



Robotic and aerospace technologies with potential application to O&M in renewable energies

Autonomous UAV inspection with contact

Description

This technology allows analyzing those internal surface structure defects that couldn't check by IRThermography or Visual sensor.

Potential application

Autonomous aerial inspection with contact thorough ultrasonic technology to analyze glass-fibre-reinforced plastic (GFRP) composite materials, generally employed in the manufacturing of wind generator blades. Detection of inner defects, delamination or interface disbond in wind generator blades

Benefits

Inspecting different types of defects/malfunction.
Minimizing personnel risks, costs (very high in this kind of works) and time.

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Category:

Aerial manipulation

Application field:

Wind

Current TRL:

2

Expected TRL:

5

Development needed:

Automatic detection and avoiding obstacles Multi coordination for UAVs to new-targeted scenarios in the renewables energies sites Adaptation of contact inspection using ultrasonic / eddy current / others.



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Microdrones

Description

Microdrones is a Drone manufacturer and retailer. They designed a special drone for inspection and control of bridges, wind turbines, CH4 detection, rails etc. Besides the equipments, they provide customers with development services in order to make it compatible with any customer's tool.

Potential application

Use of the drone for inspection of Wind turbines of Solar panels.

Benefits

Reduced inspection time by enlarging the covered area.
 Minimizing personnel risks, costs (very high in this kind of works) and time.
 Inspecting different types of defects/malfunction: any acquisition device can be embedded.

Category:

Aerial manipulation

Application field:

Wind & solar

Current TRL:

9

Expected TRL:

Development needed:

Adapting sensors and cleaning equipments on the drone platform
 Developing command interface to communicate



Entity

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Intelligent navigation for autonomous aerial inspection

Description

UAV intelligent navigation technology for autonomous aerial inspection based on GNSS, LIDAR and vision.
 Simultaneous localization and mapping (SLAM) in GNSS-denied environments.
 Real-time collision avoidance using onboard sensors.

Potential application

Autonomous aerial inspection for industrial infrastructure. Autonomus and automated non-contact NDT inspections using visual sensors.

Benefits

Minimizing personnel risks, costs (very high in this kind of works) and time.
 Inspecting different types of defects/malfunction.
 Reduced inspection time by enlarging the covered area.

Category:

Application field:

Current TRL:

Expected TRL:

Aerial inspection

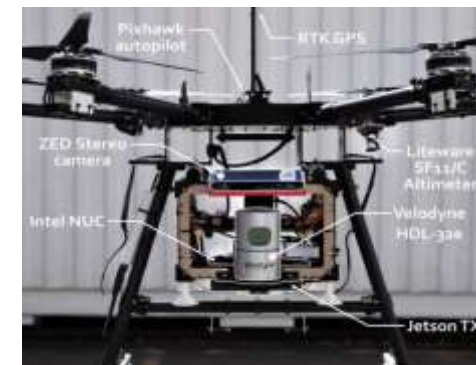
Wind & solar

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6

Development needed:

Robust automatic detection and avoiding obstacles
 Multi coordination for UAVs to new-targeted scenarios in the renewables energies sites



Entity

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Custom aerial manipulator design and development

Description

Custom UAV with an onboard manipulator.
 Several manipulator configurations, including two arms and compliant joints.
 Aerial manipulator is completely automated from take-off to landing.

Potential application

Autonomous aerial inspection of infrastructure with contact using NDT sensors.
 Detection of defects in wind generator blades and PVT panels.

Benefits

Minimizing personnel risks, costs (very high in this kind of works) and time.
 Reduced inspection time by enlarging the covered area.
 Inspecting different types of defects/malfunction.

Category:

Application field:

Current TRL:

Expected TRL:

Aerial inspection

Wind & solar

5

6

Development needed:

Payload/sensor adaptation and integration.
 Evaluation of aerial manipulator reliability.



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Autonomous UAV inspection without contact - IR Thermography

Description

Autonomous aerial inspection without contact with Unmanned Aerial Vehicles (UAVs)

Potential application

Autonomous aerial inspection without contact for industrial infrastructure. Possibility of performing autonomous and automated non-contact NDT inspections thorough infrared, with flexible and adaptable solutions for multiple scenarios considering the same inspection systems and reducing costs of bespoke solutions.

Benefits

Minimizing personnel risks, costs (very high in this kind of works) and time.
 Inspecting different types of defects/malfunction.
 Flexible solution and obtaining a digital register (georeferencing picture).
 Reduced inspection time by enlarging the covered area.

Category:

Application field:

Current TRL:

Expected TRL:

Aerial inspection

Wind & solar

5

6

Development needed:

Automatic detection and avoiding obstacles Multi
 coordination for UAVs to new-targeted scenarios
 in the renewables energies sites Analysis of
 thermographic sequences of windmill blades or
 solar panels



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Autonomous UAV inspection without contact - Visual

Description

Autonomous aerial inspection without contact with Unmanned Aerial Vehicles (UAVs)

Potential application

Autonomous aerial inspection without contact for industrial infrastructure. Possibility of performing autonomous and automated non-contact NDT inspections thorough visual sensor, with flexible and adaptable solutions for multiple scenarios considering the same inspection systems and reducing costs of bespoke solutions.

Benefits

Minimizing personnel risks, costs (very high in this kind of works) and time.
 Inspecting different types of defects/malfunction
 Flexible solution and obtaining a digital register (georeferencing picture)
 Reduced inspection time by enlarging the covered area.

Category:

Aerial inspection

Application field:

Wind & solar

Current TRL:

5

Expected TRL:

6

Development needed:

Automatic detection and avoiding obstacles
 Multi coordination for UAVs to new-targeted scenarios in the renewables energies sites
 Analysis of visual sequences of windmill blades or solar panels



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Custom UAV design and manufacture

Description

Custom multirotor UAV to fly a wide variety of payloads. The payloads can include robotic arms, onboard computers, standard cameras, thermal cameras and other sensors. The UAV total payload mass can vary from 100g to 10kg, with flight times between 30 and 60 minutes.

The aircraft can be designed to fly in cold, hot, wet and windy environments.
The UAV flight can be completely automated from take-off to landing.

Potential application

Small-scale or large-scale automated visual and thermal inspection of photovoltaic solar panels.

Flying payloads of diverse nature.

Onboard real-time data collection and processing using artificial intelligence.

Benefits

Minimizing personnel risks, costs (very high in this kind of works) and time.
Reduced inspection time by enlarging the covered area.
Inspecting different types of defects/malfunction.

Category:

Application field:

Current TRL:

Expected TRL:

Aerial inspection

Wind & solar

5

6

Development needed:

Aircraft redesign to payload, mission and environment parameters. Simulation and flight testing of UAV. Evaluation of component lifetimes for continuous operation. Evaluation of reliability of aircraft systems.



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Radio Emission Spectroscopy (RES)

Description

Wind turbines are becoming electronically and mechanically more complex. The electronic systems on board radiate electromagnetic energy, which is usually considered a nuisance. However, these emissions can be monitored thanks to "Radio Emission Spectroscopy - RES, and analysed to potentially classify turbine faults at an early stage. The required electronics is non-contact with electronic components already installed. Similar possibilities exist for related technologies, e.g. solar converters, in PV energy systems.

Potential application

Efficacy of system has been confirmed for plasma manufacturing applications. It can be adapted to the requirements of solar and wind O&M, and integrated in inspection devices and vehicles

Benefits

Early detection of defects and failures.
Minimizing personnel risks, costs (very high in this kind of works) and time.

Category:

Application field:

Current TRL:

Expected TRL:

Aerial inspection

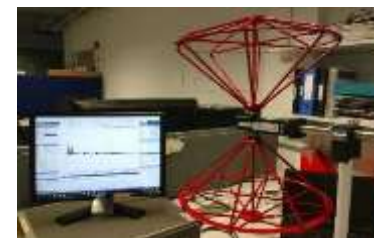
Wind & solar

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Development needed:

Deployment and test of RES prototypes.
Confirmation of efficacy system for a selected number of known faults.
Fault classification algorithms.



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Robotic inspection of structures using self-managed autonomous UAVs

Description

Development of UAV intelligent navigation technology for inspection of structures and infrastructures.

Auto-pilot programming based on self-communication to structural health monitoring sensors.

Auto-wake up system based on structural damage/displacement events. SIM-based events using SIM electronic boards.

Potential application

Robotic inspection of facilities (energy, civil, etc.) without contact using camera vision and health monitoring sensors

Benefits

Minimizing personnel risks, costs (very high in this kind of works) and time.

Inspecting different types of defects/malfunction: combination of visual information and health sensors measurements.

Category:

Application field:

Current TRL:

Expected TRL:

Aerial inspection

Wind & Solar

4

5

Development needed:

Petri-net-based system-level simulation of auto-pilot connection to structural sensors.

Sensors adaptation to UAVs



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Autonomous up-close relative navigation

Description

Autonomous navigation that allows the drone to be placed at a constant distance from the structure with the blade aligned perpendicular to the drone's body frame. The drone also determines which blade it's inspecting, which side of the blade, and the distance to the root.

Potential application

Implementation of inspection/maintenance robotic arm with autonomous control.
Useful for maintenance operators and pilots.

Benefits

Remote inspection and manipulation with high precision
Improved planning of O&M: automated and repeatable inspections.
Minimizing personnel risks, costs (very high in this kind of works) and time.

Category:

Aerial inspection

Application field:

wind

Current TRL:

3

Expected TRL:

7

Development needed:

Synchronization with contact actuator



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Real-time damage detection

Description

Real-time damage detection while the inspection is being made based on IA algorithms. After landing, a damage-report is created with all the damages and their context, like, exact position, damage type, etc.

Potential application

Remote arm robot control by natural interaction.

Benefits

Flexible inspection solutions with a digital register (for example, onsite reports, etc.)
Minimizing personnel risks, costs (very high in this kind of works) and time: no need for cloud-based infrastructure, no need of internet access.

Category:

Aerial inspection

Application field:

Wind & Solar

Current TRL:

3

Expected TRL:

6

Development needed:

Adjusting gains with training data



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Semi-autonomous UAV inspection

Description

Semi-autonomous aerial inspection

Available equipment:

- DJI M210 RTK equipped with DJI XT2 Thermal Camera, DJI Z30 Optical Zoom Camera and DJI X5S High-resolution camera
- DJI M600 Pro equipped with LiDAR System (based on Velodyne VLP16/STIM300) and DJI XT2 Thermal Camera, DJI Z30 Optical Zoom Camera

Potential application

- Asset Inspection (PV/Solar Farms, Wind Farms, Power Lines and Substations);

- IR Thermography to detect hotspots in PV Panels;
- Analytic tool for identification of structural defects on structures, equipment and components

LiDAR: Software Bundle for creating high resolution, high precision classified point cloud outputs, custom-made software for analyzing powerline corridor clearance, GIS tools for creating geographic based outputs (DTM, DSM, etc.)

Benefits

Minimizing personnel risks, costs (very high in this kind of works) and time.
 Improved planning of O&M: automated and repetible inspections.
 Reduced inspection time by enlarging the covered area.

Category:

Application field:

Current TRL:

Expected TRL:

Aerial inspection

Wind & Solar

9

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Development needed:

- 1) control software for automatic inspection of PV/Solar Farms and Wind Farms;
- 2) report software (analytic tool) for automatic identification of structural defects on this type of assets



Entity

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Autonomous UGV inspection without contact

Description

Autonomous UGV performing inspection of solar frames with contactless technologies, such as cameras, depth sensors, sonars.

Potential application

UGV equipped with sensing technologies to perform inspection operation on solar panels without contact.
Useful mainly for maintenance operators and pilots

Benefits

Minimizing personnel risks, costs (very high in this kind of works) and time. Including remote inspection of equipment located under the panels.
Improved operation: opportunity of inspection during solar panels operation or during shutdown at night, and without operators in the field.
Improved planning of O&M: logistics management to optimize the planned trajectories and sequence of operations, as well as the coordination of multiple UAV and UGV in simultaneous operations.

Category:

Ground inspection

Application field:

Solar

Current TRL:

2

Expected TRL:

5

Development needed:

Technology validation in a testing solar farm, with UGV navigating around solar frames to perform local inspection with contactless sensors, such as LIDAR, mmWave radars, depth, RGB, thermal and X-ray cameras.



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Autonomous UGV inspection with contact

Description

Autonomous UGV performing inspection of solar frames with contact technologies, such as robotic manipulators installed on the UGV to manipulate solar panels while performing inspection.

Potential application

Robotic manipulators installed on UGV with specific technologies at the end effector to perform inspection and maintenance operations with interaction with solar panels.
Useful mainly for maintenance operators and pilots

Benefits

Improved planning of O&M: plan and schedule operations during day or night, without human support in the field.
Inspecting different types of defects/malfunction: micro inspection of the photovoltaic plates to detect cracks, bubbles and dirt on the panels. Ability for scanning operations along solar panels with portable technologies, namely precise and repetitive tasks. Ability to perform similar operations with more than one manipulator at the same time.

Category:

Ground inspection

Application field:

Solar

Current TRL:

2

Expected TRL:

5

Development needed:

Technology validation in a testing solar farm, with a robotic manipulator installed on an UGV. End-effectors with different technologies are tested with interaction on solar panels.



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Guidance, navigation and control of an UGV

Description

Guidance, navigation and control (GNC) of an Unmanned Ground Vehicle (UGV), i.e., localization in real-time in a given scenario, path planning and path following, obstacle detection and avoidance.

Potential application

Navigation of UGV in solar farms and wind farms. To perform inspection/maintenance operations and to provide support in a particular panel, set of panels or in the global farm without human guidance neither manual mapping.

Benefits

Minimizing personnel risks, costs (very high in this kind of works) and time: security deployment with obstacle detection and avoidance. Surveillance, e.g., reporting when unexpected obstacles are detected.
Improved planning of O&M: plan and schedule automatic operations in the farm, where transportation is required. Logistic managements to optimize the sequence of operations, sequence of panels and cooperation of multiple UGV in operation.

Category:

Application field:

Current TRL:

Expected TRL:

Ground inspection

Wind & solar

5

6

Development needed:

Identification of UGV missions on the terrain, integration of the path planning with actual maintenance operations and validation of demonstrators.



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Ground mobile support

Description

A UGV is able to provide support for UAV, namely power support as a mobile charging station, communication support as a mobile repeater and a mobile landing platform.

Potential application

UGV to provide support of guidance, communication and charging to keep a fleet of UAV in continuous operation of inspection and maintenance of solar and wind farms.

Mobile charging station for the drones.

Useful mainly for maintenance operators and pilots.

Benefits

Minimizing personnel risks, costs (very high in this kind of works) and time: reduce the shutdown time of each UAV for charging. Providing additional resources to the drones (computational power, ground sensing, communication relay). Follow up and backup on faults reported from the drones.

Reduced inspection time by enlarging the covered area: increase the range of UAV operation.

Improved operation: autonomous grass cutting of the area.

Category:

Application field:

Ground inspection

Current TRL:

4

Expected TRL:

5

Development needed:

Technology validation in a testing solar farm, namely the network communication combining multiple UGV and UAV, UAV landing on the nearest UGV with charging capabilities.



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RobuCAR TT

Description

RobuCAR TT is a powerful mobile robot, with excellent features for rough outdoor tasks. Its capabilities make it suitable for a wide variety of applications.

It is used for defense, security, maintenance, etc.

Potential application

Kompai ground robot is already used to repair mirrors in solar farms. It is a powerful mobile robot, with excellent features for rough outdoor tasks. Its capabilities make it suitable for a wide variety of applications (vision systems, navigation (laser, dGPS...), positioning and manipulation devices (arm, Pan & Tilt units...), ultrasonic sensors, bumpers...

Benefits

Remote manipulation
 Efficient repair on site thanks to portable equipment
 Minimizing personnel risks, costs (very high in this kind of works) and time.

Category:

Application field:

Current TRL:

Expected TRL:

Ground inspection

Wind & Solar

9

Development needed:

Adapting the robot to this specific use and develop command and communication interfaces



Entity

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Autonomous UGV inspection

Description

Autonomous UGV (six-wheel and caterpillar running gears) for inspection and maintenance activities

Potential application

Operation & Maintenance of renewables' assets, namely PV farms

Benefits

Minimizing personnel risks, costs and time.
 Reduced inspection time by enlarging the covered area

Category:

Ground inspection

Application field:

Solar

Current TRL:

7

Expected TRL:

-

Development needed:

Testing in a PV farm is needed to further characterize the developments needed



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Hypercable

Description

JCDC company provides defense, survey, renewable energy industries with antennas adapted to extreme conditions. They are specialized in heavy data transmission and captive UAV/UGV to command or collect videos/data

Potential application

Hypercable RF technology has already been integrated in research prototypes in the offshore field. They recently designed antennas to communicate with army of UAV/UGV.

Benefits

Remote manipulation
 Improved operation

Category:

Application field:

Current TRL:

Expected TRL:

Ground support

Wind & Solar

9

Development needed:

Integration of the antennas in our system



Entity

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Additive manufacturing capabilities

Description

Fused deposition modeling (with filaments and pellets as feedstock materials),
 stereolithography, binder jetting, layer object manufacturing Development of
 materials for these technologies
 Design for increasing functionality of devices
 Fabrication of prototypes and demonstrators

Potential application

Prototypes of new concepts and low scale manufacturing
 Useful mainly for maintenance operators and manufacturers.

Benefits

Fast and efficient manufacturing of spare parts: for low scale pieces and elements

Category:

Additive manufacturing

Application field:

Wind & solar

Current TRL:

6

Expected TRL:

8

Development needed:

Validation of demonstrators and optimization of the manufacturing process in operational conditions



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SLM (selective Laser Melting)

Description

Additive manufacturing technology based on metallic powder as feedstock and laser as energy source. This technology needs a CAD file with the design of the part and metallic powder to fabricate a final part. The fine powdered particles and size of spot of the laser provides very good accuracy for details.

Potential application

It is oriented to the manufacturing of complex and detailed parts. It allows fabrication of broken parts without the need of waiting long delivery times. It offers the option of redesigning for weight savings and for difficult to machine materials. According to this, it is useful mainly for maintenance operators and manufacturers such as low scale or on demand part fabrication for substitution.

Benefits

Fast and efficient manufacturing of spare parts: progressive improvement or optimisation of designs (weight, shape...). This can reduce in a high amount weight, it can make very precise channels for conformal cooling and it can avoid numerous part assemblies. The savings of material is maximum.
Fast and efficient repairing of pieces

Category:

Additive manufacturing

Application field:

Wind & solar

Current TRL:

6

Expected TRL:

7

Development needed:

Identification of the inner part of the nacelle or solar panels more prone to be damaged or that causes long stoppages. A demonstrator will be built and a viability study for the implementing of the technology in the real environment will be done.



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LMD (Laser Metal Deposition)

Description

LMD combines laser beam and metallic powder or wire feedstock for additive manufacturing purposes. Laser beam forms a melt pool on the surface of a metallic substrate or part. That metal forms a deposit in a required geometry, layer by layer. Both, laser and nozzle from which the material is delivered are manipulated using a robotic arm or CNC.

Potential application

It is oriented to the repairing of complex and detailed high value parts in a fast mode.
Reparation of worn surfaces. Formation of protective coatings for extended lives.
According to this, it is useful mainly for maintenance operators and manufacturers.

Benefits

Fast and efficient repairing of pieces: material savings. Very precise and low impact into the base metal.

Category:

Additive manufacturing

Application field:

Wind & solar

Current TRL:

6

Expected TRL:

7

Development needed:

Identification of the inner part of the nacelle or solar panels more prone to be damaged or that causes long stoppages. A demonstrator will be built and a viability study for the implementing in the real environment



will be done.

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WAAM (Wire and Arc Additive Manufacturing)

Description

WAAM combines electric arc and wire feedstock material for additive manufacturing (AM) purposes. It consists of using arc welding technologies such as gas metal arc welding (GMAW), gas tungsten arc welding (GTAW) and plasma arc welding (PAW), to generate 3D objects by depositing molten metal in superimposed layers.

Potential application

It is a promising alternative to traditional subtractive manufacturing for relatively large metal components (from 0.4 m to several meters) with low to medium complex geometry and high buy-to-flight ratios (the ratio of material weight procured to the weight of the final part). According to this, it is useful mainly for maintenance operators and manufacturers such as part fabrication or part substitution.

Benefits

Fast and efficient manufacturing of spare parts: minimum human intervention and setup times based on readily available welding equipment, manipulators and filler metals: low capital cost, low material and deployment costs. Unlimited build envelope and high deposition rates (reported deposition rates usually range from 1 kg/h to 4 kg/h for aluminium and steel, respectively).

Category:

Additive manufacturing

Application field:

Wind & solar

Current TRL:

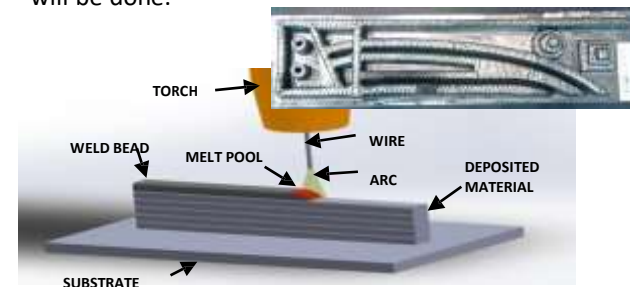
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Expected TRL:

7

Development needed:

Identification of the inner part of the nacelle or solar panels more prone to be damaged or that causes long stoppages. A demonstrator will be built and a viability study for the implementing in the real environment will be done.



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Mixed Reality (MR) Remote vehicle control

Description

A Virtual cockpit designed to be visualised into a 3D MR immersive system like HTC Vive. The cockpit allows to remote control a vehicle by physical interactors (SAITEK X52 e.g.).

Potential application

Remote vehicle driving useful mainly for maintenance operators and pilots
Supervision and Control of an UAV vehicle with a global 3D

Benefits

Minimizing personnel risks, costs (very high in this kind of works) and time: costless to maintain and more flexible than a physic cockpit
Characterization of the environment for O&M actions: compatible with next generation of technology, thanks to 3D reconstruction of the facilities in which the UAV will operate
Improved planning of O&M: efficient planning of missions thanks to the previous practice in the 3D environment

Category:

Remote control

Application field:

Wind & solar

Current TRL:

2

Expected TRL:

5

Development needed:

HCD Design
Computing performance
Natural interaction with the 3D environment
User friendly environment



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Mixed Reality (MR) Composite View

Description

The most of UAVs are mounted with a lidar system that allows to get point cloud of the surrounding environment. The idea is to get a composite view from the different views: depth, segmentation and the FPV view. The point cloud view will be displayed directly into the cockpit to be explored by the pilot.

Potential application

Remote vehicle driving & surrounding environment exploration
Useful mainly for maintenance operators and pilots

Benefits

Minimizing personnel risks, costs (very high in this kind of works) and time: improvement of the remote driving and the detection of defaults by the operator
Characterization of the environment for O&M actions: improvement of surrounding environment understanding

Category:

Application field:

Current TRL:

Expected TRL:

Augmented reality

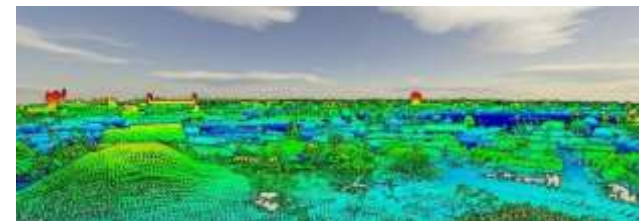
Wind & solar

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3

Development needed:

HCD Design
Computing performance



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Mixed Reality (MR) Additional environment information visualisation

Description

The virtual cockpit is able to handle and display additional environment information by superimposing the data on the regular view and/or 3D point cloud environment.

Potential application

Remote vehicle driving & surrounding environment exploration
Useful mainly for maintenance operators and pilots

Benefits

Minimizing personnel risks, costs (very high in this kind of works) and time: through UAVs by means of the display of additional information to the pilot in real time
Improved planning of O&M: thanks to the previous practice in the 3D environment with enriched information

Category:

Augmented reality

Application field:

Wind & solar

Current TRL:

2

Expected TRL:

4

Development needed:

HCD Design
Computing performance
Identification of expected contextual information



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Mixed Reality (MR) Remote arm robot control

Description

Into the virtual cockpit the pilot is able to remotely control a robot arm by biomimetism through the use of a mocap (motion capture) system.

Potential application

The natural interaction by using the pilot's own arm for biomimetism remote controlling facilitates the part manipulation and repairing
Useful mainly for maintenance operators and pilots

Benefits

Remote manipulation actions in non-accessible locations (i.e., wind blades)
Minimizing personnel risks, costs (very high in this kind of works) and time: reduction of dangerous operations thanks to remote operation of tools

Category:

Application field:

Current TRL:

Expected TRL:

Remote control

Wind & solar

2

5

Development needed:

HCD Design

Computing performance

Real time computing

Mocap efficiency

Biomimetism computing



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Prognostics methods and risk-based optimisation of maintenance

Description

Prognostics technology for failure anticipation of composite turbine blades. It includes model-based/physics-based algorithms for predicting damage evolution, fast-computing methods using neural networks, algorithm encapsulation within electronic-boards/micro-processors. Data fusion techniques, data-classification, predictive algorithms, Monte Carlo Sequential algorithms, evolutive stochastic models, filtering algorithms using on-line monitoring data, Remaining Useful Life Calculation, End of Life Calculation, turbine-blade operational analysis

Potential application

Turbine blades inspection, maintenance and operation
Useful mainly for maintenance operators

Benefits

Predictive maintenance, reducing unexpected stops
Improved planning of O&M: optimisation of planning of maintenance operations and reduction of unexpected corrective actions

Category:

Artificial intelligence

Application field:

Wind

Current TRL:

5

Expected TRL:

8

Development needed:

-



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O&M technologies for off-shore wind facilities

Description

Algorithms and methods for O&M of offshore wind turbines using combined information. Petri net system level models for event-driven modelling, concurrence modelling and decision-making using heterogeneous data: meteorological, operational, and structural information. FMEA and FMECA analysis, Fault-Tree, Event-Tree Analysis.

Potential application

Inspection of wind facilities. Technology is transferrable to solar facilities, along with other infrastructure.
Useful mainly for maintenance operators

Benefits

Predictive maintenance, reducing unexpected stops
Improved planning of O&M: optimisation of planning of maintenance operations and reduction of unexpected corrective actions

Category:

Artificial intelligence

Application field:

Wind

Current TRL:

5

Expected TRL:

8

Development needed:

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Pervasive robots modelling and simulation

Description

Design of system-level event, concurrency and synchrony modelling using Plausible Petri nets. Autonomous and intelligent robotic devices and system-level engineering devices capable of taking decisions using and based-on uncertainty, in an approximate manner as humans do.

Potential application

Robotic/autonomous inspection of facilities (energy, civil, etc.). Autonomous decision-Making support systems

Benefits

Minimizing personnel risks, costs (very high in this kind of works) and time: advanced functionalities for robotic devices during inspection and/or manipulation thanks to artificial intelligence.
Remote manipulation: improved capabilities of the devices

Category:

Artificial intelligence

Application field:

Wind & solar

Current TRL:

3

Expected TRL:

5

Development needed:

Petri-net-based system-level simulation of auto-pilot connection to structural sensors.
Sensors adaptation to UAVs



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LEO: Main Shafts Continuous Monitoring Maintenance System

Description

LEO system monitors the structural condition of the windturbine's shaft in real time and automates the maintenance decision-making process, providing alerts of integrity risk in the component and establishing when the maintenance work order for the damaged shaft withdrawal must be issued. The system is based on ultrasonic traducers attached to the main shaft which are governed by an ad-hoc designed electronic controller which evaluates the condition of the component (RUL). It also issues different warnings/alarms of integrity risk in the component.

Potential application

The application to new models would allow to optimization o maintenance costs as well as the extension of the operative life of damaged main shafts in a wide population of under risk wind turbines, providing nowcasting and forecasting information based on the diagnosis and prognosis of crack grown and the associated risk to integrity.

Benefits

Predictive maintenance
 Minimizing personnel risks, costs and time.

Category:

Sensing & monitoring

Application field:

Wind

Current TRL:

7

Expected TRL:

8

Development needed:

Crack fatigue propagation study for other windturbine models with the pathology, hardware adaptation for the hub configuration, wireless command & battery based power HW reconfiguration, SW adaptation.



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Thermography and electroluminescence

Description

Thermography (IRT): Nondestructive technique in which the infrared radiation of the surface of a component is measured in order to detect possible defects that affect heat dissipation.

Passive thermography benefits from the heat generated during a process while active thermography includes an excitation source to increase the temperature and generate heat flux on the piece.

Electroluminescence (EL): Optical and electrical phenomenon in which a material emits light in response to the passage of an electric current or to a strong electric field.

Potential application

Defect detection, such as cracks, pores or delaminations, in different materials like composites, metals, Si-based solar panels...

Inspection of solar plants during energy production (Passive thermography) or during the night (Active thermography / Electroluminescence). Wind turbine inspection assembled and disassembled.

Benefits

Flexible inspection solutions with a digital register: easily interpretable results. Repeatable. Inspecting different types of defects/malfunction. Minimizing personnel risks, costs and time.

Category:

Sensing & monitoring

Application field:

Wind & solar

Current TRL:

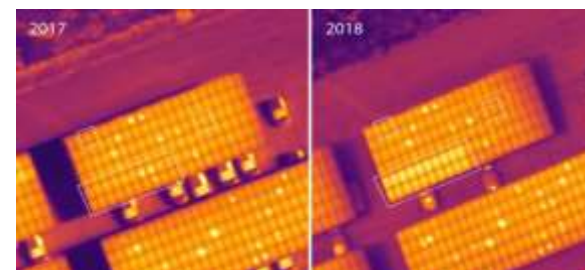
5

Expected TRL:

6

Development needed:

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Advanced material characterization techniques

Description

Different testing technologies for material characterization and failure analysis for composites, metals, joints and coatings, including:

- Mechanical testing
- Optical and electronic microscopy
- Corrosion testing
- Thermal and flammability testing
- Physic and chemistry testing
- Paints and coatings evaluations
- Ultrasonic survey

Potential application

Manufacturing and/or repairing materials characterization. Failure analysis
Useful mainly for maintenance operators and manufacturers.

Benefits

Fast and efficient repairing of pieces: application of knowledge about composite materials involved in windmill manufacturing processes
Inspecting different types of defects/malfunction (NDT)

Category:

Sensing & monitoring

Application field:

Wind

Current TRL:

8

Expected TRL:

9

Development needed:

Adaptation of the testing techniques to the materials typically used in windmill manufacturing



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3D Reconstruction

Description

Mapping the scenario in a 3D reconstruction able to support navigation, Virtual Reality and Augmented Reality needs.

Potential application

Validation of 3D reconstruction in solar farms and wind farms.
 Planning and practice of operation and protocols with VR/AR. Human machine interface (HMI) to track and visualize the status of the fleet of UAV and UGV, as well as the status of operations.
 Useful mainly for maintenance operators and pilots.

Benefits

Improved planning and assessment of operations of inspection and maintenance, as well as their profiles (dimensions, autonomy, range, etc.).
 Characterization of the environment for monitoring vegetation to prevent shadows appearing on solar panels (trees, buildings, etc.).

Category:

Application field:

Current TRL:

Expected TRL:

Sensing & monitoring

Wind & solar

5

6

Development needed:

Validation of available technologies to perform 3D reconstruction, such as LIDAR, depth cameras and mmWave radars, in solar and wind farms. Validation of demonstrators in relevant environments.



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Structural health monitoring of composite turbine blades

Description

Acoustic-ultrasonic sensors embedded within the composite layup. It includes the cabling system and communications to acquisition board

Potential application

Turbine blades inspection, maintenance and operation.
Useful mainly for maintenance operators

Benefits

Advanced detection of internal defects
Minimizing personnel risks, costs (very high in this kind of works) and time (NDT)

Category:

Sensing & monitoring

Application field:

Wind

Current TRL:

4

Expected TRL:

6

Development needed:

Physics-based methods of ultrasound wave-propagation within the composite blade.
Miniaturized piezoelectric sensors
Acquisition systems using edge-computing.
Ultrasound-based non-destructive evaluation and structural health monitoring.



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Acoustic Emissions

Description

The distributed measurement of strain by Rayleigh effect is based on the response of a pulse of light traveling through an optical fiber. This beam of light, colliding with the impurities of the fiber, suffers a backscatter phenomenon. Backscattering is generated throughout the entire fiber as the light pulse advances. Part of this backscattering returns through the fiber to the light pulse emission / reception equipment. The backscatter reception allows continuous measurement throughout the entire optical fiber. To measure, the signal received at each moment is compared with that received in the absence of excitation.

Potential application

The distributed measurement capacity makes it an appropriate technique to obtain information from a large number of points or from a large area. It is mainly used in: automation, civil works and monitoring of components based on composites, with special emphasis on the aeronautical and wind sector, e.g. on blades (residual stresses during installation, tension in junctions and joints ...)

Benefits

Reduced inspection time by enlarging the covered area: The measures obtained correspond to the length of the entire fiber, obtaining the response of the fiber and therefore of the piece in all areas where the fiber has been glued.

Advanced detection of internal defects

Flexible inspection solutions with a digital register

Category:

Application field:

Current TRL:

Expected TRL:

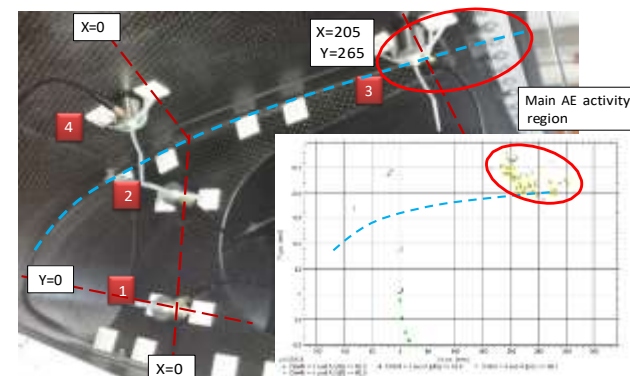
Sensing and monitoring

Wind

9

Development needed:

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Acoustic Emissions

Description

Acoustic emission (AE) is the phenomenon of radiation of acoustic (elastic) waves in solids that occurs when a material undergoes irreversible changes in its internal structure, for example as a result of crack formation or plastic deformation due to aging, temperature gradients or external mechanical forces. The waves generated by sources of AE are of practical interest in structural health monitoring (SHM), quality control, system feedback, process monitoring and other fields. In SHM applications, AE is typically used to detect, locate and characterize damage.

Potential application

Acoustic emissions is a very versatile and non-invasive way of collecting information about a material or structure. It is used to inspect and monitor pipes, pressure vessels, storage tanks, bridges, aircraft and bucket trucks, and a variety of composite and ceramic components. It is also used in process control applications, such as welding process monitoring.

Benefits

Reduced inspection time by enlarging the covered area: sensor can receive events from several meters away.

Early detection of defects and failures: the acoustic emission activity starts from the very beginning of the damage generation. It can detect damage before other inspection techniques.

Advanced detection of internal defects: damage location and damage characterization are advanced applications of acoustic emissions technique. Events from inside the material create waves which travel to the surface up to the sensors.

Category:

Sensing and monitoring

Application field:

Wind

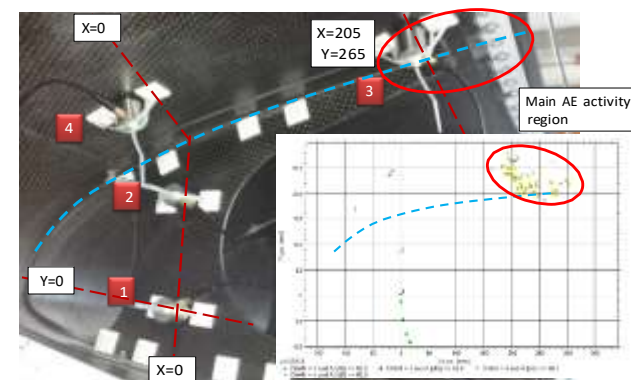
Current TRL:

9

Expected TRL:

Development needed:

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On-site tests

Description

- On-site tests: Thermography Camera, Electroluminescence Camera, I/V curve and maximum power determination of PV modules with array-tester;
- Climatic chambers and sun simulator for PV modules and cells;
 - Hipot equipment;
 - Weather station

Potential application

- On-site tests (O&M)
- Outdoor exposure tests
- Benchmarking for comparison of different technologies
- PID tests (on laboratory)
- Complete IEC 61215 ed.2 and IEC 61646 ed.2 standardized tests (on laboratory)
 - Ageing tests
 - Quality control

Benefits

Flexible inspection solutions with a digital register
 Early detection of defects and failures.
 Inspecting different types of defects/malfunction
 Predictive maintenance

Category:

Sensing and Monitoring

Application field:

Solar

Current TRL:

9

Expected TRL:

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Development needed:

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Solar selective coatings for high temperature

Description

Use of Physical Vapour Deposition (PVD) techniques to develop solar selective coatings for high temperature CSP (concentrating solar power) applications:

- Parabolic troughs (stability in vacuum $T > 600^{\circ}\text{C}$)
- Central towers (stability in air $T > 800^{\circ}\text{C}$)

Potential application

New concepts of coating materials for CSP plants using nitride and carbide multilayers. Development of new coatings with high oxidation and corrosion resistance (in vacuum and in air) at high temperature. Useful mainly for CSP facilities.

Benefits

Improved operation: Increase of the operation temperature and, consequently, the optical performance of the CSP plants.

Category:

New materials

Application field:

Solar

Current TRL:

6

Expected TRL:

8

Development needed:

Long term stability (>25 years)

Industrial Scale up



Entity

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Abrasive water jet blind machining

Description

Portable abrasion machining machine. It is the only handy system (<50kg) adapted to composite repair machining. It is composed of a portable machining robot linked to a mobile ground station.

Potential application

Patented effluent skimmer that drives out all carbon dust.
It favors a wholesome atmosphere for human and technical environment.
Guaranty of an automation with a maximum of simplicity of use and constant depth working

Benefits

Fast and efficient repairing of pieces
Efficient repair on site thanks to portable equipment

Category:

Repairing

Application field:

Wind & solar

Current TRL:

4

Expected TRL:

7

Development needed:

Implementation in the specific context of application



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Crack repairation by adheve paths

Description

Crack repairation is normally made by means of welding reparations or in some cases with composite patch adhesion.

The repairation with adhesive patch have been limited to small thickness structures. IKERLAN have develop a methodology that allows designing a adhesive patch repairation for thickness bigger than 25 mm made of metals.

The adhesive patch allows to evaluate the performance of the repairation without modifying the original structure. In case of work repairation the structure can come back to the original state with no permanent damage.

Potential application

It can be applied at any kind of repairation. The methodology allows to evaluate the performance of the repairation and to evaluate the dimension of the patches.

Benefits

Early detection of defects and failures: the repairation can reduce or even eliminate the crack propagation.

Fast and efficient repairing of pieces: the repairation doesn't damage the original structure.

Category:

Repairing

Application field:

Wind

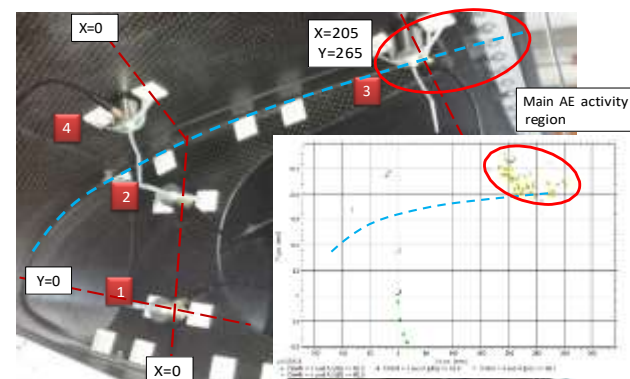
Current TRL:

7

Expected TRL:

Development needed:

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VISION: CMMS + GIS for energy furnitures maintenance planning

Description

Vision is a collaborative SaaS platform which allows CMMS, GIS, and Document Management Systems communicate with geolocated equipments using maps, menus and personalized interfaces. The objective is to create application for maintenance operators and mission planning.

Potential application

Vision may be used in several tasks:

- Visual tracking of the equipments and their materials/components
- creating maintenance workflow
- launching drone/robot mission with BIM data of the equipments as inputs

Vision is used by ENEDIS (National French electricity provider and operator) as well as many

Benefits

Improved planning of O&M
 Characterization of the environment for O&M actions
 Predictive maintenance
 Flexible inspection solutions with a digital register (for example, georeferenced pictures, onsite reports, etc.)

Category:

Application field:

Current TRL:

Expected TRL:

Tracking & Management

Wind & Solar

9

Development needed:

APIs prototyping to communicate with or integrate UAV/UGV mission planner and controller
 integration of UAV/UGV floats in the GIS integration of solar/wind equipments and facilities



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SIG-MR: CMMS + GIS for energy furnitures maintenance planning

Description

SIG-MR is a SaaS that combines GIS, CMMS and Hypervision features. It's mainly commercialized and used in underground facilities (gaz, water, telecommunication, public lightings, low voltage and electrical networks). Councils, cities and energy facilities exploitation companies use it to track and predict maintenances. Nevertheless, this SaaS can be easily parametered to adapt to the customer's need. The company has 25 years of experience in the field of electrical networks information systems.

Potential application

- Visual tracking of the equipments and their materials/components
- Accurate geolocation and view of underground facilities
- creating maintenance workflow
- launching drone/robot mission with BIM data of the equipments as inputs

Benefits

Improved planning of O&M
 Characterization of the environment for O&M actions
 Predictive maintenance
 Flexible inspection solutions with a digital register (for example, georeferenced pictures, onsite reports, etc.)

Category:

Tracking & Management

Application field:

Wind & Solar

Current TRL:

9

Expected TRL:

Development needed:

Developing API to collect equipments data
 Parametering SaaS to fit with Solar/Wind equipments data models.



Entity

SIG-IMAGE

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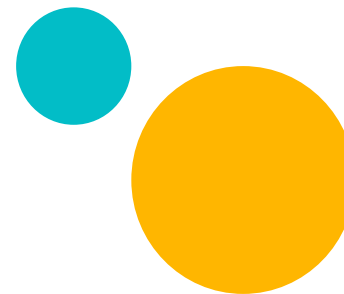
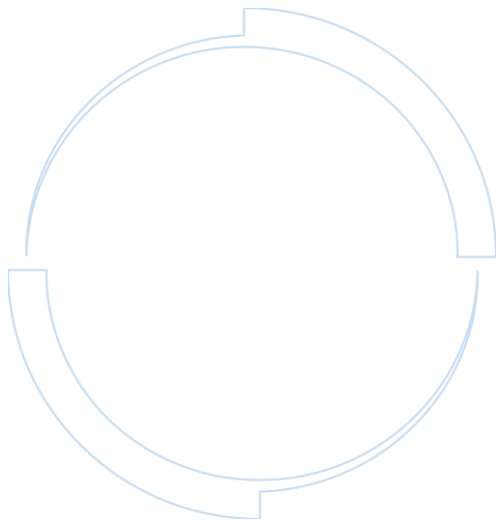
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Thank you

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