GE Fanuc
Intelligent Platforms

Video Trackers and Target Detection

GE Fanuc Intelligent Platform's ADEPT video tracker family has been developed to provide the highest performance solutions in the smallest, fully environmentally proved hardware packages. The majority of customer requirements can be met by the application of standard 'off the shelf' products that have been designed to satisfy the majority of interface and performance requirements without the need for modification.

The key features of the Adept video tracker range include:

- Easily adapted to meet a wide range of applications.
- Range of proven algorithms which can be tailored for the application.
- Single PEC configurations.
- Wide range of hardware formats - Conduction or convection cooled
- Multiple interfaces – VME, PCI, VPX, parallel/serial digital and analog video, multiple serial links.
- High level of technical support to ensure ease of integration with customer systems.

Detection

Preprocessors

The action of the image enhancement pre-processor is to increase the target intensity and decrease the background intensity.

There are three categories of pre-processor:

- Positive Contrast - enhance positive contrasts (White Hot)
- Negative Contrast - enhance negative contrasts (Black Hot)
- Bipolar - enhance either positive of negative contrasts

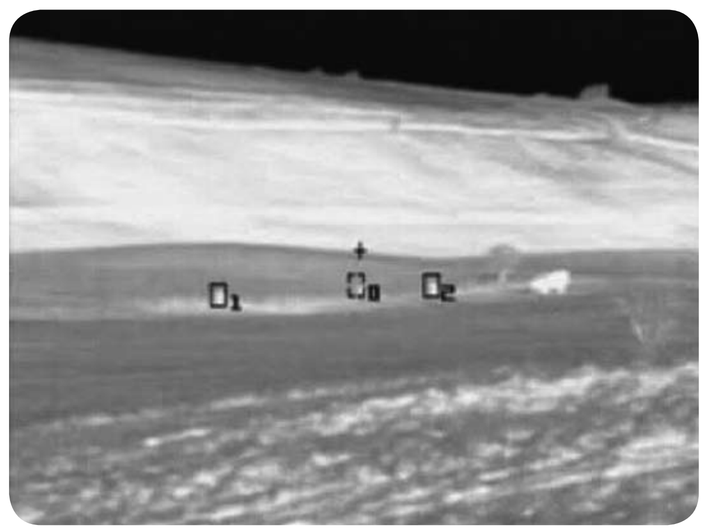
The following pre-processors are available:

- Grey pre-processor - Performs no enhancement and is used with correlation algorithms.
- Statistical pre-processor - Enhances targets with both positive and negative components
- White-Hot pre-processor - Enhances positive contrast targets
- Black-Hot pre-processor - Enhances negative contrast targets

Moving Target Detection

The Moving Target Detection (MTD) acquisition algorithm extracts objects from the scene which are moving independently in relation to the background. This is achieved by tracking the background motion using a SceneLock process and aligning the background with a reference image. Any differences between the reference image and the current aligned image are assumed to be moving targets. The MTD algorithm has a variable sensitivity setting. A high sensitivity setting will allow slow, low contrast targets to be detected, but may also produce many false alarms. Lower sensitivity settings will reduce the frequency of false alarms, but will potentially miss detections of low contrast or slow moving targets.

The MTD algorithm requires a structured scene to allow the SceneLock process to track the background motion. The detection process can be configured to detect only targets of a certain size, traveling at a certain speed, or only targets that have moved by a particular distance. The MTD process is not currently implemented as a tracking algorithm. It is recommended that when MTD is used to acquire a target, the phase correlator is used for tracking.

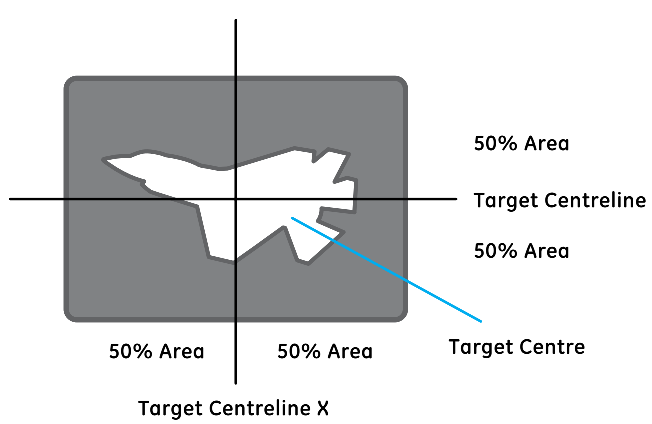


Tracking

This section provides a description of the range of functions, which GE Fanuc Intelligent Platforms can apply to the real time processing of video images.

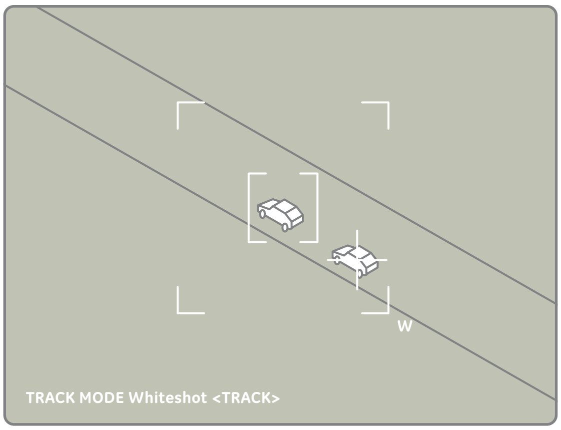
Centroid Track

Centroid tracking is used for tracking bounded objects such as an aircraft, which can be fully contained within the track window. Centroid tracking normally uses either the Centroid or MTT algorithms in Target Acquisition mode since both these algorithms initialize the track window position and size to enclose a target on entry to Autotrack mode. MTT will generally give better results since it is capable of designating a single object in the presence of other clutter. Centroid will give a better result when the target is fragmented.



MTT (Multiple Target Track)

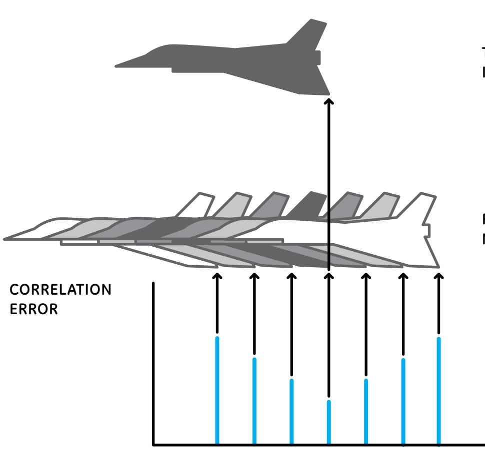
MTT is used for tracking bounded objects such as aircraft or ground vehicles that are fully contained within the track window. The MTT gives good performance with small targets in high clutter.



Correlation

Correlation can be used for tracking many types of object but is most effective when tracking unbounded targets that have low dynamics. Typically this would be objects at close range which extend outside of the sensor field of view such as a large ship.

Correlation tracking normally also uses the Correlation algorithm in Target Acquisition mode. In this case the track window is initialized to the acquisition window position and size on entry to Autotrack mode. Therefore in this mode it is important that the acquisition window is sized so that the target area fills the whole window. It is possible to re-size the window during Autotrack mode and this is often advisable as the target range changes.



Correlation tracking can also use the other tracking algorithms (Centroid, MTT and Edge) in Target Acquisition mode. In this case the track window is initialized to a specific point (Target centre or target edge) on the target on entry to Autotrack mode.

Phase Correlation

The phase correlation algorithm is a general purpose algorithm that can be used for tracking both un-bounded objects and bounded moving objects within the image. The algorithm can give good results when tracking bounded moving targets in high clutter such as tracking ground vehicles from an airborne platform.

Phase Correlation tracking can use any of the track algorithms (Centroid, Correlation, MTT and Edge) in Target Acquisition mode. In this case the track window is initialised to either window centre, target centre or target edge on entry to Autotrack mode depending on the selected algorithm in acquisition mode.

Combined

Combined tracking normally uses either the Centroid or MTT algorithms in Target Acquisition mode since both these algorithms initialize the track window position and size to enclose a target on entry to Autotrack mode. MTT will generally give better results since it is capable of designating a single object in the presence of other clutter. Centroid will give a better result when the target is fragmented.

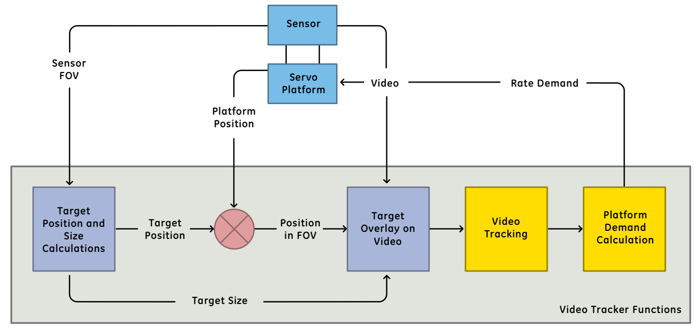
SceneLock

The SceneLock algorithm tracks a number of points in the scene and then combines the motion estimates of each point to estimate the overall scene motion. The allocation and selection of tracking points in the scene occurs automatically. When existing tracking points move outside of the field of view, new tracking points are automatically identified and assigned. The aim point is initialized to the point in the scene, which is located at the boresight when tracking is initiated. The SceneLock then continues to track and report the position of this point in the scene. The symbology uses a cross to indicate the SceneLock aimpoint

Video Trackers and Target Detectors

Synthetic Targets

The Automatic Video Tracker (AVT) has the ability to overlay the image of two targets on the incoming targets on the incoming video image. The position of the targets is governed by internally calculated target trajectories and the pointing angle of the video sensor. The overlaid video is subsequently used as an input into the Tracking function of the AVT. The AVT can then be commanded to track one of the overlaid target images. The rate demand output by the AVT platform filters completes the closed loop tracking of the overlaid target.



The functional blocks required to allow test target generation are shown above, the grey boxes indicate functionality that has been added to the AVT for this purpose.

Synthetic target has the ability to be driven by real time user inputs as an alternative option to internal trajectories. The Synthetic Test Target function can be used to:

- Demonstrate and test the closed loop performance of the video tracking system;
- Provide inexpensive, highly realistic operator training;
- Validate operational equipment configurations, i.e. target range, attitude and sensor Field of View (FOV).

Systems Integration

GE Fanuc Intelligent Platforms understands the value of effective systems integration. All ADEPT trackers feature a wide range of video and data interfaces offering total flexibility for systems integration. Video inputs can be analog, parallel digital or a range of serial digital formats.
Error outputs, operator interface and command instructions can all be accommodated as:

- Serial links
- VME, PCI, VPX bus
- Analog signals

Trackers have compensation for:

- Platform dynamics
- Sensor optics
- System configuration

Tracker 'set-up' is accomplished by Windows'-based software running on a PC.

Image Processing

Video imagery contains a lot of information but this information is frequently masked by environmental or other effects. GE Fanuc Intelligent Platforms creates a range of image processing modules designed to extract the maximum amount of information from the raw video data and present it to the end user in a clear and understandable manner.

Standard functions include

- Image Fusion
- Image Stabilization
- Image Mosaicing
- Image Enhancement
- Image Matching

Fusion

Introduction

Many modern weapon sights and surveillance systems contain sensors using different spectral bands, such as image intensifiers, thermal imagers, MMW radar or standard visible band color cameras. Typically these systems only have a single display, so the viewer must choose which image to concentrate on, or must cycle through the different sensor outputs. Image fusion is a technique which allows us to combine complementary information from each sensor into a single, superior image which displayed to the operator.

Teamwork

GE Fanuc Intelligent Platforms has teamed with Waterfall Solutions to produce a flexible and robust real-time image fusion system. The system builds on Waterfall's experience in adaptive image fusion and related image processing and combines this expertise with GE Fanuc Intelligent Platforms' long track record of implementing real-time, rugged, image processing systems.

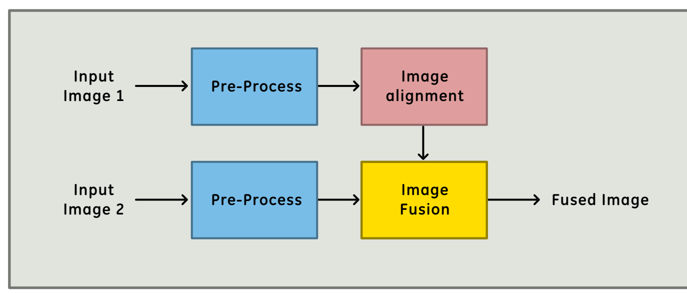
Fusion Schemes

A number of image fusion schemes are possible, including:

- Combining different imagers through different color channels
- Linear Weighting of intensities
- Adaptive multi-resolution image fusion

Pre-processing and Image Alignment

Before two images are fused, it is important that they are pre-processed in order to reduce noise or unwanted artifacts and in many cases to enhance image contrast. All image fusion schemes rely on features within each image being aligned to the same pixel position. If the sensors to be fused are not perfectly aligned, any corrections to the alignment can be made through a low-latency image warp function. An example of image fusion is illustrated below.



Stabilization

Many surveillance and targeting systems with narrow fields of view often suffer from vibrations that can lead to unstable imagery being presented to the operator. The ADEPT60 Rugged Image Stabilization System (RISS) remove unwanted global motion from a video stream. The image motion is measured using our latest SceneLock algorithms, which are capable of detecting rotations, scaling and translations.

The measured motion can then be filtered to remove unwanted high frequency jitter, and true pans and zooms can be passed through if required. The unwanted motion is removed using our image warping PMC, providing a low latency, highly accurate warped video stream. The stabilization process is robust to small independently moving objects within the scene.

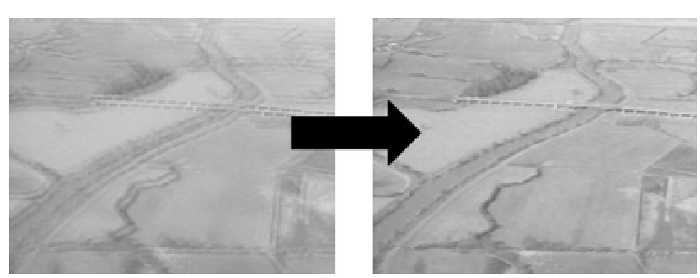


Image Mosaic

Mosaic

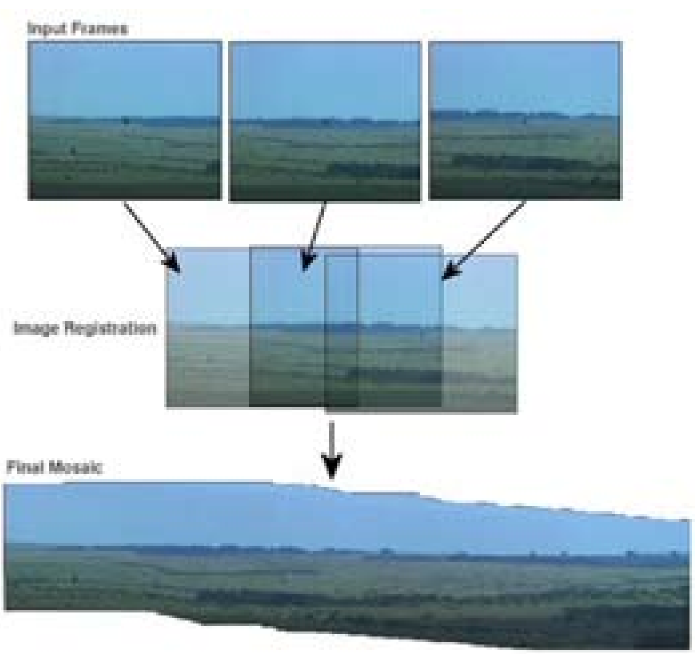
With a single sensor, there is a necessary trade-off between resolution and field of view. Higher resolution images are usually desired because they provide more information, but the use of high magnification optics results in a narrow field of view and loss of context and situational awareness.
A mosaic image, digitally generated from many individual overlapping high-resolution images, can simultaneously provide both very wide field of view and maintain full sensor resolution.

Mosaic Formation Process

A digital mosaic is formed by seamlessly joining multiple images from a single sensor into a larger image. In order to do this, a number of sophisticated and highly optimized algorithms are required, especially for smooth video rate operation.

The core of the mosaic formation process is an image registration engine that must be able to intelligently cope with sensor noise, variable image content, large displacements, rotations and other image deformations, as well as independent moving targets.

Once the relative displacements between two images are known, they must then be warped into alignment and any changes in sensor gain, offset, or color must be corrected. Finally, the overlapping images must be blended together, taking care over any moving targets, to form the mosaic. The process is then repeated for every new video frame, which represents a considerable amount of image manipulation. The mosaic formation process is illustrated below.



The mosaic formation process digitally registers and blends images into a single larger image. This results in a wide field of view whilst maintaining high resolution.

Technology

Due to its demanding nature, Mosaic formation is often performed off-line after all the images are collected and optimizes the global registration of all the available images simultaneously. However, we construct the mosaic in real-time, employing a sequential registration approach, whereby each new image is added to the mosaic as it becomes available.

Scenelock, our real-time scene tracking module, runs continuously as a background task that reports the global scene motion and provides first-guess registration parameters, even when the motion is fast. The registration is then refined as the image is blended into the mosaic, resulting in very high quality, seamless mosaic.

Enhancement

Image enhancement features include:

- Electronic enlargement.
- Freeze frame and digital recording.
- Image enhancement including:
- Frame to frame integration
- Contrast enhancement
- Edge enhancement
- High and low pass filters
- Electronic Image stabilization

Matching

Automatic Image Matching (AIM) is an image processing technique that allows images taken from different sensors at different times to be aligned. It would allow, for example, matching of an infrared image taken from the payload of a Unmanned Aerial Vehicle (UAV) to a visible band satellite image. This could assist the UAV in terms of navigation or target detection.

For example, the left hand image below shows a thermal image extracted from an airborne platform. Given the position and orientation of the imager, it is possible to approximately match the viewpoint of the imager by warping a geo-referenced photo of the area, as shown by the warped aerial photo on the right.

The AIM process can now be used to determine a more accurate alignment of the images, or to match the input imagery with a predetermined target.

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Additional Resources

For more information, please visit the GE Fanuc Intelligent Platforms web site at:

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