Towards the integration of a pointing-based human-machine interface in an industrial control system compliant with the IEC 61499 standard

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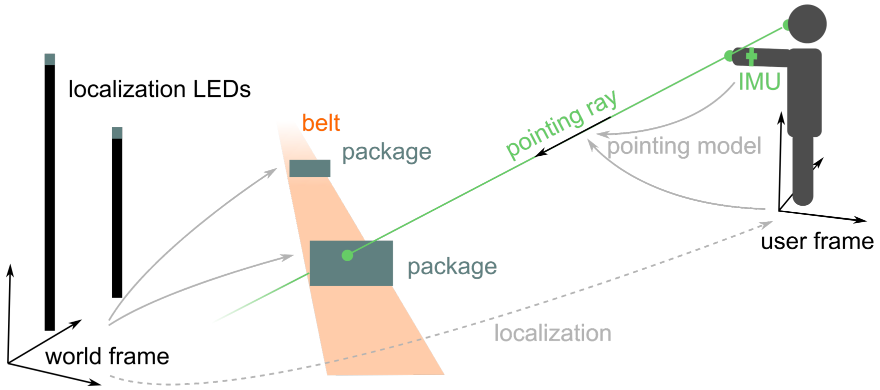
Interacting with cyber physical systems

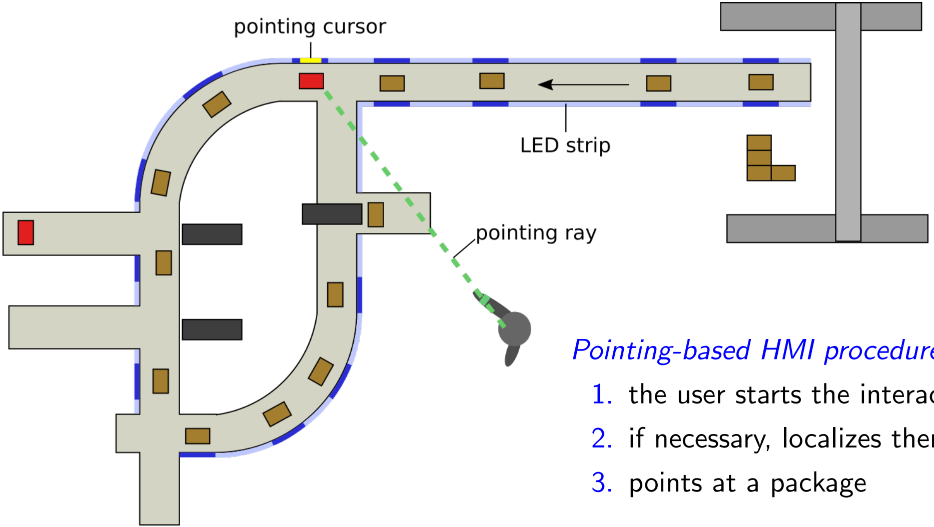
- In the context of *Industry 4.0*, machines need to interact with humans
- *Pointing gestures* are convenient to implement such human-machine interfaces (*HMI*)

The pointing-based HMI



- Based on a simple *user kinematic model* and little sensory equipment (*IMU* at their wrist)
- Using the measured orientation of the wrist, it computes the *pointing ray*
- Given the user location, the pointing object is given intersecting the ray with the world

Selection of packages on industrial conveyor belts by pointing



Pointing-based HMI procedure:

1. the user starts the interaction
2. if necessary, localizes themselves
3. points at a package

- *LED strips* mounted along the conveyor belts provides the user with visual feedback

Pros and cons of the pointing-based HMI

+ *Portability*: little equipment, almost no infrastructure, computationally light
+ *Ease of use*: no need the operator to hold specific tools; direct feedback from the plant
+ *Scalability*: easy to deploy in large plants and by multiple users

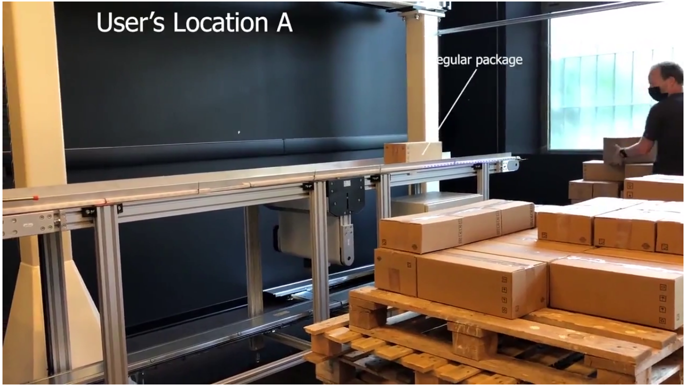
— *Reactivity*: the initialization procedures might be too slow for fast interactions

— *Ambiguity*: pointing complex structures might results in ambiguities

— *Ergonomics*: long interaction sessions might be tiring for the user

HMI implementation

- The pointed-based HMI has been implemented in ROS2 [1] and used in both real and VR scenario [2]



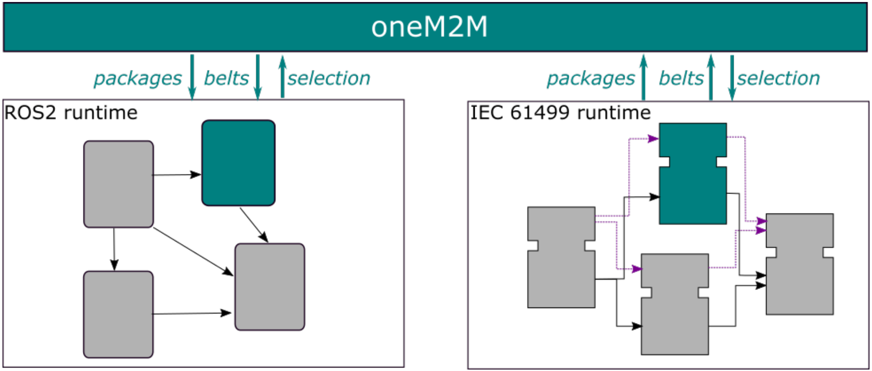
- To be deployed in real industries, our HMI has to comply with industrial standards, such as *IEC 61499* [3]

[1] Abbate, G., Giusti, A., Paolillo, A., Gromov, B., Gambardella, L., Rizzoli, A.E., Guzzi, J., "PointIt: A ROS toolkit for interacting with co-located robots using pointing gestures," *ACM/IEEE Int. Conf. on HRI*, 2022.

[2] Guzzi, J., Abbate, G., Paolillo, A., Giusti, A., "Interacting with a conveyor belt in virtual reality using pointing gestures," *ACM/IEEE Int. Conf. on HRI*, 2022.

[3] A. Zoitl, "Real-time Execution for IEC 61499," ISA, 2008.

Integration within real industrial automation systems



ROS2 HMI implementation	*IEC 61499 standard*	*The oneM2M framework*
▶ Nodes communicate using a pattern based on publisher-subscriber ▶ Input: packages and belts ▶ Output: selected packages	▶ Function blocks use two pathways to exchange data or events ▶ Input: selected packages ▶ Output: packages and belts	▶ IoT framework used to interface IEC 61499 with external systems ▶ A HMI node and IEC 61499 function block serve as oneM2M service entity

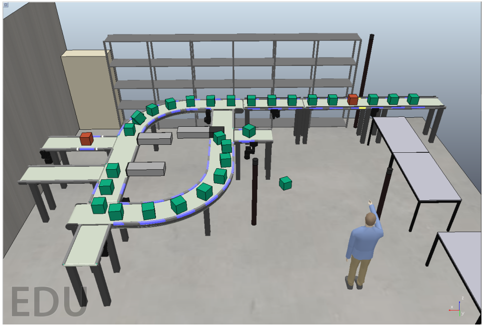
Testing results

OneM2M bridge performance

Payload (Bytes)	Max msg rate (Hz)	Latency (ms) [5th, 95th] percentiles
1	173	[10, 24]
10	173	[10, 24]
100	173	[10, 24]
1000	173	[10, 24]
10000	165	[10, 24]
100000	106	[14, 29]
1000000	20	[52, 79]

Mobius has been used as oneM2M server

System simulation



The simulated scene contains the digital twin of the automation system

Conclusion and future work

- We integrated a *pointing-based HMI* in the framework of an industrial cyber-physical system compliant with the *IEC 61499 standard*
- Both *advantages and drawbacks* of using such HMI to establish an interaction with a system of conveyor belts have been discussed
- We discussed the *novel* integration required to use the proposed HMI with an IEC 61499 automation runtime, which allows the actual deployment within an industrial setup
- *Feasibility tests* in simulation showed that the interaction requirements are respected by our integration, paving the road towards the deployment on real systems
- Future work aims at testing the HMI within a *real Industry 4.0 demonstrator*

Stay tuned and check out our activity on the pointing-based HMI
`https://idsia-robotics.github.io/pointing/`

Thank you for your attention