An artificial neural network architecture to classify workers' operations in manual production processes

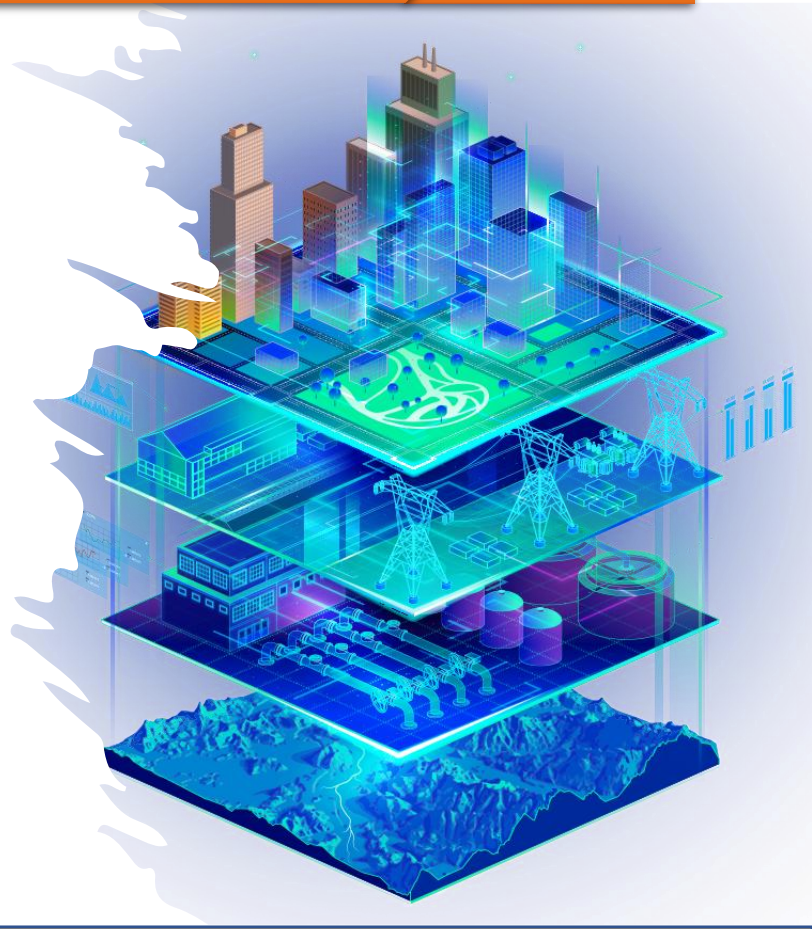
- Ass. Prof. Ph.D. Francesco Pilati
- **Ph.D. student Andrea Sbaragli**
- Ass. Prof. Ph.D. Gastone Rosati Papini
- M.Sc. Paolo Capuccini

FAIM 2023
PORTO - PORTUGAL | JUNE 18-22

UNIVERSITY OF TRENTO

Overview

- Current scenario in human-centric production systems
- Digital IIoT architecture
- Preliminary validation in a manufacturing job shop
- Final remarks & further research



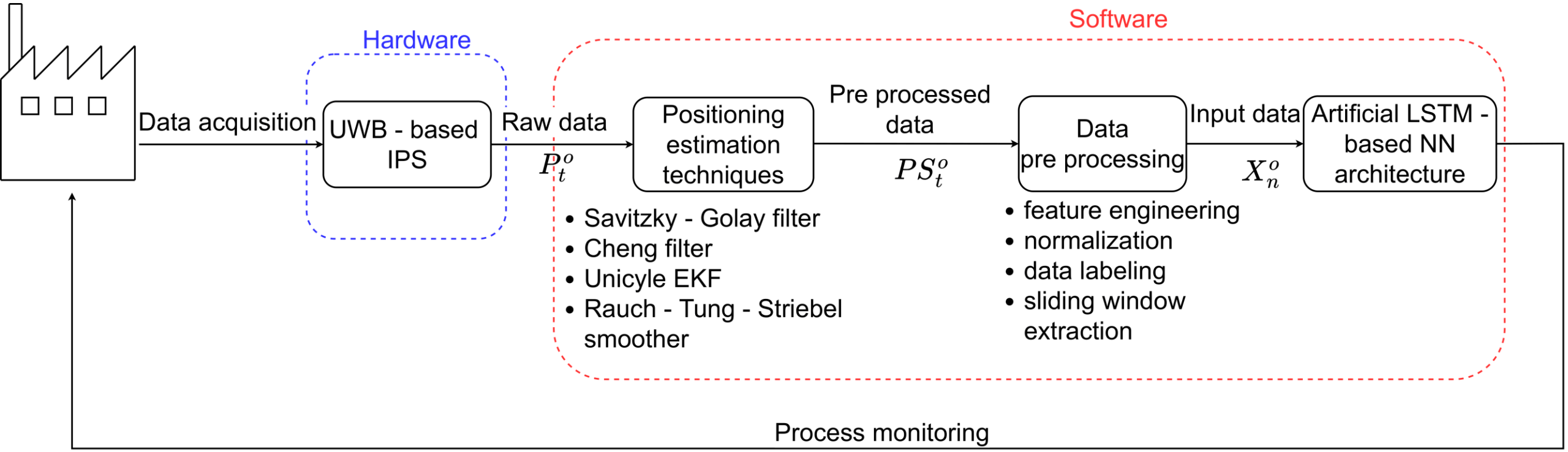
Introduction

Fully automated production systems are not always economically viable or feasible

Operators are the most flexible resources

How to monitor and manage such highly variable and unpredictable environments

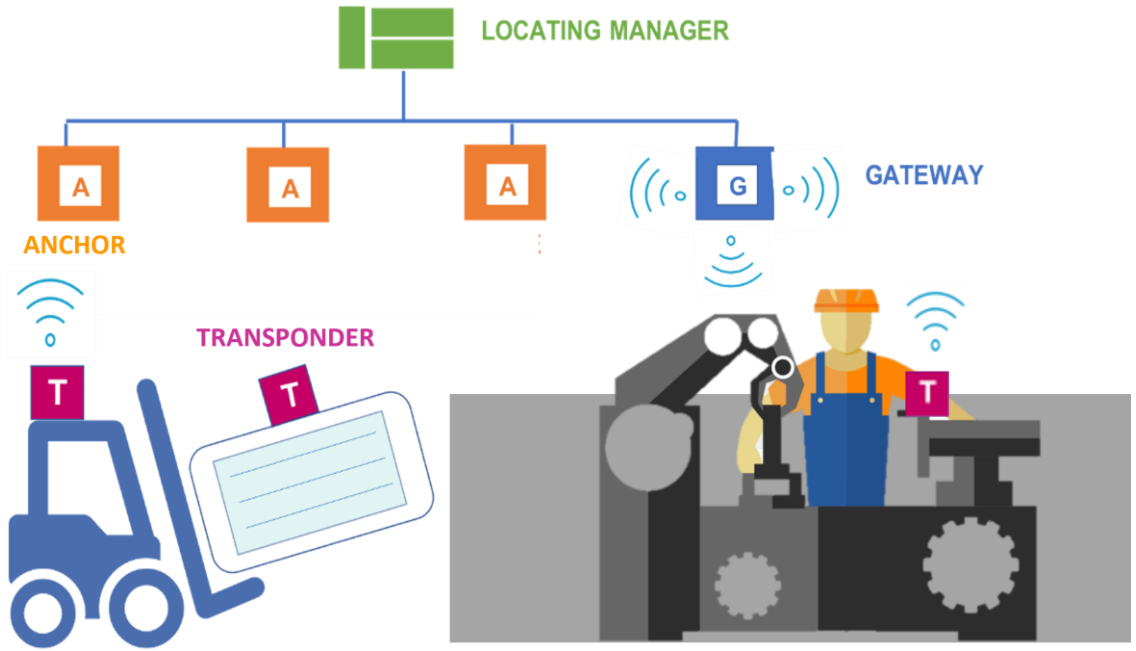
Materials & Methods: digital IIoT architecture



Materials & Methods: physical layer

The adopted indoor positioning system, based on radio-frequencies, is the **ultra-wideband** technology

1. **Anchors (ANs)**
2. **Transponders (TNs)**
3. **Gateways (GWs)**
4. **Locating manager (LM)**



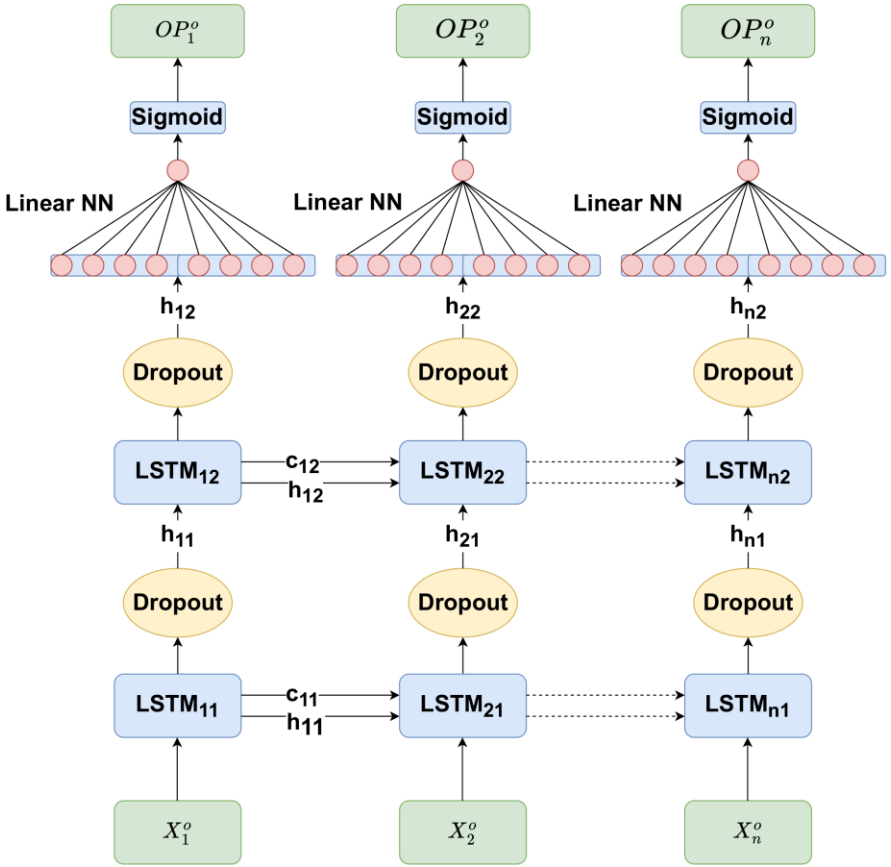
Materials & Methods: software

Dataset

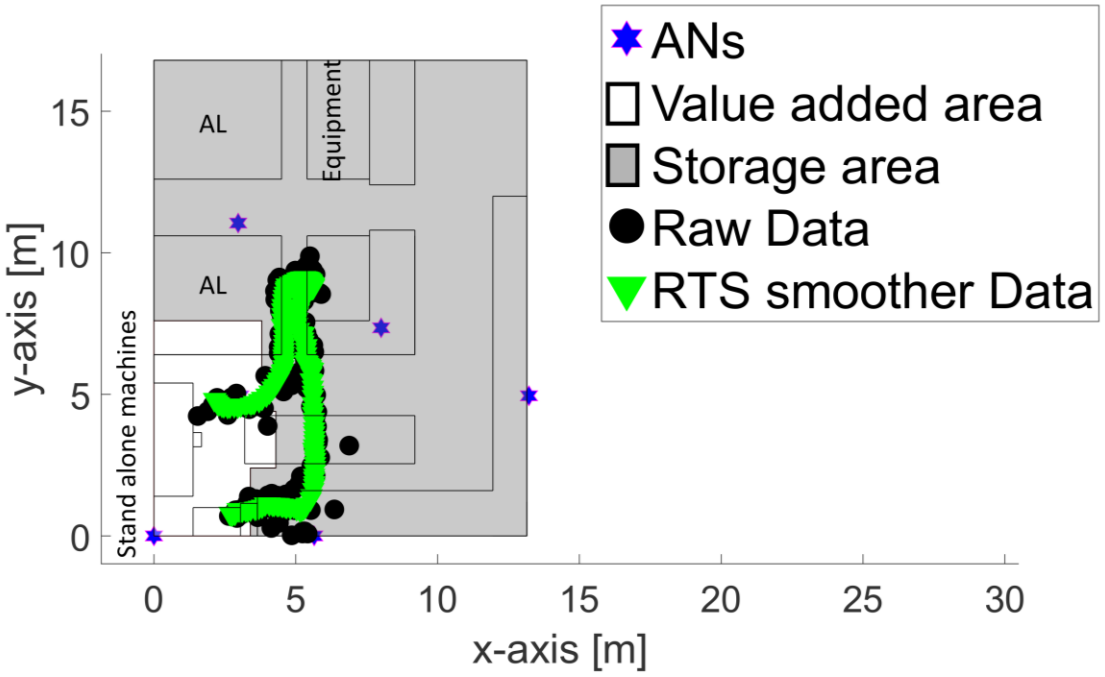
- 220000 input data (X_i^0) related to the production process of 6 workers
- Each input data consists of geometric positions, delta time, velocity, acceleration and area belonging
- **Unbalanced** dataset: 8% of picking/deposit activities

LSTM hyperparameters

- Dropout={0.3, **0.5**}
- Hidden size={**64**, 128, 256}
- Learning rate={0.001, 0.0001, **0.00001**}
- Sliding window length={**128**}
- Batch size={**64**}



Materials & Methods: Case study

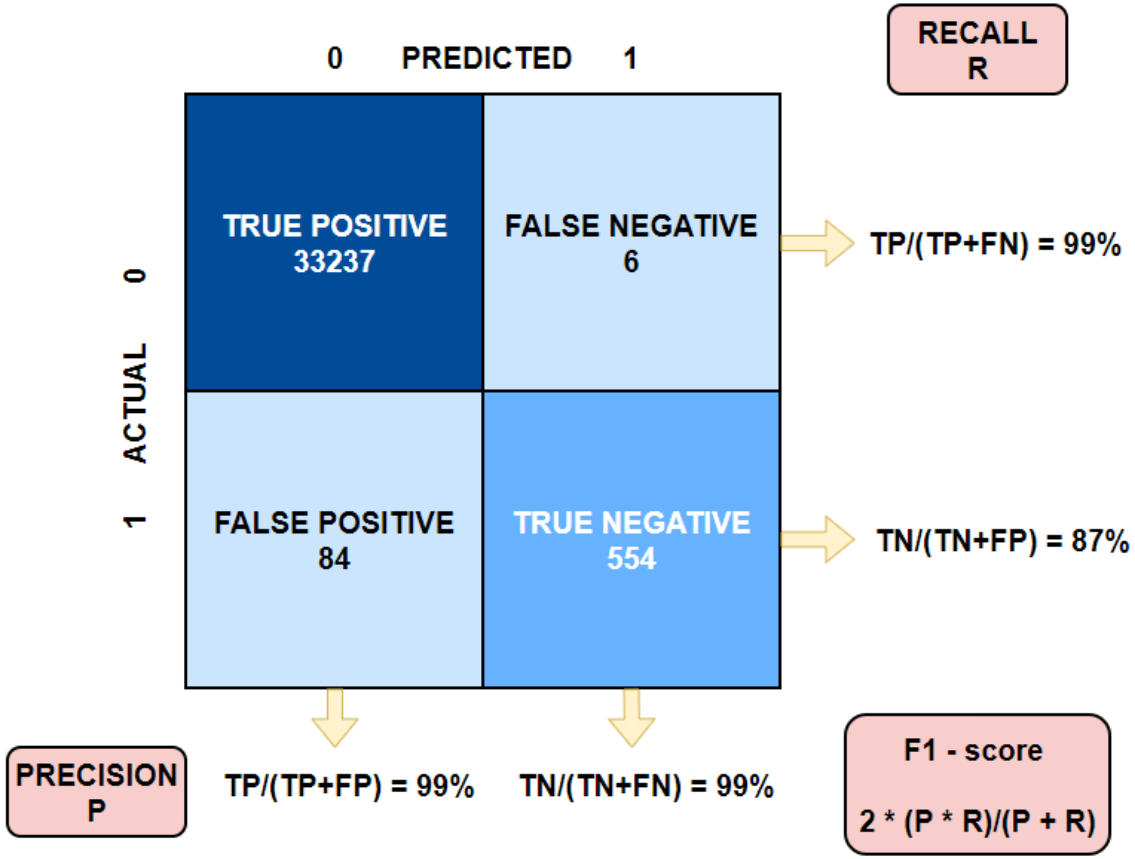


Human-centric job shop in which 2 workers perform precision machining operations

The target is to detect **picking and deposit activities** in storage areas to evaluate **products allocation** in SKUs

Results

Confusion matrix for decision threshold = 0.60



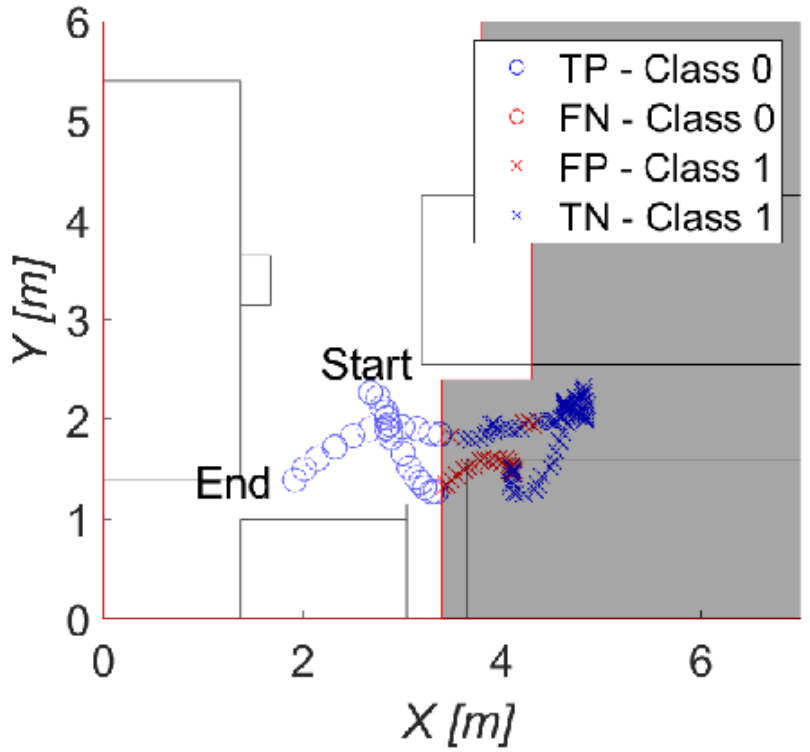
Class 1: Picking and deposit

The number of instances really belonging to **class 1** is equal to **638**, of which **554** have been correctly identified by the network, for a portion equal to **87%**, this value is represented by **recall**.

The number of instances that the network predict as belonging to **class 1** is **560**, of which **554** are correctly classified, for a portion equal to **99%**, this value is represented by the **precision**

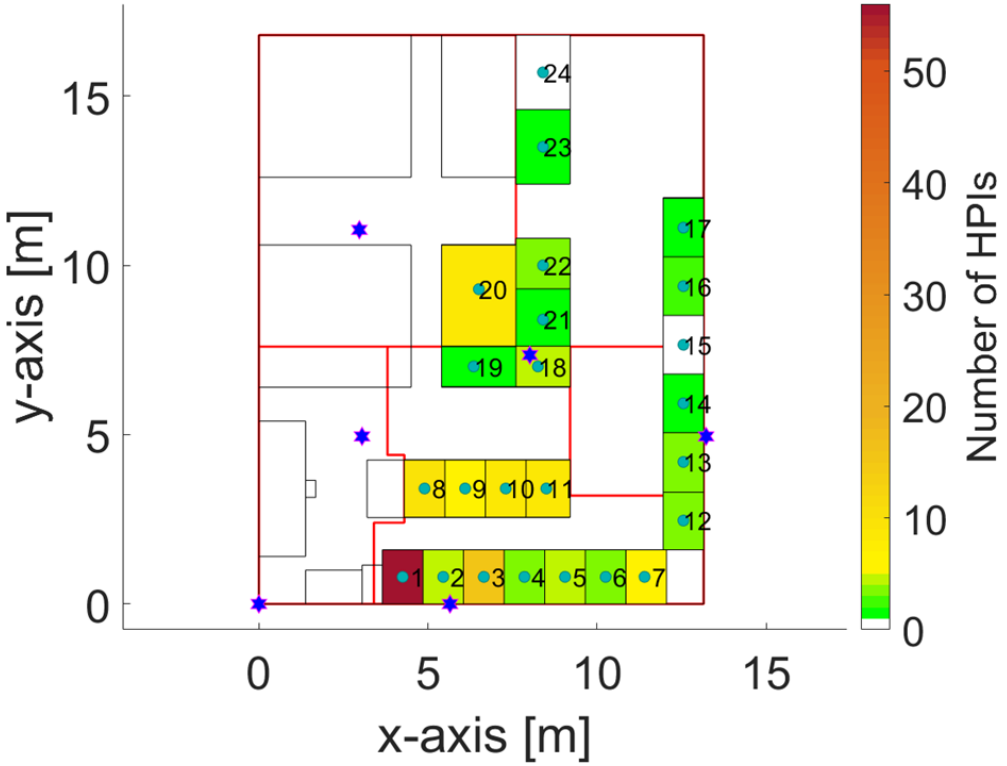
Results

- The developed architecture successfully recognizes picking and deposit activities during production processes
- These output combined with a post processing are strategic to monitor human-centered production systems



Results

How the developed IIoT architecture is beneficial in human centric environments

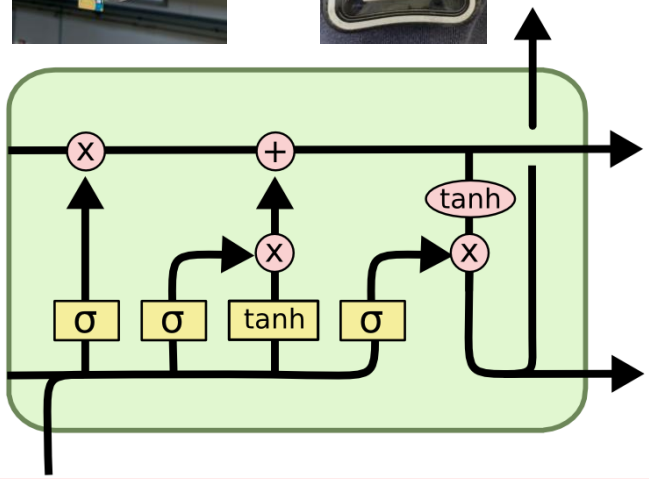


- Evaluating the distribution of picking deposit activities in SKUs
- Evaluating the social sustainability of workers during the order management

Conclusions

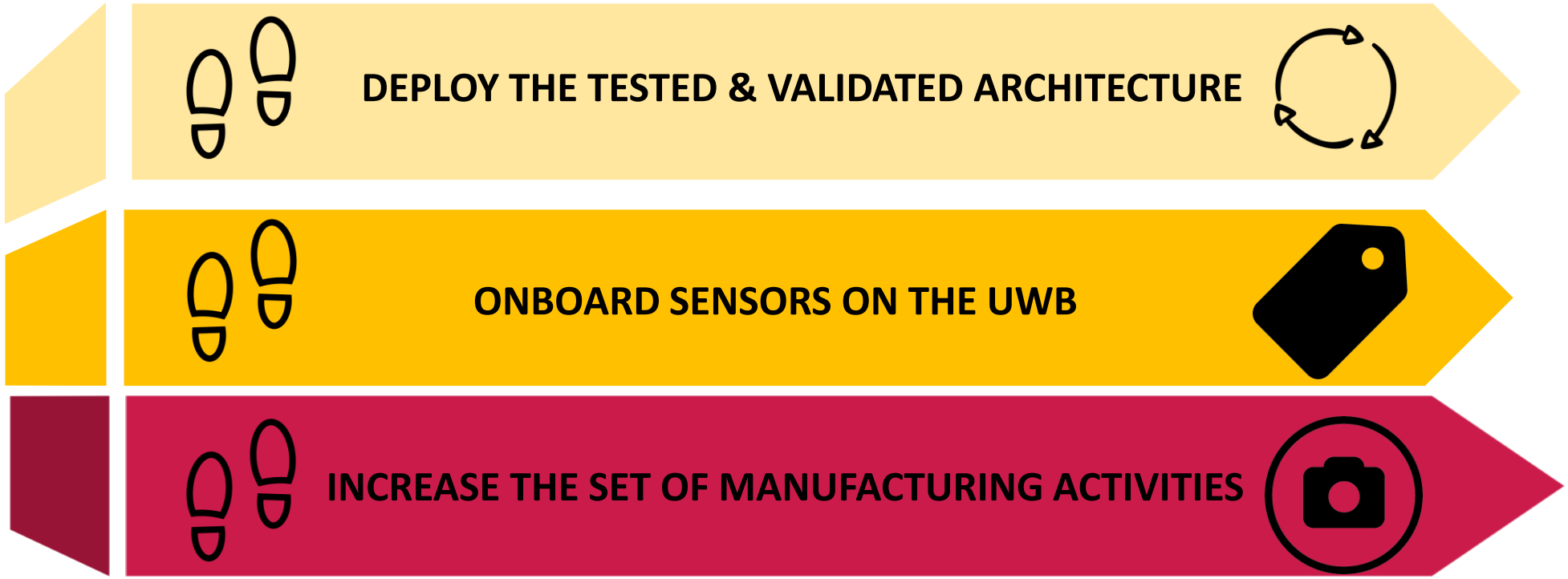
Human centered production system

Digital IIoT architecture



Process monitoring

Conclusions: further research



Acknowledgements

This work has been supported by the project “SHIELD4US- Working safely COVID19” and founded by the Valorizzazione Ricerca Trentina (VRT) foundation with call entitled “Innovation for market launch 2020” of 4 December 2020

FONDAZIONE VRT VALORIZZAZIONE RICERCA TRENTINA

Contacts

Andrea Sbaragli
PhD Student - Department of Industrial Engineering
University of Trento
38123 Trento (Italy) – Via Sommarive 9
email: andrea.sbaragli@unitn.it

Thank you very much for your attention!

- Ass. Prof. Ph.D. Francesco Pilati
- **Ph.D. student Andrea Sbaragli**
- Ass. Prof. Ph.D. Gastone Rosati Papini
- M.Sc. Paolo Capuccini

FAIM 2023
PORTO - PORTUGAL | JUNE 18-22

UNIVERSITY OF TRENTO