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USING AMAZON REKOGNITION ARTIFICIAL INTELLIGENCE TO RECOGNIZE BANK BRANCH SOLAR PANELS

Abstract. Bank branches carry out quality control of solar panels that ensure energy independence and uninterrupted operation of computer equipment in the conditions of an aggressive war caused by Russia, to ensure that the solar panels meet production standards and avoid potential damage to the brand reputation. As sensor costs decrease and connectivity increases, industry is using real-time image analysis to detect quality issues. At the same time, advances in artificial intelligence (AI) enable advanced automation, reduce overall project cost and time, and provide accurate defect detection results in manufacturing plants. As these technologies evolve, AI-assisted inspections are becoming more common outside of the factory environment.

Keywords: artificial intelligence, bank branch, AWS, solar panels.

Introduction

As the use of solar energy increases, so does the need to detect panel damage. Applying artificial intelligence services powered by AWS is a simpler and more cost-effective approach than human inspection of solar panels or custom-built manufacturing applications.

Presenting main material

Customers can capture and process video from the field and build powerful computer vision models without building a dedicated data processing team. This approach can be generalized to industrial use cases for detecting defects in wind turbines, cell towers, automotive parts, and other field components.

Amazon Rekognition Custom Labels builds on the service's existing capabilities, which are already trained to identify objects and scenes in millions of cross-category images. You upload a small set of training images - typically a few hundred or less - to our console. The solution automatically loads and validates the training data selects the correct ML algorithms, trains the model, and provides model performance metrics. You can then integrate your custom model into your applications using the Amazon Rekognition Custom Labels API.

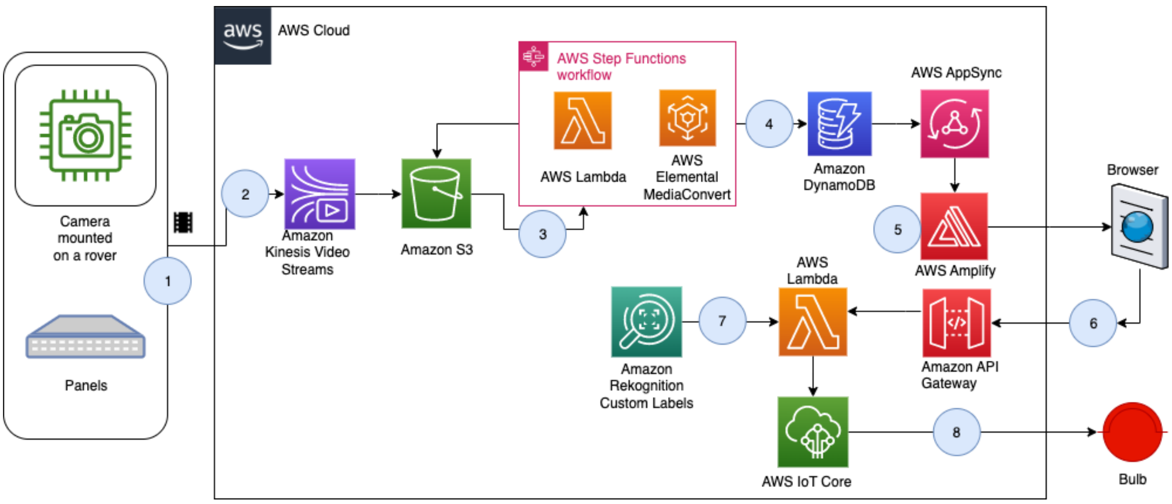

Fig. 1. System architecture of the SOLVED project

The data acquisition layer of the SOLVED project consists of a continuous video stream captured as the robot moves through a field of solar panels.

Freenove 4WD Smart Car with Raspberry Pi was used. The installed camera records video while driving across the field. Amazon Kinesis Video Streams Producer with Pi to stream live video to Kinesis Video Stream.

Preliminary processing:

1. Automatically transcodes videos uploaded to Amazon S3 into formats suitable for playback on different devices with MediaConvert.
2. Configures the MediaConvert task settings by downloading a custom file and using different settings for each input.
3. Stores transcoded files in a target Amazon S3 bucket and used CloudFront to deliver them to end users.
4. Provides output data including input file metadata, operation parameters, and output details in addition to the transcoded video.

These results are stored in a separate JSON file available for further processing Processing and visualization Every trained ML model needs quality training data. We started with publicly available images of solar panels that were classified as either "good" or "defective" and uploaded the images to an Amazon S3 bucket in their respective folders. Next, custom Amazon Rekognition labels were configured with folders to specify the labels to use when training and deploying the model. Using rover images, we tested the model.

A robot was used to record videos of healthy and damaged solar panels over a long period and evaluate the positive results. The video was split into individual frames using MediaConvert, giving us a well-labeled dataset that we trained our model on using custom Amazon Rekognition labels.

A model endpoint was used to infer the results of solar panels with different damage footprints at different locations. AWS Elemental Mediaconvert accelerated training set preparation, and model and endpoint generation was done using Amazon Rekognition.

Solar panels

Scientific and technological progress makes the unknown accessible to us and helps to create things that are completely new in terms of functionality and purpose. Inventions alone solve our problems. Others add comfort, changing every moment of our lives. One of such inventions of the 20th century can safely be called solar cells. Solar cells can provide the need for electrical energy in places remote from civilization, in deep space, and even where there is little sunlight. The advantages of using solar energy are undeniable. Depending on their power, solar panels can help solve tasks of varying degrees of complexity: from ordinary street lighting to the possibility of making the roof of your own house a place of real income through the "Green Tariff" mechanism.

Let's consider the structure of the solar panel and the reasons affecting the loss of their productivity.

Structure of the solar panel:

- silicon plates (cell);
- protective glass;
- a base for placing silicon wafers;
- anodized aluminum frame;
- connector for switching (positive and negative output).

The simplicity of the design allows the panels to work for several decades without any problems. The standard warranty from solar battery manufacturers is 25 years. The oldest photovoltaic panel in the world is 60 years old and still working. The efficiency of photovoltaic panels depends on their quality, location conditions, and professional setup of the entire system. But even high-quality solar panels can lose their performance during operation.

We will give several reasons.

1. Solar panels lose their initial power and solar power output over time due to the intensity of UV radiation and exposure to extreme weather conditions. Fortunately, in our latitudes, the intensity of UV radiation is low, and we rarely experience hurricanes, tornadoes, or sandstorms. The real climatic conditions affecting the durability of photovoltaic panels include:

- High temperatures: Solar cells lose their efficiency on hot summer days, which contributes to their intensive wear! Solar cells lose an average of about 1% efficiency per year, which is considered a good indicator of quality.

– Hail. A solar battery manufactured according to modern standards can withstand a fairly powerful hailstorm. Most manufacturers indicate exactly what hail or storm their products can withstand. However, a large enough storm can cause significant damage to even very good glass modules. In Europe, this problem is minimized by purchasing an appropriate insurance policy.

– Meltwater Freezing: A PV module, in general, works better in winter than you might think. Snow usually falls from solar panels under the influence of sunlight. However, under certain conditions (for example, at a gentle angle of the placement of solar cells), water can freeze on the panel, which, when expanded, can damage the surface of the panel.

– Cracks and microcracks on photocells. This problem occurs most often, and it is the main reason for the power loss of photovoltaic panels. Cracks can have a different nature and occur both due to improper installation of equipment and mechanical damage. Large cracks can be detected during routine cleaning. Detection of microcracks is possible only thanks to a special infrared test method.

2. Hot spots or heating centers. Hot spots are individual areas of the solar cell with elevated temperatures. A local increase in the temperature of a separate area causes a decrease in efficiency and accelerates the aging of the entire panel. To prevent the formation of hot spots, it is worth, at the installation stage, to avoid installing the panels in shaded places and wash the panels regularly.

3. Delamination. This is the name given to peeling off a special plastic-based film that protects against excessive moisture or damage to solar panels. Delamination can cause not only the loss of productivity of one photomodule but also the failure of a part of the solar power plant. This is explained by the specifics of switching solar panels (parallel or series connection). The result may be a short circuit of the non-insulated contacts of the solar battery.

4. Browning or simply burning is a process that is a consequence of the chemical interaction of incompatible components. Because of this, photovoltaic modules can overheat and reduce their efficiency.

5. Depressurization. Special tempered glass contributes to a longer service life of monocrystalline and polycrystalline solar panels. For complete resistance to moisture, manufacturers use special sealants. The junction of the aluminum frame and glass, electrical installation box are sealed. The very fact of depressurization indicates that technological requirements were violated during the production or installation of solar panels.

6. Deformation. Such a problem may arise if low-quality components were used during the production of solar photo modules (for example, a profile). If the photomodule has been deformed under the influence of weather conditions, it must be replaced.

All PV panels from any manufacturer must have a warranty on output power. Most solar panel brands offer a 25-30-year performance warranty. However, the key value included in such a warranty is the amount of panel efficiency loss that occurs over time. The lower the level of efficiency losses, the better.

If the brand you choose indicates a performance loss in the range of -0.35% to -0.5% per year, your solar panel will lose more than 7% of its efficiency after 10 years under normal operating conditions So after 25 years their efficiency should be more than 80% at maximum power.

Any mechanical contact with the front part of the panel should be avoided because they can cause such damage as:

1) A single crack that occupies a large segment of the cell. Such a crack easily turns a part of the photocell into an inactive one. In addition, the entire current-carrying path works with significantly lower efficiency, which ultimately affects the operation of the entire module. As we can see in this image, as many as 7 cells have significant damage. As a result, the output power of the panel will be lower than the nominal value, even considering a good level of solar insolation. Mostly, such damage

occurs from a direct, mechanical impact on the panel.

2) Branched microcracks can be considered common and significantly affect the production of the panel. Their main feature is the coverage of the entire cell, and, as a result, the deactivation of all damaged current-carrying tracks. The reason for this effect in most cases is walking on the module.

3) Semi-transparent areas. Such segments of a damaged photocell are difficult to detect even using ELCD (electroluminescence crack detection) testing, let alone conventional visual inspection of the panel. Although this defect does not have a significant effect on the efficiency of the cell, during operation, it is the damaged photocell that will degrade faster, as a result of which the level of production of the panel will decrease faster than expected.

Conclusions

Amazon Rekognition helps banks collect wartime images and apply AI-based analysis to interpret the state of solar panels in the images.

Using AWS MediaConvert, the video was transcoded and a set of thumbnails was created from the source videos. Amazon Rekognition custom labels were then used to train and deploy models to detect solar panel damage. AWS IoT Core has been configured to send MQTT messages to a Philips Hue smart bulb for notifications.

The paper presented a serverless architecture on AWS for detecting faulty solar panels in a bank branch.

References

1. Detecting solar panel damage with Amazon Rekognition Custom Labels (стаття) [Електронний Ресурс]. Режим доступу: https://aws.amazon.com/blogs/architecture/detecting-solar-panel-damage-with-amazon-rekognition-custom-labels/
2. Amazon Rekognition (стаття) [Електронний Ресурс]. Режим доступу: https://aws.amazon.com/rekognition/?nc1=h_ls

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