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Indoor human activity detection using micro-Doppler signatures

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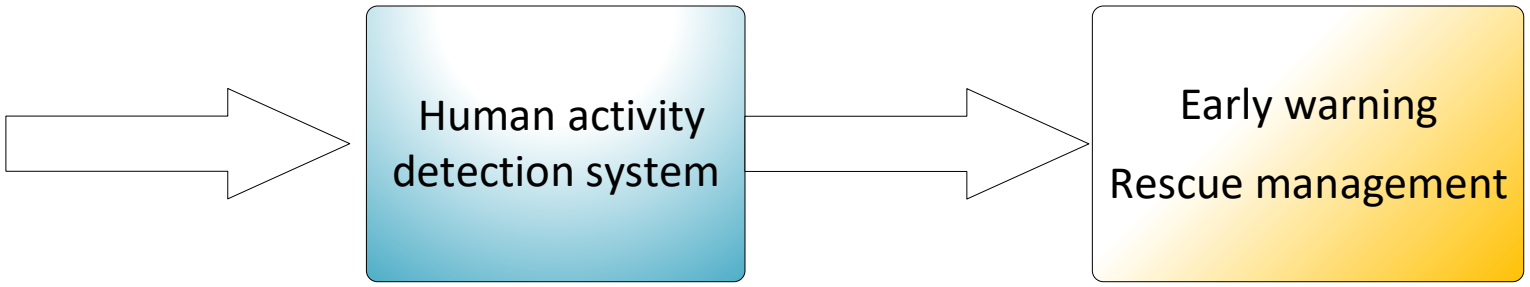
Early warning based on human activity detection

- Abnormal activities might imply a certain accident happening
- Human activity detection affords early warning



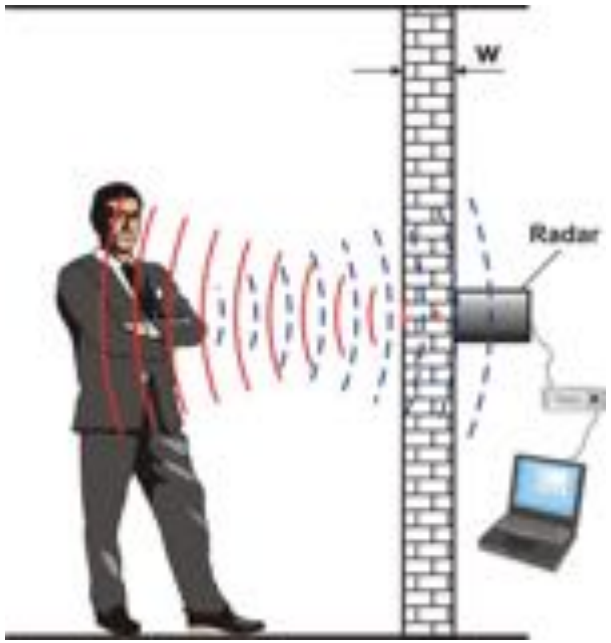
Techniques for human activity detection

- **Camera-based techniques**

- **Wearable sensor-based techniques**

- **Radar-based techniques**: (*used in this research*)

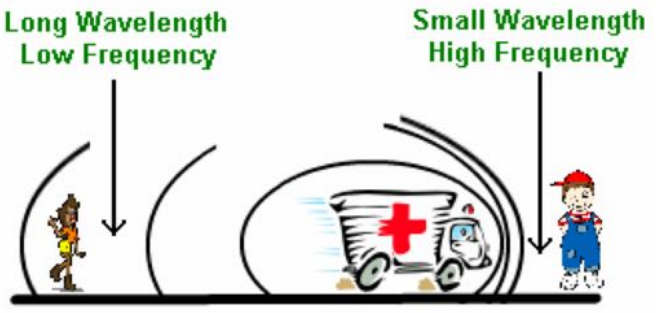
Performing human activity detection with a radar (Doppler radar, LIDAR), then analyzing the signals that captured by the radar



Micro-Doppler radar

Micro-Doppler radar is to used electromagnetic signal to detect the Doppler effect caused by the targets

Doppler effect: The target moves with a constant velocity, the carrier frequency of the returned signal will be shifted

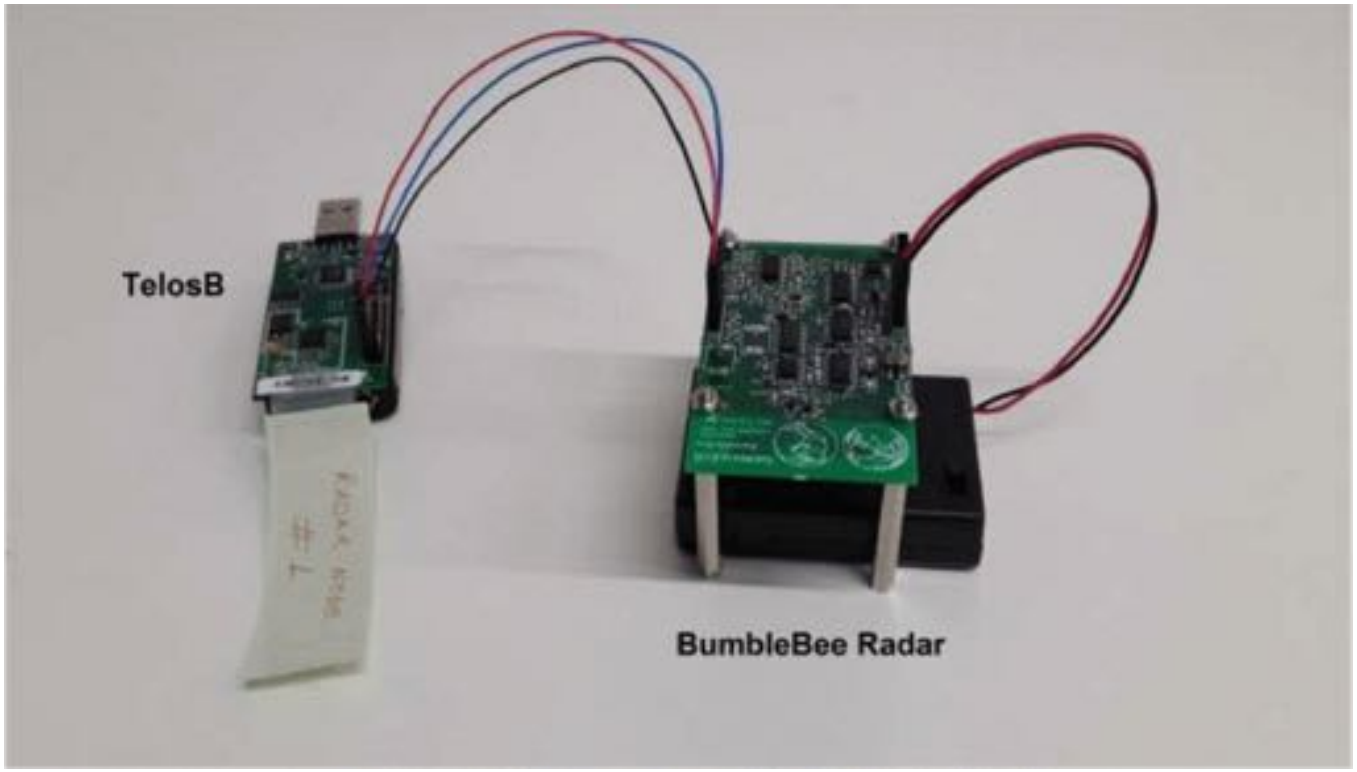


The Doppler Effect for a Moving Sound Source

Advantages of micro-Doppler signatures-based techniques:

- Unaffected by the light
- Unaffected by the weather
- Without attaching to a human body.

Devices used



BumbleBee Radar: a low-power Pulsed Doppler Radar (PDR).

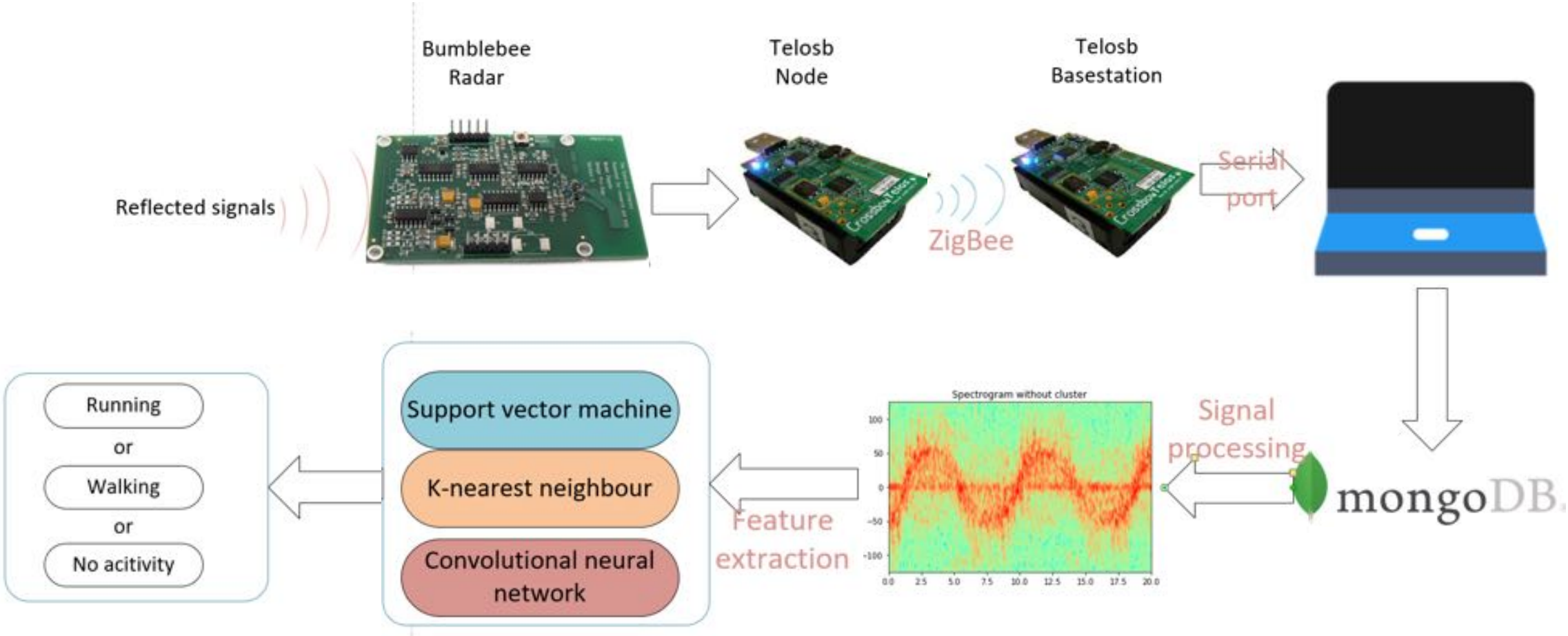
- A detection range up to of 10 m
- 60-degree conical coverage pattern.

TelosB mote: an open source platform, designed by UC Berkley

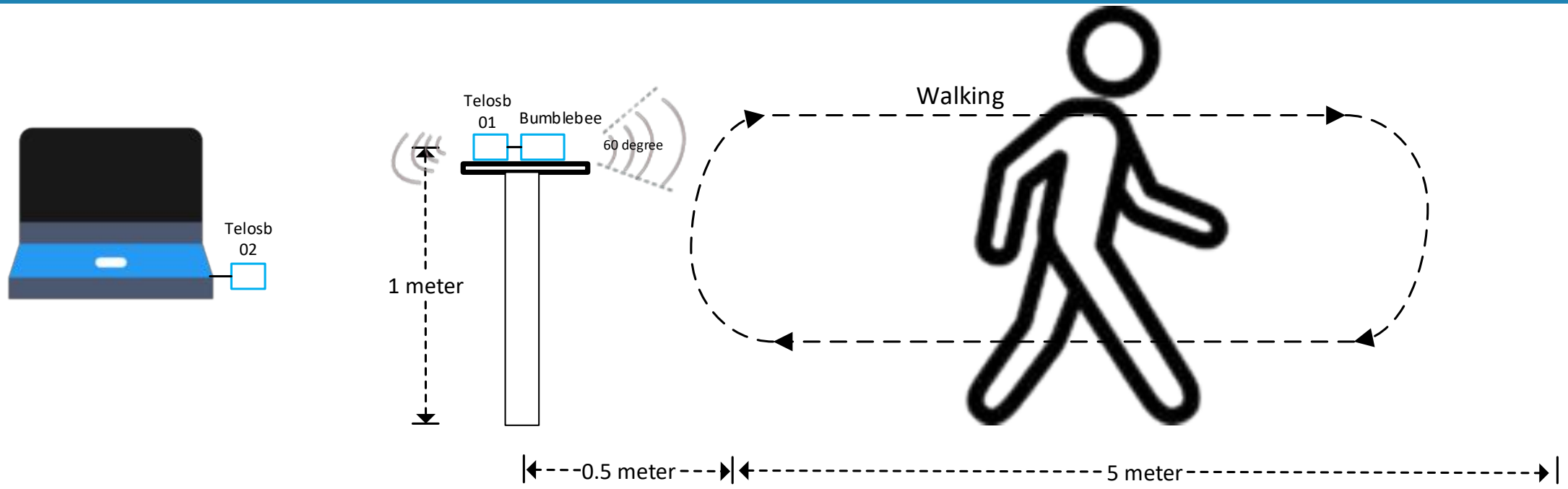
- IEEE 802.15.4/ZigBee compliant RF transceiver
- Runs TinyOS 1.1.10 or higher

low power consumption with long battery life.

Workflow


Bumblebee
Radar
Telosb
Node
Telosb
Basestation
Reflected signals
ZigBee
Serial
port
Signal
processing
mongoDB.
Spectrogram without cluster
Feature
extraction
Support vector machine
K-nearest neighbour
Convolutional neural
network
Running
or
Walking
or
No acitivity

Experimental scenario for behaviours detection



- Two subject targets' participation
- Two kinds of behaviours:
  - walking
  - running
- Three different angles (0°, 45°, 90°) between the movement direction and radar beam

Signal processing

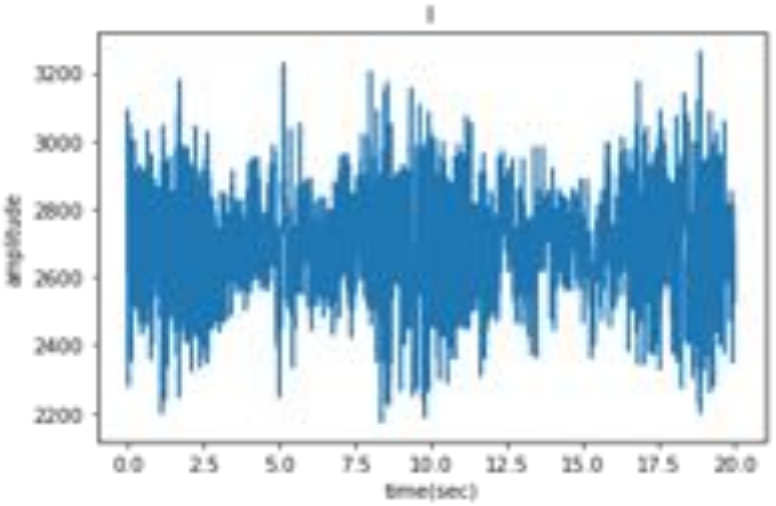
Original signals (Amplitude domain)

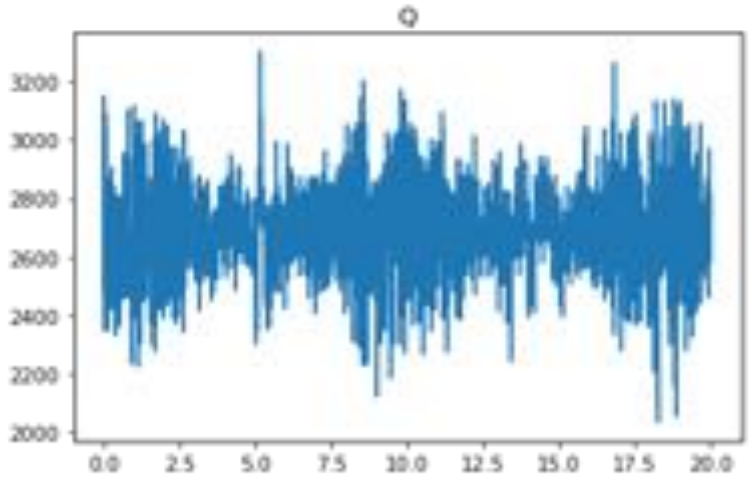
Fast Fourier Transform

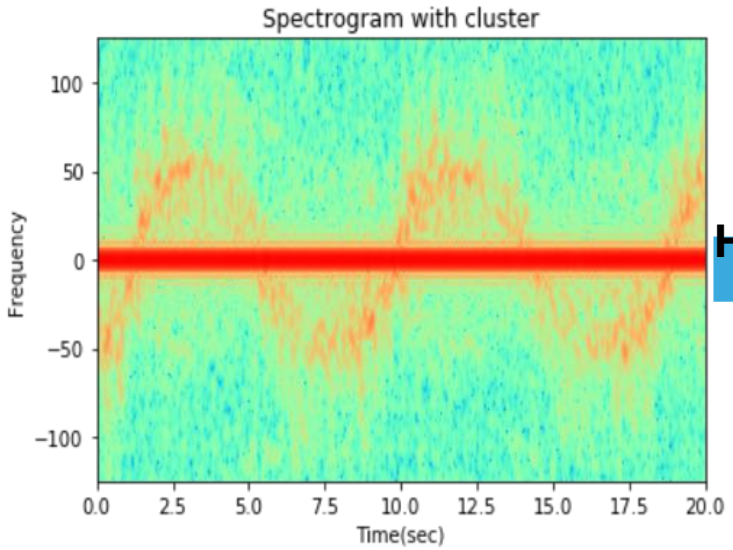
Spectrogram (Frequency domain)

High-pass filter

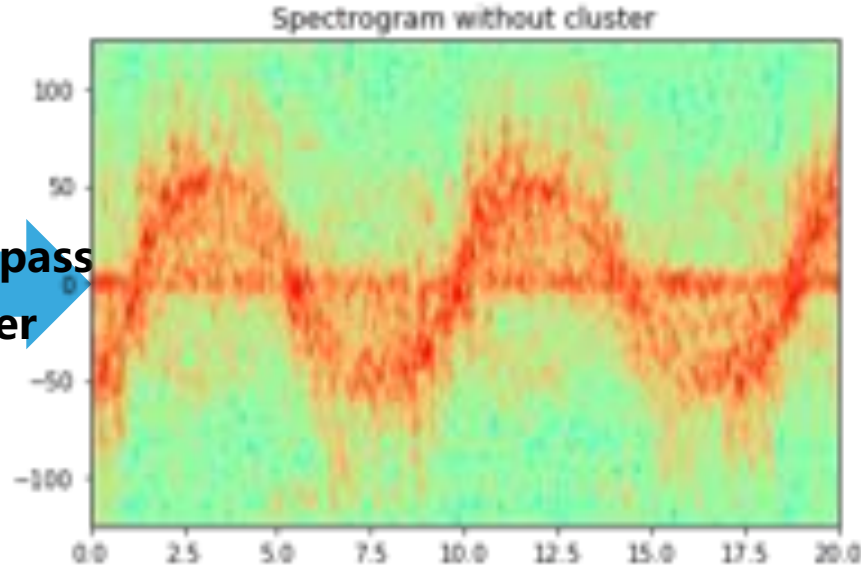
Spectrogram without cluster (Frequency domain)







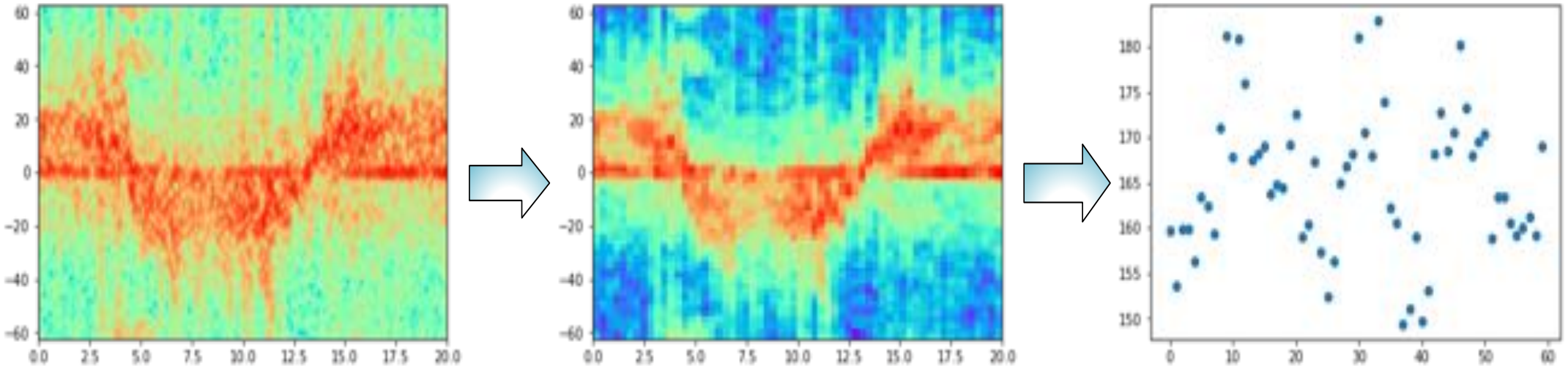
High-pass filter



Feature extraction and dimension reduction

Too many feature in each spectrogram !

Feature extraction:



2048*304*1 50*50*1 50*1

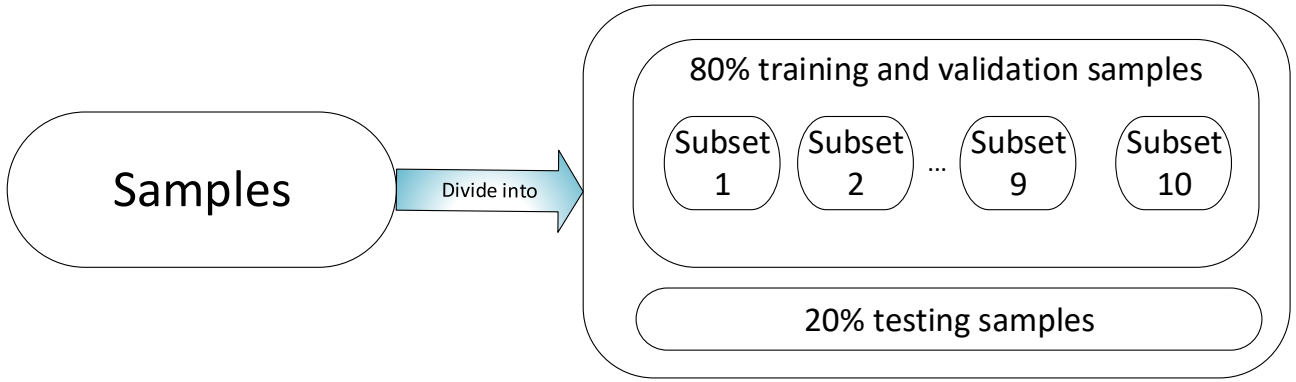
The composition of samples

The composition of the samples.

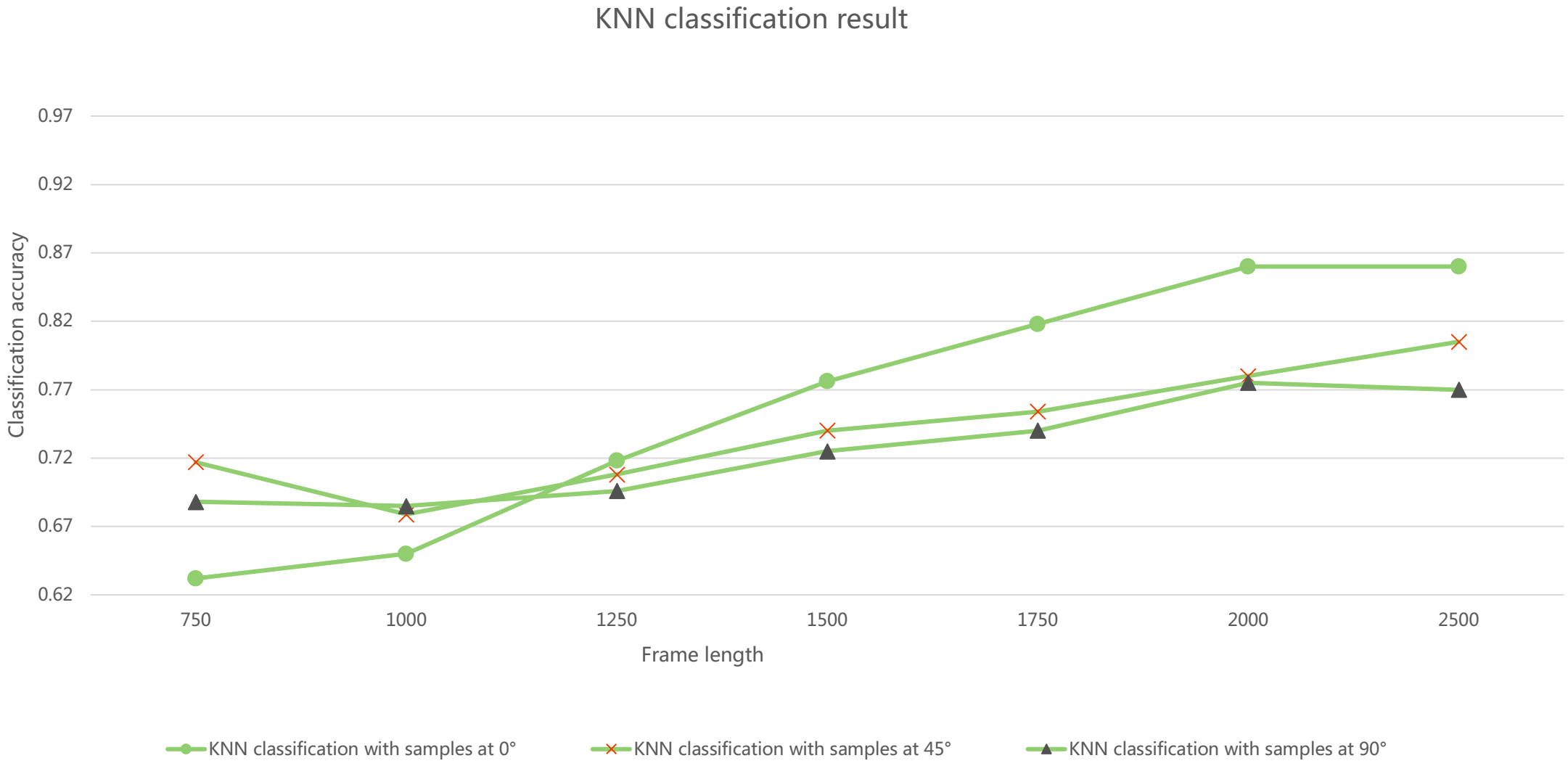
	Walking	Running	Background	Total
90°	4550	3950	3650	12150
45°	5000	3800	4000	12800
0°	3300	3200	3800	10300

80% for training and validation, and 20% for test.

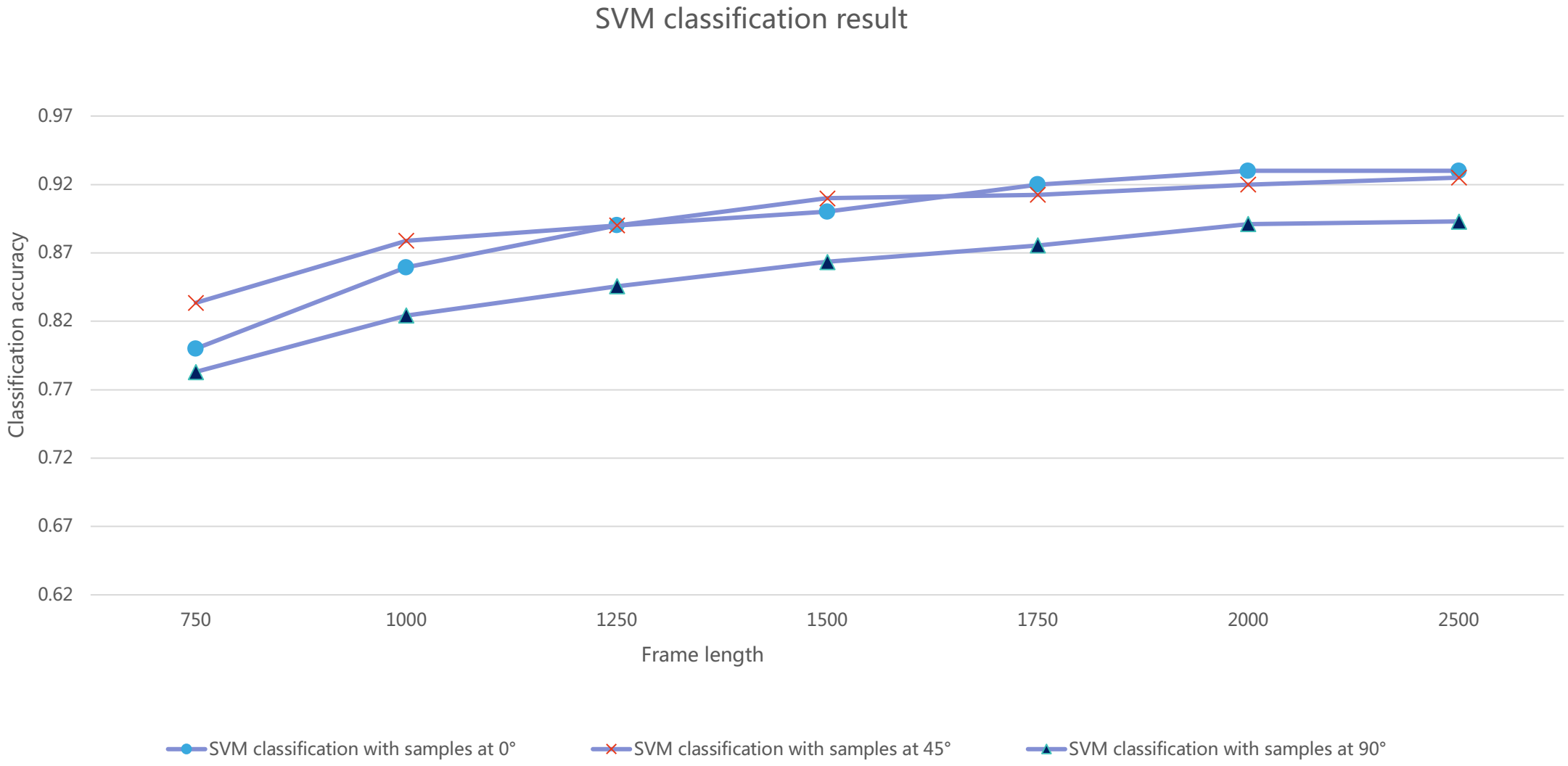
10-fold cross-validation has been applied



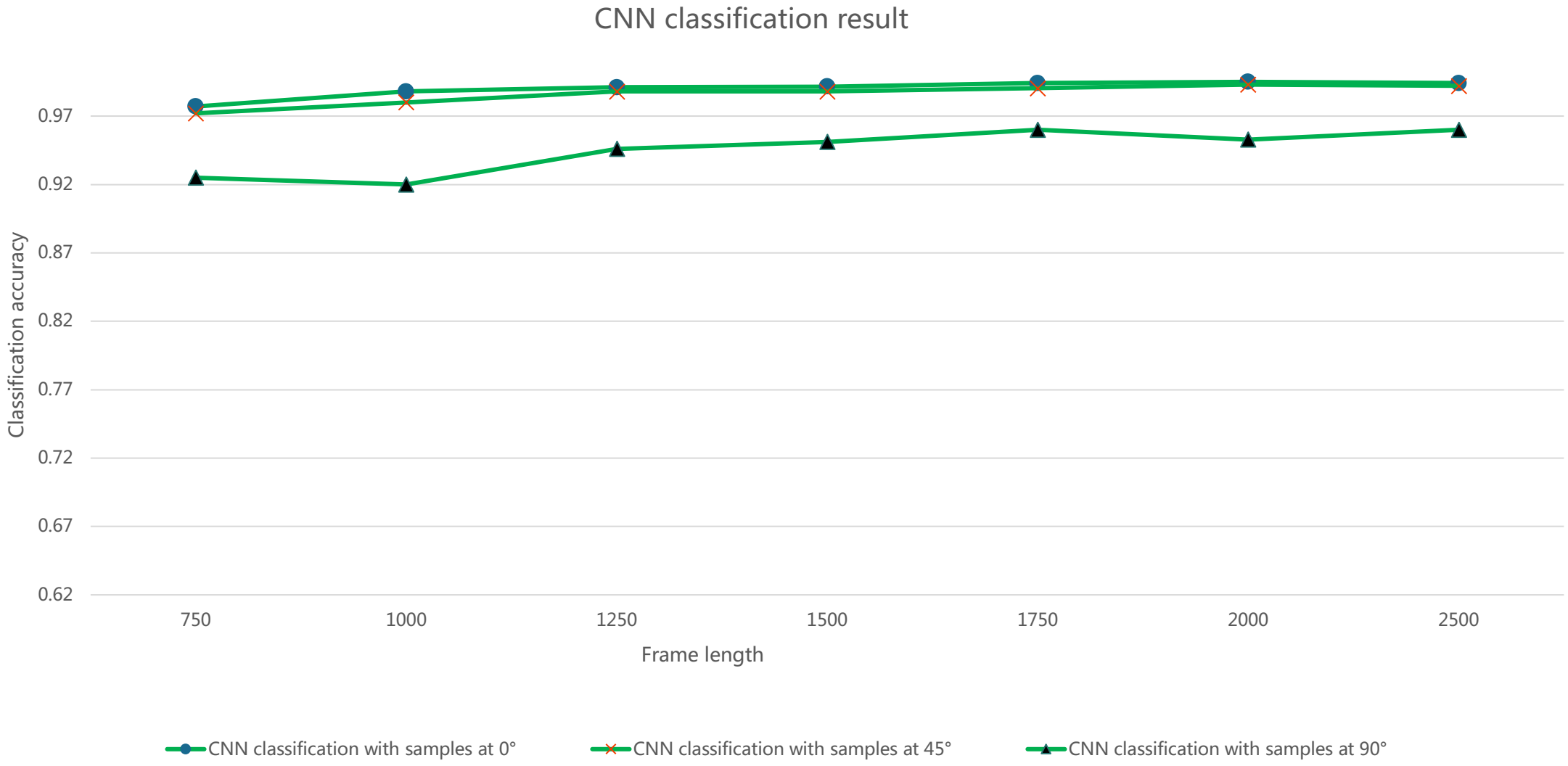
Result


KNN classification result
Classification accuracy
0.97
0.92
0.87
0.82
0.77
0.72
0.67
0.62
750
1000
1250
1500
1750
2000
2500
Frame length
KNN classification with samples at 0°
KNN classification with samples at 45°
KNN classification with samples at 90°

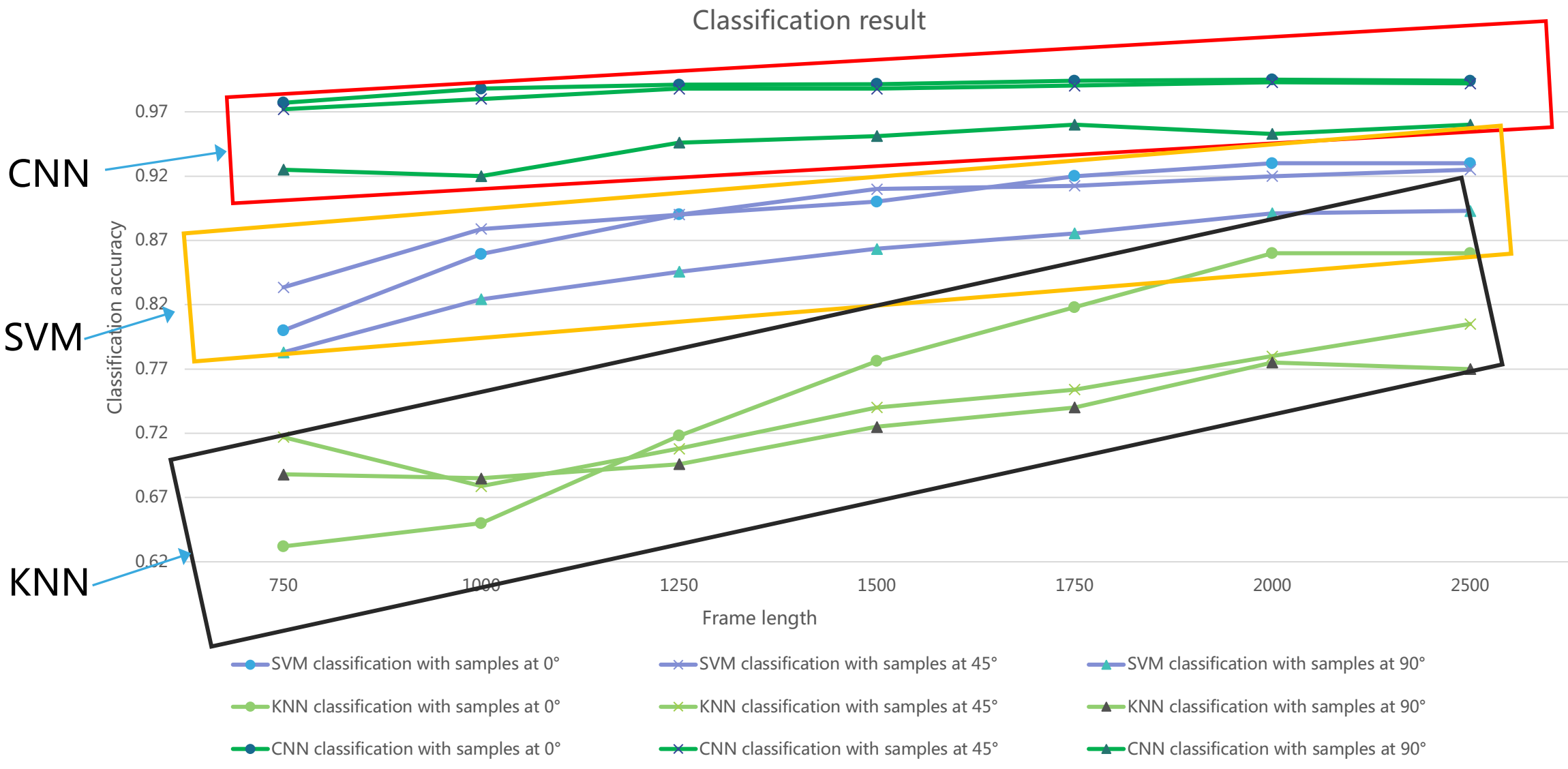
Result


SVM classification result
0.97
0.92
0.87
0.82
0.77
0.72
0.67
0.62
Classification accuracy
750
1000
1250
1500
1750
2000
2500
Frame length
SVM classification with samples at 0°
SVM classification with samples at 45°
SVM classification with samples at 90°

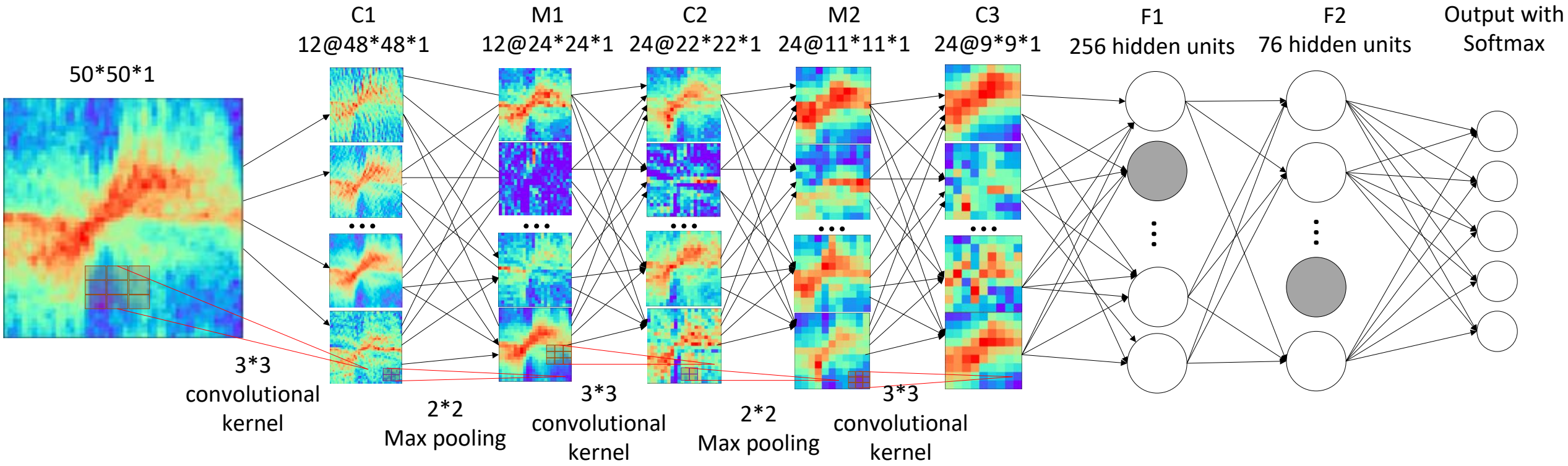
Result


CNN classification result
Classification accuracy
0.97
0.92
0.87
0.82
0.77
0.72
0.67
0.62
750
1000
1250
1500
1750
2000
2500
Frame length
CNN classification with samples at 0°
CNN classification with samples at 45°
CNN classification with samples at 90°

Result


Classification result
CNN
SVM
KNN
Classification accuracy
0.97
0.92
0.87
0.82
0.77
0.72
0.67
0.62
750
1000
1250
1500
1750
2000
2500
Frame length
SVM classification with samples at 0°
SVM classification with samples at 45°
SVM classification with samples at 90°
KNN classification with samples at 0°
KNN classification with samples at 45°
KNN classification with samples at 90°
CNN classification with samples at 0°
CNN classification with samples at 45°
CNN classification with samples at 90°

The structure of CNN



Future work

This work achieved indoor human activity (running, walking) detection using micro-Doppler radar.

Challenges:

(1) How to make sure these activities are made by human, not animals ?

(2) Whether high classification rate could still be achieved in the **outside ?**

(3) More behaviours are expected be considered in foreseen experiments.

THANK YOU !

QUESTION ?