



Nabtesco

THE POWER AT YOUR SIDE



About us!

DIGITAL WAVE GEAR

The bridge to digitalizing drive technology

Nabtesco

— x —

HBK
HOTTINGER BRÜEL & KJÆR

INTEGRATED SENSING

Force, torque, vibration
and more...

EMBEDDED INTELLIGENCE

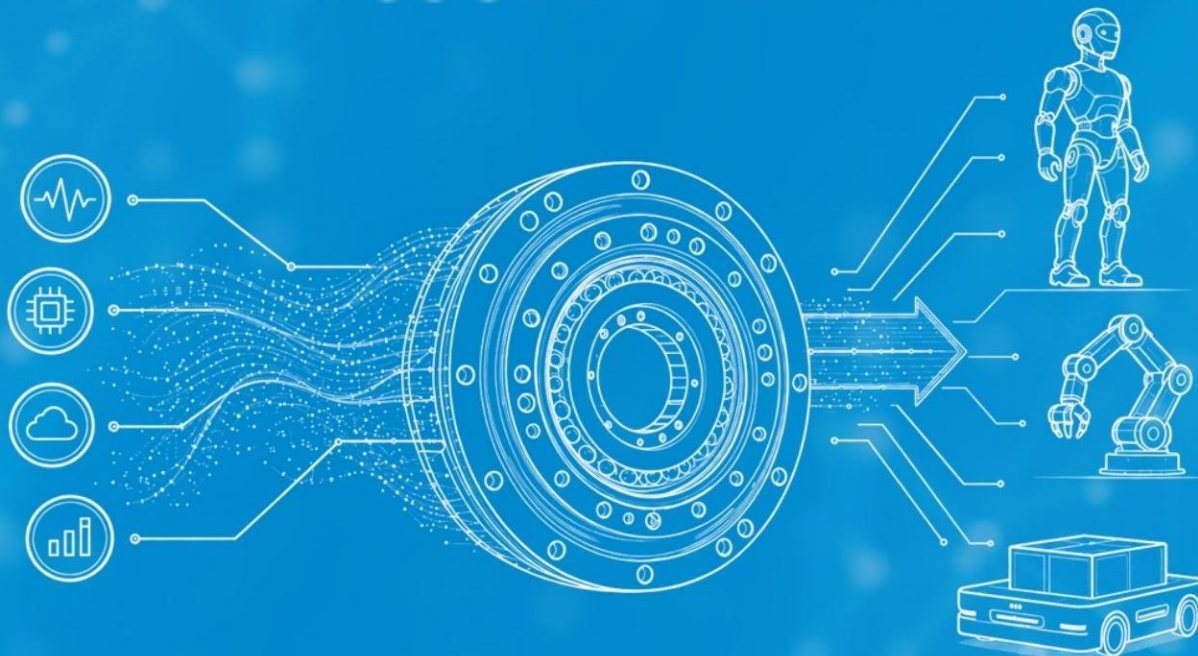
Data & analysis
Advanced algorithms

CONNECTIVITY

2-in-1 connectivity
BiSS-C & analog interface

CONDITION & LIFETIME MONITORING

Remaining useful lifetime
(RUL)
Anomaly & overload
detection



SMART DRIVE TECHNOLOGY

Increased productivity

Maximum efficiency

Absolute condition
insight

New features &
business

Data driven drives

FROM MECHANICS TO INTELLIGENCE

The digital gear for a smarter tomorrow



Physical AI as driver for innovation

Today: collaborative robots

- **≈55,000 cobots sold in 2025**

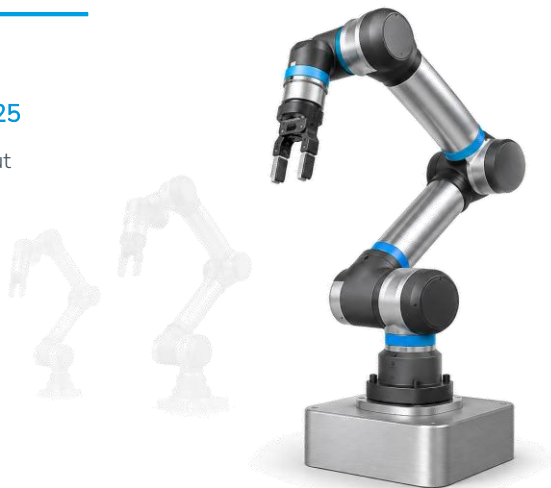
A growing installed base but still measured in tens of thousands.

- **6–7 degrees of freedom**

Typically, one actuator per joint.

- **Up to 6–7 torque sensors**

Not every axis uses dedicated torque sensing today.



Tomorrow: humanoid robots

- **Hundreds of thousands by 2030**

Scaling into millions becomes plausible as use cases mature.

- **35–55 degrees of freedom**

Far more joints create far more sensing opportunities.

- **10–20 strain wave gears with torque sensing**

The drive becomes both an actuator and a source of product data.



Tomorrow's drive systems will not only transmit torque.
They will generate data.



Technical Deep Dive into Hugging and Touching Humans

- Each move of humanoids depend on single joint movements
- Each joint movement is a regulated and highly controlled operation:
 - ⚙ Joint receives a pre-set
 - ⚙ Joint executes the pre-set
 - ⚙ Joint adjusts / tunes it's execution to reach the target properly
- Adjustment and tuning rely on live-data
- The more detailed the data the better the adjustment and tuning is



The data and information density is the key to hug and touch humans

Human's data and information density is the key to create an adaptive and sensitive system

Highest data and information density



Intelligent and powerful control algorithms



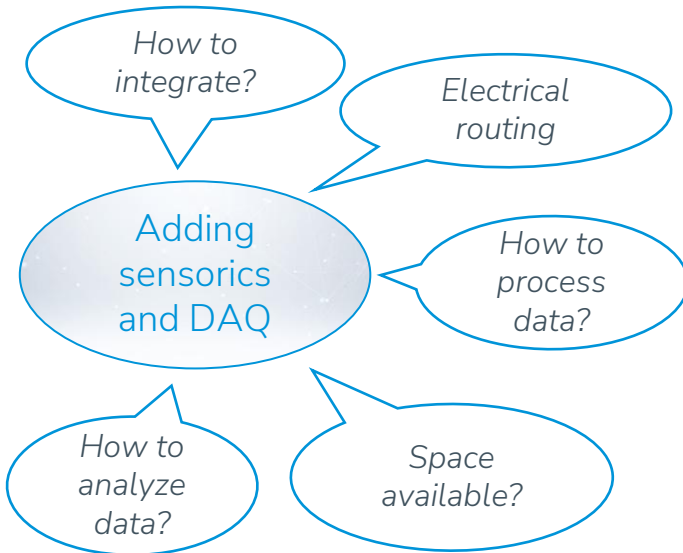
Human like movements



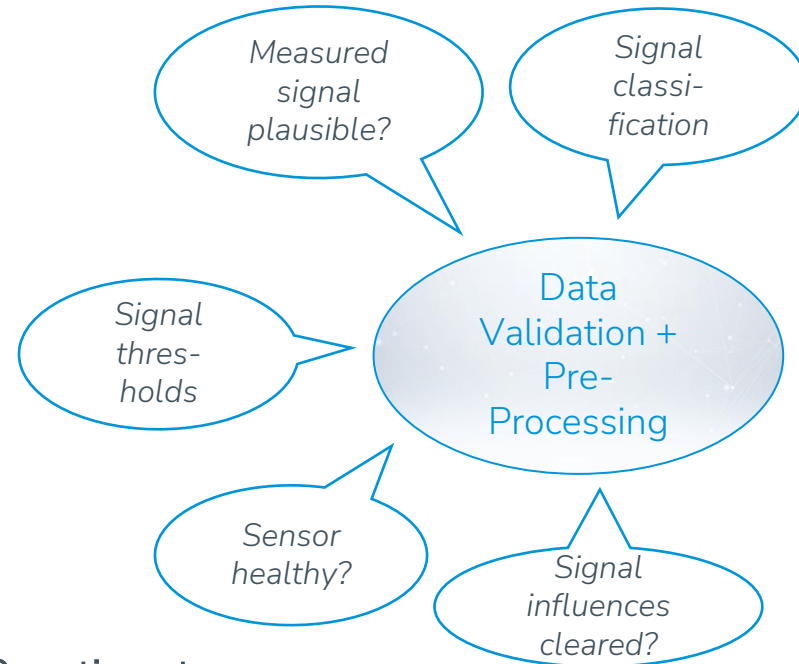


The digital gear: The supplier of dense application data

Tasks to do...

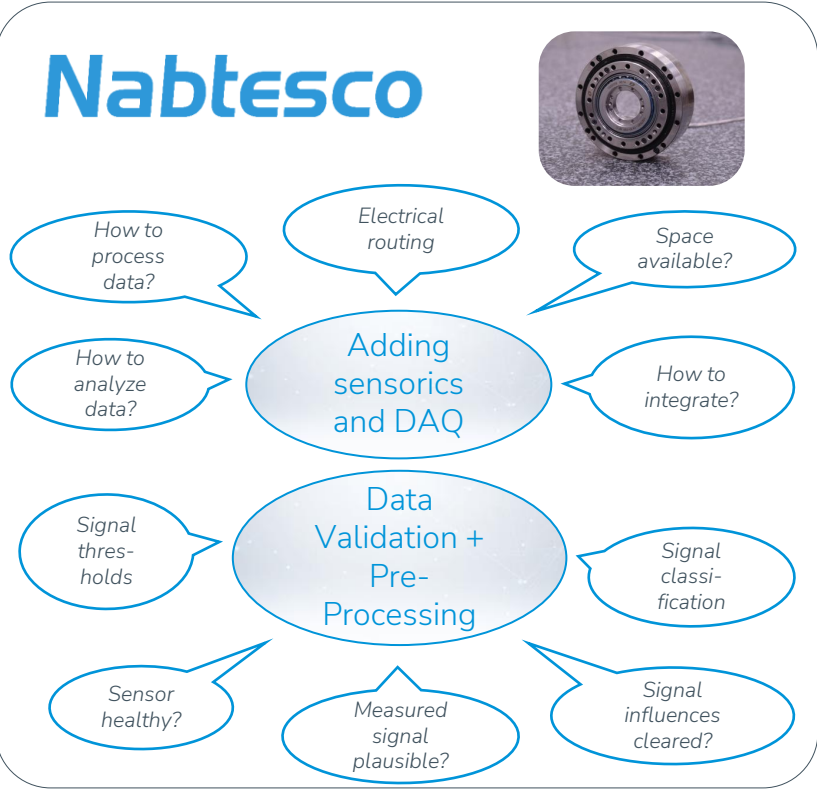


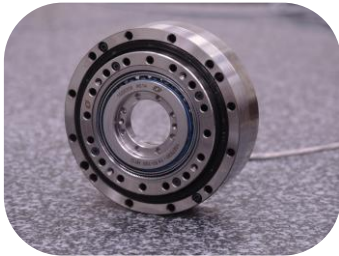
Highest data
and
information
density!



Questions to answer...

Digital gear: The supplier of dense application data





1	Flex Spline
2	Circular Spline
3	Wave Generator
4	CRB (Cross-Roller-Bearing)
5	EEU (Electronic Evaluation Unit)
6	Torque Sensor

Nabtesco's proven strain wave gear technology

Nabtesco's own designed dedicated PCB-Board

Dedicated torque sensor from the measurement tech powerhouse



HOTTINGER BRÜEL & KJÆR



Direct Measurement vs. Estimation

Indirect methods

Torque is inferred through models, displacement, or material response.

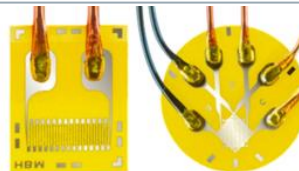
- **Motor current**
Estimated torque; accuracy depends on the motor model.
- **Dual encoder**
Measures torsional displacement and requires mechanical assumptions.
- **Magnetostrictive**
Responds to magnetic-field variation and environmental effects.

Real-system limitations

Offset • hysteresis • calibration dependence
friction • backlash • temperature • wear

Strain gauge approach

No model. No estimate. Direct mechanical behavior.



- 1 **Direct deformation**
Measures the load path itself
- 2 **Model-independent**
No drivetrain model required
- 3 **Predictable signal**
Clear, repeatable behavior
- 4 **High linearity**
Reliable across the range
- 5 **Low-torque accuracy**
Strong sensitivity where it matters



Dedicated vs. Integrated Sensor

Engineering challenge

A dedicated sensing element must add measurement capability without compromising the actuator.

- **Stiffness requirements increase**
The sensing element must deform predictably.
- **Actuator size can grow**
Added components consume valuable package space.
- **Mechanical design must be optimized**
Sensitivity and load capacity must be balanced.
- **Gearbox size should remain comparable**
Smart integration limits system-level impact.

Integrated sensor design



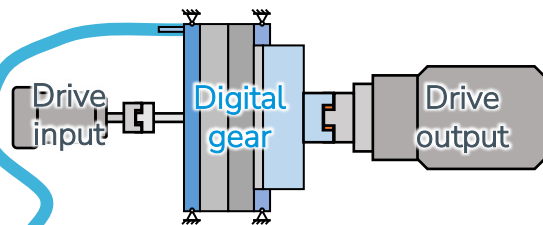
- 1 Controlled deformation
- 2 Optimized sensitivity
- 3 Clean measurement path
- 4 Reduced assembly influence
- 5 Easier calibration
- 6 Repeatable performance



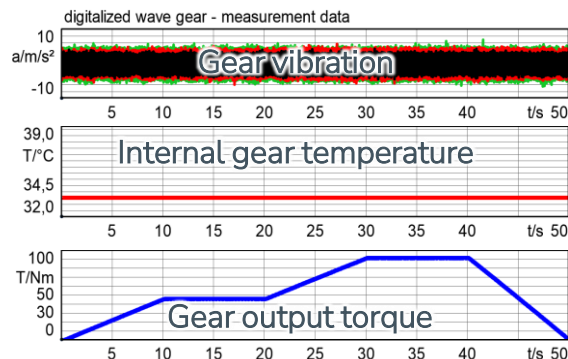
Don't measure where deformation happens. Design where it should happen.



Function 1: DAQ-functionality of digitalized wave gear



Data acquisition & pre-processing included

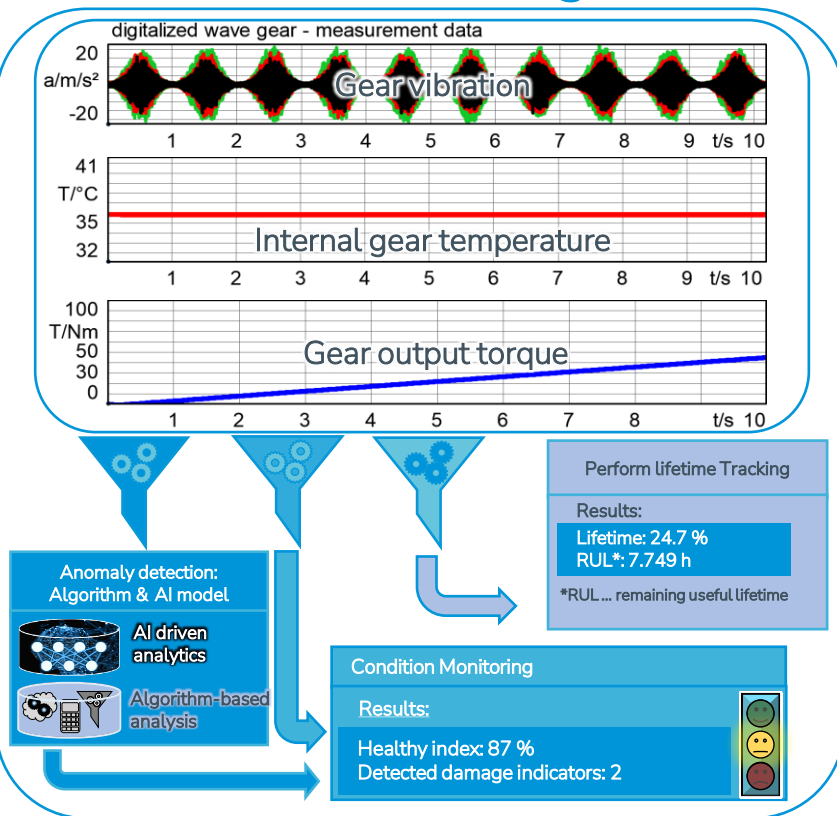


Digitalized wave gear includes an extensive data acquisition system:

- Measuring data:
 - ➔ Output torque (*reactive gear torque*)
 - ➔ Internal gear temperature
 - ➔ Gear vibration (*radial, axial and tangential*)
- Pre-Processing of data:
 - ➔ Calibration functionalities:
 - Offset Tara function*
 - Editable sensor characteristic curves*
 - ➔ Filtration and signal validation functionalities
- Providing data via electrical interface:
 - ➔ Analog interface:
 - Torque: differential voltage output*
 - Temperature: single ended voltage output*
 - ➔ BUS communication (Biss-C):
 - Torque*
 - Temperature*
 - Vibration*
 - Internal data / analysis results / Meta data / etc. (see following functions)*



Function 2: Detect Anomalies, Lifetime tracking, Condition Monitoring

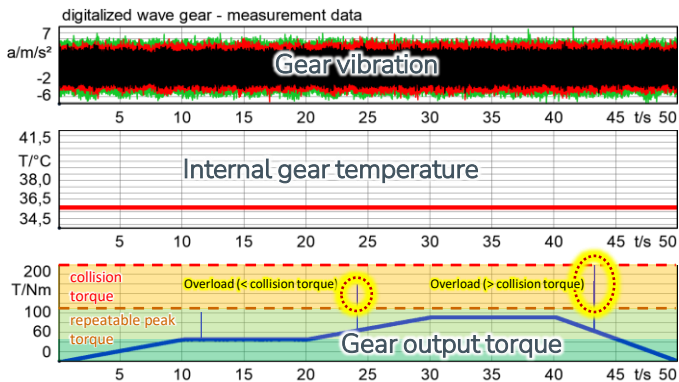


Digitalized wave gear includes a computational unit that enables performing live-analytic und monitoring functions:

- Lifetime Tracking:
 - ➔ Tracking the current lifetime of the gear
 - ➔ Estimating the remaining useful lifetime (RUL) of the gear by analyzing the measurement data
- Anomaly Detection and Condition monitoring:
 - ➔ By applying an AI based anomaly detection model and dedicated algorithms the digital gear screens the gear for damage indications or wear
 - ➔ Analytic and anomaly detection results are processed to consolidate into a Healthy index.
- All analysis results and consolidated indexes can be monitored
 - ➔ e.g. by thresholding

Function 3: Event monitoring and load classification

Screening data / analysis results



The digitalized wave gear classifies and monitors its measurement data and analysis results with its computational unit:

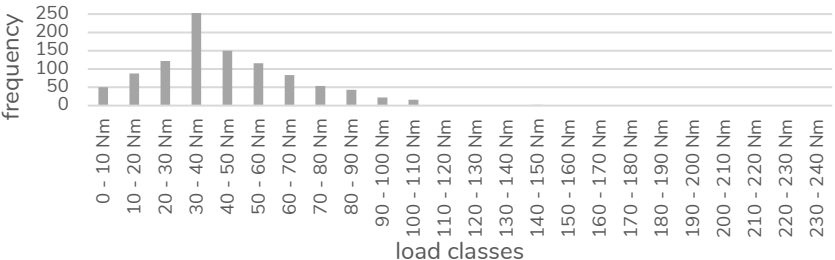
- Events (e.g. load events) are detected
- Events are remarked in an event log
- Faulty events (e.g. overload) trigger alarms
- Measuring data can be classified (e.g. load classification)
 - ➔ Load is classified into torque ranges
 - ➔ Frequency of ranges are monitored
 - ➔ Statistical view on frequency gives insights in the operational behavior (e.g. histogram of torque ranges)

Event log:

Overload events:

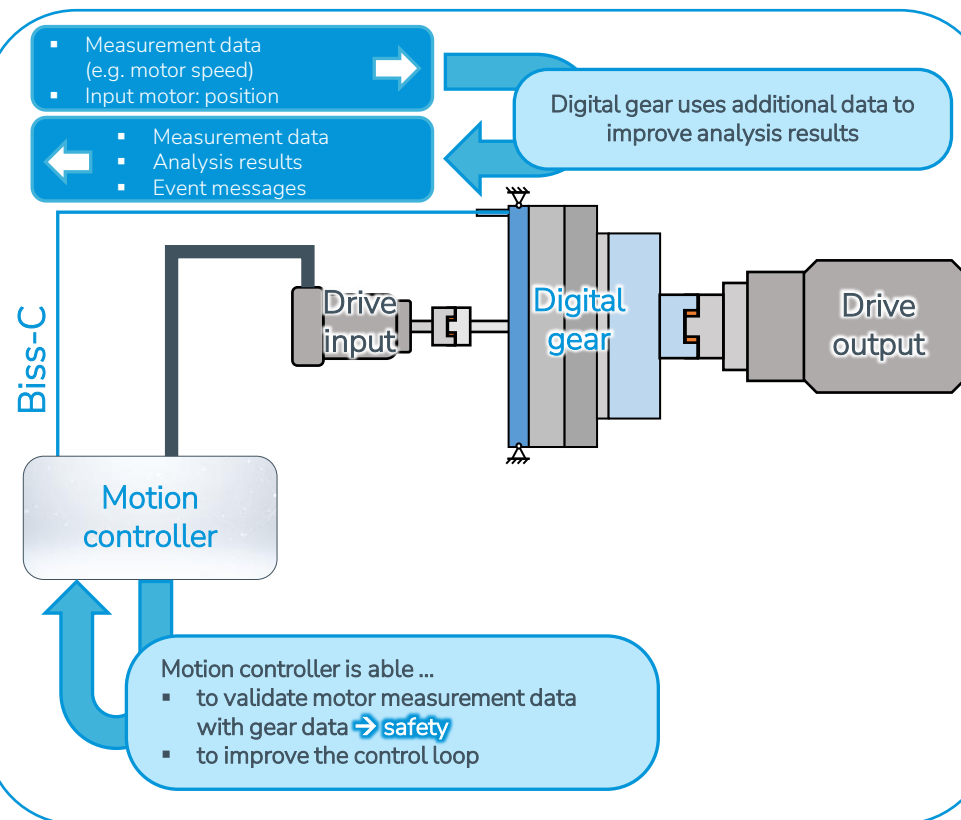
- Overload 1 (< collision torque) : 1
 - Overload 2 (> collision torque) : **1**
- and more ...

histogram of classified output torque





Function 4: Bi-directional BUS communication

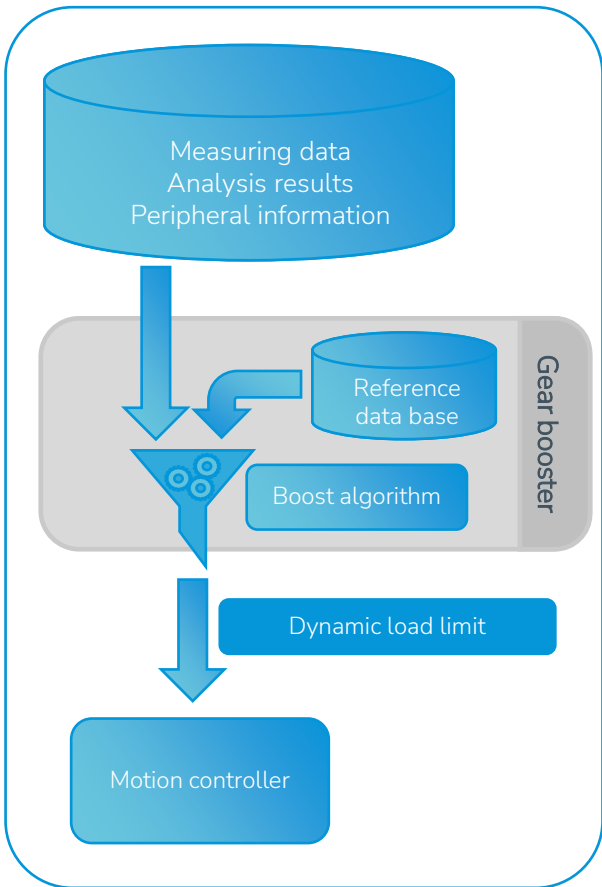


Bidirectional communication enables:

- Safety validation of the motion application
 - ➔ Motion controller can validate measuring data of different sources
 - ➔ relevant for high safety levels
- Motion controller can ...
 - ➔ use improved analysis results to improve the control loop
 - ➔ use gear data to improve performance (e.g. stiffness compensation, gear boosting)
- Improvement of analysis results of digital gear:
 - ➔ Additional / peripheral information can be used to refine analysis parameters
 - ➔ Additional / peripheral information enable higher detailed analysis structures due to better referencing of operation state of the gear

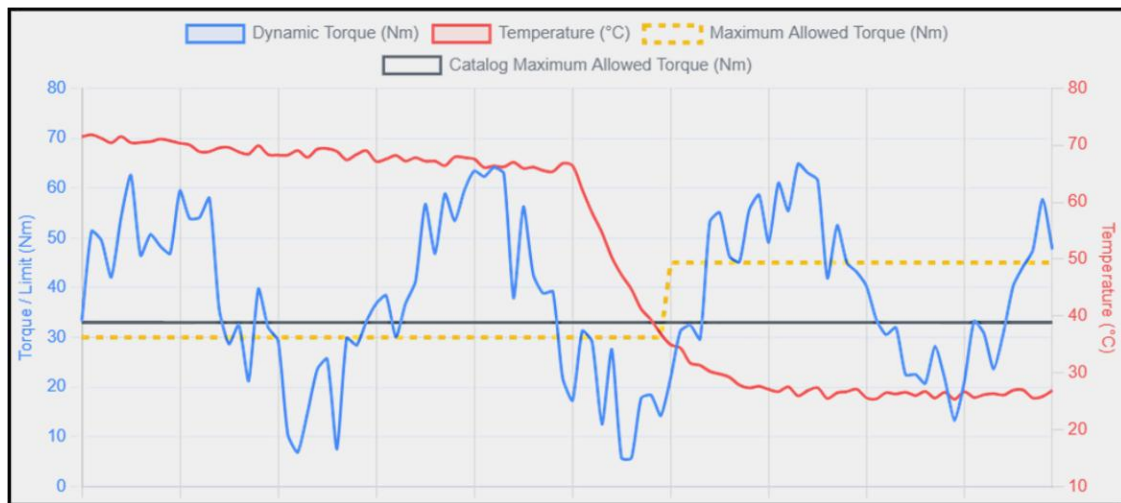


Function 5: Gear booster



Depending on the gear situation the digitalized wave gear is able to calculate a **dynamic load limit***. This load limit can be used to improve the performance of the motion application. The calculated load limit permits the controller to **overload the gear over the nominal limits**.

* similar for max. input speed

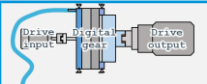


Exemplary data regarding gear boost functionality

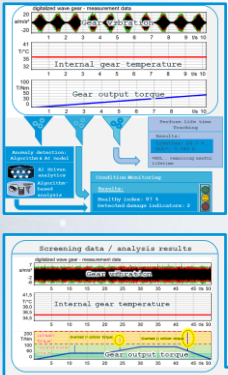
Using digital gears for Humanoid Robots



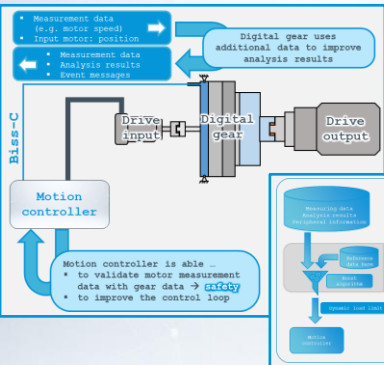
Generated by AI



Focus on creating an even greater robot using quality data and don't mind on how to collect the data.



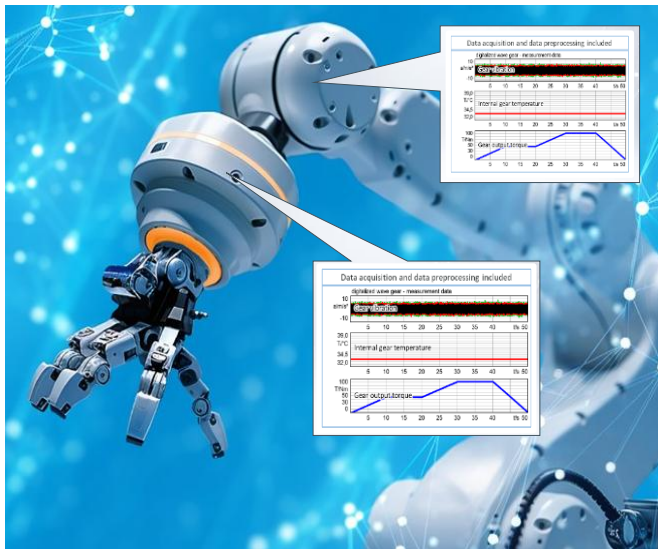
Integrate health monitoring and load metrics without caring on algorithms to detect and prognose abnormalities and events.



Implement a self-regulating and adaptive behavior without caring on the drive itself.

- Shorten your development-time by using ready-to-use technology
- Get a deeper drive insight by using gear- and component experted data
- Establish Functional Safety

Future of gears and sensoric elements



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New ways to create maximum productivity



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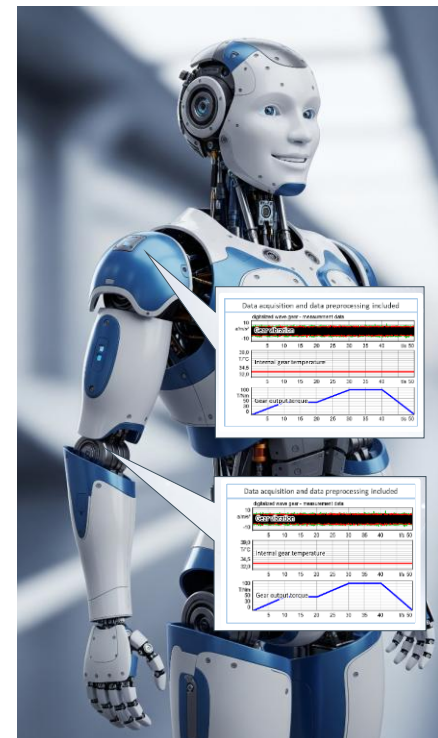
← Gear Booster
Load Consciousness →

← Condition Monitoring
Predictive Maintenance →

← Self Optimization & Training →

← Adaptive Path Planning →

Create drives that act as flexible as muscles and meets their requirements



Generated by AI

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