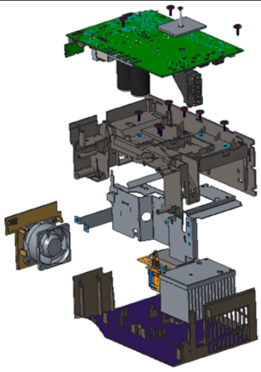
Automated assembly with tolerance tracing and compensation

Case description

Manufacturers are rapidly moving from manual assembly toward automated assembly of their products. The products are constantly redesigned and optimized to be assembled in robotic production cells. However, as the product is assembled the tolerances from different assembled parts add up to a degree that final assembly operations need to be performed manually.

One such operation is the screwing of the casing. The robust automation of screwing operations with robots is still challenging since small misalignments add up in the to the point where it is out of the tolerance limits of the robot program.



A frequency converter from Danfoss is an example where it is designed to be assembled by robots by stacking parts in a sequence. However, the screwing of the encasing is still a manual operation.

Challenge

Experiment with physical drive samples and CAD data to develop a concept to trace misalignments in a stack. Develop a concept to compensate misalignments, so that robot can be guided to screwing operations more robustly.

To get the team started, consider the following:

- Which are the relevant parameters leading to misalignments (e.g. part tolerances)?

Keywords

Tolerance chains, mechanical design, computer vision

Tools, methods and materials

The challenge can be addressed with many different tools, ranging from spreadsheet calculations to robot simulators. Regarding the methods for compensation, mechanical measures to reduce misalignments are possible as well as computer vision to measure and compensate the resulting misalignment. The selection of tools and methods is left to the team.

The team will receive 3D CAD data of drive stacks, assembly instructions and a physical product sample as input materials for the challenge. In addition, engineers from the industry will be available to discuss details of the challenge along the way.

Logistics optimization

Case description

In modern production processes, mobile platforms play an increasingly significant role in transporting materials between the different stations and areas in a flexible and automated manner. As time is of the essence in production, the objective is to transport as many packages as possible on a mobile platform and transport them as fast as possible.

However, the overall optimization for the number of packages on the platform and the motion parameters of the mobile platform requires systematic analysis. Without proper analysis the transport can fail due to falling packages from the mobile platform, or the mobile platform working under capacity with too few packages.

A mobile platform in a transport scenario in the Novo Nordisk warehouse.

Challenge

Experiment with a physical mobile platform to generate situations in which packages may fall off. Then develop a detailed dynamic simulation that can reproduce the failure. Utilize the simulation to develop strategies to avoid the failure without reducing the payload and test with the physical platform.

To get the team started, consider the following:

- Which are the relevant parameters leading to the failure (e.g. material mass, friction, and COG)?

Keywords

Mobile robots, dynamic simulation, digital twin

Tools, methods and materials

The challenge can be addressed with any 3D simulation tool allowing for detailed dynamic simulation. Regarding the methods, the team needs to closely model the situation in simulation and identify the relevant parameters from specifications, measurements, or estimates. The selection of tools and methods is left to the team.

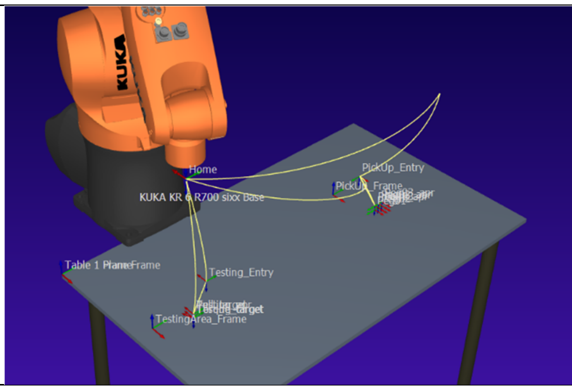
The team will receive access to a mobile platform and boxes for the physical experiments, as well as 3D CAD data and specification sheets for the mobile platform. In addition, engineers from industry will be available to discuss the challenge's details along the way.

Dynamic human robot collaboration

Case description

With the introduction of collaborative robots, an increasing number of tasks are performed mutually by robots and human workers sharing the same workspace. The robots are programmed to perform predefined motions to execute repeatable tasks, while human workers perform the intermediate tasks requiring flexibility and adaptability.

However, this puts extra pressure on human workers who must keep up with the robot and ensure to carry out the task at a constant speed. A robot which can identify the performance of human workers and dynamically adjust to match will result in a more flexible and relaxed work environment.



A planned sequences of motion for a collaborative robot in LEGO factory.

Challenge

Develop a solution for collaborative robot which can dynamically adjust its performance based on the speed of the work, so the workers do not feel time pressed during working hours.

To get the team started, consider the following:

- Which are the relevant optimization parameters (e.g. biometrics, worker tracking)?
- Which are the relevant performance indicators (e.g. productivity, cycle time)?

Keywords

Path planning, kinematic simulation, cycle time, biometrics

Tools, methods and materials

The challenge can be addressed with machine vision and can be simulation in any 3D simulation tool allowing for kinematic simulation. Regarding the methods, path and motion planner libraries such as Open Motion Planning Library are the typical reference implementations for this type of problem. The selection of tools and methods is left to the team.

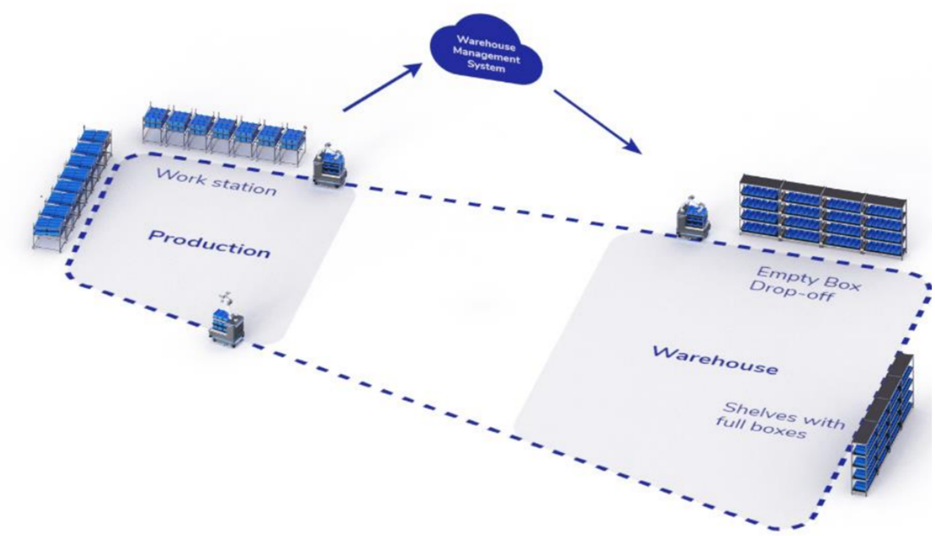
The team will receive 3D CAD data of a station with a robot arm, a sequence of target waypoints and specification sheets for the robot arm. In addition, engineers from the industry will be available to discuss details of the challenge along the way.

Pose estimation for mobile manipulation

Case description

With the introduction of affordable mobile manipulators in the market, there is an increased interest in the industry to automate the daily and routine factory logistics tasks such as transportation, loading and unloading objects, bringing, or placing items on shelves, etc.

However, automation of such tasks requires that the objects to be transported are placed in defined positions, which diminishes the value proposition of the overall case. It is important that a mobile manipulator is able to estimate the pose of the objects to be picked and placed.



A typical cycle in a factory as a demonstration use case by Enabled Robotics.

Challenge

Develop a solution for a mobile manipulator to load the empty boxes from a shelf to bring it to a workstation. The filled boxes shall then be loaded into another shelf.

To get the team started, consider the following:

- How the mobile robot can be localized (odometry, SLAM, etc.)?
- How the pose of the object can be estimated (3D model, point cloud, etc.)?

Keywords

Pose estimation, localization, point cloud

Tools, methods and materials

Two approaches can be explored. The first involves using 3D models to generate a point cloud for a complete 3D mapping of the scene. The second is scene reconstruction by identifying common features in multiple RGBD point clouds. A simulation environment such Gazebo can be used to simulate, while considering how to integrate real-world environment data into the simulation. In addition, engineers from the industry will be available to discuss details of the challenge along the way.

Data Collection for Automation Solutions

Case description

Automation solutions are helping companies to improve the efficiency of manufacturing. Such automation solutions can include both mobile and stationary robots. To optimize automation solutions companies want to collect operational data, e.g., 2D and 3D visual image streams, 3D point clouds, task processed, vibration, movements or battery power. To gather insights the manufacturing companies would like to collect such data in high data rates (up to 1000 Hz) to enable data-based analytics for quality control or diagnostics or support planning and coordination.

Companies are facing several challenges for designing the software to enable such data collection. These challenges include strict cyber-security requirements on access to manufacturing sites, high reliability and data availability goals and technical limitations in terms of storage, communication (e.g. wireless communication) and battery power.

Example of company developing platform considering cyber-security:
https://www.made.dk/artikler/beskyttet-mod-cyberangreb-made-forskning/

Examples of solution providers for data collection in manufacturing:
https://cim.as/manufacturing/
https://www.trendlog.dk/
https://www.universal-robots.com/products/service-offerings/
https://mobile-industrial-robots.com/da/produkter/software/mir-insights

Examples of operational data from collaborative robots:
https://portal.findresearcher.sdu.dk/en/datasets/dataset-of-collaborative-robots-for-energy-consumption-modeling
https://data.mendeley.com/datasets/35wb9ycrtz/1

Challenge

Develop a software solution to help developers and/or integrators to optimize the data collection from automation solutions that address (all/some) of the needs for cyber-security, reliability and technical limitations.

To get the work started, consider the following:

- How does data insights generate value for a manufacturing company?
- Which challenges do you consider particularly relevant to optimize?
- Would you focus on a specific part of the data collection pipeline?
- Will your software solution support developers or end users?

Keywords

Data collection, robots, efficiency

Tools, methods and materials

The challenge can be addressed with many different methods for data collection, processing, and cyber-security. The work can put different focus on software or hardware elements. Methods can be considered that could alter the programming of the solution or change collection frequencies, e.g., frequencies vs. power consumption.

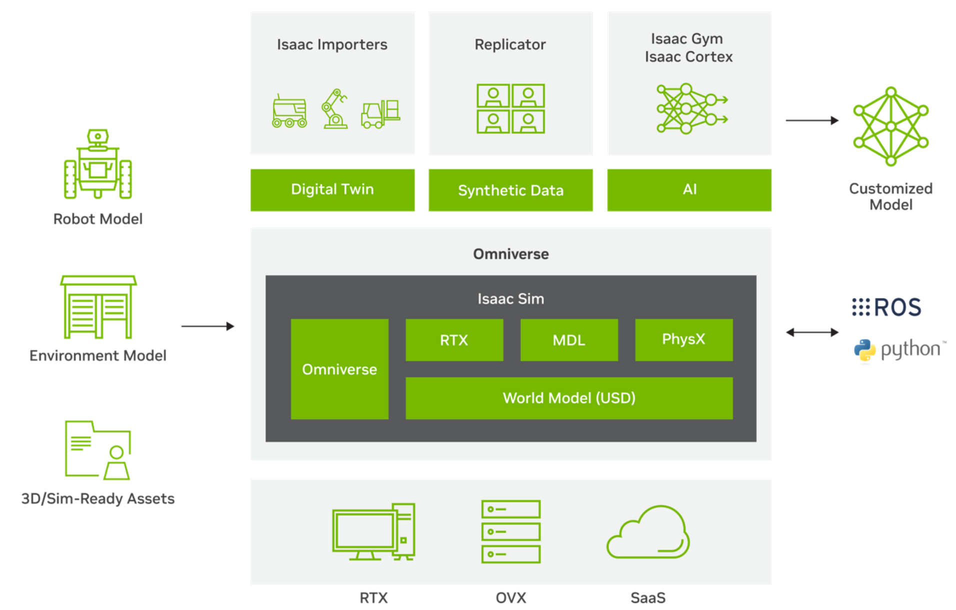
From SDU, the team will receive links to relevant datasets and software frameworks. An edge computing setup with is available at the Industry 4.0 lab. In addition, SDU will provide feedback on challenge elements.

Scalable Computing for Robotic Solutions

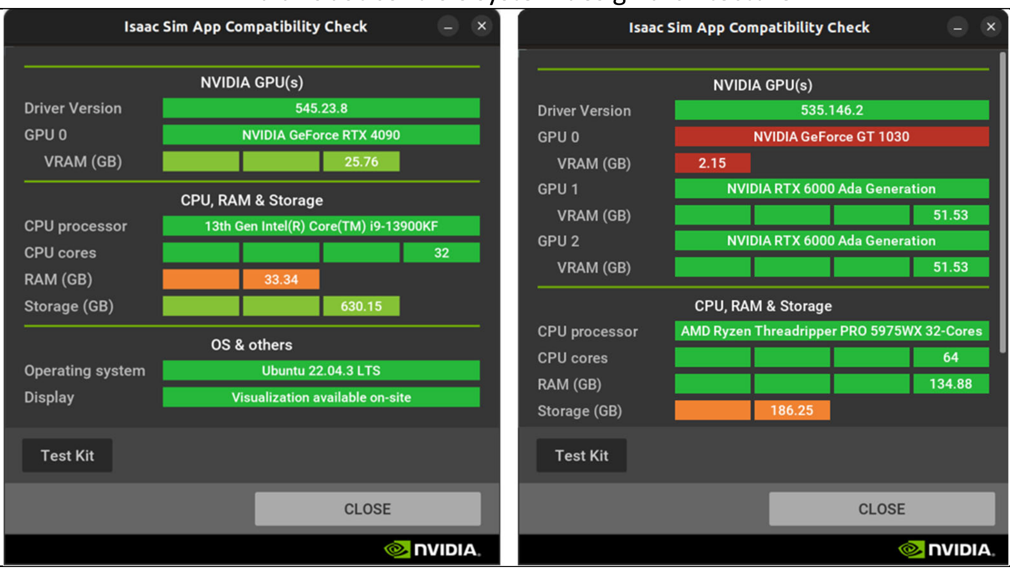
Case description

Further advancement in making robotic solutions more adaptable and intelligent depends on the ability to execute complex simulations for design exploration, synthetic data generation, train large machine learning models and run planning algorithms with many parameters. This results in increasing computing workloads that robotic companies must cover the cost of. In a software engineering perspective scalability is a software system's ability to sustain increasing workloads by using additional resources.

To optimize the business case for robotic solutions, computing cost must be minimized as much as possible. Therefore, efficient scalability is of vital importance for making robotic solutions economically viable.



Nvidia robot controls system design architecture



Nvidia Isacc Sim resource check application

Challenge

Develop a software method or tool to optimize the computing use of robotic workloads in general or a specific workload, e.g. simulation, machine learning, etc.

To get the work started, consider the following:

- What workloads would you like to focus on?
- Would you like to focus on distributed workloads or workloads on a single node distributed over CPU and GPU loads?
- How is it possible to do sensible trade-offs between accuracy vs. cost (e.g. simulation steps, physics accuracy…)
- How do you relate workloads to cost?

Keywords

Distributed computing, SaaS

Tools, methods and materials

The challenge can be addressed with many different methods considering benchmarking, software architecture or distributed computing. The methods can put different focus on software or hardware elements. Methods can be considered that could alter the programming of the solution or change off-load patterns or perform trade-offs, e.g., accuracy vs. cost.

From SDU, the team will be introduced to relevant software frameworks. Different computing options are available at SDU that can be used for experiments (e.g. ucloud.sdu.dk). In addition, SDU will provide feedback on challenge elements.

Payload pick and place via drone

Case description

The use of drones for pick up, transport and placing tasks could reduce transportation times, the need for manual labor and could potentially enhance safety by mitigating the risks associated with heavy lifting and handling hazardous materials.

Suction grippers have been highly successful in the robotic industry at picking a large variety of objects, however their use with drones still needs to be developed and tested.

Schmalz suction gripper kit which can be installed on drones

Challenge

Develop a comprehensive solution that demonstrates the integration of vacuum gripping technology with drones for payload pick and place operations.

To get the work started, consider the following:

- What is a good gripping solution to mount on a UAV drone provided by SDU?
- What is the best scientific approach to test secure attachment and release of various payloads?
- What software tools, algorithms and sensors are required to develop a control system for drones to execute precise pick and place maneuvers?
- What defines a robust software framework to handle the coordination between user input, drone, and gripping system?

Keywords

Suction grippers, logistic drones

Tools, methods and materials

This challenge can be tackled in many ways. The positional accuracy required to pick to a payload can either be accomplished either by clever use of algorithms controlling the drone's position, clever use of mechanisms or a combination of both to ensure the save pick-up and placement of various payloads.

The team will be provided with Schmalz gripping technology and will be offered some input during the half-point of the development process, ensuring that the solution meets industry standards and is potentially ready for real-world applications.

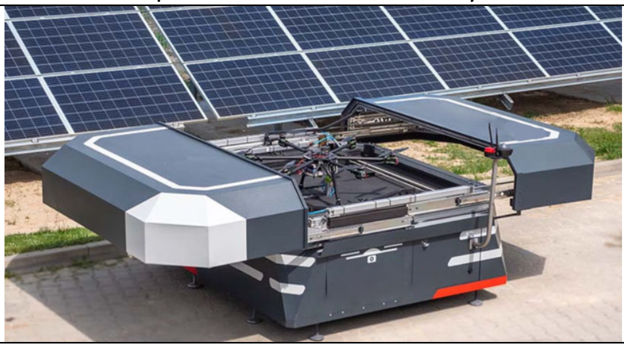
From SDU, the team will receive an introduction to the relevant frameworks to develop and test their drone-based solution. The team will have access to the SDU UAV drone, testing and production grounds at the SDU UAS Test Center and, if needed, a wide selection of sensors that can be mounted to the SDU UAV drone.

Done in a box

Case description

This drone-in-a-box solution should enhance wildlife monitoring by providing continuous and non-intrusive surveillance of natural habitats. The drone-in-the-box system shall of a self-contained drone unit that can autonomously deploy, execute missions, and return to its base for recharging and data transfer without human intervention. By utilizing a drone-in-a-box system, conservationists will receive a tool that could give valuable insights into wildlife dynamics while minimizing human impact on the environment. This technology promises the potential to revolutionize wildlife observation, making it more efficient, accurate, and sustainable.

However, many details of the drone-in-the-box system remain open and need further analysis.

Example of Robotto drone-in-a-box system used for Beyond Visual Line of Sight (BVLOS) operations

Challenge

Develop a comprehensive wildlife observation system utilizing the drone-in-a-box principle.

To get the work started, consider the following:

- What are the requirements for a robust drone-in-a-box system?
- Is the drone-in-a-box concept a solved problem within the drone industry and what approaches towards this concept are there?
- What software tools, algorithms and sensors are required for a drone-in-a-box system?
- What defines a robust software framework to handle the coordination between user input, drone, and gripping system?

Keywords

BVLOS operations, remotely deployable drones

Tools, methods and materials

This challenge can be tackled in many ways. The team must decide if they want to adapt the SDU UAV to the box or the box to the SDU UAV. Furthermore, a robust drone-in-a-box system could be accomplished either by clever use of algorithms controlling the drone's position, clever use of mechanisms or a combination of both.
Students will also be offered input from industry during the half-point of the development process, ensuring that the solution meets industry standards and is potentially ready for real-world applications.

From SDU, the team will receive an introduction to the relevant frameworks to develop and test their drone-based solution. The team will have access to the SDU UAV drone, testing and production grounds at the SDU UAS Test Center and, if needed, a wide selection of sensors that can be mounted to the SDU UAV drone or any additional hardware.