Keywords: #windmill, #maintenance #cloud-edge-IoT, #drone, #UAV, #AI, #5G

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MetaOS Project

Introduction of drones and implementation of Predictive Technology in windmill maintenance

Background

In the field of windmill maintenance, an industrial story appears, highlighting the transformative impact of advanced inspection processes and strategic technological integration. This story focuses on the adoption of an innovative inspection system that utilizes UAV on-board processing, edge computing, and cloud technology, revolutionizing the maintenance of wind turbines.

This use case involves a windmill inspection solution, developed by TTA, that uses drones and AI algorithms to help detect the damages, assess their severity and, if necessary, execute maintenance operations to remediate them. In this use case, an operator moves to the base of a windmill and deploys a drone equipped with a high-resolution Digital Single Lens Reflex (DSLR) camera. The drone is connected to an on-board computing unit capable of acquiring, processing, and transmitting images to a computer located in the operator's vehicle (ground station) for further analysis. During the flight (limited to 30 minutes), the operator needs to cover all the wind blade faces to be able to quickly assess any major defects. The operation is repeated for all the blades. The objective is that the windmill can be restored to working condition promptly if no significant issues are found. Every picture goes through initial processing on-board the drone (IoT step) and after that is sent further to the edge server for filtering, cropping etc. Finally, the data goes to cloud for final processing. TTA solution can offload some of the workload to the cloud, however, windmill farms are often situated in areas where cellular networks used for communication between the ground station and the cloud are unreliable or have limited bandwidth. To overcome these challenges, NebulOuS will exploit the cloud-edge computing continuum for deploying the data processing pipeline transparently, utilizing edge resources whenever possible while relying on the cloud when necessary. This will ensure a timely analysis of windmill data whilst limiting the amount of data sent to the cloud.

The Company

Transformation Technology for Analysis (in short TTA) is a technology start-up that specializes in the inspection of wind turbines. By leveraging advanced AI mechanisms, TTA as well has developed an edge platform that automates damage detection and classification, ensuring efficient and accurate analysis of turbine conditions. Our platform utilizes artificial intelligence and machine learning algorithms to analyze high-resolution images and data collected from wind turbines. This enables early identification of potential issues, such as blade cracks, surface erosion, and structural defects, which can significantly impact the performance and lifespan of turbines. By automating the inspection process, TTA reduces the need for manual inspections, which are often time-consuming, costly, and potentially hazardous.

The Needs

Traditionally, the inspection process for wind farms involved either the use of ground cameras with telephoto lenses or climbing crews if the blades required close-up examination. These techniques were not very efficient, being time-consuming, costly, and lacking in accuracy. The high costs of these operations led wind farm operators to perform inspections as infrequently as legally allowed. Consequently, some damages are detected too late, leading to greater costs in their correction or, in extreme cases, to the catastrophic failure of the wind turbine. With the emergence of drone technology, this kind of activities can now be performed with enhanced results, allowing maintenance operators to acquire images from any angle of each wind turbine. In order to be able to detect anomalies in a wind turbine, the acquired media has to be captured and traditionally processed at a later stage in dedicated data centres with powerful hardware. If an anomaly is detected, a second visit is scheduled to the targeted wind turbine, allowing to acquire extended detailed images on the issue detected and to confirm or discard the previously flagged potential defect. This modus operando is of course not ideal and not cost effective.

The solution

The current inspection process begins with UAVs (Unmanned Aerial Vehicles) equipped with advanced on-board processing capabilities. These UAVs perform quality assessments and detect specific blade parts, ensuring an initial layer of inspection is completed right at the source. As the UAVs capture data, it is then processed at the edge, where damage detection occurs, clearing house functions are managed, and images are cropped for further analysis. This real-time edge processing significantly reduces the amount of data that needs to be transferred, enhancing efficiency and speed.

The cloud plays a crucial role in this process, handling damage

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classification and severity assessment. By utilizing cloud computing, vast amounts of data can be stored and analysed, providing comprehensive insights into the condition of the wind turbines. This unified computation continuum—from UAV to edge to cloud—ensures that the inspection process is seamless and highly efficient.

The Challenge

Drones capture high-resolution images of wind turbine blades, which are processed by AI-enabled algorithms to automatically detect turbine damages and discover other valuable information for turbine maintenance. This process however generates a considerably high amount of data that typically is stored on the camera memory and later copied to a database for offline processing by the AI algorithms. NebulOuS will automatically and in real time handle this process being infrastructure agnostic and without needing human intervention. NebulOuS will exploit 5G networks and will cope with data streaming, efficiently utilizing cloud and edge computing paradigms to enable data processing as close to its data source as possible. NebulOuS will enable video streams data collected by the drone to be processed in near real time during the actual inspection flight. Upon any anomaly detection, the readjustment of the drone's route will be possible to collect additional data from a specific turbine in case of a confirmed defect. Data is to be processed first at the edge (lightweight version of the image recognition software) and only if a potential anomaly is detected, this data is redirected and processed using private or public cloud resources. By doing this, both network bandwidth and computational resources consumed will be considerably lower as only potential anomalies are to be fully broadcasted and analysed to the central node. This will also minimise the amount of the data collected and stored for further off-line analysis. To this end, this use case will demonstrate in a real-life deployment, the usage of drones for inspection routines on wind turbines in a wind farm environment.

The service provider

This service is being developed by a team of nearly 100 people from 16 organizations, located in 8 different European countries: France, Germany, Greece, Ireland, Norway, Poland, Portugal and Spain.

NebulOuS is a trailblazing research project committed to making substantial contributions in the realms of cloud and fog computing brokerage. Led by Eurecat in the role of project coordinator, NebulOuS brings together dedicated experts, visionaries, and innovators passionate about reshaping the landscape of cloud computing.

Project involved

This use case is supported by the project NebulOuS.

NebulOuS is a European project that aims to become the go-to Operating System for the Cloud Computing Continuum. Our mission is to revolutionize cloud and fog computing brokerage through the development of advanced provisioning tools, a unique Meta Operating System, and the comprehensive NebulOuS solution.

NebulOuS is on the path to pioneering a novel Meta Operating System (OS) and platform, forging a transformative approach to transient fog brokerage ecosystems. This addresses modeling, comparison, intelligent management, unified security, and smart contract-based SLA monitoring within the cloud computing continuum.

Envisioning a future where the dynamic cloud continuum is seamlessly managed, akin to an operating system orchestrating computing resources, our ultimate goal is to provide an adaptive application hosting environment. NebulOuS optimizes for data proximity, aligning with the highest standards of quality, security, and privacy.

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The target benefits of this integrated system are profound. A unified computational continuum streamlines data processing and analysis and will allow for the collection of precise metrics that will inform maintenance decisions. Automated infrastructure scalability will ensure that the system can handle varying workloads without manual intervention, optimizing both cost and performance. This strategic deployment of components guarantees that resources will be used most effectively, balancing the need for rapid processing with cost efficiency.

Several immediate goals will be achieved through this innovative approach. The windmill inspection process will see significant improvements, with quick quality feedback provided directly by the UAVs. The clearing house function at the edge will eliminate the need for manual image uploads, enabling quick inspection results and enhancing operational efficiency. This flexible process will allow inspection steps to be easily moved between the UAV, edge, and cloud, providing a tailored solution for both inspection companies and wind farm operators.

Through this innovative inspection process, we expect that the windmill maintenance industry will achieve remarkable advancements, demonstrating the power of cutting-edge technology in enhancing operational efficiency and reliability. This success not only will strengthen the renewable energy sector but also set a precedent for other industries to follow, showcasing a future where advanced technology and strategic integration drive industrial success.

Future developments

Looking ahead, this promising story paves the way for broader applications. The mid-term perspective includes migrating these advanced inspection techniques to other verticals such as solar plants, electricity grids, pipelines, and building inspections, particularly for heat isolation monitoring. Sensor fusion, incorporating infrared cameras, spectral cameras, and ultrasound scanners, is also on the horizon, promising even more comprehensive and accurate inspection capabilities.

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- ttanalysis.pl
- nebulouscloud.eu/use-cases-windmill-maintenance/

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