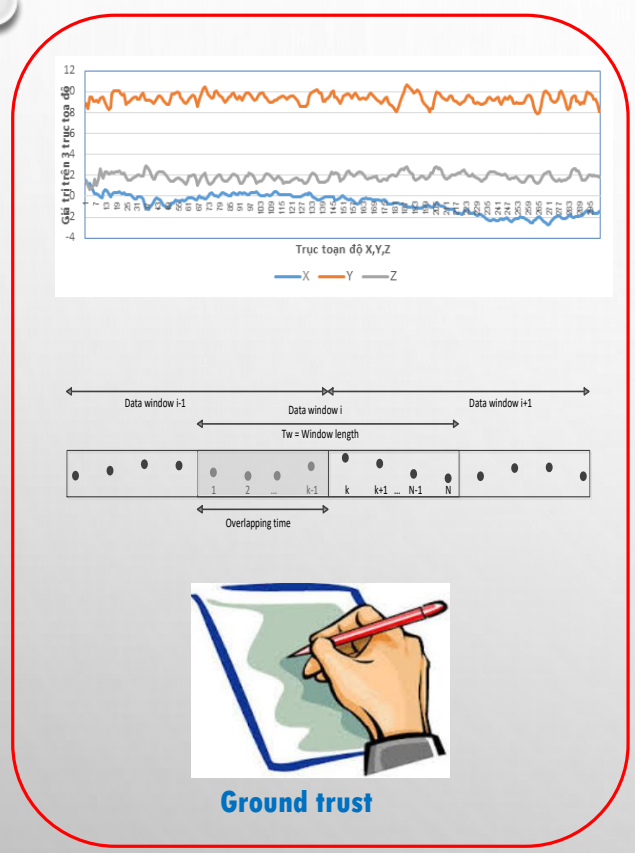
Nguyen, Ha-Nam, et al. **A Novel Mobile Online Vehicle Status Awareness Method Using Smartphone Sensors**. In: Kim K., Joukov N. (eds) Information Science and Applications 2017. ICISA 2017. Lecture Notes in Electrical Engineering, vol 424. Springer, Singapore.

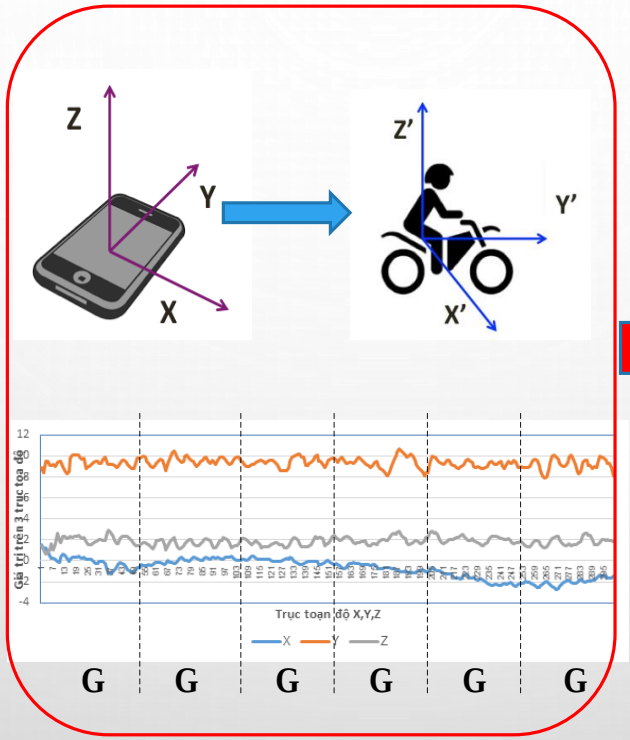
APPLICATION 2 - ACTIVITIES CLASSIFICATION

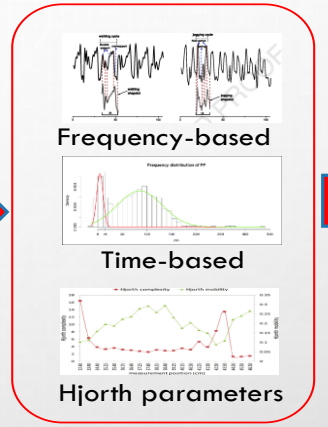




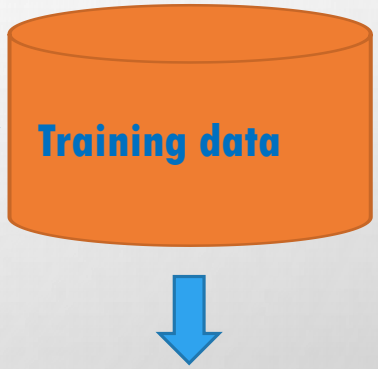
APPLICATION 2 - ACTIVITIES CLASSIFICATION







Data Preprocessing

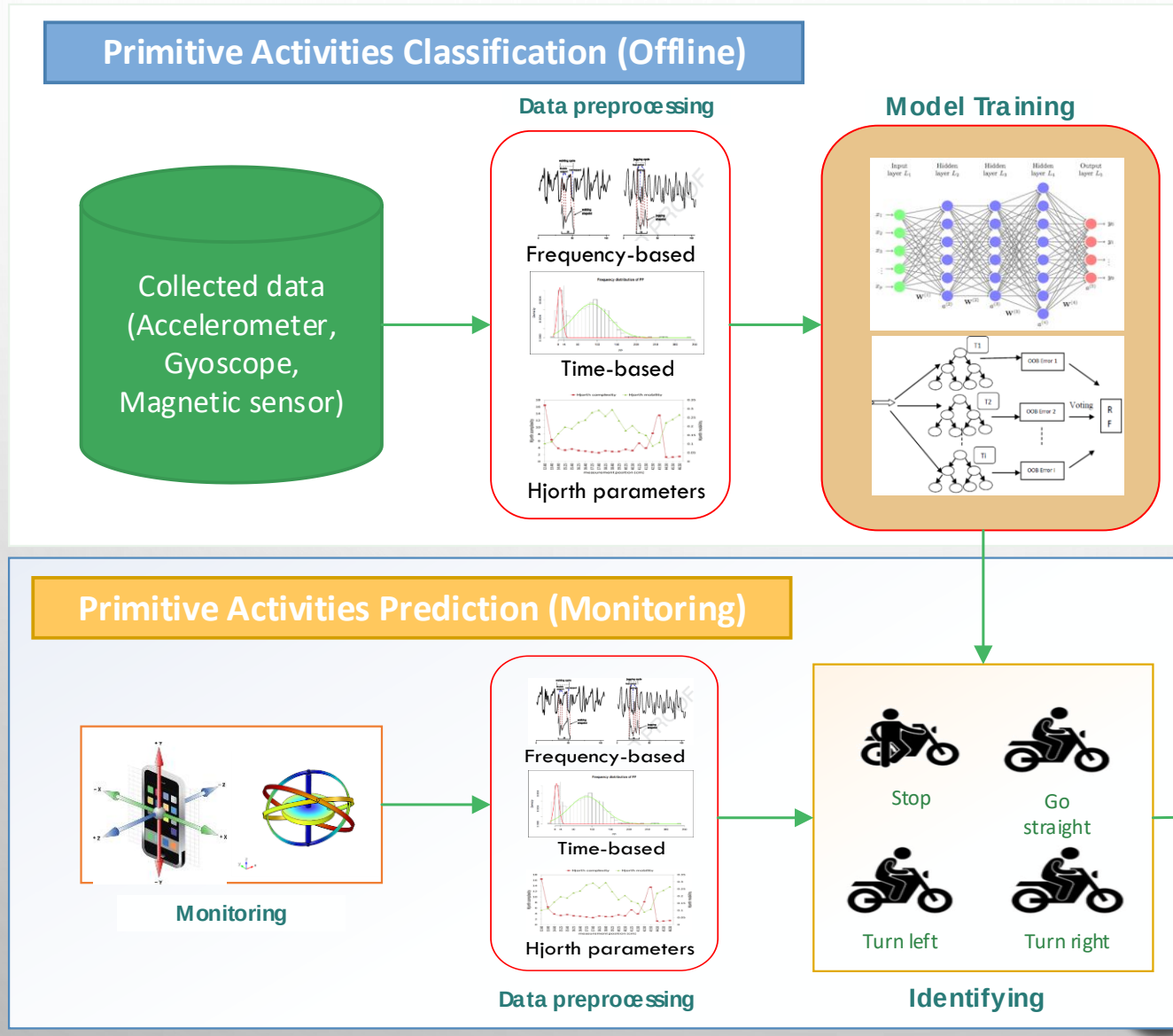


Domains	Set of Features	Number of Features
Time	T2	34
Frequency	F2	07
Hjorth	H2	18
T+F+H	TFH2	59

DATA PREPROCESSING

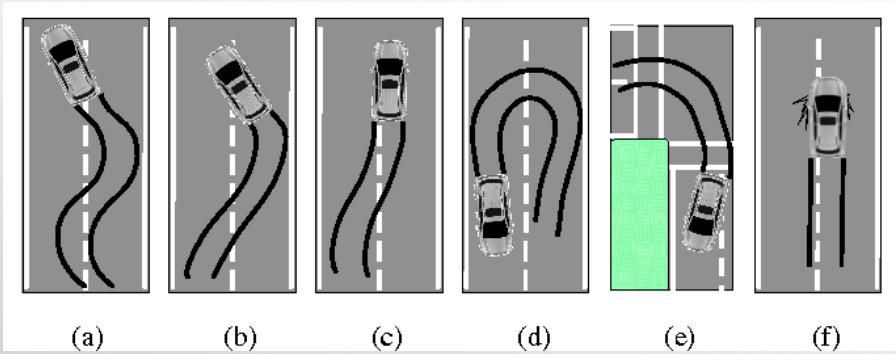
APPLICATION 2 – ACTIVITIES CLAS

Domains	Set of Features	Number of Features	Applied Module
Time	T2	34	Activity Detection
Frequency	F2	07	
Hjorth	H2	18	
T+F+H	TFH2	59	

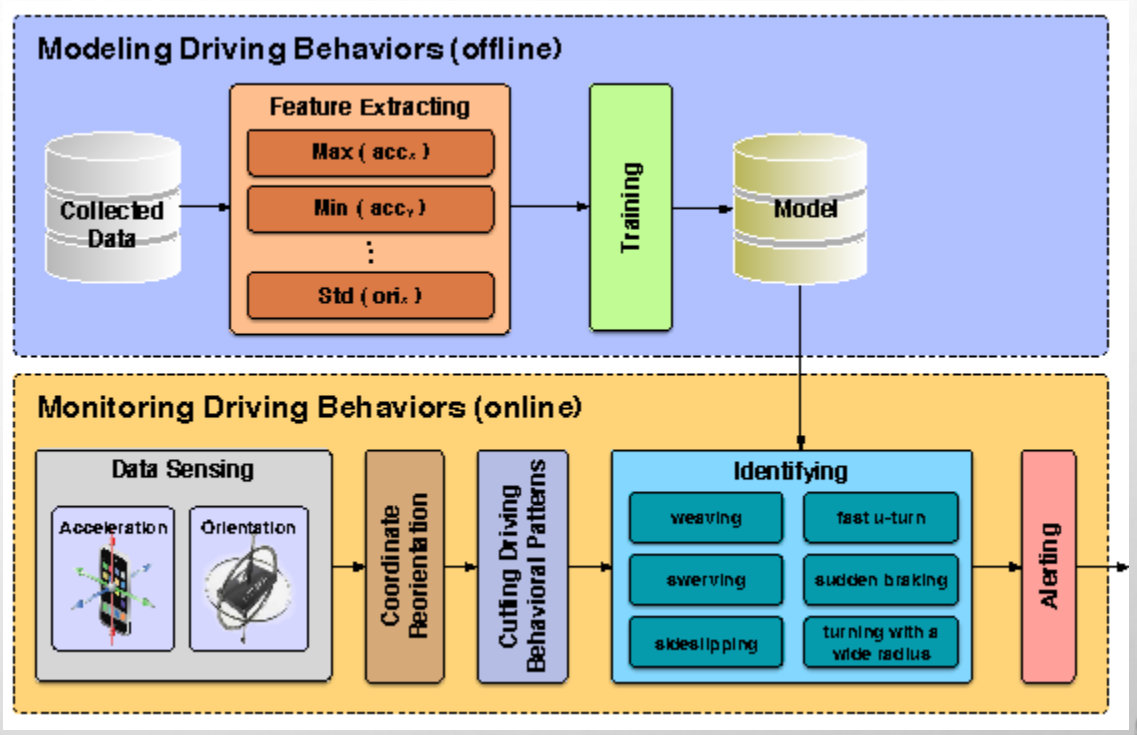


Nguyen, Ha-Nam, et al. "Vehicle Mode and Driving Activity Detection Based on Analyzing Sensor Data of Smartphones." *Sensors* 18.4 (2018): 1036.

APPLICATION 3 - DRIVING BEHAVIOR DETECTION



(a) Weaving, (b) Swerving, (c) Sideslipping, (d) Fast U-turn, (e) Turning with a wide radius, (f) Sudden braking.



Zhongyang Chen, Jiadi Yu, Yanmin Zhu, Yingying Chen, Minglu Li: **Abnormal driving behaviors detection and identification using smartphone sensors**, 2015 12th Annual IEEE International Conference on Sensing, Communication, and Networking (SECON) • 2015

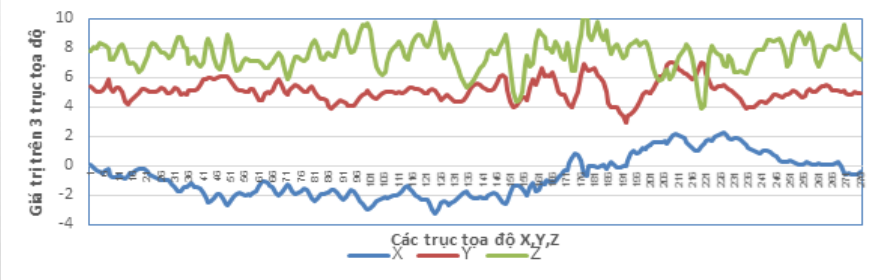
APPLICATION 3 - DRIVING BEHAVIOR DETECTION

STOP

MOVING

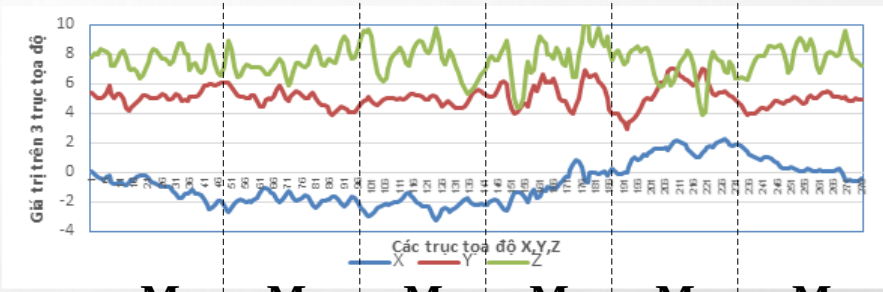
TURN LEFT

TURN RIGHT

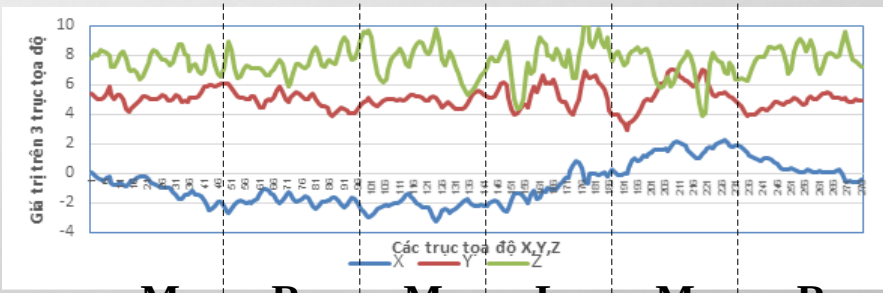


M

NORMAL



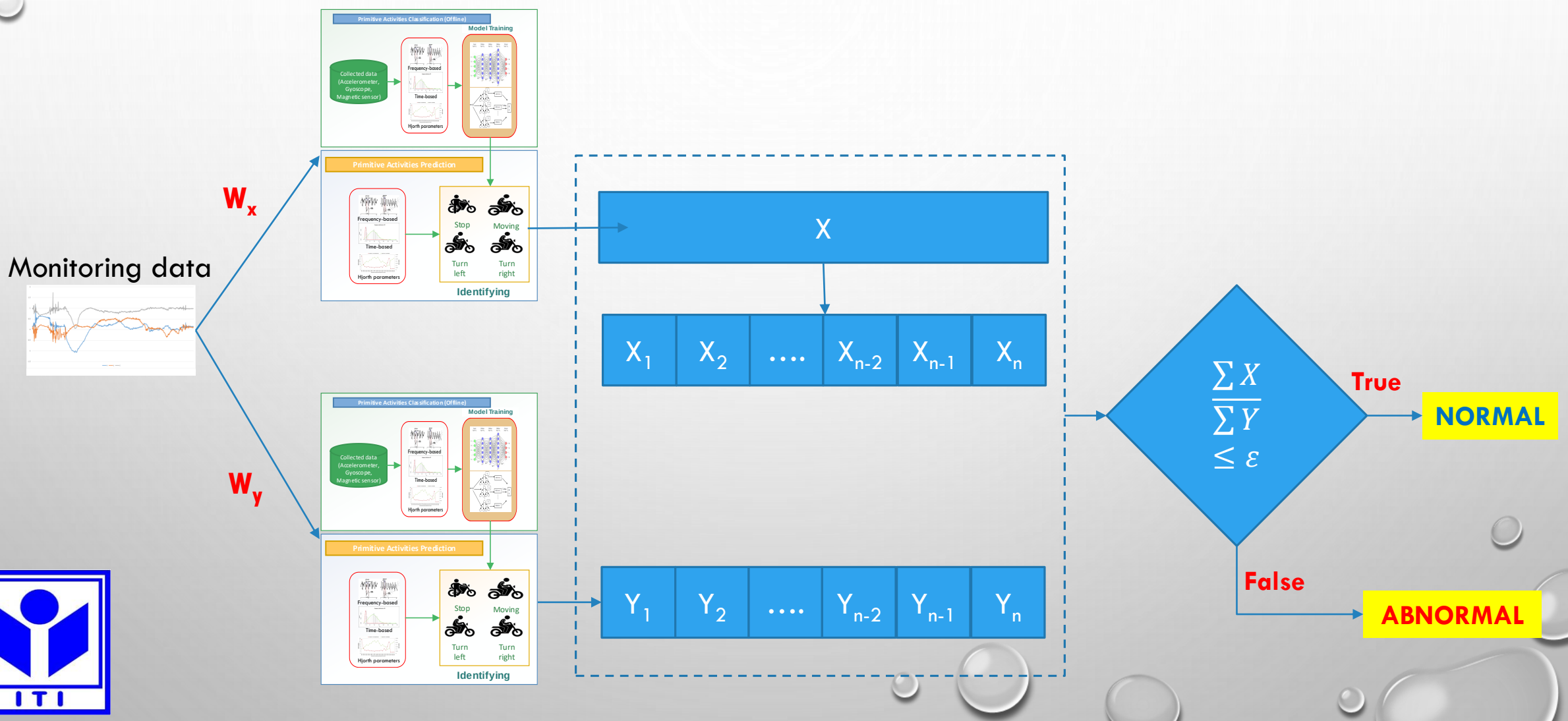
M M M M M M



M R M L M R

ABNORMAL

APPLICATION 3 - DRIVING BEHAVIOR DETECTION

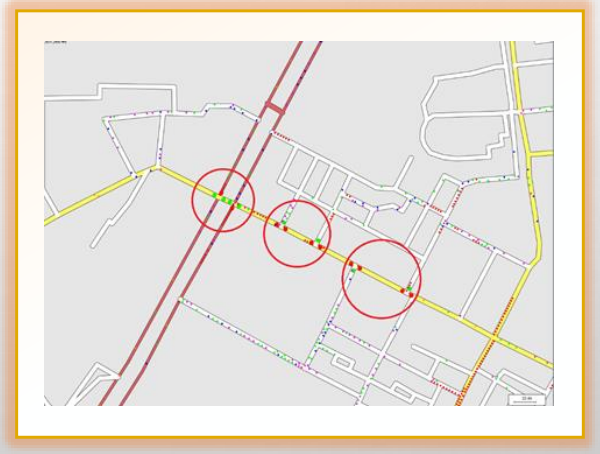


TRAFFIC MONITORING SYSTEM

Visualization

Analysis and planning

Implimentation



Simulation

- Driving behavior model
- Travel model
- Scenarios analysis

ITI

CONCLUSION

- TO PROPOSE TWO SET OF RELEVANT FEATURES FOR VEHICLE CLASSIFICATION AND ACTIVITIES CLASSIFICATION
- TO BUILD A FRAMEWORK FOR CLASSIFYING VEHICLE MODALITY AND ITS ACTIVITIES
- TO PROPOSE AND BUILD A NOVEL SOLUTION TO DETECT ABNORMAL BEHAVIOR BASED ON ACTIVITIES IDENTIFICATION

THANK YOU!?

DATA PREPROCESSING

Type	Features	Definition	Applied components
Statistic	μ	Mean	a_x, a_y, a_z, a_{rms}, ϕ, θ
Time domain	σ^2	Variance	a_x, a_y, a_z, ϕ, θ
	σ	Standard deviation	a_x, a_y, a_z
	Diff = max(x)-min(x)	Difference	a_x, a_y, a_z
	R	Cross correlation	(a_x, a_y), (a_x, a_z), (a_z, a_y)
	ZC	Zero crossings	a_x, a_y, a_z
	PAR	Peak to average ratio	a_x, a_y, a_z
	SMA	Signal magnitude area	a_x, a_y, a_z, a_{rms}
	SVM	Signal vector	a_{rms}
	DSVM	Differential signal magnitude	a_{rms}
	I	Integration	ϕ, θ
Hjorth parameters	A	Activity	a_x, a_y, a_z, a_{rms}, ϕ, θ
	M	Mobility	a_x, a_y, a_z, a_{rms}, ϕ, θ
	C	Complexity	a_x, a_y, a_z, a_{rms}, ϕ, θ
Frequency domain	E_{FFT}	Energy	a_x, a_y, a_z, a_{rms}
	En	Entropy	a_x, a_y, a_z