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Aiir Lite – Combustor



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1. Introduction

In collaboration with AI for borescope inspection expert Aiir Innovations, Waygate Technologies' Mentor Visual IQ borescopes now offer the ability to exploit artificial intelligence (AI) technology to provide customers a solution for identification of defects directly on their borescopes.

Via the InspectionWorks ecosystem, analytics can be deployed to the borescopes, placing AI and assisted defect recognition (ADR) at the fingertips of the end-user.

By providing technology that assists with defect detection, inspections become faster, more objective and uptime of the asset is increased.

2. What is the Aiir Lite Analytic?

The Aiir Lite analytic is a standalone still image version of the analytic used by the Aiir Inspection software. The analytic was trained using more than a thousand hours of borescope footage to teach the neural network about areas of interest during inspections.

Once the model is trained, it is deployed for inference to predict indications on new images. The Aiir Lite analytic was optimized to run offline on the Mentor Visual IQ edge device.

The Aiir Lite analytic comes in two variants: Aiir Lite - Combustor, for airfoil surfaces, and Aiir Lite - Combustor, for the hot section. This is the datasheet for Aiir Lite - Combustor.

3. Warnings

Analytic applications are intended to assist the user whilst performing in-situ visual inspections. Results will vary depending on your application. State-of-the-art analytic applications are generally not 100% accurate and this analytic is no different. Do not rely on this analytic to detect all indications.

You, the user, are responsible for following the appropriate procedures and standards whilst undertaking in-situ visual inspections. Aiir Innovations B.V. and Waygate Technologies USA, LP. cannot be held responsible for the accuracy and outcome of any inspection.

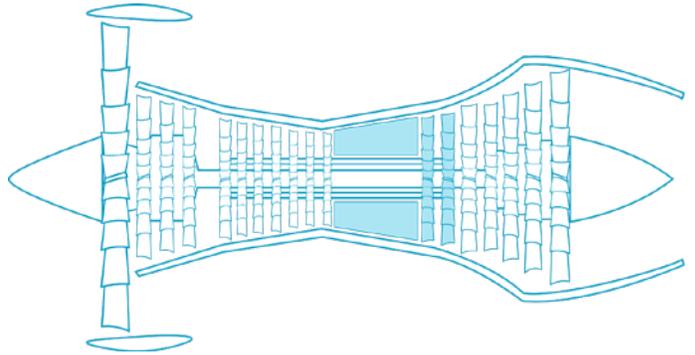
You must review the datasheet for intended use and limitations prior to use.

4. Prescribed usage

This analytic is based on ground truth data originating from a wide variety of clean and dirty turbine engines used in commercial aviation, including but not limited to:

- CF6
- CFM56 5A/B/C
- CFM56 7B
- V2500
- PW 1100
- GEnx
- CF34
- GE90
- LEAP
- PW 2000
- Trent 700
- Trent 1000

The Aiir Lite - Combustor analytic ground truth data is limited to the combustor, and the TBC coated sections of the high pressure turbine and thus does not include the high, intermediate, and low pressure compressor and low, and intermediate pressure turbine. For the latter (excluded) modules use the Aiir Lite - Rotate analytic.



Images were captured from a multitude of incident angles and stand-off distances from the target component during historical borescope inspections in order to enhance analytic robustness.

5. Accuracy metrics

Note: the Aiir Lite analytic only detects defects and does not classify them.

| | Detection in combustor | Detection in high pressure turbine |
|------------------|------------------------|------------------------------------|
| Cracks | Average | Average |
| Missing material | Average | Average |
| Missing TBC | Average | Average |

Definition:

| | Detection rate |
|---------|----------------|
| Strong | 80-95% |
| Average | 60-80% |
| Weak | < 60% |

6. Dependencies

- Only operable on the Mentor Visual iQ (MViQ) Flame (“C” model) borescope.
- MViQ must be operating software version 3.60 or later.
- MViQ handset must be activated with Aiir Lite – Combustor Feature Key (free trial or paid)
- Aiir Lite – Combustor analytic functions when MViQ is in one of the following two states:
 - o Freeze frame or ‘FF’ image
 - o Recalled image (from File Manager)

7. Operating Instructions (3.60 Mentor Visual iQ Release)

7.1 Activating/de-activating the analytic

1. Enter MViQ Global Menu and select ‘Analytics’
2. Review and accept disclaimer
3. ‘Still Analytics’ page is now displayed
Select ‘Aiir Lite – Combustor’ tile to toggle from ‘off’ to ‘on’
4. Press ‘Done’ softkey

Note the appearance of the analytics icon positioned in the status bar. This remains visible when one or more analytic has been activated.

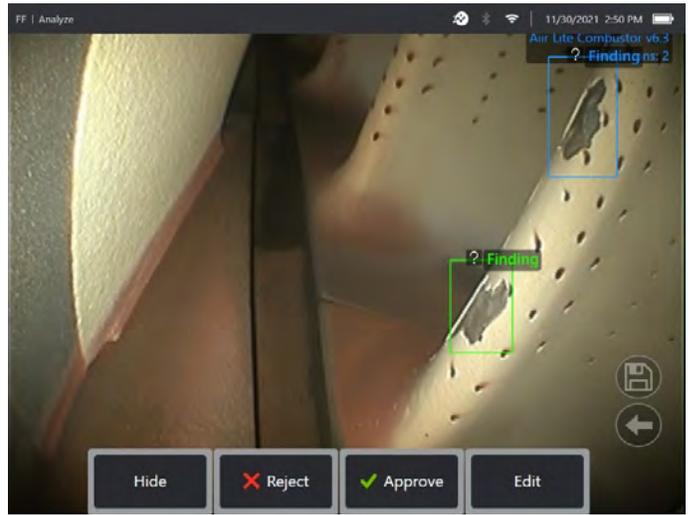
Repeat this procedure to de-activate the analytic albeit tap the tile from ‘on’ to ‘off’ within Step 3.

7.2 Generating Inferences

7.2.1 Freeze Frame Image Function

1. From the live video state, tap the touchscreen or press ‘Enter’ hardkey to activate the Freeze Frame (FF) state. “FF” should now appear in the top left status bar.

Aiir Lite – Combustor analytic will now activate and analyze the image. “Aiir Lite – Combustor v6.3” will now be visible in the top right hand corner of the screen to visually indicate its operation.



Initiate ‘Freeze Frame’ to activate Aiir Lite – Combustor analytic.

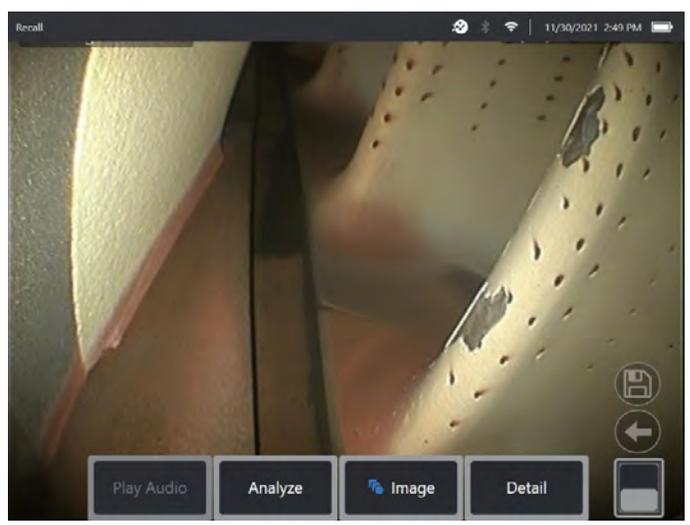
2. Now save image containing inferences or alternatively cycle through the bounding boxes to ‘accept’, ‘reject’ and alter any classification(s) as desired.

Go to section 7.3 for more details.

7.2.2 Recalled image function

1. From the live video state, tap the Global Menu shortcut on the touchscreen or press ‘Menu’ hardkey to display the Global Menu page

Select ‘File Manager’ tile and then the desired image in order to load and display on screen.



2. Tap the softkey page button to present the second row of softkeys. Select ‘Analyze’. softkey in order to process the image for indications.



2. Here we have an example where two bounding boxes are presented on-screen. The user has the choice to accept (indicated as green TICK) or reject (indicated as red CROSS) each one. Once completed, a temporary banner appears declaring "all indications have been reviewed."

3. Now save image containing inferences or alternatively cycle through the bounding boxes to 'accept', 'reject' and alter add classification(s) as desired.

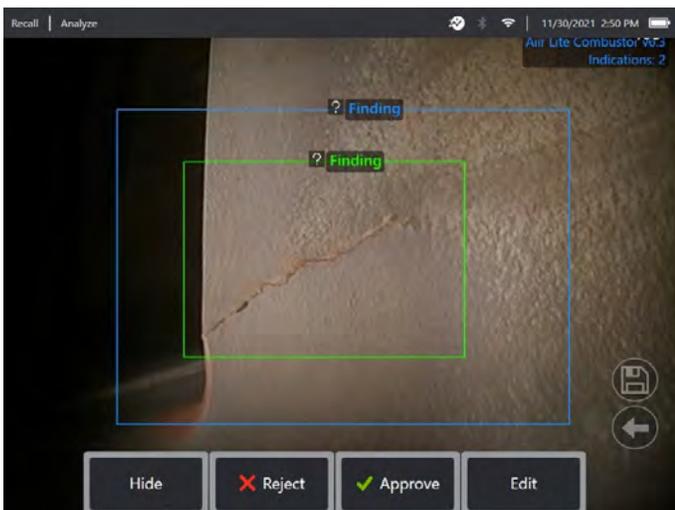
Go to section 7.3 for more details.

7.3 User Functionality

It is possible to interact with all on-screen inferences generated by the Aiir Lite - Combustor analytic.

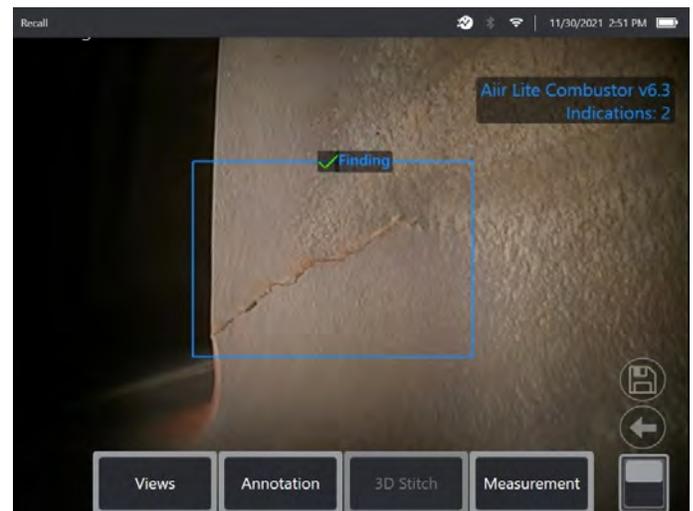
- Hide / Show all inferences
- Accept – to agree and retain inference
- Reject – to disagree and disregard (not delete) inference
- Edit – to add pre-determined defect category
- Hide / Show confidence value

1. Tap or press 'Enter' hardkey to cycle through any or all inferences whilst pressing 'Accept' or 'Reject' softkeys. Selecting 'Edit' also enables user to add pre-determined defect category as required.



3. Once the image is saved and then subsequently recalled, only the accepted bounding box(es) will be immediately visible. This image shows the one bounding box that was 'accepted'. All others remain present but 'hidden' within the file.

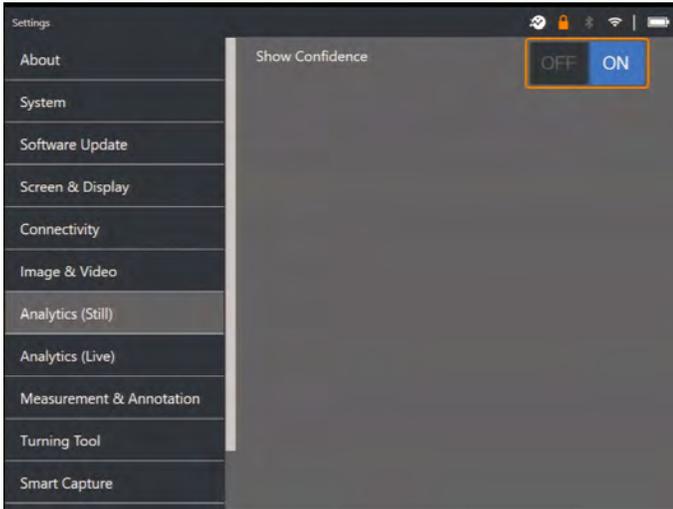
It is possible to adjust, amend or undo these adjustments at anytime once the image has been saved. No data is lost or erased.



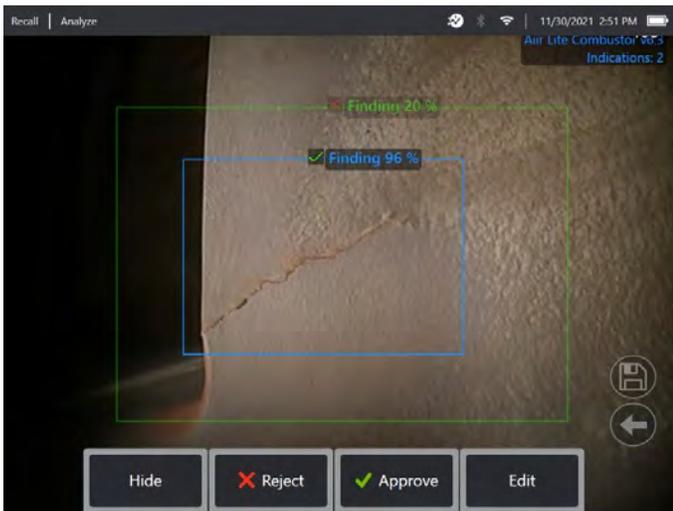
4. Confidence Values provide a percentage indication of the analytics likelihood of how similar the prediction is to the ground truth. 'Off' is the factory default setting.

To show 'Confidence Value' navigate to the 'Settings' menu and select 'Analytics (Still)' as shown below.

Tap the toggle or press 'Enter' hardkey to activate this feature.



Now recall image and select 'Analyze' softkey or activate freeze frame (FF) to generate the inference. All bounding boxes will now be presented with the Confidence Value denoted as a percentage value.



7.4 Review/reanalyze

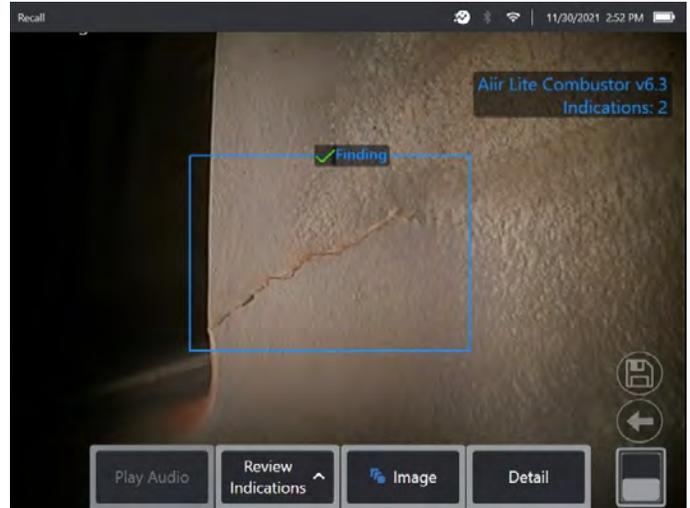
Saved images containing inferences from an analytic can be:

- Reviewed - using saved inferences from original analysis or
- Reanalyzed - using the analytic activated on the handset

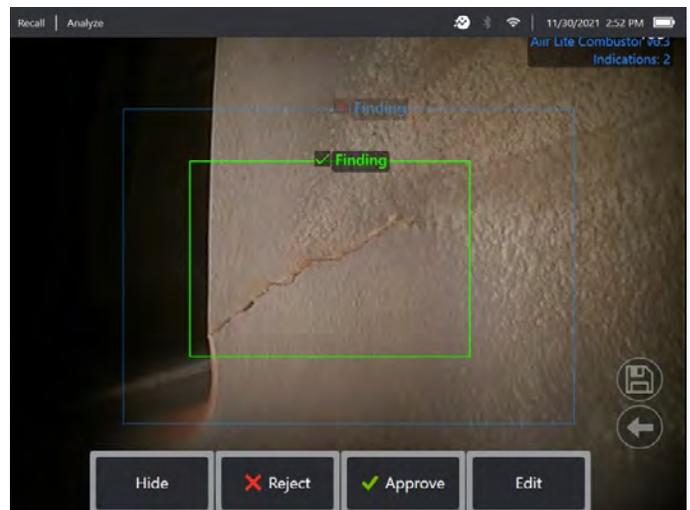
7.4.1 Reviewing saved image(s)

It is possible to review all bounding boxes contained within a saved file using any MViQ Flame handset. The Aiir Lite - Combustor analytic does not need to be activated to enable this feature since all original data is retained within the file.

1. This recalled image is displaying one bounding box although the total number of indications is two.



2. Select 'Review Indications' softkey to present all original indications i.e. making visible any 'Rejected' or unreviewed bounding box(es).



Use this function to check correct assignment of all detected indications using the original data captured within the file.

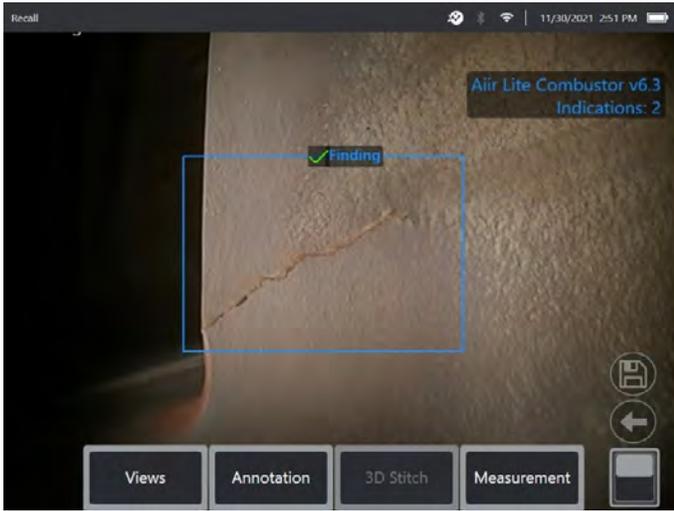
7.4.2 Reanalyzing saved image(s)

It is possible to reanalyze all bounding boxes contained within a saved file.

To enable this function, ensure the Aiir Lite - Combustor analytic is activated (see Section 7.1). This feature enables the current activated analytic to reanalyze the loaded image.

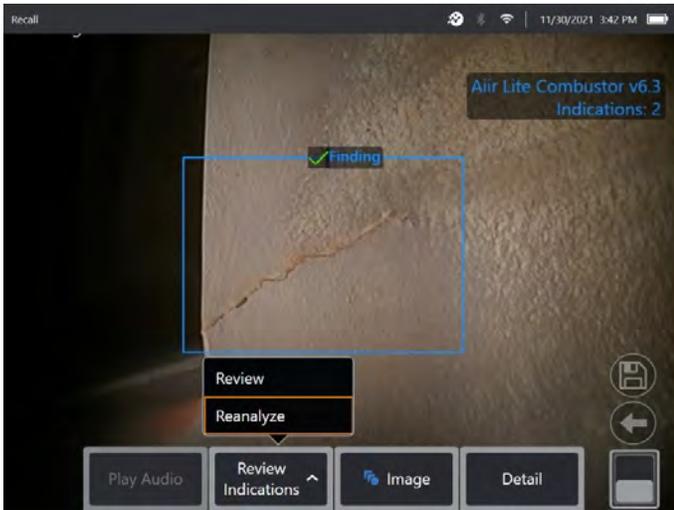
This is applicable if a different analytic version is now in use.

1. This recalled image is displaying one bounding box although the number of indications found is two.



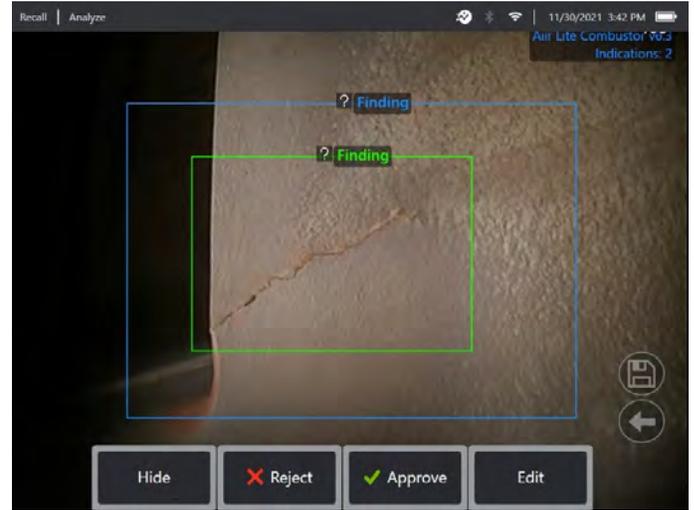
Note that Analytic is activated – icon on status bar is visible.

2. Select 'Review Indications' softkey and then 'Reanalyze.'



3. The handset overwrites any prior assignments e.g. acceptance or rejections and displays the output from the activated analytic.

Note all inferences are now visible and the user is invited to review as appropriate.



8. Technical Support

Technical Support contact information follows:

Global Phone: 1-866-243-2638 (Mon – Fri 8:00 AM – 5PM E.S.T. North America)

Waygate Technologies Remote Service email:
RemoteService@BakerHughes.com

Please also provide the following important details:

- Handset model number
- Handset serial number

9. Revision history

| Revision number | Date issued | Reason |
|-----------------|---------------|----------------|
| 1.0 | December 2021 | Initial launch |

9. Frequently Asked Questions (FAQs)

Q: Who developed Aiir Lite?

A: The Aiir Lite analytic was developed by Aiir Innovations, an Artificial Intelligence company based in Amsterdam. Aiir specializes in the development of intelligent software for the aviation industry. More info at www.aiir.nl.

Q: Does Aiir Lite connect to the Aiir Inspection Cloud?

A: No, Aiir Lite is a stand-alone offline version of the analytic active in the Aiir Inspection Cloud software. More info at www.aiir.nl.

Q: What is a 'still image' ADR analytic?

A: It is a type of Computer Vision model that predicts the presence of, and categorizes the detected indications contained within a 'still' or 'freeze frame' image.

Q: Why should I consider using an ADR analytic?

A: It is a Computer Vision model that predicts the presence of indications contained within a 'still' or 'freeze frame' image. The model was trained on over a thousand hours of video footage derived from a dataset from videoscopes used during actual in-situ inspections.

Q: Which engine components is it designed to operate on?

A: Combustor dome and high pressure turbine systems of gas turbine engines used in commercial aviation, including but not limited to CF6, CFM56 and V2500. See section 4 for the full list.

Q: How was this ADR analytic validated?

A: Aiir Innovations has validated this analytic on thousands of images from borescope inspections. This analytic has not been formally validated by engine OEMs.

Q: How accurate is this ADR analytic?

A: See section 5

Q: What does the confidence value indicate or infer?

A: This index provides an indication of how similar the prediction is to the ground truth the analytic was trained on. It indicates the likelihood of a correct prediction but is not the probability of correct predictions.

Q: Which tips or Optical Tip Adapters (OTA's) are needed for this ADR analytic to function?

A: The analytic is not currently dependent on tips or Optical Tip Adapters.

Q: Will this ADR analytic work for all MViQ probe diameter options? I.e. 4mm, 6mm and 8mm

A: Yes.

Q: What type of indications is it designed to detect?

A: Cracks, Missing TBC and Missing material (includes burned through material). See section 5.

Q: Will it measure indications?

A: No, this analytic does not have measurement capability. However, Real3D measurement technology can be used to measure indications that have been found by the analytic.

Q: Will this ADR analytic work on the MViQ 'Grey' handset?

A: No.

Q: Can I use this ADR analytic whilst inspecting other gas turbine variants?

A: Yes. Waygate Technologies is unable to guarantee its performance or even applicability to other Gas Turbine variants.

Q: Does the MViQ need to be digitally connected in some way e.g. to the Internet, in order to work?

A: No. The analytic operates entirely standalone within the device.

Q: Can I use the ADR analytic post-inspection on the MViQ device?

A: Yes. This ADR analytic can operate on recalled images within the MViQ 'Flame' handset. Such images can be: those that have either been previously processed using this analytic; or raw/unprocessed images. Inferences can be generated and subsequently saved for presentation or inclusion into the inspection report.

Q: Can this ADR analytic be accessed and operated from within Waygate Technologies Inspection Manager software?

A: No, but this functionality is planned within a future release.

Q: Do Analytics operate in conjunction with other Mentor Visual IQ features?

A: Image storage – Analytic results are stored in the still image file. This information is normally hidden when viewing jpg images on a standard consumer device like a laptop or phone. However when viewed on the MViQ

A: MDI – Analytics can be "prescribed" by an MDI template. At the time of writing, the MDI builder tool is not able to add analytics to an MDI template in a graphical fashion. The MDI template must be edited for you by Waygate Technologies. Please contact Waygate Technologies support for further information.

11. Glossary

| | |
|-------------------------------------|---|
| AI (Artificial Intelligence) | The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages |
| Analytic | A mathematical model based on computer vision logic designed to create an inference or output |
| Characterization | The ability to add or label images with data enabling analytics to generate inferences |
| Gas-washed surfaces | Surfaces within the gas turbine directly exposed to air used to generate propulsion or thrust |
| Ground truth | Characterized data used to train the analytic |
| Inference | The displayed output of an analytic |
| Bounding box | The area highlighting the presence of an indication |

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