

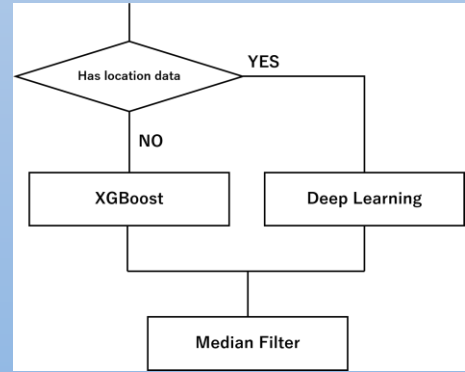
Phased Human Activity Recognition based on GPS

Ryoichi Sekiguchi, Kenji Abe, Shogo Suzuki, Masayasu Kumano,
Daisuke Asakura, Ryo Okabe, Takeru Kariya, Masaki Kawakatsu
Tokyo Denki University

Data including location were classified by Deep Neural Network including LSTM layer.
Data excluded location were classified by the Gradient Boosting Decision Tree.
The 2 outputs have been combined. They were optimized by applying a median filter.
In the submission phase, the best F-measure obtained for the SHL validation-set was 65%.

True label	Still	Walking	Run	Bike	Car	Bus	Train	Subway
Still	59.73 (1761)	4.18 (1247)	0.00 (0)	0.02 (6)	8.47 (2526)	1.26 (376)	25.24 (7522)	1.10 (328)
Walking	3.50 (94)	62.42 (1653)	7.20 (1884)	1.85 (483)	14.33 (3786)	1.83 (478)	7.12 (1833)	1.75 (458)
Run	0.00 (0)	19.97 (554)	49.06 (1263)	23.76 (609)	7.21 (186)	0.00 (0)	0.00 (0)	0.00 (0)
Bike	10.82 (282)	2.97 (75)	10.98 (283)	70.42 (1842)	3.34 (86)	1.45 (37)	0.00 (0)	0.00 (0)
Car	1.39 (36)	0.67 (17)	0.07 (2)	2.00 (51)	77.52 (1979)	10.04 (256)	5.22 (1339)	3.09 (78)
Bus	13.40 (340)	1.01 (26)	0.00 (0)	5.63 (144)	24.96 (631)	50.33 (1283)	2.30 (59)	2.36 (60)
Train	7.54 (191)	1.63 (42)	0.00 (0)	0.20 (5)	25.83 (663)	2.21 (56)	55.11 (1403)	7.48 (190)
Subway	0.51 (13)	0.03 (0)	0.00 (0)	0.30 (8)	5.31 (135)	1.63 (42)	5.52 (140)	86.71 (2192)
	Still	Walking	Run	Bike	Car	Bus	Train	Subway

True label	Still	Walking	Run	Bike	Car	Bus	Train	Subway
Still	60.21 (1764)	4.15 (1238)	0.00 (0)	0.00 (0)	10.04 (269)	0.08 (23)	25.17 (750)	0.36 (9)
Walking	3.22 (84)	63.74 (1667)	6.21 (160)	1.27 (32)	16.36 (427)	1.00 (26)	6.80 (177)	1.40 (36)
Run	0.00 (0)	29.99 (762)	36.88 (943)	25.92 (661)	7.21 (186)	0.00 (0)	0.00 (0)	0.00 (0)
Bike	10.61 (270)	2.81 (72)	10.59 (270)	72.07 (1840)	3.32 (86)	0.60 (15)	0.00 (0)	0.00 (0)
Car	1.06 (27)	0.01 (0)	0.00 (0)	1.29 (33)	81.24 (2062)	8.90 (226)	5.11 (130)	2.37 (60)
Bus	13.34 (334)	0.07 (2)	0.00 (0)	4.42 (113)	23.32 (593)	55.93 (1413)	1.70 (43)	1.23 (31)
Train	8.23 (208)	1.65 (42)	0.00 (0)	0.00 (0)	23.77 (603)	1.38 (35)	63.94 (1643)	1.04 (26)
Subway	0.41 (10)	0.02 (0)	0.00 (0)	0.00 (0)	2.51 (64)	1.99 (50)	7.16 (182)	87.90 (2221)
	Still	Walking	Run	Bike	Car	Bus	Train	Subway



Preprocessing

HuBeny formula first term was used to calculate the distance traveled per second using latitude and longitude.
The calculated distance was converted to velocity by multiplying by 3.6.

Angular acceleration was calculated from the azimuth angle. Angular Acceleration is the difference in azimuth angle.

$$D = \sqrt{(M \times dP)^2 + (N \times \cos(P) \times dR)^2}$$

D: distance between 2 points (m)

P: mean latitude from 2 points

dP: latitude difference between 2 points

dR: longitude difference between 2 points

M: radius of curvature

N: radius of prime vertical circle

$$V = D \times 3.6$$

V: velocity (km/h)

$$AA = \arctan\left(\frac{\sin(dR)}{\cos(LP) \times \tan(TP) - \sin(LP) \times \cos(dR)}\right)$$

AA: azimuth angle

dR: longitude difference between 2 points

LP: latitude of the starting point

TP: latitude of the end point

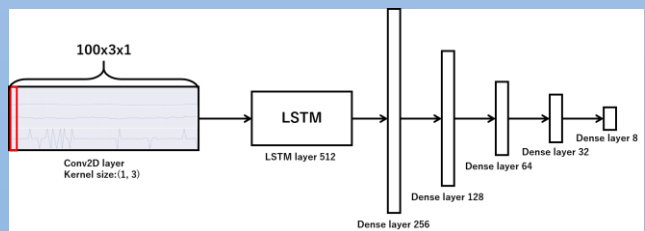
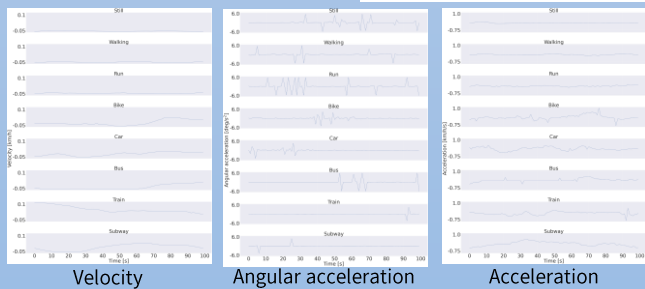
Deep Learning (data with location)

We employed a Deep Neural Network (DNN) model with a Long-Term Short Memory (LSTM) layer.

Feature values were velocity, acceleration, and angular acceleration for 100 s.

If feature values were not acquired for 100 s, we centralized it with padding by zero.

True label	Still	Walking	Run	Bike	Car	Bus	Train	Subway
Still	75.07 (1921)	1.94 (50)	0.00 (0)	0.04 (1)	17.75 (453)	2.60 (66)	0.65 (17)	1.15 (29)
Walking	1.23 (31)	68.43 (1760)	8.41 (215)	2.16 (55)	16.57 (424)	2.13 (54)	0.86 (22)	0.22 (6)
Run	0.00 (0)	19.97 (504)	49.06 (1263)	23.76 (609)	7.21 (186)	0.00 (0)	0.00 (0)	0.00 (0)
Bike	0.47 (12)	3.31 (84)	12.25 (313)	70.59 (1814)	3.73 (95)	1.61 (41)	0.03 (0)	0.00 (0)
Car	1.46 (37)	0.74 (19)	0.07 (2)	2.19 (56)	80.55 (2064)	10.98 (280)	3.39 (86)	0.61 (15)
Bus	2.20 (56)	0.99 (25)	0.00 (0)	7.20 (184)	31.91 (813)	52.72 (1353)	2.31 (59)	2.67 (68)
Train	2.76 (70)	1.45 (37)	0.00 (0)	0.57 (14)	68.79 (1760)	6.29 (161)	18.03 (458)	2.10 (54)
Subway	3.48 (88)	0.23 (6)	0.00 (0)	2.46 (62)	35.00 (893)	13.37 (341)	9.81 (250)	35.64 (906)
	Still	Walking	Run	Bike	Car	Bus	Train	Subway



XGBoost (No Location)

Cell (LTE, WCDMA, GSM) features

- The number of each cell
- Mean and variance of each signal strength from the cell

Wi-Fi features

- The number of received Wi-Fi access points
- Mean and standard deviation of Wi-Fi access point's RSSI. Calculated from 3 frequency ranges
- The number of SSID from 29 Wi-Fi access points that is received high frequency in the Training-set
- The number of Wi-Fi access point includes the following text in its SSID
 - free, hotel, restaurant

True label	Still	Walking	Bike	Car	Bus	Train	Subway
Still	45.45 (116)	6.16 (15)	0.00 (0)	0.25 (6)	0.08 (2)	47.01 (119)	1.05 (27)
Walking	17.05 (43)	26.53 (67)	0.00 (0)	0.93 (24)	0.00 (0)	44.60 (113)	10.89 (277)
Bike	100.00 (250)	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)
Car	0.62 (16)	0.00 (0)	0.00 (0)	45.35 (113)	0.00 (0)	24.60 (62)	29.42 (74)
Bus	53.65 (134)	1.10 (28)	0.00 (0)	0.00 (0)	41.74 (105)	2.25 (57)	1.25 (31)
Train	10.13 (25)	1.73 (44)	0.00 (0)	2.57 (65)	0.00 (0)	75.17 (188)	10.40 (26)
Subway	0.09 (2)	0.00 (0)	0.00 (0)	1.20 (31)	0.01 (0)	4.93 (12)	93.78 (234)
	Still	Walking	Bike	Car	Bus	Train	Subway

Post-processing

We applied a median filter to estimate from the combined output of two model outputs. The filter length is 101 s. Correcting the output label improves accuracy.

Train Train Train Train Subway Train ... Train Train



Train Train Train Train Train Train ... Train Train