On verification, safety and manufacturing in Industry 4.0

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Current Technologies for Manufacturing in Asia Pacific (APAC)

- Not 100% automated = robots + humans in sequential processes and same spaces
  - Robotic/automated machine process --- human process
  - Human process --- robotic/automated machine process
  - Repairing used components = mostly human
  - Logistics = mostly human
Current Technologies for Manufacturing in APAC

- Collaborative robots (no cages) on shopfloors

- AIVs (but very few)

- Safety certification --- limiting allowed autonomy: lack of expertise, no knowledge on techniques and tools for V&V, safety concerns for autonomous systems (fear of accidents)
Industry 4.0 Meaning

Technologies based on:
- Connectivity
- Increased automation (autonomous robots)
- Improved communication
- Self-monitoring/automated sensing
- Autonomous analysis and diagnosis

Also leading to technologies based on:
- Cloud computing
- Simulation/ mixed reality

More specific examples on next slides…
(Near) Future Technologies for Manufacturing in APAC

- Smart collaborative systems that guarantee safety and allow close interaction, e.g. operator tracking systems, smart system reaction/behaviour

- Verification and validation challenges:
  - Suitable tools for machine learning for vision and sensing, and scalability if in the cloud
  - Describing emergent system behaviours with formal languages that accept a range of resulting behaviours

From a 2020 paper: [https://link.springer.com/chapter/10.1007/978-3-030-29131-0_8](https://link.springer.com/chapter/10.1007/978-3-030-29131-0_8)
(Near) Future Technologies for Manufacturing in APAC

- Modular flexible manufacturing systems
  - Can perform a variety of processes
  - Allow intuitive robot programming or learning skills from library
  - Plug and play
  - Reduce costs and customization of automated solutions
  - Scalable solutions to solve future needs for mass customization

- Verification and validation challenges:
  - Safety system design for any application (allowed closeness for human-robot interactions, interpretation of readings, maximum/minimum safe speeds, safety zones, etc.)
  - Safety certification for multiple (any) applications
  - Scalability
(Near) Future Technologies for Manufacturing in APAC

- Hardware and software that interacts together in complex robotic ecosystems (e.g. through middlewares and cyber-physical systems)

- Verification and validation challenges:
  - How to implement runtime monitors/sensing that can observe everything for safety
  - How to model all the complex interactions for all the components
  - Security issues (due to network connectivity and scalability)
  - Suitable safety standards for equipment-equipment-person interaction
(Near) Future Technologies for Manufacturing in APAC

- Open source software and robots using ROS and ROS 2 in industrial applications
- Cloud robotics using ROS/ROS2
- Verification and validation challenges:
  - Certification of open source code for robotics (guidelines or standards for code for safe human-robot interaction)
  - Tools suitable for machine learning and cloud computing (online and offline)
  - Verification for security (e.g. ROS 2 DDS protocol implementation)
  - Education on how to develop high quality open source code
- Mindset change is required to invest in open source technologies to make them more reliable and useful
Summary of Verification and Validation Challenges to Explore

- Certification of AI and autonomous systems in the wild = industrial adoption
- First adoption of technologies and proven safe = future widespread adoption
  - Who is going to be first?
- Education on verification and validation tools and challenges is necessary for industry
  - To gain investment for developing tools and techniques
  - Use cases, insights, expertise to enhance existing tools, formal languages, etc.
  - Design for verification, implementing runtime verification
- Scalability in real life: from one robotic cell to many dynamic and interconnected, flexible industrial systems in the same warehouse
- New verification and validation guidelines are needed for autonomous systems in any setting (besides industry)
Thank you!

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