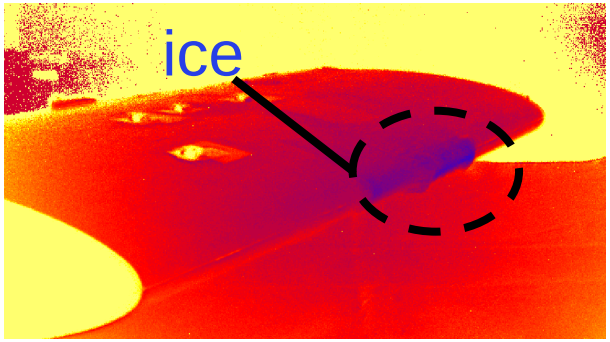


Ice detection via advanced image analysis

WinterWind 2016 / Åre Sweden / 09.02.2016
Mikko Tiihonen / VTT Wind Power
Ville Lehtomäki / VTT Wind Power
Pekka Suopajärvi / VTT Optical Instruments
VTT Technical Research Centre of Finland Ltd.

v0.1: VL, MT 13.1.15

Market need

10 GW/a wind power projects in cold climates*

Ice on blades → Production loss Ice throw → Need to know when there is ice

- Blade ice detectors to replace stationary detectors?
  - Blade is where it all happens!
- **Large need for a 1) reliable and 2) cost efficient ice detector! Considered as the Holy Grail!**

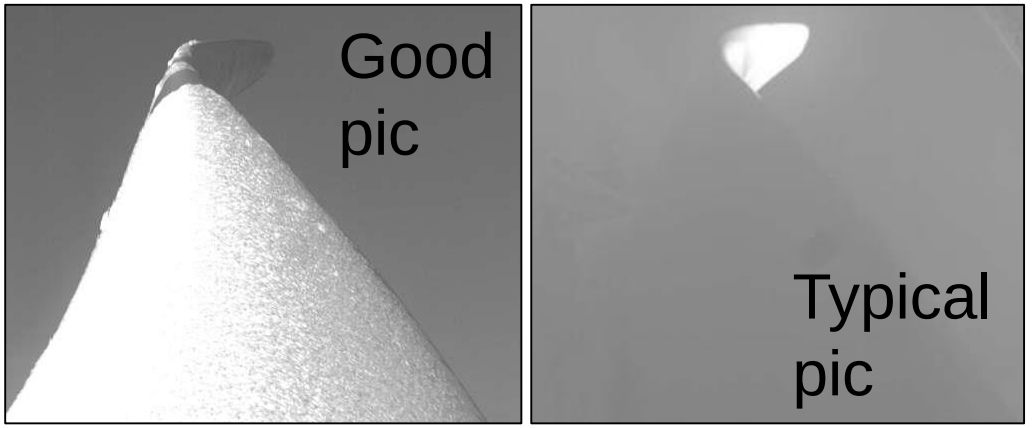
* Navigant Research: BTM WMU 2012

Market need

- Webcam is the most reliable ice detector* but
  1. Picture quality is not good enough for reliable detection
  2. Detection is not real-time
  3. Costly, manual work of interpretation

Webcam might still be the way to go, but it has to be made better to fill the need!

Wind turbine blade cam



* IEA Task19 Recommended Practices report

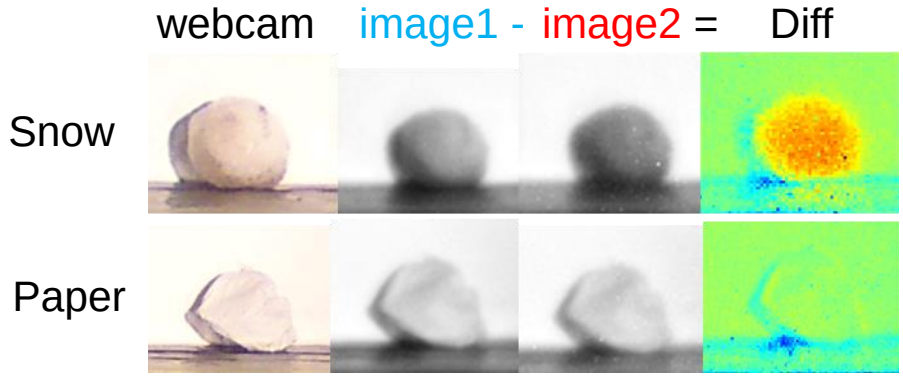
Measurement principle

Water and ice have different absorption at different wavelengths of light

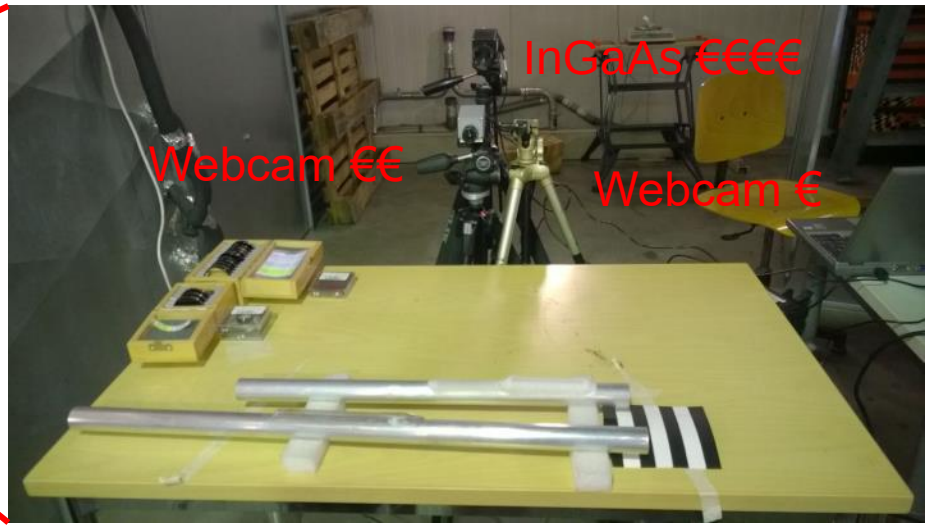
Take pictures at different wavelengths of light

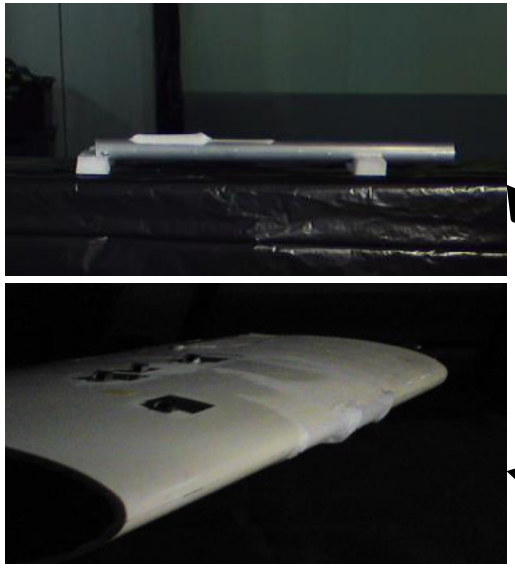
Combine pictures
(calculate difference)

Ice detection
(pic with ice highlighted)



Method validation in VTT icing wind tunnel





3 Cameras

Narrow bandwidth filters

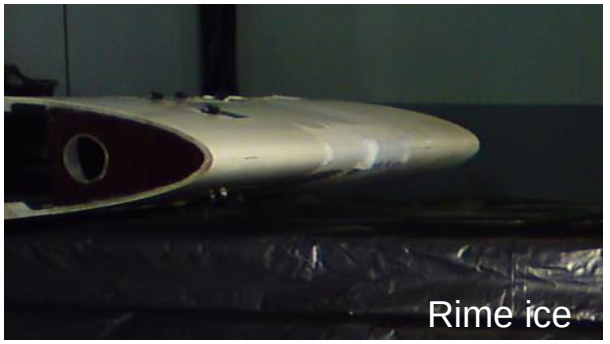
Daylight (halogen) + special light (LED)

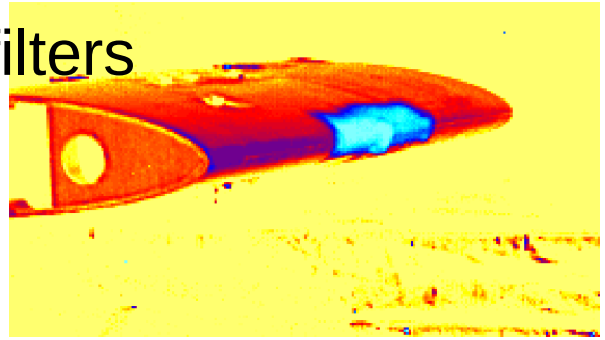
2 test specimens:

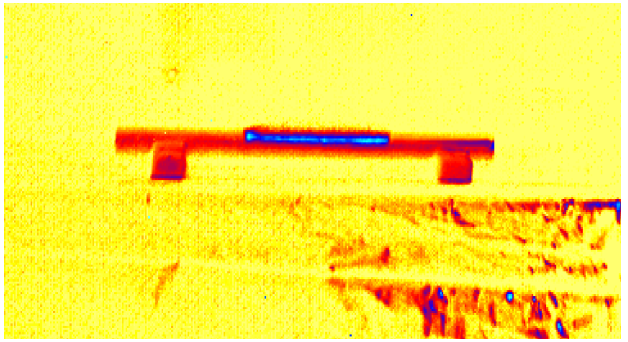
- Ø3cm tube
- airfoil section

Method validation in VTT icing wind tunnel

Results with InGaAs camera (10,000€): Reliable ice detection

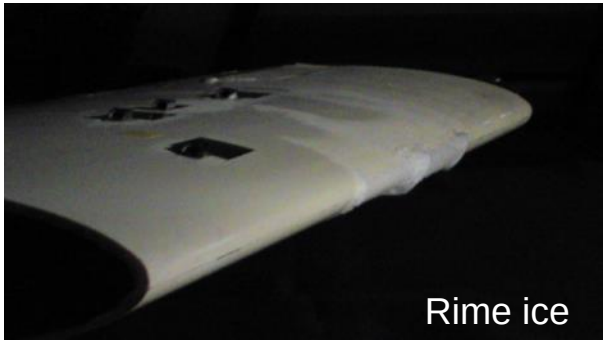


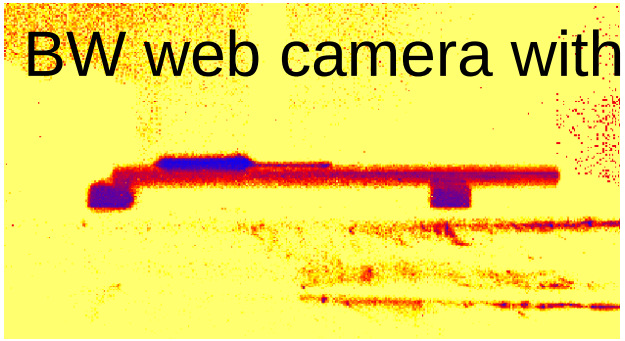


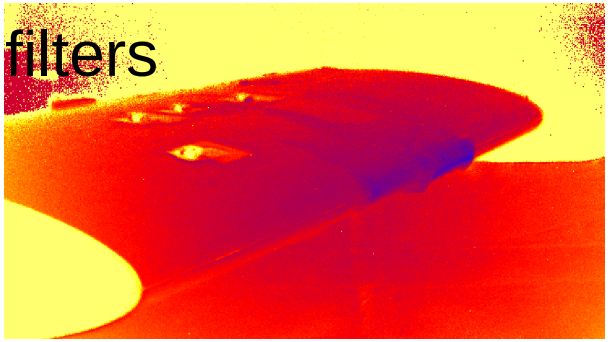


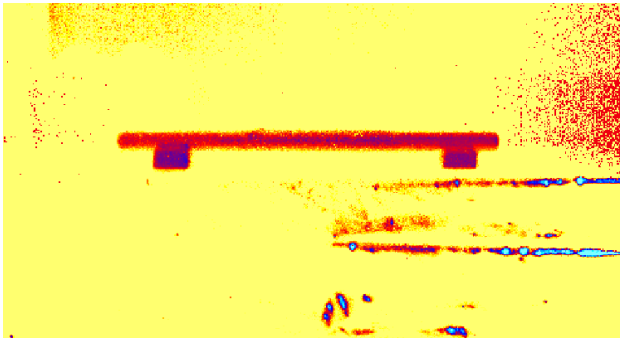
Method validation in VTT icing wind tunnel

Results with normal web camera (100€): Still reliable ice detection, with minimal cost!



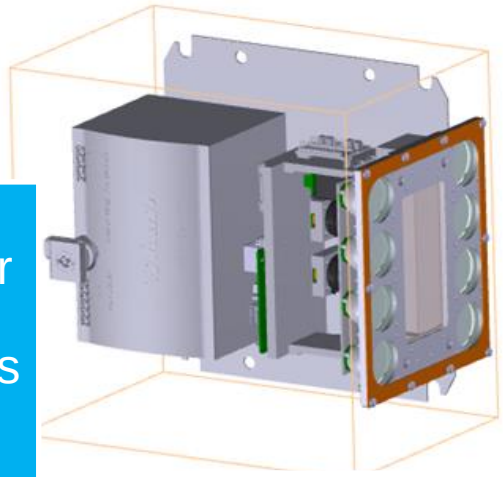






Prototype

Designed for demanding environments (MIL spec)



Raspberry Pi™

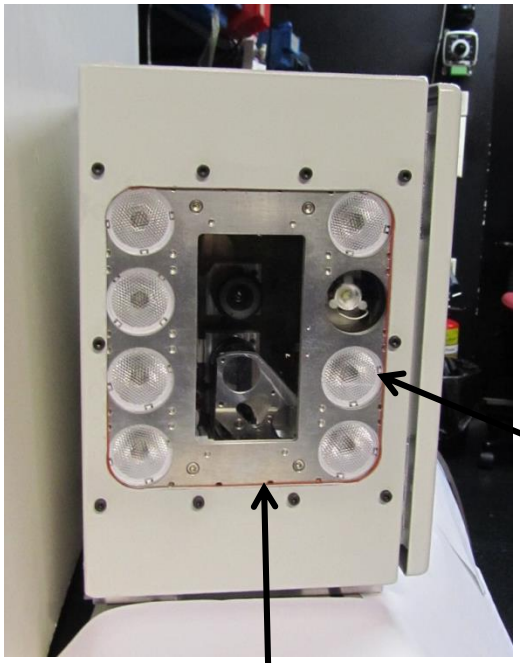
Off-the-shelf hardware and software

Super Cheap

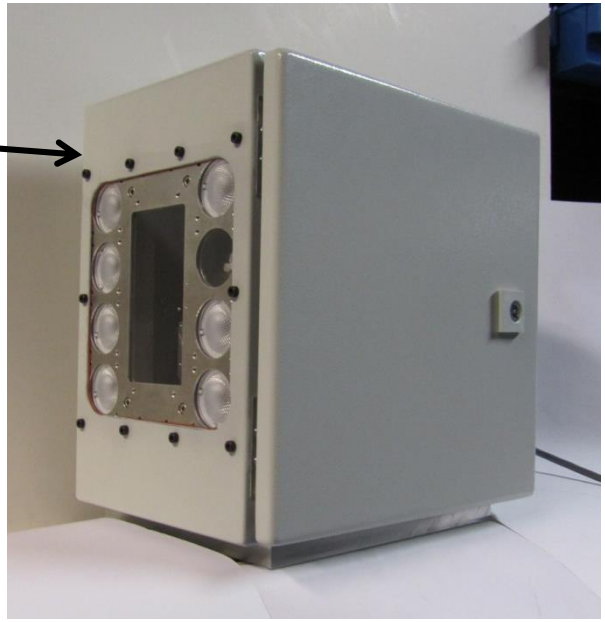
Camera retail price ~ 5k€

2 prototype units built December 2015

Prototype



Standard weatherproof cabinet



Special illumination of subject

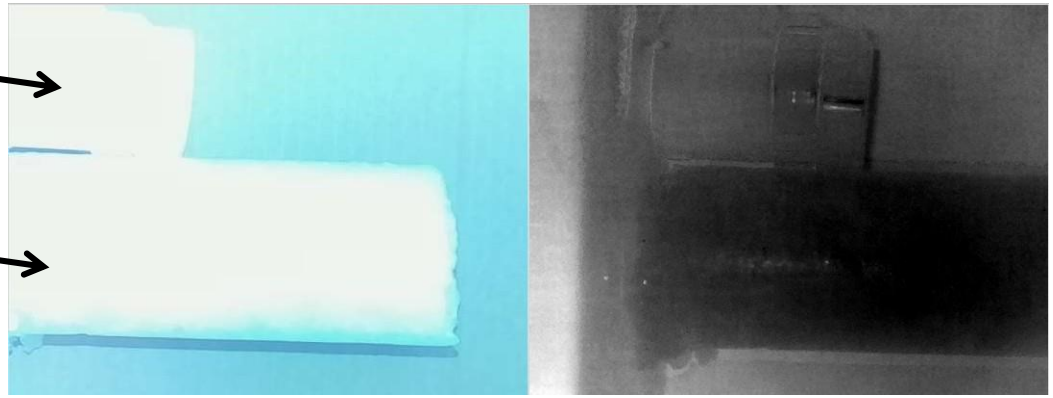
Heated faceplate stays ice free

Normal webcam

IceImage prototype

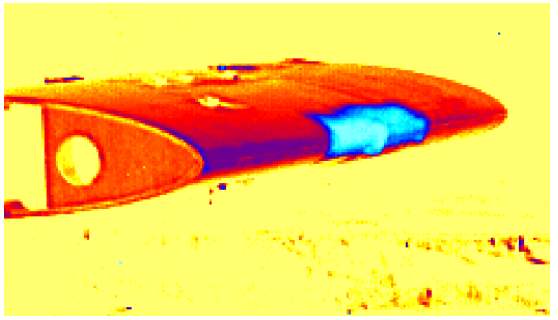
Plastic

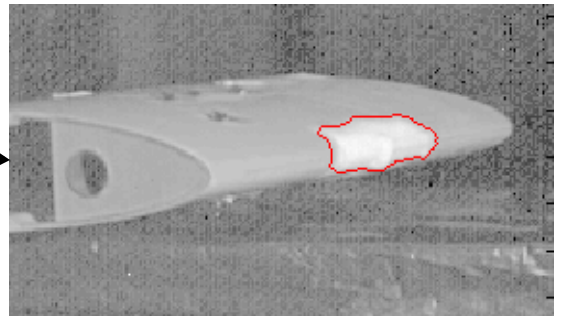
Ice



Prototype benefits

- Unique ice detector:
  - Advanced image analysis method (no competitor)
  - Using off-the-shelf HW & SW = affordable unit & easy maintenance
  - Built with tough military specs “only a meteorite can harm it”
  - Easy installation eg. on wind turbine hub
  - Markets also outside wind power
- Possibility to enable real-time ice detection with a machine vision algorithm





Benefit

- **Safety!** Know when you have ice on a structure - Avoid property & personnel damages!
- **Efficiency!** Know when to activate de- or anti-icing devices, eg save 20k€/turbine/year by minimizing standstill!
- **Low cost!** The VTT ice camera uses standard SW & HW, easy & low-cost maintenance
- **Applicability!** VTT ice camera used for wind energy, railway, high structures, road applications etc

Roadmap for next steps

Gathering results from initial tests at office roof, Oulu, Finland (ongoing)

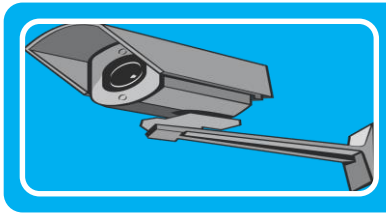
Installation of second prototype in extreme conditions in Norway (Q1/2016)

Development of machine vision algorithm to enable real time detection

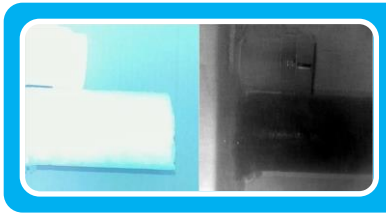
Finetuning of hardware and software

Licensing of technology?

Summary



We took the world's most reliable ice detector (camera) and made it even better!



Working prototype sends pictures with ice highlighted right now!

Roadmap to commercial product seems free of obstacles

Affordable detector made from cheap off-the-self parts

Generic use outside wind power widens the customer base making the detector even more affordable

TECHNOLOGY FOR BUSINESS

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