Seek Thermal AGC

Application Note

The Seek Thermal image processing pipeline thermal data, or pixel intensity, is maintained in a 16-bit number space. For that data to display to a screen the input data is first transformed to an 8-bit number space and then run through an 8-bit input ColorLUT (often outputting to a standard 32-bit ARGB ready for display rending). The transformation of 16-bit data to 8-bit data is done using an Automatic Gain Control (AGC) algorithm. This document details how Seek Thermal's AGC settings can be tuned in Seek Thermal devices for various thermal scenes.

AGC Modes

AGC is applied near the end of the image process including colorization, various transformations (zoom, rotate, mirror), and image overlay. Histogram Equalization (HistEQ) is *non-linear* AGC algorithm in the Seek Thermal SDK, while Linear Min/Max is a *linear* AGC algorithm.

Note: HistEQ is a non-linear transformation, meaning that pixel intensity (and therefore color) will no longer correlate to temperature. For applications that need to maintain a relationship between pixel intensity and temperature, a linear AGC algorithm must be used.

Figure 1 - Linear Min/Max

Figure 2 - Histogram Equalization

The figures above depict the same scene. Figure 1 is displayed using Linear Min/Max and Figure 2 is displayed using HistEQ. In the scene there is a table with a stapler, a hot coffee cup, a cold bottle of water, and a person in the background. Notice in the Linear Min/Max image that the color information clearly shows that the coffee is a lot hotter than the person. In the HistEQ image, the content of the table and background are enhanced. The Seek Thermal SDK allows you to select between three AGC algorithms: Legacy HistEQ, Linear Min/Max, and HistEQ

Note: Pay special attention to the color of the cup of coffee as its temperature information is lost since the person is colored using the same "hot" colors (white).

(Legacy) HistEQ

This algorithm is available to support legacy customers but should not be used in modern applications.

Linear Min/Max

The algorithm makes a linear transform AGC which results in the 8-bit output values equally being distributed across the content of the input 16-bit data. A histogram of the input data is created, and the 8-bit values are equally and linear distributed across the main content of the scene. This is the only AGC algorithm that will maintain a relationship between pixel intensity and temperature.

HistEQ

The HistEQ algorithm is a type of AGC that creates an image suitable for dynamic scenes that are displayed by optimizing contrast and dynamic range. This implementation of histogram equalization includes configuration parameters and includes default settings that are optimized to produce the best images for a large set of standard scenes.

Note: The defaults are a good starting point; however, customers are encouraged to tune parameters to their specific application (such as indoor monitoring, automotive, or hunting).

AgcMode

SDK Setting: *SETTING_AGC_MODE*
Type: uint32_t
Unit: 0=Legacy HistEQ, 1=Linear Min/Max, 2=HistEQ *(Default: 2)*

HistEQ Settings

The following settings control the creation of the histogram, transfer function, and resultant output image. The default parameters are suitable for a large range of scenes, but better results may be achieved if the parameters are tuned for a specific application.

PlateauValue

SDK Setting: *SETTING_HISTEQ_PLATEAU_VALUE*
Type: float (32-bit)
Unit: Percentage
Range: 0.0 – 1.0 *(Default: 0.05, representing 5%)*

PlateauValue limits the percentage of pixels that can be in a single histogram bin. This is necessary when a large area of the scene, such as the sky, is very uniform and should be assigned a small number of colors. The default value of 0.05 (5 %) means that a maximum of 5 % of the total number of pixels can be assigned to a single bin; bins are limited to this amount and any pixels outside are not re-distributed in the histogram. In Figures 3 and 4 below adjusting the plateau value brings out different details in the scene. Figure 3 shows more details in the stapler and water cup, but also give the overall image a grainier appearance.

Figure 3 – High Contrast with High Plateau Value

Figure 4 – High Contrast with low Plateau Value

Gain

When using Seek Thermal's AGC, the 'gain' portion essentially controls the maximum number of output values that may be assigned for each count of input data. Typically, gain is limited so that intense and concentrated data resulting in histogram peaks do not use up an extraordinary amount of output count values; reducing the contrast of in the rest of the image. For example, assigning too many colors to a low contrast scene would only increase noise. Conversely, a scene with a lot of content that is gain-limited may appear very washed out. Seek allows its users to finely adjust gain using a variety of settings explained in this section.

Figure 4 – Gain, GainLimit and GainLimitFactor

Gain Control is broken into two pieces: *GainLimit* and *GainLimitFactor*. *GainLimit* is a single setting that controls the maximum gain (slope) of output values per count. *GainLimitFactor* adds additional flexibility in automatically reducing gain as a function of the histogram width. This additional control allows the user to tune the *GainLimit* value for a given application, and then allow the algorithm to reduce gain as the scene content decreases.

GainLimit

SDK Setting: *SETTING_HISTEQ_GAIN_LIMIT*
Type: float (32-bit)
Unit: Output values/count
Range: 0.0 – 256.0 *(Default: 0.45)*

GainLimit limits the amount of output bits assigned to a single bin. The unit is in terms of the number of output values per sensor count. The default value of 0.45 means that no more than 0.45 of the available 256 output values may be assigned to a single sensor count. 4096 bins by default resulting in a bin width of 16 counts (2^{16} / 4096), which is equivalent to 7.2 (0.45 * 16) output values that may be assigned to a single bin.

While this parameter may be difficult to understand, it plays a critical role in how output values (and color) may be distributed across a scene. The examples below show how GainLimit effects a “dull” or low-contrast scene. The optimal setting for this scene would likely be a *GainLimit* setting slightly higher than Figure 6.

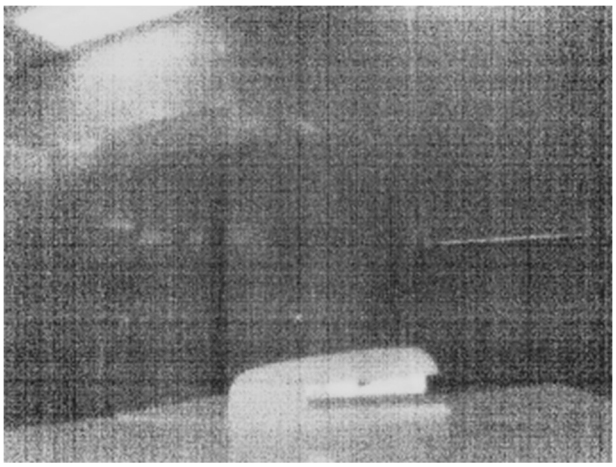

Figure 5 – High Gain Limit in Low Contrast Scene

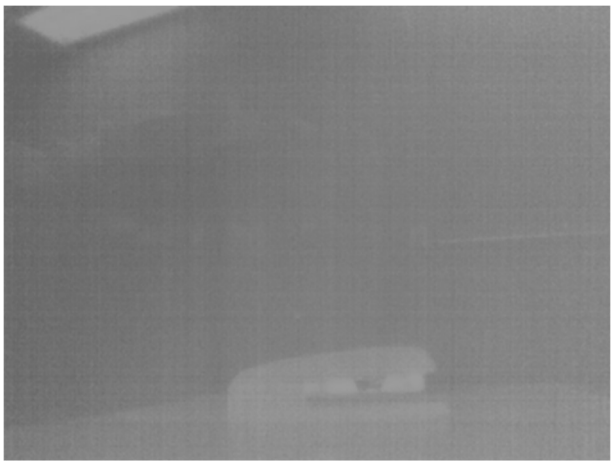

Figure 6 – Low Gain Limit in Low Contrast Scene

Figure 7 and Figure 8 show the difference between low and high *GainLimit* settings in a high-contrast scene. Note that Figure 8 appears somewhat washed out, while in Figure 7 the background wall and light have more contrast.

Figure 7 – High Gain Limit in High Contrast Scene

Figure 8 – Low Gain Limit in High Contrast Scene

Gain Limit Factor

The *GainLimitFactor* is a setting to alter the transfer function gain for particularly low-contrast scenes where noise may adversely affect the image. *GainLimitFactor* is controlled through a set of four control settings. In addition to those control settings, there are a handful of read-only settings that are useful when tuning *GainLimit* and *GainLimitFactor*.

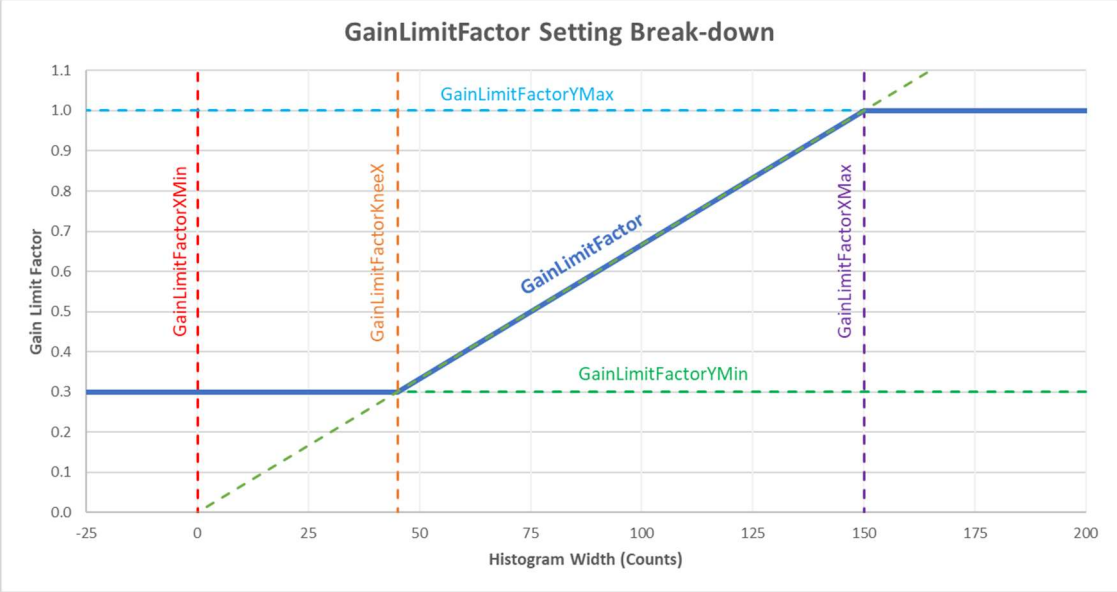

Figure 9 - GainLimitFactor Parameters

Typically, low-contrast scenes, such as a wall or empty sky, are relatively uniform and would be assigned too many output values resulting in a very noisy image. In this case, when a scene has very little content, it results in a narrow histogram. The *GainLimitFactor* collection of settings will smoothly reduce gain, thus reducing the number of output values used. This helps to make low-contrast scenes appear flat while maintaining the flexibility of having the *GainLimit* parameter set to a higher value to maintain higher contrast in non-flat scenes.

GainLimitFactorEnable

SDK Setting: *SETTING_HISTEQ_GAIN_LIMIT_FACTOR_ENABLE*
Type: uint32_t
Unit: Logical Boolean
Range: 0 (disable) or 1 (enable) *(Default: 1)*

When *GainLimitFactor* is enabled, the *GainLimit* value is multiplied by the *GainLimitFactor* to calculate the actual gain value used. When disabled, the *GainLimit* value is unaltered and used as-is for HistEQ gain.

GainLimitFactor (Read-Only)

SDK Setting: *SETTING_HISTEQ_GAIN_LIMIT_FACTOR*
Type: float (32-bit)
Unit: Percent
Range: 0.0 – 1.0 (0 – 100 %)

The *GainLimitFactor* is the value multiplied by *GainLimit* to calculate the maximum gain allowed when creating the histogram transfer function. This value can be used to determine if *GainLimitFactor* is enabled and affecting the gain.

GainLimitFactorXMax

SDK Setting: *SETTING_HISTEQ_GAIN_LIMIT_FACTOR_XMAX*
Type: uint32_t
Unit: Counts
Range: 0 – 65535 *(Default: 150)*

The *GainLimitFactorXMax* setting sets the width of the histogram where the *GainLimitFactor* will begin to kick in. The default value of 150 counts means that for scenes where the histogram content is all contained within 150 counts or less, *GainLimit* will be scaled down. The amount of scaling is proportional to the width of the histogram such that a histogram width of *GainLimitFactorXMax* (150 by default) or higher will result in no scaling, and a histogram width of anything below *GainLimitFactorKneeX* would result in a *GainLimitFactor* of *GainLimitFactorYMin* (0.3 by default).

GainLimitFactorYMin

SDK Setting: *SETTING_HISTEQ_GAIN_LIMIT_FACTOR_YMIN*
Type: float (32-bit)
Unit: Percent
Range: 0.0 – 1.0 *(Default: 0.3, representing 30%)*

The *GainLimitFactorYMin* is the minimum value for *GainLimitFactor*.

Alpha Time

SDK Setting: *SETTING_HISTEQ_ALPHA_TIME*
Type: float (32-bit)
Unit: Seconds
Range: 0.0 – 6.0 *(Default: 0.33333)*

When scene content rapidly changes, the HistEQ output can flash and distract the user. The *Alpha Time* parameter fixes this problem by blending the current frame histogram with the previous frame's histogram. The parameter controls the length of one time-constant, where three time-constants typically result in the new scene being completely blended in.

Trim

SDK Setting: *SETTING_HISTEQ_TIRM_LEFT* and *SETTING_HISTEQ_TIRM_LEFT*
Type: float (32-bit)
Unit: Percent
Range: 0.0 – 0.49 *(Default: 0.001, representing 0.1%)*

These parameters can be used to remove outliers of the input scene. The default of 0.1 % (for both left and right) trims the left 0.1 % and right 0.1 % of the scene histogram and leaves the remaining 99.8 % of image content to feed HistEQ. This parameter helps prevent situations where a small number of outlying pixels are affecting the scene's contrast.

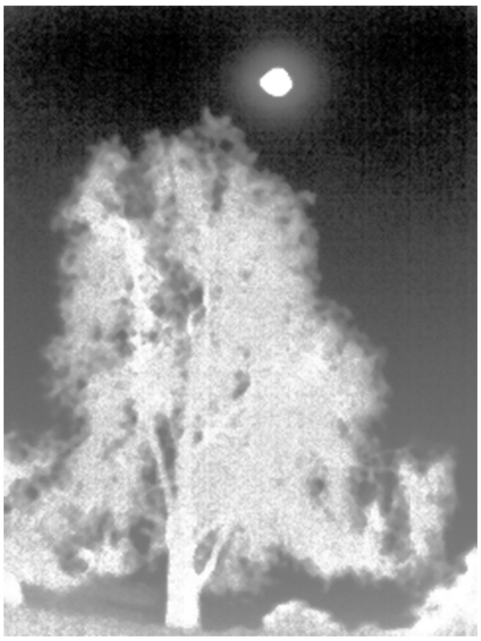

Figure 10 – Default Trim

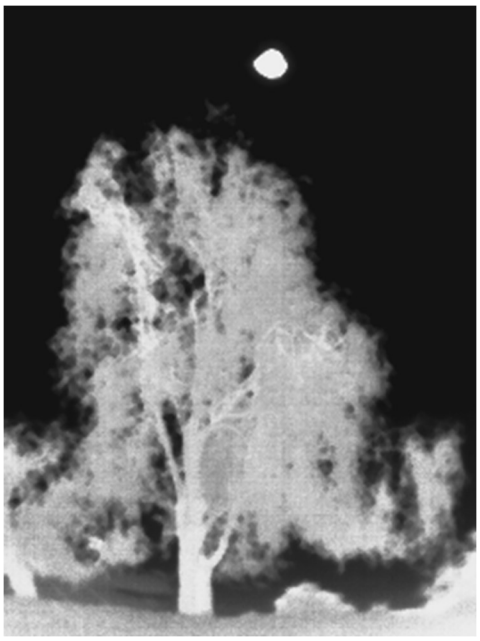

Figure 11 – 40% Left Trim with Black Sky

Linear Min/Max

Linear AGC is useful when it is important that colder scene content remain lower-valued than hotter scene content. The Linear AGC can operate in a few various modes. In Auto mode, the minimum and maximum values of the scene content are found, then the 256 output values are evenly stretched between those bounding values. In Manual mode, the minimum and maximum values are user-specified in terms of counts and the 256 output values are evenly stretched between those bounding values. The minimums and/or maximums may be user-specified, creating a hybrid mode where one setting can be manual and the other automatic.

Parameters

Linear Mode

SDK Setting: *SETTING_LINMINMAX_MODE*
Type: uint32_t
Range: 0 - Auto, 1 - Manual: Min and Max Locked, 2 - Min Locked, Max is Auto, 3 - Max Locked, Min is Auto *(Default: 0)*

The "Auto" value for the minimum and maximum are always determined from the lowest/highest scene values. Those values may be optionally locked to user-specified bounds.

Min & Max Lock Values

SDK Setting: *SETTING_LINMINMAX_MIN_LOCK and SETTING_LINMINMAX_MAX_LOCK*
Type: uint32_t
Unit: Counts
Range: 0 – 10000 *(MIN_LOCK Default: 4500) (MAX_LOCK Default: 6000)*

The lower and upper bounds of the Linear AGC. This value is not used with AgcMode = 0 (Auto) and AgcMode = 3 (Max Locked, Min is Auto).

Active Min & Max Values (Read-Only)

SDK Setting: *SETTING_LINMINMAX_ACTVIE_MIN_VALUE and SETTING_LINMINMAX_ACTVIE_MAX_VALUE*
Type: uint32_t
Unit: Counts

Returns the minimum and maximum count values in the last scene, which can be useful for characterizing and tuning.