Keysight Technologies
Using Fine Resolution to Improve Thermal Images

Application Note

Introduction

Digital imaging opened up new possibilities and has been very much part of our lives since social media use became commonplace. With digital imaging, images can be stored, duplicated, and shared digitally almost without any boundary. However, digital imaging is still a discreet system – what you can see really depends on how much resolution your digital imaging system has. However, technology advancement of a digital imaging system has come a long way and is very affordable today. On the contrary, the price of a thermal imaging system increases significantly with the detector's resolution.

The technology used to enhance the resolution of a digital image is known as super resolution. Over the course of digital imaging system development, many different techniques of super resolution have been developed; each with its advantages and disadvantages. A thermal imaging system assimilates the resolution enhancement technology used in digital imaging system to improve on its resolution. Keysight Technologies',Inc. True***IR*** thermal imager uses a specific multi-frames super resolution technique and algorithms that is known as Fine Resolution (FR), which enhances the resolution of a thermal image by four times. In this paper, we are going to discuss the high level concept of this technology.

Resolution versus cost

Instantaneous Field of View (iFOV), also known as spatial resolution, defines the smallest detail within the Field of View (FOV) that a thermal imager can detect. To measure temperature correctly the target object must be larger than the physical iFOV of the thermal imager. Depending on the distance to the object, each pixel of a thermal imager detector measures the average temperature of the area within the physical iFOV. High resolution is particularly useful when inspecting large objects (building wall, roof), objects at a distance (sub-stations, large machineries) and small objects (electronic printed circuit board assemblies (PCBA)).

A thermal imager with higher resolution provides the ability to see more details of the measured object, and get a clearer infrared (IR) image, hence making measurements more accurate. Since the cost of a thermal imager increases as resolution increases, the available budget often dictates the selection of the thermal imager solution. For example, the price of a 320 x 240 pixels thermal imager could very well be double the price of a thermal imager with 160 x 120 pixels.

Fine resolution solution

There are fundamental limitations of digital imaging systems. Given that thermal imaging systems leverage digital imaging technology, those digital imaging limitations also exist in thermal imaging systems. The discrete nature of detector arrays and finite number of pixels limit the detectable area. Hence there is some missing information on digital images. The optical system (lens) contributes to the fuzziness of digital images. This is more apparent in thermal imaging systems due to their relatively low resolution.

Fine Resolution used in the True*IR* thermal imager offers the capability to improve the effective thermal resolution four-fold and provides 1.5x better instantaneous Field of View (iFOV). This is achieved using complex algorithms on a lower resolution detector. Coupled with a powerful digital image processor, the complex algorithms can be processed without any system lag. Overall, Fine Resolution improves the effective image quality and measurement accuracy without adding much cost to overall thermal imaging system.

How fine resolution works

Figure 1 is a simplified model of the Fine Resolution processes. Each step of the processes is designed to handle different tasks. Multi-frame acquisition provides the images or data for processing at the next level. Super-positioning analyzes and merges all of the data together to prepare for reconstruction, where final touches are made to ensure a clear and sharp image is produced – a thermal image with four times more effective resolution.

Multi-frame acquisition

Looking at the process in more detail, multi-frame acquisition involves the continuous capture of multiple IR frames of images of the same scene. It also assumes that each frame will be slightly shifted due to natural hand movement of the person operating the imager. Each of the slightly shifted frames has slightly different thermal information which is extracted through subsequent processes.

During multi-frame acquisition process, all of the frames are expanded or up-scaled to higher resolution images (for example, from 160 x 120 pixels to 320 x 240 pixels) using a simpler interpolation technique. Interpolation is a technique to expand the image pixels by predicting new sub-pixels using data from adjacent pixels captured through the low resolution detector. The technique is very similar to a curve fitting mathematic function. The new pixels are predictive values instead of measured values.

The interpolation process is fast, hence, the high resolution interpolated images are real time. Instead of showing the real time low resolution image on the display, the interpolated high resolution images are displayed on the LCD, which serves as a view finder for the thermal image, just like a digital camera.

Figure 1. Fine Resolution model

Super-position

Since each of the frames captured are slightly shifted in position, simply overlapping the frames together does not work. The super-positioning process starts by identifying a set of common feature points on each of the frames. These feature points form a register map that represents common identities of all the frames. The frames are then positioned and aligned according to the register map before being superimposed together to form a higher resolution image. Figure 2 illustrates the super-positioning process.

Reconstruction

Reconstruction is needed to enhance and sharpen the thermal image. There are many mathematical models and image processing techniques being used, such as using an averaging algorithm for noise reduction and an edge enhancement algorithm for image sharpening.

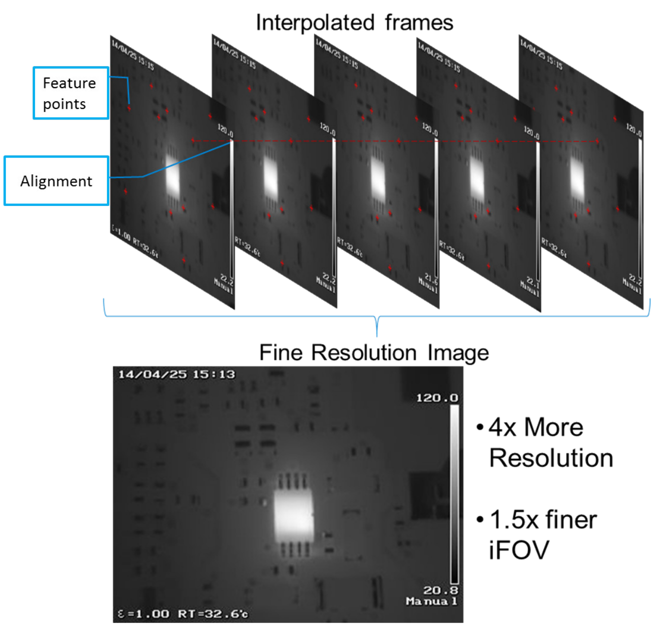

Figure 2. Super-positioning

What it means

The imaging result of Fine Resolution can be proven through lab testing. The simplest form of testing is to measure the temperature of a slim 1-mm vertical bar at a fixed distance. Figure 3 illustrates the ability of the True*IR*'s detector's array to capture the thermal image of the slim bar. Due to limitation of the physical iFOV discussed earlier, if a single frame is used (in this example that means only Frame 1 is used), only the average temperature of the bar is recorded, which is inaccurate.

Through multi-frame acquisitions, Fine Resolution is able to recover sub-pixel information. Figure 4 shows the test result comparison between using a detector with 160 x 120 pixels versus the results obtained using a Fine Resolution imager which generates a 320 x 240 pixel image. Fine Resolution provides 1.5x better iFOV, thus resulting in 1.5x more accurate temperature measurement. This means that when purchasing a thermal imaging system, the True*IR*'s Fine Resolution provides better resolution without a significant increase in cost.

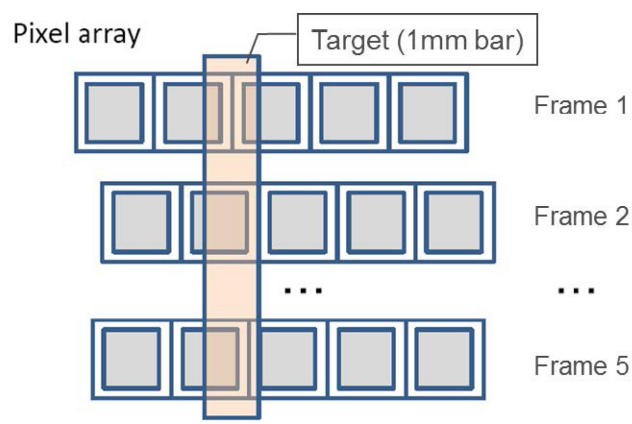

Figure 3. Detector's pixel arrays

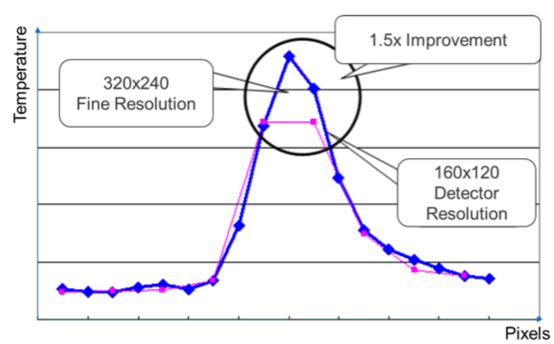

Figure 4. Lab test results (1-mm bar)

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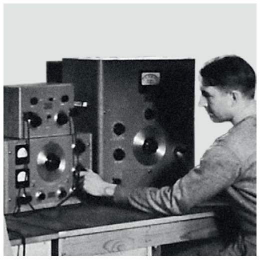
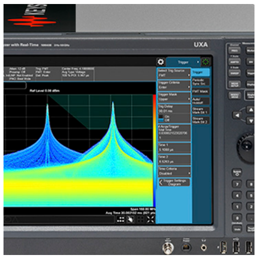


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