An Innovative Robotics Platform for Simplifying and Accelerating Deployments in the Food Industry

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Abstract

The food industry is still far behind the automotive and electronics industries in the deployment of robotics. Traditional robotics that has evolved with mature technologies for the industrial sectors is still struggling to meet the unique challenges of the food industry.

A new robotics platform, based on a unique parallel robot “Ragnar”, designed for fast and flexible pick-and-place applications, together with an intelligent and intuitive operating environment, low cost commercial sensors, and an optimized suite of grippers is designed to help food industry manufacturers to achieve their production improvement goals and optimize the value of their investment in robotics automation equipment. The role of ROS Industrial in the Blue Workforce “Ragnar” platform, along with application examples, will be presented.

A Little Background

- Principal company Blue Workforce A/S (Aalborg, Denmark) founded in 2012
- Coppelia Robotics (Switzerland) acquired in December 2016
- Preben Hjornet, Founder and CEO
  - Harvard MBA and an expert in disruptive innovation business models
  - Lecturer in EMBA and Manufacturing and Technology Programs at Aalborg University
  - Prior venture InMoTx (Denmark), founded in 2006, acquired by Adept Technology (USA) in 2010
- Blue Workforce Robotics (Asia Pacific) is a JV operation with Blue Workforce A/S
  - Alliance completed March 17, 2017
  - Public launch at ProPak China 2017 in Shanghai on July 12, 2017

Benefits of Automating Food Production

- Reduces food safety risks and introduction of pathogens associated with human labor
- Improves consistency, yield, and flexibility, and makes processes controlled and predictable
- Eliminates dangerous process and repetitive motion injuries
- Interface with other machines and computers
- Eliminates variables and costs associated with human labor
- Reduces human exposure in harsh environments (for example, cold/freezing facilities)

Food Safety and Robotics

Challenges in handling food products with robots

- Comprehensive controls need to be in place to ensure food safety and cleanliness
- Sanitary and safety requirements are rigorous
  - How to ensure robots can be washed and cleaned without damage?
  - How to ensure robots won't be damaged with industrial cleaning agents?
  - How to ensure robots won't introduce contamination or foster bacterial growth or spread allergens and micro-organisms?
- Natural product variations
  - How to handle foods with natural variations in size, shape, or consistency?
  - How to adapt to seasonal variability?

Challenges in Food Handling




High Variability

Food Products

Deformable products

Variable shapes

Randomly oriented

Consumer driven package evolution

Limited equipment engineering staffs




Low Variability

Industrial Products

Rigid bodies

Tight tolerances

Fixed infeed locations

More predictable product evolution

Extensive equipment staff

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Sanitary Design

Regulatory requirements for meat/poultry:

- FDA 21 CFR (Code of Federal Regulations)
  - Title 21 is governs food and drugs within the United States for the Food and Drug Administration (FDA), the Drug Enforcement Administration (DEA), and the Office of National Drug Control Policy (ONDCP).
  - Materials approved for FDA per 21 CFR food processing are required by USDA inspectors.
  - Regulations pertaining to food usually fall under 21 CFR Parts 174 through 189.
  - Food grade grease is not a requirement of the USDA but is required by some food processing companies.
- NSF 14159 (Hygiene Requirements for the Design of Meat and Poultry Processing Equipment)
  - NSF International, The Public Health and Safety Company, a not-for-profit, non-governmental organization, is the world leader in standards development, product certification, education, and risk-management for public health and safety.
  - NSF International provides design requirements for Meat & Poultry and Dairy food processing equipment. This is required by USDA.

Sanitary Design

General requirements cover:

- Radii: Minimum radii requirements on internal angles
- Surface finishes: Minimum surface finish (Ra) requirements depending on material
- Surface inspection
  - Parts that cannot be inspected are unacceptable
  - Surfaces that can't be inspected must be disassembled
- Crevices between metal-to-metal contact points are not allowed: Must use seals and gaskets
- Exposed threads are not allowed
- Stickers and exposed labels are not allowed
- Oil and grease: Must be contained
- CIP and COP procedures

Sanitary Design

Materials requirements:

- Rubbers to comply with 21 CFR 177.2600
- Electroless nickel plating to comply with Mil-C-2607E
- PEEK plastic to comply with 21 CFR 177.2415
- Delrin plastic such as Techaform HPV13 to comply with 21 CFR 177.105 and 177.2470
- Urethane Rubber to comply with 21 CFR 177.168
- Nylon 12 coating to comply with 21 CFR 177.1500
- Lexan clear plastic to comply with 21 CFR 177.1580
- Bonding material such as epoxy adhesive to comply with 21 CFR 175.105 and sometimes 175.300 for labels
- Materials and designs used must be capable of passing bacteria tests
- Materials must resist sanitizing solutions
- In general PH from 4 to 12, where possible

Food Handling Challenges

Primary packaging automation requires more flexible and focused solutions.

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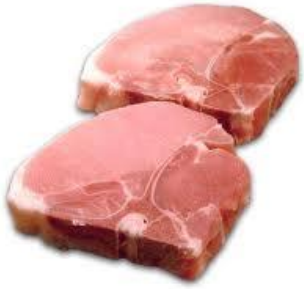
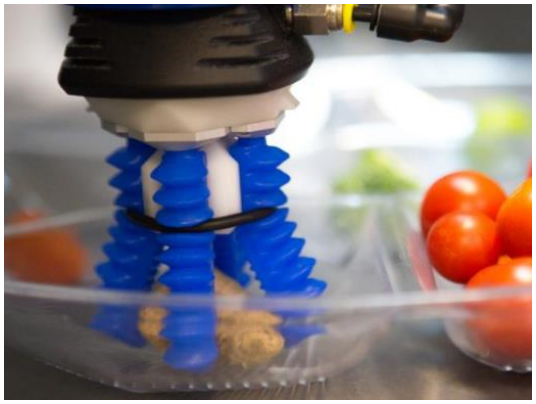
Food Handling Challenges





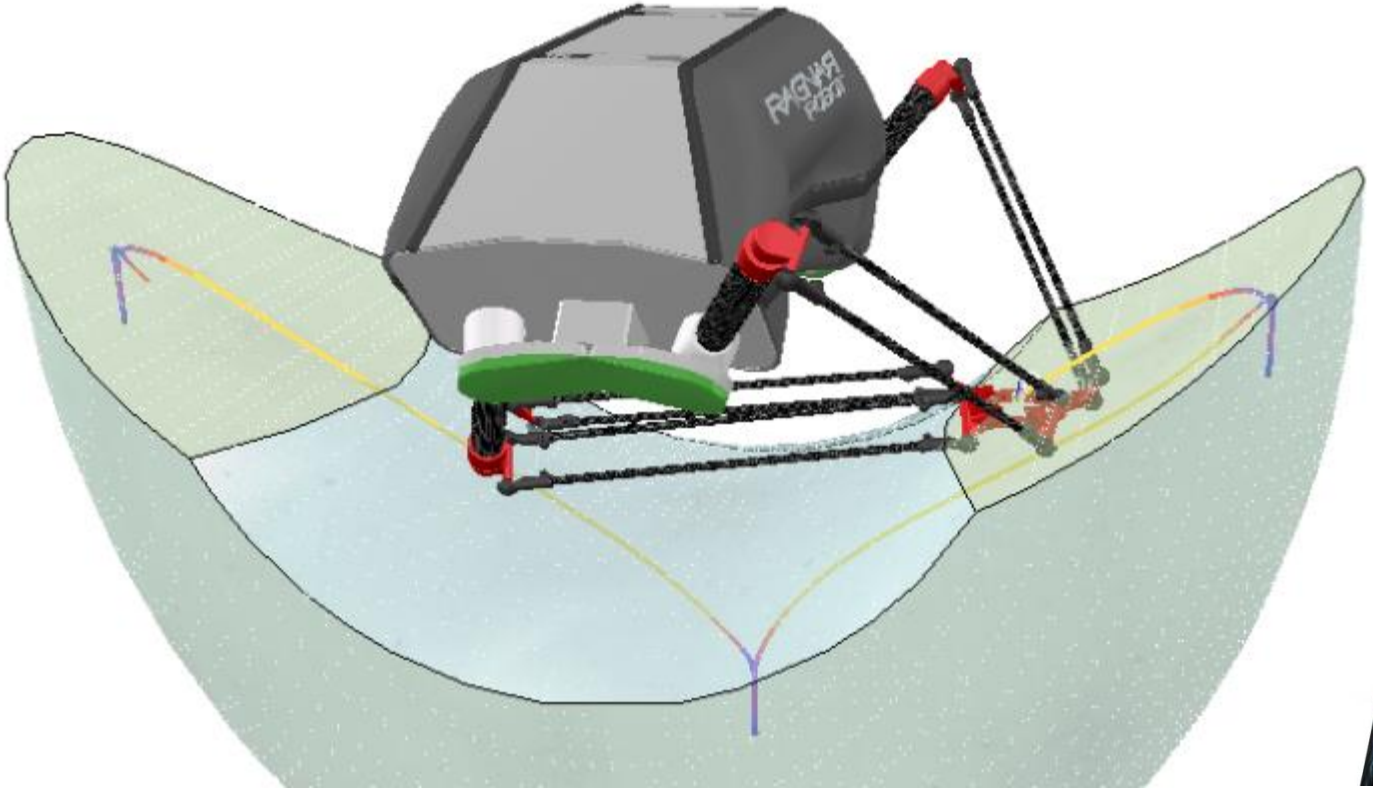

Food Application Grippers



Motivation

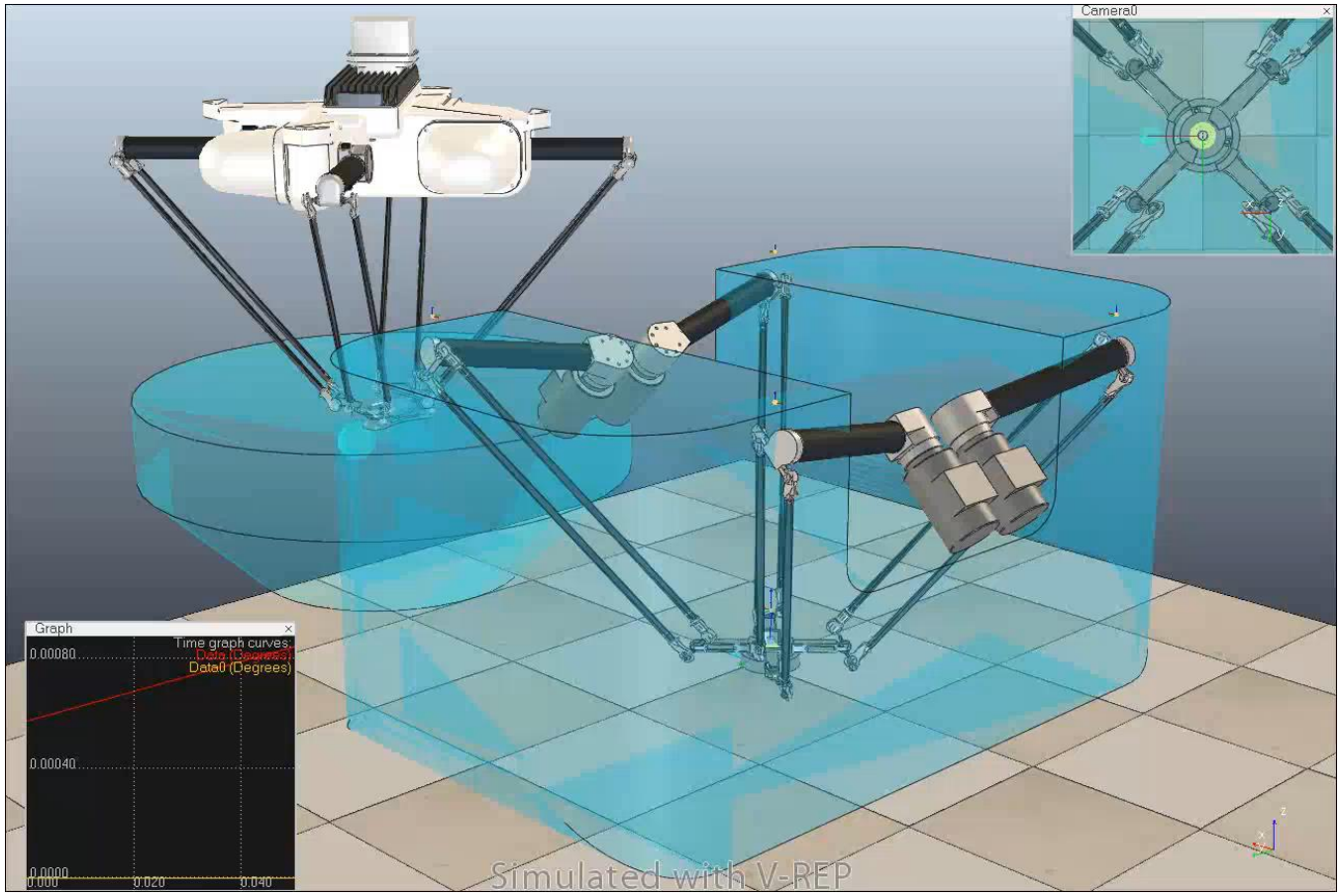
- Inspired by Harvard Professor Clayton Christensen's theory of "disruptive innovation"
- Disruptive innovation. "A process by which a product or service takes root initially in simple applications at the bottom of a market and then relentlessly moves upmarket, eventually displacing established competitors."
- Founding of Blue Workforce originated from frustration and wonderment over how expensive and complicated it is to bring robots into the industry
- Our driving philosophy is that it must be simple, it must do the designed (and not over-designed) to do the job, and it must be affordable

Unique Workspace

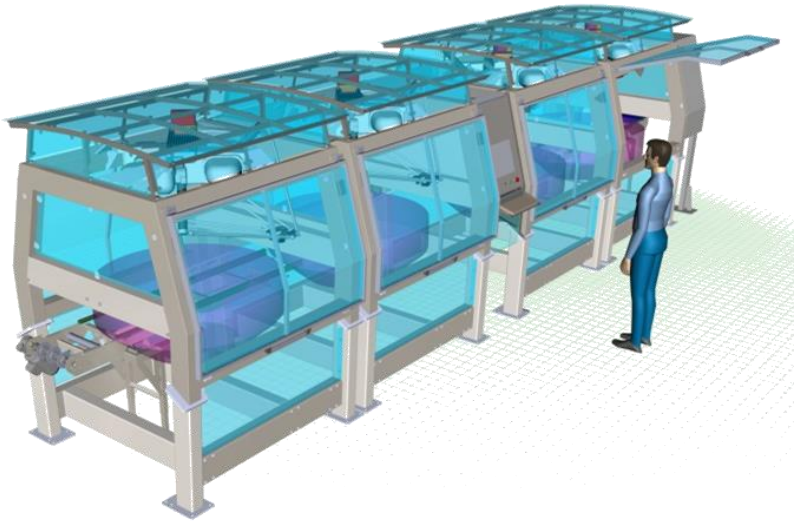


Traditional delta robots operate in a circular field limiting the workspace. The design of the RAGNAR Robot expands the operational workspace considerably, which means fewer robots can cover the same area more efficiently than traditional applications.

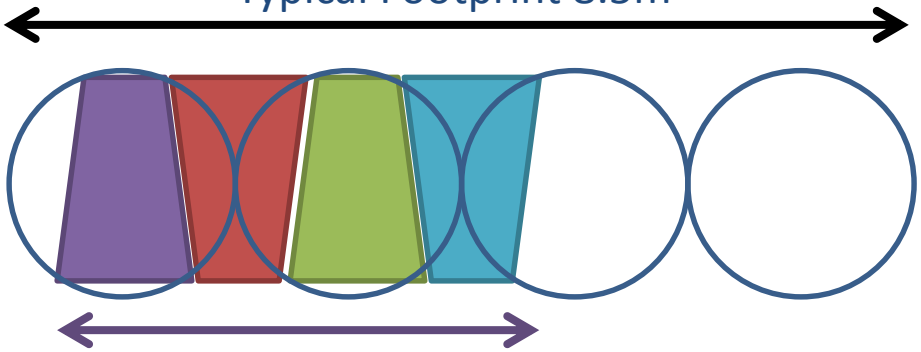
Unique Workspace



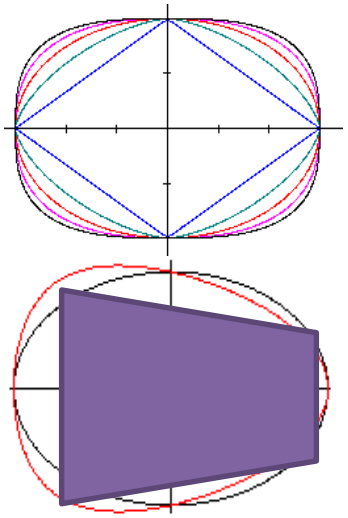
Optimized, Flexible Geometries

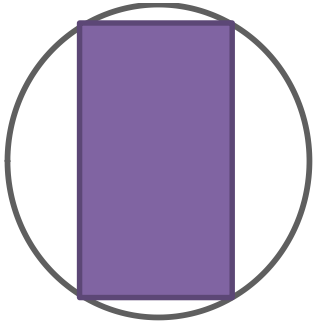


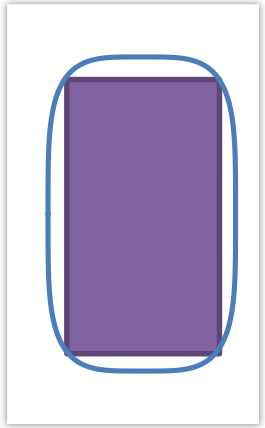
Typical Footprint 8.5m



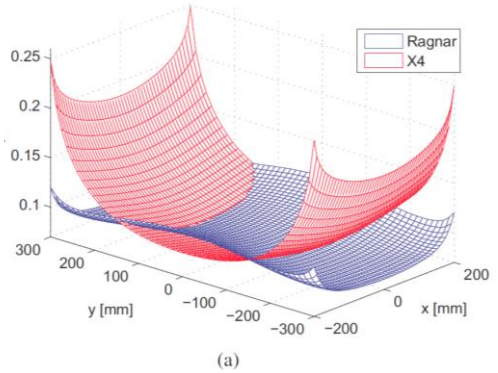
RAGNAR 3.9m







Scalable, Parametric Design



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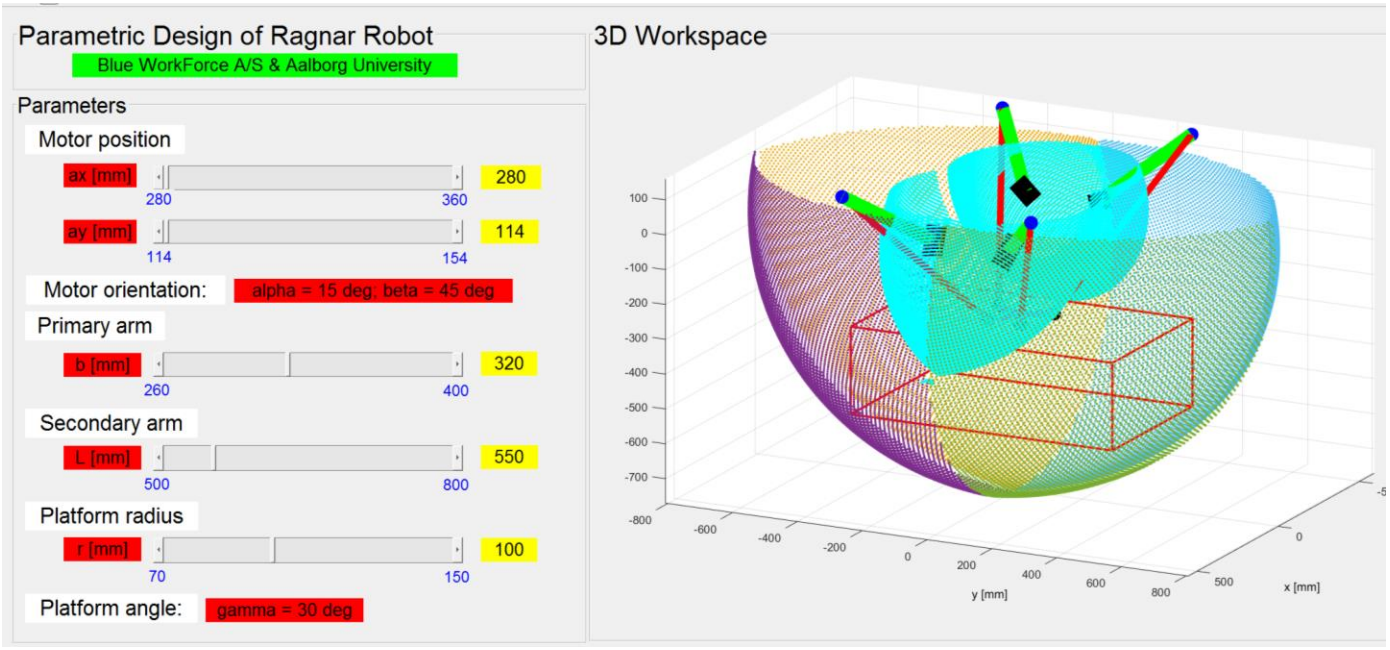
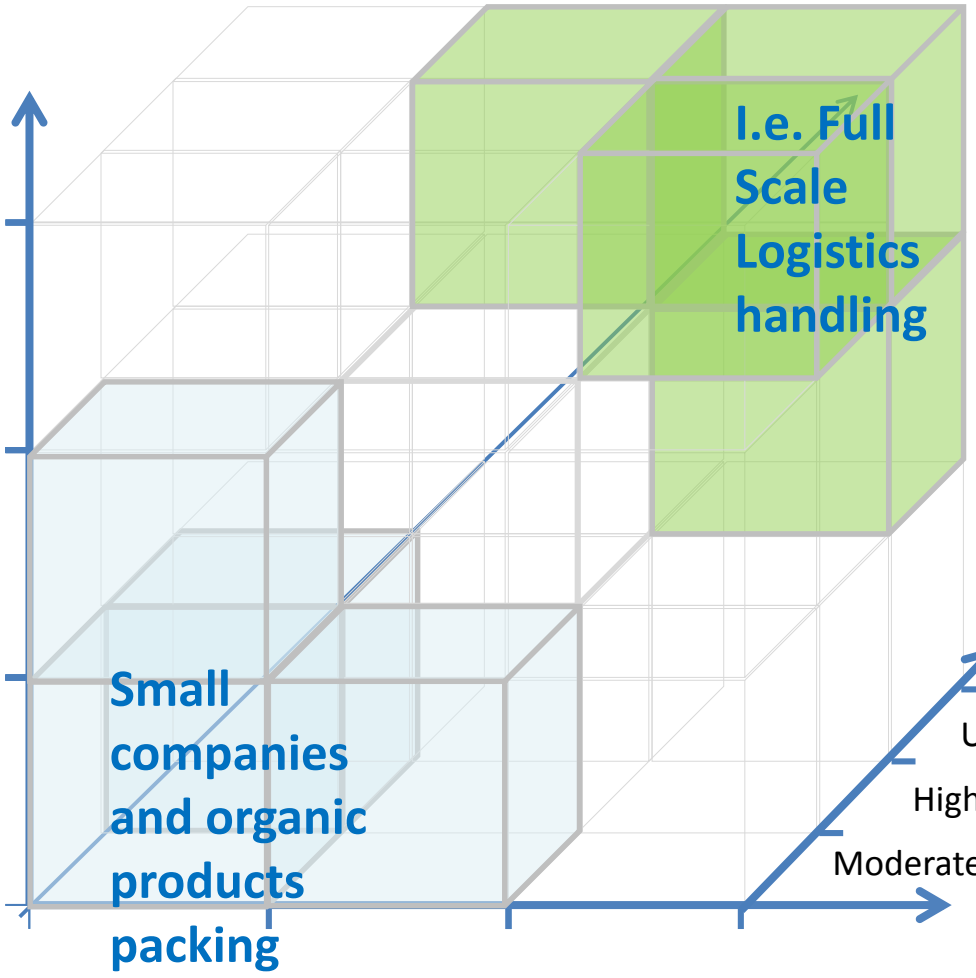


Scalable, Parametric Design



Customer part weight and process precision requirement

High Pay Load/
High Precision

High Pay Load/
Low Precision

or

Low Pay Load/
High Precision

Low Pay Load/
Low precision

Performance =
Pay Load
x
Precision
x
Speed
x
Work Space

Process speed requirements

Ultra High Speed

High Speed

Moderate Speed

Moderate Work Space

Large Work Space

Ultra Large Work Space

Work Space requirement

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Lightweight, Low-Cost Construction

Thinking on where and how our costumers need to place their robot in a work situation lead us to design an out of the box lightweight robot. Lightweight means rethinking the choice of materials without compromising performance. We replaced all possible parts with fiber-reinforced plastic on the RAGNAR Robot. Advanced thermoplastics and manufacturing delivers affordability without compromising quality and reliability. The result is a robot as light as 32kg!

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RAGNAR Robot

1/10 the weight and power consumption ratio compared to conventional solutions

1/10 the cost of SOTA 1:1 conventional solutions

Multi-purpose and portable platform is easily configured to 3D-printing etc.

Radical workspace extension compared to conventional solutions

Low complexity and number of components are the main drivers in keeping costs down

RAGNAR™ ROBOT
powered by BlueWorkforce | Denmark

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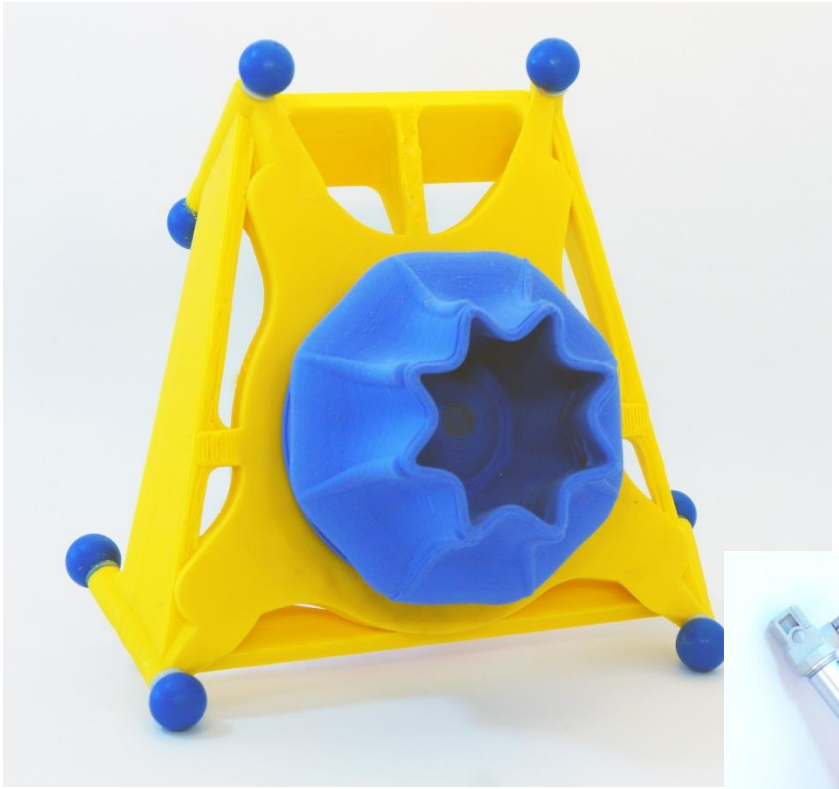
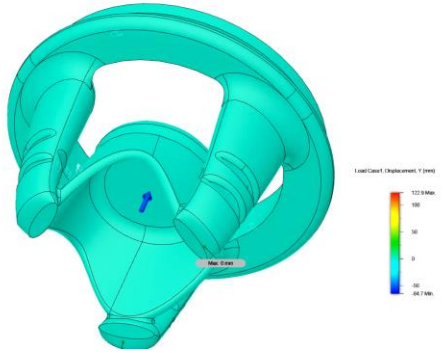
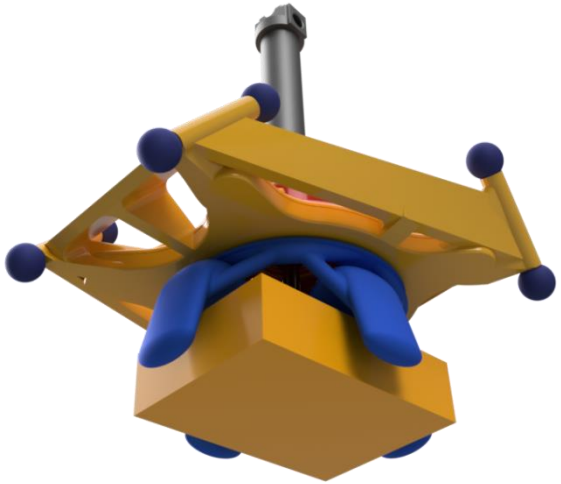
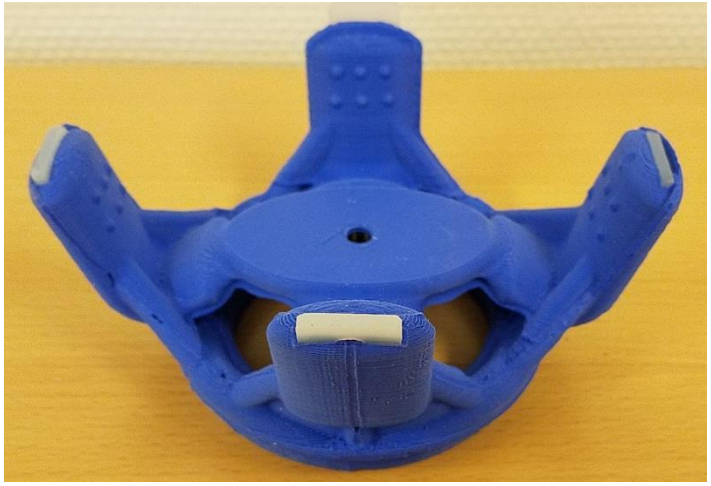
Unique Gripper Solutions





Unique Gripper Solutions





Enabling 3D-RGB Vision Technology

Integrating off-the-shelf 3D sensors designed for the consumer markets enables high performance to cost index.

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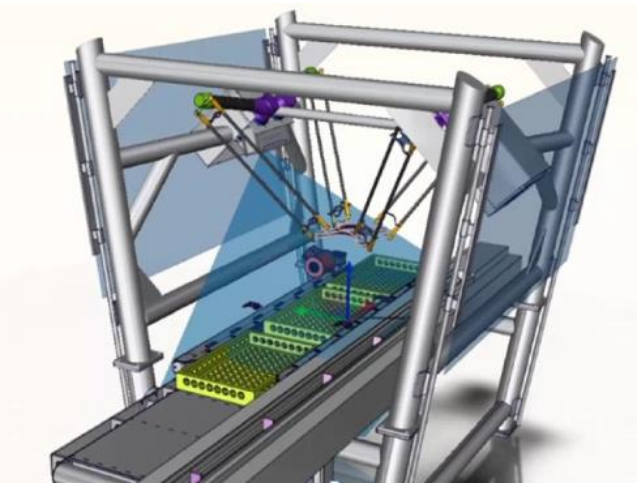
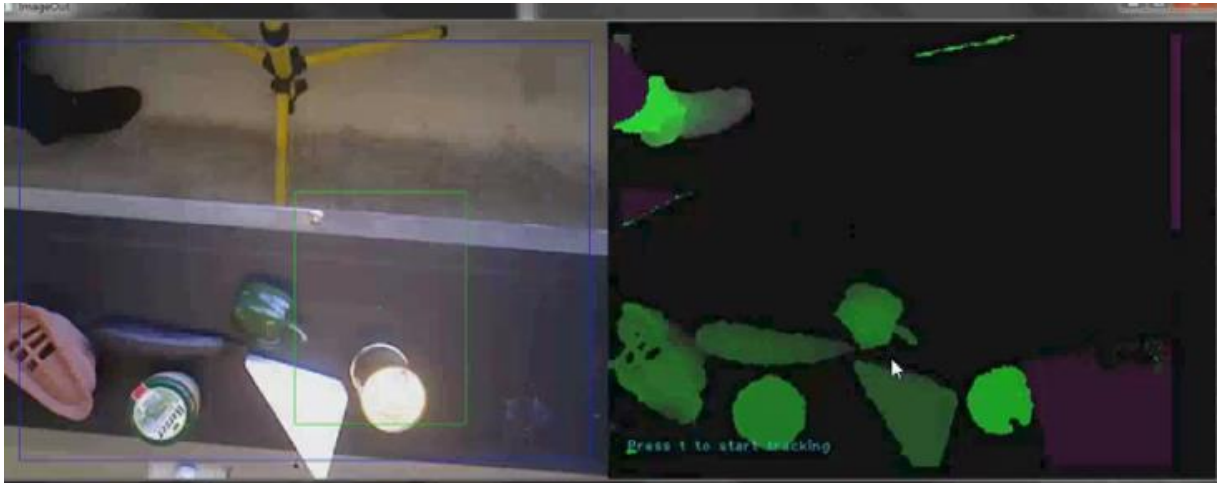
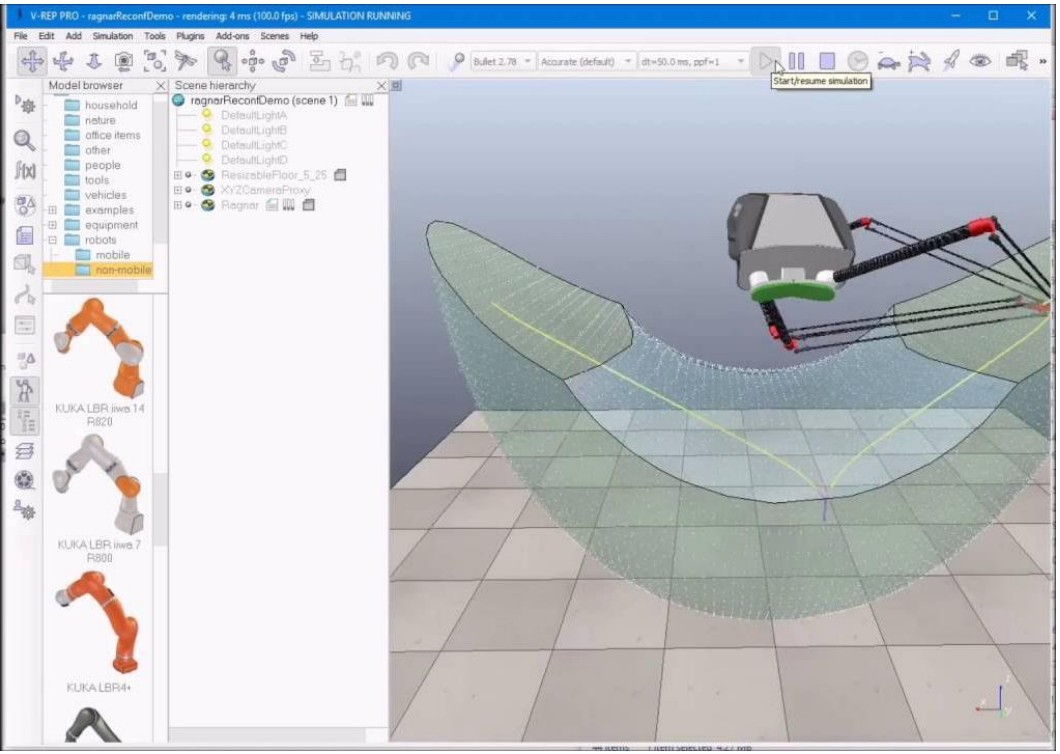
Enabling 3D-RGB Vision Technology

- Vision models are self trained via auto-learning, eliminating costly and time-consuming expert training
- Dramatically improves consistency and reliability
- Tolerates even wide natural variance in presents and appearance preserving accuracy and speed





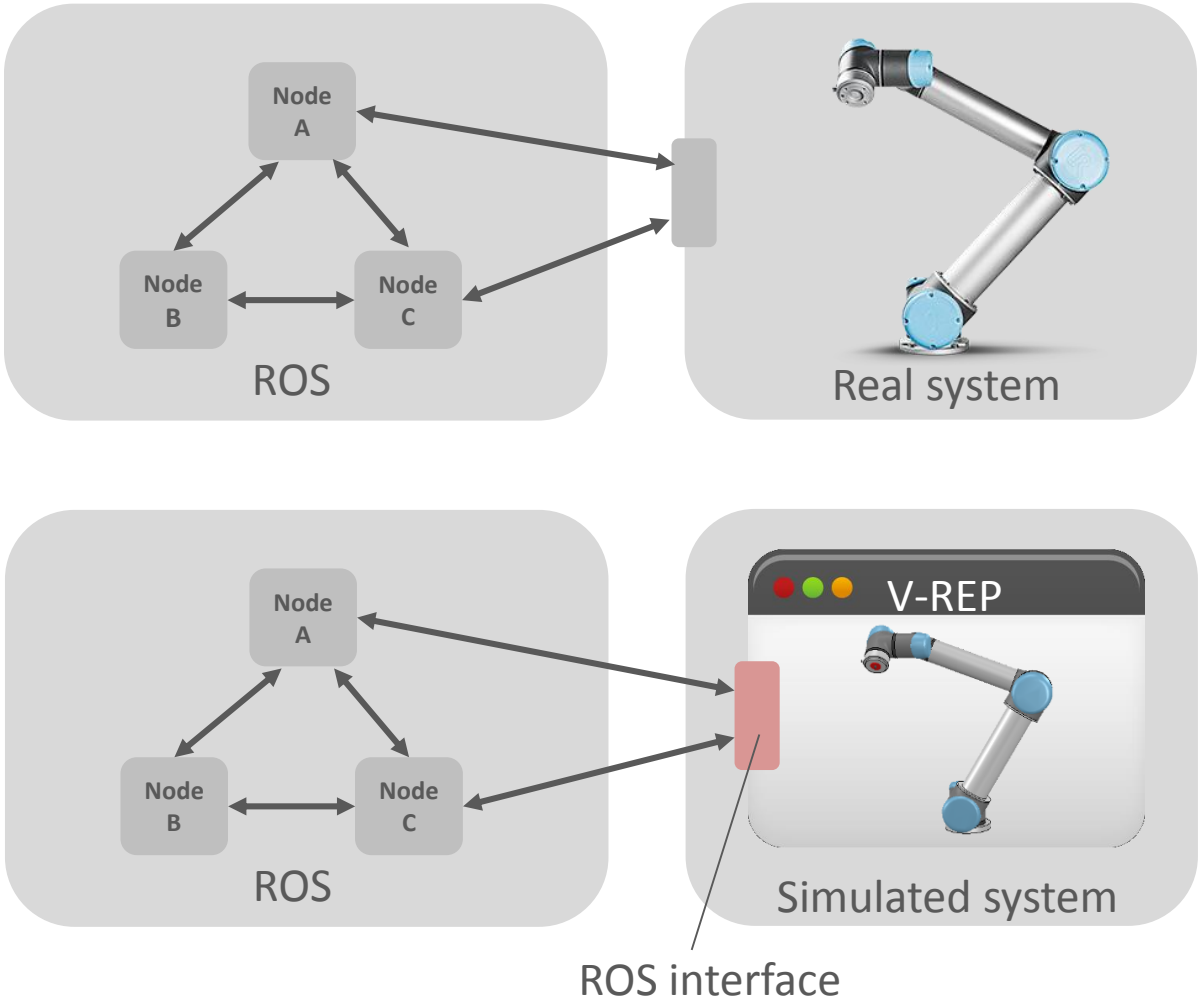
Bridging Simulation with Production



- Coppelia Robotics GmbH (Switzerland) and V-REP acquired in December 2016
- V-REP is a robot simulator, or a toolbox for robotic simulation

- Sensors, mechanisms, robots and whole systems can be modelled and simulated in various ways
- Main features
  - IK/FK solver
  - 4 physics engines
  - Collision detection, minimum distance calculations
  - Path/motion planning
  - Proximity/vision/force/torque sensor simulation
  - Octrees/point clouds/etc.
  - Several interfaces (embedded scripts, ROS, remote API, etc.)
  - Several languages (Lua, C/C++, Python, Java, Matlab, etc.)

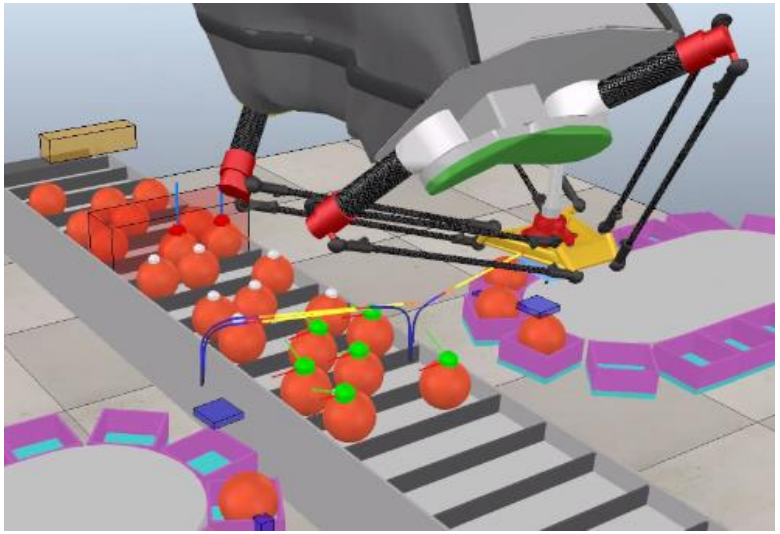
Bridging Simulation with Production



- Typical applications
  - Fast prototyping and verification
  - Fast algorithm development
  - Robotics related education, etc.

Bridging Simulation with Production

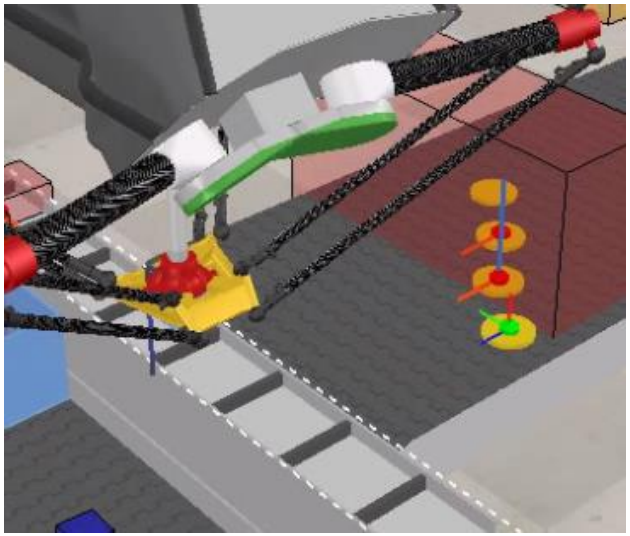
Qualify, Design,
Configure, Optimize

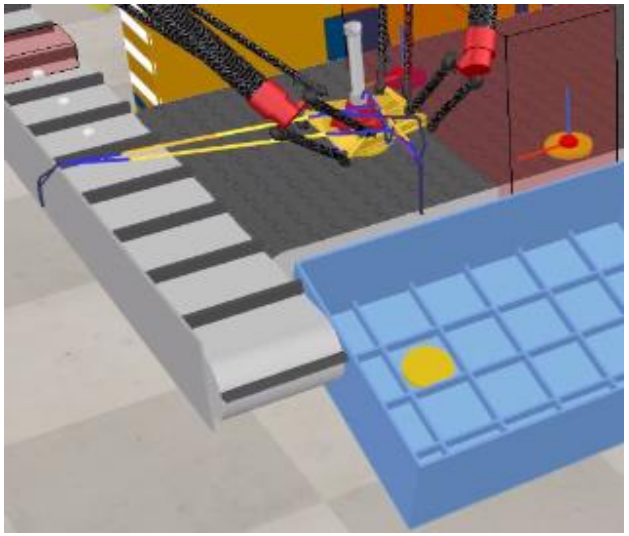


Operate, Maintain

Application Example 1

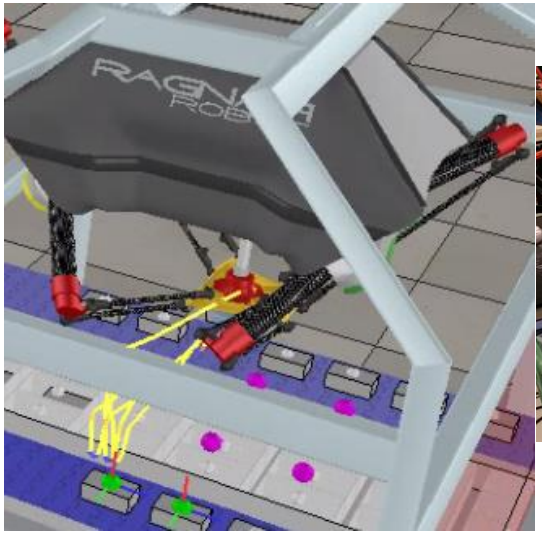
Crossflow loading cookies to flow wrapper infeed belt

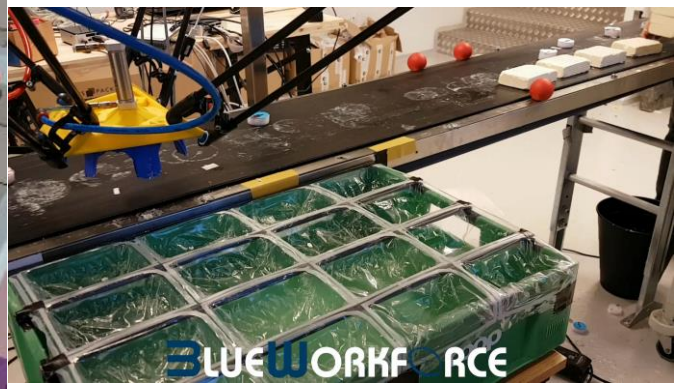


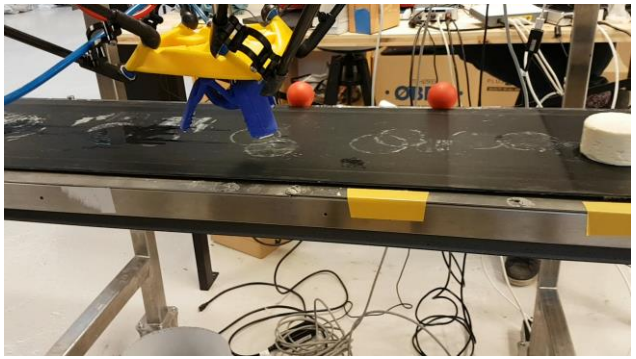


Application Example 2

Loading delicate feta cheese into thermoformer and cans

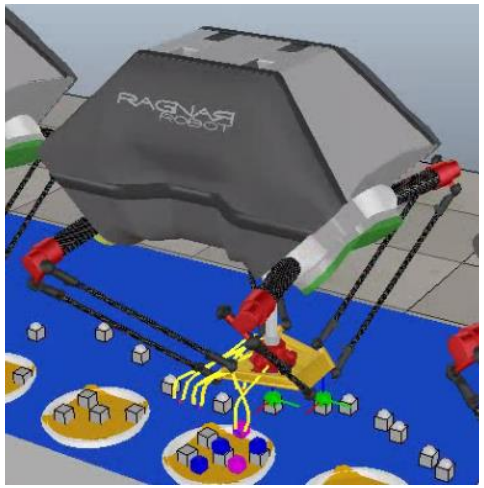






Application Example 3

Loading dough balls into pastry tin (pastry assembly)



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