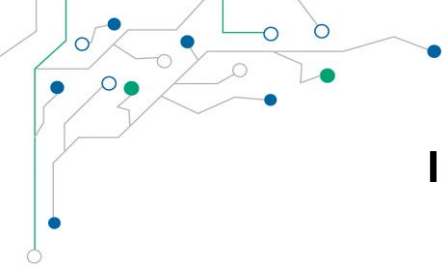# Closed-loop Systems in Robotics
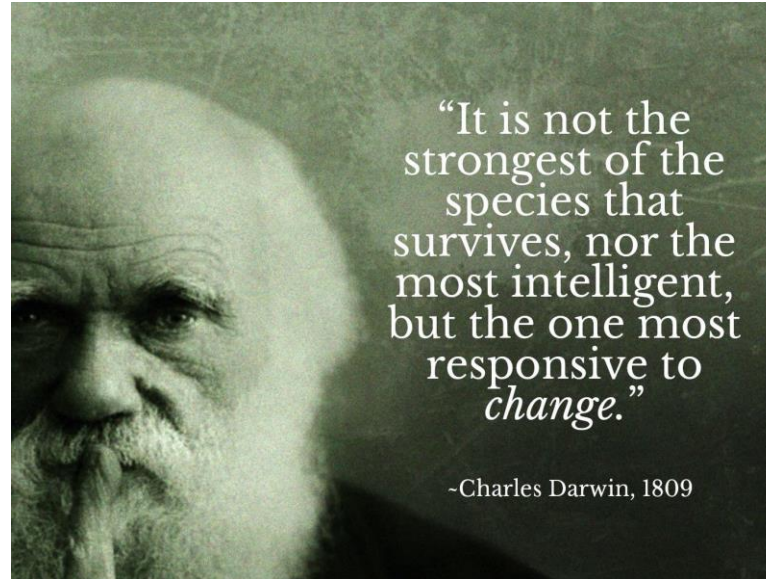
Oscar Arienti
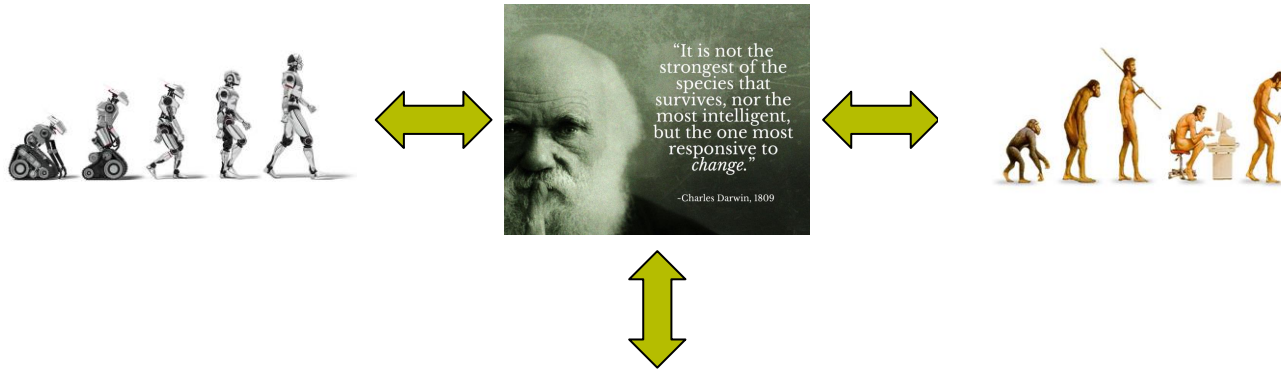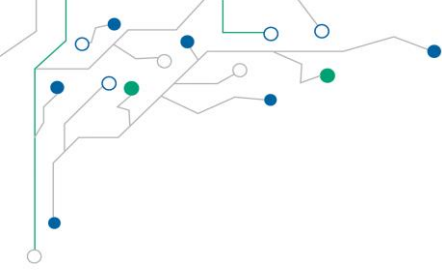
Sales Manager Atutomation Division

## HEIDENHAIN

Industrial automation is inspired by natural behavior

"It is not the strongest of the species that survives, nor the most intelligent, but the one most responsive to *change*."

~Charles Darwin, 1809

Robot evolution requires applicative flexibility and scalability

Industrial automation applications are driven by semi-Closed Loop

Semi-Closed Loop
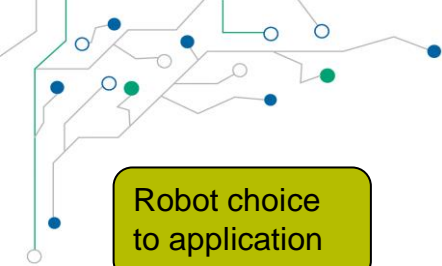One position feedback for speed and position control
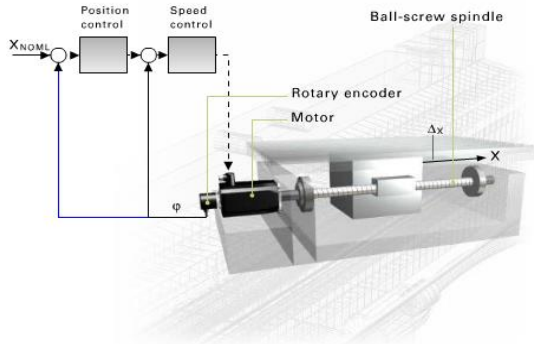
$+$ Mechanical robustness
$+$ Easy mounting
$+$ Low price level

$-$ Low positioning accuracy
$-$ Limited applications / low flexibility
$-$ Unreliable positioning

The day before yesterdays

Robot choice to application

■ Suitability to operate different repeatable tasks

Feedback device

■ Resolver
- **+** Mechanical robustness
- **+** Thermal robustness
- **+** Wide mounting tolerance
- **+** Sole data interface
- **+** Low price level
- **-** Low positioning accuracy
- **-** Low signal quality (analog)
- **-** No additional information/ I 4.0 / predictive maintenance
- **-** Slow robot "ready to work"

Robot ROI assumption

■ ~2 years

Yesterday

Robot choice to application

- Suitability to operate different repeatable and dynamic tasks

Feedback device

- Inductive absolute encoder
  - + Mechanical robustness
  - + EnDat22 digital data interface
  - + Additional information/ I 4.0 / predictive maintenance
  - + Good quality and robust signal
  - + Good positioning accuracy
  - + Good mounting tolerance
  - + Prompt robot "ready to work"
  - + Single cable (data/power)
  - - Thermal robustness
  - - Resolver price x2

Robot ROI assumption

- < 2 years

**Robot choice to application**

- Suitability to operate different repeatable and dynamic tasks in Safety systems
- Safety working area w/o hardware barriers and more rational organization of space in the shop floor

Feedback device

- Inductive Functional Safety absolute encoder
  - Mechanical robustness
  - Digital data interface EnDat22 FS
  - Safety Integrity Level up to 3
  - Additional information/ I 4.0/ predictive maintenance
  - Good quality and robust signal
  - Good positioning accuracy
  - Good mounting tolerance
  - Prompt robot "ready to work
  - Single cable (data/power)
  - Thermal robustness
  - Resolver price x4

Robot ROI assumption

- < <2 years

# As on machine tools, robots benefits from Closed Loop
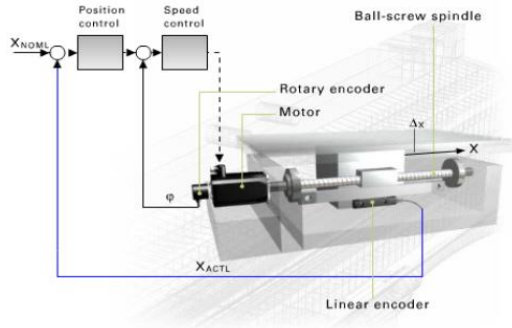
Closed Loop
Two position feedbacks, each related to speed and position

+ Improved and reliable machine positioning accuracy
+ Wider and smarter applications
+ Additional measurements (e.g. torque)

- Additional mounting space
- Semi-Closed Loop price x4

Secondary encoders mandatory for Closed Loop on robots

+ Closed Loop is based on "continuous monitoring of working conditions and process parameters by means of appropriate sets of sensors and adaptations to process drifts". This is one of the requisites envisaged by the National Business Plan Industry 4.0 about predictive maintenance

+ Improvement of robot suitability for different applications due to Tool Center Point accuracy in addition to FS encoder benefits

+ Shorter ROI timing due to multiple scalability after investment
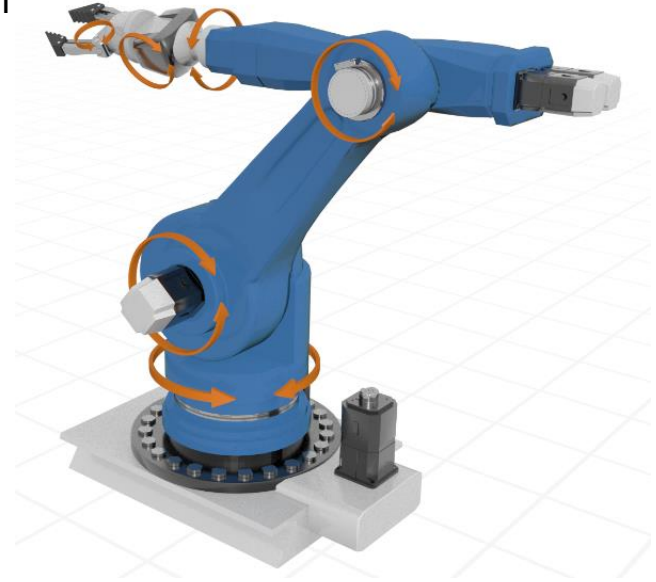
Secondary encoders mandatory for Closed Loop on robots

+ Fine torque measurement possible: no torque uncertainty caused by gear box (gear box mechanically weak)

+ Improved competitiveness due to higher quality and productivity

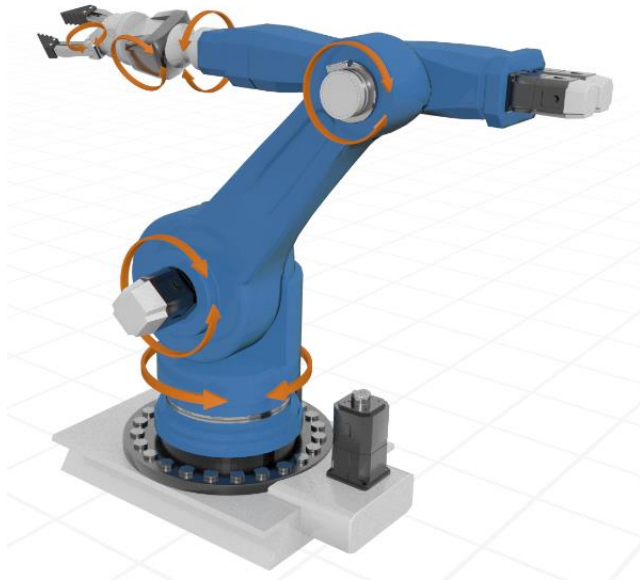+ Energy efficiency thanks to higher dynamic control performance
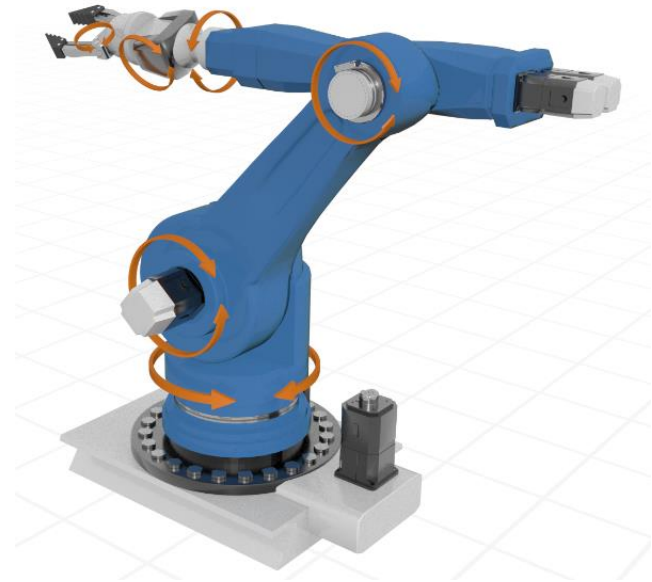
Closed Loop in robots increases interactivity to existing/future machines
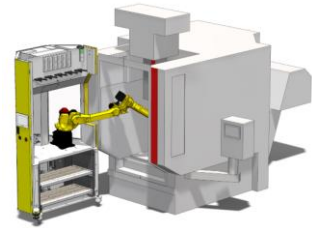
Future applications
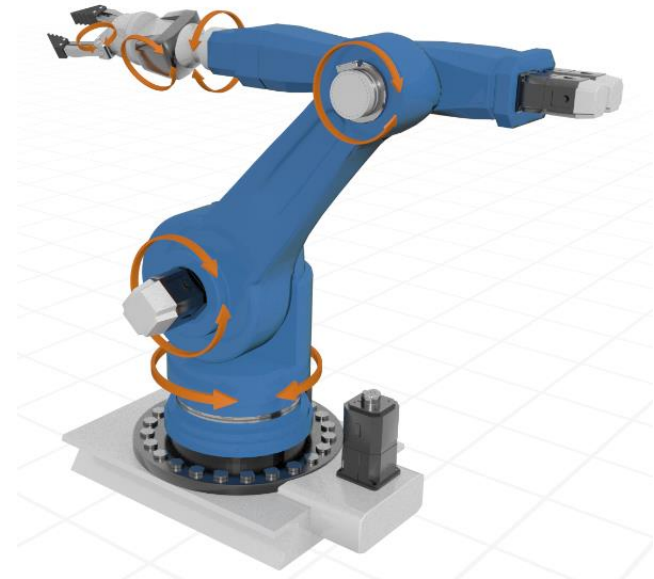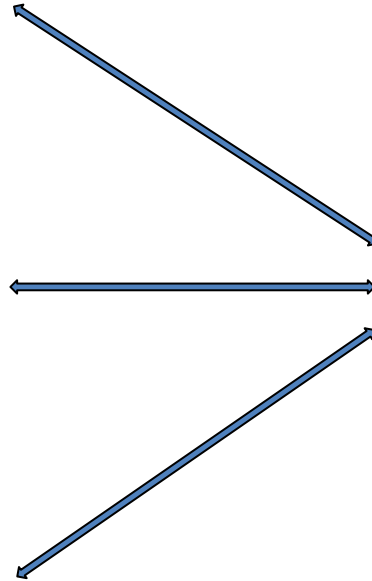
Automation product portfolio meets the needs of future industrial automation

Automation product portfolio for ROBOT Secondary Encoder

Special absolute encoder FS
+ Top technology inside
+ Multidimensional FS
+ High product integration

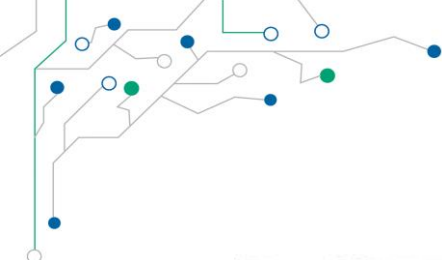**Optical absolute ring encoder**
+ High accuracy
+ PRC code or similar for reliable positioning scanning
+ Wide mounting tolerances

Inductive / Magnetic absolute ring encoder
+ High IP rate
+ High product fitting flexibility
+ Wide range of diameters

CLOSED LOOP boosts ROBOT competitiveness
Evolution of robotic feedback devices

Lead the way to new dimensions

+ **Accuracy**
+ **Productivity**
+ **Efficiency**