



Deep Ensemble Learning for Human Activity Recognition Using Smartphone

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Motivation

- Why human activity recognition based on smartphone ?

-Ubiquitous

- Nearly every mobile devices

-Application

- Indoor pedestrian tracking
- Mobile health care
- Smart cities



Challenges

-Accuracy

- various motion modes
- confusing activities

-Limited data

- poor quantity
- low sampling rate
- unbalanced distribution

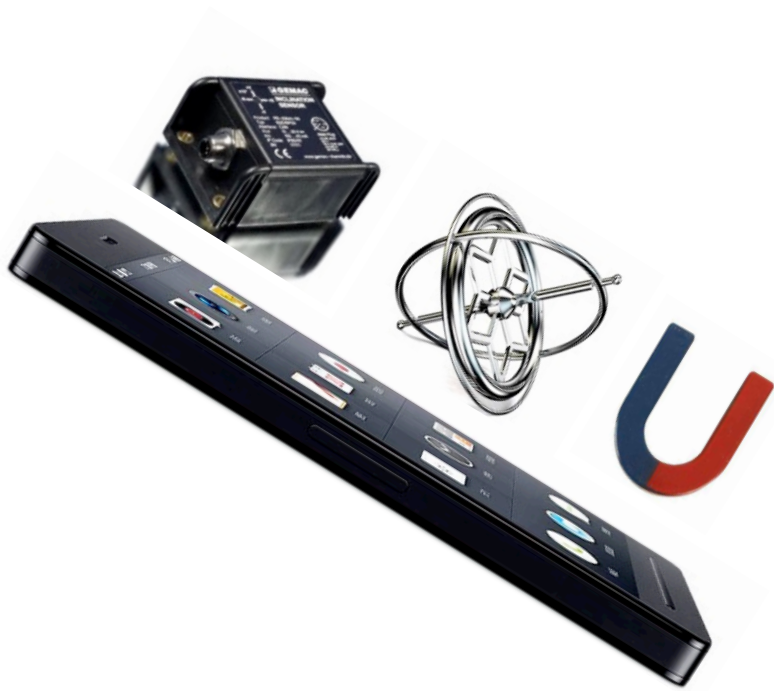


Going upstairs



Walking

Outline



- 1 Motivation
- 2 **DataSet**
- 3 CNN-based model
- 4 Analysis & Conclusion

DataSet



Data Collection	
Subject	100 participants aged 12-51
Device	Various smartphones (ios、andriod)
Sensor	Accelerometer / Gyroscope / Magnetometer
Activity	Walking / Standing / Running / Going upstairs / Going downstairs
Placement	Texting / Swinging / Trousers pocket mode
Sampling rate	50 Hz

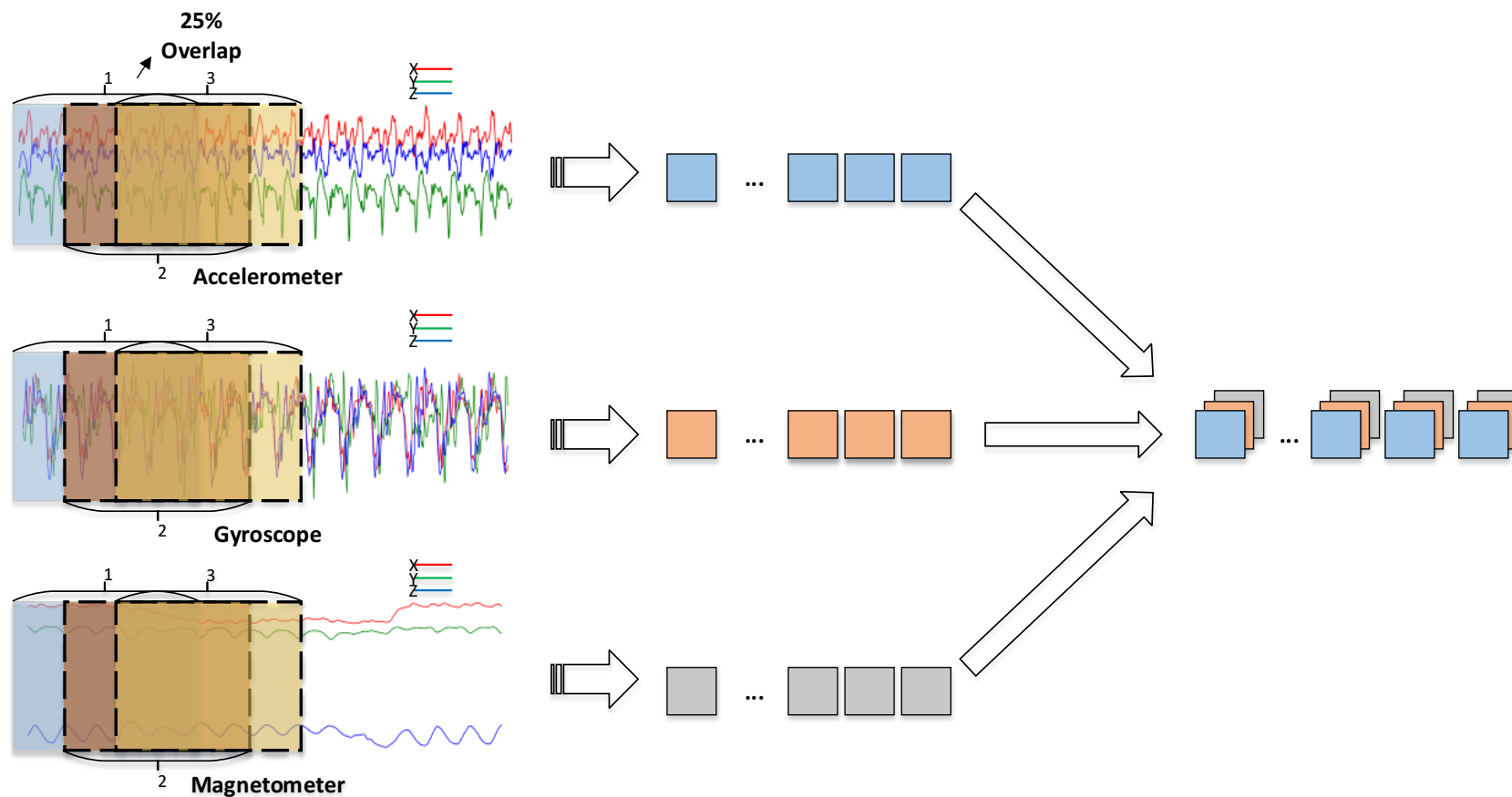
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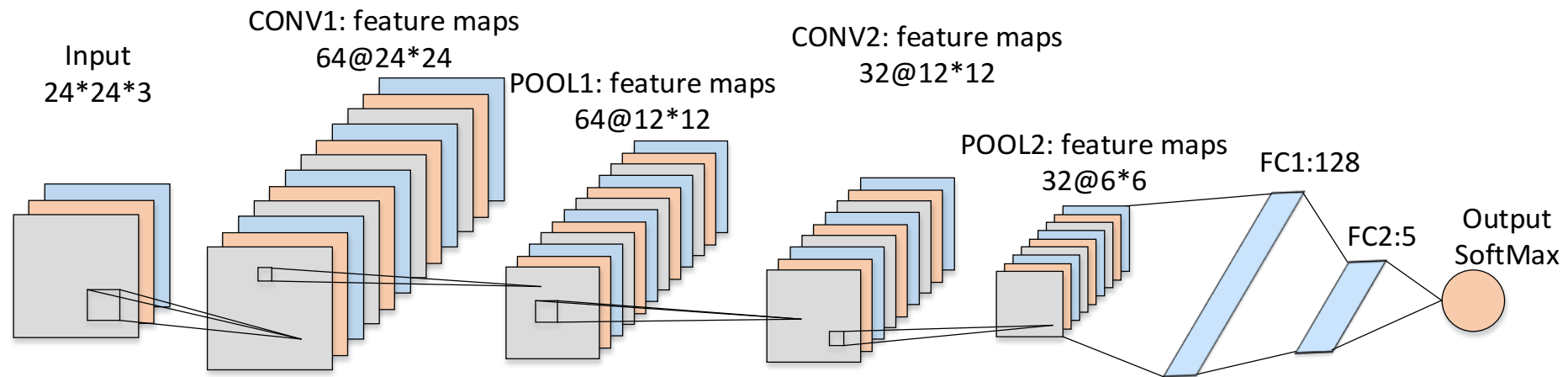
Preprocessing

- No normalization
- No de-noising
- **Data segmentation**



CNN-based model

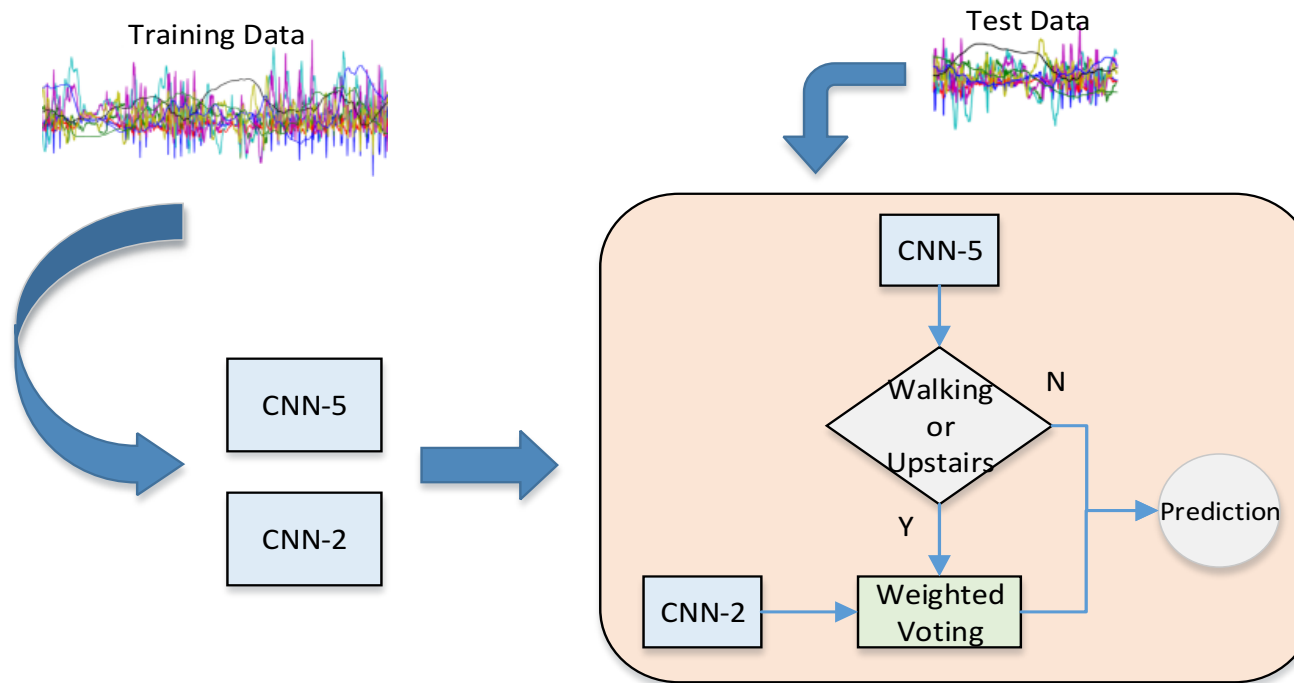
- The structure of CNN-based human activity recognition model



- Filter size is set to be 7×7
- Pooling size is set to be 2×2
- Dropout is applied in the top fully-connected layer and is set to be 0.6

Ensemble Model

- To tackle the confusion between certain activities like walking and going upstairs



- CNN-2, two-class network
- CNN-5, five-class network

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Analysis of single CNN model

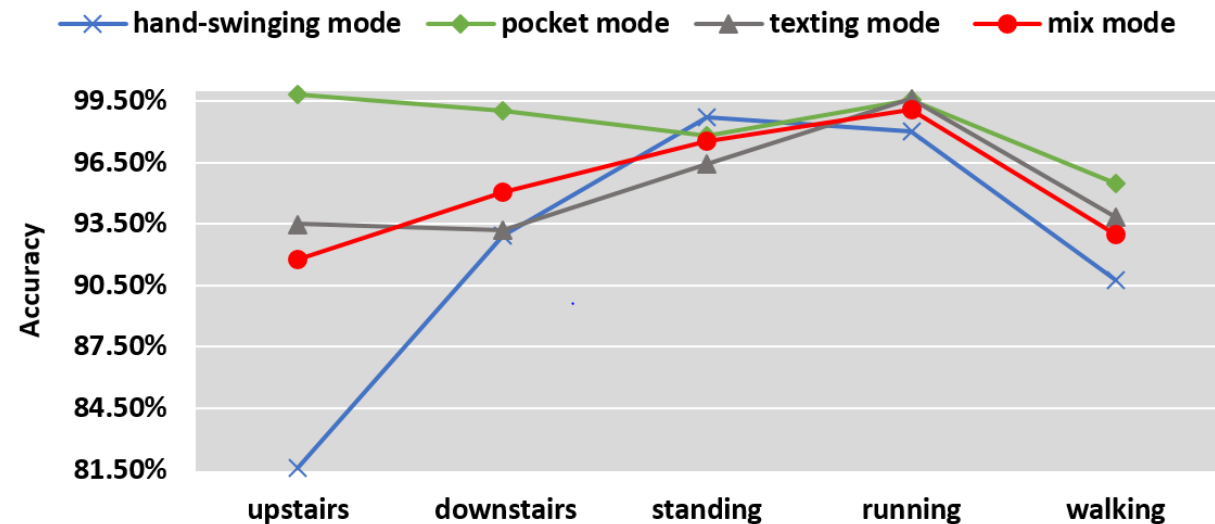
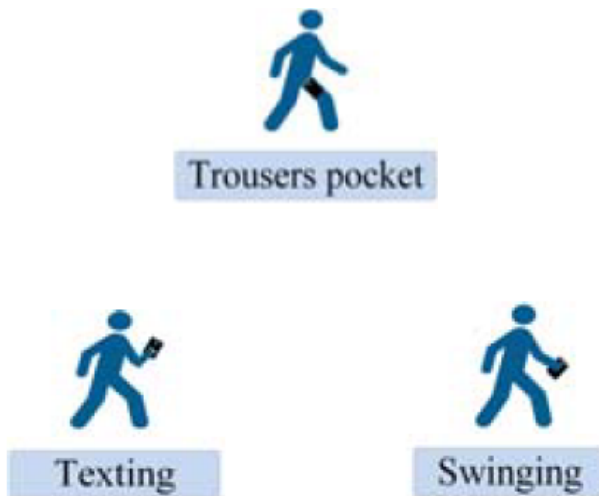
- Detailed Accuracy By Activity

Activity	Model Evaluation		
	Precision	Recall	F1-score
U	0.90	0.92	0.91
D	0.95	0.95	0.95
S	1.00	0.98	0.99
R	0.99	0.99	0.99
W	0.93	0.93	0.93
Avg/all	0.96	0.96	0.96

- The experiment randomly selects 10 participants as the testing set and the remaining 90 participants as the training set (10-fold evaluation).

Analysis of single CNN model

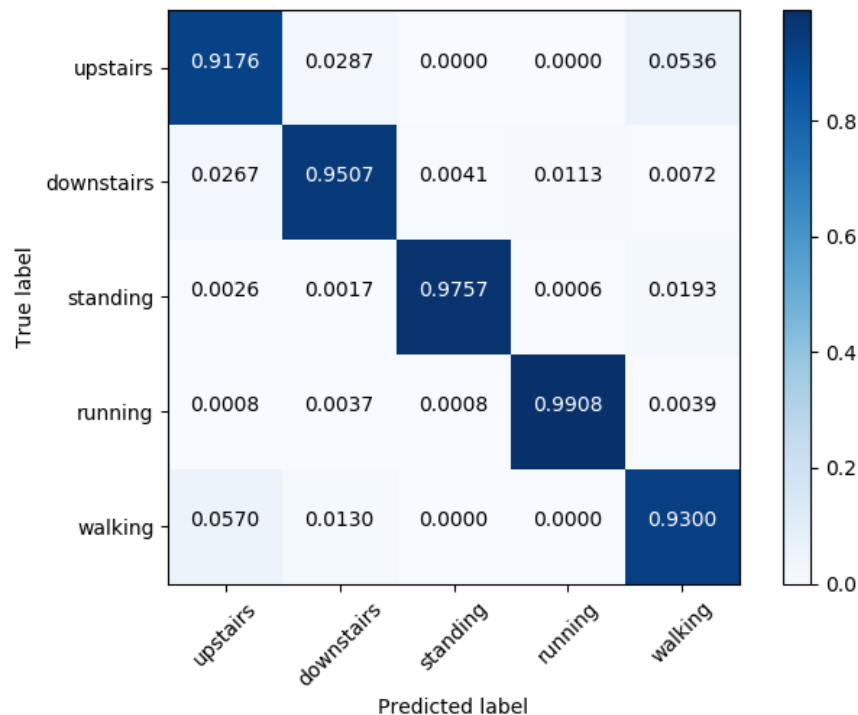
- Model performance in different smartphone-placements



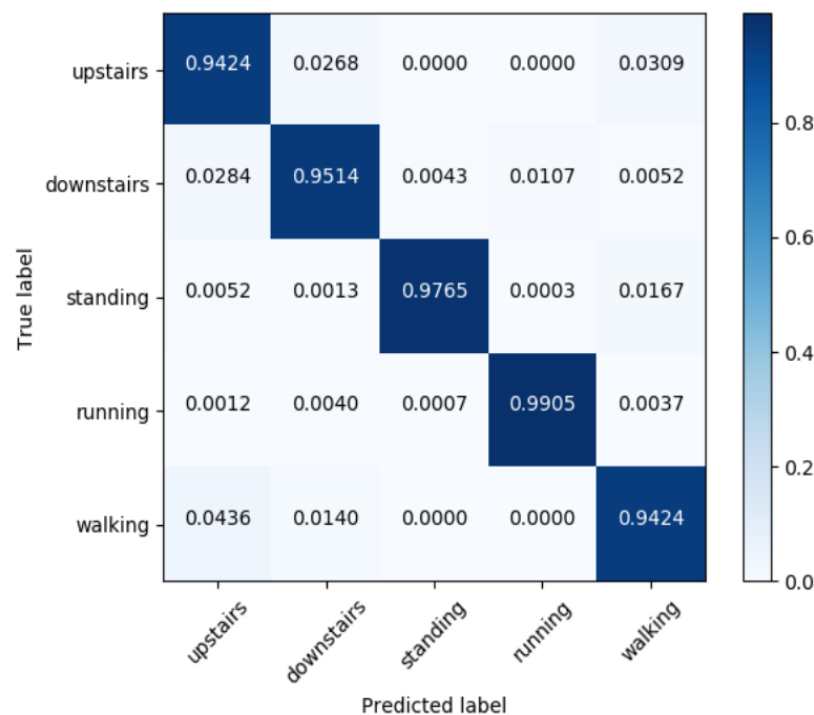
- the accuracy in pocket mode keeps consistent above 96.5% in all motions.
- The reason lies in the fact the motion of phone in the pocket is restricted, thus regular and easy to predict.

Analysis of ensemble model

The single CNN



Ensemble model



- The single CNN achieves **95.62%** accuracy and the prediction error mainly comes from the confusion between going upstairs and walking.
- Ensemble model reaches as high as **96.29%** and the recognition rate of going upstairs and walking has increased.



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Thank you !