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FORMEC

Self-charging wireless module for remote monitoring of forest machines

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Background

Agriculture and forest machine monitoring system

Agriculture and forest machine construction companies develop property system and devices to monitor and to control parameters and performance



At different level low cost solutions are available just to monitor position, working time, working condition (safety) of machinery or vehicle fleet


GPS module + accelerometer + GPRS module or OBD2/J1939 datalogger

Background

How could be an innovative monitoring device for agricultural and forest machine?

- Easy and fast plug and play
- Not wire connection
- Expandable to different forest machines, vehicles or machinery extended
- Self-charging energy supply
- Communication with smartphone apps
- Share data in cloud

The prototype

7 cm

- photovoltaic cells
- vibration energy harvesting
- small dimension
- resistent case

Android and IOS App able to store data

- GPS module
- 3-axis accelerometer
- 3-axis gyroscope
- Temperature sensors
- Wireless/bluethoot connection

…

Aims

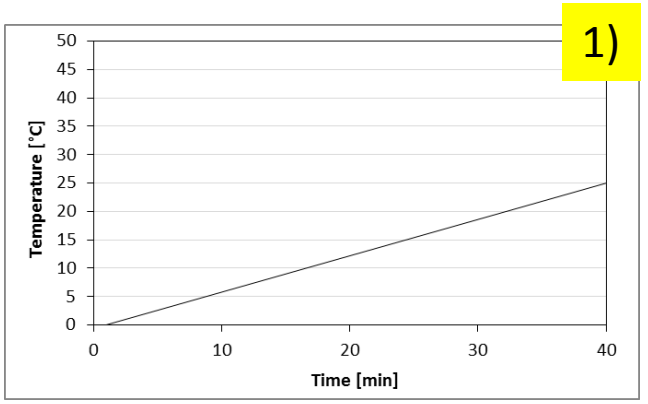
Verify the potentiality of the prototype to monitor different forest machineries

The test was based at two investigation levels:

- Controlled tests for liquid temperature measurement, working time recognition and GPS position accuracy
- Real working condition test for working time recognition and GPS position accuracy

Laboratory test

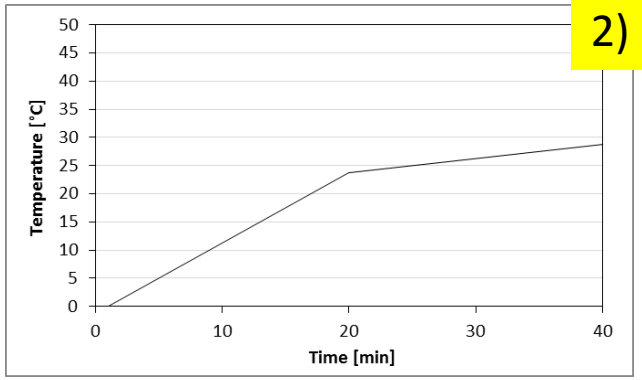
Temperature sensor



Comparison with a laboratory thermometer

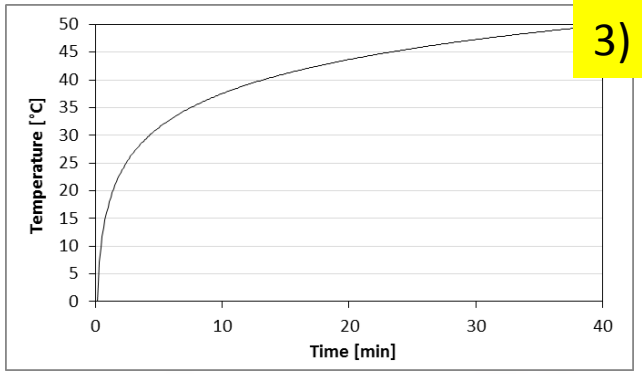
- Duration: 40 minutes
- Interval measurements: 1 minute
- Fluid: water

Control method: laboratory thermometer with a temperature probe (0.01 °C precision)



Test

1) Constant increment (+0.64 °C min^{-1})
2) Different increment rate (1.25 and 0.25 °C min^{-1})
3) Variable increment (form 6 to 0.2 °C min^{-1})



Laboratory test

Working time recognition

- Machine vibration simulation driven by a electric engine
- Vibration generated at 260 r.p.m.

GPS accuracy

GPS is active only when the prototype starts to record the machine

Test

5 positions (2 between high buildings and 3 open area)
Control points measured by a RTK-GPS
GPS sensor activated by the PTO of agriculture tractor at 540 r.p.m

$$\sigma_{H\_acc} = \sqrt{(\bar{E} - E_{true})^2 + (\bar{N} - N_{true})^2}$$

Field test applied to forest machines

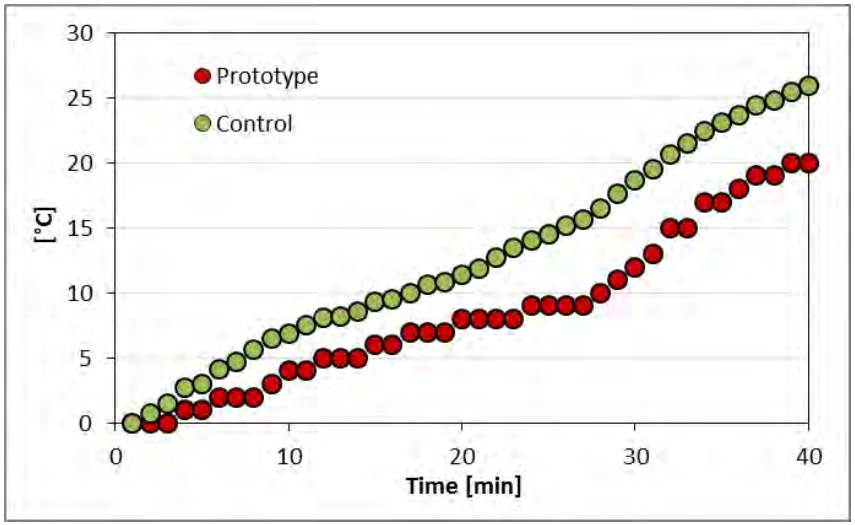
Chipping working time monitoring

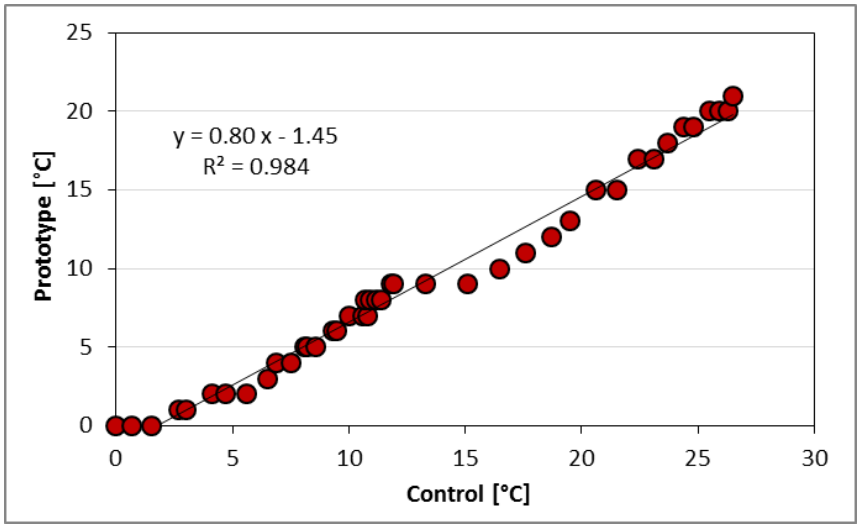
Sledge winch working time monitoring

Results

Controlled test: temperature

Constant increment

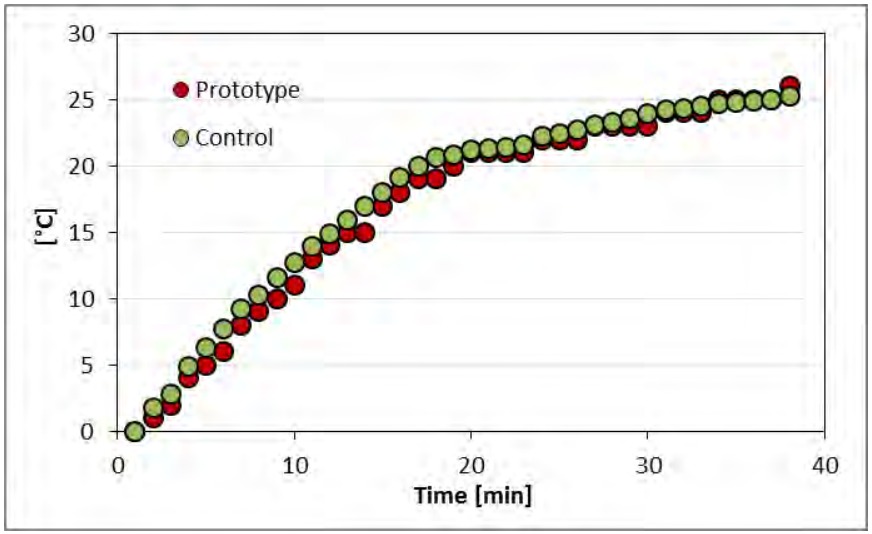


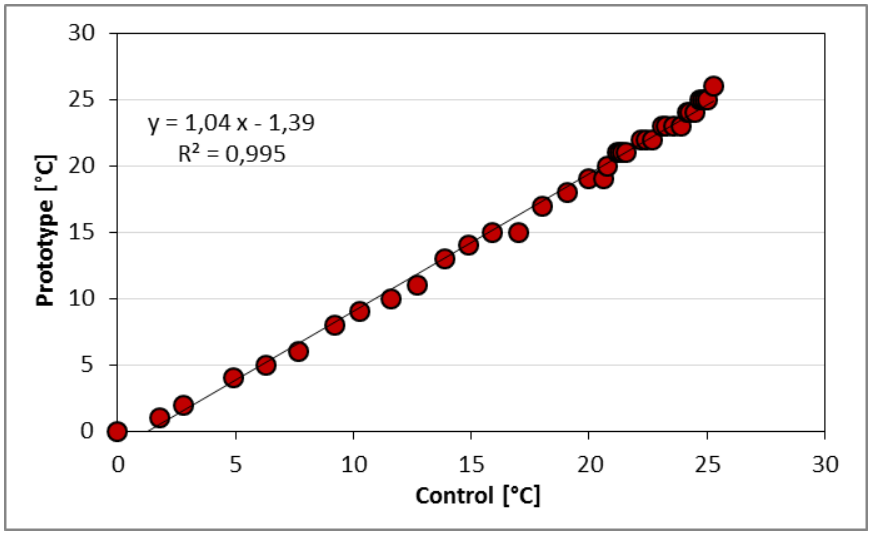


Results

Controlled test: temperature

Different increment rate (1.25 and 0.25 °C min^{-1})

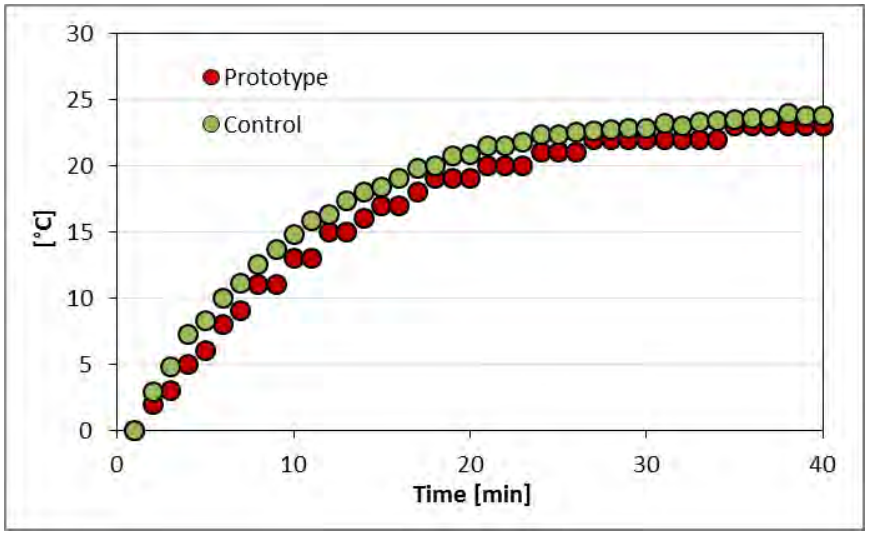


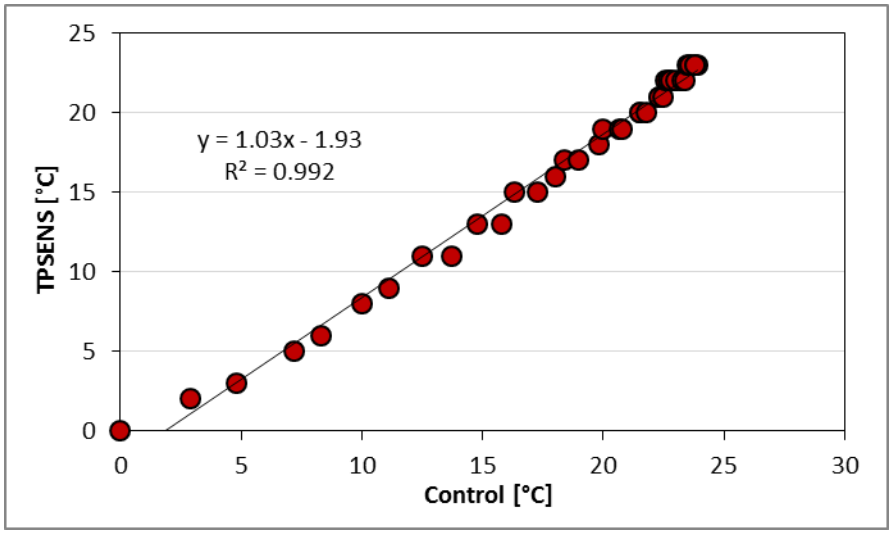


Results

Controlled test: temperature

Variable increment (form 6 to 0.2 °C min^{-1})

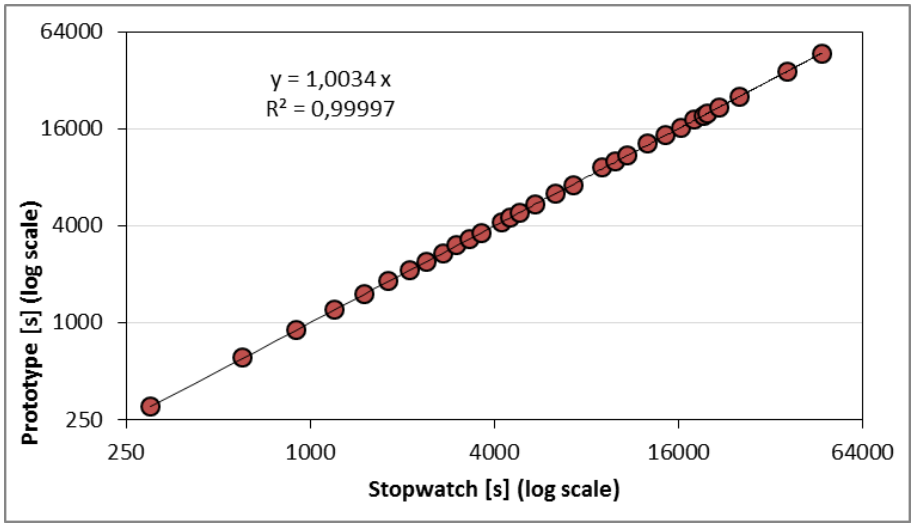


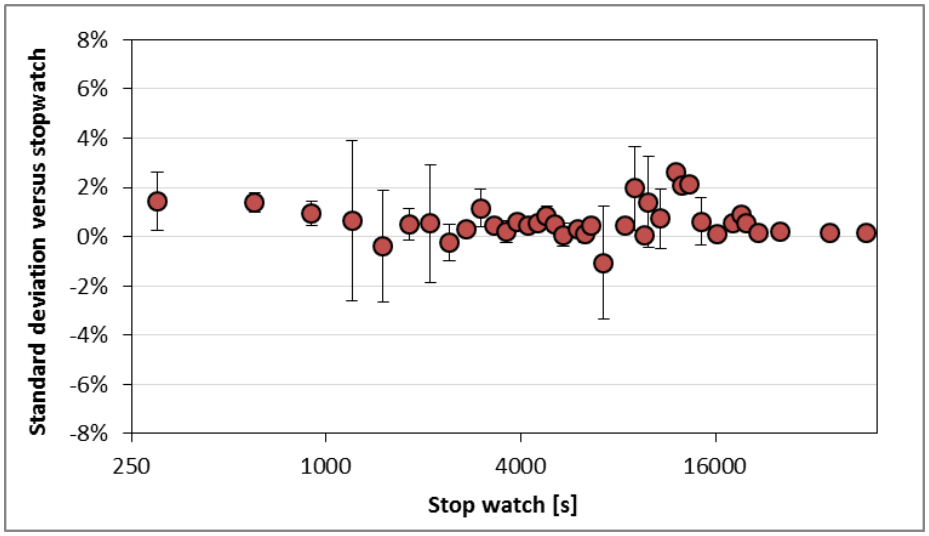


Results

Controlled test: working time

Cycles: 5,10,15,20,30,60,90,180,240,360 minutes





Results

Controlled test: GPS position

Reference point	Horizontal accuracy	Location
ID	m	
1	29.3	Between buildings 18 m high (4 side)
2	24.7	Between buildings 18 m high (2 side)
3	17.6	No obstacle in the sky view
4	16.9	No obstacle in the sky view
5	18.1	No obstacle in the sky view

Results

Real condition: chipping working time

Study site Paganella (September 2015)
Jenz HEM 561 (320 kW) mounted on truck
Tops and small diameter

	Stop watch			
Test	**A Chipper engine on**	B Chipping time	**C SENSOR**	**Difference Abs|(A-C)/A|**
1	**00.35.08**	00.32.09	**00.36.01**	**2.45%**
2	**00.38.57**	00.22.30	**00.39.18**	**0.89%**
3	**00.37.51**	00.26.32	**00.37.56**	**0.22%**
4	**00.32.06**	00.23.37	**00.32.02**	**0.21%**
			Mean	**0.84**
			SD	**1.17**

GPS horizontal accuracy: 27.3 m

Field test

Real condition: sledge winch working time

Place: Calalzo di Cadore (September 2015)
Model: Greifenberg VF 2100 Freeman (127 kW)
Line length: 1200 m

	Stop watch			
Test	**A** **Winch engine on**	B Winch operating time	**C** **SENSOR**	**Difference** **Abs|(A-C)/A|**
1	**00.41.51**	00.26.05	**00.40.08**	**1.75**
2	**00.44.50**	00.30.48	**00.43.12**	**1.44**
3	**00.43.58**	00.28.02	**00.41.14**	**0.96**
4	**00.35.02**	00.24.28	**00.34.27**	**1.67**
5	**00.43.48**	00.30.28	**00.42.19**	**1.13**
6	**00.46.56**	00.28.38	**00.45.08**	**1.24**
			Mean	**1.37**
			SD	**0.340**

GPS horizontal accuracy: not GPS position were collected

Conclusions

Laboratory test has confirmed:

- possibility to measure working time and record temperature of liquid (need calibration)
- position tests highlighted the need to improve the GPS module (external antenna)

Filed tests

- Good results in working time machinery (chipper and sledge winch in this case) detection
- GPS module need to be absolutely redesigned

…further developments

- More tests involving forest machines and machinery extended
- Improve current smartphone/tablet apps (at the moment available for agriculture machinery)
- More than one sensors working in network

THANK YOU FOR YOUR ATTENTION