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12 – 18 NOVEMBER | HANOVER, GERMANY
PREVIEW DAYS 12/13 NOVEMBER

CLUB OF BOLOGNA
strategies for the development of agricultural mechanisation

FEDER UNACOMA
Italian Agricultural Machinery Manufacturers Federation

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Andrea Ruffin presenting

Predictive Maintenance in the Agritech World

32nd Members' Meeting of the «Club of Bologna»

Agricultural Mechanization: Urgency for Food Security

12-13 November 2023
Hannover, Germany

Profile

Andrea Ruffin
Group R&D Director at
MASCHIO GASPARDO S.p.A.

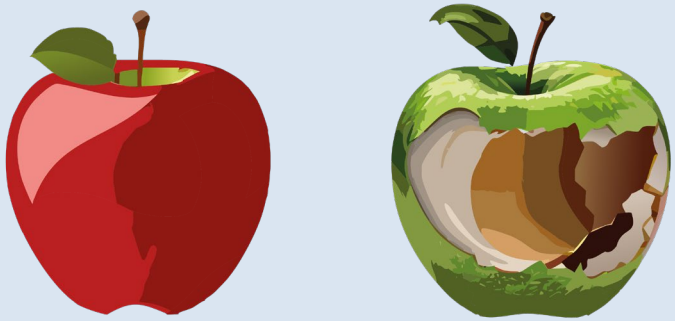
Graduated in Mechanical Engineering at the University of Padua

Working in Maschio Gaspardo since 2002, I'm the Group R&D Director in charge of all R&D offices worldwide (100+ FTEs)

We develop Products for Plowing, Tillage, Seeding, Planting, Crop Protection, Hay Making, Electronics and SW

Advisor in FEDERUNACOMA and ASSOMAO Associations, member of High-Level Group Speciality Crop in CEMA Association

Problem Statement



Why Predictive Maintenance for implements?

Agricultural operations to be performed in short time, then machines **must work properly** in order **to avoid failures**, low or under performance, and minimize risks of economic losses.

Especially for **high value/performance implements**, one cannot afford to have the implement low performing or out of order: knowing how much time remains **before** the machine requires for **maintenance becomes critical**.

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Types Of Maintenance

From the **most simple** to the **most sophisticated**:

Reactive Maintenance

Maintenance when component is damaged.

Good when spare parts are easily available and downtime is not costly.

Preventive Maintenance (PM)

Maintenance based on fixed schedules set on historical data/experience.

Maintenance operations may be wasteful (too early) or may miss the failure (too late)

Condition-Based Maintenance (CBM)

Real-time monitoring through sensors with preset limits. When advanced damage happen, the system signals maintenance request.

Types Of Maintenance

Predictive Maintenance (PdM)
Statistical and real-time data monitoring to predict the health of **components,** the system allows maintenance to be scheduled according to the expected remaining useful life.

Prescriptive Maintenance
Referred to the **entire machine**, it is now able to predict when and what specific component will fail. More statistical and real- time data from huge number of sensors are needed.

Types Of Maintenance

Cost reduction in maintenance

Minimizing downtime

Increased productivity

Offer an additional service to the customer

Obtain usage statistics

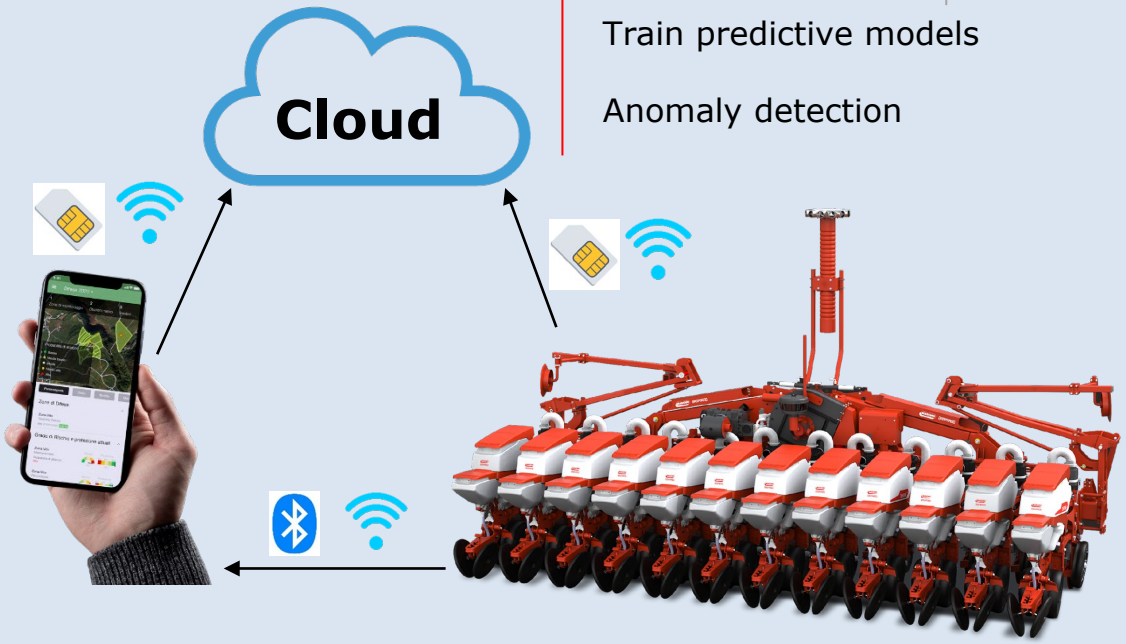
PdM is already **applied** in several industries: Automotive, aerospace, energy, manufacturing, mining, oil & gas. Less on Agricultural Implements…

Top companies doing **PdM**: Siemens, General Electric, SAP, IBM, ABB, Schneider Electric, Microsoft, AWS, Hitachi, …

Key Enabling Technologies

Sensors: temperature, vibrations, pressure, accelerations, etc.

Resources on the machine, i.e. computing resources for data pre-processing and inference, connectivity (Isobus) and internet access.



Train predictive models

Anomaly detection

Pre-processing on machine

reduce dimension of transferred data

cost saving

Key Enabling Technologies

Data analytics, **Machine Learning**, **Artificial Intelligence algorithms**

Cloud computing to train predictive models and to perform remote monitoring and anomaly detection

Digital Twins, which are virtual real-time copies of component/asset/machine, either physics-based or data-driven

Virtual prototypes of real-world systems that can be deployed to manage the entire lifecycle of products and assets

→

Increase efficiencies

Predictive methodologies

Prevent unscheduled downtimes

Lower operating costs

Practical Implementation

Due to high cost of engineering, **sensors and AI technologies**, today the target is focused on:

Expensive machine, where high performance and reliability is a must

Prone to catastrophic failures

Few key components to monitor

Availability of sensors, connectivity, computing resources, historical database

Farmers data automatically uploaded to a remote server

Challenges and Considerations

Initial investment:

- Data collection
- Test multiple sensor configurations
- Test multiple predictive/statistical models
- Time and money for Research & Development

Recurring costs:

- Cloud computing and storage resources
- Highly-skilled dedicated staff: Data scientists, Machine Learning engineers, Cloud architects, Mechanical engineers…

Data privacy:

- Either ask customers to share their private data
- Or use Federated Learning to allow training on the edge

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Future Research and Applications

Digital representations of assets with real-world sensor inputs

Hybrid Digital Twins: A Primer on Combining Physics-Based and Data Analytics Approaches

- **Physical models**
- **Data**
- **Machine Learning algorithms**

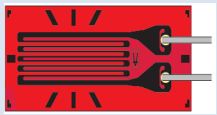
Future Research and Applications

BUILD Create hierarchical schematics of **complex multidomain system**

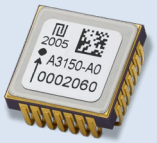
VALIDATE Optimization, what/if analyses

Possible sensors for **BUILD** and **VALIDATE** phases:

Strain gauges



Accelerometers

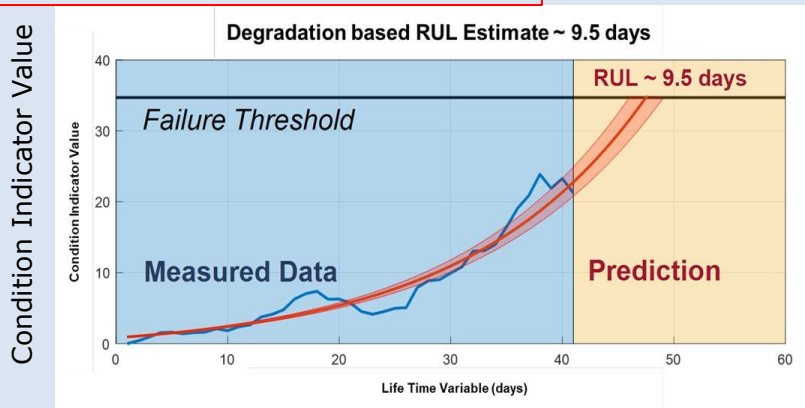


DEPLOY Deployment of the real asset equipped with low cost sensors only

Connection to **IoT**

Pre Processing: Feature Engineering to detect features from raw sensor data

Models in the cloud: Remaining Useful Life (RUL) estimation models based on the extracted features



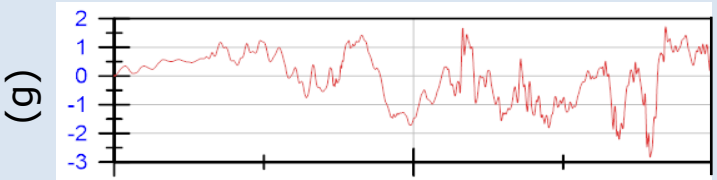
Future Research and Applications

BUILD **Basic definition** of inertial loads acting on spraying booms

Sensors:

n°3 accelerometers

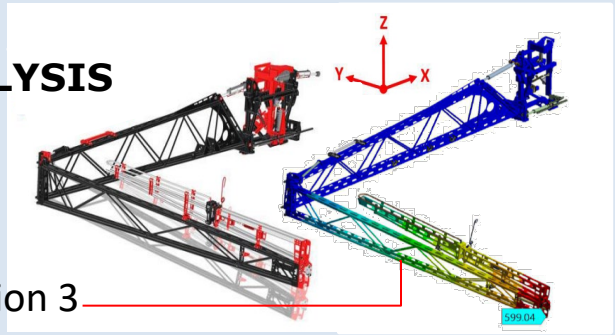
n°1 GPS



Acc2 accelerometer

Accelerations registered from Acc2 during the opening of the boom

FE ANALYSIS



Section 3

The **position values** from Acc0 can be detracted from Acc1 and Acc2 to **obtain the effective deflection of the boom**

Calculated displacements can be used to perform basic static FEM analysis and assess product

Conclusion

Crucial to define the right application perimeter

Study the best cost-benefit compromise

Choose the right technology to apply, that it may be a mix of methodologies

Staff with right resources and competences

MASCHIO GASPARDO:

Is involving University and new resources to build its own proprietary Cloud, applying methodologies for Predictive Maintenance on Planters, Crop Protection and other implements.

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Thank you

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