USO DI TECNICHE DI MACHINE LEARNING PER LA CLASSIFICAZIONE DI SEGNALI RADAR

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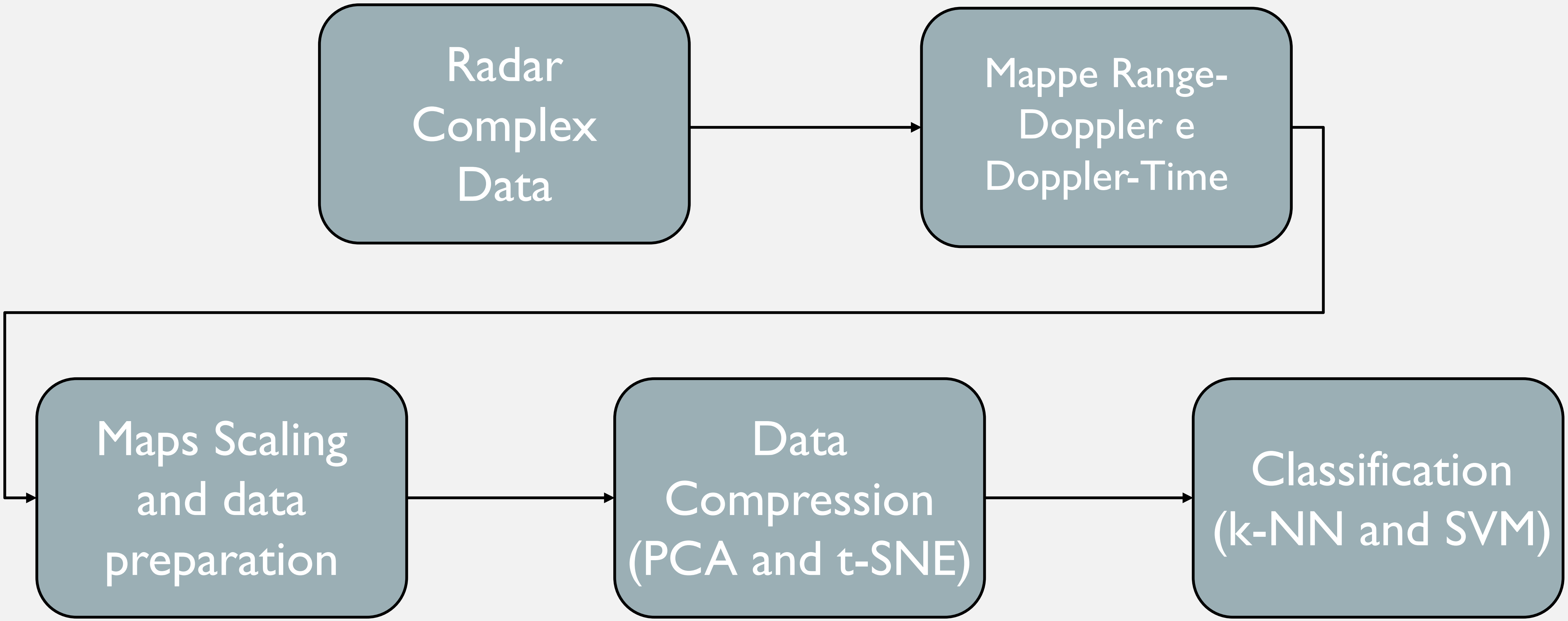
HUMAN GAIT RECOGNITION WITH RADAR SYSTEMS

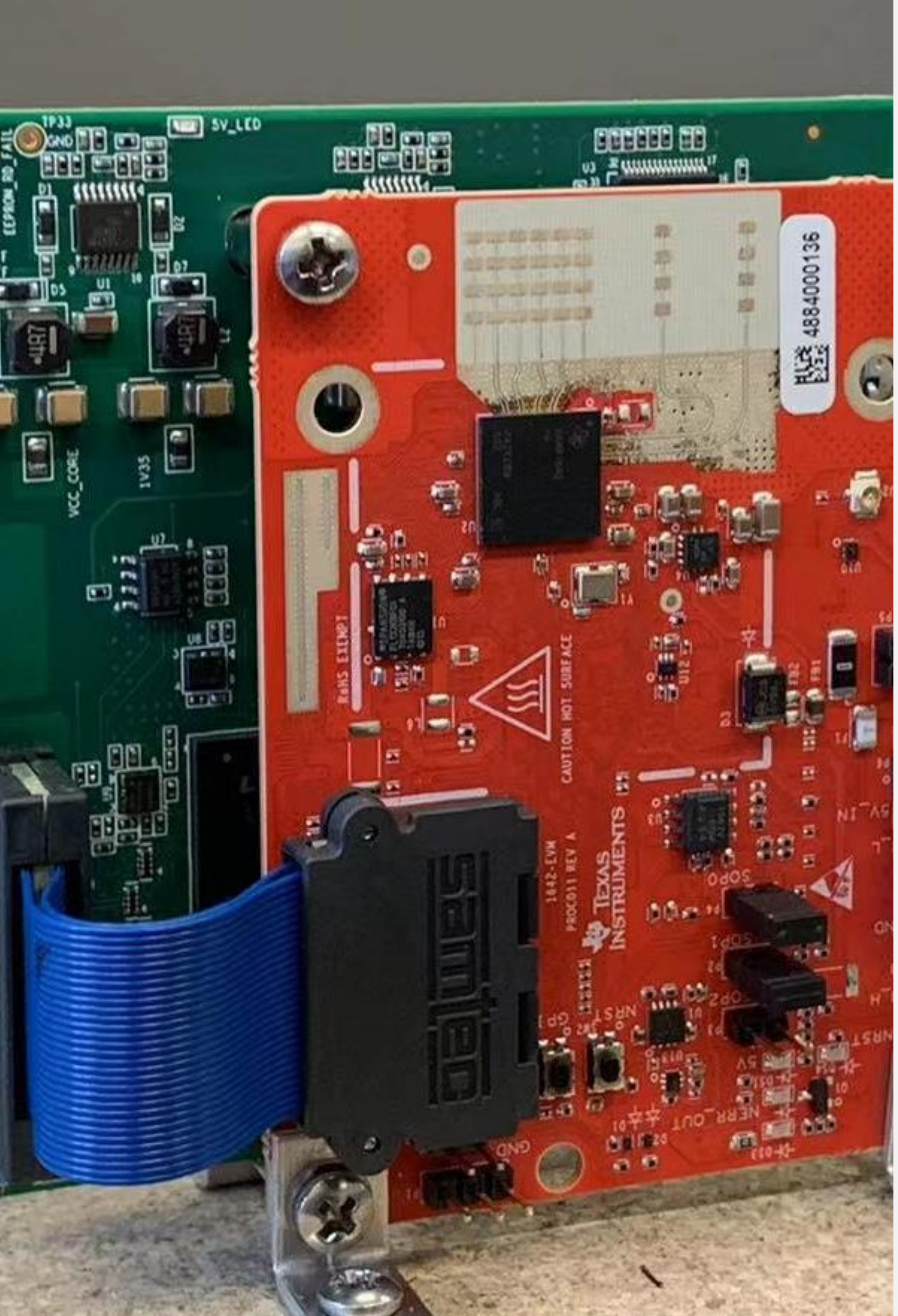
- Recognition of a person's type of movement has implications for many aspects of daily life, from security applications to monitoring for assisted living. Discriminating whether a person is running or walking normally in airports or shopping centers, for example, may help video surveillance to detect possible dangerous situations [1];

- Tools designed for this purpose involve the use of contactless devices, and radar technology is particularly suitable for the mentioned scenario. [1]

- In this work we consider the use of an automotive radar to classify different types of monitored actions.

DATA PROCESSING PIPELINE



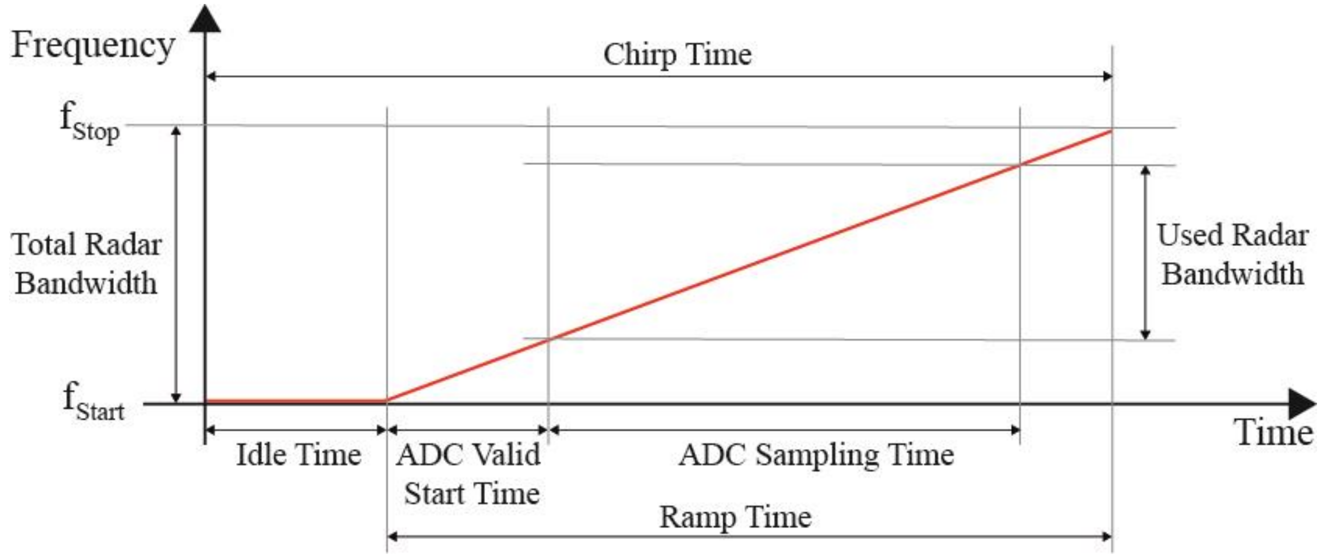


RADAR AWR1642 E DCA1000

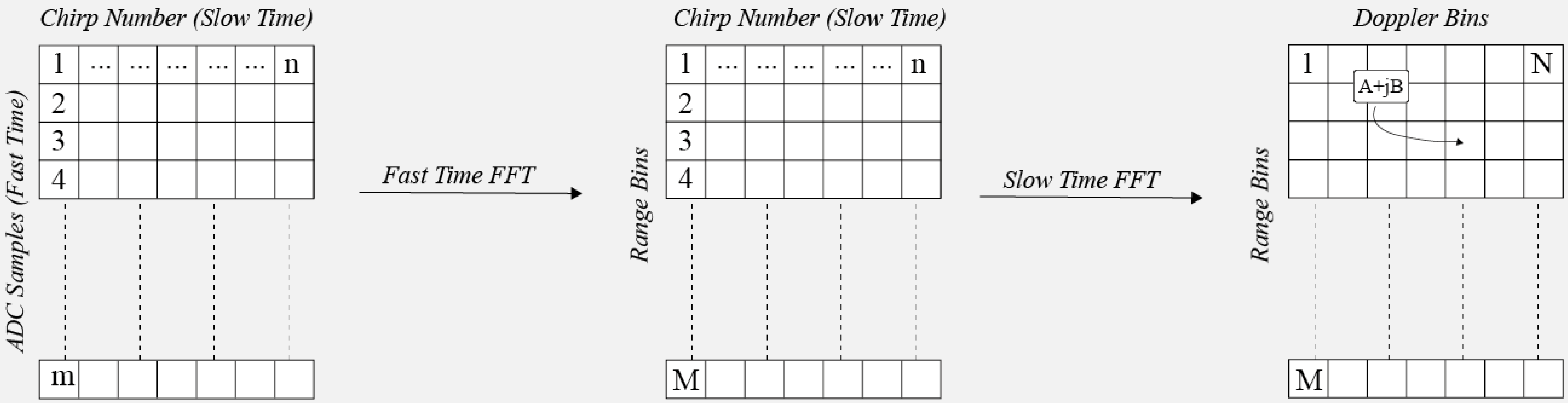
- Automotive FMCW
- Range operativo da 76-77 GHz o 77-81 GHz;
- Banda massima 4 GHz;
- MIMO: 2 TX e 4 RX;
- Fs massima 12 MSps;
- Streaming dati mediante UDP.

RADAR CONFIGURATION

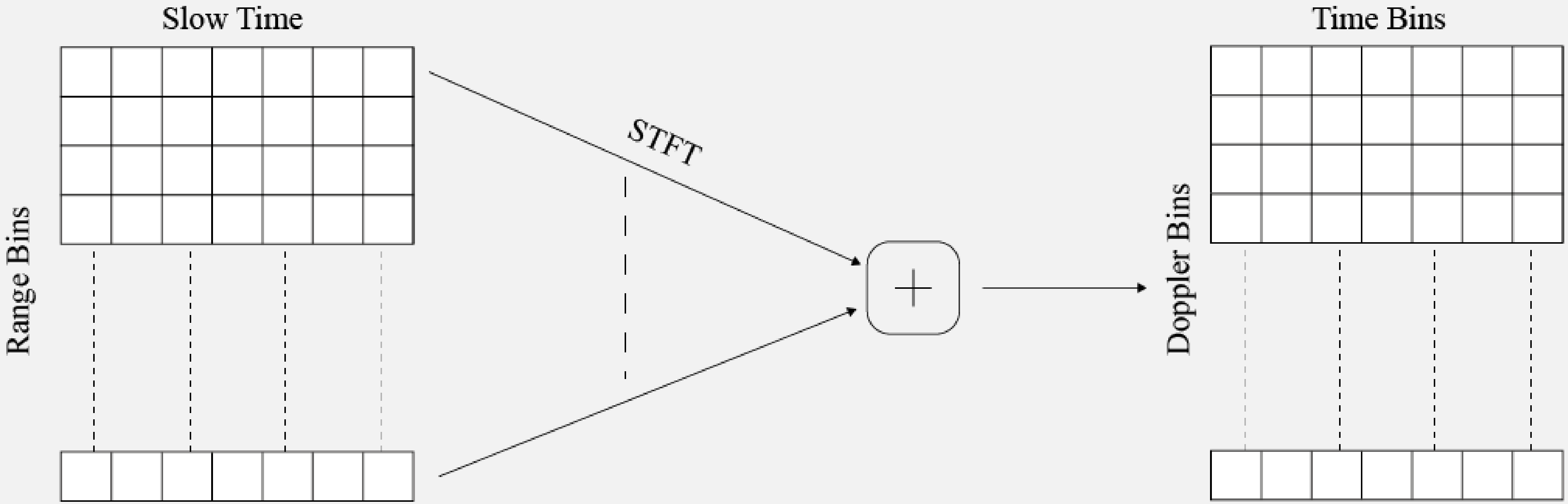
Parameter	Value
f_{start}	77 GHz
S	60.012 MHz/µs
t_{idle}	100 µs
ADC Valid Start Time	6 µs
f_s	10 Msps
t_{ramp}	60 µs
$n_{samples}$	512
n_{frame}	400
no. of chirps per frame	128
Periodicity	40 ms
Used Radar Bandwidth	3.6 GHz



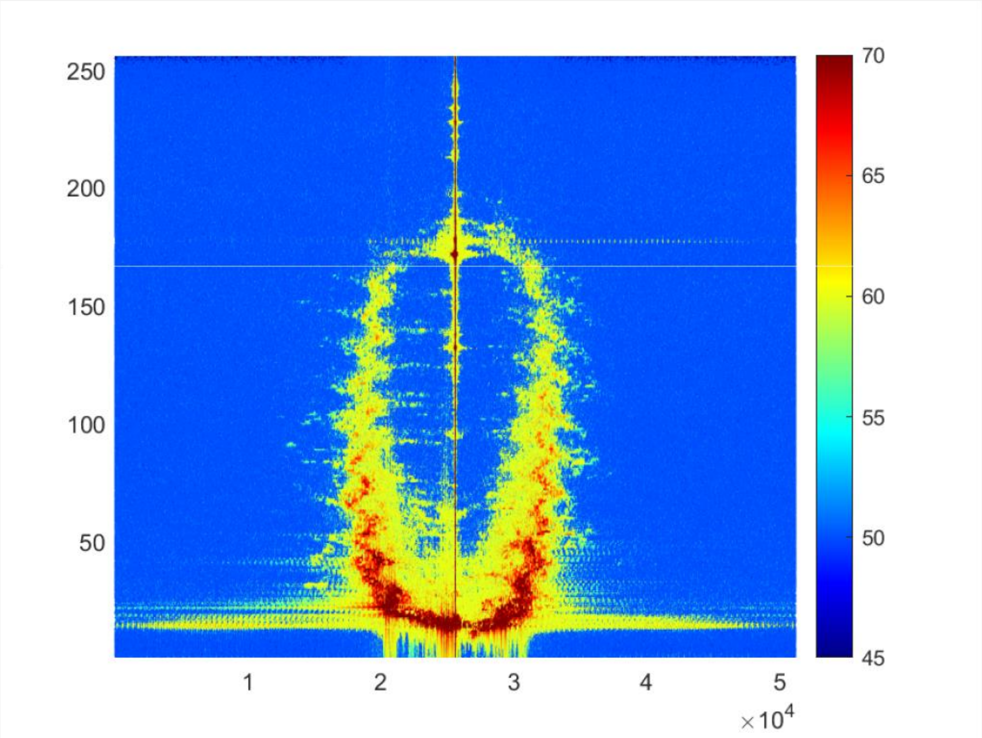
RADAR SIGNAL PROCESSING (RANGE-DOPPLER)

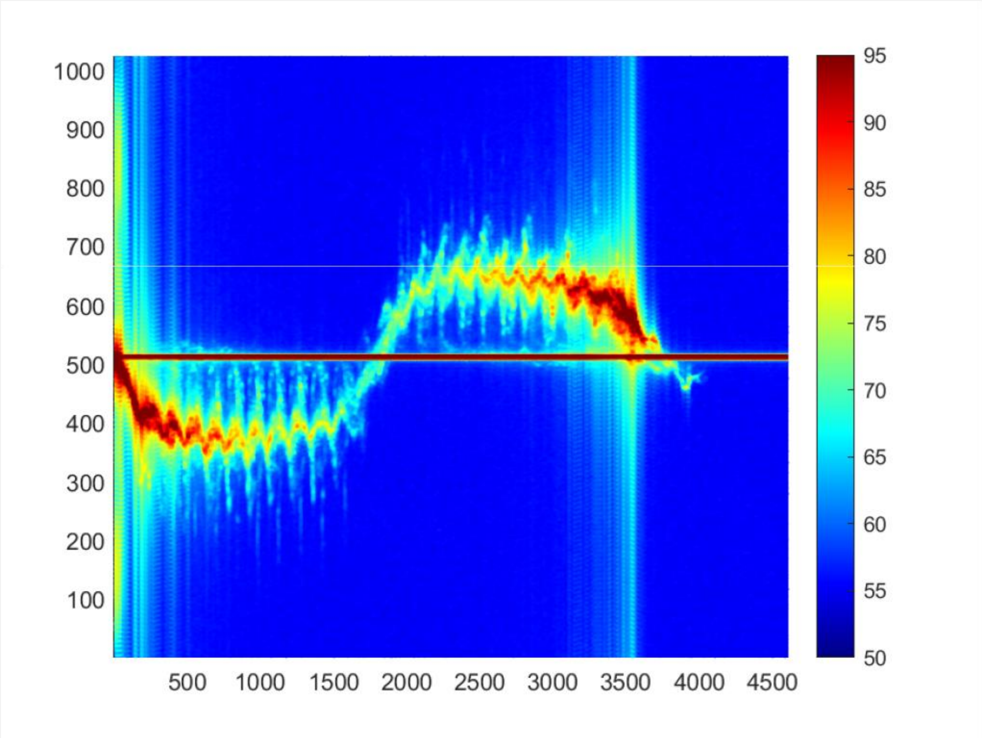


RADAR SIGNAL PROCESSING (DOPPLER-TIME)



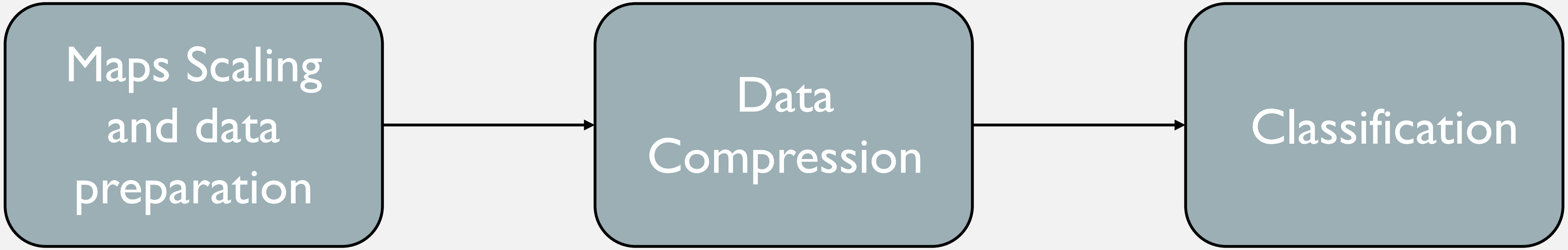
DATASET





- 19 soggetti;
- 3 diverse attività: Slow walk, Fast walk, Slow walk with hands in pockets;
- 171 acquisizioni : 60% per training e il 40% per il test.

MACHINE LEARNING PIPELINE



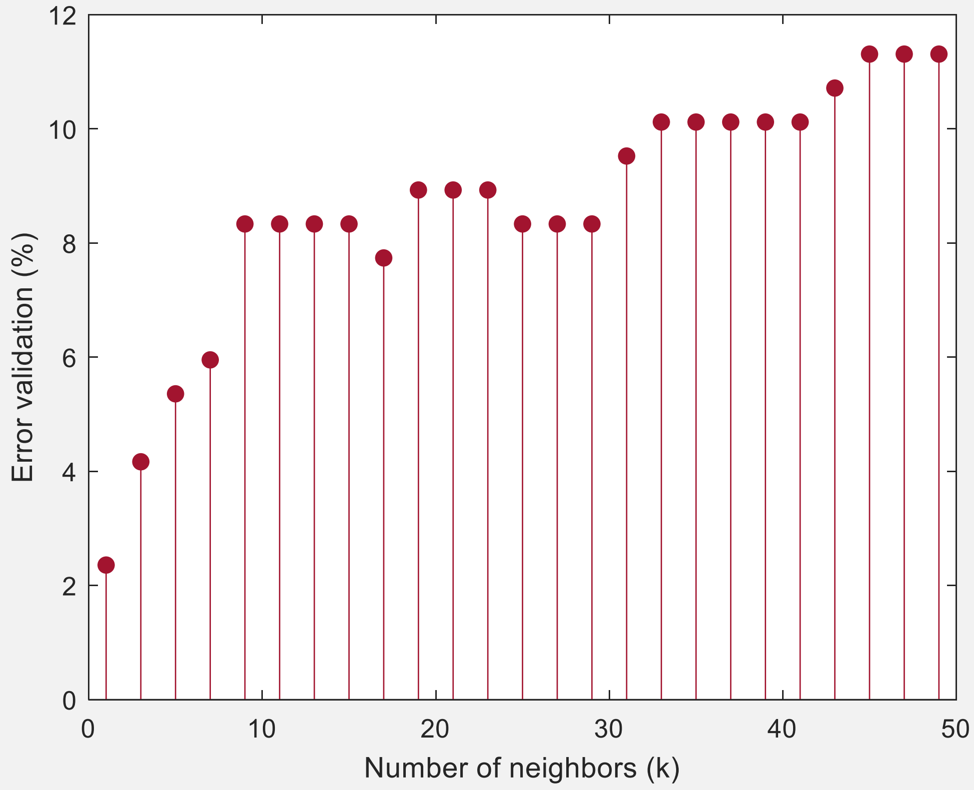
- Principal Component Analysis;
- t-Stochastic Neighbours Embedded.

- k-Nearest Neighbours;
- Support vector Machine.

CLASSIFICATION

k-NN:

- Supervised nonparametric algorithm;
- Instance-based learning;
- Storage and computation costs depend on the training set dimension;
- Majority vote among the *k* closest neighbors to a given unknown instance;
- Leave-one-out cross-validation algorithm for optimization of *k*.



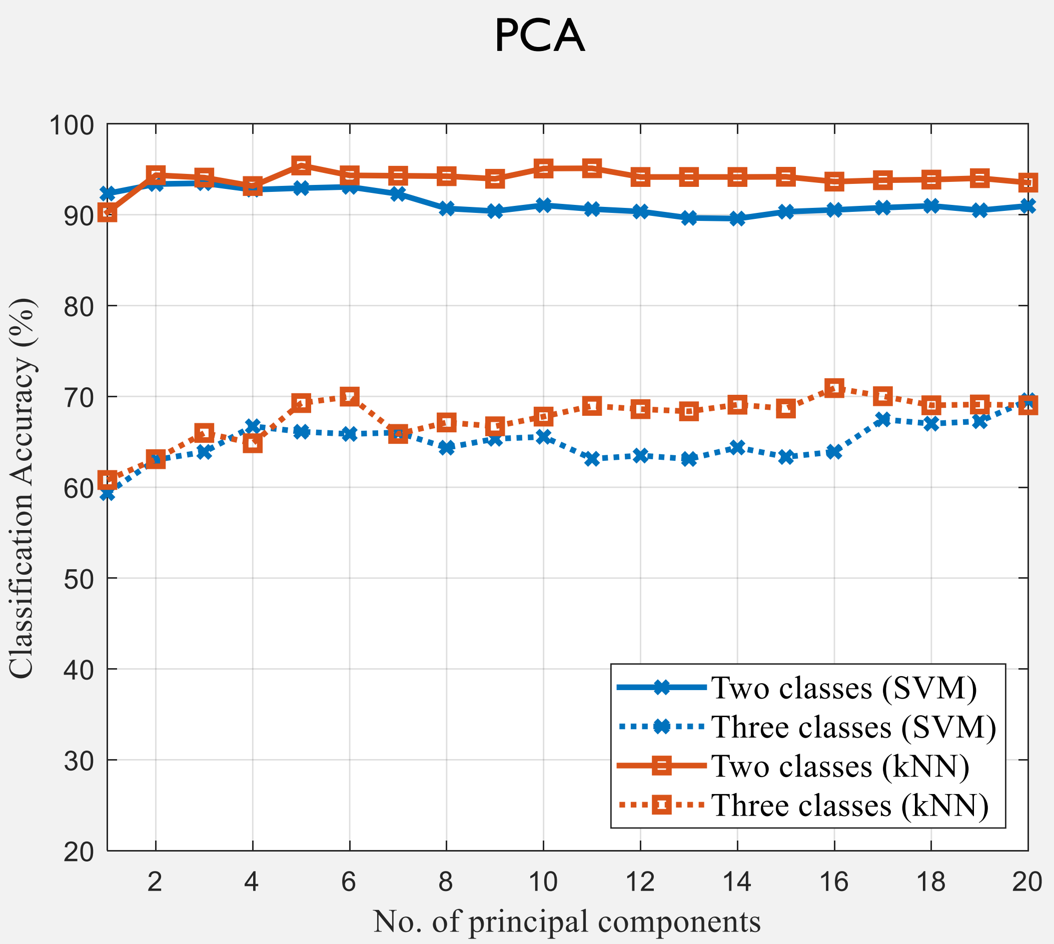
CLASSIFICATION

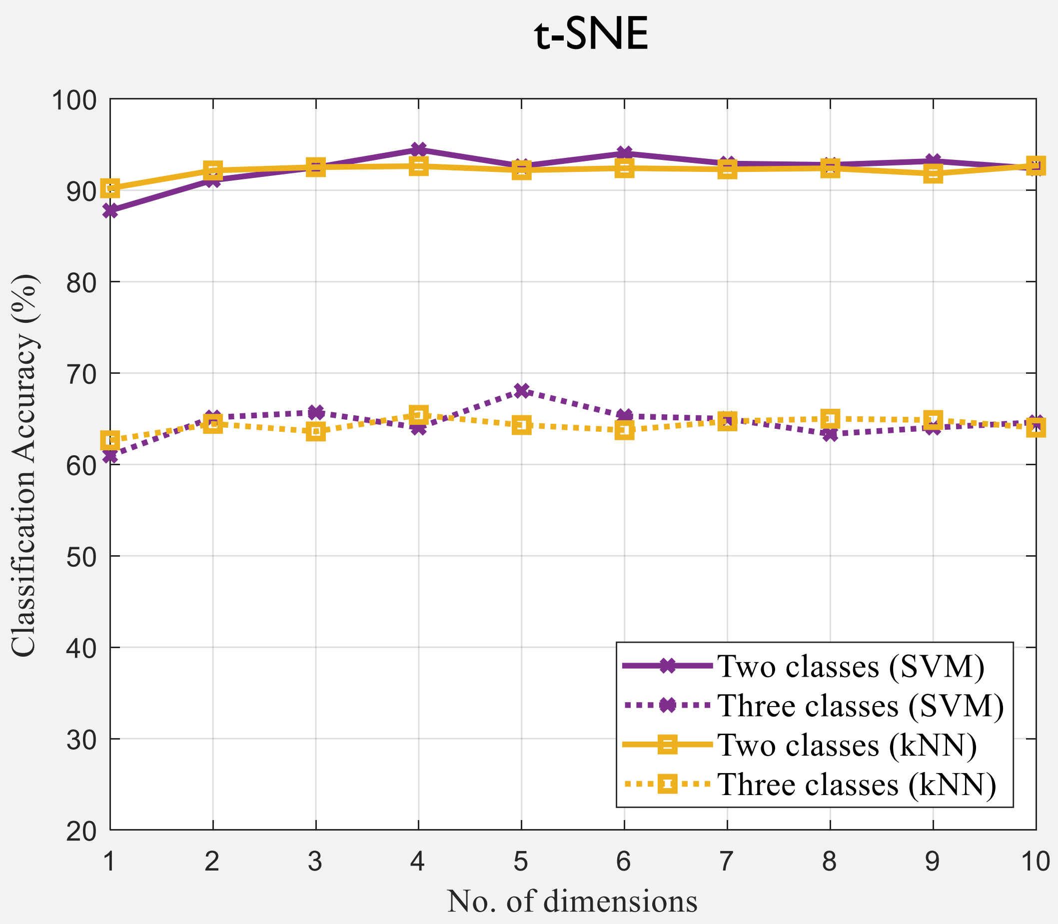
<u>SVM</u>:

- Supervised nonparametric algorithm;
- It creates a linear or non-linear decision boundary to separate different classes;
- It projects the data through a non-linear function to a space with a higher dimension;
- Different types of kernel;
- Best kernel chosen through leave-one-out-cross-validation.

Kernel	Linear	Gaussian	Polynomial
Error validation (%)	4.46	17.26	33.33

DATA COMPRESSION





RISULTATI - 1

True/Predicted	S	F
Slow walk (S)	110 (109)	2 (3)
Fast walk (F)	9 (8)	47 (48)

- 5 principal components;
- 93.5% accuracy (both k-NN and SVM).

True/Predicted	S	F	SH
Slow walk (S)	33 (32)	2 (1)	21 (23)
Fast walk (F)	4 (5)	49 (48)	3 (3)
Slow walk hands in pockets (SH)	16 (22)	1 (2)	39 (32)

- 3 principal components;
- 72% accuracy (SVM);
- 66.7% accuracy (k-NN).

RISULTATI - 2

Radar Type	N° Activities	Dataset Dimension	Algorithm	Best Accuracy
[1] FMCW mmWave	2	19 subjects, 168 acquisitions	PCA/t-SNE + k-NN/SVM	93.5%
[1] FMCW mmWave	3	19 subjects, 168 acquisitions	PCA/t-SNE + k-NN/SVM	72%
[2] UltraWide Band	7	8 subjects, 280 acquisitions	PCA + SVM	89.1%
[3] FMCW mmWave	5	3 subjects, 95 acquisitions	CV/TV + SVM	91%

RIFERIMENTI BIBLIOGRAFICI

- 1 - Senigagliesi, L.; Ciattaglia, G.; De Santis, A.; Gambi, E. People Walking Classification Using Automotive Radar. Electronics 2020, 9, 588.
- 2 - Bryan, J.D.; Kwon, J.; Lee, N.; Kim, Y. Application of ultra-wide band radar for classification of human activities. IEEE Proc.-Radar Sonar Navig. 2012, 6, 172–179;
- 3 - Björklund, S.; Petersson, H.; Hendeby, G. Features for micro-Doppler based activity classification. IEEE Proc.-Radar Sonar Navig. 2015, 9, 1181–1187.