



## hl2gener – ZeKat group

Communicating and Intelligent Systems





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# Predictive maintenance for rotating machines with IoT technologies and vibration analysis system

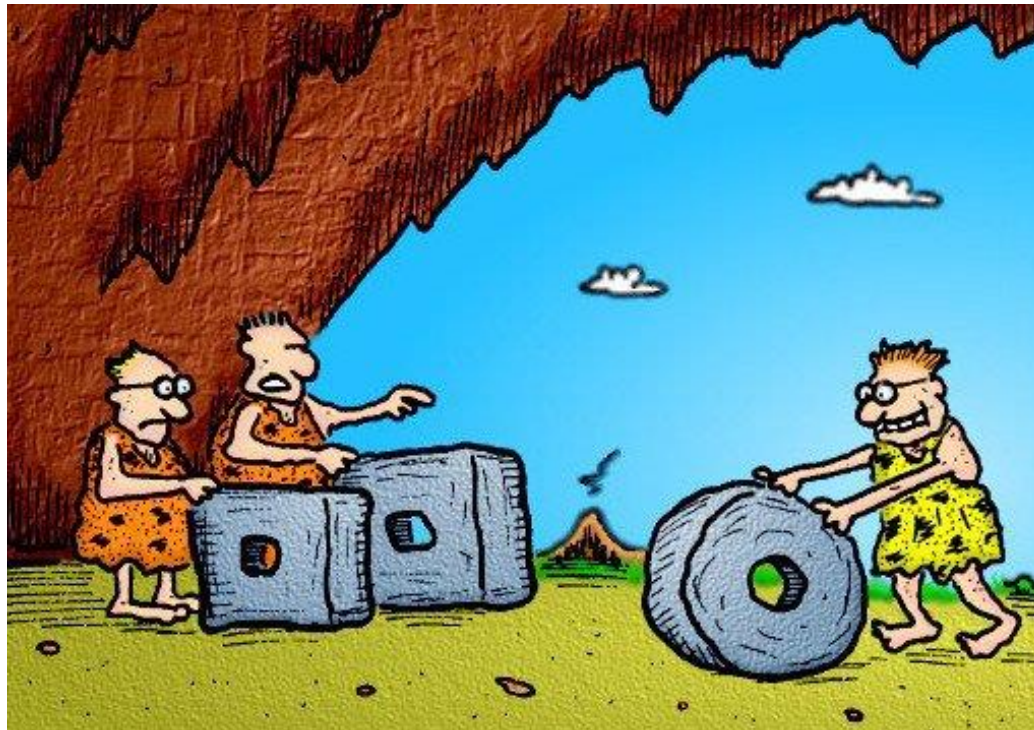
Industry 4.0 / Smart Industry , Angers 8th October 2019

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# Vibrations of rotating machines

- Probably one the most ancient concern of engineers...



Courtesy of Dr. Fun



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# Recipe for vibration analysis

- **Sensors** (piezo, magnetic, optical, acoustic, MEMS)
- **Electronics** (power supplies, amplifiers, filters, converters)
- Lots of **math** (Fourier, Hilbert, etc.) and **algorithms**
- **Physics**
- **Experience** (logs, REX, statistics)

... and a bit of touch and feel





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# What's new then?

- The time when it was necessary to use a bay full of expensive electronic devices wasn't so far: expensive, bulky, energy-greedy
- Then came the time of portable instruments; most of the advanced data interpretation required additional office work. Expensive tools, periodical visits required
- Now has come the time for IoT
  - IoT is synonymous of **small, compact, energy** autonomous and **affordable**
  - The **Edge computing** is IoT's best friend
  - One IoT per critical equipment provides periodical **business-oriented data**





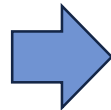
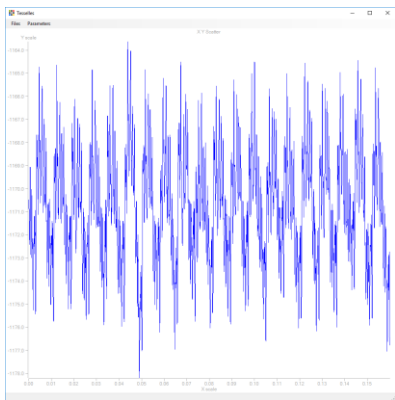
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# What's the goal?

- Mister Smith, the head of technicians, will soon retire...
- Next coming organization
  - No more **travels** on site, in sometimes **dangerous, hazardous** places
  - **Business oriented data** available on any screen (phone, tablet, PC):
  - **Targeted information**: alerts for immediate action, warning for soon coming adverse events, long term monitoring
- Benefits
  - Targeted maintenance, improved collection of long-term data
  - Reduced risk of breakage
  - Reduced cost of operation, improved ROI

# No edge computing, no fun!

- From **signal** through **math** and **algorithms** up to **business-oriented information**

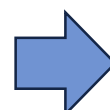


$$f(x) = a_0 + \sum_{n=1}^{\infty} \left( a_n \cos \frac{n\pi x}{L} + b_n \sin \frac{n\pi x}{L} \right)$$

```

137 float average(uint16_t lowBound, uint16_t highBound);
138 void clearVector(uint16_t dataSize);
139 void clearVector(float *vector, uint16_t vectorSize);
140 void complexToReal(uint8_t scaleType);
141 void computeFFT(uint8_t dir);
142 void computeForwardFFT(void);
143 void computeInverseFFT(void);
144 void copyVectors(float *destinationVector, float *sourceVector, uint16_t vectorSize);

```

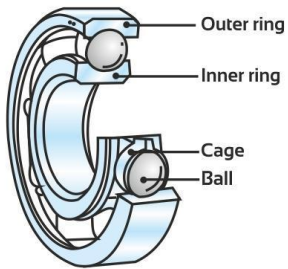


- Alerts: immediate action requested
- Warning: plan action
- Predictive maintenance due date
- Preventive maintenance optimization

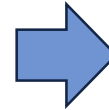
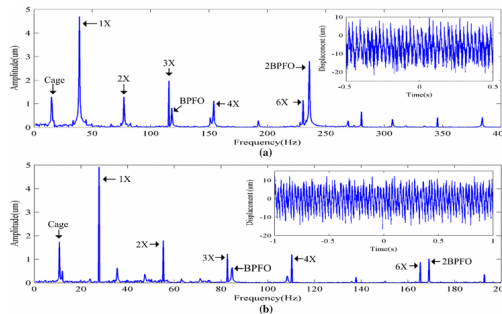
Device-embedded

# Various approaches

## ■ Deterministic

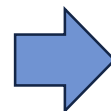
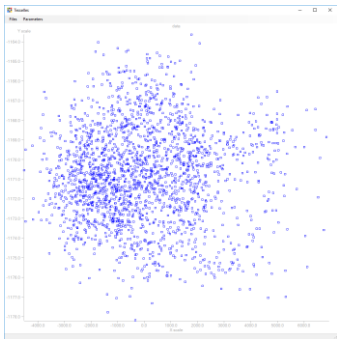


Deep Groove single Row Ball Bearing

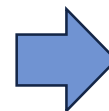


- Adaptable
- Does the equipment match the specifications (maker, ISO, etc.)?
- Reuse standard sensors

## ■ Random



AI  
 (proprietary)



- Take it or leave it
- Does the equipment match the self-learned model?
- Proprietary sensors







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Thanks for your attention!

