Human Fall Detection: A Multimodal approach

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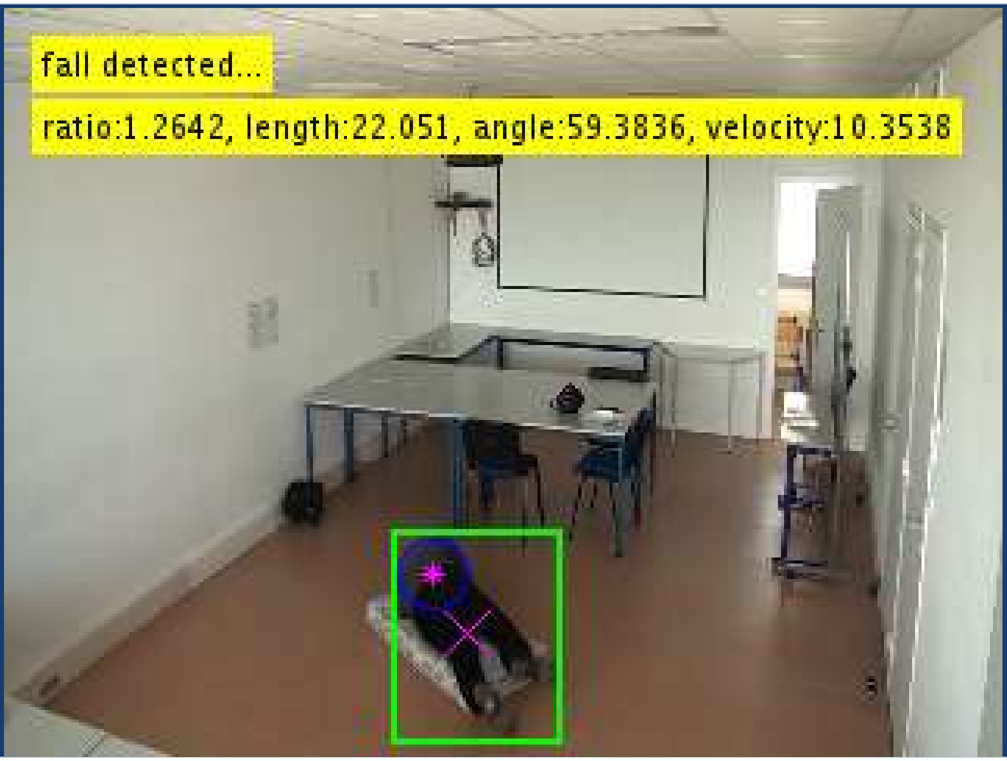
Outline

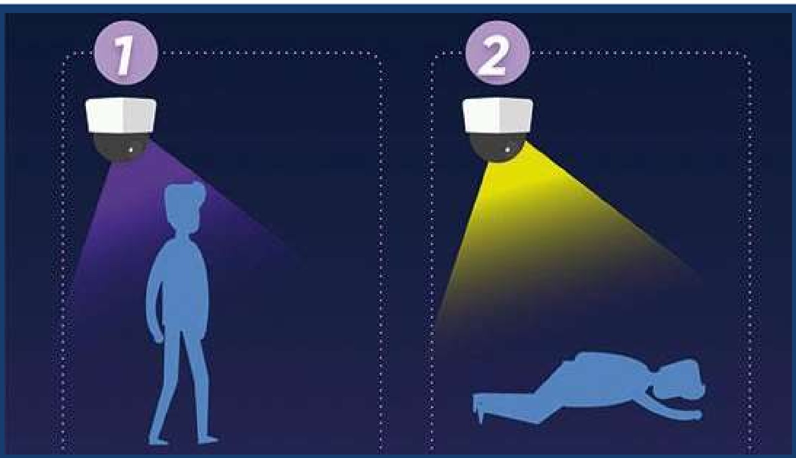
- Motivation
- Current systems
- Problems with unimodal system
- Multimodal strategy
- Dataset
- Experiments and Results
- Conclusion

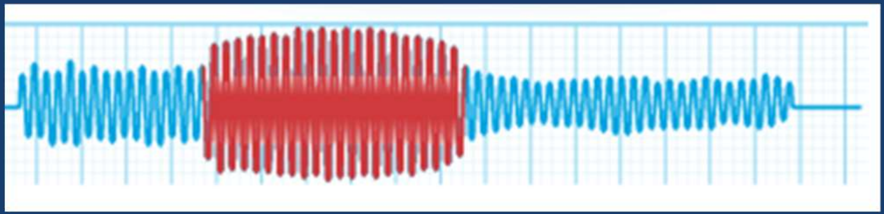
Motivation

- According to WHO fall is the leading cause of fatal and non-fatal injuries among elderly.
- According to demographic projections, the percentage of individuals aged 60 and above in the global population will almost double from 12% in 2015 to 22% by the year 2050.
- A timely assistance and recovery from fall is crucial.
- A late medical attention may lead to severe injuries or death.

Solution







Automatic, reliable, real-time fall detection system

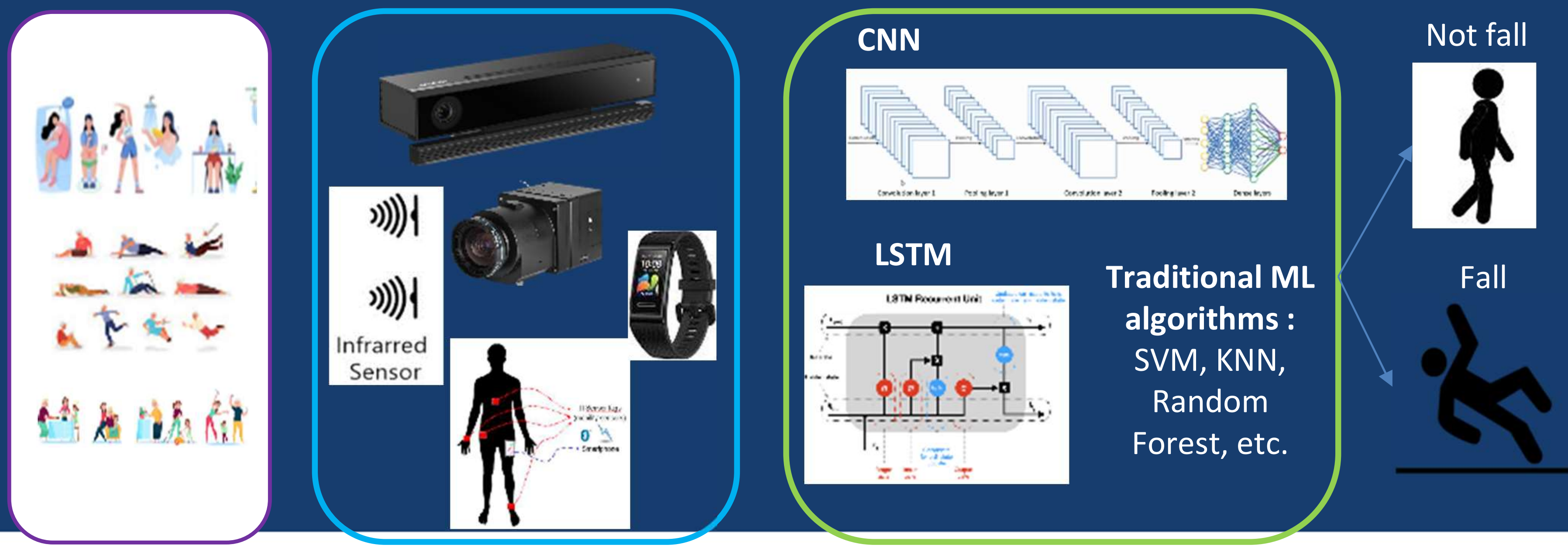
Current Fall Detection Systems

Sensor-based systems
- Gyroscope
- Accelerometer

Visual Surveillance-based systems
- RGB camera
- Depth camera
- Motion capture devices

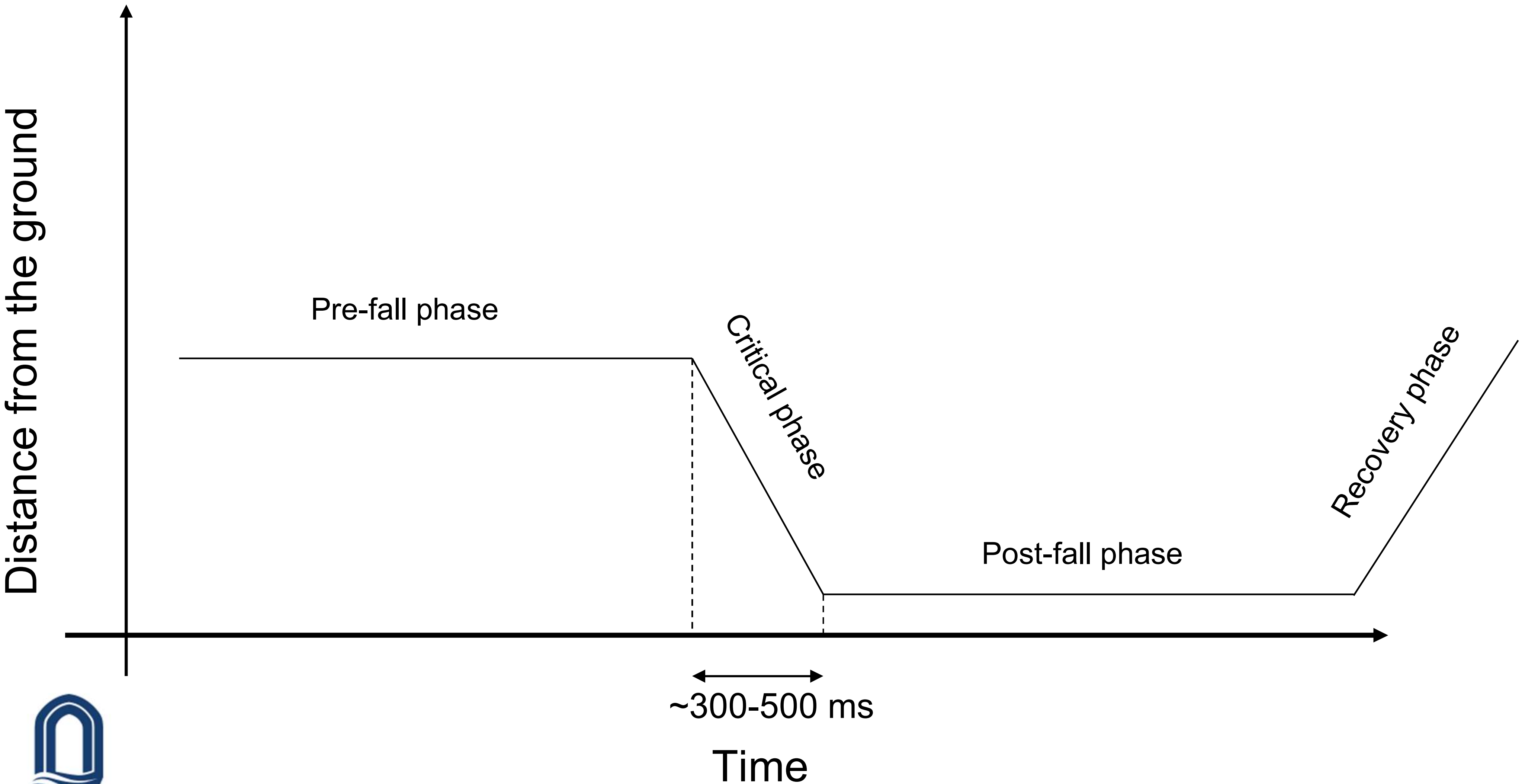
Ambient systems
- Pressure sensors on the floor

General framework for a fall detection system



Surveillance area | Sensing unit | Data processing | Fall detection

Falling down event: timing analysis



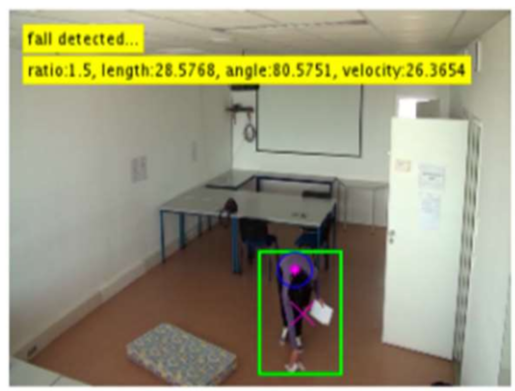
Unimodal systems characteristics

- Data collection and system training is quite easy
- It is relatively more cost effective
- The system accuracy and efficiency is limited
- Depending of the sensing unit, we may lose important information

(i) Z-fall, false negative

(d) Scouting

(k) Perpendicular-fall

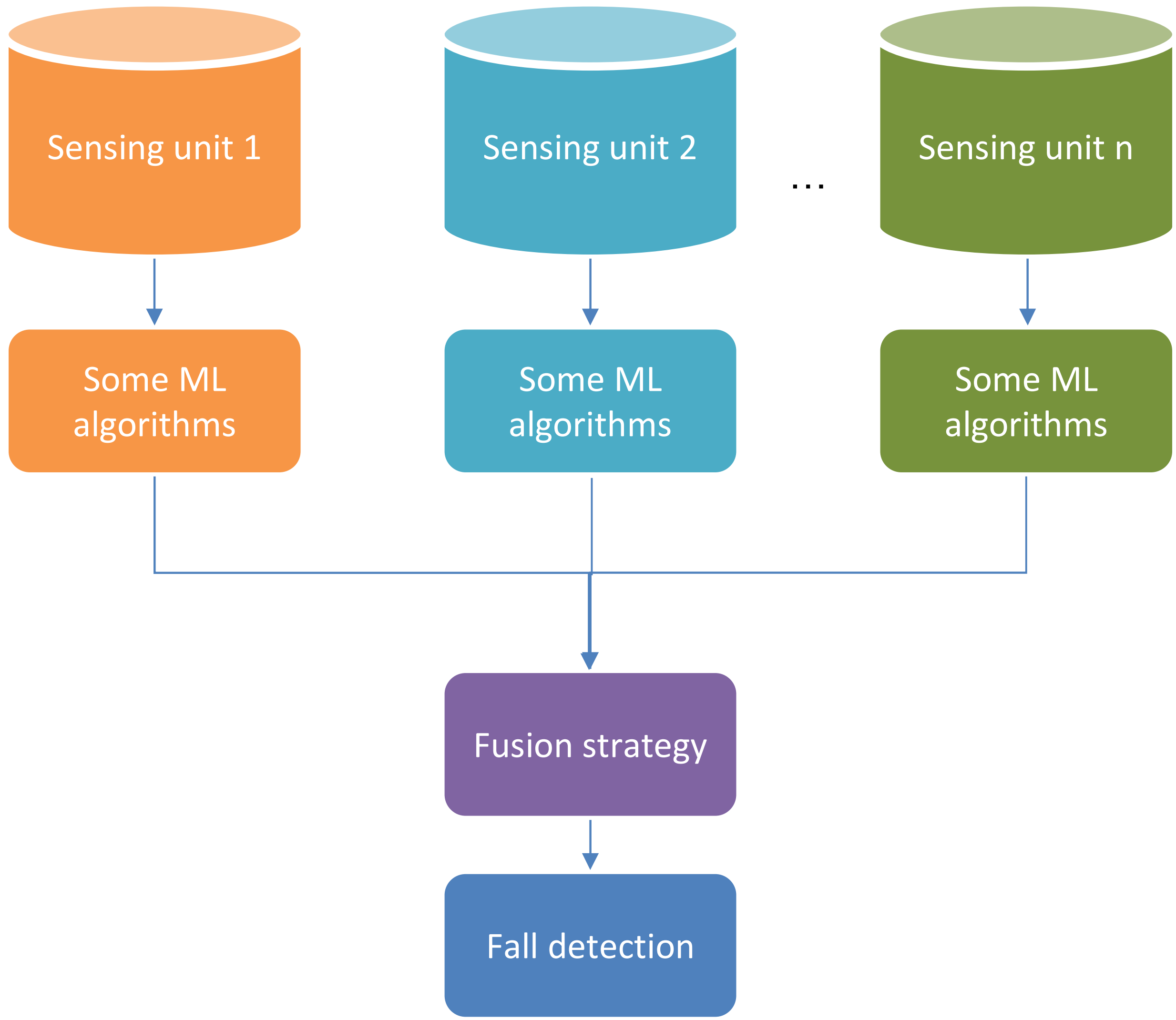


(g) Bending, false positive

Multimodal systems characteristics and challenges

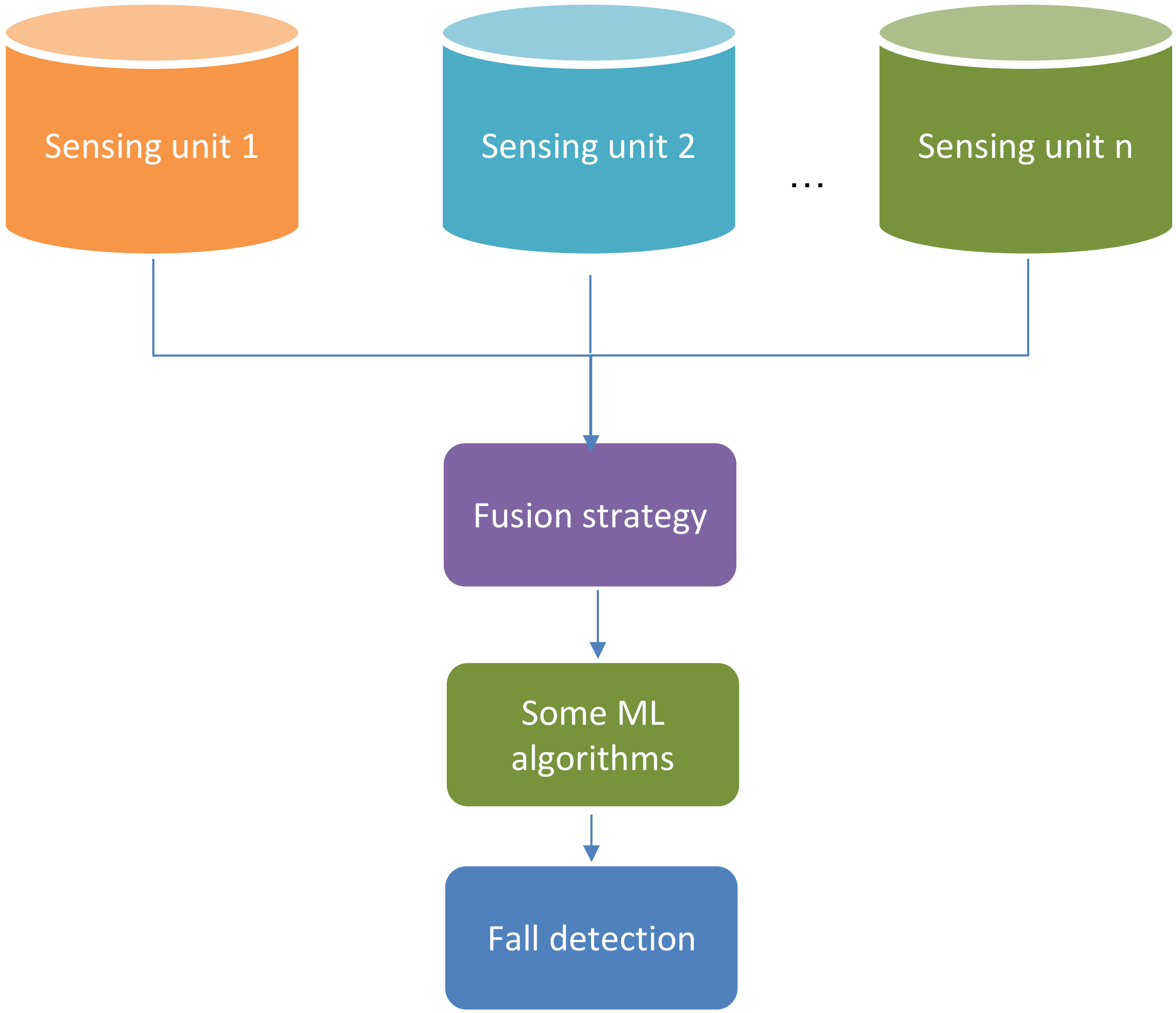
- Analyze data, find meaningful patterns and perform prediction by combining multiple heterogeneous sensing units
- Data collection will be more expensive and challenging (synchronization)
- The multimodal systems will be more accurate, efficient and robust to noises and errors
- Open question: How to fuse information from different sources?

Fusion strategies



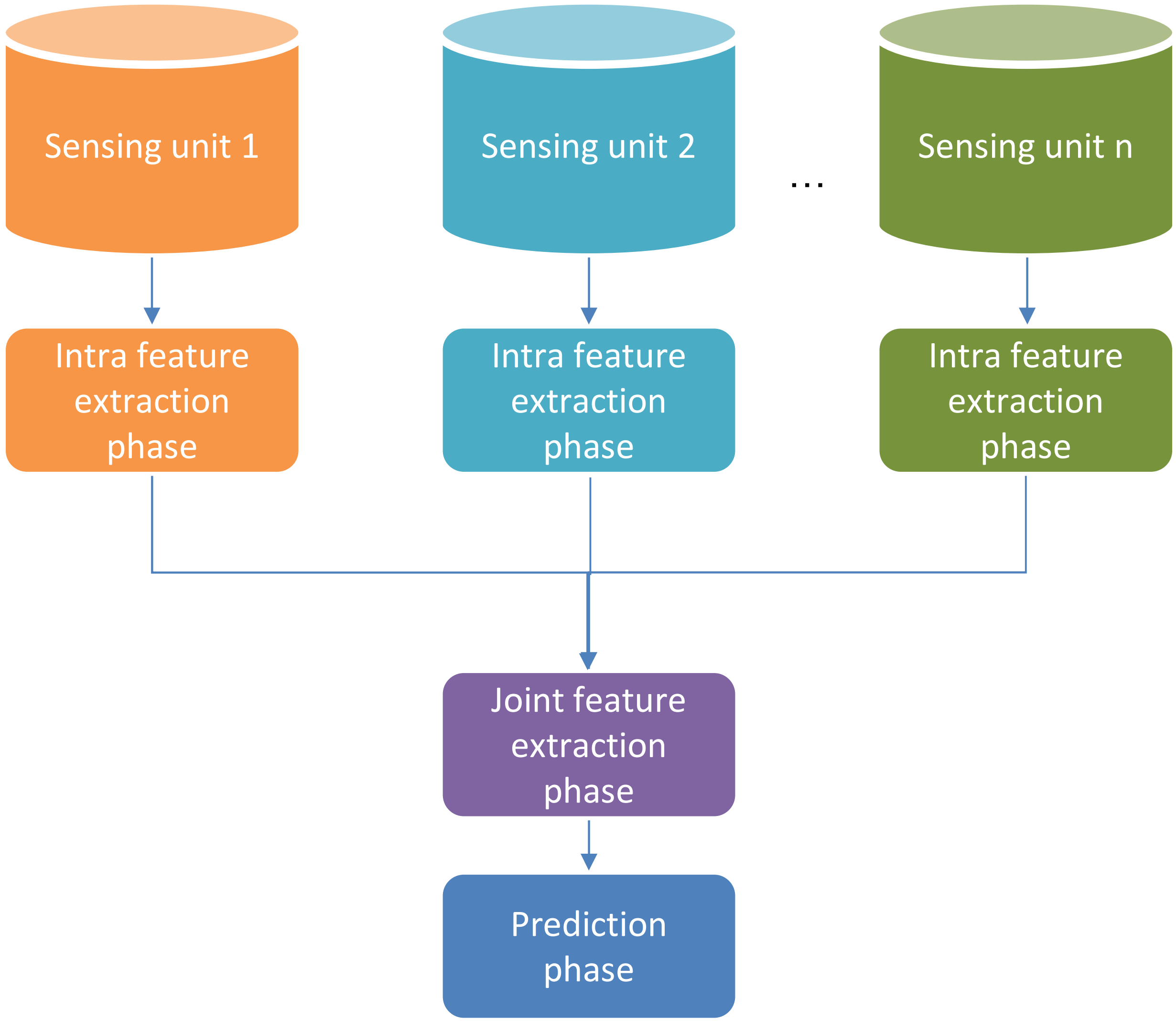
Late Fusion

Fusion strategies



Early Fusion

Fusion strategies



Intermediate Fusion

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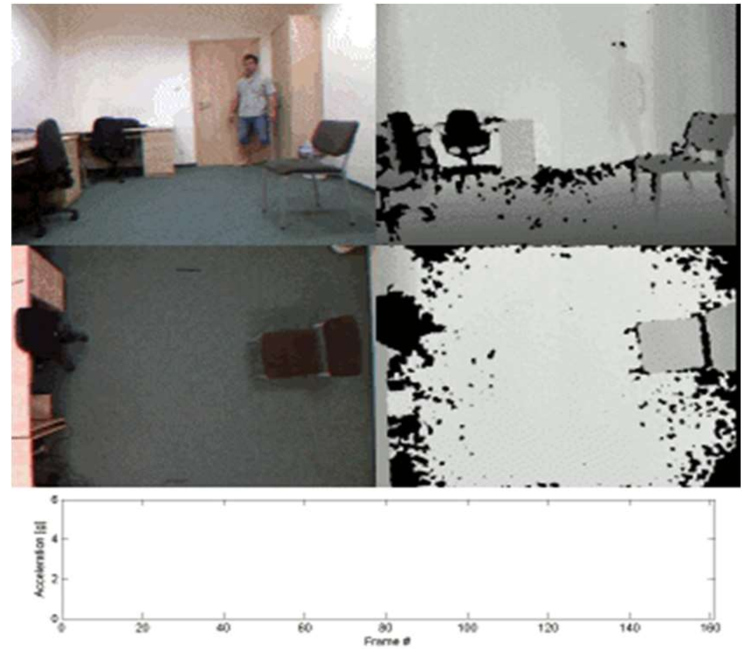
Dataset

UR fall detection dataset

Kwolek, B., & Kepski, M. (2014). Human fall detection on embedded platform using depth maps and wireless accelerometer. *Computer methods and programs in biomedicine*, *117*(3), 489-501.
http://fenix.univ.rzeszow.pl/ mkepski/ds/uf.html



Sensors model	No. subjects (F/M)	No. of samples (DLA/falls)	Position of sensors	Visual sensors	Action types (ADLs/Falls)	Fall Types
x-IMU (256Hz)	(0/5)	70 (40/30)	Near pelvis (waist)	• 2 Kinect cameras • 2 RGB cameras	4/2	• falling from standing • falling from sitting

Data preparation

- Synchronization
- Data reshaping
- Resizing
- Normalization

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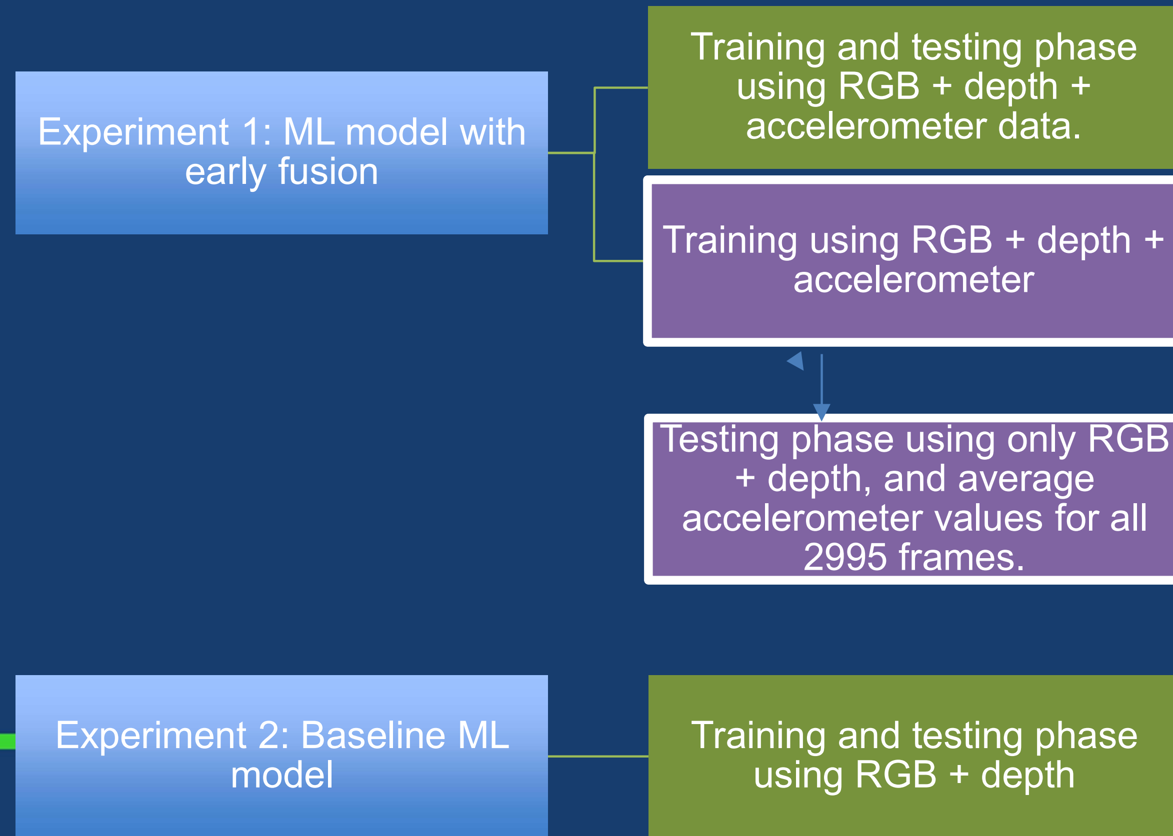
Experiments Design



Experiment	Variant	**Precision**	**Recall**	**F1-score**	**Accuracy**
1	i	**0.97**	0.96	**0.97**	**97.25**
	ii	0.94	0.98	0.96	94.99
2	i	0.91	**0.99**	0.95	95.16

Conclusion and future work

- A multimodal fall detection system is more efficient and accurate compared to a unimodal system
- A multimodal system with early fusion strategy is robust to the loss of sensing units
- More studies and experiments are needed to compare early fusion and intermediate fusion strategy

THANK YOU

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