Thermal Configuration Guide

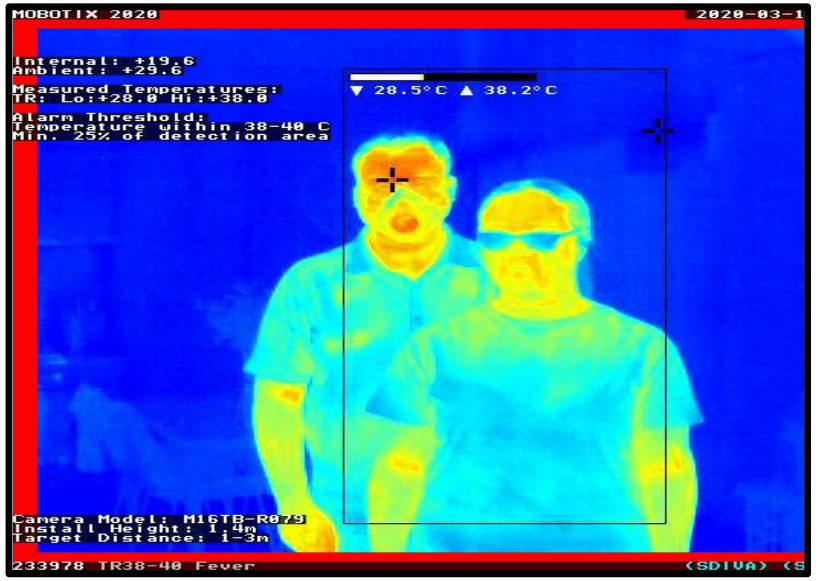
Best Practice without the use of a Black Body Radiator

Starting...

This is a guide that aims to help you understand the best-practice configurations and understanding the factors that may impact thermal measurements, while developing events to monitor smaller temperature changes and understanding the 'GTC_PreConfig' template configuration file.

Before getting started, it is important to note that:

- Thermal Radiometry (TR) models provide greater accuracy than the standard thermal models and should always be the preferred model to use when measuring thermal temperatures.
- Thermal Radiometry models are not Medical Devices
- MOBOTIX TR models are generally designed to provide an accuracy level within ranges in standard operation depending on environmental conditions and configuration
- **Further accuracy is possible only with a black body radiator present which is recommended**



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MOBOTIX Thermal Sensors	
Thermal Sensor Type:	Uncooled Microbolometer
Thermal Resolution:	336 x 252
Pixel Pitch:	17 µ m
IR Range:	7.5 to 13.5
Lens Options:	45˚, 25˚, 17˚
Housing Options:	M16 or S16 Series
Power Consumption:	< 10W max

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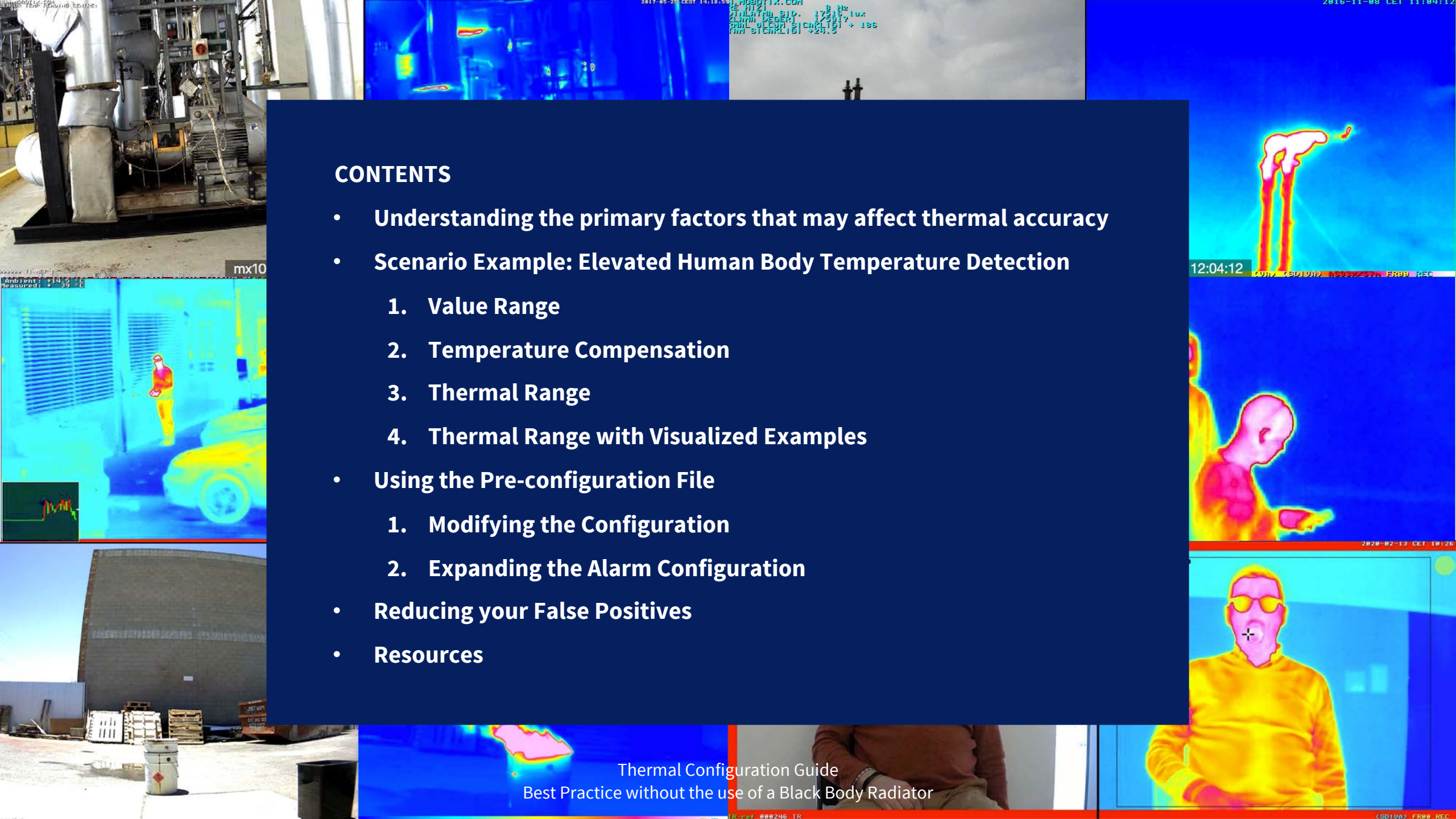

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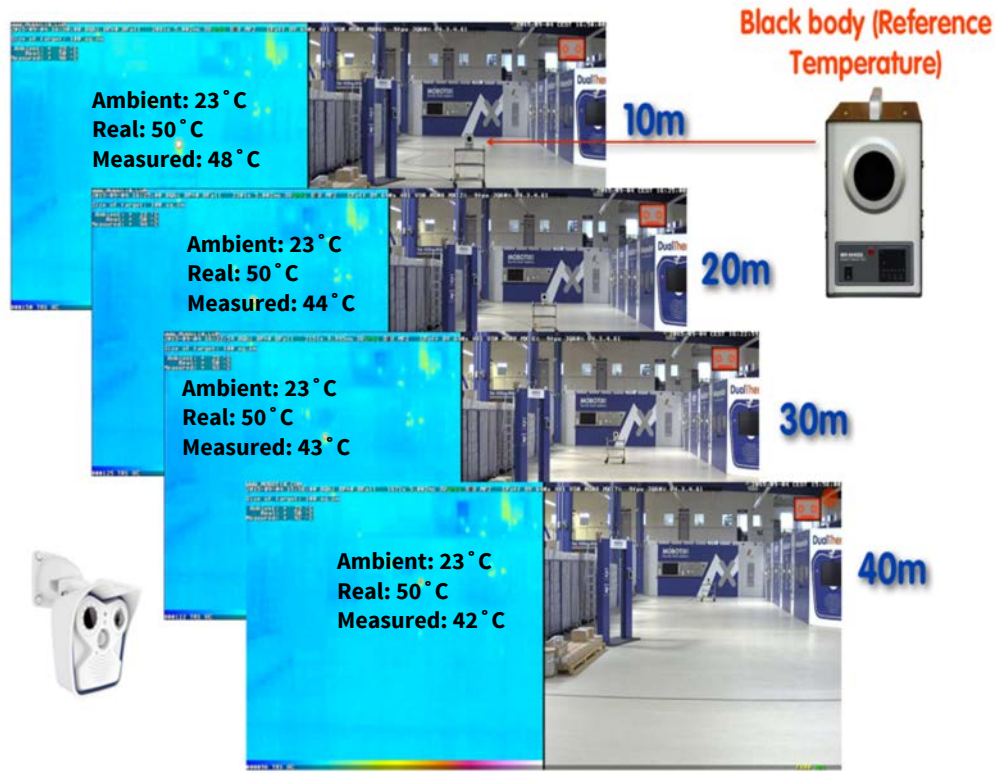
Understanding primary factors that may affect thermal accuracy

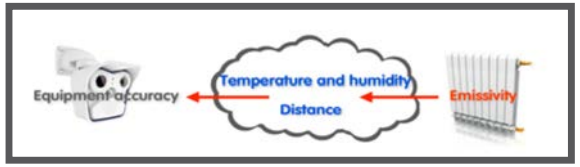
Object Emissivity is the measurement of an object's ability to emit infrared energy as thermal radiation, it is based on the surface of the object and influenced by the material it is made from. This is generally measured between 0 (e.g. mirror) and 1.0 (black body radiator)

Atmospheric Transmission is the measurement of atmospheric purity between an object and thermal sensor. In the MOBOTIX configuration this is reflected as a percentage and leverages the value configured for Ambient Temperature. A value of 100(%) would determine that there are absolutely no particles in the space between the object and thermal sensor that obstruct transmission.

Distance is not usually a factor when using conventional thermal and temperature sensors as these measurements are usually taken with minimal space between the thermal sensor and target object. Therefore, maintaining an appropriate distance to the target is key to accurate temperature readings.

The factors that can affect a thermal sensor's ability to accurately measure the temperature of object are primarily due to different gas molecules and aerosol particles - the majority of which include water vapor and carbon dioxide. Hence, by increasing the distance between the target object and thermal sensor you are effectively increasing the number of particles that exist within the space and directly affecting the relative accuracy of the thermal measurement.





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Strategic Placement

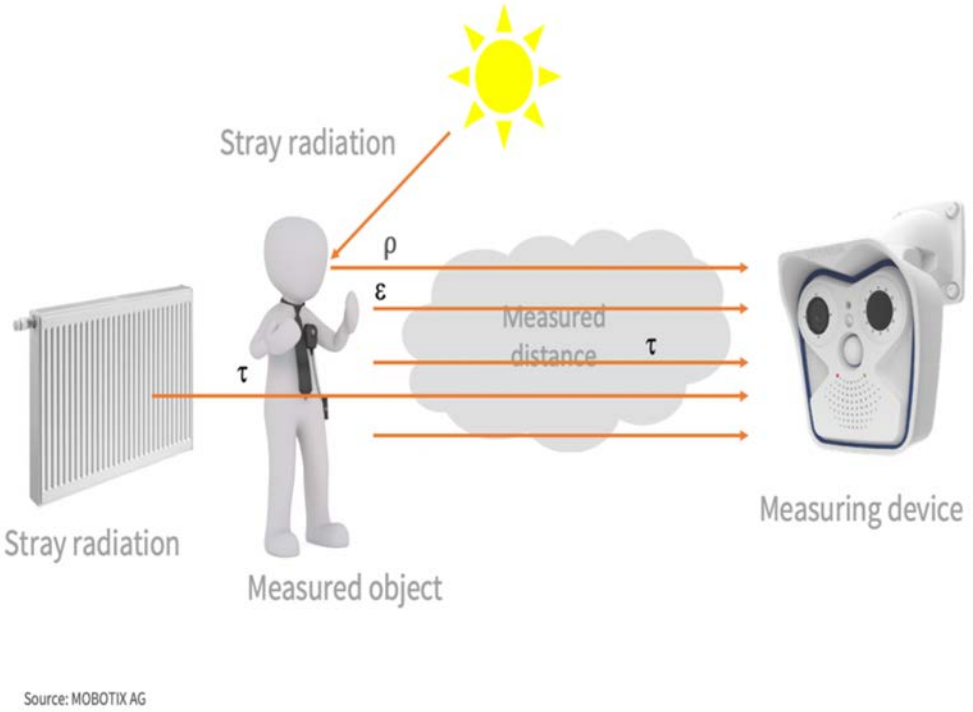
This is vital to ensuring an accurate reading – controlling the distance to the target is not enough to guarantee an accurate result as the subject of the thermal measurement must have a source that can provide a reliable temperature reference.

For the human body, this detection point has been identified as the medial canthus, near the inner corner of the eye. It is expected that the presence of external factors such as sunglasses and sweat may impact the thermal measurement.

It is important to take into account the installation point of the camera and the expected field of view that the sensor will be able to provide – If the camera is installed in an elevated position or is located far from the subject (resulting in decreased pixel density) it can become difficult to get a clear line of sight from the thermal sensor to the medial canthus.

For this application scenario the ideal field of view would be a profile similar to that of a passport photo. Depending on your project, this level of detection may not always be possible, so the next possible detection point that can be measured would include the T-Zone, particularly the area around the nose, lips and to a lesser extent, the forehead although are less reliable indicators of human body temperature than the medial canthus.

With this, keep in mind that the thermal sensor will still need a clear line of sight to the subject and that the subject's travelling trajectory should follow a path that naturally directs them to face the thermal sensor.



Source: MOBOTIX AG

Transmission: τ
Emission: ε
Reflection: ρ

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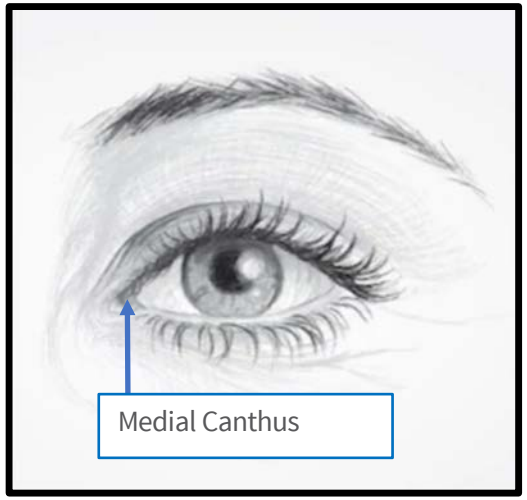
More spatial resolution

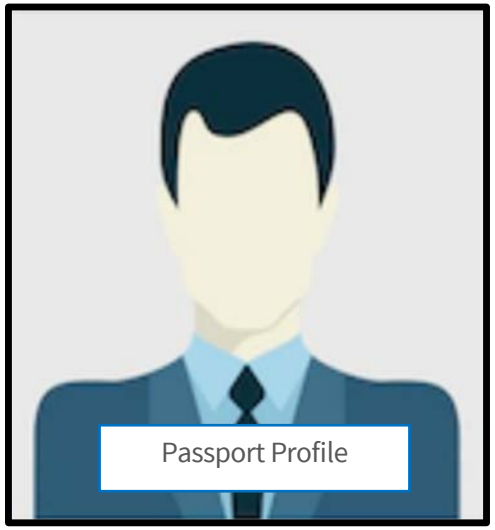
This does not necessarily guarantee higher levels of accuracy. What is important, is the distance to target and the clarity on crucial detection points such as the aforementioned medial canthus.

MOBOTIX Thermal Sensors are 336x252 in resolution so it is important to note that although the TR079 (45˚) may offer a wider field of view, depending on distance to target and the considerations taken to strategic placement of the thermal sensor, the TR119 (25˚) and TR237 (17˚) may also be considered –

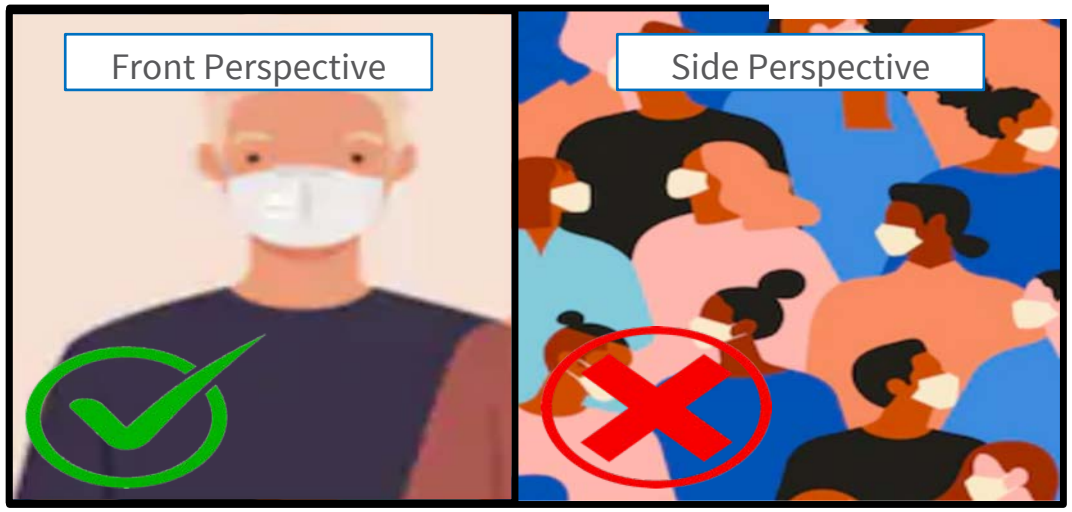
As these alternatives would allow for a higher spatial resolution for each target, however do not forget to take distance, thermal emissivity as well as atmospheric transmission into consideration as the use of these narrower lenses would natural require a greater distance to target.



Reference Shutterstock



Reference Shutterstock



Reference Shutterstock: 1 & 2

Scenario Example: Human Body Temperature Detection

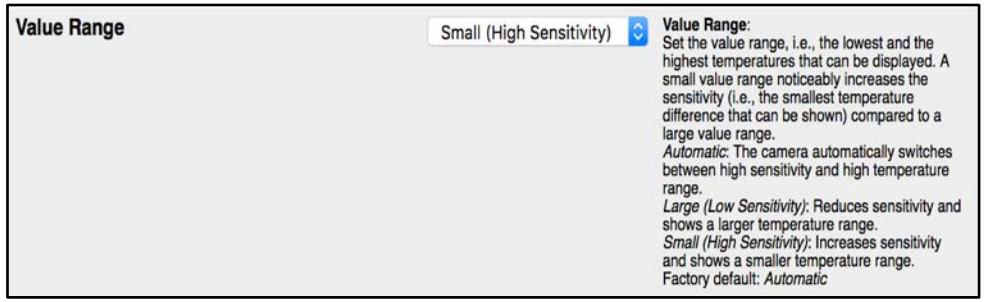
In this scenario, there is a very strict criterion for being able to detect ranges of human body temperature. If we assume that the general human body temperature should be roughly 37˚C and the general indications of a temperature range between 38-40˚C, we can use these as the baseline for our configuration for this example.

Value Range:

This setting is used to switch between detecting either a **larger range of temperatures (low sensitivity)** with slightly decreased accuracy or to detect a **smaller range of temperatures (high sensitivity)** with greater accuracy.

If the configuration is set to the default setting '**Automatic'**, then the camera will automatically adjust the value range according to the lowest vs. highest temperatures detected within the scene.

For this scenario example, the ideal configuration would be **Small (High Sensitivity).**



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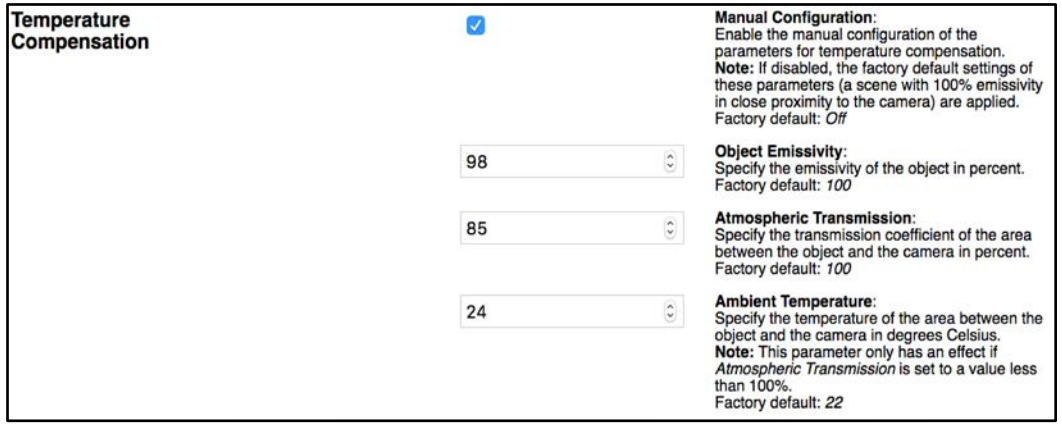
Temperature Compensation

By default, thermal sensors are configured to accurately measure temperatures of objects that are within close proximity, but when trying to accurately measure objects at a distance, a manual configuration will be necessary.

In the example below we have used an Object Emissivity value of 98[1] for human skin, 24˚C for Ambient Temperature as measured by the camera using the variable $(SEN.TOU.CELSIUS) under Text & Display Settings.

As for Atmospheric Transmission, if this value is reduced from 100 to 90 and continually subtract in increments of 10, it seems to roughly increase temperature by roughly ~1˚C at 98 Object Emissivity, when used in an environment with around 24˚C Ambient Temperature. It is worth noting that this setting directly leverages off the Ambient Temperature value - So the lower the Atmospheric Transmission value is, the greater influence that the Ambient Temperature value will have in the overall thermal measurement. In this example the value “85” was used to compensate for an approximate distance to target of 2m.



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Thermal Range

For enhanced clarity, it is highly recommended to also configure the thermal range manually (Automatic Adjustment is the default setting) which will allow operators to identify individuals with higher temperatures much more easily.

For this application, we recommend one the following configurations:

Default: Automatic Adjustment Foreground + Background		**Alternative: High temp only (~38˚C+) with Ghosting**	
Min. Thermal Value	45	Min. Thermal Value	480-485
Max. Thermal Value	500	Max. Thermal Value	500

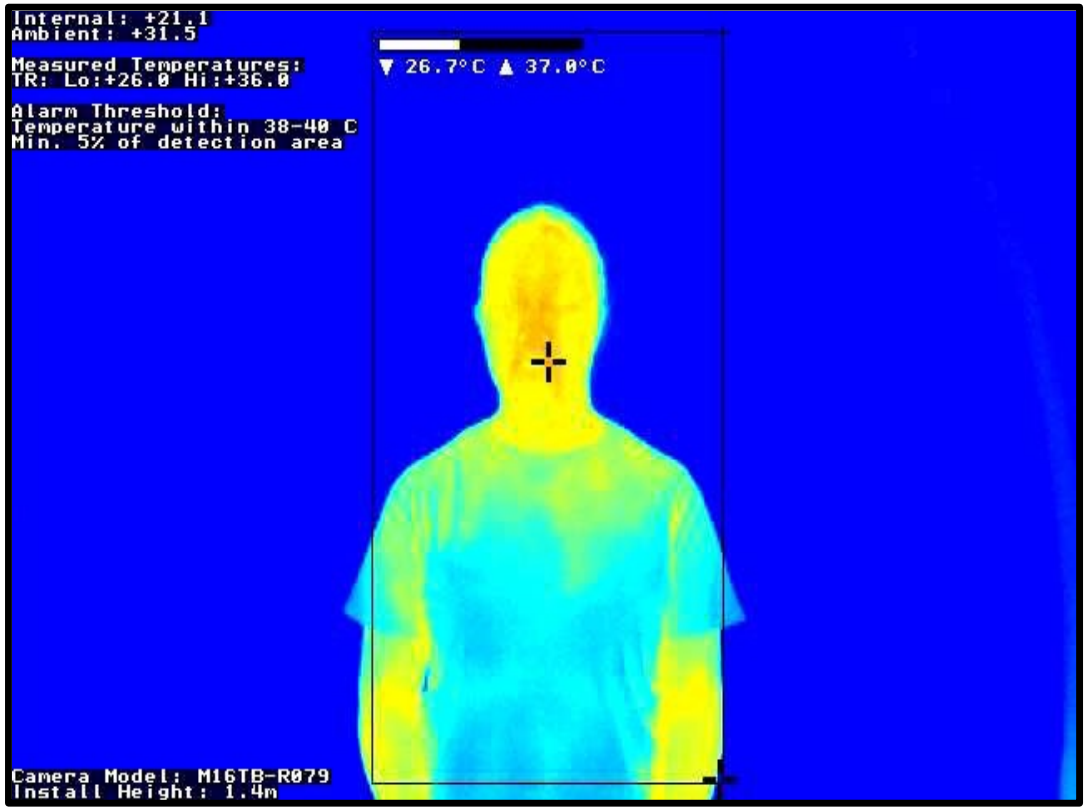
Thermal Range with Visualized Examples

The values used within the thermal range will not affect the performance of your camera, however the way you apply these settings can change the way you interact with the presented information.

It largely depends on how much the background information matters (Default) or if you only want to be able to visualize temperature similar to that of body heat (Recommended) or you could of course, filter into the higher range to primarily focus on the warmer heat sources that would actually trigger an alarm at 38˚C or higher (Alternative).

Please see examples for each of these configurations below on a 45˚ (TR079) thermal sensor.
Camera installation point was approx. 1.4m in height, with a target distance of 2m

Recommended: Thermal Range 470-500 to generally only visualize human bodies depending on the environment.



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Default:

Thermal Range 45-500 to visualize the majority of visible objects that emit heat from both the foreground and background combined.

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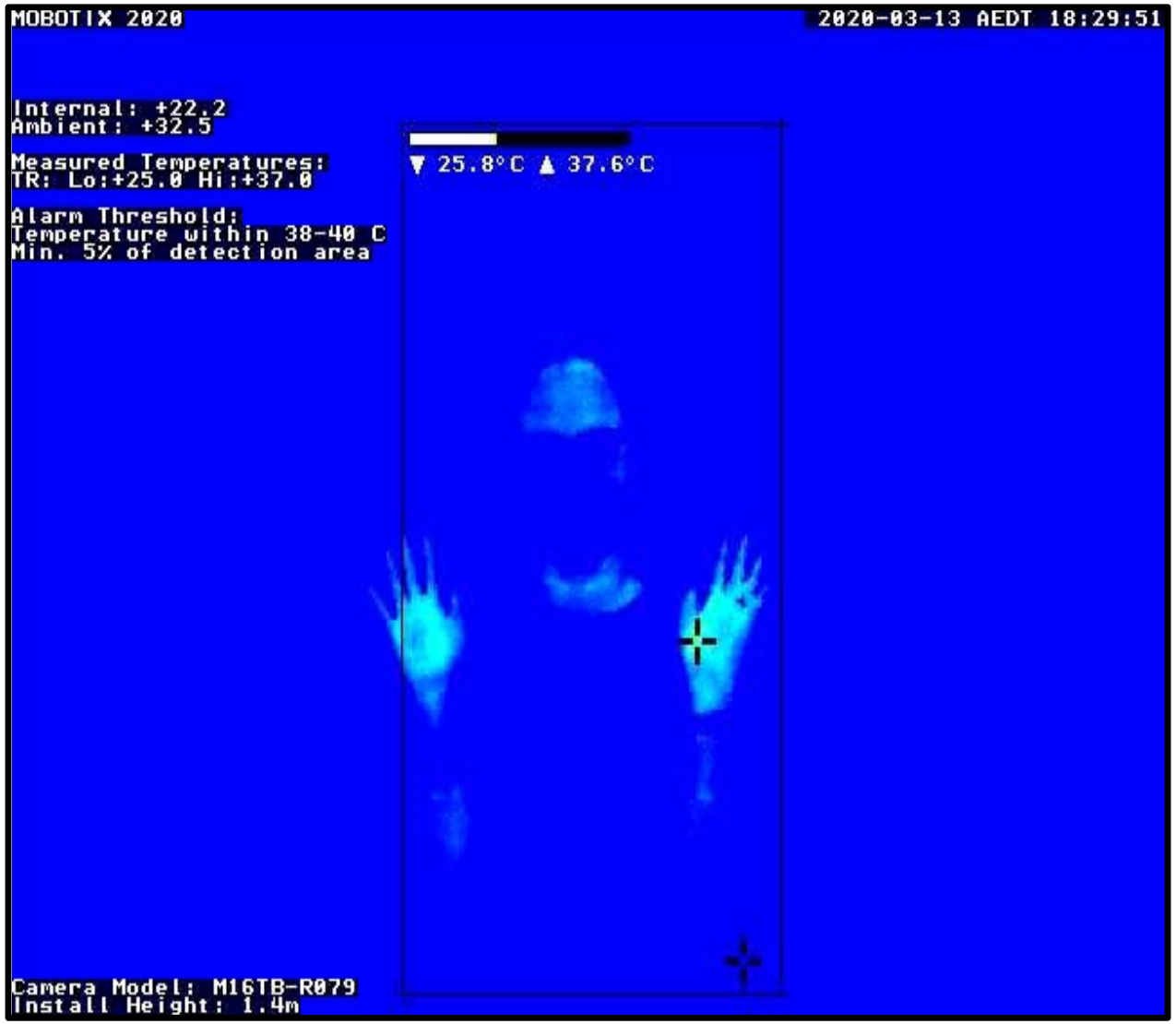
Alternative:

Thermal Range 480-500 to visualize only hotter areas with slight ghosting for better interpretation of shapes and objects that are generating alarms for this scenario



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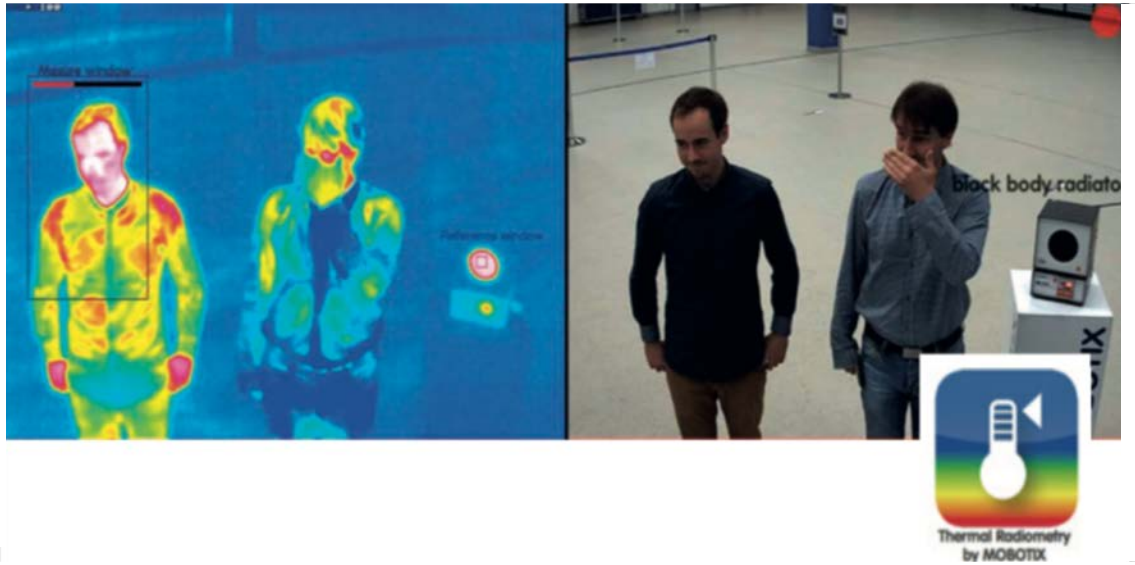
Using the Pre-configuration File

So now that we understand the criteria required to calibrate a thermal sensor to be as accurate as possible (without professional instruments such as a black body radiator) and understand the conditions required for this to succeed, we can now continue to the configuration.

The initial proposed event configuration that is required as a minimum to be successful in this application and then provide options that expand on these concepts - but ultimately it will be up to you, as an integrator to decide which configuration best suits your project.



The Pre-configuration File

MOBOTIX have developed a baseline configuration file to help speed up the overall thermal calibration and configuration process, but it is important to understand what settings need to be modified.

What does the pre-config file overwrite?

NOTE: All of the sections listed will overwrite all configurations as noted.

Please note that your admin credentials will be modified to ‘admin’ ‘meinsm1999’. This can be adjusted as per preference, but it is recommended to not adjust the “api” user as it is required for the predefined IP Notify profiles to operate properly.

*The preconfiguration assumes that your thermal sensor is installed in the **right** or **lens 0** slot.

*Configurations can be loaded into any MOBOTIX Camera using the **Load** Configuration option found within the Admin Menu.*

SECTION	Description
access	Deletes all users+groups (new admin credentials - admin:meinsm1999)
actionhandler	Replaces all Action Groups
audio	Activates Speaker at Volume Level 18 & disables microphone
eventdlite	Replaces Recordings (to Event) and General Event Settings Menus
events	Replaces All Events, keeps default image analysis events
imageimprover	Replaces All General Image & Text & Display Settings 1/2
imageimprover 2	Replaces All General Image & Text & Display Settings 2/2
ipnotify	Replaces All IP Notify Profiles
sound	Adds “Beep” Sound Profile, keeps default sound profile
vptz	Locks vPTZ usage

In general, this is a safe configuration, in that it will not overwrite any network or storage settings but as always it is recommended to backup your camera’s configuration prior.

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Modifying the Configuration

Below are a list of settings that we recommend you adjust according to your environment.

Some of these include alarm thresholds for average Ambient Temperatures to autoconfigure your part of your thermal calibration as well as activating the correct Thermal Range events. Take note of “Where” the settings are that you need to change, the “Pre-config Defaults” will show you what the existing value is within these fields that you may need to modify.

The latest pre-configuration file can be found under Resources.

Please note, that for a simplified understanding we have split this into 3 separate tables based on which alarm configuration you want to use.

- Alarm Configuration #1
- Alarm Configuration #2
- Alarm Configuration #3

Configurations that should be adjusted as necessary for each application:

Optional Configurations		
Enable the Automatic Ambient Temperature Adjustment	Setup Menu > Event Overview > Time Events Enable the “TT” Event Requires either an MX-GPS-BOX or MX-EXTIO module Optionally, you may also adjust the trigger time	Trigger Time in Hours: */4 Every 4 hours
Configure the Ambient Temperature Source	Setup Menu > Event Overview > Environment Events Edit the Ambient_L/RL/RH/H Events Requires either an MX-GPS-BOX or MX-EXTIO module	Sensor Source: Ambient

What	Where	Pre-config Default
Adjust Atmospheric Transmission as necessary	Setup Menu > Thermal Sensor Settings Increase this number to decrease (-) the temperature reading Decrease this number to increase (+) the temperature reading This setting is purely used to reconfigure the offset.	85
Adjust Ambient Temperature as necessary	Setup Menu > Thermal Sensor Settings This can also be configured automatically, see below under Optional Configurations.	24˚C
Manually adjust Thermal Range as necessary	Setup Menu > Thermal Sensor Settings For more information, click here.	Min. 470 Max. 500
Adjust Thermal Color Palette	Setup Menu > Thermal Sensor Settings Configure the thermal colour profile as preferred	Rainbow

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Alarm Configuration #1:

Measurement of targets within 3m

This configuration is the most recommended and also maintains the simplest setup. It focuses on utilising two different Environment Events, one to specify your temperature alarm threshold ("**Target**", 37.8˚C+) and another to configure a limit at which to ignore temperatures above a specified threshold ("**Limiter**", 41.0˚C+).

The 'Target' Environment Event is then placed into a Meta Event ("**Target_x2**") to count at least 2 triggers within 3s, which is then integrated into another Meta Event "**Elevated_Temp**" which looks for a 37.8˚C alarm trigger within a single pixel ("**Target**") but if something is detected as over 41˚C ("**Limiter**") then it will simply be ignored.

What	Where	Pre-config Default
Temperature Detection Area	Setup Menu > Event Overview > Environment Events "Target" and "Limiter" Events Both events should use the same detection areas.	0,430,80,430,780
Temperature Alarm Threshold	Setup Menu > Event Overview > Environment Events "Target" and "Limiter" Events "Target" should be the alarm threshold, "Limiter" is used to ignore temperatures above threshold	"Target" – 37.8˚C "Limiter" – 42.0˚C

Pros	Cons
Simplified Configuration	Cannot mitigate false positives based on object size
Accurate temperature alarms to a single decimal point	Cannot differentiate alarms from one individual to another. Configuration is based mainly for a single or small group of individuals in close proximity.

Alarm Configuration #2:

Variable measurement of targets within 5m

This configuration is designed to be centered on varying ambient temperatures within a scene and relies on having a reliable source for an ambient temperature. It is worth noting that depending on scenario these temperature values will need tweaking.

In short, this configuration is based on an Ambient Temperature alarm, whether the temperature where the thermal sensor is installed in is operating at a normal (“**Ambient_RH/RL”**, 23-26˚C), warmer (“**Ambient_H”**, 29˚C+) or cooler (“**Ambient_L”**, <21˚C) environment. When one of the ambient temperature alarms are triggered it will simultaneously turn on/off the corresponding thermal ranges.

These thermal ranges include low (“**Range_Low**”,36-38˚C), normal (“**Range_Normal**”,38-40˚C) and high (“**Range_High**”,40-42˚C) threshold ranges. In an example, in standard operating conditions the camera will trigger an alarm if a temperature is detected within 38-40˚C –However, if the ambient temperature were to increase to over 30˚C then the camera would turn off the 38-40˚C (“**Range_Normal**”) event and instead utilise the upper threshold 40-42˚C (Range_High) for alarms.

What	Where	Preconfig Default
Ambient Temperature Alarm Triggers	Setup Menu > Event Overview > Environment Events Edit the Ambient_L/RL/RH/H Events Requires either an MX-GPS-BOX or MX-EXTIO module	<21˚C, >22˚C, <27˚C, >29˚C
Ambient Temperature Auto Adjustment	Admin Menu > IP Notify AmbientLow, AmbientReset, AmbientHigh Modify the last set of numbers in the “message” field only	20˚C, 24˚C, 30˚C
Thermal Range Detection Area	Setup Menu > Event Overview > Environment Events Range_Low/Normal/High Events	0,430,80,430,780
Thermal Range Temperatures	Setup Menu > Event Overview > Environment Events: Range_Low/Normal/High Events	Low: 38-40˚C Normal: 36-38˚C High: 40-42˚C

Pros	Cons
Requires an MX-GPS-BOX or MX-EXTIO module for Ambient Temperatures	Complex Configuration
Can mitigate false positives based on object size by changing from “OnePixel” to “Percent”	Accurate temperature alarms to whole numbers only (no decimal point)
Can automatically adjust alarm conditions based on the current ambient temperature	Cannot differentiate alarms from one individual to another. Configuration is based mainly for a single or small group of individuals in close proximity.
	Configuration requires more tweaking to utilise Ambient Temperatures as variables

Optional Configuration		
Integrating a minimum object size for alarms	Setup Menu > Event Overview > Environment Events: Range_Low/Normal/High Events Modify the Trigger Mode from ‘One Pixel’ to ‘Percent’	One Pixel > Percent % is relative to the measurement area specified

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Alarm Configuration #3:

Measurement of multiple targets within 3m

This configuration utilises a similar template to Configuration #1 but instead focuses on splitting the image area into 3 parts (1/3) then configuring both Targets ("**Target_Z1/Z2/Z3**") and Limiters ("**Limiter_Z1/Z2/Z3**") to specify an alarm threshold within each 'zone'

What	Where	Preconfig Default
Temperature Detection Area	Setup Menu > Event Overview > Environment Events "Target_Z1/Z2/Z3" and "Limiter_Z1/Z2/Z3" Events All six events should use the same detection areas.	0,0,41,426,812 0,425,41,850,812 0,857,41,430,812
Temperature Alarm Threshold	Setup Menu > Event Overview > Environment Events "Target_Z1/Z2/Z3" and "Limiter_Z1/Z2/Z3" Events "Target" should be the alarm thresholds, "Limiter" is used to ignore temperatures above threshold	Target_Z1/Z2/Z3: 37.8˚C Limiter_Z1/Z2/Z3: 42.0˚C

Pros	Cons
Slightly Complex Configuration	Cannot mitigate false positives based on object size
Accurate temperature alarms to a single decimal point	Requires more configuration from the integrator to tweak each alarm threshold
Can differentiate alarms from one individual to another. Can be utilized for small groups of individuals in close proximity.	

Expanding the Alarm Configuration

Utilizing an Ambient Temperature Sensor

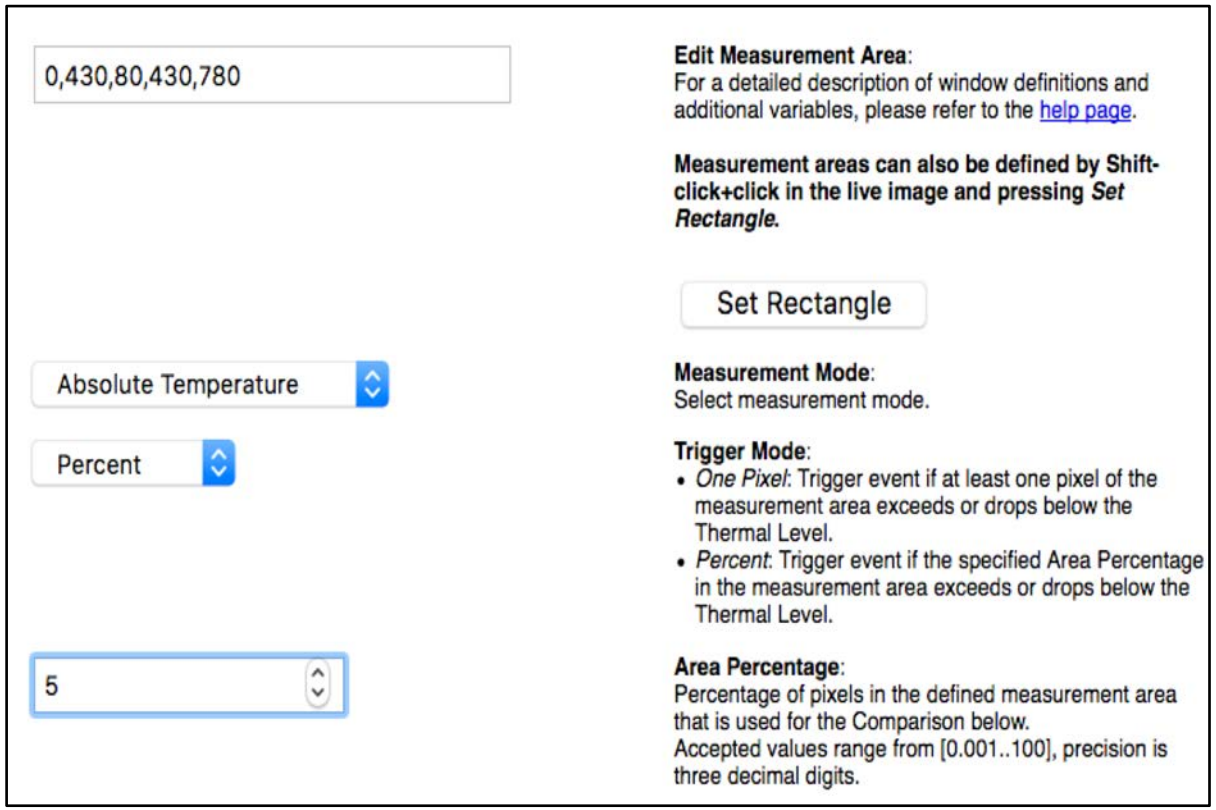
By adding an MX-GPS-BOX or MX-EXTIO to your system, you can utilize ambient temperature alarms to automatically reconfigure the thermal sensor calibration (does not configure atmospheric transmission) or to simultaneously switch between thermal temperature ranges dependent on the ambient temperature.

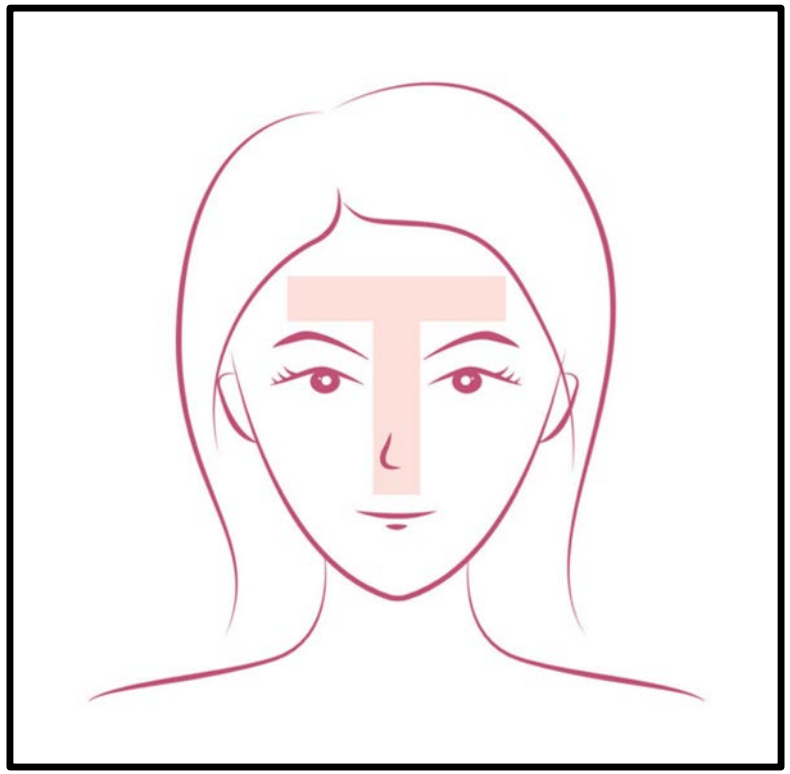
Module	MX-GPS-BOX	MX-EXTIO
Connection Type:	MxBus only (2-wire)	Same network (LAN) or USB
Power Supply:	via Camera (PoE Class 3)	Direct PoE (Class 2) or via Camera (Class 3)
Other Features:	Satellite NTP Time Server, GPS Positioning, GPS Velocity, Illumination Sensor	Built-In Speaker, Line Out, Built-In Microphone, Line Out, 2 Physical Buttons, 2 Inputs, 2 Outputs, PIR, Illumination Sensor

It is worth noting that while the M16 camera platform has its own ambient temperature sensor, when it is installed with a thermal sensor it can no longer be reliably used to provide an accurate temperature due to the heating radiated.

To activate this feature in your preconfiguration file, refer to Optional Configurations.

Mitigate False Alarms from smaller heat sources: Percentage rather than One Pixel





Reference Vectorstock

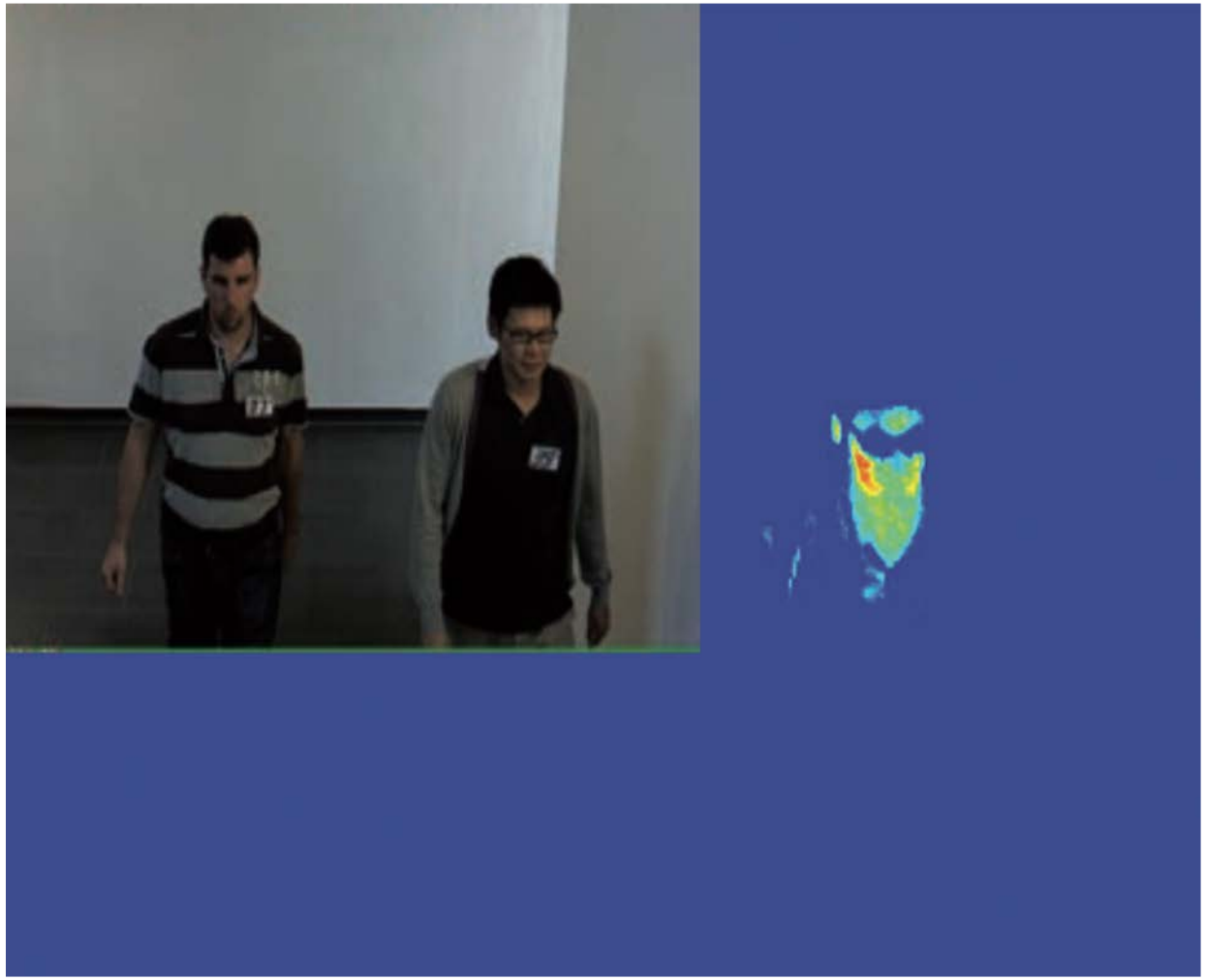
By modifying the original "**Range_Low/Normal/High"** Environmental Events to only trigger based on a "Percentage" rather than "One Pixel" will allow the operator to configure an alarm based proportionally on the size of the specified measurement area. It is important in this regard to test that the percentage used for the alarm condition does not mitigate true alarms, by only excluding objects smaller the size of a human face T-Zone for example.

Reducing your False Positives

Non-Regulated Body Temperatures in an indoor environment where there are factors such as air conditioning and insulation that are purposed to maintain an average room temperature can produce a scenario where it will become difficult to accurately measure the temperature of targets that have entered the detection window from an unregulated area.

A common mistake with this scenario is the implementation of thermal cameras at entry zones - since on hotter days (ex: 35˚C), if an individual spends time in direct sunlight, then enters an area with a thermal camera that is monitoring temperatures within a regulated zone (air conditioned building, 24˚C) then the standard threshold for an alarm condition (38-40˚C) could easily be breached as the individual hasn't spent enough time within the regulated temperature zone for their body temperatures to adjust.

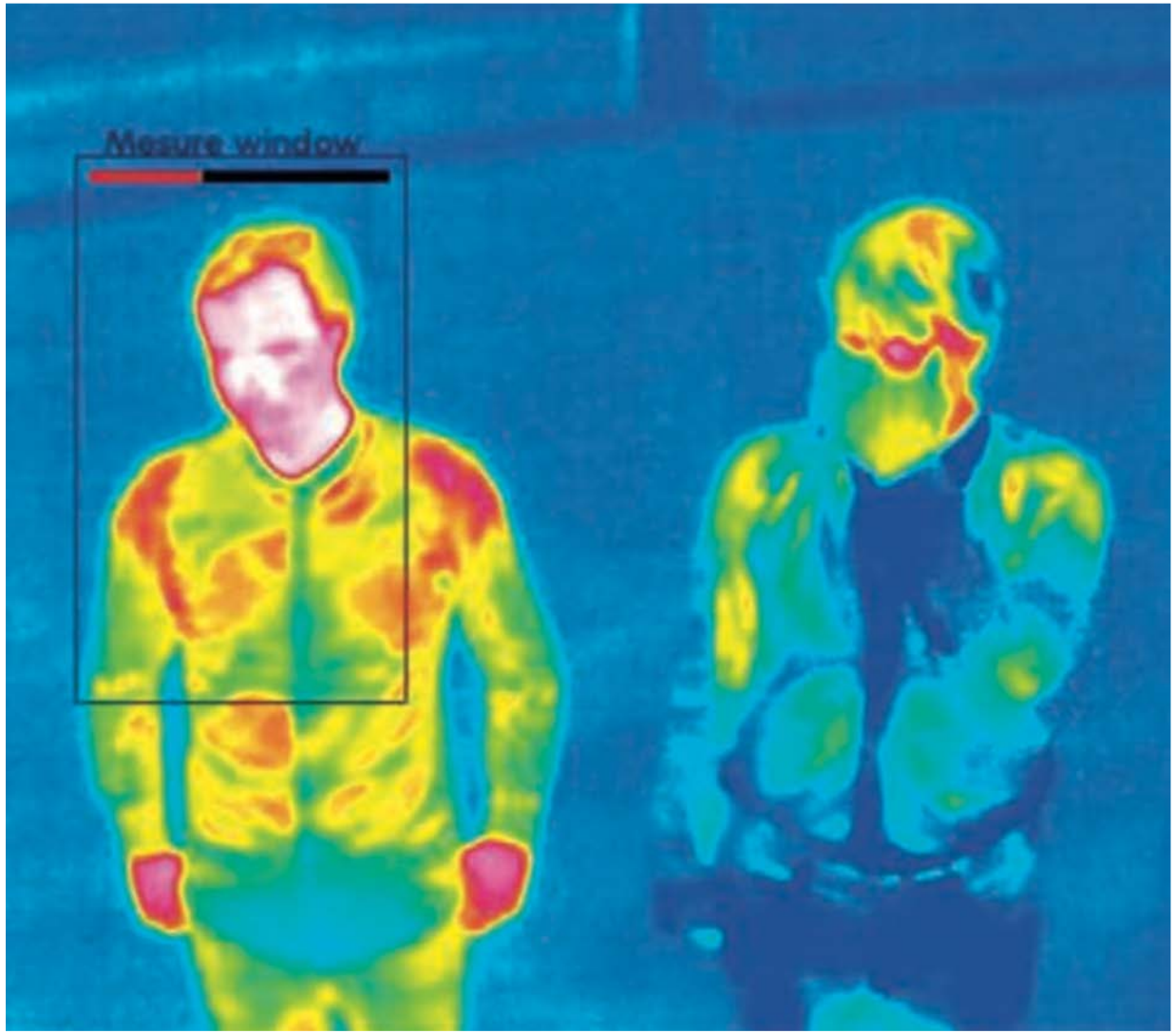
So it is recommended that for installations that require this <5˚C precision to not monitor entry points and rather be strategically placed in locations that would generally guarantee regulated body temperatures such as security screening in an indoor environment with a black body monitor.



Misaligned target area or unexpected direction of travel is another cause for false positives, as human skin generally has an emissivity rating between 98-99, parts of the human body that radiate more heat include body parts such as an open mouth, ears and armpits.

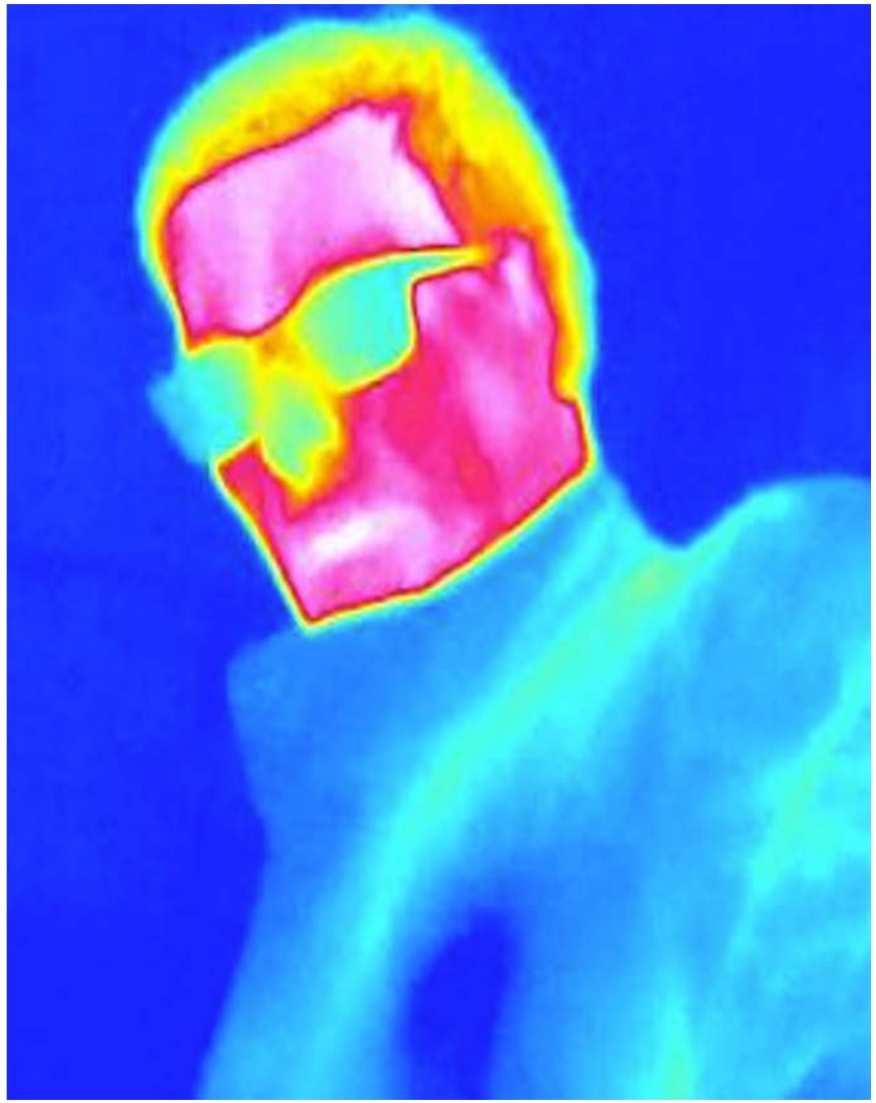
If the thermal sensor has been calibrated to trigger alarms based on the front profile of a human face, due to a level of accuracy for a minor elevation in temperature (38˚C) it can be easy to generate false positives if an individual was pictured at the calibrated target distance from a side profile, exposing the inside of the ear (or Bluetooth earphones), so it is recommended to position the camera strategically and develop a scenario that reinforces your calibration conditions.

In an airport configuration, this consideration would best be implemented at the security screening zones where passengers are required to pass through scanners or corridors where passengers either board their aircraft or the mandatory path to exit the departure section of an airport terminal as a few examples.



The presence of hotter objects within the detection area usually does not impact the alarm conditions configured for thermal sensors as even objects like coffee mugs are made of materials that either do not radiate as much heat (object emissivity) or are designed to be held for easier portability. When dealing with heat sources such as cigarettes, lighters and personal audio equipment – these can easily be managed by reconfiguring the thermal event setting from “One Pixel” to “Percentage” and use a size that is appropriate to mitigate false positives. Additionally, this can be expanded on even further as hotter objects that are seen as approaching the camera can sometimes emit a low temperature from a distance but gradually increase as the distance is shortened and can possibly trigger a short false positive – This can be addressed by developing a Meta Event that effectively ‘counts’ the number of triggers for the 38˚C alarm condition to 2x triggers within 2s with a 1s minimum delay between each event.

A current hardcoded limitation involves the scenario of a person holding a hot object that exceeds your “Target Range” criteria as the camera thermal analytic is trained to look solely for the highest (or lowest) temperature threshold, even if someone with a higher temperature would usually trigger an alarm, if they are holding a glass kettle (with boiled water) the camera will focus on this object, rather than the person.



- **Demo Video / Download**
- **Snapshot 1 - Single**
- **Snapshot 2 – Single**
- **Snapshot 3 – Couple**
- **Demo Video uploaded by G&N Electronic and Medical Solutions**
- **Latest GTC Preconfiguration File (17/03/2020)**

Additional Resources:

- **Download the latest camera firmware here**
  - Minimum firmware version required for this configuration file is V5.2.5.15-r1

- **How to manually configure and understand thermal range**
- **M16B Thermal TR Technical Data Sheet**
- **Product Announcement)**

For any enquiries on MOBOTIX products or questions regarding configurations, references or case studies, please reach out to your local MOBOTIX channels;

- **Contact Us**
- **Sales@mobotix.com**
- **Support-intl@mobotix.com**
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