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Measurement of the Minimum Temperature Difference Perceived (MTDP) of Thermal Imagers at IOSB

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Validity:

1. The MTDP applies for well and under sampled thermal imagers. The applicable spectral range is 3 µm to 14 µm or parts of this range.

   Note 1: The MTDP is a development of the known Minimum Resolvable Temperature Difference (MRTD) concept. For details on the method compare W. Wittenstein "Minimum temperature difference perceived – a new approach to assess under sampled thermal imagers", Opt. Eng. 38(5) 773-781 (May 1999).

Definition of MTDP

2. The MTDP is the minimum temperature difference which allows an observer to resolve a 4-bar-test pattern (Figure 1) in accordance with a given criterion. It depends on the spatial frequency of the test pattern, the environmental temperature, and on the position and orientation of the test pattern relative to the detector.

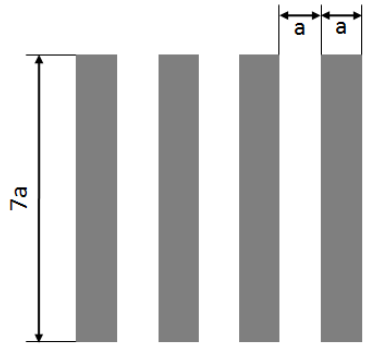

Figure 1: 4-bar-test pattern for MTDP measurement.

Measurement Conditions

3. The 4-bar-test pattern is positioned in front of a black body, the temperature of which can be varied, giving positive and negative temperature differences ΔT between the bars and the background.

4. The bar target is projected on the imager under test using a 2.5 m focal length, 0.3 m diameter off axis collimator. In doing so optical axis of imager under test and projection correspond. The position of the test pattern relative to the detector is adjustable in small steps relative to the imager's instantaneous field of view.

   Note 2: For imagers with large instantaneous field of views it may be necessary to exclude the collimator and look directly on the target.

5. Environmental temperature, which also corresponds to the bar target background temperature is kept within 22±2 °C unless otherwise specified.

6. Room illumination is set to a level that does not distract the observer from its task. Typically a low level is used to increase the observer's light sensitivity. Alterations according to the observer's demands are allowed.

7. Imager gain is set manually using an as high as possible one for the measurement. Imager brightness is adjusted by the observer to optimise results before and during the measurements.

   Note 3: Measurement of imagers with automatic gain and brightness adjustments are possible as long as linear methods are used. A homogeneous background that forces the automatic to a high gain is used. No changes to this background are allowed during the measurements. Nonlinear automatic settings may be measured but the meaning of the results is unknown at the time of writing.

8. Measurements are performed at the display that belongs to the imager. If no display is belonging to the imager in test, an IOSB standard monitor is used instead. Contrast and brightness of the monitor are adjusted before the measurements to give optimum performance. A suited video generator is used for this purpose. No alterations are allowed during the measurements. The observer is allowed to alter the distance of his eye from the monitor to give optimised results wherever applicable.

Measurement Process

9. A test pattern is presented to the observer at a temperature difference that allows a good separation from the background. The observer slightly alters the position of the test pattern relative to the detector (phase) and selects the position where the maximum number of bars is visible. This can be either four, three or two bars (Figure 2). The number of bars visible is recorded and the phase is kept for the measurement of the test pattern.

   Note 4: For a well sampled imager the number of bars that can be resolved is always four and the MTDP corresponds to the MRTD.

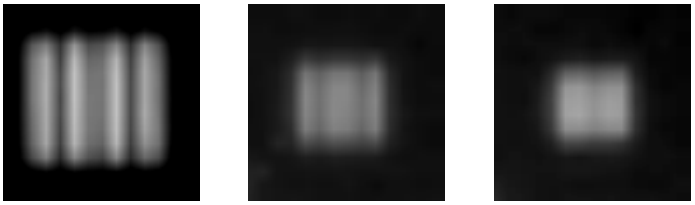

Figure 2: Test patterns as seen by an under sampled thermal imager with four, three, and two bars visible (from left).

Starting from an invisible test pattern, the temperature of the black body is increased until the test pattern can just be seen in positive contrast. The corresponding temperature difference ΔT_p is recorded. The temperature of the black body is then reduced causing the test pattern to disappear and then to reappear with negative contrast. When the observer can just resolve the bars, the corresponding temperature difference ΔT_n is recorded again. The two measurements are taken with a time delay as small as possible

to minimise drift influence. From the two measurements, the true temperature difference to resolve the bars can be determined according to

$$\Delta T = \frac{\Delta T_p - \Delta T_n}{2}$$

This measurement is typically repeated at least once, with four repetitions aimed for. The whole procedure is repeated with bar targets of increasing spatial frequencies until the observer is not able to resolve any bars in the first step of the measurement process. Spatial frequency and temperature difference used for the decision are recorded.

10. The criterion for resolving the bar target is to see the bars and not just some modulation on the display, although it is not necessary that each of the bars be visible at the same time.

11. The MTDP is measured with the bar target orientated horizontal and vertical relative to the detector of the imager.

12. Measurements typically are taken at a minimum of six spatial frequencies distributed approximately uniformly over the useful range of the imager.

Exploitation of Results

13. The MTDP for a given spatial frequency is the average value of the two or more measured temperature differences ΔT.

14. The MTDP results are be tabulated for each orientation, containing also the spatial frequency of the bar pattern not resolved by the observer. The number of bars resolved is given in the table when different from four. Additionally, the MTDP results are plotted on a graph containing the two orientations measured.

Range Calculation

15. Nominal range is calculated against customer specified standard targets using TRM4.v2 Software and the measured average horizontal and vertical MTDP.

16. There is the possibility that no intersection between the atmospheric degraded temperature difference and the minimum necessary temperature difference curve occurs. This indicates that range is limited by spatial instead of temporal resolution. In such a case, the MTDP-curve will be added with a spatial frequency 0.01 $mrad^{-1}$ higher than the last measured one. The temperature difference for this spatial frequency is set to the initial temperature difference of the assessed standard target.