CareWell

Cooperative Human Activity Recognition and Localization for Healthcare and Wellbeing

Overview

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Outline

- Introduction
- Vision of CareWell
- Objectives of CareWell
- Structure of CareWell
- Main Research Areas of CareWell
- Outlook

Introduction: Fact Sheet

Duration

01.01.2020–31.12.2023

Funded by

RCN

Research Partners

4

- University of Agder (UiA)
- Norwegian University of Science and Technology (NTNU)
- University of San Luis Potosí (UASLP), Mexico
- Aalto University, Finland

Budget

24 MNOK

RCN Funding

Ca. 16 MNOK

IKTPLUSS

Municipality Partner

1

Lillesand kommune

Industry Partners

2

- Super Radio
- Tingtun

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Vision of CareWell

Objectives of CareWell

To realize our vision of a non-wearable sensor system that can not only detect but also locate a large number of human activities with high accuracy.

1. To collect, for the first time ever, combined radio-frequency (RF) and acoustic sensor data set in the presence of active users.
2. To develop a data augmentation framework, for generating synthetic RF data that represents human movements, which consequently reduces the training data collection efforts by a factor of at least 100.
3. To estimate the velocity and localize dynamic human body parts from RF sensor data.
4. To detect at-least 20 user activities with an accuracy of 97%.
5. To develop a prototype that detects activities in real-time and localizes dynamic human body parts within a sub-decimeter range.
6. To perform market and stakeholder analysis towards a resilient business plan.

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What Makes CareWell Different?

CareWell

1. Highly realistic channel model
   - Sum-of-cisoids concept
   - Nonstationary aspects
   - Environmental aspects
   - 3D Model
2. Software-based design approach
3. Joint RF and audio sensing

Other Solutions

1. Simplified channel model
2. Experimental-based design approach
3. Mostly single sensing modality

Channel Models in CareWell: Concluding on human activities from the received RF signal

Traditional channel models: Studying the influence of walking persons on the characteristics of the received signal

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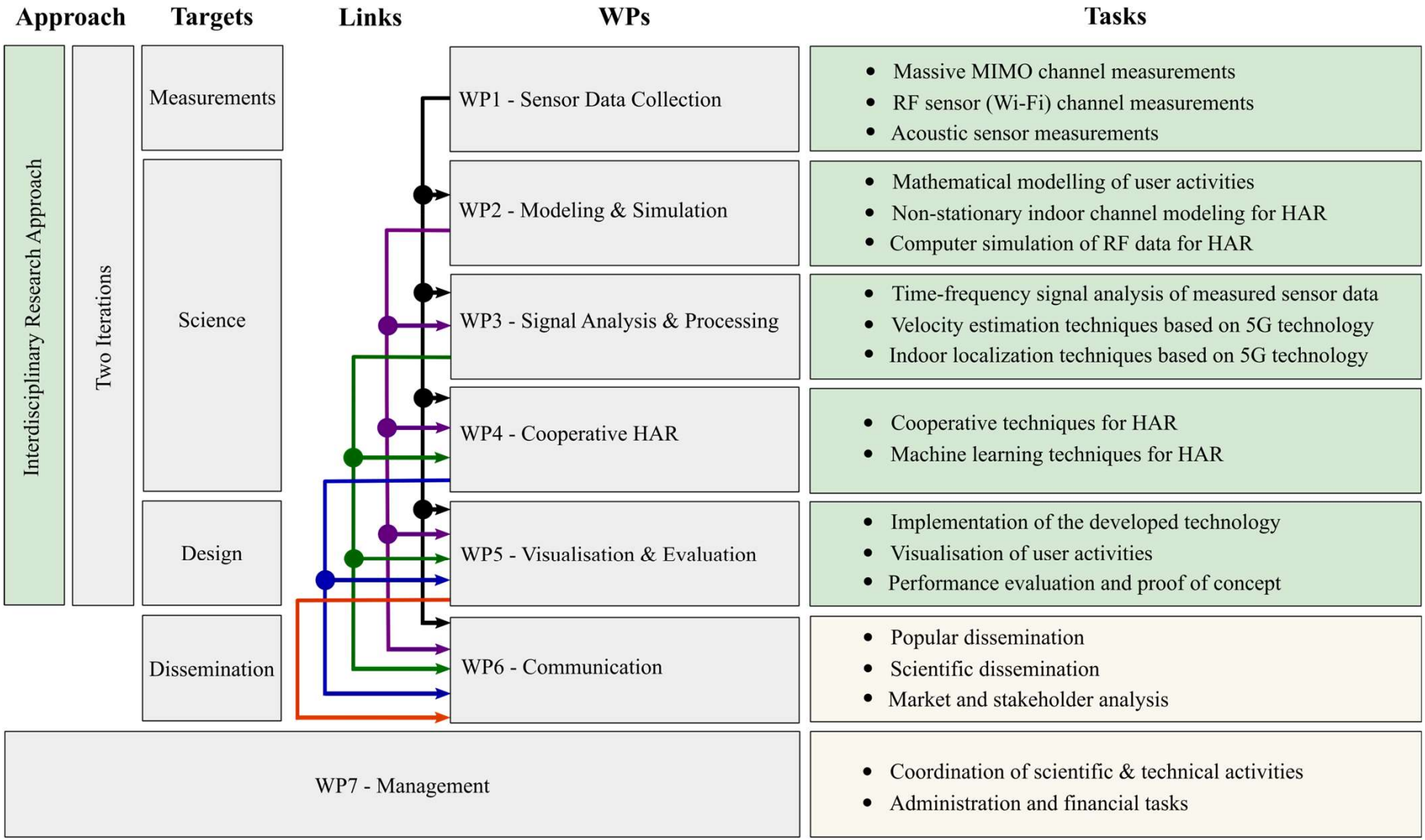
Structure of CareWell



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Main Research Areas of CareWell

1. Modelling and Simulation

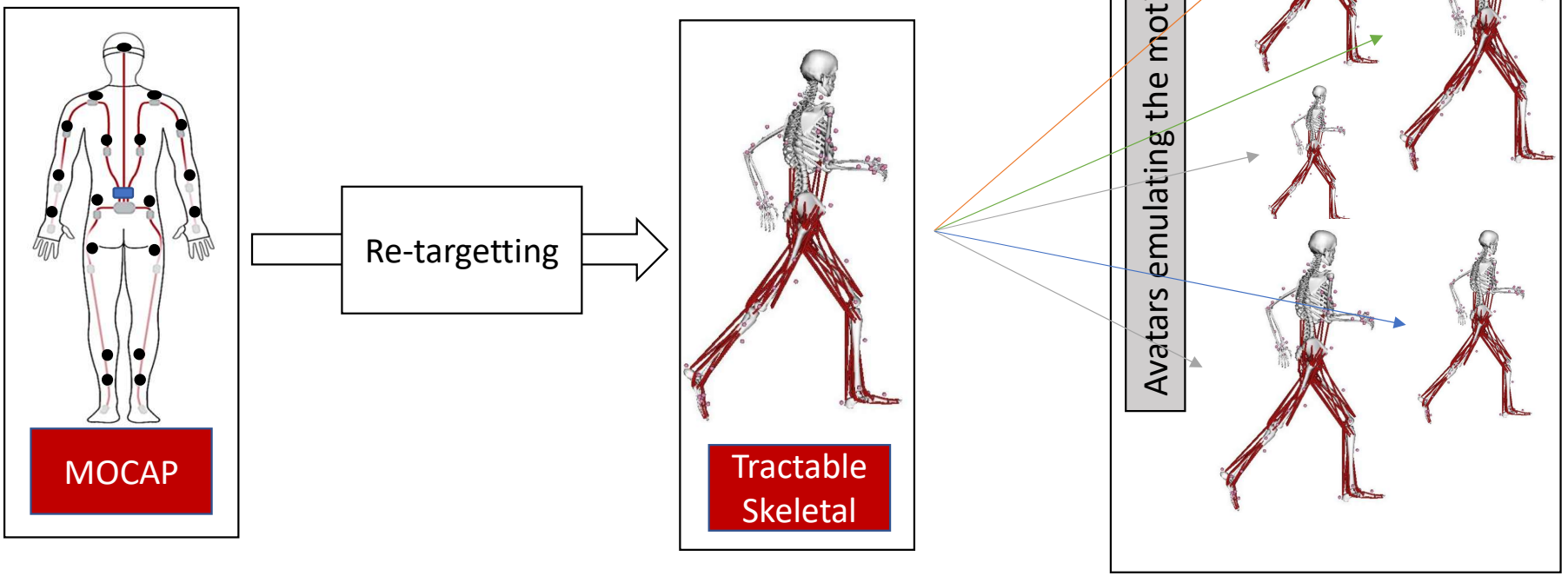
2. Localization of Moving Objects

3. Cooperative Human Activity Recognition (HAR)

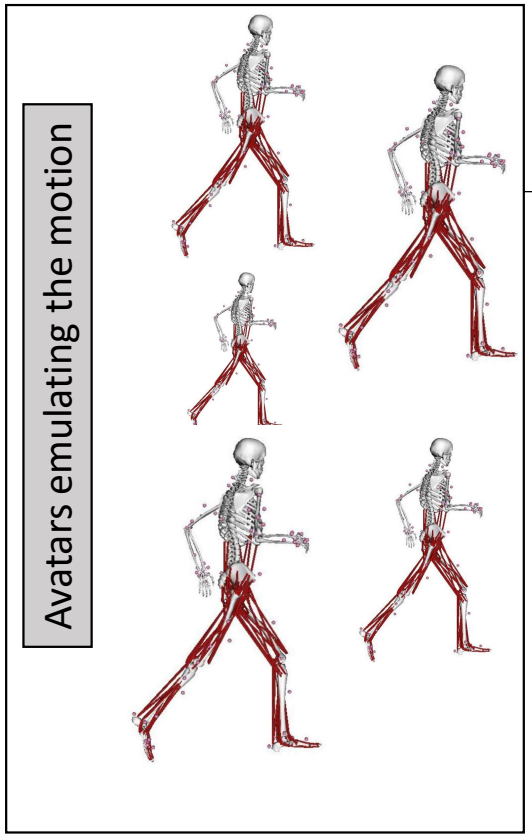
Modelling and Simulation

To investigate the impact of dynamic human body segments of a person performing different activities on the micro-Doppler signatures.

- Full-body skeletal model
- Trajectory driven channel models



Modelling and Simulation

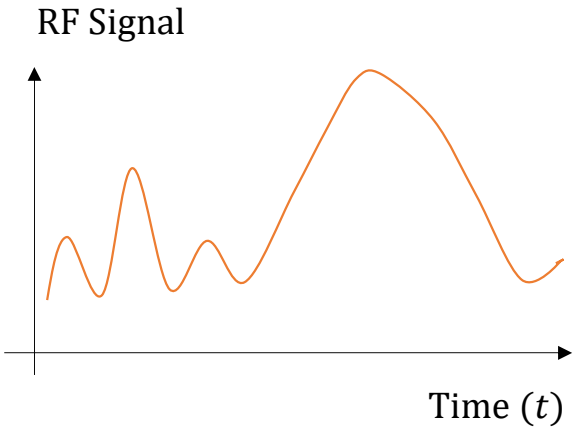


Trajectories

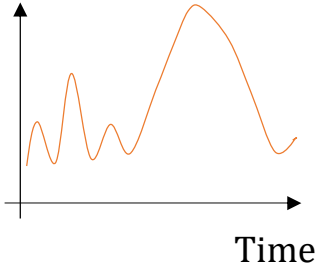
$\Gamma_1(t)$
$\Gamma_2(t)$
$\vdots$
$\Gamma_N(t)$

Channel Model

RF Signal



RF Signal



Time-Frequency Spectral Analysis

Spectrogram

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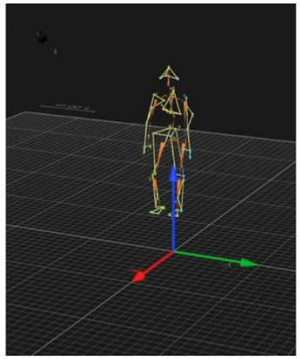
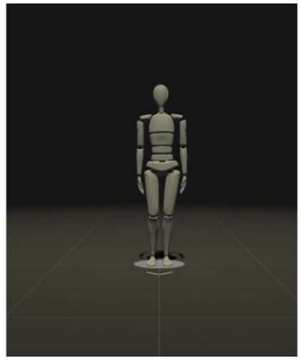
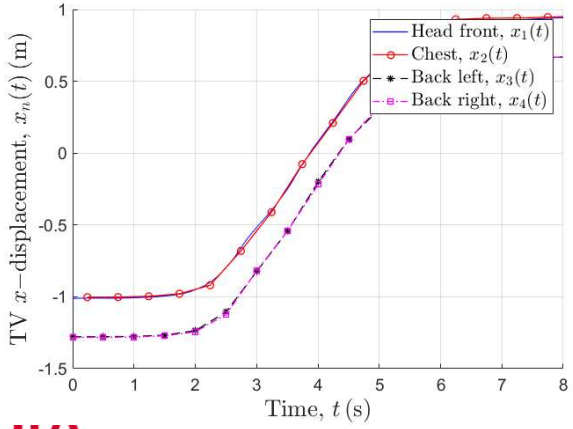
Concept in Action

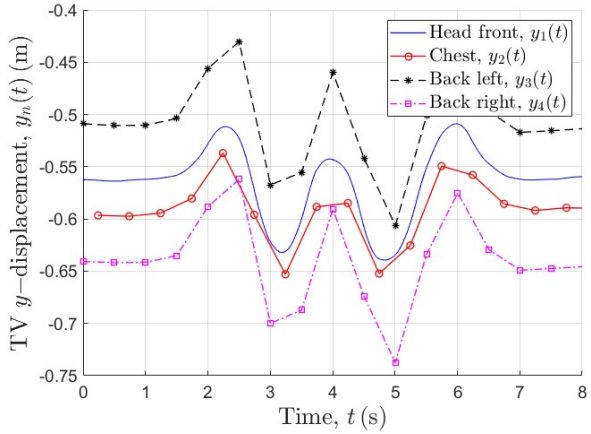


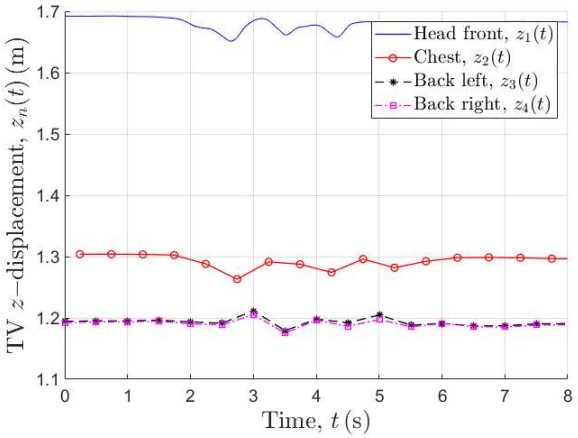


Parameters	Values
(x_T, y_T, z_T)	$(3.1, 0, 1.1)\ m$
(x_R, y_R, z_R)	$(3.1, 0, 1.1)$ m
Carrier frequency f_c	24.125 GHz
Bandwidth B	250 MHz

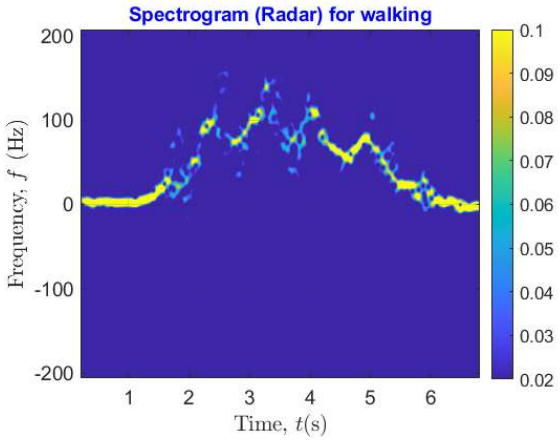
- **Trajectories of body segments for the walking activity**

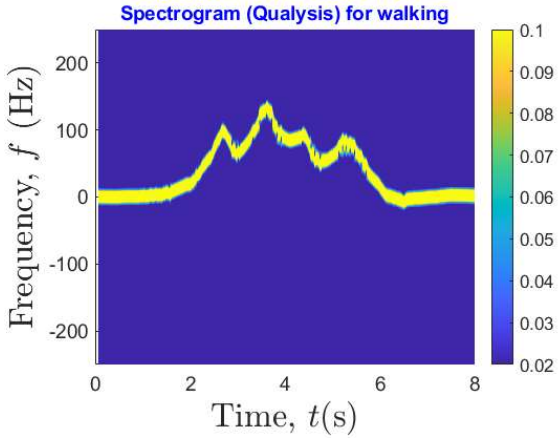


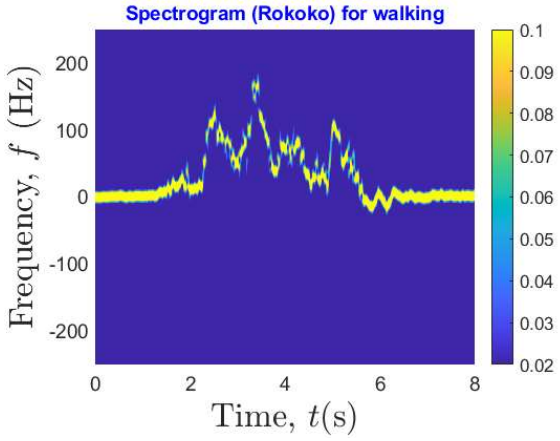


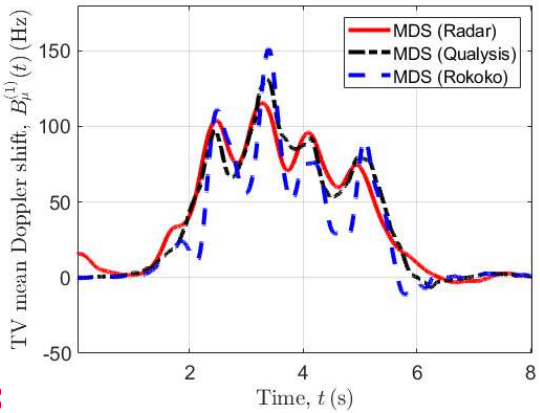


Concept in Action









- A Good match between the spectrogram of the measured RF data and those of the trajectory-driven simulation model (MOCAP data).
- The TV mean Doppler shift of the Qualisys data-driven simulation model demonstrates a good fit to the one of the measure radar data.

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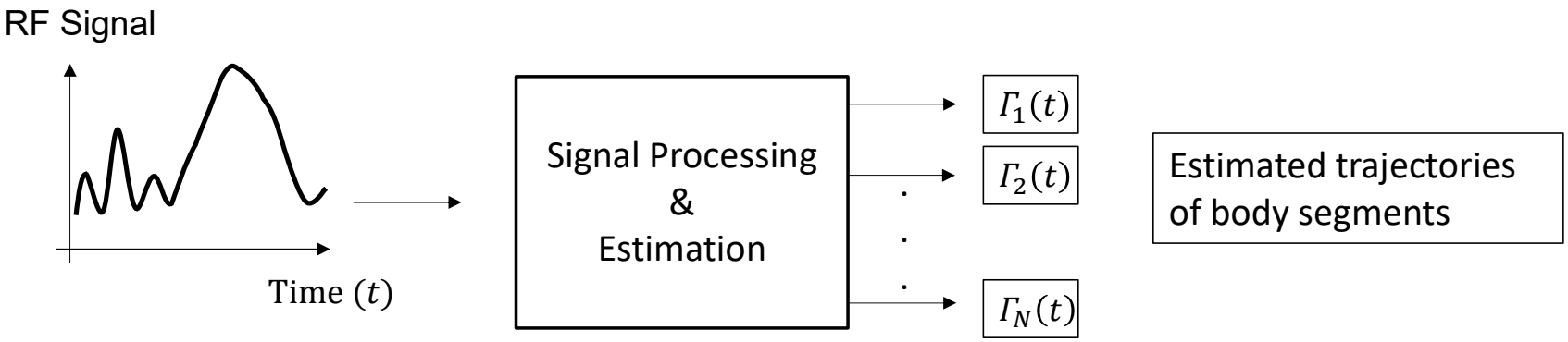
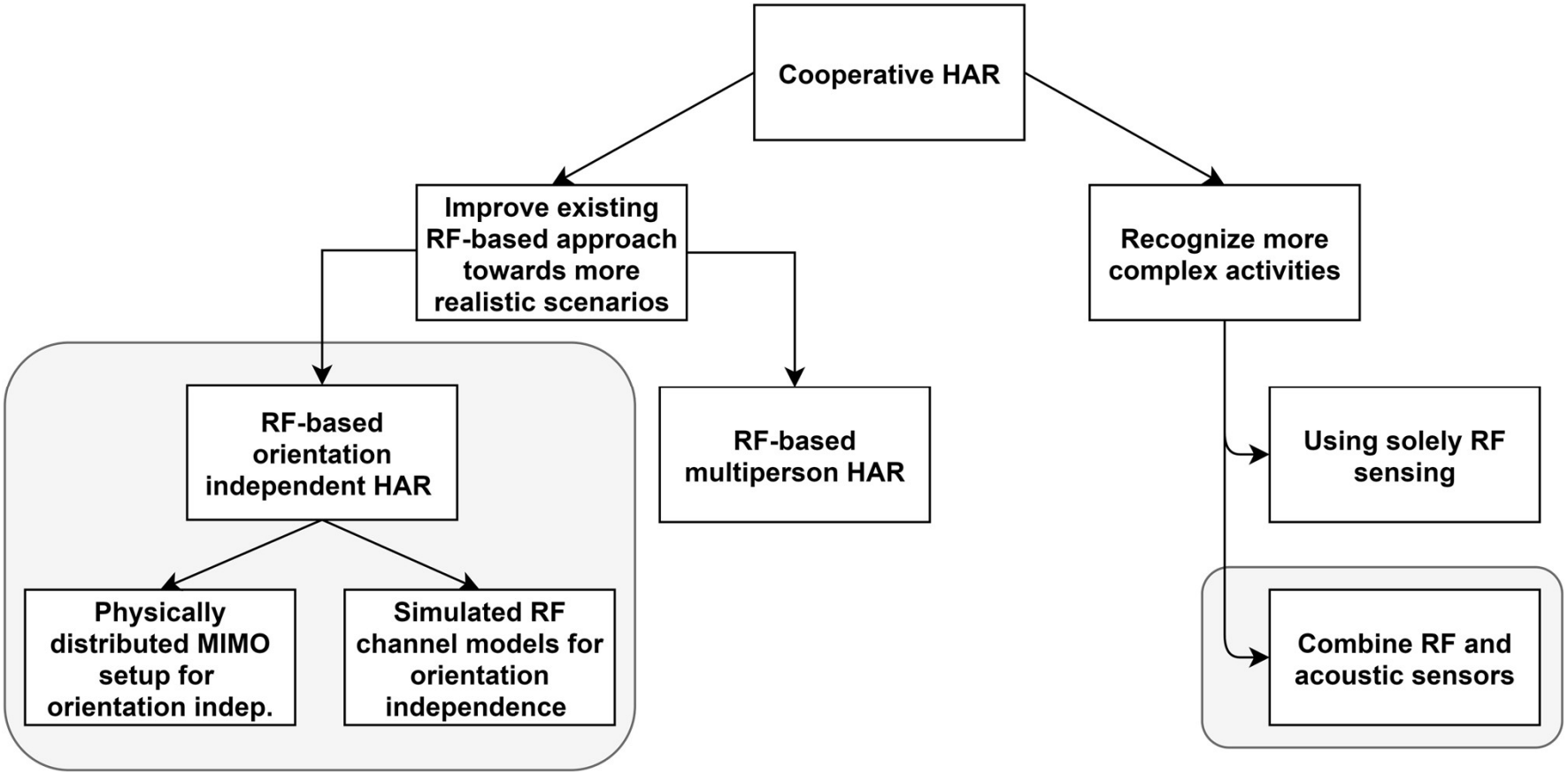
Localization of Moving Objects

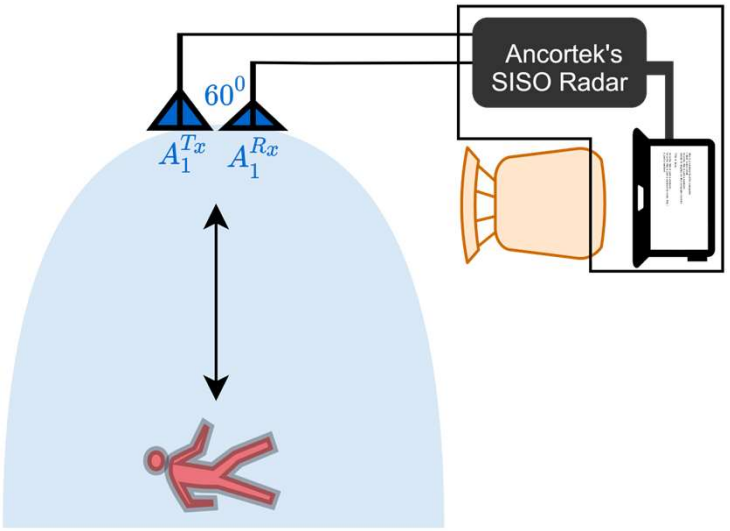
To estimate the velocity and localization of active body segments from RF sensor data.

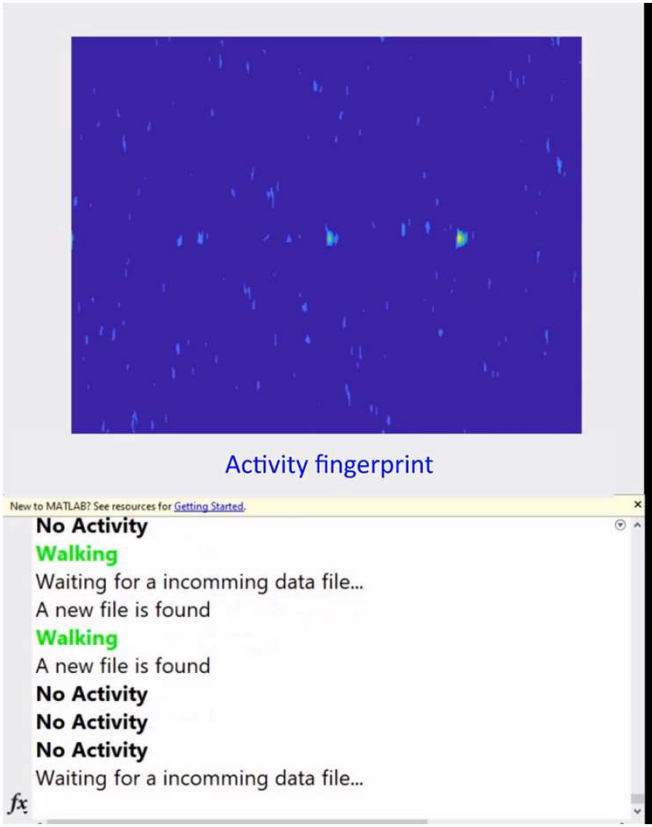


Cooperative HAR



RF-Based HAR in Action





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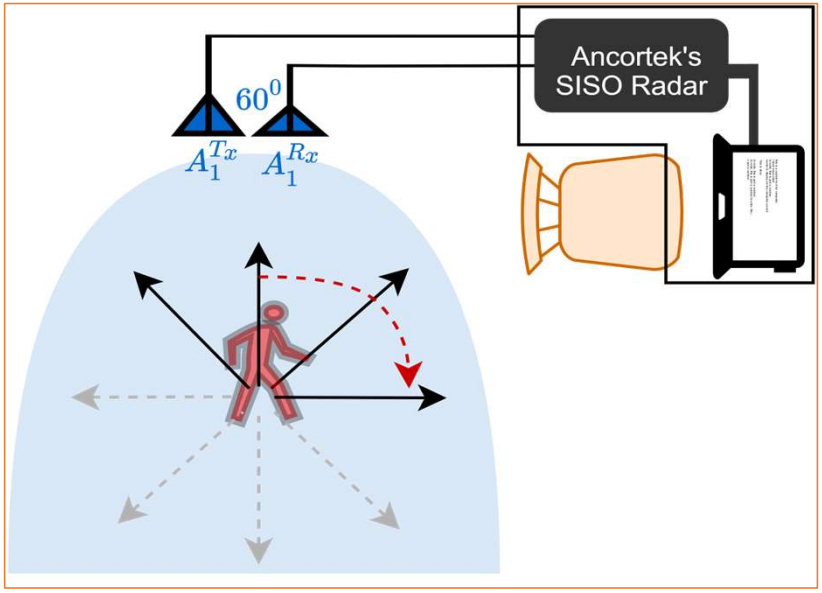
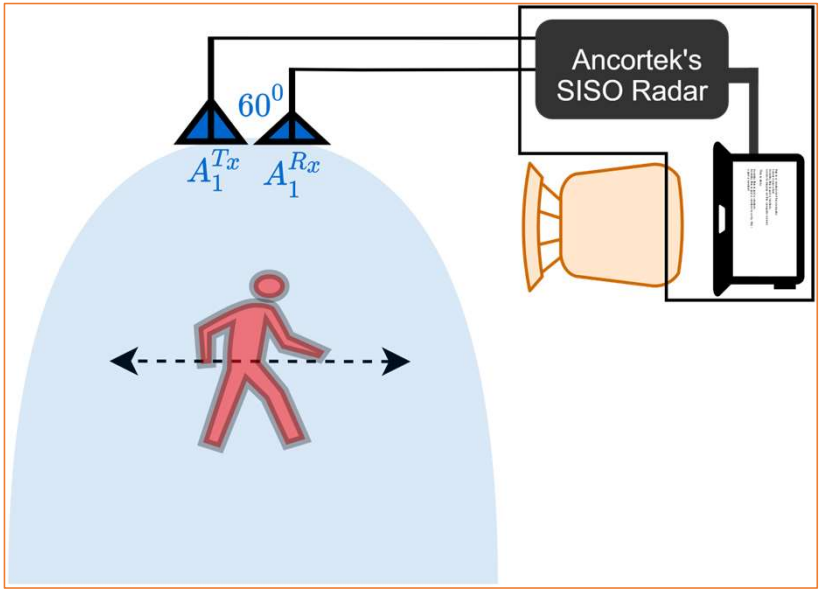
Orientation independent HAR



Activity fingerprint significantly changes and become less distinct, as we move from parallel to perpendicular.



The system does not perform well when activities are performed perpendicular to the boresight of the radar.

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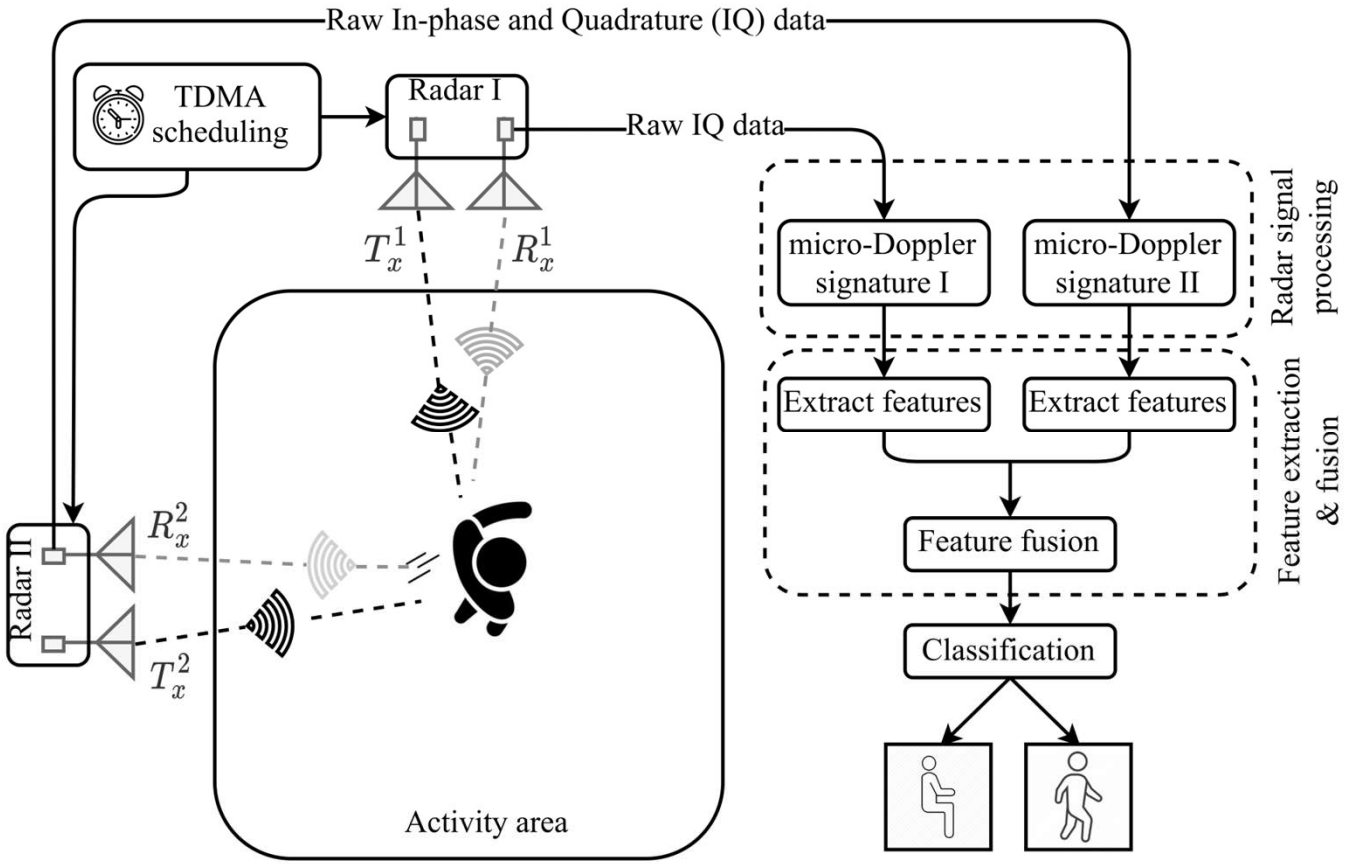
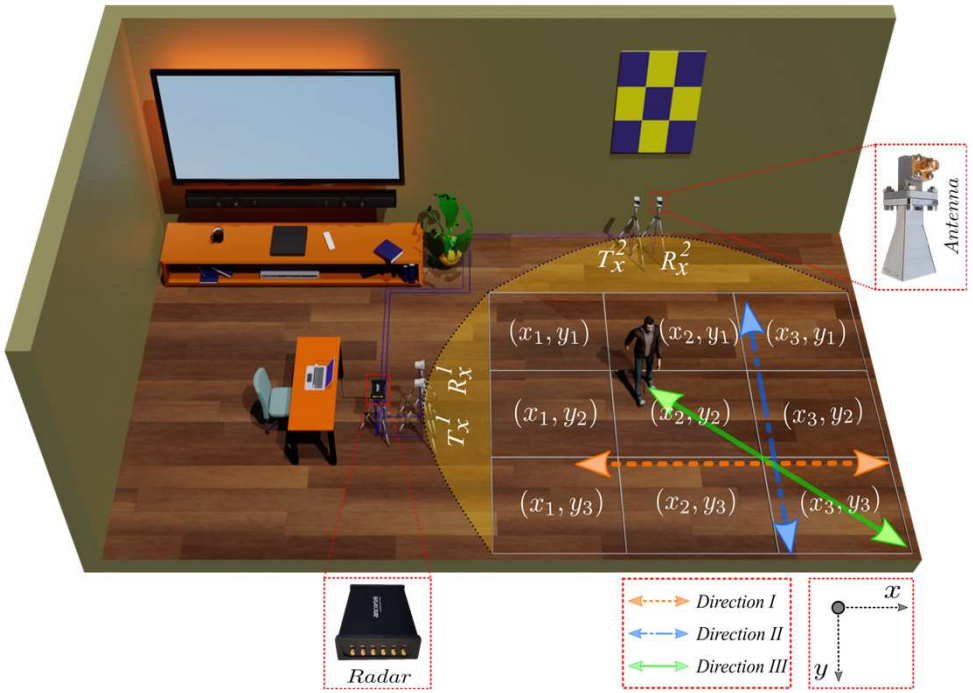
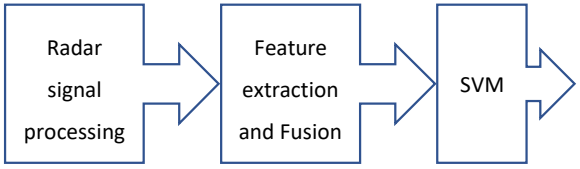
Orientation independent HAR

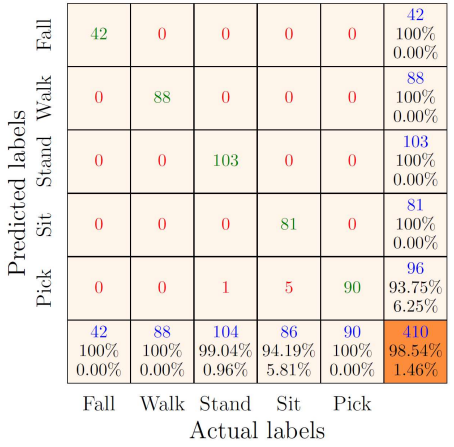


Orientation independent HAR

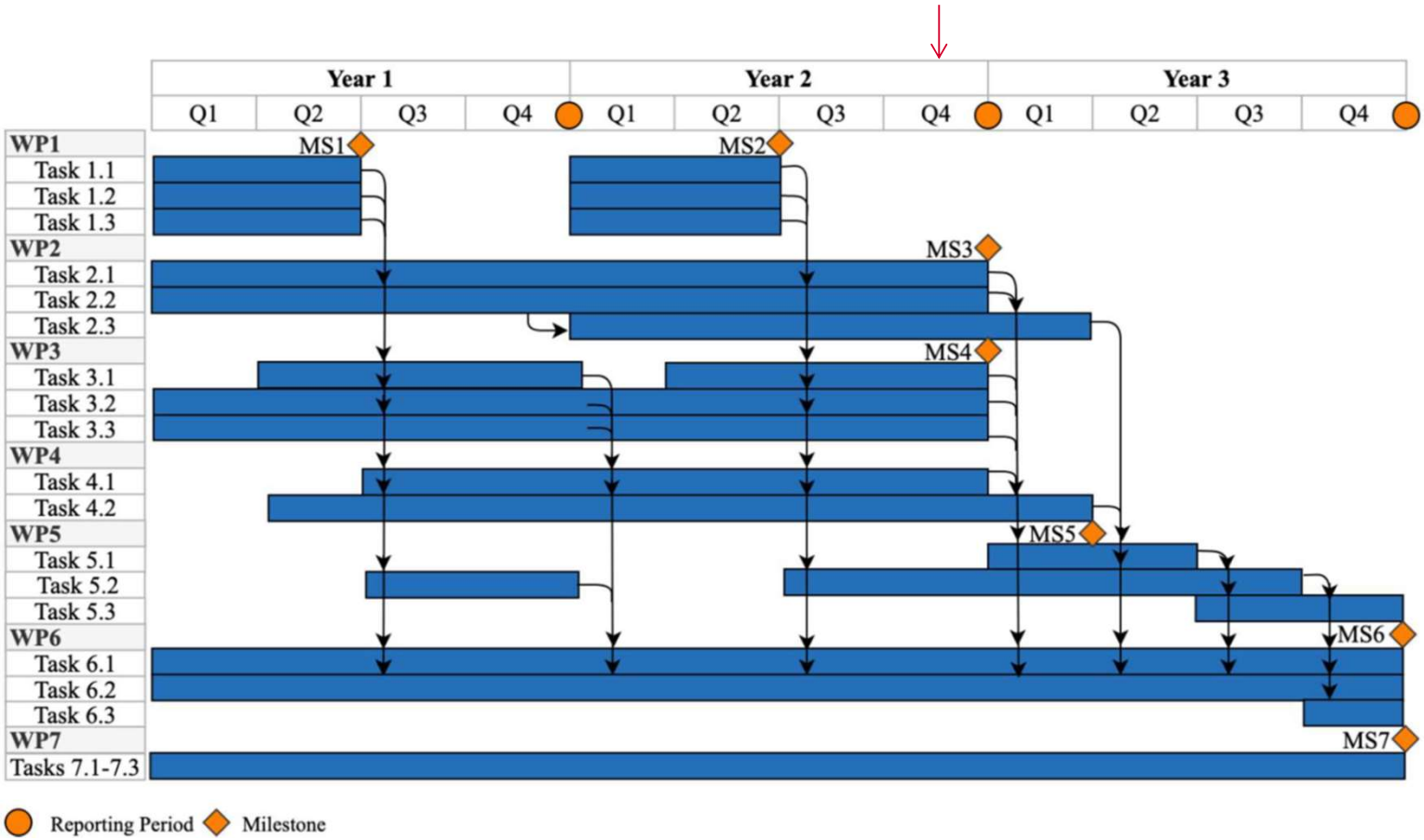


Activity description / Person #	1	2	3	4	5	6	Total Activities
Falling	60	60	18	18	-	-	156
Walking	80	80	40	40	24	24	288
Sitting down on the chair	105	105	27	27	27	27	318
Standing up from the chair	105	105	27	27	27	27	318
Picking up an object from the ground	105	105	27	27	27	27	318
Total	-	-	-	-	-	-	**1398**





Where we are?


Year 1
Year 2
Year 3
Q1
Q2
Q3
Q4
WP1
Task 1.1
Task 1.2
Task 1.3
WP2
Task 2.1
Task 2.2
Task 2.3
WP3
Task 3.1
Task 3.2
Task 3.3
WP4
Task 4.1
Task 4.2
WP5
Task 5.1
Task 5.2
Task 5.3
WP6
Task 6.1
Task 6.2
Task 6.3
WP7
Tasks 7.1-7.3
MS1
MS2
MS3
MS4
MS5
MS6
MS7
Reporting Period
Milestone

Project Pipeline and Trends in RF Sensing

Technology	WiCare (2018 – 2021)	CareWell (2020 – 2023)	Future Projects (≥ 2023)
RF Sensing system	Wi-Fi	Radar	mmWave radar
Antenna system	SISO	SISO & MIMO	MIMO & massive MIMO
Frequency range	2.4 GHz	24 GHz	> 60 GHz
Sensing modalities	RF	RF & audio	Multimodal
Features	Few basic activities (falling, walking, etc.)	Sequences of complex activities	Fine grained activities
Applications	HAR	HAR and eHealth	HAR, eHealth, sports, …

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Thank you

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